Report on the Mercury Contamination Reduction Initiative Advisory Council's Results and Recommendations

March 1999

Minnesota Pollution Control Agency

Report on the Mercury Contamination Reduction Initiative Advisory Council's Results and Recommendations

March 1998

Policy & Planning Division
Minnesota Pollution Control Agency
520 Lafayette Rd.
Saint Paul, MN 55155-4194

Acknowledgements

The MPCA thanks the members of the Mercury Contamination Reduction Initiative Advisory Council for their time and cooperation, as well as other persons who attended Advisory Council meetings and provided valuable input.

This report was prepared at a cost of $6,700 worth of MPCA staff time and $800.00 for photocopying. In addition, staff of two other state agencies and four other levels of government reviewed the report and participated in related meetings at an estimated cost of $2,500. The total cost of MPCA staff time applied toward the Mercury Contamination Reduction Initiative from its beginning in May 1997, until the time when preparation of this report began was approximately $350,000, of which $170,500 was covered by an Environmental Protection Agency grant.

Reproduced on paper containing at least 20% fibers from paper recycled by consumers.

Table of Contents

Preface

This report presents the results and recommendations of the Advisory Council formed by the Minnesota Pollution Control Agency (MPCA) to update the state's plan for addressing the problem of mercury contamination. The MPCA's management team has considered and accepted all of the Advisory Council's recommendations. Implementation of the recommended mercury-reduction strategies has begun.

The MPCA recognizes that reducing mercury contamination will follow an iterative process requiring ongoing assessment of the adequacy of the various strategies used. As called for by the advisory Council, the MPCA will report on the progress of strategy implementation in 2001 and 2005. Progress review will include assessment of whether reductions in mercury releases have met the recommended goals, and reconsideration of voluntary and mandatory strategies as well as the goal.

In preparing to make final recommendations, the Advisory Council process generated two other reports that serve as background documents to this report. The *Criteria Committee Report to the Advisory Council of the MPCA's Mercury Contamination Reduction Initiative* provides detailed definitions of the criteria to be used to evaluate mercury-reduction strategies. The *Source Reduction Feasibility and Reduction Strategies (SRFRS) Committee Report on Options & Strategies for Reducing Mercury Releases* provides information regarding sources of mercury, options that sources could use to reduce mercury releases, and strategies that can be used to provide incentive for implementation of reduction options. (The SRFRS Committee report is being revised and is expected to be available in April 1999).

To obtain either of these committee reports, contact Carol Andrews (phone 651/297-8333 or e-mail her at *carol.andrews@pca.state.mn.us*) or Bob McCarron (phone 651/296-7324 or e-mail him at *robert.mccarron@pca.state.mn.us*). Or, mail your request to Carol Andrews or Bob McCarron, Major Facilities Section, Policy & Planning Division, Minnesota Pollution Control Agency, 520 Lafayette Rd., Saint Paul, MN 55155-4194.

The MPCA welcomes your questions and comments regarding this report. Send them to Carol Andrews or Bob McCarron (see preceding paragraph for their phone numbers and e-mail addresses). Or, you may contact Carol Andrews or Bob McCarron by calling the MPCA's toll-free telephone number, (800) 657-3864).

Mercury Contamination Reduction Initiative Advisory Council Members

Member	Main Alternate	Representing
Peter Bachman	Bob Eleff	Minnesota Center for Environmental Advocacy
Alexis Cain *	Frank Anscombe * ^	U.S. Environmental Protection Agency - Region V
Richard Diercks *	Susan Lightfoot	Minnesota Dental Association
John Dwyer	Clifford Porter ^	Lignite Energy Council
David Festa * ^	Stacey Davis * ^ +	Center for Clean Air Policy
Rebecca Flood ^ +	Leo Hermes	Metropolitan Council
Dr. Daniel Foley, Chair	David Thornton * ^ +	Minnesota Pollution Control Agency
Brian Golob *	Jan Nisiewicz	Recyclights
Pam Graika * +	Lee Eberley ^ +	Northern States Power
Bill Grant * +	Amy Fredregill ^	Izaak Walton League of America
J. Drake Hamilton *	Michael Noble	Minnesotans for an Energy-Efficient Economy (ME3)
Ann Glumac ^ Dave Skolasinski * +	Stephani Campbell * Scott Hautala *	Minnesota Iron Mining Association (Campbell is with MnTAC)
Diane Jensen +	Marie Zellar	Clean Water Action/The Minnesota Project
Dave Jeronimus * +	Tim Hagley * ^ +	Minnesota Power
Kathy Svanda	Pat Bloomgren	Minnesota Department of Health
Will Kaul	Karen Utt * ^ +	Cooperative Power
Steve Keefe		Honeywell, Inc.
Rich Korman, Scott Grosscup		Minnesota Hospital and Healthcare Partnership
Gail Lewellan ^ +	Jack Skrypek	Minnesota Department of Natural Resources
Carl Michaud * +	Dave Wierens	Association of Minnesota Counties
Sherry Munyon, Rolf Hanson +		Minnesota Chamber of Commerce
Trudy Richter +	Rob Dunnette	Minnesota Resource Recovery Association
Michael Robertson ^ +		Minnesota Forest Industries
Larry Schwarzkopf * +	Fred Vande Vetter	Fond du Lac Indian Reservation
Tim Tuominen *		Western Lake Superior Sanitary District
Rosemary Wilson	John Knapp, Molly Sigel ^	Center for Energy and Economic Development

* Member/participant of SRFRS Committee
^ Member/participant of Criteria Committee
+ Member/participant of Screening and Evaluation Committee

Advisory Council Facilitator: Roger Williams, Minnesota Office of Planning

Minnesota Pollution Control Agency staff:
Carol Andrews, P.E., Project Coordinator, Policy & Planning Division
Robert McCarron, Economic Analyst, Policy & Planning Division
Dr. Edward Swain, Research Analyst, Environmental Outcomes Division
J. David Thornton, Section Manager, Policy & Planning Division
Susan Brustman, Communications Coordinator
Carri Lohse-Hanson, Lake Superior LaMP Coordinator, North District Division
Ned Brooks, Special Waste Coordinator, Environmental Outcomes Division
John Seltz, Unit Supervisor, Policy & Planning Division
Anne Jackson, P.E., Principal Engineer, Policy & Planning Division
Dann White, Pollution Control Specialist Senior, Environmental Outcomes Division
Linda Grant, Office and Administrative Specialist, Policy & Planning Division
Sam Brungardt, Information Officer, Policy & Planning Division

Minnesota Office of Environmental Assistance staff:
John Gilkeson, Pollution Control Specialist Senior

Glossary of Acronyms and Abbreviations

APC	air pollution control
Btu	British thermal unit
CCAP	Center for Clean Air Policy
CEM	continuous emission monitors
CO_2	carbon dioxide
CP	Cooperative Power
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DPS	Minnesota Department of Public Safety
dscm	dry standard cubic meters
DSM	demand side management
EERC	Energy and Environment Research Center
EPRI	Electric Power Research Institute
GL	Great Lakes
HERC	Hennepin Energy Resource Company
Hg	mercury
HHW	household hazardous waste
IMA	Iron Mining Association
KW	kilowatt, kilowatts
KWh	kilowatt hour, kilowatt hours
lb.	pound, pounds
LCMR	Legislative Commission of Minnesota's Resources
MCES	Metropolitan Council Environmental Services
MDA	Minnesota Dental Association
MDH	Minnesota Department of Health
ME3	Minnesotans for an Energy Efficient Economy
MI	Michigan
MN	Minnesota
MP	Minnesota Power
MPCA	Minnesota Pollution Control Agency
MSDS	material safety data sheets
MSW	municipal solid waste
MW	megawatt, megawatts
MWC	municipal waste combustor
MWI	medical waste incinerator
NSP	Northern States Power
OEA	Office for Environmental Assistance
P2	pollution prevention
PMW	Products, Manufacturing and Wastes (Subcommittee)
ppb	parts per billion
ppm	parts per million
SEC	Screening and Evaluation Committee

SIC	standard industrial classification
SRFRS	Source Reduction Feasibility and Reduction Strategies Committee
TRI	Toxics Release Inventory
U of MN	University of Minnesota
g/l	micrograms per liter
UMD	University of Minnesota at Duluth
US	United States
UTAC	Utilities and Taconite Subcommittee
WLSSD	Western Lake Superior Sanitary District
WWTP	wastewater treatment plant

1.0 Executive Summary

The Mercury Contamination Reduction Initiative is a Minnesota Pollution Control Agency (MPCA) project aimed at reducing mercury contamination of fish in Minnesota lakes. As part of the initiative, the MPCA formed an Advisory Council to develop recommendations on mercury-reduction strategies for the agency's consideration. The purpose of this report is to document and recommend implementation of the strategies adopted by the Advisory Council.

Background

Mercury is an environmental issue of significant concern in Minnesota and around the world. Mercury is a neurotoxin that concentrates in fish to the degree that eating the fish may expose humans and wildlife to unsafe levels of mercury. The concentrations of mercury in fish in most of the Minnesota lakes tested currently exceed the Minnesota Department of Health (MDH) fish consumption advisory level. Therefore, as a precaution, the MDH advises people who eat fish – particularly nursing mothers, children, and women of childbearing age – to limit the amount of fish they eat.

Mercury is an element found naturally in the Earth's crust. Mercury is released into the environment through natural events, such as volcanic eruptions, and through processes, such as fuel and waste combustion; ore processing; and product manufacturing, use and disposal. Most of the point discharges of mercury to water have been reduced or eliminated, so it is estimated that virtually all of the mercury that now reaches the lakes in Minnesota is due to atmospheric deposition. More than half of the mercury deposited in Minnesota is thought to be global atmospheric contamination, the mercury remaining in the atmosphere for up to a year before it is deposited. It is estimated that 10% of the deposition in Minnesota is due to mercury emitted in Minnesota. Therefore, a 50% reduction in mercury air emissions in Minnesota is estimated to result in a 5% reduction in mercury deposition in the state.

Mercury uses in many products, such as paint, fungicides and batteries, have been reduced or eliminated. Because of this and other factors, such as mandated reductions from waste incinerators and other sources, mercury air emissions in Minnesota are estimated to have already declined by approximately 45% between 1990 and 1995.

Mercury Contamination Reduction Initiative Process

To ensure that releases of mercury in Minnesota continue to decline, the MPCA established the Mercury Contamination Reduction Initiative (hereafter referred to as the "Initiative"). The MPCA's goal for the Initiative is: "To achieve significant reductions of mercury contamination, using the most cost-effective methods available, in cooperation with everyone who has an interest in the results."

To achieve this goal, the MPCA established an Advisory Council made up of representatives from industry, environmental groups and government to provide recommendations on mercury-reduction strategies for the agency's consideration (see Table 1 for a list of member organizations). The Advisory Council met nearly monthly from May 1997 through

February 1999. A number of organizations not represented on the Advisory Council also participated in Advisory Council meetings.

The goal the Advisory Council established is: "To advise the MPCA regarding policies designed to reduce mercury contamination and to recommend policy-oriented changes, taking into account the ability to reduce mercury contamination, cost-effectiveness and the need for regional, national and international cooperation."

Table 1 Advisory Council Members

Association of Minnesota Counties	Minnesota Department of Health
Center for Clean Air Policy	Minnesota Department of Natural Resources
Center for Energy and Economic Development	Minnesotans for an Energy-Efficient Economy
Clean Water Action/Minnesota Project	Minnesota Forest Industries
Cooperative Power/Great River Energy	Minnesota Hospital and Healthcare Partnership
Fond du Lac Indian Reservation	Minnesota Iron Mining Association
Honeywell, Inc.	Minnesota Pollution Control Agency
Izaak Walton League of America	Minnesota Power
Lignite Energy Council	Minnesota Resource Recovery Association
Metropolitan Council	Northern States Power
Minnesota Center for Environmental Advocacy	Recyclights
Minnesota Chamber of Commerce	U.S. Environmental Protection Agency — Region 5
Minnesota Dental Association	Western Lake Superior Sanitary District

To accomplish its goal, the Advisory Council established a three-phase process. The purpose of Phase I was to improve the information on mercury use and release ("mercury inventory"), to identify options with the greatest potential to significantly and cost-effectively reduce mercury releases, and to identify strategies that create incentives for implementing mercury-reduction options. Results of this work can be found in the Source Reduction Feasibility and Reduction Strategies (SRFRS) Committee Report, *Options and Strategies for Reducing Mercury Releases*. (The SRFRS report is being revised and the final version is expected to be available in April 1999).

In addition, a committee developed evaluation criteria to facilitate critical evaluation of the options and strategies. These criteria, which are defined in the Criteria Committee's *Report on the Strategy Evaluation Process and Criteria Definitions*, are: cost effectiveness, reduction potential, technical feasibility, comprehensiveness/fairness, social/political feasibility, permanence, flexibility, compatibility, transferability and verifiability.

In Phase II, a committee was charged with using the strategy evaluation criteria to narrow the list of potential strategies to be considered by the Advisory Council. This committee was also directed to assess the economic impact and contamination-reduction potential of the strategies.

Results of these analyses are presented in Appendix A and Appendix B. The package of strategies developed by this committee formed the basis for recommendations agreed upon by the Advisory Council in Phase III of the process.

Advisory Council Recommendations

The Advisory Council achieved consensus on the following recommendations which, taken as a whole, are designed to achieve the goals of the Initiative and the Advisory Council.

Mercury Reduction Goal

The Advisory Council recommends establishment of a statewide goal in 1999 legislation that aims to reduce mercury releases to air and water (combined) by 60% in the year 2000 and by 70% in 2005 using 1990 as the baseline year. Failure to meet this statewide goal is not a trigger for mandatory action in the legislation. The legislation would require MPCA to conduct a progress review in 2001 and 2005 to reconsider voluntary and mandatory strategies and the goal. The reduction goal applies to the statewide total of releases from existing and new mercury sources. As new information regarding mercury releases changes the 1990 baseline estimate, the goal of a 70% statewide reduction in releases to air and water by 2005 will apply to the revised 1990 baseline.

National and International Strategies

To significantly reduce mercury contamination in Minnesota, it will be necessary for reductions in mercury use and release to occur outside of Minnesota as well as within the state. To maximize mercury-reduction potential and cost-effectiveness, it makes more sense to implement certain mercury-reduction strategies on a regional or national level than only at the state level. The Advisory Council recommends pursuit of a set of national and international strategies for reducing mercury use and release, including:

- lowering the threshold above which sources would have to report mercury releases as part of the Toxics Release Inventory (TRI);
- increasing relevant mercury research;
- developing a comprehensive international mercury management plan that encourages pollution prevention and ensures that mercury is managed wisely;
- creating a mercury-related outreach position for Minnesota to share its success stories and to learn from others;
- instituting a national mercury product labeling program or law;
- evaluating the feasibility of lower emission limits for sewage sludge incinerators;
- lowering emission limits for medical waste combustors; and
- establishing a credit for early action (early reduction credits) program.

Minnesota Mercury Inventory, Research, Monitoring and Reporting

The Advisory Council recognized that additional work is needed to better understand mercury sources, environmental fate, health impacts and other risks in Minnesota. Towards that end, the Advisory Council recommends that research be conducted in Minnesota that is focused on addressing mercury issues of particular importance to Minnesota. The Advisory Council also recommends that efforts be applied towards improving the comprehensiveness and accuracy of the existing state mercury inventory. In addition, the Advisory Council recommends that the

MPCA develop monitoring, measurement and reporting protocols that would improve data consistency both within and across sectors and result in a better accounting of mercury use, release and reductions. These protocols will be developed to enhance the possibility that mercury reductions achieved in Minnesota since 1990 could earn recognition or credit under any future federal programs.

Reducing Purposeful Use of Mercury

The Advisory Council determined that the lowest-cost strategies for reducing mercury tended to be those related to mercury-containing products. In order to maximize the cost-effectiveness of mercury-release reductions, the Advisory Council recommends the following strategies for implementation in Minnesota:

- *Existing Products:* To improve the likelihood that mercury contained in products currently in use does not get released to the environment, Minnesota should improve the mercury-collection infrastructure, conduct clean sweeps to collect unneeded mercury, and step up enforcement of existing bans regarding disposal of mercury-containing products. In addition, sources are encouraged to label mercury products still in use to ensure proper disposal.
- *New Products:* To discourage use of mercury and encourage proper management of new mercury-containing products, Minnesota should increase enforcement of existing mercury labeling laws and reduce demand for mercury-containing products by discouraging procurement of mercury-containing products by state government.
- *Education and Promotion:* Education and promotion are needed to maximize the effectiveness of strategies listed above, as well as to reach larger audiences. To achieve this, the Advisory Council recommends strategies that educate the general public, schools and target industries. The Advisory Council also recommends education geared specifically toward informing dentists of appropriate amalgam waste management practices and encouraging building contractors to reduce use of mercury products in buildings.

Voluntary Agreements

As an essential strategy to achieve the mercury-reduction goals, the Advisory Council recommends that mercury sources be encouraged to develop voluntary agreements with the MPCA to reduce or work towards reducing mercury use and releases. Voluntary agreements provide a mechanism to achieve reductions from all sources, including those for which no cost-effective solutions were identified. Participation is open to any interested source; however, priority will be given to sources with releases in excess of 50 lb. per year that are not already expected to significantly reduce their mercury use or release.

Funding Mechanisms

The Advisory Council recommends that the MPCA and Office of Environmental Assistance prioritize their current budgets and staffing as well as other agency resources on mercury-reduction strategies prior to seeking general fund sources to cover cost of the strategies. After this is done, the Advisory Council supports a request of money from general fund sources to cover costs incurred by the state, counties or other government bodies necessary to implement the mercury-reduction strategies recommended by the Advisory Council.

2.0 Background

This part presents background information regarding mercury as an environmental problem, the history of mercury-contamination-reduction efforts in Minnesota, and the process used by the Advisory Council to arrive at the recommendations contained in this report.

2.1 Mercury as an Environmental Issue

Mercury is an environmental issue around the world. Minnesota and other states that have many lakes are especially aware of this because one of the primary ways that people are exposed to mercury is through eating fish that contain mercury. Some mercury is released to the environment through natural processes, such as volcanic activity. Mercury is also released through consumer product mismanagement, combustion of coal and other fossil fuels, and certain mining and manufacturing processes. While it is relatively easy to keep some mercury from entering the environment, it may be very difficult to control mercury from other sources. For example, we can purchase mercury-free products, such as digital fever thermometers. On the other hand, the mercury in air emissions from burning coal is difficult to capture. Research has identified and evaluated technology that would reduce mercury emissions from coal-fired boilers; however, such technology is considered unproven and is expected to be relatively expensive. Collecting mercury emissions that result from heating taconite pellets is considered to be technologically infeasible at this time, given that research on the subject has not begun.

Mercury, a silvery, liquid metal, is sometimes referred to as one of the "heavy metals." Like water, mercury can evaporate and become airborne. Because it is an element, mercury does not break down into less toxic substances. Once mercury is emitted to the air, it circulates in and out of the atmosphere until it ends up in the bottoms of lakes and oceans. Depending on its chemical form, mercury may travel long distances before it falls to Earth. It is thought that more than half of the mercury deposited in Minnesota is global atmospheric contamination that remains in the atmosphere for up to a year before it is deposited. It is estimated that 10% of the deposition in Minnesota is due to mercury emitted in Minnesota. Therefore, a 50% reduction in mercury air emissions in Minnesota is estimated to result in a 5% reduction in mercury deposition in the state.

Bacteria and chemical reactions in lakes and wetlands change elemental mercury into methyl mercury, a much more toxic form. Fish become contaminated with methyl mercury by eating organisms (*e.g.*, plankton and smaller fish) that have absorbed methyl mercury. As long as fish continue to be exposed to mercury, mercury will continue build up in the tissues of fish. The fish that most anglers want to catch -- bass, walleye and northern pike -- tend to be the fish that have the highest levels of mercury because they are higher on the food chain.

Human Impacts from Mercury Exposure

When people ingest methyl mercury through fish consumption, the methyl mercury tends to remain in their bodies for a considerable time. Continuous eating of fish that is relatively high in mercury may result in mercury accumulating in the body to the point that it becomes toxic.

Mercury is toxic to the nervous system, particularly the developing nervous system of a fetus or young child.

Mercury's effects can be very subtle. Adults who have been exposed to too much methyl mercury might begin to experience trembling hands and numbness or tingling in their lips, tongues, fingers or toes. These effects can begin long after the exposure occurs. At higher exposures, walking can be affected, as well as vision, speech and hearing. In sufficient quantities, methyl mercury can be fatal.

Fetuses and young children incur the greatest risks because their nervous systems are still developing. They are four or five times more sensitive to mercury than adults. Damage that occurs before birth or in infancy can cause a child to be late in beginning to walk and talk, and may cause lifelong learning problems. Unborn children can be seriously affected even though the methyl mercury causes no symptoms in their mothers.

The three common forms of mercury -- elemental, ionic and methyl mercury -- can all produce adverse health effects at sufficiently high doses. The U.S. Environmental Protection Agency (EPA) has determined that eating mercury-contaminated fish is the primary route of exposure to mercury for most people. EPA also concluded that most Americans are not at risk from mercury exposure. Therefore, most people can continue to look to fish as a healthy, low-fat source of protein and other nutrients. However, some groups of people have higher-than-average risks. The people who have higher risks are pregnant women, women of child-bearing age, children less than six years old and people who consume unusually large quantities of freshwater sport fish or large ocean fish, such as shark or swordfish. There is uncertainty as to what level of exposure creates a risk to human health.

A study is currently under way to gain a better understanding of the health effects of consuming fish that contain mercury. The study, being conducted by the National Academy of Sciences, is expected to be completed sometime in mid-2000.

Fish Monitoring and Consumption Advisories

Minnesota and other states have fish consumption advisories that recommend how many meals of fish people can safely eat over a period of time (reference: *Minnesota Fish Consumption Advisory, May 1998* issued by the Minnesota Department of Health). The Minnesota Department of Health (MDH) establishes consumption advice conservatively at a level at which no ill effects are expected, using data regarding cases of known mercury poisoning, and applying safety factors. (To request a copy of the advice or for additional information, call the MDH at 800/657-3908. Information on fish consumption advice is also included in the Department of Natural Resources' lake survey reports available on the Internet at *http://www.dnr.state.mn.us*.)

Minnesota has one of the best fish-contamination-monitoring programs in the country. Managed by the Minnesota Department of Natural Resources, more than 700 lakes have been tested in the program. The MDH has issued advice to limit consumption of fish on more than 90% of the tested lakes.

Wildlife Impacts

Fish are the main source of food for many birds and other animals. Mercury may damage the health of these species. Loons, eagles, otters, mink, kingfishers and ospreys eat large quantities of fish and rely on speed and coordination to catch them. Initial research indicates that the following environmental effects may be occurring: (a) Minnesota loons are accumulating mercury to the degree that it may be affecting their ability to reproduce, (b) elevated levels of mercury have been found in Minnesota's mink and otters and (c) walleye reproduction may be impaired by exposure to mercury. Research regarding impacts on wildlife is especially difficult because it is typically not possible to control factors other than mercury, such as weather, other pollutants and food availability, that may affect the animal. Because of this, more research is needed to determine the impact that current mercury levels in fish may have on wildlife.

2.2 History of Mercury Reduction and Current Regulatory Status

A number of state and federal actions have already reduced the rate of man-made (anthropogenic) mercury releases to the environment in Minnesota. These actions are primarily related to the intentional use of mercury or management of mercury-containing products. These programs have effectively reduced mercury releases from many sources, as shown in the emission inventory data that are presented below in Part 3.1. The main reductions have occurred at waste combustors, which reduced emissions by approximately 50% between 1990 and 1995, with the decrease continuing to the present. Another large decrease resulted from ceasing to use mercury as a fungicide in latex paint. These are the sources for which cost-effective solutions were known to exist.

A summary of existing strategies employed in Minnesota since 1990 specifically aimed at reducing mercury releases is shown in Table 2 of this part. In addition to these programs, other programs have resulted also in mercury reduction as a side benefit, including “demand side management” (reducing demand for electricity through energy efficiency projects) that utilities use to reduce energy consumption.

Minnesota is also a participant in two important projects related to mercury and the Great Lakes: the Lake Superior Binational Program and the Great Lakes Water Quality Agreement. The latter resulted in the “Great Lakes Binational Toxics Strategy: 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 to protect and ensure the health and integrity of the Great Lakes ecosystem. An implementation plan sets out a structure and process for implementation of the Binational Strategy by EPA, Environment Canada (EC) and stakeholders. The implementation process seeks to build upon existing efforts wherever possible, including remedial action plans (RAPs), lakewide management plans (LaMPs) and many others.

As noted in Table 2, Minnesota has state regulations that set emission limits for municipal solid waste and medical waste combustors. Federal regulations for these sources also exist. In addition, a federal regulation limits mercury emissions from sewage sludge combustors (40 CFR Part 61, Subpart E) to 3,200 grams per 24 hours (approximately 7 lb. per day).

EPA has considered but has not promulgated regulations for mercury emissions from coal-fired power plants. Title III, Section 112(n)(1)(A) of the Clean Air Act Amendments of 1990 requires

EPA to perform a study of the hazards to public health reasonably anticipated to occur as a result of emissions of hazardous air pollutants by electric utility steam-generating units. This study has been completed. In the final report to Congress issued on February 24, 1998, the EPA stated that mercury is the hazardous air pollutant emission of greatest potential concern from coal-fired utilities and that additional research and monitoring are merited.

The Clean Air Act Amendments also require EPA to regulate electric utility steam-generating units if the administrator finds that such regulation is appropriate and necessary. At the time that the report on hazardous air pollutants was issued, the EPA deferred making any determination whether to regulate the electric utility industry for mercury or other hazardous air pollutant emissions. EPA has concluded that obtaining additional information prior to making the required determination is necessary. Therefore EPA has issued an information collection request for coal-fired power plants. The EPA, in evaluating whether regulation of electric utility steam-generating units is appropriate, will use the data collected under this effort, along with other information. Specifically, the data will respond to the two research needs of providing EPA with updated information on the mercury content of coals and on the speciation and controllability of mercury emitted from utility boilers. EPA will also use the results of the National Academy of Sciences study on health risk in its utility regulatory determination.

EPA and the MPCA are considering establishment of a "maximum achievable control technology" (MACT) standard for emissions of hazardous air pollutants from taconite processing plants. Although it does not currently appear likely, such a standard could include mercury. Because it is a technology-based standard and because there is no current technology in use in the taconite industry for controlling mercury, it would be unlikely that EPA would pursue setting a mercury standard as part of the initial MACT process. Eight years after the MACT is promulgated, EPA is to assess whether risk to public health remains after the implementation of the MACT standard. If the "residual risk" for a source category does not protect public health with "an ample margin of safety," then the EPA must promulgate health-based standards for that source category to further reduce hazardous air pollutant emissions.

2.3 Advisory Council Process

Public concern about mercury emissions and dissatisfaction with a permit-by-permit approach to mercury controls encouraged the MPCA to seek alternative mercury-reduction strategies. This section of the report describes how the MPCA and a stakeholders' group put the Mercury Contamination Reduction Initiative into practice.

Table 2 Summary of mercury-reduction strategies used in Minnesota since 1990

Program Type	Description
Voluntary Programs	
Health Care Outreach	Education to encourage proper management and reduced use of mercury via video, slide show, posters and newsletters
Household Hazardous Waste (HHW)/ Special Waste Collection	Many counties accept mercury and mercury-containing products from homeowners and to a lesser extent businesses as part of their household hazardous waste/special waste collections
Dental Office Outreach	Effort begun in WLSSD area to educate dentists about need to collect amalgam waste for recycling and to keep it out of MSW and infectious waste streams. Statewide and Great Lakes programs are now in development.
Thermostat Take-back	Through a reverse distribution system involving contractors and wholesalers, thermostat manufacturers take back out-of-service thermostats.
Mercury Switches in Automobiles	Law requires "good faith effort" to remove mercury switches before auto crushing; included in PCA scrap yard training. Michigan and Minnesota are involved in pollution prevention and management discussions with auto manufacturers.
Regulatory Programs	
Waste Combustor Standards	Sets air emission limits on mercury and requires preparation of Mercury Reduction Plans for municipal solid waste and medical waste combustors.
Water Discharge Standards	A few wastewater treatment plants that had mercury detected above 0.2 g/l have mercury discharge limits.
State Laws	
Fluorescent Lamp Disposal Ban	Requires businesses and households to recycle fluorescent lamps. Counties have established a variety of programs.
Ban on Disposal of Mercury Products	Requires households and businesses to recycle or properly manage mercury wastes.
Dairy Manometer Ban and "Buy-back"	Law bans sale, installation and repair of mercury-containing dairy manometers after June 30, 1997 and use after December 31, 2000 and offers up to $100 for turning in an old gauge.
Relay Manufacturer Responsibility	Requires manufacturers of mercury displacement relays sold in Minnesota to provide education and incentives as well as cover the costs of managing out-of-service relays.
Battery Mercury Reduction	Bans mercuric oxide batteries (except in specialty applications and then requires manufacturer stewardship); bans addition of mercury to alkaline batteries, 25-mg limit in button batteries.
Mercury Components in Major Appliances	Research identifying mercury components in appliances; development of fact sheet and outreach to appliance processors about identification, removal and proper management of components.
Mercury in Construction/Demolition	Law prohibits disposal; implied requirement for removal prior to demolition. Education and enforcement efforts for construction and demolition contractors are in use.

Activities Preceding Establishment of the Advisory Council

Before the Mercury Contamination Reduction Initiative's Advisory Council first convened on May 20, 1997, a series of related activities occurred. During the early 1990s, the MPCA established an internal mercury task force. In 1994, this task force prepared a report, *Strategies for Reducing Mercury in Minnesota,* that called for an integrated and coordinated approach to the issues raised by mercury contamination in the environment. Three general elements of a coordinated approach -- conventional regulations, pollution prevention programs and incentive-based systems -- were recommended for development and implementation. No single approach was considered adequate by itself; but in balanced combination, all three were endorsed as ways to address the environmental problems caused by mercury contamination.

Public concern about mercury contamination led MPCA staff to find ways to put the strategy report's recommendations into practice. Environmental interest groups raised mercury issues as individual facility environmental permits came up for renewal. MPCA staff recognized that the issues were valid; but, given the relatively small amounts that most individual sources added to the mercury-emission inventory, actions on individual permits were generally postponed. Instead, MPCA staff advised permittees and environmental interest groups that the agency would rely on guidance from the EPA's *Mercury Report to Congress,* which was then in progress.

A series of delays in completion of EPA's report led the MPCA staff, managers and executives to support a state-based initiative on mercury issues. The MPCA applied for an EPA grant to help cover development costs. The selected EPA grant program was one that focused on market-based incentives for environmental protection. A feasibility study was the main feature of the grant request. Specifically, the MPCA asked for program development assistance to study the feasibility of using a cap-and-trade program to address mercury issues. (Cap-and-trade programs "cap" emissions at fixed levels and let regulated sources "trade" emission allowances if they want to. The typical result is that high-cost sources tend to buy allowances from low-cost sources, which tends to maximize program efficiency and minimize program cost.) Although evaluation of cap-and-trade feasibility was a necessary element of the initiative, the MPCA made it clear from the start that its evaluations must take place in the context of: (a) consideration of all alternatives and (b) open discussion among all interested stakeholders.

Creation of the Advisory Council, Participation by Nonmembers

Once the EPA grant was approved, contacts with prospective Advisory Council members began in late winter and early spring of 1997. Carol Andrews was named project coordinator in April. The first Advisory Council meeting took place on May 20, 1997, (a list of Advisory Council members is on page 3). Staff of the Minnesota Environmental Initiative assisted MPCA staff with selecting and contacting potential Advisory Council members as well as developing early meeting agendas and the overall initiative process.

The following organizations were not represented on the Advisory Council but attended and participated in meetings:

3M	Minnesota Environmental Initiative (MEI)
Alliant Tank	Minnesota Environmental Quality Board*
Browning Ferris Industries (BFI)*	Minnesota Petroleum Institute*
Electric Power Research Institute (EPRI)*	MnTAC*
Energy and Environment Research Center (EERC)*	North American Water Office
EPA – Duluth Laboratory*	Olmsted County*
Green Mountain Institute	Public Service Electric & Gas Company*
Hennepin Energy Resource Company (HERC)*	United Power Association (UPA)
Hibbing Taconite*	US Steel
Koch Refining*	

*Organizations that also participated in one or more Advisory Council subcommittees. In particular, many of these participants provided critical information to the SRFRS Committee's data-gathering effort.

Early Meetings

Monthly Advisory Council meetings occurred through January 1999. In July 1997, a meeting for all interested stakeholders was substituted for the monthly Advisory Council meeting. Three subjects dominated early Advisory Council meetings: (1) the Advisory Council's purpose and goals, (2) the Advisory Council's composition and (3) ground rules for Advisory Council meetings.

A final goal statement was adopted during the Advisory Council's August meeting:

> The Advisory Council is expected to advise the MPCA regarding policies designed to reduce mercury contamination and recommend policy-oriented changes, taking into account:
> - the ability to reduce mercury contamination,
> - cost-effectiveness, and
> - the need for regional, national and international cooperation.

The Advisory Council discussed membership issues until its September meeting. Advisory Council members agreed that a precise balance of interests was improbable. Instead, they adopted a position favoring full representation of all affected interest groups. After the Advisory Council adopted this position, it was applied whenever committees and subcommittees were formed.

The Advisory Council adopted its ground rules during the August meeting. Ground rules were derived from suggestions made by Roger Williams, an independent meeting facilitator associated with the state's Office of Dispute Resolution. The ground rules covered Advisory Council procedures and its communications with organizations not represented on the Advisory Council. There was considerable discussion related to the means to be used to determine Advisory Council

consensus. Advisory Council members agreed to a five-unit scale for voting on proposals and resolutions:

THE LEVELS OF CONSENSUS

Mercury Contamination Reduction Initiative Advisory Council members will use the following scale to register their agreement or disagreement with proposed recommendations.

5 I can say an unqualified "yes" to the recommendation. I'm satisfied that the recommendation is an expression of the wisdom of the group.

4 I find the recommendation perfectly acceptable.

3 I can live with the recommendation but I'm not especially enthusiastic about it.

2 I do not fully agree with the recommendation and need to register my view about it. However, I do not choose to block consensus because I trust the wisdom of the group.

1 I do not agree with the recommendation and feel the need to stand in the way of achieving consensus.

If a "1" is registered, the Task Force (Advisory Council) will attempt to understand and accommodate the concern. If, within a reasonable time period this is *not* possible, the Task Force report to the MPCA Board and the EPA will show a lack of consensus on that issue but summarize the pros and cons expressed during discussions, attributing those pros and cons to groups rather than individual members. Options may be forwarded to the MPCA Board in the absence of unanimous support. The record will reflect the strength and substance of support and objections.

Presentation of Information to the Advisory Council

Once goals and procedures were worked out, Advisory Council members turned their attention to the issues that surround mercury contamination. Speakers presented the Advisory Council with information on different aspects of mercury issues. Some speakers addressed scientific questions, others talked about relevant public policy developments.

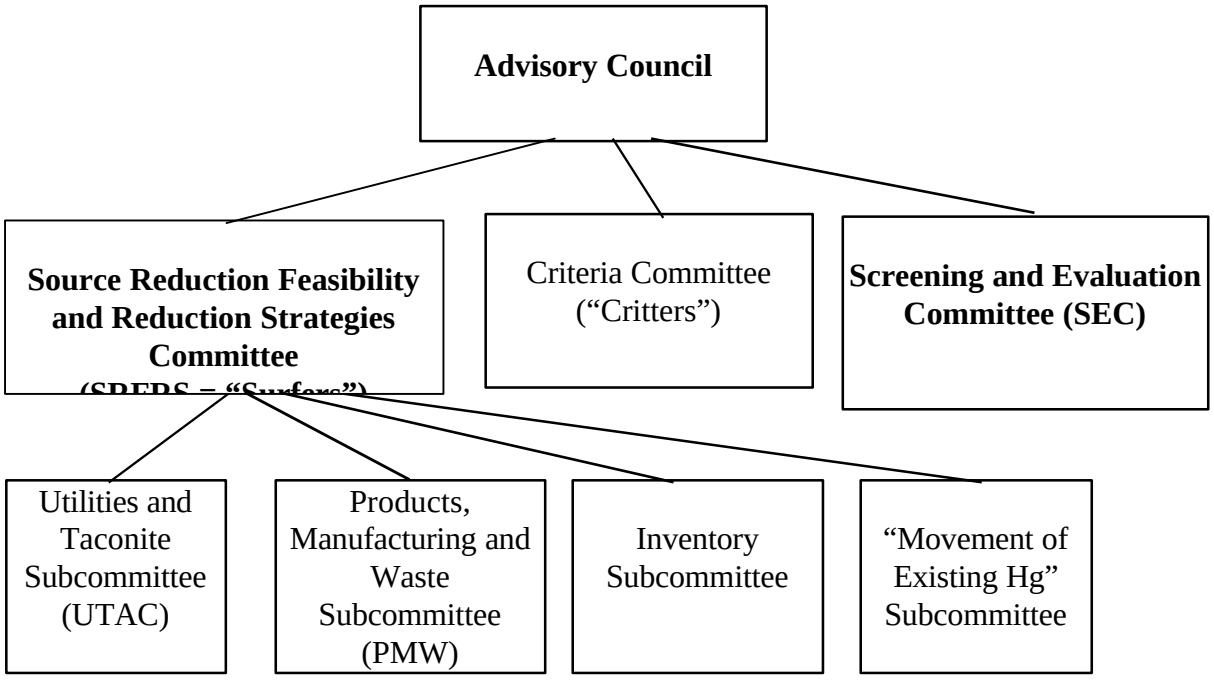
Refinement of the Advisory Council Process, Formation of Committees and Preparation of Final Recommendations

Advisory Council members also considered the steps they would need to take to meet the goals they had set for themselves. They determined that they would need to (a) consider the full range of mercury-reduction policies that the state could adopt and (b) evaluate policies with respect to an agreed-upon set of criteria.

Advisory Council members also determined that this work was too complex for the full Advisory Council. Two committees were formed in October 1997. A Criteria Committee (co-chaired by Ann Glumac of the Iron Mining Association and Gail Lewellan of the Minnesota Department of Natural Resources) was directed to define evaluation criteria to be used to compare reduction

strategies. A Source Reduction Feasibility and Reduction Strategies Committee (co-chaired by Bill Grant of the Izaak Walton League and Dave Jeronimus of Minnesota Power) was tasked with compiling technical information about mercury sources and options available to those sources to reduce mercury, including information on reduction potential and cost. Later, as described below, the Screening and Evaluation Committee was formed.

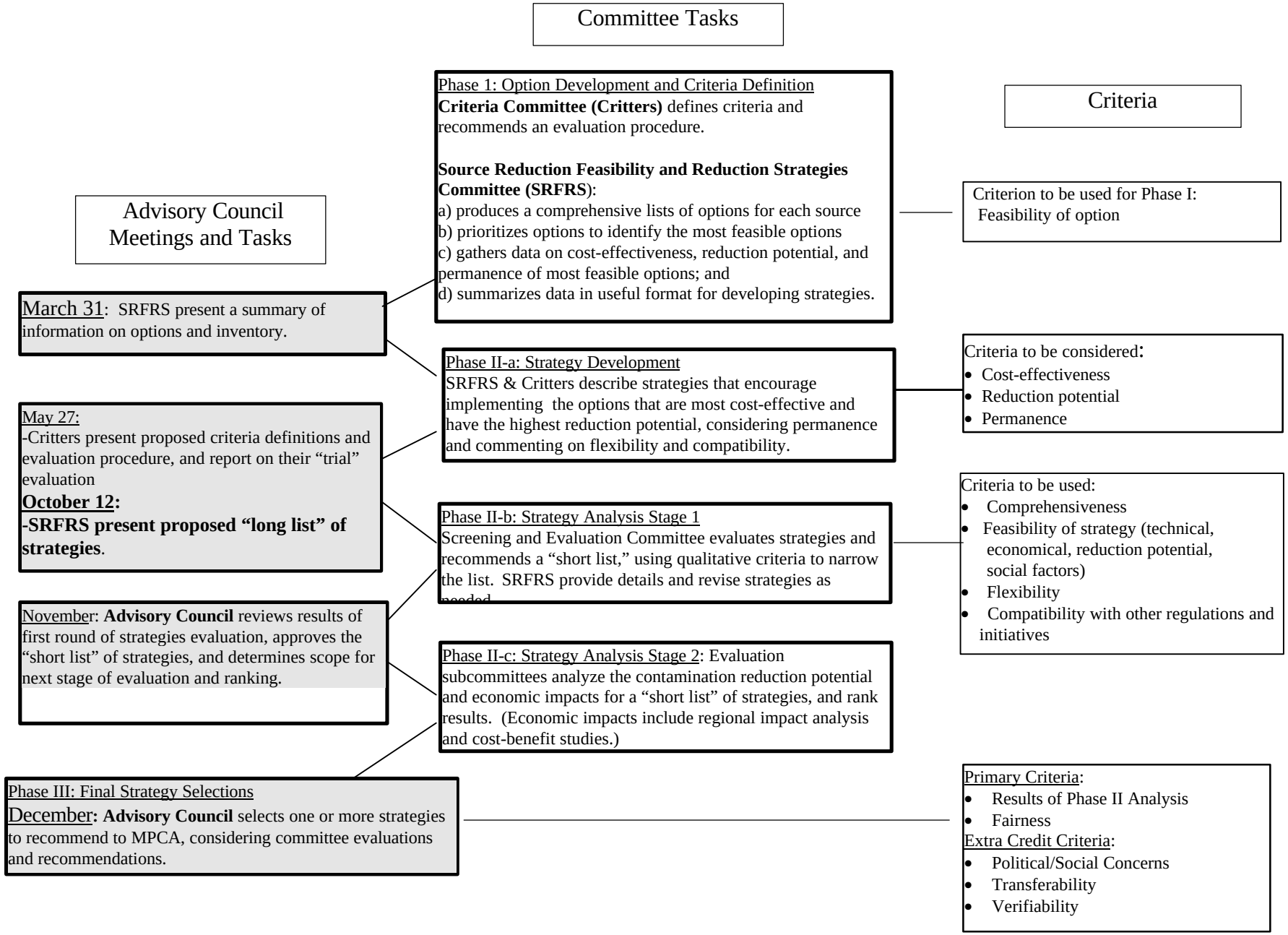
Figure 1 Relationship of committees and subcommittees to the Advisory Council



Both committees wrote reports for the Advisory Council. The Criteria Committee convened 10 meetings from October 1997 until March 1998. The Advisory Council received the Criteria Committee's final report at the Advisory Council's March 31 meeting. Thirteen criteria were recommended for Advisory Council consideration: (1) feasibility, (2) cost-effectiveness, (3) reduction potential, (4) permanence, (5) compatibility with other regulations, (6) flexibility, (7) comprehensiveness, (8) regional economic impacts, (9) cost/benefit ratio, (10) fairness, (11) political and social concerns, (12) transferability and (13) verifiability. The Criteria Committee also provided a recommendation defining the process to be followed (see Figure 2).

The Source Reduction Feasibility and Reduction Strategies (SRFRS, pronounced "surfers") Committee met from October 1997 until October 1998. Committee members found a need to form subcommittees that could compile information on an industry-specific basis and improve the mercury release inventory. The Utilities and Taconite Subcommittee (co-chaired by

Figure 2 Strategy development and evaluation procedure



Scott Hautala of Hibbing Taconite Company and Patti Leaf of Northern States Power Company) covered large-scale facilities whose mercury emissions result from processing ore or burning coal. The Products, Manufacturing and Waste Subcommittee (co-chaired by John Gilkeson of the Minnesota Office of Environmental Assistance and Tim Tuominen of the Western Lake Superior Sanitary District) covered facilities whose mercury releases derive from waste-disposal practices, product manufacturing and use. The Inventory Subcommittee (chaired by Ed Swain of the MPCA) was formed to compile higher-quality data for the MPCA's mercury emission inventory. Committee members developed a survey form that was sent to the operators of mercury-release sources. The questionnaire asked sources for their best estimates of mercury releases. The Inventory Subcommittee also developed, in concept, a predictive model of mercury releases that includes all known mercury-release sources.

The SRFRS Committee compiled the information from the three subcommittees into a single report. The Advisory Council received the committee's draft report on October 12, 1998. The Advisory Council requested that MPCA staff make revisions to the report and present it again later. The final SRFRS report is expected to be available in April 1999.

A Screening and Evaluation Committee (SEC) was formed in May 1998. This committee was directed to review the combined work of the Criteria and the SRFRS committees and to make preliminary recommendations to the Advisory Council regarding preferable strategies. The SEC provided recommendations that the Advisory Council achieved consensus on (with some revisions) at its December 16, 1998, meeting.

MPCA Outreach Beyond the Advisory Council

In addition to the Advisory Council, MPCA staff kept in touch with other interested persons regarding the initiative and provided their input to the Advisory Council. A Correspondents' Committee was developed in October 1998 to help people from distant locations follow the progress of the Mercury Contamination Reduction Initiative and share their ideas, opinions and concerns with the Advisory Council and the MPCA. The 20 Correspondents Committee members received drafts of materials that are scheduled for consideration by the Advisory Council or one of its committees. Comments from correspondents were forwarded to the appropriate group(s). MPCA staff also kept in touch with counterparts in other states and Canadian provinces and with EPA staff through a "Committee of States" as well as through conference calls and meetings arranged by EPA - Region V. In addition, a few hundred people sent a form note to the MPCA Commissioner in August and September of 1998. The note expressed their concerns about the need for the initiative to lead to reduce emissions of mercury, especially from coal-fired power plants.

3.0 Findings

This part presents the results of the Advisory Council's efforts to better identify sources of mercury along with their relative contributions to air pollution, and to identify options and strategies for reducing mercury use, release and contamination.

3.1 Sources of Mercury

In Minnesota, mercury contamination of fish is caused largely by air pollution. Available information indicates that very small amounts of mercury are directly discharged to surface waters from wastewater treatment plants and industrial discharges in Minnesota, on the order of 15 to 30 lb. per year. Air emissions -- about 5,000 lb. per year in 1995 -- are more than 100 times higher. Point source discharge to surface water constitutes only 1 to 2% of the mercury load to surface water. MPCA staff estimate that atmospheric deposition is responsible for the other 98%.

Mercury Emission Inventory for Minnesota

It is important to understand the sources of mercury to the atmosphere in order to reduce air pollution, mercury deposition to lakes and fish contamination. To that end, MPCA staff have revised estimated emissions of mercury (the "inventory") to the air for 1990 and 1995, and predicted future emissions in the years 2000 and 2005. Results are shown in Table 3. The inventory is subdivided into three main categories of emissions: (1) emissions that are incidental to energy production (the release of trace amounts in fossil fuels), (2) emissions that largely result from the purposeful use of mercury (volatilization during product disposal and incineration) and (3) emissions incidental to other activities (*e.g.*, processing natural resources, such as wood and iron ore). Category 3 is distinct from category 1 (even though they are both incidental emissions) in that once mercury is released during production of a material, such as iron, that product can be recycled without releasing additional mercury.

Table 3 Inventory of mercury emissions, in pounds, in Minnesota for the years 1990, 1995, 2000 and 2005 (Data are subject to change as better information is received.)

	confidence level	1990 (best)	1990 Min.	1990 Max.	1995 (best)	1995 Min.	1995 Max.	2000 (best)	2000 Min.	2000 Max.	2005 (best)	2005 Min.	2005 Max.
Incidental to Energy Production													
coal (total) (1)	medium	1,526	1,145	1,908	1,462	1,096	1,827	1,493	1,320	1,666	1,735	1,533	1,938
electric utility coal	medium	1,416	1,062	1,770	1,332	999	1,665	1,335	1,201	1,468	1,544	1,390	1,699
commercial/industrial coal	medium	110	83	138	130	97	162	158	119	198	191	143	239
residential coal		0	0	1	0	0	1	0	0	1	0	0	1
Petroleum Sector (including refining and combustion of products) (2)	low	250	125	250	250	125	250	250	125	250	250	125	250
wood (3)	medium	13	9	16	10	8	13	10	8	13	10	8	13
natural gas (4)	low	0.2	0.1	0.5	0.28	0	1	0.28	0	1	0.28	0	1
Subtotal incidental with energy production		1,792	1,281	2,179	1,725	1,230	2,095	1,755	1,454	1,933	1,998	1,667	2,205
% of total state emissions		21%			37%			47%			56%		
Largely Resulting from the Purposeful Use of Mercury													
Latex Paint Volatilization (5)	low	500	250	1,000	10	5	20	2	1	2	0	0	0
Municipal Solid Waste Combustion (6)	high	1,806	1,626	1,987	634	570	697	156	140	172	87	78	96
On-site Household waste incineration (7)	low	666	333	1,332	270	135	540	180	90	360	126	63	252
Medical Waste Combustion (8)	high	516	464	568	36	32	40	36	32	40	36	32	40
Sewage sludge Incineration (9)	med.	247	185	309	160	120	200	160	120	200	65	49	81
Fluorescent Lamp Breakage (10)	low	330	165	660	83	41	165	20	10	40	10	5	20
Class IV incinerators --1,000 closed by 1/96 (11)	low	55	28	110	28	14	56	0			0		
Crematories (12)	low	24	12	49	35	18	71	45	23	90	45	23	90
General Laboratory Use (13)	low	44	22	88	44	22	88	22	11	44	22	11	44
Dental Preparations (14)	low	24	12	48	12	6	24	6	3	12	3	2	6
Hazardous Waste incineration (15)	medium	5	4	6	5	4	6	5	4	6	5	4	6
Landfill volatilization (16)	low	13	6	25	3	2	7	13	6	25	13	6	25
Recycling mercury from Products within MN (17)	medium	4	3	4	35	26	44	50	38	63	65	49	81
Smelters that recycle cars and appliances (18)	medium	166	125	208	166	125	208	83	62	104	42	32	53
Volatilization from Dissipative Use (19)	low	2	1	4	2	1	4	2	1	4	2	1	4
Fungicide Volatilization (20)	low	86	43	172	25	13	50	5	3	10	5	3	10
Volatilization from spills and land dumping (21)	low	55	27	109	48	24	96	32	16	64	21	11	43
Volatilization during SW collection & processing (22)	low	1,304	652	2,607	432	216	864	288	144	576	192	96	384
Volatilization: land application of compost (23)	low	2	1	3	1	0	1	1	1	2	1	1	2
Volatilization: land application of sludge (24)	low	4	2	7	2	1	3	2	1	4	2	1	4
Subtotal associated with purposeful use of mercury		5,852	3,960	9,297	2,031	1,375	3,184	1,108	705	1,817	742	464	1,241
% of total state emissions		69%			44%			30%			21%		
Emissions Incidental to other Activities:													
Taconite Processing (25)	medium	797	598	797	828	621	828	828	621	828	828	621	828
Pulp and Paper Manufacturing (26)	low	4	2	7	4	2	7	4	2	7	4	2	7
Soil Roasting (27)	low	13	7	27	13	7	27	13	7	27	13	7	27
Subtotal emissions incidental to other activities		814	606	831	845	629	862	845	629	862	845	629	862
% of total state emissions		10%	10%	7%	18%	19%	14%	23%	23%	19%	24%	23%	20%
GRAND TOTAL =		8,457	5,847	12,307	4,600	3,235	6,140	3,708	2,788	4,612	3,585	2,761	4,307

Confidence level interpretation:
High +/- 10%; Medium +/- 25%; Low +/- 50% (except when best estimate cannot be exceeded).

NOTES to Table 3

[1] Based on data submitted by facilities with stack tests (NSP, MP) and extrapolated to other coal combustors.

[2] Based on a preliminary analysis of crude oils delivered to Minnesota refineries. The fate of the mercury in the refinery and various products is being investigated.

[3] From Pang, S.M., 1997. Mercury in wood and wood fuels. Thesis. Master of Science. University of Minnesota.

[4] Assumes the EPRI emission factor of 0.0008 lb./trillion Btu.

[5] Nationally, 24.2 tons of mercury were added to paint in 1990 (Minnesota's economy is about 2% of the U.S. economy; 2% of 24.2 tons = 968 lb.). Half is assumed to volatilize the first year. The addition of mercury to paint was discontinued by 1992.

[6] Based on stack tests.

[7] Quantity is based on Office of Environmental Assistance estimates. Municipal solid waste (MSW) is assumed to be 3.7 ppm in 1990 and 1.5 ppm in 1995.

[8] Based on stack tests.

[9] Based on sludge analyses and the analysis published by S. Balogh and L. Liang, 1995. Mercury pathways in municipal wastewater treatment plants. *Water, Air, and Soil Pollution*. 80:1181-1190.

[10] Based on the proportion not recycled and industry figures on mg/lamp, assuming 25% is volatilized.

[11] All of these small incinerators associated with grocery stores, etc. (about 1,000) closed by January 1996. It is assumed that they mostly burned cardboard with mercury at 0.2 ppm.

[12] Assumes that each person has four amalgam fillings containing 0.5 gram of mercury each.

[13] Estimate in the U.S. Environmental Protection Agency (EPA) *Mercury Report to Congress*.

[14] Estimate in the U.S. Environmental Protection Agency (EPA) *Mercury Report to Congress*.

[15] Estimate from Minnesota's only hazardous waste incinerator, 3M Chemolite.

[16] 0.1% of landfilled municipal solid waste (MSW) is assumed to volatilize to the air per year (based on studies of MSW emissions in Florida by S.E. Lindberg and J.L. Price, 1998).

[17] Products within Minnesota estimate from Brian Golob, personal communication.

[18] *Automobile Shredder Residue Report*. MPCA, 1995. The largest scrap metal smelter in Minnesota is North Star Steel; it is assumed that 50% of mercury is emitted, and that the number of mercury switches declines with time.

[19] Mercury that dissipates into the environment (excluding fungicides): ritual uses, pharmaceuticals, etc.

[20] Estimate of volatilization from fungicides applied to golf courses.

[21] Estimate assumes that 8% of the mercury removed from service each year is spilled on the ground and that 5% of that amount volatilizes.

[22] Assumes that the 5% of the mercury in solid waste is volatilized during collection, transportation and mechanical processing. Includes demolition, industrial and municipal solid waste (MSW) landfills, MSW and medical waste incineration, MSW compost, backyard burn barrels and steel-recycling facilities; fluorescent lamps calculated separately.

[23] Assumes that 1.0% of mercury applied to the surface of the land volatilizes within a year.

[24] Assumes that 1.0% of mercury applied to the surface of the land volatilizes within a year.

[25] From Engesser *et al.*, 1997. *Mercury Emissions from Taconite Pellet Production*. Univ. of Minnesota report to the MPCA.

[26] From voluntary reports to the MPCA.

[27] An average of 83,000 tons per year of surface soil is heated annually in Minnesota to remove organic contaminants. A background concentration of 0.08 ppm of mercury is assumed.

Inventory Process and Data Accuracy

Establishing an inventory of mercury in products, the waste stream, fossil fuels and natural resources, such as iron ore and forest products, is problematical because there has been no driving force to collect the data until very recently. Better data exist for points of release of mercury to air and water because of traditional concern about pollution. Even air and water releases are not completely understood because of the relatively high expense of air emission measurement and EPA's failure to adopt a low-level mercury analysis technique for water.

The best information on the mercury content of the solid waste stream comes from stack testing of incinerators prior to pollution-control devices, which often capture significant proportions of the mercury. Such information is invaluable for understanding the efficacy of pollution-prevention efforts for this sector.

Other ambiguities in the air emission inventory include variability in the mercury content of fossil fuels, the loss of mercury from products during use and disposal, methylation within MSW landfills and subsequent emission to the atmosphere, and volatilization from land application. Environmental contamination from product use and breakage is particularly poorly understood, and needs to be addressed adequately on a national scale. The EPA's *Mercury Report to Congress* does not even recognize products as a significant air emission source, apart from emissions during incineration.

Even though significant work remains in the quest to establish an accurate inventory of mercury uses, sources and releases to air, land and water (and such work should continue), MPCA staff believe that the information collected to date is sufficiently accurate to guide policy decisions.

Trends in Mercury Emissions

It is clear that air emissions declined greatly (by about 45% — from about 8,500 lb. to 4,500 lb. —from 1990 to1995). Virtually all of the decline can be attributed to emissions associated with the purposeful use of mercury. The major reductions were the elimination of mercury additives to latex paint (estimated reductions of about 500 lb.), source reduction and control at municipal waste incinerators (1,200 lb.) and on-site incinerators (about 500 lb.), and reductions from medical waste incinerators (about 500 lb.). Reductions occurred at larger incinerators due to both lower levels of mercury in waste (mercury in municipal solid waste declined from about 4 ppm in 1990 to about 1.5 ppm in 1995) and control technology (for example, the Hennepin Energy Resource Company municipal waste combustor and the Mayo Clinic medical waste incinerator installed activated carbon injection systems). Further reductions in mercury use and additional emissions control will likely result in lower emissions from waste incineration, from 878 lb. emitted in 1995, declining to projections of about 380 lb. in 2000 and 280 lb. in 2005. In addition, MPCA staff calculate that about 550 lb. less mercury were emitted to the air in 1995 simply because there was less mercury in products to volatilize when disposed of or accidentally spilled.

The trend for mercury emissions that are incidental to energy production and other activities, such as taconite processing, differs from the decreasing trend in purposeful use of mercury. Emissions from other sources stayed relatively constant between 1990 and 1995 and are projected to remain constant or increase between 1995 and 2005.

Mercury Emissions Associated with Electrical Production and Consumption in Minnesota

In 1997, a new state law (Minn. Stat. §116.925) took effect that requires the producers and retailers of electricity to report on the amount of mercury emitted in generating electricity. The law requires the MPCA to summarize this emission information in its biennial air toxics report (reference *Toxic Air Pollutant Update: A Report to the Environment and Natural Resources Policy Committee of the Minnesota Legislature,* MPCA, February 1999).

For 1997, the MPCA received reports for 28 electrical generation units in Minnesota. The major fuel for most units was coal, although two facilities depend on municipal solid waste for fuel

(Hennepin Energy Resource Company and NSP Red Wing). In 1997, a total of 1,814 lb. of mercury air emissions, corresponding to the production of 33,721,787 megawatt-hours (MWh) of electricity, were reported. These estimates of mercury emissions associated with electrical production are consistent with the estimates provided in the emission inventory shown in Table 3.

How Mercury in Products gets to the Atmosphere

Mercury has been used in many products for many reasons. Some uses, such as pharmaceuticals and fungicides, dissipate the mercury into the environment as it is used. Such uses have a relatively short life span, and then more mercury is purchased for that use. In contrast, mercury is used in some electrical switches that have an indefinite life span (lasting 40 years or longer) and may be encapsulated until the switch is decommissioned due to equipment changes. Most mercury uses in appliance and automobile switches and medical equipment, such as manometers, probably have life spans of 10 to 30 years.

MPCA staff has attempted to track the fate of mercury in products from purchase to disposal and estimate the quantity of mercury released to air, land and water during storage and use. One of the primary motivating factors was the need to understand the relative importance of reducing mercury use in products as compared to the direct release of mercury to air and water from point sources, such as coal-fired power plant stacks. Evaluation of the connection between mercury use and release indicates that, for every 100 lb. of mercury contained in products disposed of in 1995, roughly 15 lb. per year were released to the atmosphere. The remainder was either recycled or is associated with land (via a landfill or landspreading).

The 15% figure can be used as a conversion factor between mercury used in products and mercury emitted to the atmosphere. Assessment of the cost of reducing mercury releases by reducing use in products versus controlling emissions from coal-fired utilities or taconite plants showed that, in general, the cost per pound to reduce emissions is lowest by reducing mercury use in products and improper disposal.

Once all possible fates of mercury-containing products are estimated, one can add all sources of mercury to air, land, and surface water. For 1995, MPCA staff estimate that, of the approximately 11,000 lb. of mercury removed from service that year, 15% (1,655 lb.) made its way to the atmosphere, 76% (about 8,400 lb.) is on the land or in landfills, 9% was recycled and only 0.1%, or 17 lb., was discharged to surface water. (See *Toxic Air Pollutant Update: A Report to the Environment and Natural Resources Policy Committee of the Minnesota Legislature,* MPCA, February 1999, for detailed results of this analysis.)

3.2 Mercury-Reduction Options

Option Identification and Development Process

Before the SRFRS Committee could proceed with its tasks, it became apparent it was necessary to differentiate between actions that sources of mercury take to reduce emissions and approaches used to encourage sources to implement reduction options. Actions taken by sources to reduce

mercury releases have become known as "options," while the term "strategies" refers to the approach taken to create incentives. For example, installing mercury-control equipment is an option, whereas mercury emission limits, fees, recognition programs and voluntary agreements are all examples of strategies. Simply stated from a mercury source's perspective, an option is "what you do" and a strategy is "why you do it."

The following steps were used to identify options:

1. Create a comprehensive list of mercury-reduction options for all significant sources.
2. Prioritize the list of options to narrow it down to those considered most feasible. (The definition of "feasible" and other criteria are shown in Part 3.4 below.)
3. Gather data regarding the most feasible options, especially regarding cost-effectiveness, reduction potential and permanence. Other potentially relevant information was also collected (for example, regarding potential obstacles to implementation of a given option).
4. Summarize data in a format useful for developing strategies.

The subcommittee recognized that the most important criteria to focus on in the options-development phase were practicality/feasibility, reduction potential and cost-effectiveness. It should be noted that the cost-effectiveness estimates derived were based solely on the cost to reduce mercury. Other environmental benefits or impacts that may occur with the implementation of specific mercury-reduction options are often identified in the detailed option write-ups shown in Appendices C, D and E under "implementation issues," and, where information was available, under "cost-effectiveness."

The Advisory Council and SRFRS Committee have also noted and discussed the importance of the link between mercury releases and mercury contamination in fish, given that reducing mercury contamination, not just releases, is the ultimate goal of the initiative. Therefore, the committee has attempted to gather information, where available, regarding the expected environmental fate of mercury releases and the expected permanence of reduction efforts. However, other than noting the type of release (*i.e.*, to air, land or water) and potential for cross-media transfer (*e.g.*, from air to water), limited information is currently available for most sources and options regarding factors, such as mercury speciation, that affect the environmental fate of the mercury released or collected.

During option development, options were set aside at various stages for various reasons, including lack of available information, low feasibility and limited application in Minnesota. That these options have been set aside does not necessarily indicate that they are not viable options.

Data gaps affect identification and description of reduction options in four main ways: (1) there may still be significant unidentified mercury sources; (2) there are options that have been suggested but not yet researched to determine whether they are feasible or cost effective; (3) there may be options that have not been identified and (4) lack of data, which influences cost and reduction potential estimates.

Examples of data gaps affecting options include:

- A "mercury in products fate model" was used to estimate the annual decrease in mercury releases to the environment (*i.e.*, reduction potential) that results from most of the pollution prevention strategies for products (*e.g.*, reducing the amount of mercury contained in new products purchased, or from taking mercury-containing items off the shelf in schools or homes). The assumptions made regarding how and when products are disposed, especially the amount spilled or illegally disposed of via "backyard" burning, are very rough.
- The reduction potential of switching coal sources must be evaluated on a site-specific basis to determine the resulting mercury emission change.
- The potential for "re-emission" of mercury from ash and activated carbon used to collect mercury from combustion source flue gases has not been determined. As a result, the permanence of options that rely on end-of-stack controls to prevent air emissions is unknown.

RESULTS

Options for Reducing New Mercury Releases

Options have been identified that address most but not all of the known sources of mercury releases in Minnesota. Thirty-two of the most feasible mercury reduction options are described in detail in the SRFRS Committee report. Estimates of the potential reduction in the number of pounds of mercury released to air, land or water as a result of an option range from 1.0 lb. to hundreds of pounds per year. Cost-effectiveness estimates for mercury reduction options ranged from $10 to $5,500,000 per pound.

Potential for Management of Mercury in the Environment

The SRFRS Committee also attempted to identify options for managing mercury that is already in the environment to minimize the amount that bioaccumulates in fish. The subcommittee tasked with this consideration concluded that none of the options that it identified is practical for addressing the general problem of elevated mercury in the environment. However, some options may be of practical use for addressing site-specific mercury-contamination problems that have resulted from local pollution. The subcommittee identified the following options:

- decreasing the amount of mercury deposited (*e.g.*, reducing ozone or other pollutants in the air; minimizing dry deposition by reducing forest cover);
- reducing the amount of mercury deposited to land that makes its way to water bodies (*e.g.*, reducing soil erosion, reducing use of storm sewers);
- reducing the efficiency of methylation (*e.g.*, reducing sulfate deposition, eliminating wetlands; adding selenium compounds to water);
- removing mercury from the biosphere so that less is available (*e.g.*, sediment dredging, fish removal, soil removal); and
- reducing mercury cycling in the biosphere (*e.g.*, covering contaminated soil or sediment with materials that inhibit release to overlying water or air).

3.3 Mercury-Reduction Strategies

After creating the list of options, the SRFRS Committee identified strategies, striving for those that encourage the implementation of options that are most cost effective and have the highest reduction potential, considering other criteria such as permanence and flexibility. The Advisory Council did not establish formal cost-effectiveness and reduction-potential cutoffs that would eliminate some options from further consideration. It was felt that all options should be available to strategy developers with the understanding that, given the same reduction potential, strategies encouraging the most cost-effective options would be preferred.

Approximately 50 strategies were developed that would encourage the implementation of mercury-reduction options. In many cases, cost-effectiveness and reduction-potential estimates for strategies were derived from the associated options. Other costs, such as administrative costs for government staff required to implement a strategy, are included also in strategy costs. Reduction-potential estimates for strategies ranged from 9 to 3,700 lb. per year. Cost-effectiveness estimates ranged from $10 to $922,000 per year. Some strategies (*e.g.*, pollution-prevention requirements) would lead directly to reductions in mercury releases, while others (*e.g.*, education) would lead more indirectly to reductions.

The strategies identified include a range of strategy types. Some are strictly voluntary, others are regulatory or mandatory (mandatory strategies have a regulatory component, even if it does not specifically require mercury reductions, such as fees or reporting requirements). Most of the general categories of strategies that have been used in the past to reduce levels of other pollutants in the environment were considered in some form, including emission limits, fees, licensing, cap-and-trade, product stewardship, early reduction credits, education, subsidies, "jackpots" for persons who invent or install new technologies, and labeling or reporting combined with consumer choice.

Some strategies are applicable to a specific source type (*e.g.*, an emission limit on coal-fired boilers). In other cases, one strategy would apply to a number of different source types (*e.g.*, a credit for early action program and the voluntary agreements strategy). Strategies were included that would apply to all of the currently known, significant sources of mercury releases in Minnesota. Some strategies are also structured so that they would be applicable to any newly discovered, significant mercury source types.

The strategies differ in the degree to which they would directly or indirectly lead to reducing mercury contamination. Strategies can be:

- direct — strategies that directly lead to mercury-release reductions, typically by requiring that actions be taken (*e.g.*, emission caps, emission limits);
- indirect — strategies that are likely to affect releases within a few years after implementation, often by providing an economic incentive or increasing knowledge about mercury releases or health and environmental impacts to implement reduction options (*e.g.*, education, recordkeeping requirements, deposit/refund systems); or
- indirect and deferred — strategies which may eventually lead to a reduction of mercury or which collect data which could be used at a future date to change (*e.g.*, expand or eliminate)

existing strategies or to develop new strategies (*e.g.*, research on human health and wildlife impacts of mercury, or research and development of control technology).

The subset of strategies the Advisory Council selected from this list to recommend to the agency is presented in Part 4.0.

3.4 Mercury Strategy Evaluation Criteria

The criteria the Criteria Committee recommended for evaluating and comparing strategies are:

Feasibility, a qualitative assessment of:

- technical capability (the availability of the physical means to reduce mercury releases);
- economicality (the ability to compete economically);
- reduction potential (the option's likely effect on mercury releases); and
- social factors (political acceptability).

Cost-effectiveness is the total annualized cost divided by the total annual reductions (typically expressed in dollars per pound).

Reduction potential is an estimate of the annual reductions in mercury releases, total reductions over 20 years, and potential effects that reductions of mercury releases will have on mercury contamination in fish.

Permanence is the duration of mercury-reduction options, taking into account re-emission possibilities and transfer of mercury from one medium to another (*e.g.*, from air to water).

Compatibility is a measure of consistency with other programs and initiatives.

Flexibility includes two considerations:

1. Can the strategy itself be readily changed in the future (*i.e.*, is it responsive to change)?
2. Does it allow affected sources to decide site-specific details regarding what action to take?

Comprehensiveness is the extent to which a mercury contamination reduction strategy applies to all emission sources.

Economic impact is a measure of the net effects on regional jobs, personal income, etc.

Cost/benefit analysis considers the ratio of the cost of reducing mercury releases to the value of the damage caused by mercury contamination.

Fairness considers the distribution of the economic burdens among affected sectors.

Political and social concerns are qualitative evaluations of political factors and social acceptance, such as impacts on sensitive populations, including Native American and Asian American communities.

Transferability is the extent to which a system can be adapted readily in other states**.**

Verifiability assesses whether a system can be implemented to verify the success of the strategy.

4.0 Advisory Council Results and Recommendations

4.1 Goals for Reducing Mercury Releases

A strategy package should aim to reduce mercury contamination caused by releases to air and water (combined) following the schedule shown below, using 1990 as the baseline year. Establishing the following statewide goal in legislation in the 1999 session is acceptable to the Advisory Council. Failure to meet this statewide goal is not a trigger for mandatory action in the legislation. The legislation would require the MPCA to conduct a progress review in 2001 and 2005 to reconsider voluntary and mandatory strategies and the goal. The reduction goal applies to the statewide total of releases from existing and new mercury sources.

As new information regarding mercury releases changes the 1990 baseline estimate, the goal of a 70% statewide reduction in releases to air and water by 2005 will apply to the revised 1990 baseline.

Year	Percent Reduction from 1990
2000	60%
2005	70%

It is recognized that no Advisory Council member can give final approval of legislation before review of the actual legislative language.

Background

At the outset of the initiative, MPCA staff did not specify a numeric mercury contamination or release reduction goal. Rather, staff set a general goal: "significant reductions in mercury contamination, using the most cost-effective methods available, working in cooperation with everyone who has an interest in the results." In addition, MPCA staff stated that the agency intends to work toward the mercury use and release reduction goals established by the Great Lakes forums in which Minnesota participates, including the Great Lakes Binational Toxics Strategy and the Lake Superior Binational Program.

In the process of narrowing the list of recommended strategies, the Screening and Evaluation Committee found it necessary to define "significant reduction" as a quantifiable goal so that progress could be more clearly tracked. The recommended reduction schedule is similar to the goals established by the Lake Superior Binational Program, which in part calls for a 60% reduction by 2000 and an 80% reduction by 2010 from 1990 baseline levels for releases of man-made mercury from sources within the Lake Superior basin. See Figure 3 below for a comparison of the recommended reduction goals relative to estimated and projected emissions.

The progress reviews required by the goal statement fulfill an Advisory Council committee recommendation that an iterative approach be used to decrease mercury releases. The committee

recommended that occasional review of progress achieved, results of research regarding health and environmental impacts, relevant activities taking place outside Minnesota, and results of research and development of new options for reducing mercury use and release should be used to determine whether additional strategies are warranted.

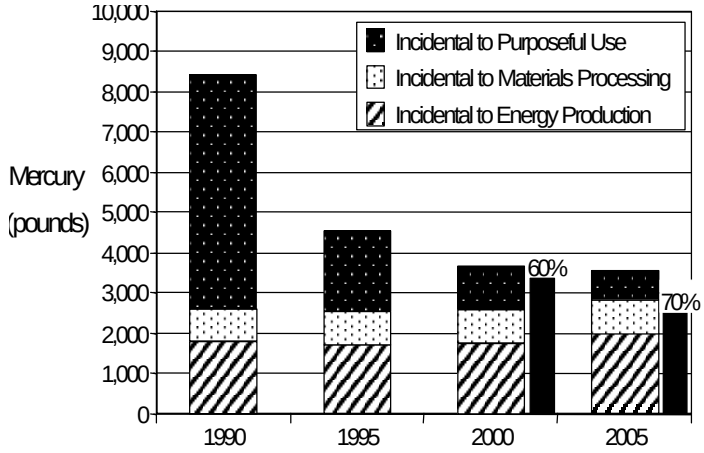
Implementation

Legislation: On January 29, 1999, the Advisory Council approved wording of draft legislation that would establish the goal in statute. The MPCA will request drafting authority from the governor's office and, if granted, will advance the legislation to the legislature.

Progress Reports: The draft legislation calls for the agency to submit a progress report to the legislature by October 15 of 2001 and 2005. MPCA staff and the Advisory Council recognize that reporting in 2005 will require use of estimates of releases to air and water based on trends and available data to predict whether a 70% reduction has already been met or will be met by the end of that year. Because the reduction goals are calculated from a baseline that might shift over time as estimates improve, the draft legislative language requires the MPCA to publish the initial baseline and any significant changes in the register. No date for publication is given to intentionally provide the agency with flexibility in determining when it is appropriate to publish and update. Advisory Council members recommended that the agency publish significant changes to the 1990 baseline as they occur.

Progress toward meeting the goal will depend on the success of all of the new mercury reduction strategies to be implemented, as well as the success of existing programs. Because the reduction goals are statewide, not facility specific, cooperation among mercury-release sources may be needed to meet them. To improve the likelihood that reduction goals are met and to share information, the MPCA may host occasional (perhaps annual) workshops for mercury sources and other interested persons. Such meetings would provide an opportunity to assess what release reductions have been made or are expected to be made, expected increases (*e.g.*, from new sources) and whether additional reductions will be needed to meet the goal.

Figure 3 Reduction goals relative to trends in Minnesota's mercury air emissions



4.2 National and International Action

The Advisory Council recommends implementation of the national and international strategies summarized below and described in detail in Appendix C.

N-1: International Mercury Management Plan

Mercury continues to be used in many products manufactured throughout the world. This strategy's aim is to address both the supply and demand considerations that affect the amount of mercury used, including impacts of mercury mining and the fate of the federal government's stockpile.

N-2: National Mercury Research Recommendations

This strategy calls for increased mercury research at the national level. This includes: researching factors other than mercury releases that may contribute to mercury contamination of fish, such as sulfate deposition or global warming; mercury air pollution control options for coal combustion; development of continuous emission monitoring systems; development of storage or disposal options for "retired" mercury; and evaluating the importance of international mercury sources.

N-3: Change Reporting Protocols for the U.S. Toxics Release Inventory (TRI) for Mercury

Under the current law, a source is only required to report mercury usage over 10,000 lb. per year. Given that mercury is a concern at very low concentrations, these levels are inappropriate. The Advisory Council recommends lowering the reporting thresholds. (EPA has recently proposed a rule change that would be in line with this recommendation.)

N-4: National Mercury Product Labeling Program

Minnesota and a few other states have passed laws that require labeling of mercury-containing products. This strategy calls for creation of a national mercury product labeling law or program designed to provide consumers with information regarding product content and characteristics. The label intent would be to assist consumers with choosing products with the most environmental benefits and with properly disposing of mercury-containing products.

N-5: Evaluate Feasibility of Lower Emission Limits for Sewage Sludge Incinerators

The concentration of mercury in air emissions from sewage sludge incinerators that is allowed by current federal regulations is 3,200 grams per 24-hour period (approximately 7 lb. per day). The objective of this strategy is to reduce the amount of mercury emitted from municipal sludge incinerators through a combination of source reduction, waste segregation and emission controls. The strategy calls for evaluation of the feasibility of adopting a 100 g/dscm or lower emission limit, plus adoption of source reduction, recycling measures, pretreatment to reduce mercury loading to waste water, and annual emissions monitoring.

N-6: Lower Emission Limits for Medical Waste Combustors

The Northeast States Governors' Mercury Action Plan calls for establishing mercury emission limits for medical waste combustors at 55 g/dscm. This is 90% lower than the 550 g/dscm mercury emission limit adopted by EPA in September 1997 for new and existing medical waste combustors. The lower emission limit could be achieved through the combined use of source reduction of materials that contain mercury, mercury waste segregation, and using high-efficiency air pollution control equipment. MPCA has already set mercury emission limits for large medical waste combustors in Minnesota that are more stringent than the federal limit (for example, the limit for Mayo Clinic is 150 g/dscm).

N-7: Establish a National Credit-for-Early-Action Program

The purpose of a credit-for-early-action program is to enable sources that use or release mercury to get "credit" for early actions — reductions in mercury use or release that are achieved before mandatory reduction requirements. Credits earned today could be redeemed under future regulatory regimes or "retired" at any time. ("Retired" means that a company or other credit owner makes arrangements to ensure that the credit is not used in the future.) By providing incentives for early action, such a program encourages consideration of mercury in decision-making, fosters creative solutions to the mercury issue and improves the monitoring and measurement infrastructure. This strategy calls for establishment of a credit-for-early-action program at the national level.

N-8: Create a Mercury-Related Outreach Position for Minnesota

This strategy recommends that the state apply staff time toward encouraging implementation of the national and international strategies described above. Outreach would also include sharing Minnesota success stories with others and learning from others ways to improve Minnesota's program.

Background

The focus of the Mercury Contamination Reduction Initiative has mainly been on mercury sources in Minnesota, since these are sources over which the state has control. However, mercury is a global pollutant. Point source discharges to surface water constitute only 1 to 2% of the mercury sources affecting surface water. MPCA staff estimates that deposition from the atmosphere is responsible for the other 98%. Most of the air emissions from sources within Minnesota are carried out of the state by winds ("atmospheric transport"). Most of the mercury deposited in Minnesota from the atmosphere comes from sources outside the state. Therefore, to significantly reduce mercury contamination in Minnesota, it will be necessary for reductions in mercury use and release to occur outside of Minnesota as well as within the state. Moreover, to maximize reduction potential and cost-effectiveness, it makes more sense to implement certain mercury-reduction strategies on a regional or national level than only at a state level.

Implementation

National recommendations will be forwarded to the EPA as part of MPCA staff's final report. At the December 16, 1998, Advisory Council meeting, the representative from EPA - Region V suggested that Minnesota's elected representatives be made aware of the recommendations as well. In addition, MPCA staff will participate in EPA rulemaking processes and other national and international forums intended to further these recommendations. It is hoped that other Advisory Council members will similarly support these recommendations at the national and international levels.

4.3 Minnesota Mercury Inventory, Research, Monitoring and Reporting

The Advisory Council recommends implementation of two strategies, "Minnesota Mercury Inventory" and "Minnesota Mercury Research," designed to improve data on mercury releases ("inventory"), accomplish environmental monitoring and research, and develop options for reducing mercury releases. These strategies are described in detail in Appendix D.

The Advisory Council recognizes that any reductions achieved in Minnesota must be verifiable in order to be accepted in any future national reduction program that allows for credit for early action. The Advisory Council recommends that the MPCA develop monitoring, measurement and reporting protocols that will enhance the possibility of acceptance in any future national reduction program.

Background

There was wide support among Advisory Council members for continued research related to mercury, including environmental monitoring, continued improvement of the emissions inventory, development of reduction options that are undeveloped or unproved, and pursuit of a better understanding of the fate and environmental risk of released mercury. The research and inventory strategies have no direct potential for reducing mercury releases but are expected to have long-term reduction potential if they are adequately funded. In addition, these strategies will play a key

role in providing data needed for measuring the success of implemented strategies as required by the proposed legislation, which includes review of the mercury-reduction program in 2001 and 2005.

There was also support among members of the Advisory Council for the concept that sources making verifiable mercury reductions in advance of mandatory requirements be rewarded for their efforts with credit towards any future requirements. While the Advisory Council recognized that MPCA does not have the authority to give credit against future federal requirements, it was felt activities could be done in Minnesota to improve the likelihood that credit would be awarded to Minnesota facilities making reductions in advance of any future federal programs.

Research

The "Minnesota Mercury Research" strategy calls for Minnesota to conduct research on issues that are unique or particularly relevant to Minnesota and to continue to evaluate national mercury research studies. The strategy recommends formation of a Research Advisory Committee to collect and evaluate findings from national and international research efforts, identify additional research needs and guide Minnesota's research efforts. The strategy also recommends involving research universities and private research entities, as well as partnering with other states. Additional research objectives that are not unique to Minnesota are covered under the "National Mercury Research Recommendations" strategy that is part of the section on national strategies described previously.

Inventory Improvement.

The "Develop Comprehensive Minnesota Mercury Inventory" strategy directs the MPCA, in cooperation with all mercury sources, to develop a comprehensive inventory of mercury releases to air, water and land, as well as mercury-containing product manufacturing, use and disposal. The MPCA will provide technical assistance, including development and distribution of information about the types of products and processes that contain mercury. The goal is to achieve an inventory of high quality that will be useful for identifying and reprioritizing mercury-reduction strategies, as well as forming the basis for measuring program success and ensuring that key mercury sources have not been overlooked. Establishment of an advisory group to assist MPCA staff and review results is also suggested.

Establishment of Measurement, Monitoring and Reporting Protocols

In addition to recommending that an early reduction credits program be adopted at the national level (see "National Strategies" above), the Advisory Council recommends that MPCA develop guidance for monitoring, measurement and reporting aspects of an early reduction credit program. Council members felt that such guidance would also enhance the quality and consistency of data within and across sectors.

Implementation

MPCA will contact members of the Advisory Council and other interested persons to solicit members for the proposed Research Advisory Committee. This same committee could also serve as the oversight committee recommended for assisting with implementation of the inventory strategy. The rate of implementation of the research and inventory improvement strategies will depend largely on funding.

In accordance with the Advisory Council's recommendation, MPCA staff will prepare guidance for a variety of source types regarding monitoring, measurement and reporting standards that, if met, would enhance the likelihood that reductions would be accepted under any future national reduction program. This strategy is included on the list of national strategies to be supported as described above under "National Strategies."

4.4 Reducing Purposeful Use of Mercury

The Advisory Council recommends implementation of all product strategies summarized below and described in detail in Appendix E.

The Advisory Council accepts the proposal that Minnesota should continue to explore the strategy of bans on nonessential mercury-containing products (products for which a no-mercury alternative is available), with participation of affected industry manufacturers and other affected parties. The Advisory Council recommends that initial product ban efforts address products used in or near water, products with a likelihood of direct release to the environment, and motor vehicles.

Background

One of the findings of the SRFRS Committee was an indication that the lowest-cost approaches to reducing mercury releases to the environment are still mainly those related to reducing the intentional use of mercury and ensuring proper management of existing mercury-containing products. Therefore, the Advisory Council recommends implementation of a comprehensive and specific set of product-related strategies (described below and in Appendix E). The intent of the recommendation is to provide a mix of strategies that cover new and existing products, and include a variety of approaches, including education, assistance and enforcement.

Recommended Strategies to Reduce Purposeful Use of Mercury in Products

Products Currently in Use

To improve the likelihood that mercury contained in existing products does not get released to the environment:

- Improve the mercury-collection infrastructure via the household hazardous waste system and other appropriate channels to make proper management of mercury-containing products more universally available.
- Conduct "clean sweeps" to encourage households and businesses to turn in unneeded mercury at designated collection locations.
- Label mercury products still in use to ensure their proper disposal. Many mercury-containing products can continue to be used until they have reached the end of their useful life without posing an environmental threat, provided that these products are not discarded with other wastes.

New Products Offered for Sale

To discourage use of mercury and encourage proper management of new mercury-containing products:

- Require labeling (before point of sale) by stepping up enforcement of existing labeling laws. Minn. Stat. 116.92 requires manufacturers of products containing elemental mercury to label the products with content information and disposal advice. The state has enforced this law (as in the case of the "toxic tennies" — tennis shoes having lights powered by mercury batteries); however, enforcement of the law should be more vigorously pursued.
- Reduce demand for mercury products by having the state set an example by discouraging procurement of mercury-containing products by the state.

Education and Promotion

Education and promotion are needed to maximize effectiveness of strategies listed above as well as to reach larger audiences (*e.g.*, households) and include:

- General education of public, schools, and target industries, including use of a mercury-detecting dog. The dog would be used mainly for nonregulatory investigation, public relations and educational purposes.
- Education geared specifically toward dentists, using a training video and other promotions, with incentive provided by offering continuing education credits for completion of training regarding proper management of dental amalgam waste containing mercury.
- Reduce use of mercury products in buildings. This strategy calls for providing positive recognition for contractors who reduce use of mercury-containing products in buildings and promote proper management of mercury products.

Enforcement

Step up enforcement of existing bans regarding disposal of mercury products and labeling laws (also listed above). This would directly affect management of existing products in the near term and would encourage proper management or reduced use of new products. Existing laws ban disposal of mercury-containing products in the solid waste and wastewater streams. The MPCA has enforced this law in a number of cases, mainly involving failure to remove mercury from

buildings prior to demolition. Education and enforcement of the law should be expanded to other sectors.

Implementation

MPCA and OEA staff will begin implementing strategies that can be achieved using existing budget resources as soon as possible. The order in which strategies are enacted will be based on a logical sequence of actions and prioritized to maximize mercury reductions. Initial strategies may include: educate users of mercury-containing products, increase collection infrastructure, reduce "installed" inventory of mercury through education and clean sweeps, and reduce use of mercury in buildings. Implementation of all product-related strategies is expected to be completed over a five-year period. Mercury sources and other interested parties may also implement the recommended strategies as part of voluntary agreements or other projects.

4.5 Establishment of Voluntary Agreements

The Advisory Council recommends use of voluntary agreements between the MPCA and mercury sources. The goal of such voluntary agreements is to promote reduced use and release of mercury. The Advisory Council accepted the following proposals related to voluntary agreements:

Affected sources: Who would participate?

Participation would be open to any interested source. However, priority would be given to sources with releases in excess of 50 lb. per year that are not already expected to significantly reduce their mercury use or release based on existing programs, such as regulations, initiatives or permits. Priority would be based also on the amount of mercury released by a source. Priority means that MPCA staff would focus implementation efforts on, and solicit plans from, priority sources first.

Voluntary vs. Mandatory Participation

Participation would be voluntary. Incentive for participation would be provided through the following factors:

- Voluntary participation provides the best opportunity for cost-effective actions.
- Participation would be beneficial to a sector or a company's image.
- Lack of participation would increase the chances of mandatory reductions being required in the future due to failure of the strategy package to meet measurable reduction goals.
- The MPCA could, as its part of the voluntary agreement, attempt to reduce uncertainty regarding possible new regulations for a participating source. Conversely, the agency would be more likely to enact at the state level, or promote at the federal level, new mercury-related regulations for a source that does not participate.
- Participation improves the ability to document reductions achieved through voluntary actions.

Background

The concept of using voluntary agreements to work toward reducing use or releases of pollutants has been applied in many situations. Examples pertaining to mercury include an agreement

between the EPA and the American Hospital Association, and agreements between three Indiana steel manufacturing facilities, the Indiana Department of Environmental Management and EPA - Region V. The goal of such agreements is to reduce or work toward reducing pollutant use or release beyond that which is required by existing regulations.

The "Voluntary Reduction Agreements" strategy is intended to allow sources to voluntarily reduce mercury use or releases and thereby remove the need for resolutions that mandate mercury reduction. This strategy also serves to make the overall set of reduction strategies more comprehensive, as it provides an approach which could cover all types of mercury sources, especially those not covered by other strategies.

As described in more detail in Appendix F, the strategy calls for mercury sources to make commitments to reduce or work toward reducing mercury use and releases. The voluntary reduction agreements, which could cover government, individual sources, whole companies or entire sectors, may include measurable performance goals and timelines for release reductions. The voluntary reduction agreements may also describe research and development studies needed to identify and create new or to further develop existing reduction options that are not currently feasible, and mercury-monitoring and reporting protocols to be used by the participating source(s).

The existence of this strategy does not preclude a source or sector from reducing mercury use or release on its own, without an agreement.

Implementation

MPCA staff would take the following steps to implement the voluntary agreements strategy:

- Develop guidance for voluntary agreements, including potential content.
- Determine how the MPCA will decide when to enter into an agreement.
- Develop monitoring and verification protocols and procedures for reporting reductions.
- Initiate development of voluntary agreements with companies emitting over 50 lb. of mercury, with a goal of concluding 50% by the end of 1999 and the remaining 50% by the second quarter of 2000.
- Begin developing voluntary agreements with smaller, unregulated sources.
- Monitor progress of agreements.
- Publish results.

4.6 Financing Reduction Strategies

The Advisory Council recommends that the MPCA prioritize (*i.e.*, shift funds as appropriate) its current budget and staffing (particularly OEA staff) as well as other agency resources on mercury-reduction strategies prior to seeking general fund sources to cover cost of the strategies. After this is done, the Advisory Council supports a request of money from general fund sources to cover costs of implementing mercury-reduction strategies incurred by the state, counties or other government bodies. Costs incurred by private firms should be covered by each sector or affected source. Alternatively, another source may provide some funding to assist with reducing mercury releases from another source or sector.

Background

Mercury sources will incur costs to implement the recommended mercury-reduction strategies. Most strategies also call for state or local government actions, such as technical assistance and program development. Public funding is required to cover the costs incurred by state and local governments. The Advisory Council recommends first using the MPCA's current budget to pay for such government administrative costs. Then, if necessary, the MPCA should ask for new money from some specific finance sources: the MPCA's appropriated budget, EPA grants, LCMR grants, the Environmental Trust Fund and the state's general fund. The Advisory Council does not support a fee-based system. Estimates of the cost of recommended strategies are summarized in Table 4 and discussed below.

State Funding Needs

Implementation of each recommended strategy will take varying lengths of time. For example, establishing a state goal in legislation should be completed within months, while enforcement of laws will be ongoing efforts. Based on assessment of the ability to cover staffing needs to implement strategies using existing MPCA and OEA staff, it appears that approximately 2.5 additional full-time equivalent (FTE) staff are needed to fully implement the strategies over the next two-year period. After that time, the agency would reassess staffing needs and status of strategy implementation and reallocate staff as appropriate.

Establishment of a Statewide Mercury Reduction Goal: No additional funding is needed.

National and International Strategies: Implementation of these strategies would initially require funding for state staff to participate in state, regional, national and international discussions to encourage enactment of the recommended strategies. MPCA staff estimates that a minimum of 0.25 FTE in addition to existing staff is needed for participation in such programs. Ideally, one entire staff person would be applied to the effort as described in Strategy N-8 in Appendix C. If the recommended strategies are enacted, additional costs would be incurred as identified under "Costs" for each national strategy described in Appendix C.

Research, Inventory Improvement, and Development of Monitoring and Reporting Protocols: For the inventory-related work, MPCA staff estimate that $30,000 per year is needed to estimate mercury releases for 1999 and 2000 at the current level of quality. Approximately $100,000 per year is needed to significantly improve the inventory and to complete all recommended tasking described as called for. Existing MPCA staff will likely be used to develop recommended monitoring and reporting protocols with assistance from interested persons outside the agency. Costs for the "Minnesota Mercury Research" strategy would depend on the type and number of research efforts undertaken. An average of $300,000 per year would allow for reasonable progress on a number of the research efforts called for in the strategy.

Strategies Designed to Reduce the Purposeful Use of Mercury and Related Impacts: Costs for these strategies include staff time at the state and local levels, production of educational materials, advertising and disposal costs for collected mercury. Total staffing required is approximately 3.5 FTEs. It is estimated that an additional 1.5 FTEs are required. Costs incurred by state or local governments for producing educational materials, promotion and disposing of collected mercury are estimated to be roughly $50,000 per year.

Voluntary Agreements: Costs for development of agreements include staff time at the MPCA as well as staff time for participating sources and other interested persons. To complete as many agreements as possible within a two-year time frame, MPCA staff predicts that 1.5 to 2.0 FTEs are required; 1.0 FTE is available from existing resources.

Table 4 Summary of strategies recommended by the Advisory Council (cost and reduction-potential estimates provided by MPCA staff)

Strategy	Total Cost ($/year)[1]	Reduction Potential
National Recommendations		
International mercury management	Unknown	Possibly millions of lb./yr.
National research	Unknown	No direct reduction potential
Change reporting standards for TRI	National costs: unknown ($160,000 for Minnesota)	No direct reduction potential
National product labeling	Unknown	Unknown
Evaluate the feasibility of lowering emission standards for sewage sludge incinerators	Unknown	No direct reduction potential; reduction from lowering standards would be approximately 80 lb./yr in Minnesota.
Lower emission standards for medical waste incinerators	National costs: unknown ($18,000 for Minnesota)	16 lb./yr in Minnesota; roughly 800 lb./yr nationally
Develop a credit-for-early-action program	Unknown	Unknown
Create a mercury-related outreach position for Minnesota	$80,000	No direct reduction potential
Research and Development Strategies		
Develop a comprehensive inventory for mercury emissions	$30,000 - $100,000	No direct reduction potential
Minnesota mercury research	$200,000 to $300,000	No direct reduction potential
Product-Related Strategies		
	Total cost of product strategies [2]: $1,770,000	**Total reduction potential 400-500 lb/yr**
Increase collection infrastructure for businesses	$190,000	See total for all product strategies shown above
Reduce "installed" inventory of mercury via education & clean sweeps	$170,000	See total for all product strategies shown above
Promote labeling of "installed" mercury-containing products	$450,000	See total for all product strategies shown above
Improve compliance with current product labeling laws	$220,000	See total for all product strategies shown above
State avoids buying mercury-containing products	$65,000	See total for all product strategies shown above
Explore expanding bans on mercury in products to include additional unnecessary uses	$60,000	See total for all product strategies shown above
Reduce mercury products in buildings	$50,000	See total for all product strategies shown above

Table 4 Summary of strategies recommended by the Advisory Council (continued)

Strategy	Total Cost ($/year)	Reduction Potential
Product-RelatedStrategies (continued)		
Educate users of mercury-containing products	$90,000	See total for all product strategies shown above.
Educate dental offices and improve amalgam waste management	$280,000	See total for all product strategies shown above
Use a mercury-detecting dog for source identification and publicity	$125,000	See total for all product strategies shown above
Increase compliance with current mercury-disposal bans	$70,000	See total for all product strategies shown above
Other Near-term Strategies		
Develop voluntary mercury reduction agreements	$120,000	1,000 lb./year by 2005

[1] Total cost includes costs to business, such as staff and costs for proper management of collected mercury; costs to counties; MPCA/OEA staffing; and nonstaff resources, such as advertising and educational materials.

[2] The total cost for product-related strategies assumed MPCA/OEA staffing of 3.5 FTEs to implement all product strategies

[3] The total available reduction potential shown is based on the mercury emission projections for sources resulting from purposeful use of mercury in 2005, and is less than the total of individual strategies because some strategies would address the same sources (*i.e.*, there is overlap).

Appendices

Appendix A: Contamination Reduction Potential

The strategies considered and recommended by the Advisory Council would primarily reduce releases of mercury to the environment. Dr. Edward B. Swain and other MPCA staff authored Appendix A to answer questions from the Advisory Council regarding the connection between strategies that reduce mercury releases and reducing mercury contamination in Minnesota's fish. This was often referred to as "contamination reduction potential."

Not All Environmental Releases Are Equally Likely to Contaminate Fish

Exposure to mercury for humans and wildlife is generally caused by mercury bioaccumulation in fish. Mercury that never reaches water can never bioaccumulate in fish. For purposes of this discussion, it is useful to differentiate between releases of mercury to the biosphere, in contrast to the environment in general. Because mercury is an element and can never be removed from the environment, we can consider it to be not in the biosphere (the portion of the environment where it is actively cycling) when it is locked up in geological deposits or when it is held by humans in appropriate and effective containers. Mercury can be released to the biosphere as an air emission, water discharge, surface application to land, in landfills, or from a contaminated site where mercury has been spilled. Mercury is not contributing to fish contamination if it does not enter surface water or if it is unlikely to make its way to surface water. When mercury associated with fly ash is disposed in a well-managed landfill, for instance, then it is essentially out of the biosphere and does not contribute to fish contamination (Felsvang *et al.*, 1994; *Fuel Processing Technology* 39:417-430). Mercury can become very stable in certain chemical forms, such as when it is collected with fly ash, and in these forms it essentially does not leach to groundwater or volatilize to the atmosphere.

Another complicating factor is that not all mercury that does reach surface water is equally likely to contaminate fish. Mercury needs to be converted to methyl mercury before it can bioaccumulate. Placing mercury in aquatic systems where methylation is active (such as wetlands) is thus less desirable than loading mercury to surface waters where methylation potential is low. Also undesirable is placing mercury in systems, such as municipal landfills, where methyl mercury may be produced and released to air or water.

Most of the mercury loading to Minnesota's surface water comes from the atmosphere. Consequently, efforts to reduce fish contamination need to focus on efforts to reduce emissions of mercury to the air. Inventory efforts and options to reduce environmental releases are therefore centered on air emissions. However, because of the mobility of mercury between environmental compartments, it is clear that to reduce air emissions mercury use must be reduced or eliminated wherever feasible. The ultimate effect of such efforts will not only reduce mercury emissions to air, but will also reduce the already low amount discharged to surface water and the relatively large amount that is discarded into municipal solid waste (MSW) and is thought to end up in landfills.

Is a Conversion Factor Needed for Water Releases?

One might argue that if it is important to be able to convert mercury in products to air emissions (as described in Part 3.1 above), then it must be important to quantify the relative importance of reducing direct water releases, as compared to air emissions. However, the MPCA has concluded that there is no practical utility in devising such a conversion factor. There is sufficient incentive to further reduce the already-small loading of mercury to surface water, and this initiative should concentrate on reducing air emissions, which are responsible for 98 to 99% of mercury loading to surfaces waters.

It has long been recognized that mercury is a problem when it is discharged to surface water. In the early 1970s, mercury-contaminated fish were discovered in Minnesota and measures were quickly adopted to reduce and eliminate sources. These measures were largely successful, and mercury concentrations in fish quickly declined in the rivers that received most of the point-source discharge. Since then, regulations to limit the concentration of mercury in surface-waters were adopted, based on limits promulgated by the EPA (12 nanograms per liter) and the MPCA (6.9 nanograms per liter). Recently a lower limit was developed for surface waters in the Great Lakes Basin (1.3 nanograms per liter). Discharge limits were developed for some point-source discharges, based on the surface water standards and the dilution capacity of the receiving water (usually rivers). These discharge limits were somewhat theoretical in that they were below the detection limit of the official EPA mercury analytical method, 200 nanograms per liter.

In any case, surface waters have been largely protected from mercury in point-source discharges, since most water treatment procedures effectively control mercury. Mercury strongly associates with the solids in wastewater treatment, so that over 95% of the mercury is associated with sludge. In 1995, of 388 lb of mercury estimated to have been disposed down sanitary sewers in Minnesota, 4% (15.5 lb) is estimated to have been discharged to surface waters of the state. In contrast, direct precipitation to the surface waters of Minnesota delivers about 300 lb of mercury per year, about 20 times more. In addition, 10 to 20% of the atmospheric mercury deposition to land makes its way to surface water, 600 to 1,200 lb per year (this mercury strongly binds with organic matter in soil, so soil erosion delivers some of the mercury to lakes and rivers). Atmospheric deposition therefore contributes 60 to 100 times more mercury to surface water than direct point-source discharge in Minnesota. It is significant that the concentration of mercury in Minnesota's precipitation often exceeds Minnesota's surface water standard of 6.9 nanograms per liter.

Point-source discharges will come under additional scrutiny when the EPA adopts a new analytical technique for surface water. By June 1999, the EPA will adopt method 1631, which has a detection limit of 0.5 nanograms per liter. Because (1) mercury associates effectively with sludge and (2) adoption of Method 1631 will reveal any facilities that cause the surface water standards to be exceeded, it appears unnecessary to adopt new regulatory initiatives to reduce point-source discharges of mercury to surface water. As a result, MPCA staff recommended that the Initiative focus on reducing mercury emissions to the air.

Conversion Factors Do Not Account for All Impacts — the Case for Virtual Elimination

It is not possible to understand totally the human and ecological impact of mercury release to the biosphere. Although it is perhaps naive to do so, for the purposes of the reduction initiative, the MPCA staff attempted to convert all environmental releases (that are not directly to water) to the amount released to the atmosphere. It is difficult to quantify the amount of mercury used in products that makes its way to the atmosphere, but MPCA staff estimated that an average of 15% of product mercury makes it to the atmosphere in the first year of disposal.

Lest anyone be tempted to judge this load as acceptably low, MPCA staff cautions that there are multiple reasons to reduce mercury use and release. First, there is currently a large amount of mercury used in products each year, and if 15% is released to the air, products exceed coal as a source to the atmosphere. In addition, there are other undesirable impacts associated with mercury use. Second, a proportion of mercury in use is obtained by children, who become exposed to it by playing with this fascinating liquid. There is no excuse for perpetuating this potential for direct exposure (let alone through fish) when cost-effective substitutes are available. Thirdly, although it appears that municipal landfills are a benign fate for mercury disposal, a proportion of mercury sent to landfills may become methylated and released to the atmosphere. Landfills that contain mercury and organic matter may be conducive to the production of organic forms of mercury that could volatilize to the atmosphere. A small proportion (1 to 3%) of mercury in precipitation is in the form of methyl mercury, which is much more likely to contaminate fish than inorganic mercury. Methyl mercury was detected in the gas-collection system of two landfills in Minnesota. The fate of mercury in landfills deserves detailed study.

The use of mercury in products therefore has multiple undesirable and unpredictable outcomes — it contributes to atmospheric emissions, children are tempted to play with it, and disposal of it in landfills may be a source of the methyl mercury in the atmosphere. To decrease the likelihood of these undesirable outcomes, it is prudent to extend the precautionary principle, and to have a goal of eliminating mercury-containing products from use.

Potential for Reducing Mercury in Fish by Reducing Air Emissions

All mercury that is emitted to the air comes down to Earth eventually, but some mercury is deposited near (less than 100 km) the source (local deposition), some in a greater region (regional deposition), and some is dispersed throughout the world before it finally comes down (global deposition). The degree of local and regional deposition depends on the chemical form of the mercury that is emitted. There may be environmental justice in the observation that when control equipment captures mercury, it most effectively captures the mercury that is the most likely to have been deposited locally (ionized mercury, mercury (II)). Therefore, there is an automatic local benefit to implementing mercury control on point-source emissions, such as incinerators. However, there is less local benefit to capturing metallic mercury vapor (mercury (0)), which is more likely to join the global pool before being deposited.

In northern Minnesota, roughly 40% of mercury deposition is from regional sources, 30% is from natural global sources and 30% is from anthropogenic global sources (Engstrom and Swain, 1997). Areas in Minnesota nearer mercury-emission sources receive a variable additional

increment of local deposition that is difficult to quantify for a variety of technical reasons. Lakes in the urban and suburban areas of Minneapolis-St. Paul may receive about 35% more mercury deposition due to the aggregate of local emissions (Engstrom and Swain, unpublished findings).

Therefore, there is an automatic local benefit to controlling ionized mercury, but only a small local benefit to controlling metallic mercury vapor. It may be tempting to focus control on just ionized mercury (because doing so is easier and imparts more local benefits), but if everyone thinks this way, the potential for reducing mercury deposition would be severely limited because global deposition is already significant and would grow. It is certainly not desirable to give anyone an incentive to convert mercury to more global forms simply to minimize local deposition.

Estimated Benefits Within Minnesota from Emission Reductions

Ideally, the linkage between emissions and mercury bioaccumulation in fish would be known quantitatively, and the effect of a given reduction in emissions modeled. Such models are still being developed; successful application will depend upon detailed information on the speciation of mercury that is emitted from all sources. In the absence of detailed information and validated models, the MPCA staff has chosen to rely on the following simplifying assumptions (Rae, 1997):

- A reduction in emissions from sources within a given area results in a proportional reduction in the rate of deposition attributable to those sources.
- A reduction in deposition results in a proportional reduction in mercury loadings to water bodies.
- Within a given body of water, a proportional reduction in mercury concentration in the water results in a proportional reduction in mercury concentrations in fish.
- One-half the proportional reduction in mercury concentrations in fish will occur in five to 10 years, but achieving the full effect will require about 20 to 25 years.

Table 5 summarizes the percentage of mercury deposition in Minnesota that is attributable to Minnesota, Midwest, U.S. and global sources. For this exercise, the United States is assumed to be the regional area that Engstrom and Swain (1997) determined contributes 40% of the deposition in Minnesota. The 40% is then subdivided into 10% being local deposition from Minnesota emissions; 15% from the rest of the Midwest and the remaining 15% from U.S. sources outside of the Midwest.

Table 5 Contributions to mercury deposition in Minnesota

Emission Source Location	Percentage	Cumulative Percentage
Within Minnesota	10	10
Midwest	15	25
United States	15	40
Global Pollution (U.S. share = 2%)	30	70
Global – Natural	30	100

In Table 6, MPCA staff applied the four assumptions described above to the data in Table 5 to project the percent reduction in mercury deposition in Minnesota resulting from reducing mercury air emissions by 50% in each progressively bigger geographic area. Using this method, a 50%

reduction in mercury emissions from Minnesota sources is projected to result in a 5% reduction in deposition in Minnesota. The same percent reduction applied to sources in the Midwest region is projected to result in a 12.5% reduction in deposition statewide. U.S. sources of mercury account for about 42% of total deposition to Minnesota (counting the 2% of global emissions contributed by the United States), so a 50% emission reduction is projected to result in a 21% reduction in deposition. Finally, a 50% reduction applied to all global anthropogenic sources is projected to result in a 35% reduction in deposition.

Table 6 Reductions in Minnesota mercury deposition if anthropogenic sources reduce by 50%

Emission Source Location	Cumulative Contribution to Deposition in Minnesota	Reduction in Deposition in Minnesota if Emissions in the Source Location Reduce by 50%
Minnesota	10%	5%
Midwest	25%	12.5%
United States	40%	21%
Global Pollution (U.S. share = 2%)	70%	35%
Global – Natural	100%	(not possible to reduce)

Reductions in mercury deposition that translate into reduced gamefish concentrations will ultimately result in changes in fish advisories. Employing the assumption of a linear relationship between deposition and fish bioaccumulation, Rae (1997) recomputed the average mercury concentration in lake trout, bass, walleye and northern pike in each lake, by size category, for each of the four deposition scenarios. Rae then determined how many lakes shift fish advisories relative to the 1997 Minnesota Department of Health Fish Consumption Advisory. For each mercury control scenario, Table 7 summarizes the number of advisories for the most sensitive populations — women of childbearing age and children. The table shows that as deposition is more substantially decreased due to mercury-release reductions occurring over a broader range, the number of more severe fish consumption advisories ("do not eat" and "one meal per month") decreases and the number of lakes with less severe advice or no restrictions increases. (The total number of advisories, 2,974, exceeds the number of lakes tested because a lake typically will have more than one advisory, dependent on fish size and species.)

Table 7 Summary of the number of fish consumption advisories, by advisory type, for women of childbearing age and children

Type of Advisory[1]	1997 Baseline[2]		Mercury-Reduction Scenario[3]							
			Minnesota: 5%		Midwest: 12.5%		USA: 21%		Global: 35%	
	Advisories									
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Unlimited	16	0.54	17	0.57	27	0.91	36	1.21	56	1.88
1 meal/wk.	546	18.36	607	20.41	659	22.16	782	26.29	1036	34.84
1 meal/mo.	2020	67.92	2000	67.25	2002	67.32	1941	65.27	1773	59.62
Do not eat	392	13.18	350	11.77	286	9.62	215	7.23	109	3.67
Total	2974	100.00	2974	100.00	2974	100.00	2974	100.00	2974	100.00

[1] The Minnesota Department of Health fish consumption advisory recommends a maximum frequency of fish meals depending on the concentration of mercury in fish sampled in a particular lake. For example, if concentrations are low, the advice is that an unlimited amount of fish may be consumed. If concentrations are moderate, a limited number of meals per week or per month is advised. If concentrations are very high, the advice recommends "do not eat" the fish.

[2] The number of fish consumption advisories issued in 1997 for each degree of advice, ranging from "unlimited" to "do not eat," is given.

[3] For each scenario, the predicted number of fish consumption advisories is shown. The scenarios refer to reductions in mercury deposition in Minnesota resulting from reductions in mercury releases in areas ranging from Minnesota alone to worldwide. For example, "Minnesota: 5%" refers to the scenario shown in Table 6 where a 50% reduction in mercury releases in Minnesota alone is predicted to result in a 5% reduction in deposition in Minnesota.

It is not possible at this time to differentiate the benefit of reducing emissions from different sectors. For instance, it might be thought that reducing volatilization of metallic mercury vapor from mercury spills would provide little regional benefit because of the inert behavior of that species. However, the vapor from spills would interact with foliage because of the low emission elevation, perhaps resulting in dry deposition. It might also be thought that reducing emissions from tall stacks such as those employed by coal-burning power plants would have little regional benefit, both because of the high emission elevation and because it is thought that most of the mercury emitted by coal combustion is not ionized. However, reductions by control equipment would probably preferentially capture whatever ionized mercury is present, thereby providing a greater regional benefit than expected.

Mercury Deposition Monitoring

Monitoring parameters, such as mercury concentrations in precipitation and deposition rates in lake sediments, can be used as indicators of contamination reduction. The MPCA participates in the National Atmospheric Deposition Program (NADP) to monitor mercury deposition in rain and snow. In 1996, four sites were established across Minnesota: Lamberton in southwestern Minnesota, Camp Ripley in central Minnesota, Marcell in north-central Minnesota (Itasca County) and Ely in northeastern Minnesota. Each site is also a NADP acid-deposition-monitoring site.

Total mercury and acid rain parameters (major cations and anions) are monitored on a weekly basis, while methyl mercury is analyzed using four-week composite samples.

The MPCA also has obtained data on historical mercury-deposition rates through sediment cores from more than 50 lakes. As sediments accumulate over time, they act as a natural archiving system for the history of contamination. By obtaining a three- to four-foot-long core of the sediment from a lake and slicing it into thin layers for analysis, the history of the mercury contamination of that lake can be reconstructed with about a five-year resolution. From these reconstructions, the degree and timing of changes in atmospheric deposition can be calculated, including the natural level of contamination. Comparing cores from Minnesota lakes to remote Alaskan lakes also indicates the amount of contamination that has resulted from sources in the Minnesota region versus contamination from mercury that contaminates the whole globe. Results from the coring program show that (1) of the mercury deposited in northeastern Minnesota, 30% is natural, 30% is global pollution and 40% is regional, and (2) in some parts of Minnesota, the regional pollution peaked in the 1970s and has declined since then due to less emission of mercury (Engstrom and Swain, 1997).

References

Engstrom, D. R. and E. B. Swain. 1997. Recent declines in atmospheric mercury deposition in the Upper Midwest. *Environmental Science and Technology*. Vol. 31:960-967.

Rae, Douglas A. 1997. *Impacts of Mercury Reductions in Minnesota*. Report to the Minnesota Pollution Control Agency, St. Paul, Minn.

Appendix B: Summary of Economic Impact Analysis

A detailed description of the economic impact assessment conducted by MPCA staff is provided in the SRFRS report. A summary of the assessment is shown below.

Economic impact analyses have been used to estimate the economic effects that would result from implementation of strategies selected by the Advisory Council to reduce the purposeful use of mercury. Net production cost increases in Minnesota's electrical utility, iron ore mining and government service sectors and increases in state and local government spending are assumed to be the primary economic effects of these proposed strategies. No significant economic impacts are expected. Findings indicate that net, per-sector production cost increases will be less than 0.001% of economic output in the affected sectors.

MPCA staff did not conduct an economic impact analysis on costs that would be incurred as a result of the proposed "voluntary agreements" strategy. It was assumed that firms would not voluntarily undertake activities that would cause them significant adverse economic impacts.

Some other findings are:

- A broad financial cost distribution helps to keep economic costs down.
- Affected sectors can absorb, without significant loss, the economic burden associated with reducing mercury contamination via the proposed strategies.

Appendix C: Descriptions of National Strategies

To significantly reduce mercury contamination in Minnesota, it will be necessary for reductions in mercury use and release to occur outside of Minnesota as well as within the state. To maximize mercury-reduction potential and cost-effectiveness, it makes more sense to implement certain mercury-reduction strategies on a regional or national level than only at a state level. The Advisory Council recommends pursuit of the following set of national and international strategies for reducing mercury use and release.

Plans for Implementing National Strategies: see Part 4.2 above.

N-1: International Mercury-Management Plan

Strategy: Reduce the international supply of mercury to encourage mercury release reductions, given that reduced mercury supply in world markets should cause prices to increase and demand to fall. Reduce the demand for mercury through education and international agreements that discourage unnecessary use of mercury. Specific suggestions:

- Recommend to appropriate federal decision-makers that the U.S. stockpile be transferred from its current owners, the Department of Energy (DOE) and the Department of Defense (DOD), to the U.S. Environmental Protection Agency (EPA), along with related authorities and financial resources. Require or recommend that EPA not sell the mercury, except under limited circumstances. Consider also recommending that EPA study the possibilities of using the stockpile for strategic purposes to influence world prices and trade of mercury.
- Purchase or otherwise procure other available reserves of mercury worldwide. By purchasing the available reserves of mercury, the United States could make more expensive alternate products more cost feasible.
- Request that the federal government (State Department) look into potential ways in which the United States could request or create incentive to reduce mercury mining.
- Work through new or existing international organizations to use education and treaties to voluntarily reduce mercury use.

Background: Mercury continues to be used in many products manufactured throughout the world, as well as for certain industrial processes. This strategy's goal is to address both the supply and demand side of the equation that affects the amount of mercury used. Mining of new mercury and sales of mercury from stockpiles affect supply. Demand is determined by a very wide array of users.

U.S. Mercury Stockpile: The DOD and the DOE maintain stockpiles of "surplus" mercury that contain a total of approximately 11million pounds. Until 1994, the Defense Logistics Agency had made it a practice to reduce the stockpile by selling mercury. A moratorium on mercury sales was imposed in 1994. The matter has been under study since then, with no resolution yet reached. Selling mercury from the stockpile becomes an issue because different federal agencies view the

stockpile differently. To the DOD and DOE, the stockpile is a commodity reserve that they no longer need and that has a positive value in world markets. To the EPA, the stockpile is a mercury source that could cause contamination if it is released by sale to industrial users.

Mining: Mercury mines currently operate in Spain and Kazakhstan. Output from these mines varies somewhat, as world prices change and other factors influence decision-makers. It is reported that the governments keep the mines in production primarily to provide employment.

Affected Sources: Federal agencies, especially the EPA, DOD, DOE and State Department, and the industrial sectors worldwide that use mercury in manufacturing or industrial processes.

Geographic Scope: National and international.

Associated Options: Source reduction for municipal solid waste and wastewater and other options related to intentional use of mercury.

Cost-effectiveness: $0.20 to infinitely expensive. Lower bound: $640,000 ÷ 0 lb = infinitely expensive. Upper bound: $640,000 ÷ 3,600,000 lb = $0.20/lb.

Cost: Costs for the proposed program are largely administrative. The strategy in general may result in some increased cost to consumers from increased price of mercury, although low-cost or no-cost alternatives available for many mercury applications would likely be phased in over time. In 1995, mercury sold for an average price of $250 per 76-lb flask ($3.29/lb). Most mercury-containing products contain much less than 1 lb. There should be no change in the stockpile maintenance costs already incurred by the federal government. Foregone future mercury sales would increase total costs over time.

Rough estimate: Assuming that eight full-time staff at EPA or other federal government offices are required to implement the strategy, cost = 8 x $80,000/yr = $640,000/yr. (Note that the loss of a potential revenue source, sale of mercury from the federal stockpiles, has not been included.)

Reduction Potential: Direct, 0; indirect, up to 3,600,000 lb/year total, assuming that the 11,000,000 lb in the U.S. stockpile were sold over a three-year period.

The reduction potential of this strategy covers a wide range. The primary near-term reduction would be achieved through permanently retiring the U.S. stockpile rather than selling it. If increased mining offset the reduction in U.S. mercury sales, the net impact on emissions reductions could be negative, due to releases from the mining practices. Conversely, if mining does not increase and use declines as a result, then the reduction potential upper bound is roughly equal to the quantity of mercury in the stockpile divided by the number of years over which it would be sold. If DOD and DOE were to take three years to sell all the mercury, the maximum rate of release would be 11,000,000 lb ÷ 3 years = 3,600,000 lb/year. In addition to the rate of sale, the rate of release would be influenced by the use of the purchased mercury. Some uses, such as gold mining, would result in nearly 100% release, while others, such as incorporation into

fluorescent light bulbs, thermostats or other products which have to the potential to be collected and processed at a mercury recycler, would result in a lower release rate.

Implementation issues:

- The impact of limiting sales from the stockpile should be evaluated to determine the likely connection between stockpile sales, mining rates and use rates. In that sales have been suspended for a few years, it should be relatively easy to review what impacts it has had on mining operations. This information would help refine the estimated reduction potential and cost-effectiveness.
- Coordination between government agencies, particularly large federal agencies, which is sometimes difficult, would be needed.
- The EPA does not have storage sites like DOD does, so the potential for EPA to physically take control of the stockpile is limited.
- A number of international organizations exist which are already addressing mercury, but they could be used to more aggressively pursue international reduction in mining and use. These include the Great Lakes Binational Strategy mercury workgroup and the Long Range Transport of Air Pollutants (LRTAP) program. The EPA, State Department and any other involved federal agencies would be more effective if they were able to put forth a coordinated mercury-reduction agenda that recognizes the global nature of mercury as a pollutant.
- This strategy could result in lost revenue due to reduced mercury sales and/or mining.

N-2: National Mercury Research Recommendations

Strategy: Recommend to EPA that more emphasis be placed on mercury research. Research should be focused to address national and international needs such as:

- Better predictive modeling capabilities for:
  1. source apportionment, atmospheric transport and deposition;
  2. mercury accumulation in fish and its effects on fish-eating wildlife and humans; and
  3. the benefits of reducing mercury emissions and deposition (Is mercury in fish linearly related to mercury deposition?).
- Understanding man-made (anthropogenic) factors contributing to mercury contamination of fish aside from mercury pollution (*e.g.*, sulfate deposition, global warming).
- Mercury-control options for coal combustion.
- Continuous emission monitors (CEM) for mercury.
- Quantifying the relative environmental impact of different mercury releases (*e.g.*, direct discharge to surface water vs. air emission; discharge of methyl mercury vs. inorganic mercury; land application vs. air emission).
- Disposal or storage options for retired mercury.
- Understanding the impact of anthropogenic mercury already circulating in the environment (legacy mercury), and finding answers to these questions:
  4. How fast will mercury loading to lakes decrease if anthropogenic emissions decrease?
  5. Because previously deposited mercury is stored in soils, what is the role of soil erosion and leaching of this mercury from soils?

6. How does re-emission of mercury from soil to the atmosphere obscure reductions in anthropogenic emissions?

- Evaluating the importance of international sources, such as coal combustion in China, gold mining in Brazil and mercury emissions from 340 chlor-alkali plants worldwide.
- Identifying the source(s) of methyl mercury in rainfall, and any reduction options.
- Enhance the mercury inventory, including improving emission estimates for steel recyclers, chlor-alkali plants, soil roasters and oil refineries, and answering the questions:
  7. How fast does land-applied mercury (in sludge, fly ash, MSW compost and landfill leachate) volatilize? How much methyl mercury is produced and how much of that volatilizes?
  8. How much mercury in solid waste landfills escapes through volatilization and leachate? How much methyl mercury is produced and released in leachate and volatilization?
  9. How much mercury in ash landfills escapes through volatilization and leachate? How much of this escapes as methyl mercury?
  10. Where ash is used in construction (cement, soil stabilization, etc.), what is the rate of mercury volatilization? How much methyl mercury is produced?
  11. How much mercury in the solid-waste stream is lost to the air prior to incineration or landfilling (in dumpsters and during transport)?

Affected Sources: All mercury sources.

Geographic Scope: National.

Associated Options: None.

Cost-effectiveness: The near-term cost-effectiveness cannot be calculated because the strategy's direct reduction potential is zero. The long-term cost-effectiveness cannot be determined. Given that the strategy has the potential to identify, through the proposed research, opportunities to achieve large mercury-emission reductions at very low cost, the long-term cost per pound could be relatively low, although total cost would include the reduction option cost plus research costs.

Cost: Not determined. Cost would depend on such factors as the research selected and timeline.

Reduction Potential: Direct, 0; indirect, research may lead to development of mercury-reduction techniques. Also, additional information on sources may help identify cost-effective reduction opportunities that are currently unknown.

Implementation Issues:

- Limited financial resources.
- Sharing resources/information and coordination at the state, federal and international level among researchers to optimize use of funds and usefulness of research results.
- The lack of near-term reduction potential resulting from the proposed strategy may lead to low social and political acceptance among persons who believe that mercury contamination is a problem that warrants action now. Combining research strategies with others that would achieve reductions earlier may be seen as an acceptable "package" of strategies.

N-3: Change Reporting Protocols for the U.S. Toxics Release Inventory

Strategy: Lower the usage threshold for mercury so that the existing Toxic Release Inventory (TRI) reporting mechanism would require reporting mercury releases from more facilities. The public availability of data encourages industry to attempt to find ways to reduce pollution. In addition, the TRI laws require preparation of pollution prevention plans in certain cases.

Background: Mercury is on the list of chemicals reportable on the TRI. For a facility to report, it must have 10 full-time employees, be in Standard Industrial Classification (SIC) codes 20-39 and meet annual usage thresholds (either 25,000 or 10,000 lb, depending on how the chemical is used). Minnesota has additional SIC codes that must report and EPA has added seven sectors which will be reporting by July 1999, covering the 1998 reporting year. The public availability of data, under both the TRI and Minnesota Pollution Prevention Act, encourages industry to focus on their processes and attempt to find ways to reduce pollution. A recent press release from EPA regarding the national TRI report indicates a 71% reduction in releases in Minnesota since 1988.

It is unlikely that an individual facility will meet the annual usage threshold of 25,000 lb per year for mercury. As a result, data pertaining to the release and or transfer of mercury are typically not submitted under the existing TRI reporting requirements. Currently, electric utilities are required to report mercury emissions on an annual basis under separate Minnesota law.

This strategy is contained in the Northeast States Governors' Mercury Action Plan released on June 8, 1998, which makes recommendations for actions in that region and nationally. This approach has also been considered in the past by MPCA staff and staff of the Minnesota Department of Public Safety who oversee the TRI system.

The EPA is developing regulations that would lower the threshold for mercury and other chemicals to 10 lb.

Affected Sources: The number and type of affected sources would depend on what level the reporting limit was lowered to and whether any new industry types were added to the types of sources (determined by SIC code) covered by the law.

Geographic Scope: National.

Cost-effectiveness: The near-term cost-effectiveness cannot be calculated because the strategy's direct reduction potential is zero. The long-term cost-effectiveness depends on whether and to what degree reporting would lead to mercury use and emission reductions.

Cost: Nationwide costs have not been estimated. In Minnesota, the rough estimated total cost statewide is $162,000/yr. Costs would depend on how many new facilities would be required to report mercury emissions under a lowered TRI threshold. The costs of this proposal are mostly from added staff time to process the data at both company and state levels. It is estimated that

roughly 0.5 additional FTE state staff would be required at $60,000/yr = $30,000/yr. The estimated cost to facilities would be one week of staff time to gather data, complete forms, etc. at a cost of $1,000/yr. Assuming that 12 waste combustors, 20 coal boilers and 100 other facilities would be required to report mercury emissions, then the total cost to facilities in Minnesota would be $132,000/yr.

Note that the number of facilities that would need to track releases is likely higher — even if they don't meet the actual threshold, they will need to track to determine if they do or not. On the other hand, the estimated staff time per facility may be overly conservative, given that most affected sources would already be completing TRI forms for other pollutants.

Reduction Potential: Direct, 0. This strategy relates to data collection, which may lead some companies to reduce mercury releases to avoid reporting or being the subject of negative publicity.

Implementation Issues:

- The purpose of this strategy is twofold: (1) to provide the MPCA with data regarding mercury use and releases, and (2) to make such data publicly available. Regarding fulfilling the first purpose, it should be evaluated whether collection of data through the TRI process would provide the most accurate data or if a separate state effort or other national approach (e.g., EPA's proposed information collection request for electric utilities) would result in better data. The TRI process does not guarantee that very accurate data will be obtained because there are no monitoring requirements, only submittal of the best available data is required. However, one benefit that the TRI has over some of the other information-collection programs is that TRI is an ongoing program.
- As noted, the appropriate threshold level needs to be evaluated.
- Minnesota law currently requires facilities that report under TRI to submit pollution prevention (P2) plans, which would add to the cost estimates. These P2 plans may not be relevant to some sources on the list, because no alternatives exist.

Information Sources: [1]Steve Tomlyonovich of Minnesota Department of Public Services.

N-4: National Mercury Product Labeling

Strategy: Create and require compliance with a comprehensive, national, mercury-product-labeling law or program. The law or program would establish product-specific labeling approaches designed to provide consumers with necessary information regarding product content, characteristics and performance. The information would assist consumers in choosing products that provide the most environmental benefits and in properly disposing of mercury-containing products. Labeling may include information on the availability of end-of-life management programs, options or requirements for the product.

Background: In 1992, the Minnesota Legislature passed laws governing the sale, use, labeling and disposal of mercury and mercury-containing products. The major purposes of the labeling requirement are:

- to provide disclosure of hazardous contents to sellers and purchasers;
- to encourage the sale, purchase and use of non-mercury products (where appropriate alternatives exist); and
- to provide information about content and disposal prohibitions to the consumer at the time of disposal, to help ensure management in accordance with the state's disposal ban.

With the widespread acceptance of Toxic Release Inventory (TRI) reporting and other right-to-know measures, product labeling for hazardous components is becoming more acceptable and expected, and is seen by some as a corporate responsibility to society.

In Minnesota, labeling does not stand alone, it is part of a larger package of mercury-reduction/management measures, including the disposal ban, producer and servicer responsibility requirements, and the Special Waste Pilot Project/Universal Waste Rule to facilitate end-of-life management for all mercury-containing products.

On a national level, the primary purposes of mercury product labeling are for expanding "right-to-know" to consumer products, and for informing them about purchase and disposal decisions. In other words, its purpose is primarily educational and informational. Ideally, a labeling requirement should be accompanied by the other program components used in Minnesota.

Vermont has passed a product-labeling law that is currently being implemented by rule. Maine and Connecticut are also considering a labeling requirement, and the Northeast States Governors' Mercury Action Plan (June 8, 1998) contains general recommendations for a product-labeling requirement for regional/national implementation. As individual states set their own labeling laws, the danger of conflicts between laws increases, and this decreases the potential for achieving a high compliance rate.

Affected Sources: Product manufacturers.

Geographic Scope: National.

Associated Options: Source reduction in municipal solid waste and wastewater.

Cost-effectiveness: Not determined. Product-labeling costs vary depending on the product, but generally represent a very small portion of the product-manufacturing cost, typically a few cents per label. The effect on pollution prevention and proper management is difficult to quantify.

Cost: Not determined. Product-labeling costs vary depending on the product, but generally represent a very small portion of the product-manufacturing cost, typically a few cents per label.

Financing: Cost to be borne by product manufacturer.

Reduction Potential: Unknown.

Implementation Issues:

- The strategy needs to avoid discouraging purchase of mercury-containing products when the alternative may be worse for the environment. For example, use of fluorescent lamps, which contain small amounts of mercury, is recommended as part of energy-conservation measures.
- Disposal information needs to be available to the consumer at the time of disposal. However, in some cases (*e.g.*, thermometers or button batteries), the item is too small to put a label directly on the product.
- The strategy should be consistent with other state and federal laws, such as Federal Trade Commission rules.
- Creation of a consistent, uniform labeling law could be complicated by inconsistencies between states in waste-management/recycling laws. Some state-specific disposal instructions may still be necessary. For example, in states that have not adopted a "universal waste rule," providing for proper mercury disposal would be more difficult and instructions to consumers may vary.

N-5: Evaluate Feasibility of Lowering Emission Limits for Sewage Sludge Incinerators

Strategy: Modify regulations regarding mercury emissions from sewage sludge incinerators to add requirements that facility owners or operators prepare and submit an evaluation of the feasibility, cost and release reductions expected if the facility were required to meet a mercury-emission limit of 100 g/dscm.

The objective is to reduce the overall amount of mercury emitted from municipal sludge incinerators through a combination of source-reduction, waste-segregation and emission controls. The strategy calls for evaluation of the feasibility of adopting a 100- g-per-dscm or lower emission limit, plus adoption of source reduction, recycling measures and pretreatment to reduce mercury loading to wastewater, and annual emissions monitoring.

Background: A similar strategy is contained in the Northeast States Governors' Mercury Action Plan released June 8, 1998, which makes recommendations for actions in that region and nationally.

Affected Sources: Sewage sludge incinerators.

Geographic Scope: National.

Associated Options: Treat scrubber water or, more cost-effectively, source-reduction options.

Cost-effectiveness: The cost-effectiveness range for the option "treat wet scrubber water" (described in the SRFRS report) is $11,000 to $37,200/lb. The cost effectiveness of most source-

reduction options that would reduce mercury loading to a wastewater treatment plant fall within the given range or would cost less; however, their reduction potential is more difficult to predict.

Costs: Cost would depend largely on whether the limit could be met through pollution-prevention measures only or if installation or alteration of exhaust stack control equipment would be required.

Reduction potential: Nationally, not determined; 80 lb/yr in Minnesota. As of 2000, two sludge incinerators, Seneca and Pigs Eye (both are Met Council facilities) are expected to be operating in the state. Test results for Pigs Eye sludge incinerators for August 15, 1995 and September 15, 1996, showed emissions of 186 and 155 g/dscm at 7% oxygen, respectively. Compliance with a 100- g-per-dscm emission limit would require a reduction of approximately 50% in emissions. Assuming that current emissions from the two Minnesota plants are roughly 160 lb per year, the reduction potential would be very roughly 80 lb per year.

Implementation Issues:

- It is not known whether control technology would be required to meet an emission limit of 100 g/dscm or if the limit could be met through source reduction alone.
- The Metro (Pigs Eye) facility is in the planning stages of replacing existing sludge incinerators with a new solids-processing system. If the new system again uses sludge combustion, preliminary plans call for including mercury-control technology. The timing of complying with a requirement that calls for use of stack control equipment would greatly affect costs for the Metro facility, given that retrofitting the existing plant with mercury controls operated for a few years is expected to cost much more than including equipment on a new processing facility.

N-6: Lower Emission Limits for Medical Waste Combustors

Strategy: Establish mercury-emission limits for medical waste combustors at 55 g/dscm. This is 90% lower than the 550 g/dscm mercury-emission limi t that EPA adopted in September 1997 for new and existing medical waste combustors.

The lower emission limit is expected to be achieved through the combined use of source reduction of materials that contain mercury, mercury waste segregation, and using high-efficiency air-pollution-control equipment. The object of the strategy is to reduce the amount of mercury emitted from medical waste combustion sources.

Background: This strategy is contained in the Northeast States Governors' Mercury Action Plan released June 8, 1998, which make recommendations for actions in that region and nationally.

The EPA established mercury-emission limits as part of the standards for new and existing medical waste combustors. The federal standards regulate more than just mercury emissions. EPA has predicted that, rather than comply with the new standards, most medical waste combustors will cease operating, leaving the large and very remote waste combustors subject to

the standard. States must adopt standards for existing facilities that are at least as restrictive as the federal emission limits. That is, states must have a mercury limit in place that allows mercury emissions no greater than 550 g/dscm. MPCA already has mercury-emission limits for large medical waste combustors in Minnesota that are more stringent than the federal limit. The Mayo Clinic incinerator operates well below its limit, with mercury emissions routinely below 12 g/dscm.

Current mercury limits for medical waste incinerator facilities in Minnesota (7% oxygen)

Medical Waste Combustor	Minnesota Current Emission Limit	EPA Emission Limit
Mayo Clinic	Permit limit set at 150 g/dscm	550 g/dscm
Medical Safety System	300 g/dscm (long term)	550 g/dscm
18 other hospital incinerators	None	7,500 g/dsc m

Affected Sources: Medical Waste Combustors.

Geographic Scope: National.

Associated Options: Replace mercury-containing items, laboratory pollution prevention, enhanced air pollution control, waste material separation and proper management, reduce mercury use in consumer products, and purchase and use fewer mercury-containing products.

Cost-effectiveness: $1,200/lb for reducing air emissions. Cost: $18,000/year per incinerator. Assumptions: Capital recovery factor = 0.087 (6%, 20 years); equipment setup based on system currently in use at Mayo Foundation medical waste incinerator; purchase and installation of activated carbon storage and feed system at $45,000 per combustor unit; operating cost based on powdered activated carbon at $0.65/lb and injection rate at 2.5 lb of carbon per ton of waste burned. This results in an annual operating cost of $18,000/yr for a 1,000 lb/day medical waste combustor unit, and reduces mercury emissions by 16 lb.

Medical waste combustors are operated as private facilities or as commercial disposal facilities. In either case, expenditures needed to comply with this emission limit would likely be borne by the waste generators using the waste combustor.

Reduction Potential: Roughly 800 lb/yr nationally. In Minnesota, 16 lb/yr to air (national scale roughly = 50 times Minnesota's).

Reduction potential depends on the difference between existing emission rates and the proposed emission limits, which would dictate to what degree, if any, a given facility has to reduce emissions to meet the standards. In Minnesota, the reduction potential represented by the 55 g/dscm standard would occur through air pollution control changes at the commercial incinerator Medical Safety Systems (MSS). MSS currently uses a dry sorbent injection/baghouse system for controls. Emissions testing at the facility shows mercury emissions to be 183 g/dscm (25 lb/yr), which currently meets the EPA standard. Adding activated carbon injection to achieve

a 55 g/dscm limit (estimated injection rate: 2 .5 lb carbon per ton medical waste, per Mayo) would result in reducing mercury releases by about two-thirds from this facility, or about 16 lb.

Remaining medical waste combustors in Minnesota either already meet the limit or will cease operating due to other factors involved in complying with federal emission limits. Mayo Foundation facility is currently using dry sorbent injection, powdered activated carbon and a baghouse. Ongoing emissions testing shows mercury emissions to be routinely below 12 ug/dscm, well below the proposed standard. Because of the economics involved in adopting the federal standards, nearly all remaining hospital incinerators in Minnesota are expected to cease operating by March 2000.

Implementation Issues:

- Medical waste combustor operators are waiting for states to complete the process of establishing state programs implementing the recent federal standards, which are required by the Clean Air Act to be submitted to EPA for approval by September 1998. The window of opportunity is closing quickly where states can examine further alternative mercury emission limits without backing up and undoing existing decisions, and then directing affected facilities appropriately.
- Standards are typically technology-based, not risk-based. The standard reflects the capabilities of control equipment, and is chosen so that well-operated equipment will meet the limit under nearly all operating conditions.
- The standard needs to be evaluated for long-term compliance. Mercury emissions from waste combustors are highly variable. Even if activated carbon is used, a facility could have a violation if a high-mercury-content item were incinerated. The 55 g/dscm limit should also be accompanied by an associated removal efficiency to ensure that well-operated facilities are not unduly charged with violating an emissions limit.
- Minnesota waste combustors test mercury emissions at least annually.
- The regulation could result in facility shutdowns, because Minnesota law currently requires shutdown of waste combustors that fail stack tests.
- EPA has negotiated an agreement with the American Hospital Association to reduce mercury use. The agreement calls for hospitals to virtually eliminate mercury from the waste stream by 2005 by replacing equipment, such as blood pressure cuffs and thermometers, with mercury-free alternatives.

N-7: Credit for Early Action

Strategy: The credit-for-early-action program described here is loosely modeled after and builds upon the Department of Energy's 1605(b) greenhouse gas emissions reporting program. The purpose of a credit-for-early-action program is to enable sources that use or release mercury to get "credit" for early actions — reductions in mercury use or release that are achieved in advance of any future mandatory reduction requirements. Credits earned today could be redeemed under any future regulatory regimes or "retired" at any time. Whether they are used or retired, the end result is the same: an equal or greater amount of mercury reductions occur than would have been

the case without credit for early actions except that the reductions are more likely to occur sooner. By providing incentives for early action, a credit-for-early-action program encourages consideration of mercury in decision-making, fosters creative solutions to the mercury issue, and improves the monitoring and measurement infrastructure.

One important aspect of a credit-for-early-action program is that it provides a high degree of flexibility. Sources participating in such a program are free to choose any verifiable method of reducing releases at their own facilities or at other facilities. In this way, participating sources will have access to the most cost-effective reduction opportunities. Similarly, once a source has credits, it is free to decide how they should be used. The primary prerequisite to participating in the early reductions credit program is a good emissions baseline.

Affected Sources: Any and all sources that have an emissions baseline and are able to quantify their reductions in accordance with accepted methods could be allowed to participate in a credit-for-early-action program. From a cost-effectiveness standpoint, the greater the number of participants, the greater the number of lower-cost reduction opportunities. On the other hand, allowing a large number of participants from a variety of sectors creates an added monitoring and verification burden.

Geographic Scope: National

Associated Options: In general, credit-for-early-action programs for mercury would provide an incentive for lower-cost, low-regrets options, such as source reduction for waste combustors and wastewater treatment plants, and phasing out use of mercury-containing equipment for many different industries, including utilities. In addition, a credit-for-early-action program would provide an incentive, in conjunction with other pollutant benefits, for some higher-cost reduction options, such as switching to natural gas. The level of the incentive may or may not be strong enough to result in a decision to implement the various options. The strength of the incentive depends on the likelihood of a mandatory requirement in the future as well as other factors such as those noted below under "implementation issues."
Cost-effectiveness: Sources participating in a voluntary credit-for-early-action program would be expected to take advantage of only the most cost-effective reduction opportunities. Sources will be willing to make reductions to the point at which the marginal cost of reduction equals the expected value of the credits (including sales, public relations benefits, etc.).

Costs: Costs would include government administrative costs associated with program design and implementation. Costs to facilities are difficult to predict. A decision to participate in a credit-for-early-action program would ordinarily result from a company having determined through a broader cost-benefit evaluation that participation would be beneficial to its bottom line. Furthermore, it can be expected that emission reductions would be achieved using the most cost-effective opportunities available.

Reduction Potential: The reduction potential of an credit-for-early-action program depends on several factors. These factors include (1) the likelihood that a mandatory program will be put in place and the likely severity of that program; (2) the amount of time an credit-for-early-action

program is in place before the onset of a mandatory program; (3) the availability of low-cost reduction opportunities and (4) the level of certainty on the part of the regulated community that credits earned can be applied later to mandatory control requirements. Depending on these factors, based on cost curves and the results of similar programs, it is expected that a credit-for-early-action program would achieve a level of reductions on the order of 0-20%.

Implementation Issues: A credit-for-early-action program is very consistent with many of the other strategies adopted. In particular, credit for early action would provide an incentive to undertake voluntary reduction strategies. Such a program is also consistent with efforts to enhance the existing mercury inventory and baseline as well as research-and-development programs.

There are clearly a number of issues that need to be worked out. Key issues include:

- Developing a mechanism to establish a consistent and verifiable baseline emissions or mercury use levels. This involves establishing a base year or methodology for establishing a baseline and reaching agreement on acceptable measurement or monitoring techniques.
- Developing procedures to ensure that reductions achieved are credible.
- Developing assurances that (1) credits earned may be applied; (2) credits represent real reductions; (3) participants will be treated equitably.
- Determining whether some form of recognition should be provided for reductions that cannot be reliably measured according to agreed upon procedures.

Timeline: The credit-for-early-action program should begin as soon as possible to take advantage of near-term mercury-reduction opportunities in association with other pollutants. It would last indefinitely or until a mandatory program is put in place. A decision would need to be made on how to treat voluntary reductions that were achieved before the establishment of the credit-for-early-action program. Timing is especially important for a credit-for-early-action program; the sooner a credit-for-early-action program can be implemented, the sooner the benefits can be realized.

N-8: Create a Mercury-Related Outreach Position for Minnesota

Strategy: Create a two-year duration, full-time position at MPCA or OEA, with the assignment to lobby at the national and international level for mercury reduction, to encourage others to implement existing MPCA/OEA programs (*e.g.*, Healthcare outreach), and to gather information from others that will enhance Minnesota's programs.

Affected sources: Those inside and outside Minnesota.

Geographic scope: Global.

Associated Options: The most cost-effective options, largely related to source reduction.

Cost-effectiveness: Near-term cost-effectiveness cannot be calculated because the strategy's direct reduction potential is zero. Long-term cost-effectiveness cannot be determined because it will depend on the success of the outreach effort.

Cost: One FTE staff position = $80,000/yr.

Reduction Potential: Direct, 0; indirect, dependent on the success of the outreach effort.

Implementation Issues: Others (*e.g.*, EPA and some nongovernmental organizations) are already doing this to some extent.

Appendix D: Descriptions of Strategies for Research and Development, Inventory Maintenance and Improvement

The Advisory Council recognized that additional work is needed to better understand mercury sources, environmental fate, health impacts and other risks in Minnesota. Towards that end, the Advisory Council recommends that research be conducted in Minnesota which is focused on addressing mercury issues of particular importance to Minnesota. The Advisory Council also recommends that efforts be applied towards improving the comprehensiveness and accuracy of the existing state mercury inventory. In addition, the Advisory Council recommends that the MPCA develop monitoring, measurement and reporting protocols which would improve data consistency both within and across sectors and result in a better accounting of mercury use, release and reductions.

Plans for Implementing Research and Inventory Strategies: See Part 4.3 above.

R-1: Minnesota Mercury Research

Strategy: Conduct research on issues that are unique or particularly relevant to Minnesota. Continue to evaluate national mercury-research studies. Establish advisory panel to collect and evaluate national and international research efforts, identify additional research needs and guide Minnesota research efforts. Involve research universities and private research entities and explore the possibility of partnering with other states. Research should be peer reviewed, published and could include such things as:

1. An assessment of state fish consumption advisory levels comparing Minnesota with other state, federal, provincial and tribal advisories and methodologies, identifying differences and comparability. Consider establishment of an appropriate and consistent nationwide or regional advisory.
2. A study to determine the current level of actual risk to state residents from mercury based on actual fish consumption, taking into account fish consumption rate and mercury levels from a statistically representative population. Emphasize impacts on at-risk populations in addition to reviewing overall population impacts.
3. An assessment of the impact of fish consumption advisories on the tourism industry.
4. Promote research and demonstration of technologies for reducing mercury from various sources through tax incentives or other means, focusing on industries that primarily are Minnesota based, such as taconite mining.
5. Promote research on the fate of mercury from sources which are primarily Minnesota based, or which the fate is unique to Minnesota due to climatological conditions, etc. An example would be to assess the long-term stability of mercury in taconite tailings.
6. Continue study on historical and current deposition and accumulation rates.
7. Develop understanding (to the greatest extent possible) on relationship between emissions, deposition and fish mercury in Minnesota, including scientific assessment of the effect recent reductions in mercury deposition have had on fish mercury, and what other factors (sulfate,

nutrients, etc.) may influence methylation rates (sediment and fish mercury data, etc.). Define further research needs in this area.
8. Promote development of methods to better measure/quantify mercury forms from various process streams.
9. Promote national efforts to evaluate mercury transport and fate.
10. Monitor, track and participate in national research efforts.
11. Assess mercury-related wildlife impacts that are particularly relevant to Minnesota, such as effects on walleye, mink, otters and loons; encourage national wildlife studies.
12. Develop new and expand existing monitoring programs to detect time trends in atmospheric deposition, fish contamination, lake loading and other aspects of the mercury cycle, including other relevant parameters that may affect bioaccumulation of mercury in Minnesota (*e.g.*, land use, groundwater and changes in the food chain).
13. Assess impact of urban runoff on receiving waters in Minnesota.
14. Assess impact of climatic seasonal effects on mercury deposition and methylation rates in Minnesota.
15. Determine appropriate measurement or monitoring techniques (both total mercury and its various forms) for different sources in Minnesota to ensure consistency and completeness in the inventory.
16. Investigate the feasibility of reducing the amount of mercury deposited to land that makes its way to surface water (*e.g.*, reducing soil erosion, reducing use of storm sewers).
17. Investigate the feasibility of reducing mercury cycling in the biosphere (*e.g.*, covering contaminated soil or sediment with materials that inhibit release to overlying air or water).

Affected Sources: All sources, depending on source of funding.

Geographic Scope: Minnesota.

Associated Options: None.

Cost-effectiveness: Cannot be determined due to a direct reduction potential of zero.

Cost: Will be determined by such factors as the research priorities established by the advisory committee, the availability of research funds, etc.

Reduction Potential: Direct, 0; indirect, research may lead to development of viable mercury-reduction techniques. Also, additional information on sources and quantities may lead to further voluntary reductions.

Implementation Issues: Financial resources, sharing resources/information and coordination with other states. Implementation timetable would be two to five years.

R-2: Develop a Comprehensive Minnesota Mercury Inventory

Strategy: The goal is to fill in data gaps in the Minnesota mercury inventory in a comprehensive manner. The current Minnesota mercury inventory focuses on mercury air emissions only, and includes several source categories that have low-confidence data or no data at all. In addition, the current estimate for mercury in products currently in use in Minnesota is highly significant (50 to 100 metric tons). Low-cost, high-reduction-potential options for addressing mercury that have been identified are primarily associated with product manufacturing and use and disposal. Yet, the current inventory estimate does not contain enough confidence or detail to facilitate a strategy to address mercury in products. Also, discharges of mercury to water have not been quantified. Filling these data gaps will improve our confidence in existing cost-effectiveness and reduction-potential estimates and may help us identify and reprioritize options and strategies. These data gaps need to be filled in order to determine the most cost-effective options with large reduction potential. The timeline for implementation would be 18 months.

This strategy would direct the MPCA to develop a comprehensive inventory of mercury releases to air, water and land, as well as product manufacturing, use and disposal, within 18 months by working with industry and others on a voluntary basis. This will be accomplished by involving all sources in the inventory development. If sources do not participate, then the MPCA will estimate releases and uses of mercury for those sources. The MPCA will provide technical assistance, including development and distribution of information on the types of products and processes that contain mercury and the estimated amount. An advisory group of stakeholders would be set up to assist in:

- program establishment,
- determining positive incentives that would encourage voluntary participation,
- defining the data quality elements,
- prioritizing information-gathering efforts and
- reviewing results.

Those sources for which no information exists, for which the current information has a low confidence associated with it, and those with a medium confidence would be prioritized in that order. The goal would be to achieve an inventory of high quality that will be useful for identifying and reprioritizing options and strategies, as well as for forming the basis for measuring program success. For some source categories, the approach could be to use funds to conduct independent source category monitoring in addition to voluntary reporting. Also, there would be a focus on products containing mercury, including manufacturing, use and disposal. Information would be gathered also to be able to define the media impacted or potentially impacted (land, water, air).

Affected Sources: All emitters, all discharges, and all manufacturers, users and disposers of mercury-containing products that sell or buy these products in Minnesota.

Geographic Scope: Sources in Minnesota, manufacturers who sell mercury-containing products in Minnesota but are located elsewhere.

Associated Options: None.

Cost-effectiveness: Cannot be determined due to a direct reduction potential of zero.

Cost: Estimated total cost is $100,000. This would cover administrative costs, technical assistance and limited monitoring. Research necessary for inventory improvement would be covered in a research strategy.

Reduction Potential: Direct: 0. Indirect: better inventory information will increase potential for significant reductions. Educational factor would likely encourage reductions.

Implementation issues:

- Necessary to secure sufficient funding; identify all sources, agency should work with all relevant associations, adequate participation by all sectors.
- The inventory can be used as a measure of success for many strategies.
- Some funding sources (*e.g.*, LCMR) may not be available during the timeframe for this effort.

Appendix E: Descriptions of Product-Related Strategies

The Advisory Council determined that the lowest-cost strategies for reducing mercury tended to be those related to mercury-containing products. In order to maximize the cost-effectiveness of mercury-release reductions, the Advisory Council recommends the following strategies for implementation in Minnesota.

Plans for Implementing Product-Related Strategies: See Part 4.4 above.

P-1: Increase Mercury Collection Infrastructure Through Household Hazardous Waste Programs

Strategy: Encourage household hazardous waste (HHW) programs to voluntarily accept mercury wastes, especially out-of-service products and bulk mercury from one-time, nonhousehold generators. Assist programs in obtaining a special waste-collection license from the MPCA. Work with generator groups and commercial recyclers/consolidators to develop collection programs and develop demand for their services. For example, work with mercury recyclers, scrap yards and appliance processors who remove mercury switches to develop a collection and recycling system. Help organize a comprehensive system for amalgam recycling. Get the word out regarding availability of this mercury-product-management option in conjunction with other education strategies.

Background: Some type of HHW collection program, including more than 40 permanent programs, serves nearly every county in the state. These programs will accept mercury waste from homeowners free of charge. Only a few of these programs have exercised the option to accept mercury wastes from businesses allowed by the state's Special Hazardous Waste Pilot Project. About 10 private companies located in the state also offer specialized mercury collection and recycling services to businesses. These companies collect at the business location and can receive mercury wastes at their facilities, usually through common parcel delivery. This system is not fully developed as businesses are not aware of the services and not all the waste-management companies have offered their services to all possible customers.

Affected Sources: All users of mercury-containing products, commercial and residential.

Geographic Scope: Minnesota.

Cost Effectiveness: $1,300/lb for reduced air emissions, $200/lb to all media.

Costs: $190,000/yr. Costs are associated with increased administration and waste-management costs for HHW programs, which are generally operated by the counties. Cost estimates assuming 50 programs:

Administration: $2500 x 50 = $125,000.
MPCA staff to help develop this network: .25 FTE = $15,000.

Seed money/subsidy for disposal system: $25,000.
Additional waste management costs to businesses: 1,000 lb. @ $50/lb = $25,000.

Financing: Presently, counties receive partial funding from the state to operate problem materials collection programs. The additional expense of this program could be at least partially user paid (disposal) along with state, local or other subsidy.

Reduction potential: 150 lb/yr reduced air emissions, 1000 lb/yr reduced releases to all media. Basis: collect an additional 1,000 lb/yr, of which 15% would have been released to air.

Implementation Issues: This is a natural extension of the service provided by many HHW programs that are eager to keep problem materials out of solid waste and wastewater. Some would willingly expand their programs while others would be reluctant to add this increased responsibility and expense on their often overburdened programs.

HHW programs that have expanded into the collection of waste from small businesses usually charge a fee for this service. The fee to businesses would be approximately $5-10 per pound for waste handling and recycling/disposal of the elemental mercury and associated apparatus.

P-2: Voluntarily Reduce "Installed" Inventory of Mercury via Education and "Clean Sweeps"

Strategy: Collect unneeded mercury containing products and bulk mercury to prevent release through spills or improper disposal in the future. Use all available low-cost public announcement options, including press releases, outreach via industry associations and notices in local newspapers to implore people to look for mercury-containing products and turn them in to county household hazardous waste (HHW) centers. The state could provide financial assistance to counties to cover costs of implementation. Press releases could coincide with fishing opener or some other event that would make the collection more than just a day-to-day thing. Schools could be asked to pledge to be "mercury free" after the clean sweep removes existing mercury, including an explanation of why mercury is a problem.

Mercury "round ups" or "clean sweeps" like this have been conducted successfully by WLSSD and counties in Minnesota and in other states, including Michigan. As an incentive, WLSSD suggests offering non-mercury thermometers to people who turn in mercury-containing products.

Affected Sources: Many; first target households, schools, universities and dentists; expand to other targeted audiences later.

Geographic Scope: Minnesota, coordinated with other states as appropriate.

Associated Options: Clean sweeps

Cost-effectiveness: $1,400/lb to air.

Costs: Total Cost: $168,000/yr. Three main types of costs are associated with this proposal. The costs are (1) disposal for the collected mercury, (2) advertising and public information for the collection programs and (3) associated staff costs.

Disposal Costs: The price for mercury disposal by companies that accept bulk mercury and mercury-containing devices ranged from $0.95 to $5/lb. These prices do not include pick-up, storage and transportation. Hennepin County estimated the total cost for disposing of mercury collected through its HHW system, including transportation, labor, storage drums and disposal, to be $50/lb. Assuming that 800 lb/year is collected and disposed at a cost of $50/lb, cost = $40,000/yr.

Advertising Costs: $40,000/yr statewide MPCA staff received a cost report from Winona County on its mercury bulb collection program. Winona County spent $1,800/yr on advertisements, which includes both ads in local papers and ads on the local radio station. Cost estimates statewide must take into account an overlapping of information between counties, such as a larger regional radio station and papers with higher circulations. Although advertising in these media outlets would cost, they would reach more people in more than one county.

Personnel Costs: $88,000/yr. Assume that it would take one staff person per county one week to set up a 1-2 times/yr mercury collection. The cost for this staff person would be about $1,000 per county (1 week of $50,000/yr salary). Cost = $88,000. (Note that this type of activity would fall within existing staff's typical work, so it shouldn't be necessary to hire new staff at either the state or county level.)

Reduction Potential: 120 lb/yr reduced air emissions, 800 lb/yr reduced releases to all media. Assumptions: 800 lb/yr would be collected, of which 15% would have been released to air through improper disposal or spills.

Implementation Issues:

- The appropriate disposition of collected mercury (*i.e.,* sent to a mercury recycler or to a more permanent mercury retirement system) should be considered.
- This strategy is clearly feasible in that it is already in use.
- The strategy does not conflict with any existing regulations or initiatives.

P-3: Promote Labeling of "Installed" Mercury-Containing Products

Strategy: Label products that contain mercury to clearly indicate that they contain mercury, that they should not be disposed of in the trash, and how theyt should be managed. Focus on products that have not reached the end of their useful life that can continue to be used with little chance of accidental mercury release. This would be a voluntary program. MPCA/OEA and others could promote labeling by designing and providing fill-in-the-blank labels to sites (*e.g.,* "Do not place this in the regular trash. Give it to _____ or call _____ for disposal instructions.") Lists

targeted at industry types could be provided to explain the most common mercury-containing products.

Affected Sources: All users of mercury-containing products except households; especially targeted industries where mercury-containing products are most commonly used.

Geographic Scope: Minnesota.

Associated Options: Source separation; replace mercury-containing products.

Cost Effectiveness: $ 3,300 to $6,400/lb for reduced air emission; $500 to $1,000/lb for total reduced releases to all media.

Cost: $425,000/yr + $50/lb x reduction potential to all media ˜ $450,000/yr. Assuming that the program covers five years, with 2,000 facilities per year conducting labeling the costs would be:

$400,000/yr = $200/affected facility x 2,000 affected facilities/year,
$15,000/yr for state agency staff to develop and promote the program,
$10,000/yr for promotional materials, including providing free labels, plus
the cost of proper handling and disposal = $50/lb x (0 to 975 lb/yr).

Financing: Facilities would be expected to cover costs of staff time needed to learn about the program and do the product labeling, as well as covering costs of proper disposal.

Reduction Potential: Zero to 145 lb/yr reduced air emissions; 0 to 975 lb/yr total to all media
It is estimated that the amount of mercury contained in installed products in Minnesota adds up to tons. The points at which reductions would be seen mainly are at "secondary" sources (WWTP, waste combustors, landfills, etc.). Releases from spills, which are very difficult to estimate, would also be reduced, along with the potential for direct human health impact and clean up costs associated with spills.

Because the program is voluntary, reduction potential estimates start at zero. If labeling led to a 25% reduction in improper disposal of mercury-containing products by the affected sectors, then maximum reduction potential would be .25 x (0 to 580 lb/yr to air; 3,900 lb/yr total to all media) = 145 lb/yr to air, 975 lb/yr to all media.

Permanent: Yes.

P-4: Improve Compliance with Existing Mercury Product Labeling Requirements

Strategy: Increase education and enforcement of the labeling requirement in existing Minnesota laws (Minn. Stat. § 116.92) and educate key consumers to look for the label. Such an effort should include as an integral component an analysis of compliance by manufacturers with the labeling requirement, effectiveness of the current law at accomplishing legislative intent of influencing purchase and disposal behavior, and recommendations for improvements. MPCA staff would inspect products sold at Minnesota stores to determine which products are in compliance with the law and which are not. A system would be instituted to track (1) change in compliance due to enforcement effort, (2) impact of labeling on consumer choice and behavior, and (3) how labeling is being used to promote environmentally friendly products.

Background: Current Minnesota law requires manufacturers of products containing elemental mercury to label the product with content information and disposal advice. The purpose of the law is to have a label on the product that influences consumer purchasing and disposal decisions based on knowledge of mercury content. The law may also affect manufacturers' design and marketing decisions. Responsible manufacturers have made an effort and incurred expense to comply with the intent of this law. The extent of compliance is not known, nor is it known to what extent such efforts are effective in advancing the legislative intent of affecting consumer purchase and disposal behavior. Current resources do not allow for the widespread enforcement of this law. Some labeling is currently required in other states (*e.g.*, Vermont) and stricter enforcement could lead to nationwide adoption of consistent, across-the-board standards (as recommended in Strategy N-4: National Mercury Product Labeling), as well as more consistent voluntary labeling by manufacturers that goes beyond the letter of the law.

Affected Sources: Manufacturers and consumers of mercury-containing products.

Geographic Scope: Minnesota.

Associated Options: Source reduction in municipal solid waste and wastewater.

Cost effectiveness: $600/lb for reductions to air.

Costs: $220,000. This includes: $15,000/yr to cover .25 of an MPCA position; $5,000 for outreach materials, and $200,000/yr for businesses to comply (one-time and ongoing averaged over time = $1,000 x 200 = $200,000/yr).

Reduction Potential: 360 lb. to air, 2,400 lb/yr total to all media. Over time, this program could lead to a 20% reduction in discarded and purchased products, or 2,400 lb less mercury per year due to increased recycling, decreased purchase and decreased manufacture of mercury-containing products.

Implementation Issues: In cases where Minnesota's law is inconsistent with those of other states, enforcement may cause some confusion and added expense to product manufacturers.

P-5: State Avoids Buying Mercury-Containing Products

Strategy: Reduce purchase of mercury-containing products by the state government. Where the state continues to purchase mercury-containing products, implement procurement policies and contractual requirements for take back at end of product life. Work with the Minnesota Department of Administration to adopt and implement purchasing specifications that establish a clear preference that products purchased by the state not contain mercury if environmentally preferable alternatives exist.

Affected Sources: State of Minnesota (government), manufactures and sellers of mercury-containing products.

Geographic Scope: Minnesota.

Associated Options: Change to more environmentally friendly, non-mercury alternatives (where such alternatives exist) for products, including thermostats, electric switches, pressure gauges, and many more used throughout the state, including at state healthcare and laboratory facilities and motor vehicles (switches and headlights).

Cost-effectiveness: $10,000/lb for reduced air emissions, $1,400/lb total.

Cost: $65,000/yr. This includes $15,000/yr for staff (assumes .25 FTE at OEA) and $50,000/yr in increased product costs (a very rough guess).

Reduction Potential: 17 lb/yr to air, 120 lb/yr to all media. State government makes up approximately 3% of the state work force. One could infer the reduction potential from this option to be 3% of total emissions associated with products used in the workplace, which would be 3% of the estimate for the option "replace mercury-containing items" described in the SRFRS report: 0.03 (580 lb/yr to air; 3,900 lb/yr total to all media) = 17 lb/yr to air, 120 lb/yr to all media.

Implementation issues: Exceptions would be made for products for which acceptable non-mercury alternatives do not exist or where the alternatives have other environmental implications or are not cost-effective; review would be required to verify which products indeed lack acceptable alternatives. The term "no mercury" would be defined as "no intentionally added mercury." The state program of buying environmentally preferable cleaning products, which is currently being implemented, should be considered as an example for determining cost and other implementation issues, and could be used as the vehicle for implementing the strategy.

P-6: Expand Existing Mercury Product Sales Bans

Strategy: Explore additional product sales bans for nonessential uses, with participation of affected groups. The following areas were identified for further work, but this list is not intended to limit discussion of candidate products and applications: recreational products, watercraft, motor vehicles. The discussion process could lead to voluntary phase-out of nonessential uses, as well as recommendations to the Legislature.

Affected Sources: Potentially affected sources include motor vehicle manufacturers; motor vehicle scrap yards; households; manufacturers, marketers and users of recreational products.

Geographic Scope: Minnesota.

Associated Options: Educate users of mercury-containing products; laboratory pollution prevention; reduce mercury use in consumer products; purchase and use fewer and less of mercury-containing products.

Cost-effectiveness: It is assumed that elimination of nonessential uses is a cost-effective and permanent means of eliminating mercury use and the potential for release. Most non-mercury alternative products are comparably priced.

Costs: $60,000/year over two to three years for state agency staff (1 FTE) to work with the affected sources, affected product user and the Legislature.

Reduction Potential: Unknown.

P-7: Reduce Mercury Products in Buildings Using a Strategy Mix

Strategy: Use a combination of education, recognition and laws to reduce the number of mercury-containing products used in buildings, and ensure mercury-containing products, such as thermostats and electric switches, are managed to prevent mercury releases by:

- issuing a policy statement from MPCA and/or Office of Environmental Assistance stating that it is state policy that use of mercury products should be minimized, and such products may not be disposed of as solid waste;
- educating heating, ventilating and air-conditioning (HVAC) and demo contractors and others (per strategy E-1);
- publicly recognizing HVAC and demo contractors that “do the right thing”; and
- requiring that state buildings constructed by the state or primarily for use by state agencies avoid using mercury-containing products wherever possible.

Affected Sources: HVAC contractors; thermostat and electric switch manufacturers and suppliers, building demolition contractors, State of Minnesota (government); exactly which type(s) of buildings are included would need to be determined.

Geographic Scope: Minnesota.

Associated Options: Reduce mercury discards to municipal solid wastes.

Cost-effectiveness: $4,600 to $6,400/lb for reduced air emissions; $350 to $475/lb for reduced releases to all media.

Costs: $50,000/year. This includes: $15,000/yr for 0.25 FTE state staff position; $15,000/yr in outreach, education and recognition materials; $20,000/yr for removing and handling wastes ($50/lb x 400 lb/year = $20,000/yr).

Reduction Potential: Zero to 30 lb/yr reduced air emissions; 0 to 400 lb/yr to all media. Because the program is voluntary, reduction-potential estimates start at zero. Each year, 1.7 million tons of demolition debris are disposed in Minnesota. The mercury contained in this debris is estimated at 490 lb. Assuming that 80% of the mercury could be diverted, this would give a total reduction of approximately 400 lb. MPCA staff predict that, on average, 15% of mercury contained in improperly disposed products is released via air emissions, mainly from waste combustors. However, given that most demolition debris is landfilled, not combusted, the 15% air emissions factor was reduced by one-half: 400 lb/yr x (0.15 ÷ 2) = 30 lb/yr to air.

Related notes: The annual reduction resulting from such a program would decrease as more and more non-mercury products are installed and mercury-containing products are removed. A similar program in Indiana aimed at HVAC contractors estimates that they have diverted 5,000 to 10,000 thermostats from the waste stream, for a total reduction of 55 to 110 lb of mercury.

Implementation Issues: This strategy could be patterned after the Indiana Department of Environmental Management's program.

P-8: Educate Users of Mercury-Containing Products

Strategy: Implement an educational program that will lead to voluntary reductions in the use and release of mercury. Audience priorities should be established based on reduction potential. Potential audiences for such a program include:

- heating, ventilating and air-conditioning industry (for thermostats);
- dentists;
- homeowners;
- demolition industry (for thermostats and mercury switches);
- students;
- educational institutions (for laboratory equipment, chemicals, etc.);

- industries, especially those operating boilers;
- electricians (mercury switches) and
- laboratories.

Affected Sources: All users of mercury-containing products.

Geographic Scope: Minnesota.

Associated Options: The intent would be to encourage particular business sectors (through trade associations, etc.) and the general public to eliminate the use of mercury-containing products where it is possible to substitute environmentally preferable alternatives and to ensure that the mercury from such products is recovered when the products are disposed. This would be accomplished by means of a campaign to raise awareness of the problems of mercury contamination, laws regarding disposal of mercury-containing items, and proper disposal methods. Such campaigns have already been undertaken for some sectors, and in some cases the scope of these campaigns could be expanded.

To be effective, campaigns must be designed sector by sector. Materials for such campaigns may include written information, posters, information booths at strategic conferences, presentations, videos, public service announcements, endorsements of environmentally preferable products, and much more. Public recognition programs can be used to create incentive to participate. These programs might employ awards and uniform patches and door decals that show a company is participating in an earth-friendly program. A five-year program should allow time for preparation, several years of concerted effort and some time to assess the program's effectiveness and the need for additional work.

Cost-effectiveness: $200/lb.

Cost: $90,000/year on average ($60,000/year for OEA staff time and $30,000/year for promotional materials).

Reduction Potential: 400 lb/year. The effectiveness of such campaigns depends in large part on the extent of the funding. A very minimal program might consist of one full-time professional staff member and the costs of producing and distributing information. It is doubtful that one person could carry out a campaign for all sectors at once, hence the need to determine priority sectors.

Implementation Issues: With a minimal program, it may not be possible to reach the reduction goals above. It may be important to fund convenient disposal options for sectors such as demolition contractors and electricians, where manufacturer take-back programs do not exist. There are some sectors and products where the use of mercury does or may provide some benefit in performance, resource or energy conservation, or other areas. In these situations, the educational materials will need to fully reflect the various operational, resource and financial tradeoffs involved, so consumers can make the best choice for the life cycle of the product. The strategy could be implemented without any change in regulations, provided funds became

available, and it would be compatible with other strategies, such as product bans. The state could look to entities outside of government to do some of the educating.

P-9: Educational and Training Video and Waste-Management Program for Dental Offices

Strategy: The Minnesota Dental Association (MDA) would produce a video that would instruct dentists about appropriate amalgam-disposal practices. This video would include the "do's and don'ts" of amalgam management and would be accompanied by a manual, a best practices checklist, a poster and a test to document the understanding of procedures. The test would be designed in consultation with the MDA's Northeastern District Dental Society instructors and regulators. Completed tests would be returned to the MDA for grading. Acceptance of test results for continuing education credit would be sought from the Minnesota Board of Dentistry. This program would be followed up with a program to recognize environmentally responsible dental offices.

Affected Sources: All dentists in Minnesota.

Geographic Scope: Minnesota.

Associated Options: Collect bulk mercury, replace mercury-containing items, increase recycling of chairside traps and increase recycling of vacuum system filters; also, possibly use additional amalgam-capture equipment.

Cost-effectiveness: $1,600 to $60,000/lb for reduced air emissions; $540 to $20,200/lb for total reductions to all media.

Costs: More than $280,000/yr. The cost to dental offices of the increased recycling from the three dental options ranges from $282,400 to $10,461,400. The cost of developing and distributing a video and the other related materials and establishing a recognition program is estimated to be about $100,000.

Reduction Potential: Zero to 175 lb/yr reduced air emissions; 0 to 525 lb/yr reduced releases to all media. The reduction potential of this strategy is based in the reduction potential for the three dental options that relate to capturing and recycling dental office amalgam waste. The reduction potential from those three options is estimated to be 525 lb/yr to all media, 175 lb/yr to air. However, since the strategy is voluntary, the low-end reduction potential estimate is zero.

Implementation Issues: Recycling opportunities vary around the state. New technologies will be accepted in the marketplace only when adequate testing has been done and adequate information is available to dentists.

References: Minnesota Dental Association.

P-10: Mercury-Detecting Dog for Nonregulatory Investigation and Education

Strategy: Trained dogs are commonly used to detect small quantities of illegal drugs. Sweden reportedly has used the same approach to train dogs to detect very low levels of mercury. This strategy recommends that the state or another entity purchase and train a dog to detect mercury. The dog would first tour schools for the dual purposes of sniffing out mercury in school laboratories (*e.g.*, in sink traps) and as part of an educational program to be presented by an accompanying human. County or city personnel could also request use of the dog as part of their source-reduction programs to minimize mercury in wastewater and solid waste.

Affected Sources: Laboratories, especially at schools and universities, and other common users of bulk mercury, mercury-containing chemicals or mercury-containing products most likely to break (*e.g.*, thermometers).

Geographic Scope: Minnesota.

Associated Options: Eliminate use of mercuric chemicals and compounds in college and high school laboratories.

Cost-effectiveness: $500/lb for reduced air emissions.

Cost: $126,000/yr. This cost includes $6,000/yr for the trained dog ($40,000 for purchase and training ÷ 7 years = $6,000); $15,000/yr for a 0.25 FTE human companion; $5,000/yr for educational and promotional materials; and $100,000/yr for dog maintenance and travel.

Reduction Potential: 250 lb/year to air. MPCA staff estimate that up to 600 lb of bulk mercury could be collected from laboratories, which roughly equates to 70 lb per year of avoided air emissions. The educational influence on school children and from publicity would also lead to reduced use of mercury-containing products in homes. Assuming this would result in a 10% decrease in annual purchase of mercury-containing products, MPCA staff predicts that avoided air emissions would be (12,000 lb/yr) (.10) (.15) = 180 lb/year. Releases to land and water would also be reduced. Total reductions to air = 180 lb + 70 lb = 250 lb/year.

Implementation Issues:

- It would take a few years for one dog team to visit most schools and universities.
- Schools and other facilities may not be interested in such a program. For example, they may find it intrusive, more like an unwanted inspection. Program development should work with potential dog-users and schools to promote the program as assistance/outreach.

P-11: Increase Compliance with Existing State Disposal Bans Related to Mercury

Strategy: Following outreach, assistance and education to targeted sectors, MPCA and county solid and hazardous waste personnel increase investigation and enforcement of the disposal prohibition in key sectors. Enforcement could consist of a warning/informational letter, followed by a fine for continued noncompliance. Information and assistance would be provided at all sites visited.

Background: Existing laws ban disposal of mercury-containing products in the solid waste and wastewater streams. When the Legislature passed the bills regarding mercury-product disposal, no funding was provided, which has led to a lack of program administration, education and enforcement.

Affected Sources: All users of mercury-containing products removed from service (those covered in § 115A.932 and § 116.92 Subd. 4 **"**Removal from service; products containing mercury").

Geographic Scope: Minnesota.

Associated Options: Source reduction of municipal solid waste and wastewater.

Cost-effectiveness: $500/lb reduced air emissions; $70/lb reduced releases to all media.

Costs: $70,000/yr. This includes $5,000/yr for outreach materials, $15,000/yr for 0.25 state staff to cover ongoing enforcement; and $50,000/yr for the increased cost of properly managing wastes (1,000 lb. x $50/lb = $50,000).

Reduction Potential: 150 lb/yr to air, 1,000 lb/yr total.

Implementation Issues: For industries that are currently voluntarily putting effort into using education to get their sector's sources to comply, this may be welcomed as a move that will level the playing field. The estimated compliance with the law for fluorescent lamps is 70% (*i.e.*, 70% are recycled). The compliance rate for other mercury products is thought to be much lower.

Appendix F: Description of a Voluntary Agreement Strategy

Plans for Implementing the Voluntary Agreements Strategy: See Part 4.5 above.

Voluntary Reduction Agreements

Strategy: This strategy calls for mercury sources to make commitments to voluntarily reduce or work toward reducing mercury use and releases. Commitments would be described in reduction agreements worked out with the MPCA. These voluntary agreements, which can cover individual sources, whole companies or entire sectors, may include measurable performance goals and schedules and plans for measuring and reporting progress towards those goals. Agreements may also describe research-and-development studies needed to adopt currently infeasible reduction options.

Participation would be voluntary. Incentive for participation would be provided through the following factors:

- Voluntary participation provides the best opportunity for cost-effective actions.
- Participation would be beneficial to a sector or company's image.
- Lack of participation would increase the chances of mandatory reductions being required in the future due to failure of all of Minnesota's mercury-reduction activities to meet the measurable reduction goals adopted by the Advisory Council.
- The MPCA could, as its part of the voluntary agreement, attempt to reduce uncertainty regarding possible new regulations for a participating source. Conversely, the agency would be more likely to enact at the state level, or promote at the federal level, new mercury-related regulations for a source that does not participate.
- Participation improves the ability to document reductions achieved through voluntary actions.

Voluntary agreements can include, but are not limited to, steps to be taken to achieve one or more of the following:

- reduce the use and release of mercury;
- sponsor research and development of promising mercury reduction options;
- conduct full-scale demonstrations of mercury reduction options;
- develop a better understanding of the fate of mercury within various processes at a source to better target control strategies;
- mercury emissions inventory improvement;
- measure and/or monitor mercury use or release;
- implement other strategies recommended by the Advisory Council; and
- assist other sources, including the public sector, in addressing mercury releases.

Sources would be asked to supply biennial progress reports for the MPCA. MPCA staff would then compile a statewide progress report for legislative committees and interested members of the

general public every other year, to be incorporated into the biennial air toxics report to the Legislature.

Geographic Scope: Minnesota.

Affected Sources: Participation would be open to any interested source; however, priority would be given to sources with releases in excess of 50 lb/yr that are not already expected to significantly reduce their mercury use or release based on existing programs, such as regulations, initiatives or permits. Priority would be based also on the amount of mercury released by a source. Priority means that MPCA staff would focus implementation efforts on and solicit plans from priority sources first.

Cost-effectiveness: Not estimated. Sources are expected to consider only cost-effective options as they develop mercury-reduction plans. The SRFRS committee's cost-effectiveness estimates can be ranked to show how decisions are expected to proceed. Relatively cost-effective options, such as product substitution or product recycling ($10 to $500/lb), are expected to be chosen first. More expensive options would likely be implemented next.

Costs: A voluntary program would require staff work at both the MPCA and mercury sources. Sources would develop and submit plans and write and submit progress reports. MPCA staff would review plans and source progress reports and compile individual source progress reports into the statewide progress report.

If many sources participated, two MPCA staff members would be needed to receive, discuss, compile and report on mercury-reduction plans. In this scenario, annual costs for state administration can be estimated as: 2 staff x $80,000/yr = $160,000/yr. Affected sources would incur internal staff costs and costs for research and/or reductions. With no plans yet written, the total costs that sources would incur as they adopt mercury-reduction options cannot be estimated. It seems safe, however, to expect that a voluntary program would be one of the lower-cost strategies available.

If the proposed voluntary program proved unpopular, it would require fewer staff hours both at the MPCA and within source firms. The expected reduction potential would also be less.

Reduction Potential: Zero to 600 lb/yr reduced air emissions by year 2000; 0 to 1,500 lb/yr to air by 2005. Because the strategy is voluntary, the reduction potential estimate starts at zero. The maximum reduction potential estimate shows the estimated decreases in overall state air emissions needed to meet the reduction goals set by the Mercury Contamination Reduction Initiative. These reduction goals are to be met using the combination of all strategies, including voluntary agreements.

Implementation Issues: Issues related to competition and sector-wide agreements may, in some cases, preclude use of sector-wide agreements.

Historical Use: A similar approach has been used often before at a state and national level. Examples include a memorandum of understanding signed by the EPA and the American Hospital Association (AHA) which sets out the AHA's intentions to work toward "mercury-free" hospitals. In addition, Minn. Stat. 115D.15 already requires the agency to prepare biennial progress reports regarding air toxics for submittal to the Legislature. The next report is due January 1, 2001.