Appendix A

Mercury Emission Inventory for Minnesota (October 2005 Update)

Appendix A. Estimated Mercury Emissions in Minnesota for 1990 to 2005 — October 2005

To provide a baseline for assessing progress on mercury-reduction efforts, Minnesota Statutes, section 116.915, requires that the Minnesota Pollution Control Agency (MPCA) publish updated estimates of mercury releases. A draft of our most current estimates, or "inventory," of releases in Minnesota due to human activities is provided in Table 1 for every five years from 1990 to 2005. The 2005 estimates are by necessity projections because the year is not yet concluded and data will not be available for at least another half year. Notes 1 through 27 at the end of this document provide explanations of each subcategory listed.

For this update, no changes were made to the 1990-2000 estimates from the last update, released in March 2004. The only difference is that estimates for 2005 are added.

Mercury emissions in Minnesota declined significantly from 1990 to 2000, by about 68 percent. In 1990, emissions are estimated to have been about 11,300 pounds (lbs.). In the early 1990s, emissions declined rapidly to about 4,300 lbs. in 1995, and then less rapidly, to about 3,640 lbs. in 2000. From 2000 to 2005, the rate of decline slowed further, reaching about 3,340 lbs. in 2005.

The trend in reduced emissions is most likely a national or even international trend. Sediment core studies from lakes in Minnesota and elsewhere show slight declines in atmospheric deposition relative to a peak in the 1970s and 1980s. There is evidence that concentrations of mercury in Minnesota's fish have declined about 10 percent, an encouraging response.

The MPCA divides mercury emitted to the atmosphere into three categories: (1) emissions incidental to energy production, (2) emissions due to purposeful use, and (3) emissions due to material processing. Although emissions from fossil fuel combustion and the processing of metal ores are both the result of the incidental release of trace contaminants of natural geological materials, we have placed them in separate categories (energy production and material processing, respectively). Separate categories are appropriate because the emission-reduction strategies, including pollution prevention, can be quite different between energy production and material processing.

Background

Mercury contamination of fish is a well-documented problem in Minnesota. The Minnesota Department of Health advises people to restrict their consumption of sport fish due to mercury on virtually every lake that has been tested. Testing of fish preserved in museums in the 1930s compared to similar fish from the same lakes in the 1980s showed that fish became significantly more contaminated with mercury, roughly in concert with increased atmospheric loading of mercury to lakes, which is about three times higher than natural conditions. Nearly all — probably about 98 percent — of the mercury in Minnesota lakes and rivers comes from the atmosphere. Consequently, the data presented here only include releases to the atmosphere.

About 30 percent of the mercury in the atmosphere is the result of the natural cycling of mercury. The other 70 percent of the mercury in the atmosphere is the result of human activities that have released mercury from the geological materials in which it had been locked up. These activities include the mining of mercury ores, the use of this mercury in products and manufacturing, and the incidental release of trace concentrations of mercury naturally present in coal, crude oil, and metal ores, such as taconite.

Table 1 Estimated mercury emissions (pounds) from human activity in Minnesota for the years 1990, 1995, 2000 and 2005.

Mercury Emission Inventory for Minnesota Date of Estimates: October 12, 2005	confidence	1990	1995	2000	2005 (projected)
Incidental to Energy Production					
Coal combustion (total) (1)	high	1,518.6	1,612.1	1,648.7	1,738.1
electric utility coal	high	1,418.3	1,512.8	1,544.8	1,650.0
commercial/industrial coal	medium	60.8	68.5	73.4	51.3
public utility / university & college heating	medium	39.0	30.5	30.2	36.4
residential coal	medium	0.4	0.4	0.4	0.4
Petroleum Product Refining and Consumption (2)	low	136.0	156.0	175.0	175.0
Wood combustion(3)	high	12.5	10.5	10.0	10.0
Natural gas combustion(4)	low	0.2	0.3	0.3	0.3
Subtotal incidental with energy production		1,667	1,779	1,834	1,923
% of total state emissions		15%	42%	50%	58%
Largely Resulting from the Purposeful Use of Mercury					
Latex paint volatilization (5)	medium	2,850.0	2.8	0.0	0.0
Class IV incinerators (6)	low	55.2	28.0	0.0	0.0
Golf course fungicide volatilization (7)	low	1,487.0	1.0	1.0	0.0
Volatilization: land application of compost (8)	low	2.2	1.3	0.3	0.2
Medical waste incineration (9)	high	516.0	36.0	6.1	0.4
Volatilization: land application of sludge (10)	low	3.6	1.8	1.4	0.7
Volatilization from dissipative use (11)	low	0.8	0.8	0.8	0.8
Landfill volatilization (12)	low	5.9	2.2	2.4	1.2
Hazardous waste incineration (13)	medium	5.0	5.0	5.0	5.0
General laboratory use (14)	low	44.0	44.0	22.0	10.0
Sewage sludge incineration (15)	medium	247.0	160.0	112.0	11.0
Fluorescent lamp breakage (16)	low	272.3	59.4	32.2	15.0
Volatilization from spills and land dumping (17)	low	54.7	48.0	48.0	24.0
On-site household waste incineration (18)	low	402.0	93.0	60.0	40.0
Recycling mercury from products within MN (19)	medium	3.5	35.0	50.0	65.0
Crematories (20)	low	30.8	49.5	68.2	80.0
Dental preparations (21)	low	103.0	99.0	95.0	84.0
Municipal solid waste combustion (22)	high	1,806.4	633.9	168.6	93.5
Smelters that recycle cars and appliances (23)	medium	186.0	186.0	176.0	125.0
Volatilization during solid waste collection & processing (24)	low	805.5	251.5	195.9	183.0
Subtotal associated with purposeful use of mercury		8,881	1,738	1,045	739
% of total state emissions		79%	41%	29%	22%
Emissions Incidental to Material Processing					
Taconite processing (25)	high	710.5	742.3	745.4	665.7
Pulp and paper manufacturing (26)	low	0.0	0.0	0.0	0.0
Soil roasting (27)	low	13.3	13.3	13.3	13.3
Subtotal emissions incidental to material processing		724	756	759	679
% of total state emissions		6%	18%	21%	20%
GRAND TOTAL =		11,272	4,273	3,637	3,341
Percent Reduction since 1990=			62%	68%	70%

Notes to Table 1

Emissions Incidental to Energy Production

1. Coal combustion: This is based on data submitted by facilities with stack tests (Xcel, Minnesota Power and Rochester Public Utility) and extrapolated to other coal combustors. Constant emission factors (pounds of mercury emitted per ton of coal combusted) submitted for 2000 for each unit are applied backwards and forward in time, except for Minnesota Power (MP). In the late 1990s, MP began to burn more low-mercury coal, which decreased its emission factor beginning in 2000. According to the data submitted, MP now burns less of coal "Y" (mercury concentration of 0.055 ppm, standard deviation = 0.012), and more of coal "W" (mercury concentration of 0.026 ppm, standard deviation = 0.006).

The MPCA has made the following assumptions for the calculation of mercury emissions from coal-combustion units. In the absence of evidence to the contrary, it is assumed that coal-combustion units have constant control efficiency for mercury for the period 1990 through 2005. In the absence of evidence to the contrary, it is assumed that the mercury content of coal has been constant since 1990, on a concentration basis. Therefore, net mercury emissions for a given unit can be expressed as a constant emission factor (pounds of mercury per ton of coal combusted) times the coal consumed by that facility in a given year. For facilities that have not submitted data to the MPCA, an emission factor of 8.00 E-05 lbs. per ton of coal is assumed, an average figure for facilities utilizing low-sulfur western subbituminous coal. A constant emission factor is assumed over time because unless there have been documented changes in combustion equipment, pollution-control equipment, or coal types that are predicted to change mercury emissions, multiple stack tests representing mercury emissions are merely different estimates of average emissions and do not represent real changes in emission.

2. Petroleum product refining and consumption: The mercury content of crude oil is poorly known, so estimates of emissions have low confidence. Minnesota has two refineries: Flint Hills Resources (formerly Koch Petroleum Group) Pine Bend Refinery and Marathon Ashland Petroleum's St. Paul Park Refinery.

In 2000, the Pine Bend Refinery had about five times the capacity of the St. Paul Park Refinery — 280,000 barrels per day, compared to about 70,000 barrels per day. Actual production in 2000 for both refineries was about 30 percent more than in 1990. Based on two small studies of the mercury content of crude oils refined in Minnesota, the MPCA estimates that the refineries received 136 lbs. of mercury in 1990 and 175 lbs. in 2000 and 2005. It is not clear how much of this mercury was emitted during refining and how much was contained in products such as fuel oil and gasoline. It is even possible that some of the mercury may have been caught on catalysts during refining. Additional studies on the mercury content of crude oil and the fate of that mercury would be helpful.

3. Wood combustion: Mercury emission factors are from Pang (1997). (Pang, S.M. 1997. *Mercury in wood and wood fuels.* Thesis. Master of Science. University of Minnesota). It is assumed that all the mercury in the wood is emitted to the atmosphere. Pang obtained samples of firewood and samples of mill residues burned in Minnesota, and analyzed 183 samples. Bark had the highest median mercury concentration (5.4 ng/g) among the three types of mill residues (chips = 1.28 ng/g; sawdust = 2.56 ng/g). Bark was also highest in the firewood samples. It is thought that mercury is higher in bark because of atmospherically-derived mercury in the dust and soil that bark is exposed to. Statewide emissions are based on the types of wood and wood waste that are actually burned.

4. Natural gas combustion: This estimate is based on an emission factor of 0.0008 lb. mercury/trillion Btu (Electric Power Research Institute. Mercury in the Environment - A Research Update. TR-107695. Palo Alto, December 1996).

Emissions Largely Resulting from the Purposeful Use of Mercury

5. Latex paint volatilization: Mercury-containing fungicides were added to latex paint until 1991. Estimates of Minnesota emissions are based on *Substance Flow Analysis of Mercury in Products* (August 2001, www.pca.state.mn.us/air/mercury-mn.html#publications). Basically the report concludes that it is reasonable to assume that 75 percent of the mercury in paint volatilizes within a year, with the residual available to volatilize the next year. The report calculates that 3,800 lbs. of mercury was held within painted surfaces in 1990, and that 2,850 lbs. (75 percent) likely volatilized that year. An earlier version of this Minnesota mercury inventory, contained in the January 2001 Report to the Minnesota Legislature, erroneously used the 3,800-lb. figure as the amount of mercury that was volatilized. This inventory uses 2,850 lbs., a change that lowers the 1990 baseline by 950 lbs.

6. Class IV incinerators: Small incinerators were once commonly used at grocery stores and other small businesses to incinerate waste, largely cardboard. All of these small incinerators, of which there were about 1,000 in 1990, closed by January 1996 because of new state regulations to reduce particulate emissions. It is assumed that they mostly burned cardboard with mercury at 0.2 ppm. The MPCA estimates that Class IV incinerators burned about 138,000 tons in 1990 and 70,000 tons in 1995.

7. Golf course fungicide volatilization: Mercury-containing fungicides were used in large quantities on golf courses to prevent snow mold until about 1992. The estimate of volatilization from these fungicides applied to golf courses is based on *Substance Flow Analysis of Mercury in Products* (August 2001, www.pca.state.mn.us/air/mercury-mn.html#publications). An earlier version of this Minnesota mercury inventory, contained in the January 2002 Report to the Minnesota Legislature, estimated that 86 lbs. of mercury were volatilized from golf courses in 1990, an amount that is much lower than the estimate of 1,487 lbs. in the August 2001 report. The estimate of 1,487 lbs. is much better documented than the earlier estimate, so this inventory uses 1,487 lbs.

8. Volatilization from the land application of compost: Assumes that one percent of mercury applied to the surface of the land volatilizes within a year.

9. Medical waste incineration: Emission data are based on stack tests submitted to the MPCA, as summarized in the following table.

Facility	1990	1995		2000		2005	
	Lb. Hg emitted	Lb. Hg emitted	Lb. Hg/ton	Tons burned	Lb. Hg emitted	Tons burned	Lb. Hg emitted
Mayo Foundation, Rochester[1]	115	1	7.71E-05	5,292	0.40	5,300	0.4
Medical Safety Systems, Cannon Falls[2]	33	25	3.10E-03	1,851	5.70	0	0.0
Small Class IV incinerators at hospitals (about 80 in 1990, 20 in 1995, 6 for part of 2000)	368	10	2.10E-04	200	0.04	0	0.0
Total Mercury Emitted (lb.)	516	36			6.14		0.4

[1] After 1990, the Mayo Foundation Incinerator was replaced with a new facility that controls mercury emissions with activated carbon injection.

[2] The Medical Safety Systems facility in Cannon Falls closed permanently in August 2000.

Most hospital (Class IV) incinerators were required to close by February 2000 due to federal regulations; those still operating in 2000 are listed below:

Date Operation Ceased	Hospital
January 2000	Fairmont Community Hospital
February 2000	Worthington Regional Hospital
February 2000	St. Cloud Hospital
June 2000	Lakewood Health Center, Baudette
October 2000	NW Medical Center, Thief River Falls
November 2000	Northcountry Regional Hospital, Bemidji

10. Volatilization from the land application of sludge: After correcting for the water content, about 50,000 dry tons of sewage sludge are land applied in Minnesota each year. The mercury content of the sludge has been declining over time.

Sludge averaged 3.6 ppm of mercury in 1990, 1.8 ppm in 1995, 1.4 ppm in 2000, and is expected to be 0.7 ppm in 2005. This estimate assumes that one percent of the mercury applied to the surface of the land volatilizes within a year, but does not attempt to calculate any carryover from previous years.

11. Volatilization from dissipative use: Mercury is used purposefully in a variety of ways. When the mercury is contained in a product, it can be captured and recycled. But some purposes simply dissipate the mercury into the environment, especially when it is used as a fungicide, pharmaceutical preservative, or in ritual uses (The use of mercury in rituals is thought to be most common in Caribbean communities, which are not well represented in Minnesota.). The estimate used here, 0.8 lb. per year, is prorated from the U.S. Food and Drug Administration's estimate of use for the entire United States, as discussed in *Substance Flow Analysis of Mercury in Products* (August 2001, www.pca.state.mn.us/air/mercury-mn.html#publications).

12. Landfill volatilization: 0.1 percent 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).

13. Hazardous waste incineration: Minnesota has only one hazardous waste incinerator, 3M Chemolite. Based on data submissions from that facility, the MPCA estimates annual mercury emissions of 5 lbs. per year. 3M did not submit any data recently, and 5 lbs. may be an overestimate.

14. General Laboratory: Chemical laboratories have traditionally used mercury for a variety of uses, including physical measurements and chemical analyses. The EPA Mercury Report to Congress (1997) estimated that in 1995, 2,200 lbs. of mercury were volatilized from laboratories nationally. Given that Minnesota represents two percent of all economic activity nationally, the MPCA estimates that 44 lbs. of mercury were emitted in 1990 and 1995, and that this source declined to 22 lbs. by 2000.

15. Sewage sludge incineration: Sewage sludge contains mercury from a variety of wastewater sources. There are two sludge incinerators in Minnesota — the Metropolitan Plant, and the Seneca Plant. Based on data provided by the Metropolitan Council, the MPCA estimates that 247 lbs. of mercury were emitted in 1990, 160 lbs. in 1995, 112 lbs. in 2000, and only 11 lbs. in 2005. In late 2004, a new incinerator with 99 percent mercury-control efficiency began operation at the Metropolitan plant.

	1990	1995	2000	2005
Metropolitan Plant	212	136	95	1
Seneca Plant	35	24	17	10
Total Emitted (lb.)	247	160	112	11

16. Fluorescent lamp breakage: Mercury is a necessary component of fluorescent lamps, although manufacturers have succeeded in reducing the quantity of mercury in an average four-foot lamp from about 45 mg in 1990 to about 15 mg in 2000. After 1990, Minnesota law no longer allowed the disposal of mercury-containing lamps in the solid waste stream, so that progressively more lamps have been recycled. The MPCA estimates that lamps that are not recycled usually get broken in the solid waste stream, in which case 25 percent of the mercury is volatilized.

	1990	1995	2000	2005
No. lamps disposed of in U.S.	550,000,000	600,000,000	650,000,000	700,000,000
No. lamps disposed of in Minnesota	11,000,000	12,000,000	13,000,000	14,000,000
mg Hg/lamp	45	30	15	10
Percent recycled	0	50	70	80
Hg in lamps not recycled (g)	495,000	108,000	58,500	28,000
Hg volatilized (lb)	272.3	59.4	32.2	15

17. Volatilization from spills and land dumping: The MPCA estimates that large quantities of mercury are in use in Minnesota, and that a portion that is removed from service each year (8 percent) is spilled, and that five percent of the mercury that is spilled volatilizes:

Year	Hg in use (lb.)	Hg removed from use (lb.)	Spilled (%)	Hg volatilized (lb.)
1990	190,000	13,667	8.0	54.7
1995	160,000	12,000	8.0	48.0
2000	130,000	12,000	8.0	48.0
2005	70,000	6,000	8.0	24.0

It may appear unlikely that such large amounts of mercury are being removed from use, yet these estimates are supported by mercury content of the solid waste stream, as quantified by stack tests at solid waste incinerators.

Based on stack tests, the solid waste stream contained at least 16,000 lbs. of mercury in 1990, 5,000 lbs. in 1995, and 4,000 lbs. in 2000. Although it is likely that more mercury was properly disposed of after 1990, it also seems likely that as long as mercury is in use, it will be accidentally spilled and volatilized.

18. On-site household waste incineration: It is thought that a significant quantity of solid waste produced by households in Minnesota is not introduced into any organized collection system, but rather is burned on site. This practice could be a significant source of mercury emissions, given that there is no pollution-control equipment and that we know from testing at large municipal solid waste (MSW) incinerators that MSW contains mercury.

In rural areas, on-site disposal often takes the form of an outdoor "burn barrel." In urban and suburban areas, older houses and apartments were designed with a basement incinerator, although the use of these incinerators has undoubtedly decreased since regulation in the early 1970s.

The following table outlines available data on the production and fate of MSW in Minnesota, and estimates mercury emissions. These figures imply that about two percent of MSW is burned on site. This may be an underestimate, given that at least two studies have shown much higher rates of on-site incineration. Zenith Research Group (1997) found that 11 percent of residents in the Duluth area affirmed that they use a burn barrel. A 2000 Zenith study of Minnesota residents in the Duluth area found that 18 percent of residents surveyed admitted to the practice (Zenith Research Group. 2000. Increased Awareness. Prepared for Western Lake Superior Sanitary District.).

Fate of Municipal Solid Waste	1990	1995	2000	2005 (projected)[4]
Recycling (tons)	1,381,690	1,766,528	2,267,952	2,400,000
MSW Compost (tons)	Not available	67,997	21,092	20,000
Resource Recovery (combustion) (tons)	Not available	1,379,329	1,228,830	1,230,000
Landfill (tons)	Not available	1,145,067	1,909,152	2,400,000
PMNR[1] (tons)	Not available	110,868	110,841	120,000
On-site disposal[2] (tons)	Assume 110,000	95,226	96,064	80,000
TOTAL (tons)	Not available	4,565,015	5,633,932	6,250,000
Mercury Content[3] (Assumes 30% control at mass-burn waste combustors.)	3.7 ppm	1.0 ppm	0.6 ppm	0.4 ppm
Mercury Emissions (Assumes 50% is emitted from burn barrels.)	402 lb.	93 lb.	60 lb.	40 lb.

[1] PMNR = Problem Materials Not Recycled, such as washing machines, tires, oil filters and used oil.

[2] The State of Minnesota did not estimate on-site disposal until 1992 (estimated 113,000 tons for that year). For this calculation, 110,000 tons is assumed for 1990, which may be a slight underestimate.

[3] The mercury content of the waste is based on the average emissions of mass-burn MSW incinerators that do not sort or process waste before combustion, excluding Fergus Falls, which had unusually good mercury capture due to the use of a wet scrubber.

[4] Please refer to Minnesota's SCORE reports for more up-to-date data as it becomes available at www.moea.state.mn.us/lc/score.cfm. 2004 data will be available about November 1, 2005.

19. Recycling mercury from products within Minnesota: It is difficult to estimate the emissions associated with recycling mercury in Minnesota because the recyclers are not required to submit information to the state and because it is unclear what the emission factor is for recycling mercury. This estimate was made by Brian Golob, who at the time was employed by one of the three mercury recycling companies in Minnesota.

20. Crematoria: Cremation can release significant quantities of mercury because of the mercury amalgam that is present as dental fillings, and cremation probably releases all of this mercury to the atmosphere. The MPCA estimates for this source are based on calculations presented in Substance Flow Analysis of Mercury in Products (August 2001, www.pca.state.mn.us/air/mercury-mn.html#publications).

21. Dental preparations: Dentists have used mercury amalgam for more then 150 years in the United States. Mercury amalgams typically contain between 42 and 50 percent mercury.

The mercury used in the amalgam has a variety of pathways to the atmosphere, including direct volatilization during preparation in the dental office, from the patient's mouth, after removal in the dental office, during transit in wastewater pipes, from sewage sludge, from crematoriums, and a variety of more subtle pathways. In this estimate, the MPCA includes direct volatilization from the dental office, from the consumer, and during transit in wastewater pipes, but excludes all other pathways, which are included in other emission categories. The MPCA based the estimates on information in the report *Substance Flow Analysis of Mercury in Products* (August 2001, www.pca.state.mn.us/air/mercury-mn.html#publications).

However, the MPCA reduced volatilization during transit from 10 to five percent, although no data on the subject are presently available.

	1990	1995	2000	2005 (projected)
Dental office (lb)	46.2	46.2	46.2	
Customer breathing (lb)	11	12.1	13.2	
Transit loss (lb)	46.2	40.7	35.2	
Total Emissions (lb)	103.4	99.0	94.6	84.0

Note: 1995 figures are extrapolated from 1990 and 2000.

22. Municipal solid waste (MSW) combustion: The mercury emissions in the table on the following page are based on stack tests submitted to the MPCA. "Mass burn" facilities burn solid waste with virtually no sorting, except to exclude the largest and most obvious undesirable waste, such as propane tanks. "RDF" facilities burn refuse-derived fuel, which is municipal solid waste that has been sorted and shredded before combustion.

	1990		1995		2000		2005 (projected)	
Facility Type	**MSW (tons)**	**Hg emitted (lb.)**	**MSW (tons)**	**Hg emitted (lb.)**	**MSW (tons)**	**Hg emitted (lb.)**	**MSW (tons)**	**Hg emitted (lb.)**
Mass Burn Facilities								
Covanta (HERC)	321,900	496	365,000	45	372,258	20.7		40.6
Perham	27,150	89	30,500	52	0	0.0		8.7
Pope Douglas	17,455	26	20,562	25	25,494	33.0		0.8
Olmsted County	58,935	201	67,838	63	62,500	48.0		4.2
City of Fergus Falls	25,187	8	30,900	8	22,983	18.0		8.2
City of Red Wing	18,149	153	17,030	25	16,800	9.0		10.4
Richards Asphalt	24,831	326	23,510	42	Closed		Closed	
Polk	25,446	101	28,785	46	20,700	29.0		3.9
RDF Facilities								
NSP Wilmarth	90,312	5	194,117	5	203,320	1.0		4.5
WLSSD*	33,900	47	35,748	13	0		0	
NSP Red Wing	178,274	333	197,818	304	181,697	0.1		9.8
Great River Energy (Elk River)	277,970	22	277,800	6	279,800	2.4		2.4
TOTAL	1,099,509	1,807	1,289,608	634	1,185,552	161.1		93.5

* By 2000, WLSSD had switched to burning sewage sludge and coal, not RDF. Combustion at WLSSD was later ceased. MSW is being landfilled, and sewage sludge is being treated and land applied as a soil amendment.

23. Smelters that recycle cars and appliances: Mercury is released during the recycling of cars and appliances because of the mercury switches in these products. There is one mini-mill in Minnesota that melts steel from recycled cars and appliances, North Star Steel. These figures are based on a mercury mass balance for North Star Steel's Minnesota facility submitted to the MPCA on December 28, 1999 by the company.

The mass balance shows that in 1998 the total mercury output from the facility was 449 lbs., of which 11 lbs. were recycled and 147 lbs. were emitted directly to the air (136 from the electric arc furnace stack, plus 11 lbs. from the auto shredder stack). According to the mass balance, 214 lbs. of mercury per year is associated with the flue dust captured by pollution-control equipment on the electric arc furnace. The flue dust is processed outside of Minnesota to reclaim useful metals, such as zinc. The mercury in the flue dust is likely released to the atmosphere during the processing, but little information is available on that stage of recycling.

The MPCA utilized the findings of the 1998 mass balance to calculate air emissions for 1990 and 2000, assuming the increased processing of scrap steel in 2000. Mercury emissions are calculated to have been 186 lbs. in 1990, which decreased in 2000 to 176 lbs. as a result of removing mercury-containing switches prior to shredding at North Star Steel. Emissions for 2005 are estimated to be 125 lbs., as a result of continued efforts to remove mercury-containing switches.

24. Volatilization from solid waste collection and processing: This estimate is based on the assumption that five percent of the mercury in solid waste is volatilized during collection, transportation and mechanical processing. It includes MSW that is landfilled, incinerated and composted, but does not include Problem Materials Not Recycled (washing machines, oil filter, tires), waste that is recycled

(newspaper, glass, cans), demolition, medical waste incineration, MSW compost, backyard burn barrels. Emissions from steel-recycling facilities and fluorescent lamp breakage are calculated separately.

Fate of Municipal Solid Waste	1990	1995	2000	2005 (projected)*
Recycling	1,381,690	1,766,528	2,267,952	2,400,000
MSW Compost	30,000	67,997	21,092	20,000
Resource Recovery (combustion)		1,379,329	1,228,830	1,230,000
Landfill	800,000	1,145,067	1,909,152	2,400,000
PMNR		110,868	110,841	120,000
On-site Disposal	110,000	95,226	96,064	80,000
TOTAL (tons)		4,565,015	5,633,932	6,250,000
Calculated Mercury Content (ppm) (from incinerators)	3.66	0.97	0.62	.5
Total landfill, combusted, composted (tons)	2,200,000	2,592,393	3,159,074	3,650,000

Mercury content (lb) of SW (excluding recycling, PMNR)	16,109	5,031	3,919	3,650
Volatilization during handling and transport (lb) (5% of landfill, combustion, composting)	805	252	196	183

Emissions Incidental to Material Processing

25. Taconite processing: In Minnesota, the iron in taconite ore is concentrated and marble-size pellets are baked, or indurated, for ease of handling before they are shipped for smelting outside of the state. Induration volatilizes virtually all of the mercury that is present in the concentrate.

For this volatilization estimate, emission factors (lbs. per million long ton) are calculated from Jiang et al., 2000 ("Mercury Emissions from Induration of Taconite Concentrate Pellets – Stack Testing Results from Facilities in Minnesota." A presentation at the U.S. Environmental Protection Agency conference, Assessing and Managing Mercury from Historic and Current Mining Activities, San Francisco, Calif., November 28-30, 2000.).

Taconite Facility	Mercury Emission Factor (lb. Hg/million Long Tons)		1990	1995	2000	2005 (projected)
LTV	11.24	L tons/yr.	7,798,292	7,440,366	7,400,000	0
		lb Hg/yr.	87.7	83.6	83.2	0
EVTAC	25.20	L tons/yr.	4,417,255	5,141,072	4,200,000	4,400,000
		lb. Hg/yr.	111.3	129.6	105.8	110.9
Hibbing	27.80	L tons/yr.	8,136,923	8,386,431	8,100,000	8,100,000
		lb. Hg/yr.	226.2	233.1	225.2	225.2
Inland	11.89	L tons/yr.	2,265,876	2,560,350	2,878,000	2,900,000
		lb. Hg/yr.	26.9	30.4	34.2	34.5
National	22.18	L tons/yr.	4,809,930	5,026,048	5,450,000	5,400,000
		lb. Hg/yr.	106.7	111.5	120.9	119.8
Northshore	1.10	L tons/yr.	2,384,061	3,658,130	4,300,000	4,300,000
		lb. Hg/yr.	2.6	4.0	4.7	4.7
Minntac	11.73	L tons/yr.	12,709,299	12,788,787	14,607,000	14,600,000
		lb. Hg/yr.	149.1	150.0	171.3	171.3
SUM		L tons/yr.	42,521,636	45,001,184	46,935,000	397,00,000
		lb. Hg/yr.	710.5	742.3	745.4	666

26. Pulp and paper manufacturing: In earlier mercury emission inventories for Minnesota, 3.5 lbs. per year were attributed to emissions from boilers at pulp and paper facilities. However, these emissions are primarily due to combustion of fuels (coal and wood products, such as bark) that are accounted for elsewhere in the inventory.

27. Soil roasting: An average of 83,000 tons of surface soil is heated annually in Minnesota to remove organic contaminants. A concentration of 0.08 ppm of mercury is assumed in the soil, and it is assumed that all of the mercury in the soil is emitted to the atmosphere.