

**Estimated Mercury Emissions in Minnesota for 1990, 1995, & 2000:
March 2004 Update
Minnesota Pollution Control Agency**

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 1990 mercury releases. The MPCA's most current estimates, or "inventory," of 1990 releases in Minnesota (due to human activities) is provided below. To evaluate trends, estimates for 1995 and 2000 are provided as well. Notes 1 through 27 at the end of this document provide explanations of each subcategory listed.

The data presented here show that total mercury emissions in Minnesota declined significantly from 1990 to 2000, by about 68%. In 1990, emissions are estimated to have been 11,272 lb. By 2000, mostly due to discontinued use of mercury in products and mandated controls on incineration of solid waste, emissions were just 3,638 lb. This 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 some evidence that concentrations of mercury in fish have also declined, but not to the point of significantly reducing concerns about fish consumption. However, it is encouraging that efforts to reduce the use and release of mercury appear to have resulted in measurable environmental improvement.

Mercury emitted to the atmosphere due to human activities is divided by the MPCA 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 reduction strategies can be 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 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. Although the data are limited, there is some evidence that other factors may have exacerbated the increase in mercury in fish. The fish in Brule Lake in the Boundary Waters Canoe Area (BWCA), for example, have increased by a factor of about 10, when the increase due to mercury alone would be expected to be about three.

Nearly all — probably about 98% — 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% of mercury in the atmosphere is the result of the natural cycling of mercury. But 70% of the mercury is a result of human activities that have increased the release of 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.

Because mercury vapor can be transported long distances by the atmosphere, most of Minnesota's emissions are deposited in other states and countries, and Minnesota receives some of their emissions. In rural Minnesota, about 10% of mercury deposition is the result of emissions within the state. Further research and analysis is needed to determine if there is enhanced mercury deposition in the urban area surrounding Minneapolis and St. Paul.

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

		1990			1995			2000		
		(best)	Min.	Max.	(best)	Min.	Max.	(best)	Min.	Max.
Mercury Emission Inventory for Minnesota (pounds per year)										
Date of Estimate: February 2004										
		confidence level								
Incidental to Energy Production										
Coal combustion (total) (1)	high	1,518.6	1,366.7	1,670.4	1,612.1	1,450.9	1,773.3	1,648.7	1,483.8	1,813.6
electric utility coal	high	1,418.3	1,276.5	1,560.2	1,512.8	1,361.5	1,664.1	1,544.8	1,390.3	1,699.2
commercial/industrial coal	medium	60.8	45.6	76.0	68.5	51.3	85.6	73.4	55.0	91.7
public utility / university & college heating	medium	39.0	29.3	48.8	30.5	22.8	38.1	30.2	22.6	37.7
residential coal	medium	0.4	0.3	0.5	0.4	0.3	0.5	0.4	0.3	0.5
Petroleum Product Refining and Consumption (2)	low	136.0	68.0	204.0	156.0	78.0	234.0	175.0	87.5	262.5
Wood combustion(3)	high	12.5	11.3	13.8	10.5	9.4	11.5	10.0	9.0	11.0
Natural gas combustion(4)	low	0.2	0.1	0.5	0.3	0.1	0.6	0.3	0.1	0.6
Subtotal incidental with energy production		1,667.4	1,446.1	1,888.7	1,778.9	1,538.5	2,019.4	1,834.0	1,580.5	2,087.6
	% of total state emissions	15%			42%			50%		
Largely Resulting from the Purposeful Use of Mercury										
Latex paint volatilization (5)	medium	2850.0	2137.5	3562.5	2.8	2.1	3.5	0.0	0.0	0.0
Municipal solid waste combustion (6)	high	1806.4	1625.8	1987.0	633.9	570.5	697.2	168.6	151.7	185.4
On-site household waste incineration (7)	low	402.0	201.0	603.0	93.0	46.5	139.5	60.0	30.0	90.0
Medical waste incineration (8)	high	516.0	464.4	567.6	36.0	32.4	39.6	6.1	5.5	6.7
Sewage sludge incineration (9)	med.	247.0	185.3	308.8	160.0	120.0	200.0	112.0	84.0	140.0
Fluorescent lamp breakage (10)	low	272.3	136.2	408.5	59.4	29.7	89.1	32.2	16.1	48.3
Class IV incinerators (11)	low	55.2	27.6	82.8	28.0	14.0	42.0	0.0	0.0	0.0
Crematories (12)	low	30.8	15.4	46.2	49.5	24.8	74.3	68.2	34.1	102.3
General laboratory use (13)	low	44.0	22.0	66.0	44.0	22.0	66.0	22.0	11.0	33.0
Dental preparations (14)	low	103.0	51.5	154.5	99.0	49.5	148.5	95.0	47.5	142.5
Hazardous waste incineration (15)	medium	5.0	3.8	6.3	5.0	3.8	6.3	5.0	3.8	6.3
Landfill volatilization (16)	low	5.9	2.9	8.8	2.2	1.1	3.3	2.4	1.2	3.6
Recycling mercury from products within MN (17)	medium	3.5	2.6	4.4	35.0	26.3	43.8	50.0	37.5	62.5
Minimills that recycle cars and appliances (18)	medium	186.0	139.5	232.5	186.0	139.5	232.5	176.0	132.0	220.0
Volatilization from dissipative use (19)	low	0.8	0.4	1.2	0.8	0.4	1.2	0.8	0.4	1.2
Golf course fungicide volatilization (20)	low	1487.0	743.5	2230.5	1.0	0.5	1.5	1.0	0.5	1.5
Volatilization from spills and land dumping (21)	low	54.7	27.3	82.0	48.0	24.0	72.0	48.0	24.0	72.0
Volatilization during solid waste collection & processing (22)	low	805.5	402.7	1208.2	251.5	125.8	377.3	195.9	98.0	293.9
Volatilization: land application of compost (23)	low	2.2	1.1	3.3	1.3	0.7	2.0	0.3	0.1	0.4
Volatilization: land application of sludge (24)	low	3.6	1.8	5.4	1.8	0.9	2.7	1.4	0.7	2.1
Subtotal associated with purposeful use of mercury		8,880.8	6,192.2	11,569.3	1,738.2	1,234.3	2,242.2	1,044.8	678.0	1,411.6
	% of total state emissions	79%			41%			29%		
Emissions Incidental to Material Processing										
Taconite processing (25)	high	710.5	639.5	781.6	742.3	668.1	816.5	745.4	670.8	819.9
Pulp and paper manufacturing (26)	low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil roasting (27)	low	13.3	6.7	26.6	13.3	6.7	26.6	13.3	6.7	26.6
Subtotal emissions incidental to material processing		723.8	646.1	808.2	755.6	674.7	843.1	758.7	677.5	846.5
	% of total state emissions	6%			18%			21%		
GRAND TOTAL =		11,272.0	8,284.5	14,266.2	4,272.7	3,447.5	5,104.8	3,637.5	2,936.0	4,345.7
Percent Reduction since 1990					62%			68%		

Notes

Emissions Incidental to Energy Production

1. Coal combustion: Based on data submitted by facilities with stack tests (Xcel, Minnesota Power, and Rochester Public Utility) and extrapolated to other coal combustors. For this update, constant emission factors (pounds of mercury emitted per ton of coal combusted) submitted for 2000 for each unit are applied back in time, except for Minnesota Power (MP). In the late 1990s, MP began to burn more low-mercury coal, which decreased its emission factor for 2000. According to the data submitted, MP burned 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 2000. In the absence of evidence to the contrary, it is assumed that the mercury content of coal has been constant from 1990 through 2000. 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 lb per ton of coal is assumed, an average figure for facilities utilizing low-sulfur western 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 between 1990 and 2000 are merely different estimates of average emissions and do not represent real changes in emission.

Of the electric utilities submitting information on mercury emissions to the MPCA, only MP has documented a reason for decreased emission factors. Minnesota Power has provided data on the quantities and mercury concentrations of the coal utilized in its facilities, showing that the mercury emission factor decreased significantly between 1995 and 2000 at Laskin and Clay Boswell, as shown in the table below.

Coal consumption for 1990, 1995, and 2000.

Facility	Unit	1990 tons coal	1990 Hg (lb)	1995 tons coal	1995 Hg (lb)	2000 tons coal	2000 Hg (lb)	EF lb Hg/ton	EF lb Hg/ton (2000)
US Steel Minn Ore Operations - Minntac	Indurate	11,003	0.9	1,409	0.1	15,737	1.3	8.00E-05	
US Steel Minn Ore Operations - Minntac	Indurate	9,222	0.7	1,774	0.1	5,545	0.4	8.00E-05	
Northshore Mining Co - Silver Bay	Boiler 2	78,407	0.6	175,011	1.4	255,081	2.1	8.07E-06	
Northshore Mining Co - Silver Bay	Boiler 1			3,681	0.0	199,600	2.1	1.06E-05	
LTV Steel Mining - Hoyt Lakes	Boiler 2	5,017	0.4					8.00E-05	
LTV Steel Mining - Hoyt Lakes	Boiler 1	7,883	0.6					8.00E-05	
EVTAC Mining - Plant	L2 Pellet Induration	8,001	0.3	21,321	0.7	31,479	1.0	3.20E-05	
EVTAC Mining - Plant	L2 Pellet Induration	8,001	0.3	21,321	0.7	31,479	1.0	3.20E-05	
Farmland Foods Inc	Boiler 3	1,341	0.1					8.00E-05	
Farmland Foods Inc	Boiler 2	1,341	0.1					8.00E-05	
Farmland Foods Inc	Boiler 1	1,341	0.1					8.00E-05	
Minnesota Corn Processors LLC	Boiler 2	21,878	1.8	12,538	1.0	20,817	1.7	8.00E-05	
Minnesota Corn Processors LLC	Boiler 1	21,878	1.8	12,538	1.0	20,817	1.7	8.00E-05	
Southern Minnesota Beet Sugar COOP	Boiler 1	103,050	8.2	145,187	11.6	172,435	13.8	8.00E-05	
American Crystal Sugar - Moorhead	Pulp dryers	22,025	1.8	28,478	2.3			8.00E-05	
American Crystal Sugar - Moorhead	Boiler B3	25,792	2.1	30,892	2.5	30,213	2.4	8.00E-05	
American Crystal Sugar - Moorhead	Boiler B2	25,792	2.1	30,892	2.5	30,214	2.4	8.00E-05	

American Crystal Sugar - Moorhead	Boiler B1	25,792	2.1	33,713	2.7	30,214	2.4	8.00E-05
American Crystal Sugar - E Grand Forks	Pulp dryer	12,440	1.0	16,086	1.3			8.00E-05
American Crystal Sugar - E Grand Forks	Pulp dryer	12,440	1.0	16,010	1.3			8.00E-05
American Crystal Sugar - E Grand Forks	Pulp dryer	12,440	1.0	7,312	0.6			8.00E-05
American Crystal Sugar - E Grand Forks	Boiler B2	59,946	4.8	68,028	5.4	98,004	7.8	8.00E-05
American Crystal Sugar - E Grand Forks	Boiler B1	56,546	4.5	61,983	5.0	103,432	8.3	8.00E-05
American Crystal Sugar - Crookston	Pulp dryers	22,542	1.8	32,748	2.6			8.00E-05
American Crystal Sugar - Crookston	Boiler B3	24,022	1.9	35,832	2.9	20,777	1.7	8.00E-05
American Crystal Sugar - Crookston	Boiler B2	24,022	1.9	35,832	2.9	34,627	2.8	8.00E-05
American Crystal Sugar - Crookston	Boiler B1	24,022	1.9	35,832	2.9	34,627	2.8	8.00E-05
ADM - Mankato	Boiler 5	45,400	3.4	70,448	5.3	65,394	4.9	7.49E-05
Stroh Brewery	Boiler 4	9,474	0.8	2,567	0.2			8.00E-05
Potlatch - Cloquet	Boiler 9	4,332	0.3	1,690	0.1	600	0.0	8.00E-05
Potlatch - Cloquet	Boiler 7	13,566	1.1	3,342	0.3	2,480	0.2	8.00E-05
Potlatch - Brainerd MN Pulp & Paper Div	Boiler 4	494	0.0	755	0.1	15,428	1.2	8.00E-05
Potlatch - Brainerd MN Pulp & Paper Div	Boiler 3	636	0.1	865	0.1	15,542	1.2	8.00E-05
Potlatch - Brainerd MN Pulp & Paper Div	Boiler 2	687	0.1	1,065	0.1	1,317	0.1	8.00E-05
International Paper - Sartell	Boiler 3	72,073	5.8	78,037	6.2	82,828	6.6	8.00E-05
International Paper - Sartell	Boiler 2	3,080	0.2	5,553	0.4	8,285	0.7	8.00E-05
Blandin Paper Co/Minnesota Power	Boiler 6	19,751	1.6	14,426	1.2	18,707	1.5	8.00E-05
Blandin Paper Co/Minnesota Power	Boiler 5	20,475	1.6	14,425	1.2	15,797	1.3	8.00E-05
3M - Cottage Grove Center Utilities	Boiler 3	18,472	1.5	14,223	1.1			8.00E-05
3M - Cottage Grove Center Utilities	Boiler 2	8,168	0.7	10,462	0.8			8.00E-05
TOTAL commercial/industrial		842,792	60.8	1,046,275	68.5	1,361,475	73.4	

Springfield Power Plant	Boiler 2	1,597	0.1	1,697	0.1			8.00E-05
Rochester Public Utilities - Silver Lake	Boiler 4	52,613	2.0	39,318	1.5	101,590	4.0	3.90E-05
Rochester Public Utilities - Silver Lake	Boiler 3	11,793	0.5	4,405	0.2	35,925	1.4	3.90E-05
Rochester Public Utilities - Silver Lake	Boiler 1					7,575	0.3	3.90E-05

Otter Tail Power Co - Hoot Lake Plant	Boiler 3	87,699	7.0	88,146	7.1	245,707	19.7	8.00E-05	
Otter Tail Power Co - Hoot Lake Plant	Boiler 2	88,064	7.0	152,053	12.2	211,414	16.9	8.00E-05	
Otter Tail Power Co - Hoot Lake Plant	Boiler 1	1,209	0.1	407	0.0	504	0.0	8.00E-05	
NSP/Xcel Energy - Riverside Plant	Boiler 6+7	332,125	27.7	414,801	34.6	647,157	54.0	8.34E-05	
NSP/Xcel Energy - Riverside Plant	Boiler 8	710,226	39.3	790,905	43.8	794,806	44.0	5.54E-05	
NSP/Xcel Energy - High Bridge Plant	Boiler 6	340,748	23.4	375,994	25.8	481,399	33.0	6.86E-05	
NSP/Xcel Energy - High Bridge Plant	Boiler 5	203,553	14.0	224,861	15.4	287,692	19.7	6.86E-05	
NSP/Xcel Energy - High Bridge Plant	Boiler 4	105,849	7.3	121,037	8.3	95,835	6.6	6.86E-05	
NSP/Xcel Energy - High Bridge Plant	Boiler 3	80,274	5.5	67,529	4.6	97,118	6.7	6.86E-05	
NSP/Xcel Energy - Black Dog	Boiler 4	318,015	16.9	482,663	25.6	632,391	33.6	5.31E-05	
NSP/Xcel Energy - Black Dog	Boiler 3	168,605	9.0	255,248	13.6	287,755	15.3	5.31E-05	
NSP/Xcel Energy - Black Dog	Boiler 2	63,060	3.3	102,678	5.5	3,045	0.2	5.31E-05	
NSP/Xcel Energy - Black Dog	Boiler 1	18,396	1.0	58,078	3.1			5.31E-05	
NSP/Xcel Energy - Sherburne Cnty	Boiler 3	3,481,299	387.2	3,507,936	390.2	3,704,110	412.0	1.11E-04	
NSP/Xcel Energy - Sherburne Cnty	Boiler 2	2,585,750	232.8	2,606,497	234.6	2,357,279	212.2	9.00E-05	
NSP/Xcel Energy - Sherburne Cnty	Boiler 1	2,340,576	210.7	2,562,463	230.6	2,908,594	261.8	9.00E-05	
NSP/Xcel Energy - Minnesota Valley	Boiler 4	44,830	3.6	53,849	4.3	159	0.0	8.00E-05	
NSP/Xcel Energy - Allen S King Generating Plant	Boiler 1	1,768,796	65.3	1,703,412	62.9	1,751,483	64.6	3.69E-05	
Minnesota Power Inc - ML Hibbard	Boiler 4	19,575	1.8	8,667	0.8	20,428	1.8	8.98E-05	
Minnesota Power Inc - ML Hibbard	Boiler 3	32,583	2.9	10,979	1.0	15,218	1.4	8.98E-05	
Minnesota Power Inc - Laskin Energy Ctr	Boiler 2	28,300	2.7	103,200	9.8	179,559	8.5	9.49E-05	4.71E-05
Minnesota Power Inc - Laskin Energy Ctr	Boiler 1	33,100	3.1	104,600	9.7	202,627	9.5	9.32E-05	4.71E-05
Minnesota Power Inc - Boswell Energy Ctr	Boiler 4	2,222,300	208.5	2,057,059	193.0	2,085,107	165.7	9.38E-05	7.95E-05
Minnesota Power Inc - Boswell Energy Ctr	Boiler 3	1,332,300	115.8	1,325,075	115.1	1,247,606	91.2	8.69E-05	7.31E-05
Minnesota Power Inc - Boswell Energy Ctr	Boiler 2	191,000	6.6	235,690	8.1	264,296	3.1	3.44E-05	1.18E-05
Minnesota Power Inc - Boswell Energy Ctr	Boiler 1	191,600	6.5	192,734	6.6	239,570	2.8	3.41E-05	1.18E-05
LTV Steel Mining - Schroeder	Boil 3			176,249	14.1	196,038	15.7	8.00E-05	
LTV Steel Mining - Schroeder	Boil 2			168,290	13.5	228,942	18.3	8.00E-05	

LTV Steel Mining - Schroeder	Boil 1			157,873	12.6	196,948	15.8	8.00E-05
Interstate Power Co - Fox Lake Station	Boiler 3	76,297	6.1	17,300	1.4		0.0	8.00E-05
Austin Utilities - NE Power Station	Boiler 1- ne	10,264	0.8	39,920	3.2	61,354	4.9	8.00E-05
TOTAL Electric Utilities		16,942,396	1418.3	18,211,614	1512.8	19,589,232	1544.8	
Willmar Municipal Utilities	Boiler 3	41,649	3.3	42,422	3.4	44,845	3.6	8.00E-05
Willmar Municipal Utilities	Boiler 2	4,358	0.3					8.00E-05
Willmar Municipal Utilities	Boiler 1	25	0.0					8.00E-05
Sleepy Eye Public Utilities	Boiler 3	7,603	0.6					8.00E-05
New Ulm Public Utilities Commission	Boiler 4	2,614	0.2	1,256	0.1		0.0	8.00E-05
Hibbing Public Utilities Commission	Boiler 3	26,136	2.1	25,037	2.0	27,176	2.2	8.00E-05
Hibbing Public Utilities Commission	Boiler 2	26,136	2.1	15,100	1.2	22,213	1.8	8.00E-05
Hibbing Public Utilities Commission	Boiler 1	26,136	2.1	21,276	1.7	20,677	1.7	8.00E-05
City of Virginia Dept Public Utilities	Boiler 9	66,713	5.3	48,298	3.9	64,842	5.2	8.00E-05
City of Virginia Dept Public Utilities	Boiler 8	24,639	2.0	3,534	0.3			8.00E-05
City of Virginia Dept Public Utilities	Boiler 7	15,883	1.3			26,791	2.1	8.00E-05
Western Lake Superior Sanitary District	Fluidized Bed Reactor 1					24,900	2.0	8.00E-05
University of MN - Mpls SE Steam Plant	Boiler 4			1,627	0.1			8.00E-05
University of MN - Mpls SE Steam Plant	Boiler 3			900	0.1			8.00E-05
Duluth Steam Cooperative Association	Boilers 1-4	19,937	1.6	31,559	2.5	50,737	4.1	8.00E-05
District Energy St Paul Inc-Hans O Nyman	Boiler 4	4,331	0.3	4,375	0.4	18,036	1.4	8.00E-05
District Energy St Paul Inc-Hans O Nyman	Boiler 3	12,994	1.0	11,011	0.9	16,010	1.3	8.00E-05
District Energy St Paul Inc-Hans O Nyman	Boiler 2	11,551	0.9	11,929	1.0	16,726	1.3	8.00E-05
University of MN - Twin Cities	SG201 - Circulating Fluidized Bed Boiler					26,011	2.1	8.00E-05
University of MN - St Paul Heating Plant	Boiler 6	11,833	0.9	6,171	0.5	73	0.0	8.00E-05

University of MN - St Paul Heating Plant	Boiler 5	10,969	0.9	6,428	0.5	84	0.0	8.00E-05
University of MN - St Paul Heating Plant	Boiler 2	2,786	0.2	928	0.1			8.00E-05
University of MN - St Paul Heating Plant	Boiler 1	2,658	0.2	961	0.1			8.00E-05
University of MN - Mpls SE Steam Plant	Boiler 4	54,561	4.4	55,885	4.5	4,095	0.3	8.00E-05
University of MN - Mpls SE Steam Plant	Boiler 3	30,040	2.4	18,594	1.5	479	0.0	8.00E-05
University of MN - Mpls Heating Plant	Boiler 5	21,710	1.7	24,301	1.9			8.00E-05
University of MN - Mpls Heating Plant	Boiler 4	18,903	1.5	10,088	0.8			8.00E-05
University of MN - Mpls Heating Plant	Boiler 3	10,401	0.8	11,982	1.0			8.00E-05
University of MN - Mpls Heating Plant	Boiler 2	12,886	1.0	7,697	0.6			8.00E-05
University of MN - Mpls Heating Plant	Boiler 1	14,413	1.2	12,084	1.0			8.00E-05
University of MN - Crookston	Boiler 4	2,538	0.2	3,093	0.2	2,596	0.2	8.00E-05
St Johns University Order of St Benedict	Boilers 1-2	2,147	0.2	1,412	0.1	3,964	0.3	8.00E-05
St Johns University Order of St Benedict	Boiler 4	1,515	0.1	2,716	0.2	6,951	0.6	8.00E-05
TOTAL public utility/university & college heating		488,065	39.0	380,665	30.5	377,207	30.2	

TOTAL coal use in Minnesota	18,273,253	1,518.2	19,638,554	1,611.7	21,327,914	1,648.3
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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% 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 lb of mercury in 1990 and 175 lb in 2000. 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 fate of mercury in crude oil 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 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, 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 is based on *Substance Flow Analysis of Mercury in Products* (August 2001, <http://www.pca.state.mn.us/air/mercury-mn.html#publications>). Basically the report concludes that it is reasonable to assume that 75% of the mercury in paint volatilizes within a year, with the residual available to volatilize the next year. The report calculates that 3,800 lb of mercury was held within painted surfaces in 1990, and that 2,850 lb (75%) 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 lb, a change that lowers the 1990 baseline by 950 lb.

6. Municipal solid waste (MSW) combustion: The mercury emissions in the following table 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.

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

*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.

7. 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, although it is not clear what the source of the mercury is. 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 Minnesota Office of Environmental Assistance (OEA) estimates the quantity of waste not collected in Minnesota, which is thought to be burned on site, commonly in burn barrels. The following table outlines available OEA data on the production and fate of MSW in Minnesota, and estimates mercury emissions. These figures imply that about 2% 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% 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% 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
Recycling	1,381,690	1,766,528	2,267,952
MSW Compost	Not available	67,997	21,092
Resource Recovery (combustion)	Not available	1,379,329	1,228,830
Landfill	Not available	1,145,067	1,909,152
PMNR	Not available	110,868	110,841
On-site disposal	Assume 110,000	95,226	96,064
TOTAL	Not available	4,565,015	5,633,932
Mercury Content (ppm) (Assumes 30% control at mass-burn waste combustors.)	3.7	1.0	0.6
Mercury Emissions (lb) (Assumes 50% is emitted from burn barrels.)	402	93	60

Notes:

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

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

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

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

Facility	1990 lb Hg emitted	1995 lb Hg emitted	2000 lb Hg/ton	2000 Tons burned	lb Hg emitted
Mayo Foundation, Rochester	115	1	7.71E-05	5,292	0.4
Medical Safety Systems, Cannon Falls	33	25	3.10E-03	1,851	5.7
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
Total Mercury Emitted (lb)	516	36			6.14

Notes:

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

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
November 2000

NW Medical Center, Thief River Falls
Northcountry Regional Hospital, Bemidji

9. 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 lb of mercury were emitted in 1990, 160 in 1995, and 112 in 2000.

	1990	1995	2000
Metropolitan Plant	212	136	95
Seneca Plant	35	24	17
Total Emitted	247	160	112

10. 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% of the mercury is volatilized.

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

11. 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 Hg at 0.2 ppm. The MPCA estimates that Class IV incinerators burned about 138,000 tons in 1990 and 70,000 tons in 1995.

12. Crematoria: Cremation can release significant quantities of mercury because of the mercury amalgam that has been used in people's teeth, and that cremation probably releases all of this mercury to the atmosphere. The MPCA estimates of this source are based on calculations presented in Substance Flow Analysis of Mercury in Products (August 2001, <http://www.pca.state.mn.us/air/mercury-mn.html#publications>).

13. 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 lb of mercury were volatilized from laboratories nationally. Given that Minnesota represents 2% of all economic activity nationally, the MPCA estimates that 44 pounds of mercury were emitted in 1990 and 1995, and that this source declined to 22 pounds by 2000.

14. Dental preparations: Dentists have been using mercury amalgam for over 150 years in the United States. Mercury amalgams typically contain between 42 and 50% mercury. The mercury employed in the amalgam has a variety of pathways to the atmosphere, including direct volatilization during preparation in the dental office, from the consumer'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 5%, although there are presently no data available on the subject

	1990	1995	2000
Dental office	46.2	46.2	46.2
Customer breathing	11	12.1	13.2
Transit loss	46.2	40.7	35.2
Total	103.4	99	94.6

Note: 1995 figures are extrapolated from 1990 and 2000.

15. Hazardous waste incineration: Minnesota has only one hazardous waste incinerator, 3M Chemolite. Based on data submissions from that facility, MPCA estimates annual emissions of 5 lb per year.

16. Landfill volatilization: 0.1% of landfilled 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. 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.

18. Mini-mills that recycle cars and appliances: Mercury is released from the recycling of cars and appliances because of the historical use of 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 North Star Steel. The mass balance shows that in 1998 the total mercury output from the facility was 449 pounds, of which 11 pounds were recycled and 147 pounds were emitted directly to the air (136 from the electric arc furnace stack, plus 11 pounds from the auto shredder stack). According to the mass balance, 214 pounds 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 pounds in 1990, which decreased in 2000 to 176 pounds as a result of removing mercury-containing switches prior to shredding at North Star Steel.

19. Volatilization from dissipative use: Mercury is purposefully used 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 latter 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.)

20. 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 lb of mercury were volatilized from golf courses in 1990, an amount that is much lower than the estimate of 1,487 lb in the August 2001 report. The estimate of 1,487 lb is much better documented than the earlier estimate, so this inventory will use 1,487 lb.

21. 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%) is spilled, and that 5% 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

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 lb of mercury in 1990, 5,000 lb in 1995, and 4,000 lb 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.

22. Volatilization from solid waste collection & processing: This estimate is based on the assumption that 5% of the mercury in solid waste is volatilized during collection, transportation, and mechanical processing. (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
Recycling	1,381,690	1,766,528	2,267,952
MSW Compost	30,000	67,997	21,092
Resource Recovery (combustion)		1,379,329	1,228,830
Landfill	800,000	1,145,067	1,909,152
PMNR		110,868	110,841
On-site Disposal	110,000	95,226	96,064
TOTAL (tons)		4,565,015	5,633,932
Calculated Mercury Content (ppm) (from incinerators)	3.66	0.97	0.62
Total landfill, combusted, composted (tons)	2,200,000	2,592,393	3,159,074
Mercury content (lb) of SW (excluding recycling, PMNR)	16,109	5,031	3,919
Volatilization during handling and transport (lb) (5% of landfill, combustion, composting)	805	252	196

23. Volatilization from the land application of compost: Assumes that 1.0% of mercury applied to the surface of the land volatilizes within a year.

24. 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, and 1.4 ppm in 2000. This estimate assumes that 1% of mercury applied to the surface of the land volatilizes within a year, but does not attempt to calculate any carryover from previous years.

Emissions Incidental to Material Processing

25. Taconite processing: In Minnesota, the iron in taconite ore is concentrated and marble-sized 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 (lb 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 USEPA 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
			L tons/yr		
LTV	11.24	lb Hg/yr	7,798,292 87.7	7,440,366 83.6	7,400,000 83.2
EVTAC	25.20	L tons/yr lb Hg/yr	4,417,255 111.3	5,141,072 129.6	4,200,000 105.8
Hibbing	27.80	L tons/yr lb Hg/yr	8,136,923 226.2	8,386,431 233.1	8,100,000 225.2
Inland	11.89	L tons/yr lb Hg/yr	2,265,876 26.9	2,560,350 30.4	2,878,000 34.2
National	22.18	L tons/yr lb Hg/yr	4,809,930 106.7	5,026,048 111.5	5,450,000 120.9
Northshore	1.10	L tons/yr lb Hg/yr	2,384,061 2.6	3,658,130 4.0	4,300,000 4.7
Minntac	11.73	L tons/yr lb Hg/yr	12,709,299 149.1	12,788,787 150.0	14,607,000 171.3
SUM		L tons/yr lb Hg/yr	42,521,636 710.5	45,001,184 742.3	46,935,000 745.4

26. Pulp and paper manufacturing: In earlier mercury emission inventories for Minnesota, 3.5 lb 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.

Summary of Changes between the Draft Report (September 2002) and the Final Report (March 2004)

These estimates are an update from a draft first released in September 2002. Comments and corrections on the September 2002 draft were received from Xcel Energy, Rochester Public Utilities, Northshore Mining, and the Office of Environmental Assistance. As a result of these comments, estimated total mercury emissions from 1990 decreased a net 1.8 pounds (lb) and 2000 emissions decreased 5.4 lb.

Overall, the September 2002 draft estimated that mercury emissions in Minnesota declined 67.7% (7,631.0 pounds) between 1990 and 2000, from 11,273.8 pounds, to 3,642.8 pounds. The final report incorporates a number of minor corrections, resulting in similar figures: a decline of 67.7% (7,634.5 pounds) between 1990 and 2000, from 11,272.0 pounds to 3,637.5 pounds.

The following specific changes have been made to Minnesota's Mercury Emission Inventory in this Report, compared to a September 2002 draft Mercury Emission Inventory for which comments were solicited by the MPCA:

Coal Combustion:

EVTAC: Coal data had been missing from the draft inventory for 1990 and 1995, which has been added. For all inventory years, the mercury emission factor was changed from 8.00 E-05 lb/ton coal to 3.2 E-05, in accordance with a 1997 stack test that demonstrates that the blend of eastern and western coal used at the facility yields a lower emission factor than the Minnesota average of 8.00 E-05. These changes result from a comment received October 18, 2002 in e-mail from Bradley E. Anderson, EVTAC.

Rochester Public Utilities (RPU): A stack test shows a net mercury emission factor of 3.896 E-05, probably due to the use of Indiana and Illinois coal (capture efficiency of 64%). The new EF is roughly half of the Minnesota average for western coal (8.00 E-05). The lower EF is applied to all inventory years. These changes result from a comment received November 20, 2002 in e-mail from Joe Hensel, RPU.

Riverside (Xcel Energy): The mercury emission factor for Riverside Boiler 8 has been decreased from 6.43E-05 to 5.54 E-05 for 1990-2000, based on stack tests. Fuel totals are also changed slightly to represent the sum of coal plus pet coke. These changes result from a comment received September 30, 2002 in e-mail from Richard Rosvold, Xcel Energy.

Black Dog (Xcel Energy): The quantity of coal combusted in 1990 at Black Dog has been increased slightly, changing 1990 total Hg emissions by about 0.1 lb. These changes result from a comment received September 30, 2002 in e-mail from Richard Rosvold, Xcel Energy.

Minnesota Valley Boiler 4 (Xcel Energy): The quantity of coal consumed in 1995 at Minnesota Valley Boiler 4 has been corrected to 53,849 from 51,599, increasing calculated mercury emissions from 4.1 lb to 4.3 lb. These changes result from a comment received September 30, 2002 in e-mail from Richard Rosvold, Xcel Energy.

Municipal Waste Combustion:

Wilmarth Facility (Xcel Energy): The quantities of refuse-derived fuel (RDF) combusted at Wilmarth was corrected for 1990 and 2000. The 1990 data was changed from 90,312 tons to 90,663 tons. The 2000 data was changed from 203,320 tons to 203,322 tons. The net Hg emissions were also corrected from 1.0 to 7.38 lb for 2000. These changes result from a comment received September 30, 2002 in e-mail from Richard Rosvold, Xcel Energy.)

Red Wing Facility (Xcel Energy): The quantity of refuse-derived fuel (RDF) combusted at Xcel's Red Wing facility for 2000 was corrected from 181,697 tons to 182,204 tons. The net Hg emissions were also corrected from 0.1 to 1.17 lb for 2000. These changes result from a comment received September 30, 2002 in e-mail from Richard Rosvold, Xcel Energy.

Taconite Processing:

Northshore Mining: The emission factor of 0.98 lb Hg emitted per million (short) ton of pellets fired (= 1.10 lb Hg per million long tons fired), was adopted in replacement of the previously used 4.06 lb Hg per million long tons. For 2000, this correction decreases mercury emissions from 17.5 pounds to 4.7 pounds, a decrease of 12.8 pounds. These changes result from a comment received November 22, 2002 in e-mail from Nancy Smith, Northshore Mining.

Mini-mills that recycle cars and appliances:

The study on which these emission estimates are based was reexamined (a mercury mass balance for calendar year 1998, attached to December 28 1999 letter from North Star Steel (NSS) to the MPCA), based on new information on the mercury content of switches in vehicles. The net result of this information is not to change the mercury emission rate from North Star Steel's facility, but rather to change our understanding of the mercury content of various types of scrap, as described below. These changes result from a comment received February 20, 2004 in an e-mail from John Gilkeson, MN Office of Environmental Assistance.

For this revision, the mass balance was adjusted for better information about the mercury content of vehicles and for 2000 throughput (in tons per year), which is slightly different than that for 1998: scrap shredded at NSS declined 0.5 percent, but mercury switch recycling doubled from 11 lb of mercury to 23 lb. In addition, the amount of purchased scrap steel was 45 percent higher in 2000 than in 1998. Throughput varies from year to year at this facility. Because throughput data from 1990 are not available, 1990 inputs are assumed to be identical to 2000 inputs, and emissions are estimated from 2000 data, with the difference that no mercury-containing switches were removed prior to shredding in 1990. Based on this information, the previous emissions estimate for 2000 of 164 pounds per year is revised upward to 176 pounds (165.6 lb from the electric arc furnace, plus 10.5 lb from the shredder). The MPCA assumes that the mercury in the steel scrap is largely associated with mercury switches in vehicles, since appliances (potentially containing mercury switches) represent less than two percent of NSS's total input. According to the 1998 mass balance, 45% of the mercury in switches entering the shredder at the North Star facility is emitted to the atmosphere in Minnesota, mostly in the melt process. Therefore the difference between the 1990 and 2000 calculated air emissions is about 10 pounds, based on the

22.5 pounds of mercury removed by recycling switches in 2000. The previous draft of this mercury emission inventory had estimated 1990 emissions at 171 lb, which is now revised upward to 186 lb.

These figures are based on the 1990 and 2000 mass balances presented below (Figure 2), which were in turn based on the mass balance conducted for the 1998 calendar year (Figure 1). These mass balances assume that all of the material shredded at NSS consists of vehicles, and that each vehicle weighed 3,100 pounds, there were 0.6 switches per vehicle, and that switches contain 1.2 g mercury per switch.

The mercury content of the fluff (0.8 ppm, from the 1998 mass balance) is assumed to have been incorporated into the plastic vehicle components, presumably having been utilized as a curing catalyst. The fluff is separated from the steel prior to melting, and landfilled. No air emissions are assumed from the fluff. The revised mass balance for 1998 calculates that the steel scrap from off-site suppliers contained mercury at the rate of 0.31 ppm (Figure 1). The mercury concentrations found for 1998 are assumed for 1990 and 2000.

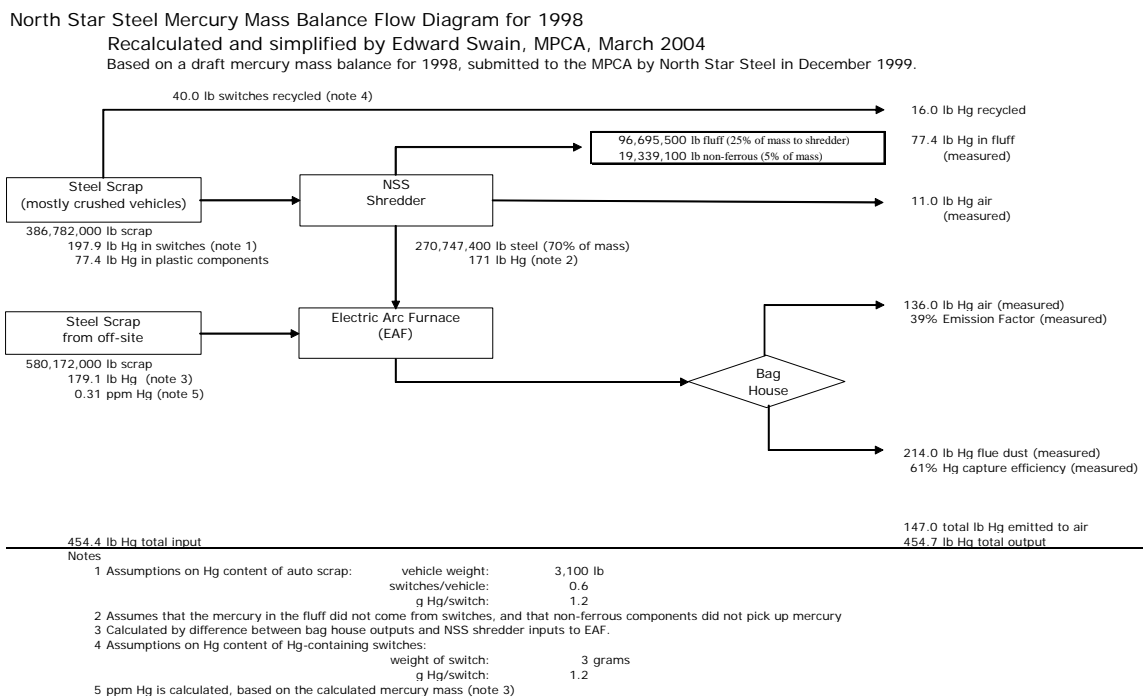
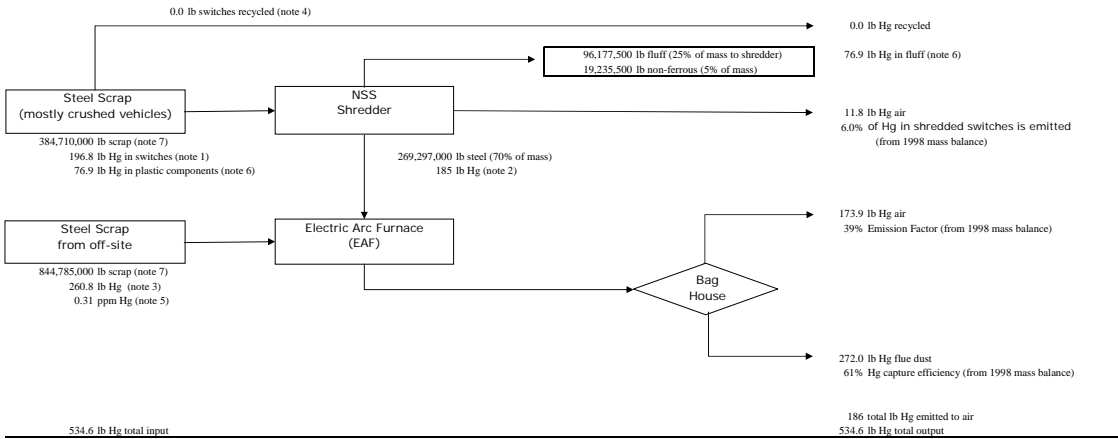


Figure 1. Revised 1998 mercury mass balance for the processing of scrap steel at North Star Steel. In this mass balance, all quantities were measured except the mercury inputs. Mercury in the steel scrap introduced to the NSS Shredder is calculated from estimates of the mercury content of switches in vehicles (see note 1 in the figure). The mercury concentration in the “Steel Scrap from off-site” is calculated by difference.

North Star Steel Mercury Mass Balance Flow Diagram for 1990
 Recalculated and simplified by Edward Swain, MPCA, March 2004
 Based on a draft mercury mass balance for 1998, submitted to the MPCA by North Star Steel in December 1999.



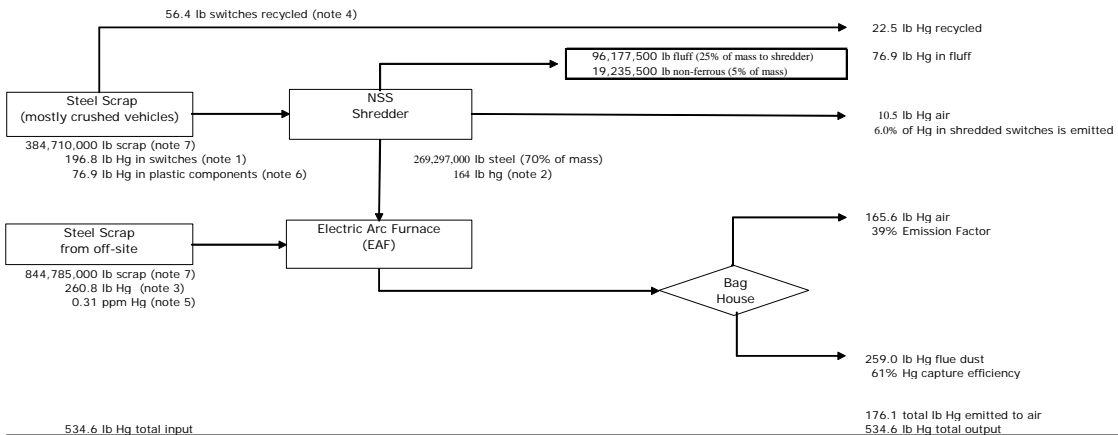
- Notes
- Assumptions on Hg content of scrap:

vehicle weight:	3,100 lb
switches/vehicle:	0.6
g Hg/switch:	1.2
 - Calculated as the difference between the Hg in switches and the sum of recycling and emissions within the shredder.
 - Based on the Hg concentration calculated for the 1998 mass balance, 0.31 ppm Hg.
 - Assumptions on Hg content of Hg-containing switches:

weight of switch:	3 grams
g Hg/switch:	1.2
 - Based on Hg concentration calculated from 1998 mass balance
 - Assuming that 25% of the mass produces plastic fluff, which is 0.8 ppm Hg (1998 mass balance finding)
 - From data provided by NSS, March 3, 2004

192,355 tons to shredder
557041 tons to EAF

North Star Steel Mercury Mass Balance Flow Diagram for 2000
 Recalculated and simplified by Edward Swain, MPCA, March 2004
 Based on a draft mercury mass balance for 1998, submitted to the MPCA by North Star Steel in December 1999.



- Notes
- Assumptions on Hg content of scrap:

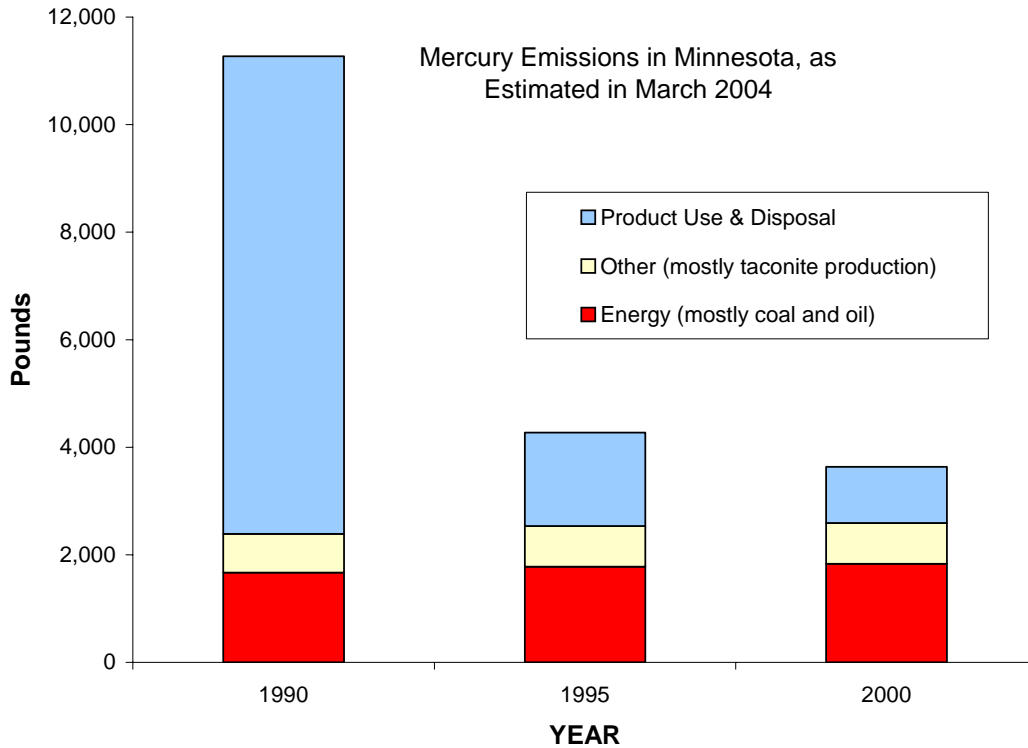
vehicle weight:	3,100 lb
switches/vehicle:	0.6
g Hg/switch:	1.2
 - Calculated as the difference between the Hg in switches and the sum of recycling and emissions within the shredder.
 - Based on the Hg concentration calculated for the 1998 mass balance, 0.31 ppm Hg.
 - Assumptions on Hg content of Hg-containing switches:

weight of switch:	3 grams
g Hg/switch:	1.2
 - Based on Hg concentration calculated from 1998 mass balance
 - Assuming that 25% of the mass produces plastic fluff, which is 0.8 ppm Hg (1998 mass balance finding)
 - From data provided by NSS, March 3, 2004

192,355 tons to shredder
557041 tons to EAF

Figure 2. 1990 and 2000 mercury mass balances for the processing of scrap steel at North Star Steel. The 2000 mass balance uses 2000 data for quantities of steel scrap and the quantity of recycled mercury switches. All other calculations are proportional to the 1998 mass balance. The 1990 mass balance shows the effect of not recycling any mercury switches; all data is the same as for 2000, except for zero recycling. Actual throughput data is not available for 1990.

The calculated emission reduction between 1990 and 2000 is conservative, because of significant enhancements in air pollution control equipment at North Star Steel at both the melt shop (air flow was increased to bag house in 1994 and the shredder (a wet scrubber was added in 1997).



Minnesota Mercury Emissions (2000)

