Binational Toxics Strategy — Mercury Sources and Regulations, 1999 Update

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A Note on Methodology and Sources

This paper updates an original report written by Ross & Associates in 1993, entitled Virtual Elimination Pilot Project: Mercury Sources and Regulations. The analytical framework and organization remain largely the same, with a few notable changes. First, this paper adds a section on the global mercury reservoir as a source of mercury deposition, to incorporate new knowledge derived from scientific research published since 1993 on the behavior of mercury in the environment, especially the cycling of mercury from the oceans to the atmosphere, and its retention, chemical transformation, and long-range transport. A corresponding section on international regulations has also been included.

Second, the original paper's focus on the regulations and data sources for Great Lakes States has been broadened to capture a national picture of States' activities. In part, this is made possible by several other EPA publications and documents, whose contents have been liberally employed in this paper. Foremost is the 1997 Mercury Study Report to Congress, an exhaustive review of every environmental aspect of mercury. This 9-volume report has numerous charts and diagrams, and extensive references for those interested in detailed information on mercury. EPA's Mercury National Action Plan, the United States Status Report on Mercury, and the Mercury Products Study by John Gilkeson of the Minnesota Pollution Control Agency were also extremely helpful. Other references include a 1997 report done by the Swedish National Chemicals Inspectorate (KEMI), Mercury in Products - a source of transboundary pollutant transport. For a full list of sources see **Appendix G, Bibliography.**

Third, paper does not distinguish between different types of mercury in its discussion of sources. The scientific literature emphasizes the significant behavioral differences among elemental mercury, ionic mercury, and organic and inorganic mercury compounds, in terms of accumulation in the aquatic food chain, atmospheric and oceanic residence times (the former greatly influencing long-range transport), and rates and forms of deposition. However, available source data do not specify the forms of mercury emitted from sources. Current scientific research will improve understanding of this issue in the years to come.

Background Information on Mercury Sources and Regulations

I. Introduction

Mercury enters our lives more frequently than we may imagine. It may be in the fluorescent lights in our office, in old cans of latex paint, in our batteries, in our dental fillings, and numerous other sources. In the United States manufacturers used an estimated 381 tons of mercury in 1997, in products or in manufacturing processes.

A naturally-occurring element, mercury's value in numerous industrial processes was discovered centuries ago. Over time, however, we have discovered that mercury is a potent neurotoxin, particularly in the organic, methylmercury, form, capable of impairing neurological development in fetuses and young children and damaging the central nervous system of adults. People are most likely to be exposed to harmful quantities of mercury through consumption of fish contaminated with methylmercury. Exposure to elemental mercury vapor in indoor air can also cause serious harm.[1]

Fish consumption advisories throughout Great Lakes water bodies testify to the health risks caused by mercury present in the Great Lakes ecosystem. Mercury contamination is the most frequent basis for fish advisories issued by States or Tribes, represented in 60 percent of all water bodies with advisories. Thirty-nine states have issued fish consumption advisories in one or more water bodies, and ten States have issued statewide mercury advisories.[2&3]

The Great Lakes Binational Toxics Strategy, signed by Canada and the United States in April 1997, is an effort to reduce mercury and other persistent toxic substances in the Great Lakes. The Strategy sets a goal of virtual elimination of mercury from the Great Lakes Basin, with a U.S. challenge of 50 percent reductions nationwide in the use and release of mercury by 2006, and a Canadian challenge of 90 percent reduction in release of mercury in the Great Lakes basin by 2000. It creates a four-step process for each pollutant it addresses. Step one is information gathering about sources and uses; step two is analysis of current regulations, initiatives and programs which manage or control the pollutant; step three is identification of cost-effective options to achieve further reductions, and step four is implementation of actions towards the goal of virtual elimination. This report documents steps one and two, relating to sources and regulations of mercury in the United States.

Mercury in the Environment

[1] Exposure to elemental mercury is most likely in occupational settings, but also occurs in schools and homes, when spilled mercury is not properly cleaned up. When exposed to air elemental mercury evaporates at room temperature, creating potentially harmful vapors. Exposure to inorganic mercury can also occur from drinking contaminated water and touching contaminated water and soil, although harmful exposures are much less common through these routes.

[2] USEPA 1997b, p. 2.

[3] USEPA 1997a, Vol. I, 2-6.

When released to the environment inorganic mercury can be converted to methylmercury. Most environmental releases of mercury are inorganic, either in the elemental or ionic form. Most emissions of ionic mercury deposit within the region of the source, while elemental mercury enters a global atmospheric reservoir where it can remain for approximately one year, potentially traveling long distances.[4] In the environment, these forms of mercury can be converted to methylmercury, which can bioaccumulate and can reach dangerous levels in fish at the top of the aquatic food chain.

Mercury does not degrade and is not destroyed by combustion. Although the global mercury cycle is imperfectly understood, scientists have reached consensus on important aspects of the behavior of mercury in the environment. Mercury cycles extensively between soils, the atmosphere, and surface waters. Scientists believe that atmospheric deposition of mercury emitted into the air by combustion, incineration, or manufacturing processes, contributes a large portion of the mercury found in waters and soils. In Minnesota, researchers estimated that in 1995, direct industrial discharges of mercury to surface water contributed only 1 to 2 percent of the mercury load to surface waters, while atmospheric deposition was responsible for 98 percent[5]. Mercury also has a long retention time in sediments and soils, and so may continue to be released from such depositions to surface waters and the atmosphere for long periods of time, possibly hundreds of years.[6]

Mercury emissions come from natural sources including marine and aquatic environments, as well as volcanic and geothermal activity. However, recent studies suggest that anthropogenic sources contribute the majority of mercury releases, and that the total atmospheric mercury burden has increased by a factor of between 2 and 5 since the beginning of the industrial age. Human activity has thus increased the amount of mercury circulating globally, the global mercury reservoir. Approximately one-third of total current global mercury emissions are thought to cycle from the oceans to the atmosphere and back, but it is believed that much less than 50 percent of the oceanic emission is from mercury originally mobilized by natural sources.[7] Recycling of mercury at the earth's surface, especially from the oceans, extends the influence and active lifetime of anthropogenic mercury releases. One study conservatively estimates that if all anthropogenic emissions ceased, it would take 15 years for mercury reservoirs in the oceans and the atmosphere to return to pre-industrial conditions. Others have estimated it could take much longer.[8]

Like global climate change and acid rain, therefore, mercury is a long-term, international concern that has disparate regional impacts. Mercury vapor in the atmosphere disperses widely, and can travel thousands of miles. However, in general, atmospheric deposition is higher in areas closer to emissions sources, and in those with greater annual precipitation. The 1997 Mercury Report to Congress (MRC)

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[4] MRC modeling indicates that less than two percent of U.S. elemental mercury emissions deposit within the United States, while more than 70 percent of U.S. ionic mercury emissions deposit with the United States. Roughly 40 percent of U.S. particle-bound mercury are thought to deposit within the United States. (Vol 1, 3-14).

[5] Minnesota Pollution Control Agency 1999, p. 22.

[6] USEPA 1997a, Vol. I, 2-4.

[7] USEPA 1997a, Vol. II, ES-2.

[8] USEPA 1997a, Vol. I, 3-3.

predicts the highest deposition rates in the United States to occur in the Great Lakes Basin, the Ohio River Valley, the Northeast and scattered areas in the South, with the Miami and Tampa areas experiencing the greatest mercury deposition.

The MRC used pollution fate and transport modeling to assess whether mercury deposition within the United States can be attributed primarily to anthropogenic U.S. sources, or to natural and foreign sources. The MRC estimated that, in 1995, of the total global annual input of 5,500 tons of mercury to the atmosphere from all sources, natural and anthropogenic, U.S. anthropogenic emissions contributed about 3 percent, or 158 tons. Of these, about one-third (~ 52 tons) are deposited in the lower 48 States, while the remaining two-thirds (~107 tons) diffuse beyond U.S. borders into the global reservoir.[9] The U.S. also receives mercury deposition from the global reservoir, calculated at about 35 tons in 1995.[10] Thus, U.S. anthropogenic emissions account for an estimated 60 percent of deposition in the United States, with remaining 40 percent attributed to the global reservoir. It is likely that reductions in emissions from incinerators since 1995 have reduced the share of mercury deposition in the United States attributable to U.S. sources.

The MRC estimates contain considerable uncertainty. Most importantly, there are uncertainties in the emissions inventory used for this modeling, including the mass of emissions from many sources, including natural sources. Moreover, the species of mercury emitted by most sources is highly uncertain; this issue is significant because ionic mercury emissions are expected to contribute substantially more deposition in the United States would an equal amount of elemental mercury emissions. Elemental mercury emissions have a greater impact on the global mercury pool.

Another means of assessing the relative contribution of U.S. sources to deposition in the United States makes use of actual environmental measurements. This approach compares levels of (and changes in) mercury deposition in remote areas, primarily influenced by deposition from the global pool of mercury, with deposition in areas closer to major sources of mercury emissions. One such study, using comparison of sediment cores from lakes in Minnesota and Alaska, concluded that roughly 40 percent of mercury deposition in the upper Midwest is attributable to U.S. anthropogenic sources, with the remainder divided approximately equally between natural emissions and global anthropogenic sources. This study noted that the importance of U.S. anthropogenic sources is likely declining, while global anthropogenic sources are contributing increasing amounts of mercury deposition.[11]

Reducing Mercury

At the state, federal, and international levels, numerous efforts are underway to curtail mercury releases into the environment. To understand what options are available to reduce mercury use and release we must first answer three basic questions:

[9] USEPA 1997a, Vol. I, O-1.

[10] USEPA 1997a, Vol. I, 3-3.

[11] Engstrom & Swain, 1997.

(1) What are the **sources** of the mercury (supplying mercury and releasing mercury) into the environment?

(2) What **products** contain mercury?

(3) What **regulations** and **non-regulatory measures** currently influence mercury use and release?

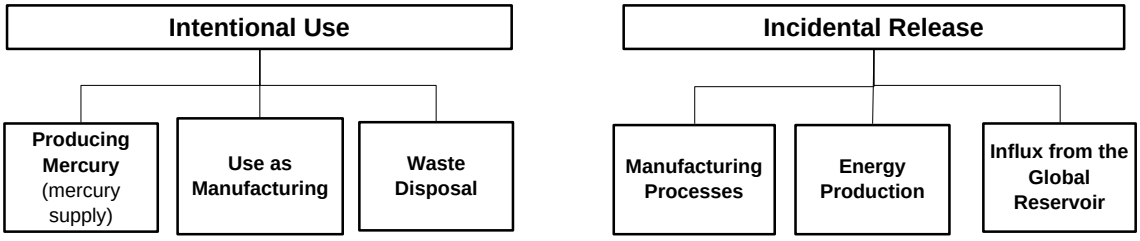
The objective of this background paper is to provide a context for understanding the full range of mercury sources and existing regulations that affect mercury use and release. From this information, we will be able to understand the extent to which existing regulations encourage a reduction in mercury use and release, and identify other opportunities--including regulatory and non-regulatory programs--that might hasten the pace of reductions.

Table 1 provides an overview of the material covered in this background section.

Table 1: Overview of Mercury Sources and Regulations

What are the Sources of Mercury?

Describes the six categories of anthropogenic mercury sources covered in this analysis.



How is Mercury Regulated?

Characterizes the different types of mercury regulations.
Describes how mercury use and release is regulated by the relevant statutes in each category.

Links regulations to specific mercury sources.
Identifies mercury-related products, processes, and standards regulated at the international, federal and state levels.

II. What Are the Sources of Mercury?

Mercury enters the atmosphere through the mobilization or release of geologically bound mercury by natural processes and human activities. Mercury is also re-emitted to the atmosphere by biological and geological processes drawing on a pool of mercury that was deposited to the earth's surface after initial mobilization by either human or natural activities.[12] This report focuses on anthropogenic sources of mercury.

This report divides U.S. anthropogenic mercury sources into two broad groups, based on these two different roles of mercury: is mercury intentionally used or is it incidentally released? In addition to U.S. anthropogenic sources, the Great Lakes receive mercury deposition as the result of inputs from the global reservoir of atmospheric mercury emitted by natural sources and global anthropogenic sources. **Table 2** details the categories of mercury sources used in this report.

Intentional Use: When mercury is used intentionally as an input in production processes or consumer products, three distinct but inter-related types of activities contribute to mercury releases. Activities in this category include:

(1) **Production** or **supply** of mercury;
(2) **Use** of mercury as part of a manufacturing process or within a product; and
(3) **Disposal** of mercury-containing wastes.

These activities, especially waste disposal, release mercury into the environment. Because the quantity of mercury used directly influences a significant amount of the mercury ultimately released into the environment, several leverage points are potentially available to reduce mercury releases. The price and supply of mercury, the feasibility of recycling, the availability of alternative inputs or processes, and the structure of existing regulations all contribute to a company's decision to use mercury in their production processes or products.

Incidental Release: Incidentally released mercury comes from three categories of sources:

(1) **Energy Production** where the fuel source (primarily coal) contains mercury;
(2) **Mobile sources** where the fuel source (primarily diesel) contains mercury; and
(3) **Manufacturing processes** where the raw materials contain trace amounts of mercury

These activities, particularly coal combustion, contribute a large portion of overall mercury air emissions. In many countries, copper, lead and zinc smelting are also large mercury emitters. However, because these processes do not rely on mercury, their mercury emissions are not influenced by the costs associated with using mercury. They are affected only by regulatory costs associated with releasing mercury. Therefore, the opportunities for reducing mercury releases from these sources will differ from those for sources that rely on mercury for some aspect of their business.

[12] USEPA 1997a, Vol. II, ES-1.

Table 2: Sources of Mercury

Related to Intentional Use			Incidental Use		
Producing or Supplying Mercury	Use In Manufacturing* (products containing or processes using mercury)	Waste Disposal (mercury- containing products or wastestreams)	Manufacturing Processes (raw materials containing mercury)	Energy Production (fuel source contains mercury)	Influx from the Global Reservoir
Primary Hg Production (by-product of gold mining)	**Chemical and Allied Products**	Municipal Waste Incinerators	Carbon Black Production	Utility Boilers	Emissions from other countries
Secondary Hg Production (mercury recovery)	Chlorine/Caustic Soda Lab Uses Paint Catalysts Pesticides Pharmaceuticals	Commercial/ Industrial Waste Incinerators	Coke Production	Commercial & Industrial Boilers	Returning U.S. Emissions
Mercury Compound Production	**Electrical & Electronic Uses**	Sewage Sludge Driers & Incinerators	Petroleum Refining	Residential Boilers and wood stoves	Natural Emissions
Government Stocks	Electric Lighting Wiring Devices & Switches Battery Manufacturing	Wastewater Treatment (POTWs)	Lime Manufacturing	Mobile Sources (gas, diesel combustion)	
National Defense Stockpile (primary mercury)		Hazardous Waste Incinerators	Portland Cement Manufacturing	Gas Turbines & Stationary Internal Combustion Engines	
DOE Stocks (secondary mercury)	**Instruments & Related Products**	Medical Waste Incinerators	Phosphate-based Fertilizer Production		
Imports	Measuring & Control Devices Dental Equipment & Supplies Hospitals, Dentists	Landfill	Copper Smelting & Refining		
		Iron & Steel Production	Non-ferrous Metals Smelting (Except Copper & Aluminum)		
		Ash Disposal Facilities	Pulp & Paper Manufacturing		
		Auto Salvage/Scrap yards			
		Crematories			

The source categories used throughout this report are, for the most part, consistent with sources identified in recently released reports that track mercury use and emissions, specifically the U.S. Geological Survey *Minerals Yearbook* and the *Mineral Commodity Summary* (formerly the Bureau of Mines *Mineral Industry Surveys*), the USEPA 1997 Mercury Study Report to Congress, and the USEPA *1990 Emissions Inventory of Forty Potential §112(k) Pollutants* under the Clean Air Act Amendments of 1990 (§112(n)(1)(B)). By using similar source categories, we can combine information on mercury use and emissions trends at a national level with an overview of existing regulations.

Influx from the Global Mercury Reservoir: According to the MRC, a computer simulation of long-range transport of mercury suggests that 35 tons of mercury from the global reservoir is deposited in the

continental United States annually.[13] While some of the mercury in the global reservoir has been mobilized by natural processes, human activity is responsible for several-fold increases in the total atmospheric mercury burden over the last two hundred years. These increases have raised atmospheric deposition rates, even in areas far from mercury sources, and make mercury emissions an international policy issue.

According to the MRC computer simulation, U.S. sources add roughly three times more mercury to the global reservoir annually than is deposited from the global reservoir to the continental United States. Other nations will therefore look to reduce U.S. emissions. Over the last decade, however, the United States has both drastically reduced the use of mercury in products and manufacturing processes, and passed regulations that will limit mercury emissions from waste combustion (see **Table 14: Actual and Projected Mercury Emissions**). The United States has an interest in encouraging other nations to make similar reductions. Domestic regulation of mercury releases will therefore reduce U.S. mercury levels more effectively if it helps encourage international efforts to control mercury releases abroad.

Appendix A includes a detailed "use tree" of mercury sources.

A. U.S. Anthropogenic Mercury Emissions Inventory

Note: the following information about the mercury emissions inventory, while based on official USEPA estimates, differs from these estimates in some details. This is preliminary information that has not been fully reviewed within USEPA, and should not be considered an official USEPA emissions inventory. These estimates are likely to be revised in the final version of this report, particularly after release of the 1996 National Toxics Inventory.

Estimated anthropogenic mercury emissions in the United States during 1994/95 were 149 tons per year, a 25 percent reduction from 1990 estimated emissions. **Table 3** summarizes mercury emissions in 1990 and 1994/95, based primarily on two mercury emissions inventories prepared by USEPA--the 1990 inventory, published in 1999 under Section 112k of the Clean Air Act, and the 1994/1995 inventory, which was published in 1997 in the Mercury Report to Congress. The figures reported here reflect some adjustments to the inventories as published by USEPA.[14]

[13] USEPA 1997a, Vol. I, O-1.

[14] The 1990 inventory figures remove some apparent errors in the 112k inventory, which seems to have double-counted emissions from the category “chlorine production” under the categories “chemical manufacturing: alkalies and chlorine,” “hydrochloric acid production” and “industrial inorganic chemical manufacturing.”

The 1994/95 data contains some significant adjustments from the Mercury Report to Congress inventory. These adjustments were made in two different situations:

- where the 1990 112k inventory contained a category not included in the Report to Congress inventory (note that the 1990 inventory was prepared more recently than the 1994/95 inventory). For instance, the 112k inventory estimates nearly 12 tons emitted from non-road and on-road mobile sources, while the Report to Congress made no estimate for this category.
- where the 1990 112k inventory and the Report to Congress inventory contained widely differing estimates for a source sector that do not appear to reflect actual changes in emissions, but rather a change in the estimating technique. For instance, the 112k inventory estimates 2 tons of emissions from industrial boilers and one ton of emissions from

Source sectors are listed in order of 1994/95 emissions mass. Coal-fired utility boilers are the largest source category, accounting for approximately one-quarter of emissions in 1990 and one-third of emissions in 1994/95. Medical waste incinerators drop from approximately one-quarter of 1990 emissions to one-tenth of the 1994/95 emissions, while municipal waste combustors are approximately one-fifth of emissions in both 1990 and 1994/95.

Table 3: U.S. Mercury Emissions Estimates (tons)

	1990	*1995*
Utility Boilers-coal	51.0	51.6
Municipal Waste Combustors	41.7	29.6
Medical Waste Incinerators	50.2	16.0
Chlorine Production	10.0	7.1
Hazardous Waste Incineration	5.7	7.1
Mobile Sources-non Road	6.8	6.8
Mobile Sources-on Road	5.0	5.0
Portland Cement (Non-hazardous Waste Fired)	4.0	4.0
Industrial Boilers	2.1	2.1
Pulp and Paper (Combustion) MACT Sources	1.9	1.9
Animal Cremation	1.7	1.7
Lamp Breakage	1.5	1.5
Petroleum Refineries: CCUs, CRUs, SPUs	1.4	1.4
Geothermal Power	1.3	1.4
Residential Heating, Distillate Oil Combustion	1.3	1.4
Institutional/commercial Heating	1.1	1.1
General Laboratory Activities	0.8	1.1
Sewage Sludge Incineration	1.8	1.0
Other*	9.2	6.8
Total	198	149

* Other:

Electric Lamps
Lime Manufacturing
Dental Preparation and Use
Pulp Mills (not subject to Pulp and Paper MACT)
Human Cremation
Residential Heating: Bituminous & Lignite Coal Combustion
Landfills
Primary Copper Smelting
Petroleum Refining (not subject to Pet Ref MACT)

institutional/commercial heating. By contrast, the Report to Congress estimated 28.4 tons of emissions from commercial and industrial boilers. This difference cannot be explained by increased coal combustion in this sector, since DOE data shows flat or declining coal combustion for the industrial/commercial sectors. In other cases, no adjustment was made because the difference between the two inventories could be explained through changes in a sector, such a reduced production (chlorine production sector, copper smelting) or pollution reduction efforts (medical waste incinerators, municipal waste combustors).

Instrument Manufacturing	*Utility Boilers-Coke*
Secondary Mercury Production	*Residential Heating: Anthracite Coal Combustion*
Carbon Black Production	*Industrial Organic Chemicals Manufacturing*
Blast Furnace and Steel Mills	*Secondary Lead Smelting*
Secondary Nonferrous Metals Production	*Electronic Components, nec*
Utility Boilers-Oil	*Fluorescent Lamp Recycling*
Space Research and Technology	*Inorganic Pigments Manufacturing*
Stationary Internal Combustion Engines	*Nonmetallic Mineral Products Manufacturing*
Custom Compound Purchased Resins Manufacturing	*Polymers & Resins (I, II and IV)*
	Aerospace Industries
Clay Products Manufacturing	*Plating and Polishing*
Primary Lead Smelting	*Electrical Industrial Apparatus, nec*
Miscellaneous Organic NESHAP Sources	*Primary Battery, Dry and Wet Manufacture*
Mobile Sources: Commercial Marine Vessels	*Paints and Allied Products Manufacturing*
Residential Heating: Wood/Wood Residue Combustion	

There are significant uncertainties in many of the emissions estimates. For instance, emissions from the most significant emissions source within the chlorine production sector, the chlor-alkali mercury cell room, are not directly measured but rather are based on emission factors developed during the 1970s. Mobile source emissions estimates were developed recently, but are based on a small number of emissions tests.

In general, few categories in the 112k and MRC inventories in have estimates developed from a true "bottom-up" basis, that is, estimates developed specifically for individual sources and then summed to obtain a national total. Instead, both reports adopt "top-down" emissions estimate techniques. For example, the MRC used an emission factor-based approach to develop both facility-specific and nationwide emissions estimates. This approach requires an estimate of the ratio of the mass of mercury emitted to a measure of source activity, such as total heat input for fossil fuel combustion. Using this ratio, called the "emission factor," and an estimate of the annual nationwide activity level for each source, the report generates a national emissions estimate for that source activity. Emission factors reflect the 'typical control' achieved by the air pollution control measures applied across the population of sources within a source category. The emission factor-based approach does not generate exact emission estimates. Uncertainties are introduced in the estimation of emission factors, control efficiencies, and the activity level measures.[15]

Moreover, at least two potentially significant sources are missing from the 112k and Report to Congress inventories–use of iron and steel scrap and solid waste processing and transport. Using emission estimates developed for these categories in **Section II, 3, B**, would make total emissions for 1995 176 tons, a 27 percent decrease from 1990 [**see Table 4**]. These estimates are highly uncertain.

Table 4: U.S. Anthropogenic Mercury Emissions (tons)

	1990	*1994/95*
Emissions from 112k and MRC categories	198	148

[15] USEPA 1997a, Vol. II, ES-2.

Use of steel scrap	12	12
Solid waste processing and transport	32	16
Adjusted Total	242	176

The inventory can be divided between emissions related to intentional use of mercury and emissions related to use of fuels or materials that contain trace amounts of mercury.[16] Taking just those sources that account for more than one ton of mercury emissions per year in 1994/95, sources that result from intentional mercury use are: municipal waste combustors, medical waste incinerators, chlorine production, hazardous waste incineration, sewage sludge incineration, land breakage, and general laboratory activities. Emissions from these sources added to 63.4 tons annually in 1994/95. If the estimates for use of steel scrap and solid waste processing and transport are added, emissions related to deliberate use add to 91.4 tons per year. Incidental release sources greater than one ton in 1994/95 are: coal-fired utility boilers, non-road and on-road mobile sources, Portland cement production, industrial boilers, pulp and paper production, animal cremation (though these emissions may be partly the result of deliberate use as well), petroleum refineries, geothermal power, distillate oil combustion for residential heating, and commercial/institutional heating. These sources added to 79.1 tons annually in 1994/95.

The source categories that emit the most mercury nationally are likely the biggest emitters in the Great Lakes region as well, with some differences. The Great Lakes States account for 29 percent of U.S. population, but 36 percent of estimated mercury emissions from electric utilities,[17] likely as the result of greater coal use by Midwestern utilities than the national average. Two mercury cell chlor-alkali facilities in the Great Lakes basin account for 19 percent of chlorine production capacity among the 12 mercury cell facilities nationwide. Some sources that are not significant in the national inventory are important in the Great Lakes Region; for instance, the only taconite production in the United States occurs in Minnesota and Michigan, and accounts for roughly half a ton of estimated mercury emissions annually.

B. Intentional Use

This section provides a brief overview of the three stages of the mercury life cycle that contribute to mercury releases as a result of intentional mercury use: 1) production; 2) use; and 3) disposal. Most releases come during the disposal stage, but the production and use stages provide potential intervention points to influence the amount of mercury ultimately released in the disposal stage.

1) Production or Supply of Mercury

The mercury available for use in the United States comes from five main sources: 1) Primary mercury production; 2) Secondary mercury production (mercury recovery); 3) Mercury compound production; 4)

[16] The MRC divides anthropogenic mercury sources into the following broad groups, based on their emission properties: (1) combustion point sources; (2) manufacturing point sources; (3) miscellaneous point sources; and (4) area sources. Note that the individual source categories in the mercury study are similar to the ones used in this report.

[17] Derived from USEPA 1997a, Vol. II, Table A-1.

Government stocks; and 5) Imports. **Table 8** illustrates the relative contributions of these sources to the United States mercury supply.

Primary Mercury Production. Virgin mercury is mined from mercury ore or produced as a by-product of gold mining. In the United States, mercury is produced only as a by-product of gold mining. The last mercury ore mine, the McDermitt Mine in Nevada, closed in 1990. No by-product mercury mines are located in the Great Lakes States. Primary mercury production continues in other countries including Spain, China, and the former Soviet Union.

Table 5: Byproduct Mercury-producing Mines in the United States (1997)
Source: U.S. Geological Survey, Minerals Yearbook, 1998

Mine	Location	Operator
Alligator Ridge	White Pine, NV	USMX Inc
Carlin Mines Complex	Eureka, NV	Newmont Gold Co.
McGlaughlin	Napa, CA	Homestake Mining Co.
Mercur	Tooele, UT	Barrick Mercur Gold Mines Inc.
Pinson	Humboldt, NV	Pinson Mining Co

- **Secondary Mercury Production**. Mercury is recovered from discarded products and industrial wastes such as chlor-alkali wastes, dental amalgams, fluorescent light tubes, electronic devices, batteries, and other instruments such as thermometers. There are two basic categories of secondary mercury production: recovery of liquid mercury from dismantled equipment and mercury recovery from scrap products using extractive processes[18]. Liquid extraction involves draining the liquid mercury from dismantled equipment. Recyclers use thermal or chemical processes to extract mercury from scrap. Most commonly, the mercury is vaporized in a retort and collected by condensation. Condensed mercury is then distilled to remove impurities. Triple-distilling yields the highest purity mercury.

  Recovery of liquid mercury accounts for most secondary production. One mercury recycler, Bethlehem Apparatus Company, estimated that mercury recovered using extractive processes accounted for 15 to 20 percent of the total mercury reported as recycled from industrial scrap in 1995. Secondary production reached a high of 534 tons (122 percent of industrial demand) in 1995, but has since fallen. **Table 6** below shows the trends in U.S. mercury consumption and secondary mercury production.

Table 6: Secondary Mercury Production in the U.S. (Tons)
Source: U.S. Geological Survey Minerals Yearbook, 1997

	1950	*1960*	*1970*	*1980*	*1990*	*1995*	*1997*

[18] USEPA 1997a, Vol. II, 4-47.

Industrial demand (consumption)	1867	1940	2332	2236	792	480	381
Secondary production (industrial)	76	202	278	257	119	587	428
Secondary production as a percent of consumption	4%	10%	12%	12%	15%	122%	112%

Three facilities, all located in Great Lakes states, produce the bulk of secondary mercury in the United States. D.F. Goldsmith Chemical and Metal in (Evanston, IL) specializes in distilling 99 percent or greater flowable mercury, and Bethlehem Apparatus (Hellertown, PA) and Mercury Refining Company (Albany, NY) retort and distill a wide variety of mercury wastes and scrap material. However, they do not accept certain types of Resource Conservation and Recovery Act (RCRA) wastes. Currently, eleven plants in the U.S. recycle mercury from fluorescent lights, using physical separation to recover mercury. Six of these facilities opened in 1993.

Secondary mercury production released an estimated 0.4 tons of mercury in 1995.

- **Mercury Compound Production**. Mercury compounds are used in a wide variety of pharmaceuticals and other products. Commonly used mercury compounds include mercuric oxide (cathode material in batteries), mercuric chloride (pharmaceuticals), phenylmercuric acetate (used in paints and pharmaceuticals), mercuric sulfide (used in red pigment and pharmaceuticals), and thimerosal (a preservative used in medicines and contact lens solution). One mercury compound manufacturer is currently located in Great Lakes states:

Table 7: 1995 U.S. Mercury Compound Producers
Source: Mercury Study Report to Congress, 1997.

Producer	Location	Compound(s)
Elf Atochem North America, Inc., Chemical Specialties Division	Tulsa, OK	HgF_2, Hg_2F_2
Johnson Matthey, Inc.	Ward Hill, MA	$Hg_2 (NO_3)_2$
GFS Chemicals, Inc.	Columbus, OH	$HgBr_2$, HgI_2, $Hg (NO_3)_2$, $HgSO_4$
R.S.A. Corp.	Danbury, CT	Hg(SCN)2 - thiocyanate

- **Government Stocks**. The United States government maintains a supply of mercury as part of the National Defense Stockpile, established at the end of World War I to maintain adequate supplies of materials deemed critical to national defense. The Defense Logistics Agency (DLA), a unit of the Department of Defense, manages the stockpile. DLA periodically evaluates the quantity of mercury and other materials needed in the stockpile, and may sell any "excess" material on the open market. Mercury is stored and sold in flasks, which contain 75.9 pounds of mercury. Regulations governing the sale of excess mercury are described in Section III ("Regulations").

  At the end of April 1994, DLA held 127,000 flasks (4,819 tons) of mercury in the stockpile. With a current stockpile goal of zero for mercury, all of this material is considered excess. After

selling its entire 1994 mercury allocation (10,000 flasks), DLA suspended future mercury sales in July 1994 until the environmental implications of these sales are addressed.

The Department of Defense (DOD) recently completed an Environmental Assessment on the sale of its currently managed mercury stockpile. Based on the National Environmental Policy Act and the results of this assessment, DOD will now conduct an Environmental Impact Statement (EIS) on the disposition of the stockpile. Because EIS process is comprehensive, a final EIS may take several years to complete. In the meantime, DOD has begun a complete review of the five facilities across the U.S. currently storing its mercury, and is inspecting all the mercury containing flasks to ensure proper and safe storage.

The Department of Energy (DOE) is storing approximately 145 tons of mercury. DOE has identified 5 tons of mercury-contaminated wastes currently awaiting disposal as part of an ongoing inventory of such wastes. DOE's Mixed Waste Focus Area-Mercury Working Group, in conjunction with EPA, has initiated studies of the direct treatability and disposal of high mercury-inorganic subcategory wastes that contain radioactive materials resulting from nuclear weapons production. These treatability studies include the evaluation of technologies such as alternative oxidation technologies, stabilization using specialized amendments, amalgamation technologies, sulfur polymer cement stabilization, and mercury solubilization and removal.

- **Imports**. The United States imported 180 tons of mercury in 1997, the most recent year for which data are available. Estimated 1998 imports are 220 tons. From 1994 to 1997, 37 percent of U.S. imports came from Russia, 25 percent from Canada, 13 percent from Kyrgyzstan, and 10 percent from Spain. Mercury compounds are also imported. **Section III, B, 1 "Mercury in Commerce"** discusses mercury imports and relevant tariffs in more detail.

Table 8: United States Mercury Supply and Demand (tons)
Sources: US Bureau of Mines, Mineral Industry Surveys, 7/22/1994, US Geological Survey, Mineral Commodity Summary, 1999

	1988	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***1997***	***1998e***
Producing Mines						9	7	8	6	5	5
Mine production (1) - tons	417	455	493	0	0	0	0	0	0	0	0
By-product production (2)	w	w	125	64	70	w	w	w	w	w	w
Secondary production:											
Industrial	306	151	119	182	194	385	491	587	491	428	440
Government (3)	235	198	212	237	113	0	0	0	0	0	0
Industry stocks, year-end (4)	372	239	217	344	480	440	516	353	491	223	220
Shipments from the National Defense Stockpile (5)	57	187	57	113	294	597	95	0	0	0	0
Imports for consumption	362	144	17	62	101	44	142	415	374	180	220
Exports	NA	243	342	865	1075	428	348	197	50	147	165
Industrial demand (consumption)*	1653	1333	792	609	683	614	531	480	409	381	440

(1) Comprises only the mercury produced at the McDermitt Mine, as reported in Placer Dome Inc. annual and 10-K reports. The mine was

closed in November 1990.
(2) Mercury by-product from nine gold mining operations.
(3) Secondary mercury shipped from U.S. Department of Energy stocks.
(4) Stocks at consumers and dealers only. Mine stocks withheld to avoid disclosing company proprietary data.
(5) Primary mercury. This quantity represents shipments during the 1993 calendar year. Congressional authorization for stockpile sales
is based on a fiscal year (October-September) which bridges 2 calendar years.

w = withheld to avoid disclosing proprietary information / e = estimated
* Note: See Table 4 for a breakdown of mercury consumption by industrial category.

2) Use of Mercury

Mercury is used in industries worldwide because of its distinctive properties. It conducts electricity, acts as a biocide, is useful in the measurement of temperature and pressure, and forms alloys with almost all other metals. With these and other properties, mercury plays an important role in several industrial sectors.

Table 9 shows the trends in domestic mercury use since 1980, and the relative amounts of mercury used in the following industrial categories: Chemical and Allied Products; Electrical and Electronic Uses; and Instruments and Related Products.

Mercury use in the United States declined 79 percent between 1980 and 1995, from 2231 tons per year to 480 tons per year. From 1995 to 1997 mercury use declined a further 21 percent to 381 tons per year. The most significant changes in reported mercury consumption are the dramatic reduction in mercury used in paints, and especially in batteries. In addition, there have been significant reductions in the 1980s and 1990s in use of mercury in laboratories, wiring devices and switches, and measuring and control instruments.

Public pressure has also driven manufacturers to seek alternatives to non-essential mercury in their products. For example, public outcry against mercury switches contained in children's light-up sneakers caused the manufacturer to change to a non-mercury switch that accomplishes the same purpose. The manufacturer now provides a toll-free number for customers to request a postage-paid mailer and return the shoes for proper mercury disposal.

Table 9: U.S. Industrial Consumption of Refined Mercury Metal, by Use* (tons)
Sources: US Bureau of Mines, Mineral Industry Surveys, July 1994, US Geological Survey, Minerals Yearbook 1998

SIC Code	*Use*	*1980*	*1990*	*1991*	*1992*	*1993*	*1995*	*1996*	*1997*	*1997 Category Total*	*% of 97 Total*
28	**Chemical and allied products**									**160**	**46.2%**
2812	Chlorine and caustic soda manufacture	359	272	202	230	198	169	150	176		46.2%
2819	Laboratory uses	14	35	33	31	29	NA	NA	NA		
2851	Paint	327	15	7	0	0	0	0	0		
	Other chemical and allied products[1]	NA	32	29	22	20	NA	NA	NA		
36	**Electrical and electronic uses**									**86**	**24.9%**
3641	Electric Lighting	40	36	43	61	42	33	32	32		8.4%

3643	Wiring devices and switches	117	77	78	90	91	92	54	63		16.5%
3692	Batteries	1055	117	20	14	11	NA	NA	NA		
38	**Instruments and Related Products**									**64**	**18.4%**
382	Measuring and control instruments	116	119	99	88	72	47	45	26		6.9%
3843	Dental equipment and supplies	67	48	45	46	39	35	34	44		11.5%
	Other Uses[2]	138	64	54	101	113	102	95	40	**36**	**10.5%**
	Total[3]	2233	815	610	683	615	478	410	381	186	100.0%

* The input of refined liquid mercury to domestic manufacturing establishments.
[1] Includes agricultural chemicals, pigments, and miscellaneous catalysts.
[2] Comprises unclassified uses and those uses from the three principal end-use categories for which the figures are withheld to protect company proprietary data or for which the volume of use is small. In 1991 and 1992, a large amount of mercury that was not reported by end use was included in this category.
[3] Data may not add to totals shown because of independent rounding.
Note: The total for 1990 does not accord with that from Table 8. This discrepancy will be addressed in the final draft.

2.a. Use of mercury in manufacturing processes (chlorine and caustic soda manufacture)

The largest user of mercury in the United States, and perhaps globally, is the chlor-alkali industry, which produces chlorine, caustic soda and hydrogen gas. Mercury emissions from this sector were estimated at 10 tons in 1990, falling to seven tons in 1995, reflecting closure of several mercury cell chlor-alkali facilities.

The mercury cell production process, responsible for less than 15 percent of U.S. chlorine production capacity, relies on a mercury as a cathode in the electrolytic separation of salt. Within the mercury cell, a long, shallow, covered trench, a thin layer of mercury flows under a layer of brine; caustic soda adheres to the mercury, while chlorine migrates to electrodes above. The mercury is subsequently separated from the caustic soda and added back to the process. Mercury is lost from the process through evaporation of mercury that spills or leaks; moreover, opening of the mercury cells for maintenance is potentially a significant source of mercury emissions. Emissions from the mercury cell room are in the nature of an area source, and are not routinely measured. Other sources of mercury within a chlor-alkali plant are measured, and include the hydrogen and end box ventilation streams. In addition, caustic soda produced from this process contains traces of mercury.

While this industry is the largest U.S. mercury user, the fate of much of this mercury is uncertain. Reported releases of mercury from the chlor-alkali sector account for a small percentage of mercury purchased by this sector.[19] Purchases of mercury by this industry either increase the inventory of mercury within chlor-alkali plants, or replace losses of mercury to the air, water, solid wastes or products. Unfortunately, only one chlor-alkali plant (Vulcan Chemical, in Port Edwards, Wisconsin) conducts a mass balance for mercury, so the amounts lost to the environment versus added to inventory cannot be determined. To improve this situation, the Chlorine Institute has developed a guidance on conducting a mercury mass balance, and several plants are planning to begin doing mass balances. In addition, the Chlorine Institute and Olin

[19] Ayres, 1997.

Corporation are working with USEPA on a project to better characterize emissions from the mercury cell room, the major area of uncertainty about environmental releases from this industry.

As of 1999, twelve mercury-cell chlor-alkali plants remain in the United States, two in the Great Lakes. On a per-facility basis, chlor-alkali plants are the largest emitters of mercury. For more information about this sector, see the **Chlor-Alkali Commitment** under **Section IV "Non-Regulatory and Voluntary Approaches to Mercury Reduction"**. Table **10** lists U.S. Mercury-Cell Chlor-Alkali Production Facilities.

2.b. Use of mercury in products.
Mercury use in products can lead to emissions in the production process, as well as during the use and disposal of the product. Manufacture of mercury-containing instruments caused an estimated 0.5 tons of emissions in 1995, and preparation and use of dental materials an estimated 0.7 tons. Several states regulate mercury-containing products directly by limiting or prohibiting mercury content in certain products, and restricting disposal options. Both state and federal content and regulations have had a direct impact on the quantity of mercury consumed in industrial activities. These are discussed in more detail in **Section III "Regulations".** Disposal of mercury-containing products is covered in **Section II, 3, B, "Waste Disposal and Recycling**".

- Paint Manufacturing: Until the early 1990s, the mercury compound phenylmercuric acetate was used to control mildew in latex paints. However, EPA curtailed this use, eliminating mercury in interior latex paints in 1990 and exterior paints in 1991. Mercury emissions from volatilized paint and demolition waste may continue from paints manufactured before the ban. Minnesota Pollution Control Agency estimates that latex paint volatilization caused 500 pounds of emissions annually in Minnesota in 1990; by 1995, estimated emissions dropped to 10 pounds.

- Batteries: In 1988, battery manufacturing alone consumed almost 25 percent of the total mercury use in the United States. Since then, as manufacturers have found alternatives to mercury in alkaline batteries, and both the Congress and the States have begun limiting mercury content in batteries, the amount of mercury used in batteries has declined by over 95 percent. The battery industry has eliminated the use of mercury in alkaline batteries, except for button cells.

- Electric Lamps: More than half a billion mercury-containing lamps, including fluorescent, mercury vapor, metal halide, and high-pressure sodium lamps, are produced each year. From 1989 to 1995, the average mercury content of fluorescent bulbs fell roughly 53 percent, from 48.2 mg to 22.8 mg. Additional reductions are expected; Philips Lighting announced in 1995 that it would be selling 4-foot fluorescent lamps with less than 10mg of mercury. At the same time, sales of fluorescent lamps increased between 3 and 5 percent a year. Emissions of mercury resulting from the breakage of these lamps is estimated to be 1.5 tons per year. In 1993, 98 percent of these bulbs were treated as municipal solid waste, while the remaining 2 percent were recycled. In July 1999, EPA added mercury-containing lamps to the Universal Waste Rule to facilitate

their collection and recycling, by reducing the regulatory burden associated with these activities.[20]

- Wiring Devices and Switches: Mercury's ability to conduct electricity makes it useful for wiring devices and switches, although substitutes exist. In addition to home thermostats and silent wall switches, relays and switches containing mercury have various industrial uses in high-voltage applications, telecommunications switching equipment, alarms, and semi-conductors. Mercury is also used in automobiles for a variety of switches, but the prominent use (85 percent of mercury in U.S. autos) is in hood switches.[21]

- Measuring and Control Instruments: Mercury's mechanical properties as a high-density/low friction metal fluid make it useful for a wide variety of measuring and control instruments, although, as with wiring devices and switches, substitutes for mercury exist. Mercury has been widely used in a variety of temperature measurement and sensing devices such as medical and laboratory thermometers, flame sensors, and thermostat sensors. Many instruments that measure and control pressure and flowrate also contain mercury including manometers, barometers, air flow measurement devices, and pressure safety devices.

- Dental Equipment: Mercury is used frequently in dental amalgam tooth fillings; amalgam is a mixture of roughly equal parts metallic mercury and an alloy of silver, tin, copper and zinc. Dental preparation and use cause an estimated 0.7 tons of air emissions annually. In addition, dental offices are an important source of mercury in sewage. Substitutes for mercury amalgam in dental restoration are available; these substitutes are preferred in some applications, but the majority of dentists prefer to use amalgam for restoration of posterior teeth.

Table 11 lists the primary products that contain mercury in each of the source categories discussed in this section. In addition, **Appendix A** includes a detailed mercury use tree.

Table 10: 1996 U.S. Mercury-Cell Chlor-Alkali Production Facilities
Source: SRI International, 1996

Facility	*Location*	*Capacity 10^3 tons/year*
Georgia-Pacific Corp., Chemical Division	Bellingham, WA	90
BF Goodrich, Chemical Group	Calvert City, KY	120
Hamlin Group, Inc.,	Reigelwood, NC	53
LCP Chemicals Division	Orrington, ME	80
ASHTA Chemicals, Inc.	Ashtabula, OH	40
Occidental Petroleum Corporation,	Deer Park, TX	383

[20] USEPA 1997a, Vol. II, 3-1.

[21] Gilkeson, 1996, page 5.

Table 10: 1996 U.S. Mercury-Cell Chlor-Alkali Production Facilities *Source: SRI International, 1996*		
Facility	*Location*	*Capacity 10^3 tons/year*
Electrochemicals Division	Delaware City, DE Muscle Shoals, AL	139 146
Olin Corporation, Olin Chemicals	Augusta, GA Charleston, TN	112 254
Pioneer Chlor Alkali Company, Inc.	St. Gabriel, LA	176
P.G. Industries, Inc., Chemicals Group	Lake Charles, LA New Martinsville, WV	256 77
Vulcan Materials Company, Vulcan Chemicals Division	Prot Edwards, WI	72
TOTAL		1,998

3) Waste Disposal and Recycling

Incineration of wastes that contain mercury leads to substantial mercury emissions; mercury releases from other waste disposal pathways are less well characterized, but potentially substantial as well. The Mercury Report to Congress estimates that incineration of municipal waste, medical waste, hazardous wastes and sewage sludge accounted for one-third of mercury emissions, or 54 tons. Incinerator emissions have fallen substantially since 1990, when incinerators accounted for 99 tons of emissions, nearly half of the estimated total. A decline in the amount of mercury in discarded batteries probably accounts for most this decrease, along with other pollution prevention efforts and regulations on incinerators in some states.

According to the MRC, mercury emissions from municipal waste combustors (MWCs) will decline in the future for three reasons. First, EPA has issued New Source Performance Standards and guidelines for new and existing MWCs estimated to reduce mercury emissions by about 90 percent from the 1990 baseline. Second, the inlet concentration of mercury in the MWC waste stream is estimated to be half of what it was in 1990, as fewer mercury-containing components such as batteries, thermometers, thermostats, pigments, and paints are entering the municipal solid waste (MSW) stream. Third, some states, led by Florida, New Jersey and Minnesota, have enacted either MWC legislation requiring the use of activated carbon injection, mandatory recycling for or bans on the sale of certain mercury-containing products.[22]

Mercury emissions from wastes that are not incinerated, but rather landfilled or recycled, are less well characterized than emissions from incinerators. However, such emissions, from landfills, product breakage, processing, storage and transportation of wastes, and from recycling of metal scrap, could be substantial. The Swedish National Chemicals Inspectorate estimates that 18 percent, or 72 tons, of mercury emissions in Europe are attributable to mercury use in products. Of the emissions attributable to products, 47 tons (66 percent) result from incineration, but an additional 14.5 tons (20 percent) results from recycling of steel scrap; 9.2 tons (13 percent) is emitted by landfills, and 0.8 tons (1 percent) results

[22] USEPA 1997a, Vol. II, 4-17.

from breakage of products during use. More than half of these estimated non-incineration emissions result from disposal or recycling of lighting and electrical equipment, with disposal of batteries and measuring and control devices responsible for the remainder.

Minnesota Pollution Control Agency (MPCA) has independently arrived at similar conclusions regarding the importance of non-incineration waste disposal and recycling as source of mercury to the environment. MPCA estimates that 2,031 pounds of emissions (44 percent of the total mercury emissions in Minnesota) resulted from purposeful use of mercury in 1995, down from 5,852 pounds (69 percent) in 1990. Most of these emissions occurred during waste disposal.[23] Of the 1995 emissions resulting from purposeful use of mercury, slightly more than half resulted from incineration. Incineration of municipal solid waste, medical waste, hazardous waste, sewage sludge, accounted for 1133 pounds of emissions. This total includes 270 pounds of emissions estimated from on-site household waste incineration, a source not calculated in national estimates and a source that will not be affected by regulation of incinerators. Unlike the Swedish study, MPCA attributed a negligible amount of emissions to landfills, but did estimate 432 pounds of emissions resulting from mercury volatilization during solid waste collection and processing. An additional estimated 166 pounds of emissions resulted from use of metal scrap at a single facility in Minnesota, 83 pounds resulted from fluorescent lamp breakage and 48 pounds resulted from spills and land dumping.[24]

MPCA's estimate of 432 pounds of emissions resulting from volatilization during solid waste collection and processing in 1995 represents a 67 percent reduction from estimated 1990 emissions from this category, based on reductions in the mercury content of solid waste. These estimates assume that five percent of mercury in solid waste is volatilized during collection, transportation and mechanical processing. Scaling MPCA's 1990 estimate for this category up to the national level would yield an estimate of approximately 32 tons of emissions annually.[25] Assuming that efforts to reduce the mercury content of solid waste have been three-quarters as successful nationwide as in Minnesota, 1995 emissions would be 16 tons.

Thus, even if incinerator emissions were eliminated, disposal and recycling of mercury-containing products would likely remain an important source of mercury releases. The various sources of mercury release resulting from waste disposal and recycling are described in greater detail below.

Municipal Solid Waste: Municipal solid wastes are contaminated by a variety of mercury-containing items. A 1992 EPA study found that household batteries were the primary source of mercury to the municipal solid waste stream. Discarded batteries contained an estimated 621 tons of mercury in 1989, more than 85 percent of the total. Another significant source, paint residues, contained an estimated 18 tons of mercury in 1989. Both of these sources, batteries and paints, have been significant reduced as the result of reductions in the mercury content of these products. Reductions in the mercury content of discarded batteries is likely to continue to decline. The remaining significant sources of mercury to municipal solid waste are mercury-containing lamps, fever thermometers, thermostats, and light

[23] Some of the emissions occurred during use, including 44 pounds from laboratory use, an estimated 25 pounds volatilization from fungicides and 10 pounds volatilization from paint.

[24] Minnesota Pollution Control Agency, 1999, pages 22-26.

[25] Based on the assumption that Minnesota generates two percent of the nation's solid waste.

switches.[26] A 1999 study by the Florida Department of Environmental Protection found that in 1995, batteries were still the largest source of mercury to the solid waste stream, followed by mercury devices (switches, thermometers, and thermostats) and lighting, with a total of 12 tons of mercury discarded in Florida. By 2000, however, mercury discards to municipal solid waste are projected to decline to less than six tons per year, with mercury devices accounting for more than half of the total remaining and batteries declining from more than seven tons of mercury in 1995 to less than two tons in 2000.[27]

Incineration of municipal solid waste accounted for 30 tons of mercury emissions in 1995, down from 42 tons in 1990. Mercury is less likely to reach the environment if it is landfilled than if it is incinerated, since incineration causes mercury to volatilize while landfilling can immobilize significant amounts of mercury. However, only about 15 percent of municipal solid waste is incinerated; most of the remainder is landfilled. The Mercury Report to Congress estimates that landfills emit 0.074 tons of mercury annually, based on measurements of mercury in landfill gas. However, a recent Oak Ridge National Laboratory (ORNL) study of landfills in Florida indicates that the working face of the landfill may be more important than landfill gas as a source of mercury emissions. While most of the mercury buried within the landfill may be immobilized, operations on the working face lead to emissions as mercury-containing devices break. Moreover, the study found that emissions of landfill gas may include highly toxic organic mercury, as the result of reactions that take place within the landfill.[28]

Disposal of mercury-containing wastes leads to mercury emissions from waste storage, transport and processing, as well as from landfills. The ORNL landfill study in Florida found that waste transfer stations, dumpsters, and garbage trucks are potentially also sources of mercury emissions. The Mercury Report to Congress estimates that breakage of mercury lamps (primarily during disposal) cause 1.5 tons of emissions annually, but no estimates are provided for other mercury containing products, such as thermometers and thermostats.

Medical Waste: Medical waste contains much higher concentrations of mercury than municipal solid wastes as the result of the disposal of thermometers and other mercury-containing medical devices, and the use of mercury in medicines and laboratory chemicals. Incineration of medical waste accounted for an estimated 16 tons of emissions in 1995, down from 50 tons in 1990. While most medical waste is incinerated, mercury emissions can occur during the transport and processing of waste prior to incineration. Ongoing efforts to implement pollution prevention at medical facilities, for instance through the American Hospital Association-USEPA Memorandum of Understanding, will help reduce both these sources of emissions.

Scrap Metal: Recycling of scrap metal leads to emissions from scrap processing and from metal production, if the scrap is contaminated by mercury devices contained in autos, appliances, and scrapped industrial equipment. The New Jersey Department of Environmental Protection estimates 719 lbs/year emissions from three sources (one electric arc steel furnace and two iron foundry cupolas), based on

[26] EPA, 1992.

[27] Florida Department of Environmental Protection, 1999, Chapter 5.

[28] Lindberg, SE, and J Price,1999. In a follow-up study, these authors identified that the organic mercury in landfill gas was present as toxic dimethylmercury. S.E. Lindberg, et al, 1999.

stack tests. Contamination of iron and steel scrap with mercury-containing devices is the most likely cause of these emissions. Assuming that mercury in scrap is the sole source of the emissions and that the New Jersey facilities are representative, an estimate of mercury emissions nationwide from iron and steel production can be derived. Depending on the New Jersey facility that this estimate is based on, emissions are between 7 tons and 18 tons annually, with a central estimate of about 12.5 tons. These estimates are strikingly similar to the Swedish National Chemical Inspectorate's estimate of 14 tons of annual emissions resulting from steel scrap in Europe. They are also in accord with a mass balance approach -- roughly 10 tons of mercury were used in autos annually, until recent years,[29] and more than one ton is used annually in white goods. Scrapped industrial equipment contains additional mercury. While additional testing is needed in order to develop a more certain emissions estimate, emissions at these levels would be a significant addition to the estimated 0.25 tons from "blast furnaces and steel mills" in the 1990 112k emissions inventory, based on Toxics Release Inventory reporting (the Report to Congress makes no estimate for this sector). The amount of mercury emitted from scrap metal smelting is likely to decline as U.S. automakers reduce the use of mercury switches in their vehicles (see **Section IV, "Voluntary Initiatives and Non-Regulatory Approaches to Mercury Reduction"**). Additional reductions could be achieved by programs to remove mercury switches from existing autos.

Demolition Debris: Demolition debris is another potential source of mercury. Buildings are equipped with numerous mercury-containing devices, such as thermostats and fluorescent lamps. If these devices are not removed prior to demolition, emissions can result as these devices are broken. There are no estimates available of mercury emissions from this source.

Hazardous Wastes: USEPA has established six different categories of mercury-containing hazardous waste: D009 Wastes--Characteristic Mercury Wastes; K071 Wastes--Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used; K106 Wastes--Wastewater treatment sludge from the mercury cell process in chlorine production; P065 Wastes--Mercury fulminate; P092 Wastes--Phenylmercury acetate; U151 Wastes--Mercury. These wastes are described in greater detail in **Appendix H**.

Disposal of these wastes depends on mercury content and the presence of hazardous organic wastes. Wastes with mercury content higher than 260 ppm must be roasted or retorted (yielding mercury for recycling), and if organics are present, they must be incinerated. Incineration of hazardous wastes at cement kilns, hazardous waste incinerators and lightweight aggregate kilns caused emissions of an estimated 6.6 tons of mercury in 1997. Retort units released an estimated 0.4 tons of mercury in 1995.

Water Releases: Mercury enters directly into water and wastewater from a number of small, diffuse sources. Landfills leach mercury which is carried by runoff into water systems. Homes, small laboratories, medical offices and clinics, and commercial/industrial sites dispose of mercury-containing products such as reagents, cleaning solutions, and medicines, and clean-up from small spills and broken products such as thermometers, directly down the drain. These discharges are not monitored, and usually end up in water treatment plants. Some of the mercury discharged to water treatment plants ends up in sewage sludge. Incineration of sewage sludge accounted for an estimated 1.0 ton of emissions in 1995.

[29] U.S. auto manufacturers began an effort to eliminate use of mercury switches in the mid-1990s, and had reduced this use by about half by 1999. Scrapped autos, however, are primarily those cars manufactured prior to implementation of this effort.

Table 11: Products that May Contain Mercury

This table lists the primary products that may contain mercury. It is not an exhaustive list of all mercury products. Rather, it illustrates the types of products where mercury may be used. In several cases, manufacturers are moving away from mercury use. See Appendix G for a detailed list of products containing mercury. See Appendix A for a detailed mercury use tree.

Chemical and Allied Products

Paint (existing stocks only)

- latex paint
- maritime paint

Other

- agricultural products
- catalysts
- cosmetics
- explosives
- fireworks (foreign manufacturers only)
- livestock and poultry remedies
- packaging
- pharmaceuticals
- pigments/dyes
- poisons
- preservatives
- special paper coatings
- turf products (existing stocks only)

Electrical and Electronic Uses

Electric Lighting

- fluorescent lights
- high intensity lamps
- incandescent lamp filaments
- mercury vapor lamps
- metal halide lighting
- UV disinfectant lamps

Wiring Devices and Switches

- electric wall switches
- shoes
- thermostats
- toys
- white goods (appliances)

Batteries

- alkaline batteries (no longer used)
- carbon zinc batteries (no longer used)
- mercuric oxide batteries
- zinc air

Instruments and Related Products

Electrical Components

- high purity copper foil
- mercury arc rectifiers
- relays
- tilt switches

Instruments and Related Products

Measure and Control Instruments

- barometers
- medical and scientific instruments
- thermometers

Dental Equipment and Supplies

- dental amalgam

Table 2 lists the different types of waste disposal sources. **Appendix B** provides details on the mercury-specific regulations for waste disposal sources. Note that cement kilns are not listed as a waste disposal source. However, cement kilns, used frequently as a waste disposal option, may burn hazardous wastes as a fuel source. Mercury may accumulate in the cement kiln dust. Metals emissions from cement kilns,

which are regulated under EPA's interim standards for boilers and industrial furnaces (BIFs), are currently under review.

C. Incidental Release

1) Energy Production

Electricity-generating utility boilers contribute a large portion of the overall U.S. atmospheric mercury emissions due to the presence of mercury in fuel, especially coal. Utility boilers accounted for 34 percent of 1995 emissions. Although currently unregulated for mercury emissions, they were the subject of intensive study under a separate Utility Study mandated by the 1990 Clean Air Act amendments (§112(n)(1)(A)). Use of coal at electric utilities is expected to rise over the next several years; these increases might be partly offset (even in the absence of controls specifically targeting mercury) by reductions that occur as a by-product of installing scrubbers to control sulfur emissions.

An improved mercury inventory for coal-fired utility boilers is being developed through collaborative efforts of the Department of Energy Federal Energy Technology Center (DOE/FETC), the Electric Power Research Institute (EPRI), and the utility industry (USSR, final, p.5). In November 1998, EPA issued a Information Collection Request for mercury-in-coal data from each coal-fired utility in the U.S. and additional speciated mercury emissions data from a subset of these coal-fired utilities, as a possible basis for developing regulations for coal-fired utility boilers. Data collection will be completed by the end of 1999.

Commercial, industrial, and residential boilers also contribute to mercury emissions, primarily as a result of coal combustion. In 1995, emissions from these sources totaled about 2.5 tons. Coal combustion in these sectors is declining.

2) Mobile Sources

Mercury emissions also result from the consumption of fuel, primarily diesel. The Mercury Report to Congress omitted mobile sources of mercury emissions as too difficult to calculate. The 1990 112(k) emissions inventory, however, listed mobile sources including on-road vehicles, non-road vehicles and equipment as responsible for 11.13 tons per year, or 5.74 percent of the 1990 national total.

3) Manufacturing Processes

Mercury is emitted from numerous manufacturing processes that use raw materials containing mercury as a trace element. A list of these sources is included in **Table 2**, and **Appendices A** and **B** describe these sources in greater detail. The Mercury Report to Congress estimated that Portland cement manufacturing emitted about 4.8 tons in 1995, or three percent of the national total. Other processes such as pulp and paper manufacturing, copper, lead, and zinc smelting, and petroleum refining also emit mercury.

D. Influx from the Global Mercury Reservoir

The Mercury Report to Congress estimates that about 35 tons of mercury from the global reservoir is deposited each year into the lower 48 states. Much of this mercury is mobilized by anthropogenic sources outside of the United States (the U.S. contributes an estimated 3 percent of total global emissions, natural and anthropogenic). Consequently, there could be considerable benefit to the U.S. environment from international controls on the mercury content of products, from international restrictions on the improper disposal of mercury products, and from international controls on mercury emissions. Domestic controls on the mercury content of products will not only limit emissions from domestic incinerators, but will also reduce the export of mercury-containing products to countries where incinerator mercury emissions are not controlled.

III. How is Mercury Regulated?

Mercury releases are regulated under numerous statutes, under the jurisdiction of multiple agencies. The Environmental Protection Agency (EPA) regulates mercury in pesticides, and mercury releases into the environment through air, water, and land disposal limits. The Food and Drug Administration (FDA) regulates mercury in cosmetics, food, and dental products. The Occupational Safety and Health Administration (OSHA) regulates mercury exposures in the workplace. In addition to regulations governing mercury release, there are regulations limiting the use of mercury. Application of most of these regulations depends on the type and/or the size of the mercury source.

Existing regulations have encouraged a dramatic decline in mercury use, and have begun to lead to reductions in releases as well. New MACT (Maximum Available Control Technology) Standards are expected to result in further drops in mercury releases (see **Table 14: Actual and Projected Mercury Emissions**). Mercury has begun to command more public concern, leading to additional regulatory and voluntary efforts to reduce mercury, particularly in states that have identified local fish contamination problems.

This section describes the federal regulations that affect mercury use and release. We have provided tables that describe how existing mercury regulations apply to mercury-containing products and sources that use and/or release mercury. From this information, we can identify the extent to which individual mercury sources are covered--or not covered--by existing regulations, and the opportunities that might exist to encourage additional reductions in mercury use and release.

Table 12 illustrates the different categories of mercury regulations used in this report, and the applicable statutes or regulations for each category. **Table 15** shows the federal environmental management standards for mercury. **Table 13** shows the tariff schedule for mercury and mercury-containing products. **Table 16** summarizes the potential changes in mercury regulation. **Table 14** lists projected impacts of national regulations on mercury emissions for selected source categories. At the end of the report, **Appendix B** provides a detailed description of mercury sources and specific release regulations; **Appendix C** describes the regulations affecting mercury products; and **Appendix D** lists examples of State mercury controls; **Appendix E** describes Federal mercury regulations; and **Appendix F** describes voluntary programs and initiatives that target mercury. **Appendix H** describes RCRA waste categories for mercury.

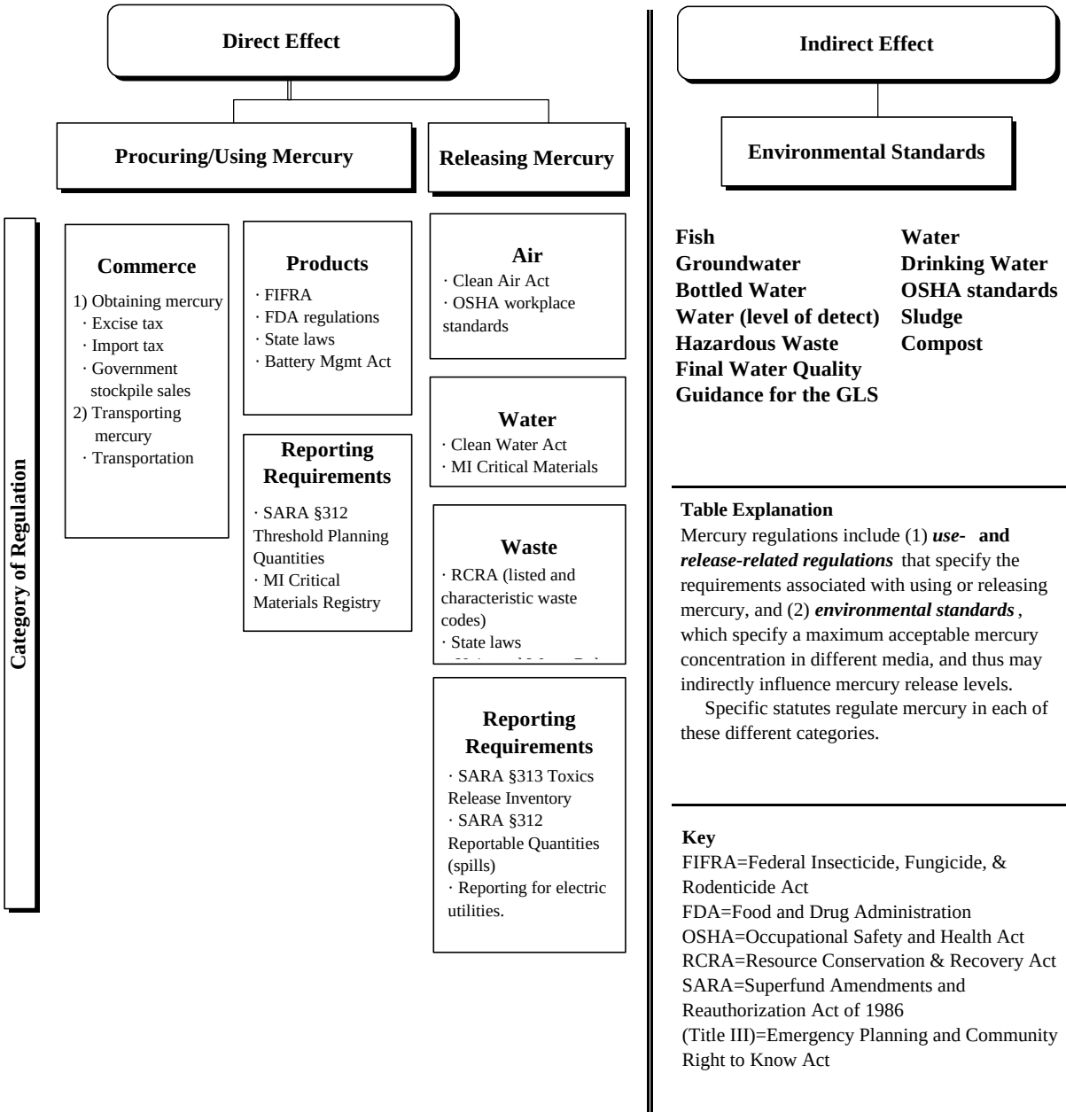
A. Types of Mercury Regulations

To understand how existing mercury regulations influence the full spectrum of economic activities that involve mercury, it is helpful first to distinguish between regulations that have a *direct* effect on sources from those that have an *indirect* effect on sources.

Use- or release-related regulations have a *direct* effect on sources that use mercury or release mercury into the environment. These regulations specify, for individual mercury sources, the amounts or concentrations that can be released to the environment, and the ways mercury may be used, transported, and disposed, all which influence the costs associated with using or releasing mercury. This paper is

concerned primarily with the *structure* of use- or release-related regulations and the extent to which existing regulations encourage pollution prevention.

Table 7: Mercury Regulatory Overview



Environmental management standards, on the other hand, have an *indirect* effect on individual sources. Environmental standards are numeric criteria that specify a maximum acceptable mercury concentration for different media, based on scientific or risk-based criteria. For instance, mercury standards exist for

water, sludge, fish tissue, drinking water, and several other media. These standards provide a yardstick against which to measure the effectiveness of mercury release regulations.

In contrast to use- and release-related regulations which apply directly to individual sources, environmental standards remain independent of specific sources, although source standards may be connected to environmental standards. For example, where a water point source is not subject to a technology-based standard, water discharge levels are determined by the impact a given discharge level will have on ambient water quality, and thus derive from those ambient water quality standards. Where mixing zones are being phased out, as in the Great Lakes, discharge standards will become the same as water quality standards.

However, environmental standards exert an important effect on sources that release mercury to any media. For instance, sewage treatment plants must ensure that the mercury content of their sludge remains below the mercury concentration specified for land application. Even absent a specific mercury effluent limit, the POTW must still work with its dischargers to minimize mercury content in their discharges to the treatment plant.

Reporting requirements, such as the Toxics Release Inventory (TRI) and EPA Requests for Information, enhance public awareness of mercury releases and aid in the crafting of regulations. Reporting data help EPA identify both sources for potential regulation and industries and sectors that could benefit from pollution prevention and compliance assistance.

B. Mercury Use Regulations

Regulations associated with mercury use in commerce impose costs, conditions, and/or restrictions on obtaining, selling, using, or transporting mercury. We have used the following categories to describe mercury use regulations: 1) commerce-related regulations such as taxes and transportation requirements; 2) product-related restrictions; 3) reporting requirements; and 4) human exposure to mercury.

Mercury use regulations affect only those facilities that use mercury as an input. They do not affect those sources that release mercury incidentally as a by-product. For each statute, we describe the mercury-specific information, the type of regulatory mechanism used, and any potential changes to the current regulatory status.

1) Mercury in Commerce

Provisions of several statutes regulate different aspects of mercury in commerce. Excise taxes and import taxes directly affect the cost of using mercury as an input in manufacturing processes; regulations governing mercury sales from the National Defense Stockpile influence the amount of mercury available for purchase; and transportation requirements impose restrictions on mercury transport.

1.a. Obtaining Mercury

Excise Tax: Internal Revenue Code of 1986 (26 USCA §4661)

- **Mercury Information**: The Internal Revenue Code imposes taxes on 40 chemicals, including mercury, that are sold by the manufacturer, producer, or importer . The tax rate for mercury is $4.45/ton, the second highest tax rate listed (10 substances have the highest tax rate of $4.87/ton).
- **Regulatory Mechanism:** Input/sales tax
- **Potential changes**: None identified

Import Tax: Harmonized Tariff Schedule of the United States

- **Mercury Information**: Mercury and several mercury compounds are subject to import taxes under the Harmonized Tariff Schedule of the United States, which identifies import taxes on all goods imported into the United States from most-favored-nation (MFN) countries, as well as from special treaty nations and non-most-favored-nation (non-MFN) countries.

  For 1999, the tax rates differ between various mercury compounds and mercury-containing products. Due to special treaty agreements, no duty is imposed on mercury imports from Canada, Israel, Bolivia, Colombia, Ecuador, and Caribbean Basin countries, and Mexico.
- **Regulatory Mechanism**: tax
- **Potential Changes**: None identified.

Table 13: Tariffs on Mercury and Mercury-Containing Products; Harmonized Tariff Schedule of the United States 1999

Tariff Code	Product	MFN[1]	Non-MFN[2]	Special[3]
Section VI — Products of the Chemical or Allied Industries				
2805.40.0000	Chemical Elements: Mercury	1.7%	5.7%	Free (A, CA, E, IL, J, MX)
2825.90.4500	Mercuric Oxide	Free	25.0%	
2827.39.2000	Chlorides, Hydroxides, Bromides of Mercury	5.1%	31.9%	Free (A, CA, E, IL, J, MX)
2931.00.2700	Organo-mercury compounds	6.5%	$.154/kg + 40%	Free (A, CA, E, IL, J) (MX: 2.6%)
3815.90.2000	Mercury Catalysts	2.8%	18.0%	Free (A, CA, E, IL, J, MX)
3824.90.3300	Mixtures of mercury	4.2%	26.3%	Free (A, CA, E, IL, J, MX)
Section XVI — Machinery and Mechanical Appliances				
8506.30.00	Primary cell and primary batteries, parts thereof: mercuric oxide	2.7%	35.0%	Free (A, CA, E, IL, J, MX)
8539.32.00	Mercury or sodium vapor lamps-- metal halide lamps	2.4%	20.0%	Free (A, CA, E, IL, J, MX)

1 Most nations are MFN with the exceptions of 2 and 3.
2 Non-MFN countries: Afghanistan, Laos, Vietnam, Cuba, and North Korea
3 A = Generalized System of Preferences
CA = Canada
MX = Mexico
E = Caribbean Basin Economic Recovery Act
IL = United States-Israel Free Trade Area
J = Andean Trade Preference

Government Mercury Stockpile Sales: Strategic and Critical Materials Stockpile Act (50 USCA §98)

- **Mercury Information**: The Strategic and Critical Materials Stockpile Act regulates mercury that the Defense Logistics Agency (DLA) sells from the National Defense Stockpile. The amount of mercury sold from the stockpile has the potential to affect the mercury market, although DLA considers its impact on the market when requesting Congressional authorization for sales. DLA accepts daily bids for mercury. In 1994, the last year of government sales, the price of DLA mercury ranged from $57 - 82 per flask.

  DLA must submit an Annual Materials Plan to Congress that includes its requests for selling materials deemed excess to stockpile needs for each fiscal year, including projections for the following four years. For fiscal year 1994, DLA initially received authorization to sell 10,000 flasks of mercury, but reached that limit by early 1994. In April, DLA received Congressional authorization to increase fiscal year 1994 mercury sales to 50,000 flasks, a five-fold increase that is more than three times the estimated total US consumption of mercury for 1993. By comparison, DLA had authority to sell 10,000 flasks of mercury (380 tons) in fiscal year 1993, but by year's end, sold only 8,250 flasks (313 tons).

  Until fiscal year 1994, funds received from stockpile sales were used only for stockpile-related activities. However, the Defense Appropriation Act for fiscal year 1994 (PL 103-160, §305) changed the allowable uses of stockpile revenues, specifying that up to $500 million be transferred to Department of Defense operations and maintenance accounts. This change, combined with favorable market conditions and increasing interest in stockpile materials, motivated DLA to seek approval to sell additional quantities of several stockpile materials, including mercury.

  In July, 1994, DLA suspended future mercury sales pending analysis of the environmental consequences. DOD is conducting and Environmental Impact Statement to determine the disposition of the stockpile. EPA is represented on the market impact committee that review stockpile sales. Because the EIS process is comprehensive, a final EIS may take several years to complete. In the meantime, DOD has begun a complete review of the five facilities across the U.S. currently storing its mercury, and is inspecting all the mercury containing flasks to ensure proper and safe storage. DLA sales remain suspended pending completion of an environmental impact analysis.

1.b. Transporting Mercury

Transportation: The Hazardous Materials Transportation Act

- **Mercury Information**: The Department of Transportation regulates hazardous materials transport under the Hazardous Materials Transportation Act (HMTA). Mercury and mercury compounds are hazardous substances subject to packaging, shipping and transportation rules for hazardous materials. RCRA regulations for hazardous waste transporters incorporate HMTA rules.
- **Regulatory mechanism**: operating requirements, labeling
- **Potential changes**: None identified

1.c. Using Mercury

Mercury Information: Minnesota has a use-restriction law providing that mercury sold in the state will be used only for medical, dental, instructional, research, or manufacturing purposes. Sellers must provide buyers with a material safety data sheet and require the buyer to sign a statement committing to proper use and disposal.

2) Mercury in Products

Mercury-containing products are regulated in several different ways. At a federal level, mercury product regulation has generally centered around health-based reasons to eliminate mercury from products, using the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA) regulations.

In recent years, many states have taken a different approach. Restrictions on mercury-containing products, once used sparingly by the federal government, are increasing rapidly at the state level. States are beginning to address the environmental contamination associated with disposal of mercury-containing products, and some have banned the sales of certain products that contain mercury (e.g., toys and shoes), limit the content of mercury in other products (e.g., batteries and packaging), and impose recycling requirements and disposal restrictions on mercury-containing products.

At present, mercury product laws represent a patchwork of regulations that vary by state. **Appendices C** and **D** describe each of these regulations in more detail. **Appendix E** shows federal mercury product legislation.

At a federal level, three statutes have been used to limit mercury content or curtail mercury use in specific products.

Statute: Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

- **Mercury Information**: FIFRA covers the sale and use of pesticides, including registration of chemicals that meet health and safety tests. Until recently, several mercury compounds were registered as pesticides, bactericides, and fungicides. By 1991, however, all registrations for mercury compounds in paints had been canceled by EPA or voluntarily withdrawn by the manufacturer. Registrations for calo-chlor and calo-gran, the last mercury-based pesticides registered for use in the United States (to control pink and grey snow mold) were voluntarily canceled by the manufacturer in November 1993. Existing stocks may be sold until depleted.
- **Regulatory Mechanism**: ban, cancellation
- **Potential changes**: None identified

Statute: Mercury-Containing and Rechargeable Battery Management Act

This law, enacted in 1996, phases out the use of mercury in batteries and provides for the efficient and cost-effective collection and recycling or proper disposal of used nickel cadmium batteries, small sealed lead-acid batteries, and certain other batteries. Title II prohibits the sale of 1) alkaline-manganese batteries containing mercury (alkaline-manganese button cell batteries are limited to 25mg mercury per button cell), 2) zinc-carbon batteries containing mercury, 3) button-cell mercuric-oxide batteries for use in the US, and 4) any mercuric-oxide battery unless the manufacturer identifies a collection site that has

all required federal, State, and local government approvals, to which persons may send batteries for recycling and disposal (MRC II, 4-21).

The Act contains labeling requirements and encourages voluntary industry programs by eliminating barriers to funding the collection and recycling or proper disposal of used rechargeable batteries. The Act also grants the States the authority to add other batteries to the recycling program. This federal law followed the lead of several states that passed legislation in the early 1990s limiting the mercury content of batteries.

3) Reporting Requirements

Mercury *use* reporting is seldom required under the existing regulatory framework. Most reporting requirements track mercury *releases*, and are discussed separately in the "Mercury Release" section that follows.

At a federal level, only facilities that exceed threshold planning quantities for mercury under SARA Title III regulations must report that quantity to their local emergency planning commission. This program is included under "Releases," because it is geared toward spill prevention, rather than use. EPA is currently considering a chemical use inventory, which would track the quantities of chemicals used at individual facilities.

Currently, only Michigan has regulations that specifically require facilities to report the quantities of chemicals used. Under the Part 9 rules of Act 245, Michigan's water pollution control act, businesses that use any substance listed on the "Critical Materials Registry" must report the quantities of each substance used and released. Mercury is included the Critical Materials Registry. The state uses this information to assist in permit development and compliance in its water program.

4) Human Exposure to Mercury

Statute: Federal Food, Drug, and Cosmetic Act (FFDCA)

- **Mercury Information**: The Food and Drug Administration (FDA) regulates mercury in food, drugs, and cosmetics. FDA sets an action level of 1 ppm methylmercury in fish, shellfish and other aquatic animals, and may remove from commerce foods that violate this action level. FDA has advised women of childbearing age to limit their consumption of shark and swordfish, based on methylmercury content. States, tribes and territories are responsible for issuing fish consumption advise for locally-caught fish; many state health departments use 0.5 ppm methylmercury as a trigger for such advice. Comprehensive information about state fish advisories is available at http://www.epa.gov/OST/fish/.

  In eye-area cosmetics or ointments, mercury use as a preservative or antimicrobial is limited to 60ppm (21 CFR 700.13). Yellow mercuric oxide is not recognized as a safe and effective ophthalmic anti-infective ingredient. [and therefore what? It can't be used? Use isn't advised?]

  The FDA also regulates dental amalgam under FFDCA. Dental mercury is classified as a Class I medical device, with extensive safety regulations on its use. Dental amalgam alloy is classified as a Class II device, subject to additional special controls.
- **Regulatory Mechanism**: content restriction, use conditions, labeling
- **Potential Changes**: None identified.

Statute: Food and Drug Administration Modernization Act

- **Mercury Information:** Under the Food and Drug Administration Modernization Act of 1997, FDA is required to assess the risk of all mercury containing food and drugs. Under this provision, FDA asked vaccine manufacturers to provide information about thimerisol content of vaccines. Based on this information, the Public Health Service, the American Academy of Pediatrics, and vaccine manufacturers agreed that thimerisol-containing vaccines should be removed as soon as possible. Manufacturers have been asked for a clear commitment to eliminate mercury from vaccines, and FDA will do expedited reviews of resulting revisions to product license applications.
- **Regulatory Mechanism:** voluntary action.
- **Potential Changes:** none identified.

Statute: Occupational Safety and Health Act

- **Mercury Information**: The Occupational Safety and Health Administration has responsibility for maintaining safe workplace conditions. OSHA sets permissible exposure levels for elemental mercury in workplace settings. Mercury is listed as a neurotoxin capable of causing behavioral changes, decreased motor function and other effects on the nervous system (29CFR1926.59). OSHA mercury standards also recommend that skin contact should be avoided.

  Workplace standards may influence the types of processes used at a facility. For instance, when OSHA tightens its standards for a particular substance, it may force users of that substance to modify their processes or eliminate use of that substance entirely in order to meet these new standards.
- **Regulatory Mechanism(s)**: operating requirements, inspections
- **Environmental Standards**: workplace air concentration levels for exposure to elemental mercury. Section 29 CFR 1910.1000 sets the permissible exposure limit (PEL) for an 8-hour time weighted average (TWA) of 0.1 mg/m^3.
- **Specific Sources covered**: Facilities that use mercury are subject to the mercury standard.
- **Potential Changes**: none identified.

Other Exposure Guidelines: The Agency for Toxic Substances and Disease Registry (ATSDR) evaluates exposure levels for hazardous substances at superfund sites under CERCLA. ATSDR endorses a lifetime acceptable daily exposure level for methylmercury exposure of 0.3 micrograms per kilogram of body weight per day. EPA's reference dose is three times lower, at 0.1 micrograms per kilogram of body weight per day. The reference dose is an estimate of the maximum daily exposure level over a lifetime in which no appreciable risks are expected. Although these levels do not directly change regulatory requirements, they may cause agencies that evaluate mercury exposure levels to re-evaluate existing regulatory standards. To help resolve the issue of acceptable levels of risk for methylmercury, the US Congress has directed the National Research Council's National Academy of Science to complete a report by mid-2000.

C. Mercury Release Regulations

This section describes regulations that affect mercury *release* into air and water, as well as waste disposal, and requirements for public disclosure of releases (e.g., TRI reporting). Specific statutes--at a federal and/or state level--regulate mercury in each of these different categories. **Appendix B** shows the specific mercury release regulations that apply to each mercury source.

The Clean Air Act (CAA), Clean Water Act (CWA), and the Resource Recovery and Conservation Act (RCRA) all operate differently, and impose different thresholds that influence the extent to which mercury releases are covered. In addition, states have the flexibility to impose site- specific mercury regulations on individual sources. With the exception of the Toxic Chemical Release Inventory (TRI), which specifically requires facilities to report chemical releases into all media, programs that require mercury release reporting are incorporated into broader regulatory programs.

The following information is provided for each statute discussed: the principal provisions that affect mercury releases; the specific sources regulated; the threshold that triggers coverage; the regulatory mechanism(s) used; environmental standards included in the statute; potential changes to existing regulations; and other relevant statutes that may provide similar information.

1) Mercury Air Emissions

Statute: Clean Air Act

Principal Provisions That Affect Mercury Releases: Mercury and mercury compounds are considered Hazardous Air Pollutants (HAPs) under the Clean Air Act. EPA established National Emission Standards for Hazardous Air Pollutants (NESHAPs) for mercury emissions based on risk under the pre-1990 version of the Clean Air Act. These NESHAPS cover three source categories: ore processing facilities, mercury cell chlor-alkali plants, and sewage sludge driers (40 CFR 61, Subpart E).

Under the Clean Air Act Amendments of 1990 EPA regulates Hazardous Air Pollutant Emissions by source categories using maximum achievable control technology (MACT) standards for each "major source" in any listed source category. Major sources are defined as those sources that release 10 tons per year of any HAP, or 25 tons per year in total HAP emissions. Mercury releases alone are unlikely to trigger the major source definition. For instance, Wisconsin's 1994 air point source inventory showed the highest mercury release at 1000 pounds, well below a 10 ton (20,000 pound) threshold for major sources. However, EPA may set lesser quantity cutoffs, which would redefine the level at which a facility would be defined as a major source.

A MACT standard is defined based on an analysis of existing control technology among the best-controlled sources in a given source category. New sources must be as well controlled as the “best controlled similar source,” while existing sources must be at least as well controlled as the best-performing 12 percent of existing sources. Thus, the extent to which MACT standards influence mercury release levels varies with the source category--if mercury controls are not currently in use for a particular source, they will not necessarily be part of a defined MACT standard. However, EPA does have the authority under the Clean Air Act to go beyond existing technology and consider a “health threshold” in setting emissions standards (§112(d)(4)), or to revise existing MACT standards “in order to provide an ample margin of safety to protect public health” (§112(f)).

Table 14 shows projections for year 2006 emissions for all source sectors that emit more than an estimated two tons of mercury in 1995. For these source sectors, 2006 emissions are projected to be 86 tons, a 34 percent reduction from 1995 and a 51 percent reduction from 1990. These reductions are primarily the result of MACT standards, particularly those governing municipal waste combustors (MWC), medical waste incinerators (MWI), and Hazardous Waste Combustors (HWCs). Emissions from electric utilities are projected to increase, and emissions from chlorine production are projected to decline as a result of that industry's commitment to voluntary mercury reduction. The Binational Toxics Strategy has set a challenge of 50 percent reduction in mercury releases by 2006, from a 1990 baseline. In order to achieve a 50 percent reduction in total mercury emissions from 1990 levels, it will be necessary to find an additional six tons of reductions, either from the projected emissions for sectors emitting more than two tons, or from the estimated 19 tons of emissions in 1995 from sectors emitting less than two tons each.

Under the Title V Operating Permits program, states may impose emissions fees up to $25/ton of emissions for all chemicals. Facilities releasing mercury are subject to this fee for their mercury emissions. Without a differential fee structure, the fee alone is not likely to be high enough to spur reductions in mercury emissions. For instance, Wisconsin's largest source of mercury air emissions, would only pay $15.90 for its mercury releases (.63 ton @ $25/ton).

Specific Sources Covered: Significant mercury-emitting sectors covered by a NESHAP or MACT standard are listed below.

- Municipal Waste Combustors: In compliance with Sections 111 and 119 of the CAA Amendments of 1990, EPA has set performance standards and emission guidelines for new and existing MWCs based on MACT requirements, with emission limits for mercury. Available data indicates the control systems achieve over 90 percent mercury reduction. New MWCs must comply at start-up and existing MWCs must comply by December 2000.

- Medical Waste Incinerators: In September 1997 EPA set emission limits for MWIs based on MACT standards, with emission limits for mercury. Available data indicates the control systems achieve over 90 percent mercury reduction. New MWI units must comply at start-up and existing MWI units must comply by September 2002.

- Mercury Cell Chlor-alkali Plants; Ore Processing Facilities: Under 40 CFR 61.01 emissions from mercury ore processing facilities and mercury cell chlor-alkali plants are limited to a maximum of 2,300grams/24 hours. Chlor-alkali plants will also be subject to a MACT standard (see below).

- Hazardous Waste Combustors: On September 30, 1999 EPA promulgated revised emission standards (60 FR 189) for hazardous waste incinerators, hazardous waste burning cement kilns, and hazardous waste burning lightweight aggregate kilns under joint authority of the Clean Air Act (CAA) and Resource Conservation and Recovery Act (RCRA). The standards limit emissions of chlorinated dioxins and furans, other toxic organic compounds, toxic metals (including mercury), hydrochloric acid, chlorine gas, and particulate matter. EPA expects that mercury emissions will be roughly halved by this regulation. RCRA also regulates airborne emissions of mercury (and other substances) from the burning of hazardous waste in boilers and

industrial furnaces, including cement kilns (see **Part 3 of this Section--Mercury Waste Disposal**).

- Portland Cement Plants: Emissions of HAPs from Portland Cement plants, other than those resulting from combustion of hazardous waste, are regulated under a MACT standard (Federal Register, 6/14/99, 64 FR 31898). This standard does not, however, limit mercury emissions.

- Sewage Sludge Incinerators: Under 40 CFR 61.52 emissions from sludge incineration plants, sludge drying plants, or a combination of these that process wastewater treatment plant sludges are limited to a maximum of 3,200 g/24 hours. Development of a MACT standard for sewage sludge incinerators is pending.

- Pulp and Paper Mills: In 1998, EPA set NESHAPs to control emissions from existing and new major sources within the pulp and paper production source category, using maximum achievable control technology (MACT) to control hazardous air pollutants (63 FR 18504). This regulation does not control mercury emissions.

Threshold that triggers coverage: Listed source category for NESHAPs (no numeric thresholds); MACT thresholds are 10 tons per year of any HAP, or 25 tons per year in total HAP emissions.

Regulatory mechanism(s): emissions limits, emissions fees, permits, monitoring, operating requirements (which may include pollution prevention), reporting.

Environmental Standards: No federal ambient air mercury standards

Potential Changes: The 1990 Clean Air Act amendments single out mercury for additional study--and potential future regulations--especially with regards to coal-burning electric utilities.

- Utility Study (§112(n)(1)(A)): Section 112(n)(1)(A) of the 1990 Clean Air Act amendments mandates EPA to conduct a Utility Emissions Study. This study, completed in 1998, describes in detail the contribution of utilities to mercury emissions and other HAPs, and identifies coal-fired utility boilers as the largest remaining source of mercury emissions to air. A regulatory determination is due December 15, 2000.

- Industrial Combustion Coordinated Rulemaking: The EPA has determined that the following source categories may be sources for emissions of one or more of the hazardous air pollutants listed in Section 112(b) of the CAA: industrial, commercial, and institutional boilers; process heaters; reciprocating internal combustion engines; and stationary combustion turbines. The source category list schedule published by EPA requires that the NESHAPs for these source categories be promulgated by November 15, 2000.

- Chlorine Production Facilities Rule: EPA is developing a rule that would further limit mercury emissions from plants that produce chlorine using the mercury cell method. The rule will include emissions limits based on MACT and on management practices, and will shift from the current standard that applies equally to all facilities, regardless of size, to one normalized for production levels . In June 1999, EPA published an Information Collection Request to owners and operators

of 274 sludge incineration and drying plants and 24 mercury-cell chlor-alkali plants currently subject to NESHAP emissions standards for mercury.

- Industrial/Commercial Waste Incineration Rule: Section 129 of the Clean Air Act requires that Non Hazardous Solid Waste Incineration be addressed for nine toxins (including mercury). Industrial/commercial waste incineration, and crematorium/pathological unit rules will be proposed November 1999.

- NESHAP Reporting Requirements: EPA published an ANPRM (Advance Notice of Proposed Rule-Making) for information collection from facilities subject to NESHAP for Mercury Emissions 40 CFR 61.E (64 FR 119, June 22, 1999). This information collection would require sludge incineration and drying plants, and mercury-cell chlor-alkali plants to maintain records and submit reports of any physical and operational changes that could increase their mercury emission rates, as well of any startup, shutdown, or malfunction in the operation of a facility.

- Municipal Solid Waste Landfill Rule: EPA's Office of Air Quality Planning and Standards (OAQPS) is required to promulgate emission standards for Municipal Solid Waste Landfills by November 15, 2000 under §112 (d) of the CAA. The rule will address emissions of the hazardous air pollutants (HAP) listed in §112 (b) of the CAA (includes mercury). Taking the maximum achievable control technology (MACT) approach, EPA will develop emission standards for this source category which consists of contiguous geographical space/facilities receiving household waste, and other types of RCRA Subtitle D waste, such as commercial solid waste, non-hazardous sludge, conditionally exempt small quantity generator waste and industrial solid waste. Proposed and final rules are scheduled for November 1999 and November 2000, respectively.

- Mobile Sources: While mobile sources contribute significantly to estimated mercury emissions, this is a recently-identified source, based on limited monitoring. Before controls can be contemplated, additional research must be done to verify that this is a significant source. If mobile sources were found to be an important source, and if control technologies were available, regulation of fuels or vehicles could be promulgated under section 202(l)(2) of the Clean Air Act.

- Great Waters Program: Section 112(m) required EPA to study atmospheric deposition of mercury and other substances into several large water bodies, including the Great Lakes. The program is geared toward building an improved atmospheric monitoring network that will enable EPA and other agencies to study the relative contributions of different HAPs and the extent to which atmospheric deposition causes human health or environmental problems. If necessary, EPA may require additional controls on certain sources as a result of this study. Under §112(m)(5), EPA is required to assess the contribution of atmospheric deposition to pollutant loadings, the environmental and public health effects of atmospheric deposition and the extent to which atmospheric deposition contributes to water quality standard exceedances. The Great Waters report recommends that EPA promulgate Lesser-Quantity Emissions Rates for mercury.

Other Relevant Statutes: Mercury air releases are listed in a facility's TRI report, provided the facility meets the TRI threshold reporting requirements. RCRA regulations cover emissions from hazardous

waste combustion, and boilers and industrial furnaces. Existing regulations do not include specify mercury standards.

- Potential State Approach: Mercury Cap and Trade Concept in Wisconsin. Wisconsin Department of Natural Resources (WDNR) is exploring the potential for an innovative program that could provide a model for other states and the Federal government. WDNR staff have developed a concept that would involve establishing a mercury cap for air emissions that would achieve a 20 percent reduction in air emissions by 2005 and a 50 percent reduction by 2010. Reductions would take place below a baseline established by average annual emissions during the three years prior to establishment of the program. Sources that could not reduce emissions by the required amount would have a limited ability to purchase excess reductions from sources that reduced emissions more than required. The concept includes reassessment of the 50 percent goal in 2005, taking into consideration new scientific findings, including those developed under an effort to determine a regional Total Maximum Daily Load.

2) Mercury Discharges to Water

Statute: Clean Water Act

Principal Provisions that Affect Mercury Releases: Mercury is listed as a toxic pollutant under §307(a) of the Clean Water Act. For mercury discharges, Clean Water Act regulations specify technology-based effluent limits for classes and categories of industries (see 40 CFR 401, 403, Appendix B), and describes the circumstances in which states may require effluent limits or monitoring requirements more stringent than technology-based standards . States may also set water quality standards for pollutants including mercury. The Clean Water Act relies on a permit system, known as the National Pollutant Discharge Elimination System (NPDES) to regulate direct discharges to surface water bodies. Facilities are assigned a specific mercury discharge limit, and/or are required to monitor their discharge for mercury. Facilities report actual discharge levels in Discharge Monitoring Reports (DMRs), which serve as the basis for determining compliance.

Pretreatment standards regulate industries that discharge into a publicly owned treatment plant (POTW) instead of discharging directly into a receiving water body. Regulations list industrial categories subject to national categorical pretreatment standards for new and existing facilities that discharge into treatment plants. POTWs with approved pretreatment programs may set permit limits and conduct inspections of industrial users. Facilities that do not have specific pretreatment standards for mercury (or other hazardous substances), are supposed to notify the POTW of any hazardous waste discharge that exceeds 100kg per month. Wastestreams from certain manufacturing processes that may involve mercury, such as fluorescent lamps and switchgear, are excluded from categorical pretreatment standards because they are considered dilute.

Mercury is included in the list of chemicals eligible for removal credits at a POTW. That is, a POTW may allow a facility to discharge a higher quantity of mercury provided that the POTW meets the applicable mercury standard in its sludge without additional costs.

EPA Region 5 Water Division revised its enforcement program for certain chemicals to trigger enforcement investigations earlier than the previous program. Under the Great Lakes Enforcement Strategy, EPA targets violations of *daily* maximum permit limits. This screening criteria is more

stringent than the national definition of significant noncompliance, which targets violations of *monthly* average limits.

- The Final Water Quality Guidance for the Great Lakes System: In recognition of the vulnerability of the Great Lakes to bioaccumulative pollutants, including mercury, in 1995 EPA published water quality criteria designed to protect aquatic life, wildlife, and human health on a long term basis. The Final Water Quality Guidance for the Great Lakes System (60 FR 15366, March 23, 1995) established water quality criteria for 29 pollutants, including mercury (see **Table 15: Environmental Standards for Mercury)**. The Guidance is designed to remedy the differences in water quality standards of the Great Lakes states and protect lakes from chemicals that bioaccumulate in the food chain.

Specific Sources Covered: The Clean Water Act lists technology-based standards for the following industry source categories: Inorganic Chemicals Manufacturing, chlor-alkali subcategory (mercury cell process)(40CFR415.60); Nonferrous Metals category including, primary antimony subcategory (40CFR421.140), secondary mercury subcategory (40CFR421.200), primary precious metals and mercury subcategory (40CFR250); Steam electric power generation (40CFR423--mercury is an Appendix A priority pollutant); Ore Mining and Dressing Category including, mercury ore subcategory (40CFR440.40), copper, lead, zinc subcategory (40CFR440.100), platinum ores subcategory; Pesticide Manufacturing category, metallo organic pesticide chemicals subcategory (40CFR455); Battery Manufacturing category, LeClanche and zinc subcategories (40CFR461.40).

However, this list does not limit the types of dischargers that may have mercury effluent limits or monitoring requirements in their NPDES permits. Individual states may impose specific mercury discharge limits and/or monitoring requirements on individual facilities that discharge into water quality-limited water bodies. These state regulations require the use of EPA-approved analytical testing methods (for the purposes of data gathering and compliance monitoring under the Clean Water Act and the Safe Drinking Water Act) by industrial and municipal facilities to analyze chemical and biological components of wastewater, drinking water, sediment, and other environmental samples.

In addition, groundwater at hazardous waste treatment, storage, and disposal facilities must be monitored for the presence of mercury (40 CFR 302.4, 264.94).

Threshold That Triggers Coverage: No volume or quantity threshold.

Regulatory Mechanism(s): effluent limits, effluent fees (WI), permits, operating requirements, control requirements, monitoring/reporting

Environmental Standards: Ambient Water Quality Criteria for surface water and organisms; drinking water; sludge. Water Quality Guidance for the Great Lakes System: aquatic life, human health, wildlife.

On June 8, 1999 (64 FR 109) EPA issued final approval for *Method 1631: Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence*, that can detect mercury at 0.5 ng/L (parts-per-trillion). This detection limit is approximately 400 times lower than the detection limits achieved by other mercury methods previously approved at 40 CFR Part 136. Approval of this method is significant because it will allow stricter enforcement of existing water quality criteria and discharge

standards. Older methods had detection limits substantially higher than the criteria in the Final Water Quality Guidance of the Great Lakes System, so that while the criteria were strict, practical ability to enforce these criteria were limited by the measurement method. There are different standards for different uses. For protecting wildlife the standard is 1.3 ng/L while the standard is 1.8 ng/L for protecting human fish consumers.

Potential Changes:

- Hazardous Waste Listings A number of waste streams have been listed as hazardous wastes (40 CFR Part 261) due to their mercury content. These include two wastestreams from chlorine production using the mercury cell process as well as several mercury compounds if spilled or discarded. EPA is currently evaluating a wastewater treatment sludge from the production of vinyl chloride monomer using a mercury catalyst. A proposal on sludge wastestream is due in 1999.

- Clean Water Action Plan: The Clean Water Action Plan states that EPA will consider revisions to water quality criteria for mercury. This will help EPA to take better account of bioaccumulation of mercury in the aquatic food chain.

Other Relevant Statutes: Mercury water releases are listed in a facility's Toxic Release Inventory, provided the facility meets the TRI threshold reporting requirements (see discussion under Mercury Reporting Requirement). Michigan also collects information on use and release in its Critical Materials Registry.

3) Mercury Waste Disposal

Statute: Resource Conservation and Recovery Act (RCRA) (*see also 40 CFR 261*)

Principal Provisions That Affect Mercury Disposal: RCRA regulations outline specific classification and disposal requirements for products and wastes that contain mercury. RCRA regulations are waste-specific, not source-specific, and thus may apply to any facility that generates mercury-containing wastes.

Waste code identification: Current RCRA regulations classify certain mercury-containing wastes either as "characteristic" wastes or "listed" wastes. Mercury is both a characteristic and a listed waste under RCRA. Six different mercury-containing wastes or discarded chemical products have been listed as hazardous wastes. Additionally, RCRA regulations limit the airborne emission of mercury and other substances from boilers and industrial furnaces, including cement kilns, that burn hazardous wastes.

Wastes are considered "characteristic" hazardous wastes if they exhibit any of four specified characteristics: ignitability, corrosivity, reactivity, or toxicity. Ignitability, corrosivity, and reactivity describe general properties of the waste, whereas the toxicity characteristic identifies wastes likely to leach specific toxic constituents into groundwater if managed improperly. Wastes that exhibit concentrations above a specific regulatory level for any of 40 substances, including mercury, are considered hazardous.

A specific "D" waste code identifies the contaminant(s) for which a waste exhibits the toxicity characteristic. The regulatory level for mercury is 0.2 mg/l (or 0.2ppm), and the waste code **D009**, identifies wastes that exceed the toxicity characteristic for mercury (40CFR261.24). Regulations outline the required toxicity characteristic leaching procedure (TCLP) test necessary to determine the concentration of each substance (40CFR261 AppII).

"Listed" wastes are specifically identified wastestreams or products that appear on one of three hazardous waste lists in RCRA. Each listed waste is assigned a different waste code. Wastes from non-specific sources such as spent solvents, are assigned an "F" code. Wastes from specific sources are assigned a "K" code. Each of these wastes are listed for a specific substance (40CFR 261.30). Appendix VII of the regulations lists the constituents that caused specific wastestreams to be listed.

Commercial chemical products such as manufacturing chemical intermediates, off-specification species, container residues, and spill residues may also be considered hazardous wastes when discarded. Two sublists identify waste codes for commercial chemical products. Chemicals assigned a "P" code are considered acute hazardous wastes when discarded (40CFR261.33 (e)); chemicals assigned a "U" code are toxic chemicals considered hazardous when discarded and are regulated like other listed hazardous wastes (40CFR261.33(f)). The P and U lists are triggered only when the P or U chemical is the sole active ingredient, a commercial product is discarded, or a listed chemical is spilled. These lists do not apply to manufacturing process wastestreams that contain listed chemicals.

In addition to the D009 waste code, the following waste codes identify mercury-containing wastes or discarded chemical products:

- **F039**: Leachate (liquids that have percolated through land disposed wastes) resulting from the disposal of more than one restricted waste classified as hazardous. F039 is listed for multiple substances and may not be a reliable indicator of mercury in the wastestream.
- **K071**: Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used. K071 is listed only for mercury.
- **K106**: wastewater treatment sludge from the mercury cell process in chlorine production. K106 is listed only for mercury.
- **P065** identifies mercury fulminate (mercury compound used in explosives) as an acute hazardous waste.
- **P092** identifies phenylmercuric acetate (mercury compound used in paints) as an acute hazardous waste.
- **U151** identifies mercury as a toxic waste.

Disposal Requirements, Including Prohibitions on Land Disposal: RCRA regulations describe specific disposal requirements for individual waste codes. All mercury-bearing wastes (wastewaters and nonwastewaters) are subject to land disposal restrictions. That is, the mercury concentration in these wastes must be below the regulatory concentration level before the wastes may be land-disposed. For some types of waste, the regulations require a specific treatment, such as incineration or thermal treatment. In other cases, only a maximum mercury concentration is required, and any treatment method may be used. As a result of recently imposed land disposal restrictions on chlor alkali wastes (K071 and K106), some facilities are building their own mercury recovery facilities, whereas others are shipping their wastes to Canada or elsewhere for disposal.

RCRA regulations also influence product disposal and recycling options for mercury containing products. Discarded products considered hazardous wastes are subject to storage, transportation, and permitting requirements under RCRA subtitle C (hazardous wastes). Currently, batteries and fluorescent lamps are included in a "universal waste rule" that eases RCRA restrictions on hazardous waste management and enables states to set up special collection programs.

Universal Waste Rule: EPA issued the universal waste rule (UWR) in 1995. It is designed to reduce the amount of hazardous waste in the municipal solid waste stream, encourage the recycling and proper disposal of some common hazardous wastes, and reduce the regulatory burden on businesses that generate these wastes. Universal wastes are items commonly thrown into the trash by households and small businesses. Although handlers of universal wastes must meet less stringent standards for storing, transporting, and collecting wastes, the waste must comply with full hazardous waste requirements for final recycling, treatment, or disposal. This management structure removes these wastes from municipal landfills and incinerators. In July 1999, EPA added mercury-containing lamps to the UWR, which already covered batteries, thermostats, and pesticides.

Requirements for Owners and Operators of Hazardous Waste Land Treatment Facilities: Landfill owners must determine the mercury concentrations in any wastes if food chain crops are grown at the facility. Food chain crops cannot be grown on the treated area of a hazardous waste land treatment facility unless the owner or operator can demonstrate, based on field testing, that any mercury and other specified constituent will not impair the quality of the food grown there (40CFR 265.273 and .276).

Hazardous Waste Combustion: RCRA regulates air emissions from hazardous waste combustion and boiler and industrial furnaces (BIFs). Cement kilns, regulated under interim BIF standards, frequently burn hazardous waste as a fuel source. EPA has issued new emission standards for mercury from hazardous waste combustors, and is considering proposing a rule to limit emissions of HAPs for four other source categories (see **Section III, C, 1--Mercury Air Emissions**).

Specific Sources Covered: Any facility that uses mercury may generate waste that exceeds the toxicity characteristic for mercury. Facility operators use best professional judgment to determine whether or not to test their waste specifically for mercury. Mercury-cell chlor-alkali facilities are the only mercury sources that have specifically listed wastestreams (K071, K106).

Threshold that triggers coverage: Facilities must meet RCRA hazardous waste quantity thresholds before they are required to report information on their hazardous waste generation and management. Thresholds are based on the *total amount* of hazardous waste generated at a facility, not on the amount of any one kind of waste (e.g., facilities that generate more than 2,200 pounds per month of hazardous waste are considered large quantity generators; facilities that generates 220 - 2,200 pounds of hazardous waste per month are considered small quantity generators). Therefore, levels of mercury waste alone are not likely to determine whether or not an individual facility is subject to RCRA requirements.

Regulatory Mechanisms: disposal restrictions, labeling, control requirements, inspections, planning requirements, operating requirements, permits, reporting

Environmental Standards: hazardous waste concentration, groundwater standards

Potential Changes:

- Land Disposal Restriction Rule: The EPA is considering publication of a proposed rule to revise the 40 CFR Part 268 Land Disposal Restrictions treatment standards applicable to mercury containing wastes. The revisions under consideration by the Agency will involve a comprehensive reevaluation of the treatment standards for mercury containing wastes. The recent Advanced Notice of Proposed Rule Making (64 FR 103, 28 May, 1999, p. 28949) was intended to give advance notice of EPA's consideration of the revisions and to solicit public comment and applicable data. A proposed rule is scheduled for mid 2000.

Other Relevant Statues:

- Develop Disposal Options for Hazardous Wastes Containing Mercury: Current waste treatment standards for many hazardous wastes containing mercury are based on recovery of mercury through retorting. EPA is planning to evaluate other options because 1) the supply of recycled mercury is increasing while demand is decreasing and 2) there are concerns over potential emissions from retorting. For organic hazardous wastes which contain mercury, the current treatment standards also are often based on incineration. Therefore, EPA is considering an Advance Notice of Proposed Rulemaking (ANPRM) to revise its hazardous waste treatment standards to include alternatives based on permanent stabilization of mercury. These alternatives could also apply to elemental mercury.

4) Mercury Reporting Requirements

Several sections of the Superfund Amendments and Reauthorization Act of 1986 (SARA), which amended CERCLA to address ongoing activities that result in releases of hazardous substances, impose reporting requirements on mercury use, release, and spills. Title III, known as the "Emergency Planning and Community Right-to-Know Act" (EPCRA) establishes emergency release, inventory, and release reporting requirements. The best-known requirement is the Toxics Release Inventory (TRI), which requires facilities in the manufacturing sector (SIC codes 20-39) to report releases to air, water, and land for all listed chemicals, including mercury. Other sections require facilities to report spills of listed substances above a threshold reporting quantity (reportable quantities), and the quantities of chemicals stored above a specified threshold planning quantity. Each of these sections is discussed separately below.

Statute: (SARA Title III, §313) Toxic Chemical Release Inventory (TRI)

- **Principal Provisions that affect mercury reporting**: All facilities in the manufacturing sector (SIC codes 20 - 39) that meet the threshold reporting requirements must report their releases of mercury to all media. TRI thresholds are based on the quantity of each substance used, processed, manufactured, or imported at any of these facilities.

  Mercury and mercury compounds are currently listed under section 313 of EPCRA and reports are received from facilities that manufacture, process, use, release into the environment, or otherwise manage as waste mercury and mercury compounds. These reports are made available to the public through the Toxics Release Inventory (TRI). To date, only a small number of large sources, such as chlor-alkali plants, have been required to report mercury releases. In 1997, the categories of industrial facilities required to report under EPCRA section

313 were expanded to cover, among others, electric utilities, and hazardous waste treatment, storage and disposal (TSD) facilities.

- **Specific Sources covered**: Any manufacturing facility that uses quantities of mercury above the reporting threshold.
- **Threshold that triggers coverage**: Facilities that manufacture, process, or import 25,000 pounds of mercury and/or otherwise use 10,000 pounds of mercury must report releases to all media. These thresholds are generally too high to capture the vast majority of sources that use mercury.
- **Regulatory Mechanism**: public disclosure, reporting
- **Potential Changes**: Only a small number of mercury releases have been received under EPCRA §313 because reporting thresholds have been too high to capture mercury releases from many covered facilities. To ensure that mercury release reporting will be effective, especially taking into account releases from facilities newly subject to EPCRA section 313, EPA issued a proposal to lower the 25,000/10,000 pound thresholds to 10 pounds or 100 pounds.[30] The proposed rule would impose the 10-pound threshold for PBTs "of greatest concern." These include mercury and mercury compounds, and eleven other chemicals or chemical categories. Under this proposed threshold, EPA calculated that approximately 9,500 facilities would be required to submit approximately 17,000 additional copies of the standard TRI reporting form.
- **Other relevant statutes**: Clean Air Act, Clean Water Act, RCRA. Courts are currently reviewing whether or not a facility that reports mercury releases to water in its TRI report but does not have a Clean Water Act NPDES permit for those discharges is in violation of its NPDES permit.

Statute: SARA Title III §302, §304, §311 and §312 (threshold planning quantities and reportable quantities)

- **Principal Provisions That Affect Mercury Reporting**: SARA reportable quantities are linked closely to CERCLA §102 reporting requirements. Under SARA §302, any facility that produces, uses, or stores "extremely hazardous" substances must notify the State Emergency Response Commission. Mercuric acetate, mercuric chloride, and mercuric oxide (mercury compounds) are considered extremely hazardous substances (40CFR355). Under §304, a facility must notify the state emergency response commission and a local emergency planning committee of releases that exceed reportable quantities for hazardous substances. Facilities must also notify the National Response Center (1-800-424-8802). The reportable quantity for mercury spills is one pound (40CFR302).

  Under §311 and §312, facilities that keep hazardous substances on-site in quantities greater than threshold levels must submit a chemical inventory to the state emergency response commission, the local emergency planning commission, and the local fire department (40CFR370). The threshold for mercury (a hazardous substance) is 10,000 pounds, and the threshold for listed mercury compounds is 500 pounds (extremely hazardous substances).
- **Specific Sources Covered**: Any facility that uses mercury may be potentially subject to these regulations.
- **Threshold That Triggers Coverage**: Hazardous substances in quantities greater than 10,000 pounds, and extremely hazardous substances in quantities greater than 500 pounds must be reported. The reporting threshold for mercury spills is one pound (40CFR355.40).

[30] 64 FR 688, 5 January, 1999.

- **Regulatory Mechanism(s)**: reporting, public disclosure.
- **Environmental Standards**: n/a
- **Potential Changes**: None identified.
- **Other Relevant Statutes**: Clean Air Act, Clean Water Act, CERCLA. Ohio imposes an annual chemical inventory filing fee of $100 base fee, plus $10 for each additional hazardous substance over 5 substances and $50 per extremely hazardous substance reported. The facility filing fee cap is $2,500.

Table 14: Actual and Projected Mercury Emissions (tons)

	1990	*1995*	*2006*
Sectors that will be affected by regulation[31]			
Municipal Waste Combustors	41.7	29.6	4
Medical Waste Incinerators	50.2	16.0	1
Hazardous Waste Incineration	5.7	7.1	3
Sectors that will be affected by regulation/voluntary action[32]			
Chlorine Production	10.0	7.1	3.5
Sectors that will be affected by regulation but effect on emissions is unclear			
Utility boilers-coal	51.0	51.6	57.0
Industrial boilers	2.1	2.1	2.1
Sectors that will not be affected by anticipated regulation			
Mobile sources-non road	6.8	6.8	6.8
Mobile sources-on road	5.0	5.0	5.0
Portland Cement (non-hazardous waste fired)	4.0	4.0	4.0
Subtotal	176	130	86

[31] Based on anticipated effects of Maximum Achievable Control Technology Standards.

[32] Based on assumption that 50 percent reduction in mercury use by the chlorine producing sector will result in a 50 percent reduction in emissions.

Sectors less than 2 tons:			
Other	22.0	19.3	??
TOTAL	198	149	??

5) International Agreements and Protocols

Mercury's ability to cycle globally poses both a challenge and an opportunity to the U.S. As long as mercury is produced, used and released into the environment in other countries, the U.S. will be on the receiving end of some mercury, thus reducing the overall impact of domestic mercury control measures.

The U.S. is participating in bilateral and international fora to encourage the cooperative development and use of relevant scientific and technical information about mercury. These fora include the U.S.-Canada Binational Toxics Strategy, the North American Commission for Environmental Cooperation (CEC) Regional Action Plan on Mercury , and its Sound Management of Chemicals Initiative, the U.N. Economic Commission for the Convention on Long-Range Transboundary Air Pollution (LRTAP) and its legally binding protocol on mercury and other heavy metals, the Organization for Economic Cooperation and Development (OECD) and its programs on heavy metals risk management and the elimination of environmentally adverse economic subsidies, the Arctic Monitoring and Assessment Program (AMAP), and the New England Governors/Eastern Canadian Premiers (NEGT/ECP) Mercury Action Plan. A brief description of each of the various international fora in which the US is addressing mercury is provided below.

Binational Toxics Strategy: On April 7, 1997, the United States and Canada signed the Great Lakes Binational Toxics Strategy. The Strategy's purpose is to establish a collaborative process for the achievement of virtual elimination of persistent toxic substances resulting from human activity, particularly those which bioaccumulate, from the Great Lakes basin, so as to protect and ensure the health and integrity of the Great Lakes ecosystem.

For mercury, the Strategy sets a U.S. challenge of 50 percent reductions nationwide in the use and release of mercury by 2006, and a Canadian challenge of 90 percent reduction in release of mercury in the Great Lakes basin by 2000.[33] The baseline for the U.S. challenges is the most recent year for which there was an inventory available at the time the Strategy was signed. For the release challenge, the baseline year is 1990; for the use challenge, the baseline is 1995 mercury consumption as estimated by the U.S. Geological Survey. While the purpose of the Strategy is to protect the Great Lakes Basin, implementation of the U.S. challenge requires a national effort to reduce use and air emissions of mercury. The release challenge is national as it applies to air emissions, because mercury emissions have the potential to be transported across the continent. The mercury use challenge is national in scope as

[33] The Strategy states that the United States will: "Seek by 2006, a 50 percent reduction nationally in the deliberate use of mercury and a 50 percent reduction in the release of mercury from sources resulting from human activity. The release challenge will apply to the aggregate of releases to the air nationwide and of releases to the water within the Great Lakes Basin. This challenge is considered an interim reduction target and, in consultation with stakeholders, will be revised if warranted, following completion of the Mercury Study Report to Congress. The Canadian challenge under the Strategy is to: "Seek by 2000, a 90 percent reduction in the release of mercury, or where warranted the use of mercury, from polluting sources resulting from human activity in the Great Lakes Basin. This target is considered as an interim reduction target and, in consultation with stakeholders in the Great Lakes Basin, will be revised if warranted, following completion of the 1997 Canada Ontario Agreement review of mercury use, generation, and release from Ontario sources."

well, both because mercury use affects national air emissions and because the import of mercury-containing products into the Great Lakes Basin could lead to local mercury releases.

While already-planned regulatory activities are expected to achieve most of the U.S. challenges, the focus of the Binational Toxics Strategy is encouragement of voluntary reductions. EPA and Environment Canada have established a stakeholders workgroup--including industry, States, Tribes, environmental groups and the public--to track progress towards achievement of the challenges and to share information about mercury reduction accomplishments and opportunities. In addition, the Binational Strategy process encourages voluntary mercury reduction commitments: the chlor-alkali industry, the American Hospital Association, and Northwest Indiana steel mills have made such commitments (see section 4). The workgroup has conducted workshops on reduction opportunities for electric utilities and local communities, and is working to share information about reduction opportunities related to schools, autos and thermostats. A Binational Toxics Strategy report on mercury reduction opportunities, based largely on work accomplished by the Great Lakes States in recent years, will be published in 2000.

North American Commission for Environmental Cooperation (CEC): The North American Regional Action Plan (NARAP) is one of a number of regional undertakings that stem from the North American agreement on Environmental Cooperation between the governments of Canada, the united Mexican states, and the USA (Parties). The NARAP calls for the develop of regional actions plans for selected persistent and toxic substances as a first priority in the Parties' common desire to address national and regional concerns associated with the sound management of chemicals.

Under the CEC Resolution #95-5 mercury was identified as one of the first four chemicals selected for the Sound Management of Chemicals Initiative. The CEC released a draft of the phase II NARAP for Mercury on August 17, 1999, and accepted public comments through October 20. The phase II NARAP will identify actions that the Parties will commit to in order to reduce mercury use and release.

LRTAP: In February 1998 the U.S. and other Parties to the U.N. Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (LRTAP) concluded negotiations on a legally binding protocol on mercury and other heavy metals. The protocol includes obligations to control mercury emissions from stationary sources and to establish and report mercury emissions inventories. It also contains obligatory and voluntary provisions regarding the use of mercury in products. The U.S signed the LRTAP Heavy Metals Protocol in June 1998 agreeing in principle to this international agreement, however, it is still under review and has not yet been ratified. The U.S. is participating in U.N. ECE LRTAP working groups to resolve some of the uncertainties involving various mercury issues.

Arctic Monitoring and Assessment Program (AMAP): AMAP collects information on pollution threats, detects changing conditions and emerging problems, and conducts risk reduction activities. AMAP is performing a study on mercury in the arctic atmosphere. The Protection of the Arctic Marine Environment (PAME) program is drafting a regional action plan for pollution from land-based sources which includes voluntary commitments by Arctic Council members on persistent organic pollutants (POPs) and heavy metals.

New England Governors/Eastern Canadian Premiers (NEG/ECP): On June 8, 1998, the New England Governors/Eastern Canadian Premiers signed a resolution, concerning mercury and its impacts on the environment. In addition, the Governors and Premiers adopted the Mercury Action Plan, which has as its

regional goal "The virtual elimination of the discharge of anthropogenic mercury into the environment." The NEG/ECP has established a task force, which includes the New England states, the Eastern Canadian Provinces, to coordinate and implement the Mercury Action Plan. The action plan identifies 45 specific actions to reduce mercury emissions. Including emission reduction targets from specific source categories, such as municipal waste combustors, medical waste incinerators, sludge incinerators, utility and non-utility boilers, industrial and area sources and source reduction and safe waste management of mercury.

IV. Voluntary and Non-regulatory Approaches to Mercury Reduction

Voluntary programs to encourage and promote the reduction of mercury use and release are an important part of governmental efforts, both at the State and Federal levels. Voluntary initiatives, while not a substitute for regulatory efforts, can complement regulations in important ways. First, voluntary initiatives have the flexibility to reach sources not covered by regulations. Second, they promote achievement of more than regulations require. Third, voluntary initiatives may achieve reductions better, cheaper, and faster, in part because they encourage innovation and create a climate that emphasizes seeking the best way to accomplish a reduction. Finally, voluntary action is an important avenue of involvement for non-profit environmental, community, and other organizations.

Michigan's Mercury Pollution Prevention Task Force, a stakeholder group organized by the Michigan Department of Environmental Quality, undertook a comprehensive effort from 1994 through 1996 to identify voluntary actions that could achieve mercury reduction. As a result of this process, several sectors made significant mercury reduction commitments. Most notably, in response to a request from the Task Force, Chrysler, Ford, and General Motors committed to phase out mercury switches from automobiles, starting with the 1997 and 1998 model years, and the American Automobile Manufacturers Association agreed to develop a procedure for removing switches from the existing vehicle fleet.[34]

On July 10, 1997, the Chlorine Institute, on behalf of U.S. mercury cell chlor-alkali facilities, committed in 1997 to reduce mercury use 50 percent by 2005 , and to report annually on progress. The second annual report was submitted in May 1999; this report showed a 35 percent reduction below the industry's 160 ton average annual mercury use in the early 1990s, to 104 tons in 1998. USEPA, together with interested State agencies and academic researchers, has been meeting with industry representatives to coordinate projects that will help better to characterize mercury emissions from chlor-alkali facilities.

In December 1997, the Thermostat Recycling Corporation (TRC) launched a program to recycle mercury-switch thermostats in nine states. The TRC is a private corporation established by thermostat manufacturers Honeywell, General Electric, and White-Rodgers. Since the program's inception, TRC has recycled 274 pounds of mercury from thermostats. TRC collected and processed more than 110 pounds of mercury in the first six months of 1999.

On June 25, 1998, EPA and the American Hospital Association (AHA) signed a memorandum of understanding committing to work together to significantly cut hospital wastes by 2005. The agreement envisions the virtual elimination of mercury-containing hospital wastes and a one-third reduction in total hospital wastes by 2005.

On September 15, 1998, three northwest Indiana steel mills, Bethlehem Steel Burns Harbor, Ispat Inland Inc. Indiana Harbor Works, and U.S. Steel Gary Works, signed a voluntary agreement with the Lake Michigan Forum, U.S. Environmental Protection Agency (EPA), and the Indiana Department of Environmental Management (IDEM) to reduce the use of mercury at their facilities. . The companies have completed a report inventorying mercury in equipment, materials, storage, and waste streams (see http://www.lkmichiganforum.org/mercury/index.html); the report found that there are more than 1200

[34] Michigan Mercury Pollution Prevention Task Force, 1996.

pounds of mercury present at the three plants combined: almost one-half (572 pounds) is contained in equipment, primarily in mercury gauges. The next stage of the project is to develop mercury reduction plans for each facility.

Table 15: Environmental Standards for Mercury

Media	*Mercury Standard*	*Explanation*
Ambient Water	• 0.144 ug/l for ingestion of both water and aquatic organisms; • 0.146 ug/l for ingestion of only aquatic organism. • 2.10 ug/l for freshwater acute exposure; • 0.012 ug/l for freshwater chronic exposure; • 1.8 ug/l for marine acute exposure; • 0.025 ug/l for marine chronic exposure.	• Toxics criteria for those States Not Complying with CWA Section 303(c)(2)(B)-criterion concentration for priority toxic pollutants (40 CFR 131.36) EPA 1992a
Ambient Water WQGGLS	• 1.694 ug/l for acute exposure of aquatic life • 0.908 ug/l for chronic exposure of aquatic life • $1.8x10^{-3}$ ug/l water quality criteria for protection of human health • $1.3x10^{-3}$ ug/l water quality criteria for protection of wildlife	• The Final Water Quality Guidance for the Great Lakes System established water quality criteria for 29 pollutants, including mercury. (40 CFR 132) EPA 1995d
Drinking Water	• Maximum contaminant level = .002 mg/l (40 CFR 141.62)	• Maximum contaminant level for mercury established under the Safe Drinking Water Act.
Air	• No ambient standard outdoors. • 0.1 mg/m^3 permissible exposure limit (PEL) • 0.3 mg/m^3 RfD • 0.3 mg/m^3 acceptable daily exposure level.	• OSHA workplace standard. • EPA reference dose. • Agency for Toxic Substances and Disease Registry (ATSDR).
Sludge	Limits: • 17 mg/kg (dry wt) and 17 kg/hectare cumulative loading for sludge applied on agricultural, forest and publicly accessible lands. • 17 mg/kg (dry wt) and .85 kg/hectare annual loading rate for sludge sold or distributed for application to a lawn or home garden. • 57 mg/kg (dry wt) for sludge sold or distributed for other types of land disposal • 100 g/kg (dry wt) for sludge disposed in lined or unlined facilities (40 CFR 503).	
Compost	• No federal standards.	• Minnesota sets mercury concentration limits in compost.
Fish	• 1 ug/g (1 mg/kg or 1 ppm)	• FDA action level for methyl mercury. ug/g (1 mg/kg or 1 ppm)
Groundwater	• 2 ug/l	
Bottled Water	• .002 ug/l (21 CFR 165.110) FDA 1995	
Water-level of detect	• Method 1631 detects mercury 0.5 ng/liter (parts-per-trillion)	• EPA-approved method to detect Hg in water. • EPA is scheduled to promulgate a lower detection method, Method 1631 in December 1999.

Hazardous Waste	• TCLP = .2 mg/l or .2 ppm (40 CFR 261.24, 264)	• Land disposal (Subtitle D, nonhazardous landfills) prohibited unless leachate contains less than .2 mg/l.

Table 16: Potential Changes in Mercury Regulations

Regulation Category	*Fed/State*	*Potential Change*
Using Mercury		
Commerce		No potential changes
Products		No potential changes
Releasing Mercury		
Air emissions	Fed (CAA)	Industrial/commercial waste incineration, and crematorium/pathological unit rules (CAA §129) will be proposed November 1999.
		Utility study: evaluating utility HAP emissions and public health effects; may recommend emissions limits
		Great waters study: EPA will study atmospheric deposition of mercury into large water bodies and may require additional controls on certain sources as a result.
		Chlorine Production Facilities Rule: EPA is developing a rule that may further limit mercury emissions from plants that produce chlorine using the mercury-cell method.
		EPA is required to promulgate emission standards for municipal solid waste landfills by November 15, 2000 (CAA §112(d)).
	WI	In April 1999, Wisconsin legislators introduced a bill to cap 1999 mercury emission levels in the year 2000 for power plants, incinerators, and chemical plants. The bill also mandates reductions of mercury emissions in 2005, 2010, and 2015 (LRB-0989). Using 1999 as the baseline year, major utilities in 2001-2004 may not emit more mercury each year than they did in 1999. For 2005-2009, the yearly limit is 85% of baseline year emissions. For 2010-14, the limit is 70% of baseline year emissions, and 50% on and after 2015 (LRB-0989).
	Fed (RCRA)	EPA has proposed emission standards for mercury emitted from hazardous waste combustion facilities. The final rule is scheduled for 1999.
		EPA is considering proposing a rule that will limit emissions of hazardous pollutants, including mercury, for five source categories.
Water discharge	Fed (CWA)	EPA is currently evaluating a wastewater treatment sludge from the production of vinyl chloride monomer using a mercury catalyst. A proposal on sludge wastestream is due in 1999 (40 CFR 261).
Waste disposal	Fed (RCRA)	Air emissions standards for hazardous waste combustion facilities rule (59 FR 17358).
		A Land Disposal Restriction Rule would revise 40 CFR 268 treatment standards applicable to mercury containing wastes. A proposed rule is scheduled for mid 2000.
		EPA is considering an ANPRM to revise its hazardous waste treatment standards to include alternatives based on permanent stabilization of mercury.
Reporting Requirements	Fed (TRI)	EPA has proposed lowering the reporting threshold from 10,000 pounds to 10 pounds (64 FR 688).