Background Paper for Stakeholder Panel to Address Options for Managing U.S. Non-Federal Supplies of Commodity-Grade Mercury

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Department of State
Office of Management and Budget
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Office of the U.S. Trade Representative

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INTRODUCTION

In *EPA's Roadmap for Mercury*,[1] the U.S. Environmental Protection Agency (EPA) committed to work with other Federal agencies to initiate a process with technical experts and interested parties to assess options for managing domestic elemental, commodity-grade mercury surpluses. In order to meet this commitment, a stakeholder panel has been established to provide the United States Government (USG) with a reasonable range of options and an assessment of these options for managing non-federal supplies of mercury. The panel will present a robust discussion of the pros and cons of these options for managing non-federal supplies.

There are different sources of mercury, including mercury recovered from the conversion or closure of chlor-alkali plants, mercury recovered as a by-product from gold mining, mercury recovered from product collection programs, and other recycled mercury. How each of these sources are and should be addressed in the short and long-terms may differ depending upon the sources. For example, the options for mercury recovered from the closure or conversion of chlor-alkali plants may focus primarily on storage, while the options for mercury recovered as a by-product from gold mining may focus on storage only in the longer-term, because in the short-term it may be seen as a preferred source of mercury to meet on-going demand. Thus, an analysis of each of the different sources listed above may result in a different set of options for each, particularly given that, although decreasing, there are still domestic and global demands for mercury.

All options that involve storage of excess mercury would require an assessment of a number of issues, including: 1) which entities (e.g., a state or private company) could be allowed to store mercury; 2) who should pay for costs of initial and ongoing storage; 3) who would be responsible and liable for security costs; 4) what should the technical standards be for safe long-term storage; 5) where storage should be allowed, both geographically (e.g. multiple sites or a single site) and types of storage (e.g. abandoned mines, warehouses, etc); 6) what is the legal authority for the storage of the mercury; 7) who will legally own the stocks and be liable for environmentally safe long-term storage; 8) what is the applicability of RCRA and other existing domestic statutes; and 9) what legislative/regulatory changes may be needed. All management options that involve marketing of non-federal mercury supplies should include an examination of likely commodity mercury transactions given trends in the global price of mercury.

This background paper provides a basic overview of information on mercury supplies and stocks (both globally and domestically); demand; and mercury management technology. The paper also provides references to more detailed reports on these topics.

ISSUE OF U.S. NON-FEDERAL SUPPLIES

Mercury is a naturally-occurring metal that is processed and sold as a commodity in its elemental, liquid form, and subsequently used in manufacturing and industrial processes and in industrial and consumer products such as thermometers and thermostats.

[1] EPA. EPA's Roadmap for Mercury, July 2006.

While there are potential health concerns with the inhalation of elemental mercury, the greater potential concern is exposure through the ingestion of fish and marine mammals that contain mercury. Mercury that is emitted from a stack or is otherwise released to air or water during disposal or recycling of mercury-containing products and wastes can be the source of much of that mercury. Once emitted and transported in the atmosphere, it is deposited, such that it finds its way into waterbodies, e.g., lakes and oceans, where it can be biotransformed by bacteria into an organic form of mercury—methylmercury—that accumulates in plants, then fish, then in humans and wildlife that eat the fish.

EPA expects that excess supplies of elemental, commodity-grade mercury could emerge on the world market over the coming 10 to 30 years, as various global sources of mercury–especially surpluses resulting from the shift away from mercury use by chlor-alkali manufacturing plants—exceed a shrinking demand for mercury-containing products and industrial use of mercury, particularly in the developed world. However, demand for mercury use in artisanal mining, a major source of mercury emissions to the environment, is expected to increase during this time frame. As a result, there is likely to be an increasing need to ensure that programs are in place to safely manage mercury supplies for the long-term.

On a global basis, there is currently a net flow of mercury from developed countries to developing countries. According to a report prepared for the European Commission (EC) in 2006, almost one-third of the global mercury supply is used for small-scale gold mining (mostly in Africa, Asia, and South America), much of which is lost to the environment.[2] There is increasing concern that as mercury from developed countries continues to be readily available, this supply will contribute to a continuing reliance on mercury in developing countries, particularly in small-scale gold mining, thus facilitating human exposures and mercury releases to the global environment. However, the United States is a fairly small player in the global mercury market. In 2001, for example, the United States mercury demand was about 274 metric tons, which represented approximately 8 percent of annual global consumption.

Stakeholders have urged the Federal government to develop a coordinated position to address government surpluses and large private sector stocks of mercury. These stakeholders foresee an increasing need for a coordinated approach to safely manage mercury supplies over the long term and are looking to the Federal government to address this issue.

The Federal government has now adopted a policy of continuing to store, rather than sell, all mercury stockpiles being managed by the Department of Defense (DOD) and the Department of Energy (DOE). However, the Federal government also sees a need to consider policies for addressing non-federal domestic mercury supplies

[2] Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.

INTERNATIONAL CONTEXT

Overview

Domestic policies regarding mercury must also be considered in a global context. While this paper examines domestic mercury issues, domestic management of non-federal mercury stocks may affect international policies and trends as they apply to the global management of commodity grade mercury.

International discussions have been underway on global issues of mercury supply, demand and flow in the world market. The United States has been a major player in supporting the commitments of the 2005 United Nations Environment Program (UNEP) Governing Council mercury decision and to agreeing upon a number of strategic global steps to further protect human health and the environment from mercury pollution. To that end, the U.S. has supported a number of partnerships aimed at reducing mercury use and exposure. The issue of managing global stocks to prevent increased mercury use and releases was a major focus of the February 2007 Governing Council Meeting in Nairobi. Another recent international consideration is the October 26, 2006, European Commission announcement that it had introduced legislation to ban all mercury exports outside the EU by 2011. If this ban goes into effect, it will have significant impacts on the global market, since Europe is currently the largest exporter of mercury. In conjunction with a potential ban, European chlorine producers are working toward a declared goal of closing all of their mercury cell chlor-alkali plants by 2020.

The proposed European Commission export ban raises the obvious question of how such a ban will affect the global price of mercury and whether it will lead to increased supply of mercury, including primary mining of commodity-grade mercury in other countries. While most policy makers agree with efforts to seek a solution to the global mercury supply issue, this is not an issue that this panel should attempt to address. The economic issues associated with a European export ban could have unintended, serious, long term consequences, most of which would be felt in the developing world.

International Supplies

Mercury is currently mined only in Kyrgyzstan and China. Kyrgyzstan exports almost all the mercury it mines; China currently mines mercury primarily to meet its domestic demand.[3] The remaining mercury supplies come from secondary sources, such as industrial wastes and scrap products, as byproduct from gold and other metal mining, natural gas manufacture and from closing mercury-cell chlor-alkali plants. The European Commission estimates that in 2005 the amount of mercury available in commerce globally was 3,690 tons.[4]

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[3] Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.

[4].Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.

Global Demand

The European Commission estimates that current world demand for mercury is approximately 3,439 metric tons per year.[5] While global demand remained fairly constant from 2000 to 2005, the demand distribution changed. With the increase in the price of gold, the use of mercury in small-scale gold mining increased by 54% becoming the single largest use of mercury. Vinyl chloride monomer manufacture increased significantly from very little in 2000 to 700 metric tons, becoming the second largest use of mercury in 2005.[6] Concurrently, the use of mercury in products decreased from 57% to 32% and chlor-alkali manufacture from 24% to 18%.[7] However, the global price per metric ton of mercury has increased over this time period from approximately $4,000 per metric ton in 2000 to more than $16,000 per metric ton in 2007. It is expected that the price would continue to increase following an export ban by the European Union. Further, given the high price of gold, it is anticipated that supplies of mercury on the global marked will continue to flow to developing countries where it will be used in small-scale gold mining. The use of mercury in small-scale gold mining is inefficient with much of the mercury being released. A substantial quantity contributes to the global pool of mercury.

Summary

The issue of global mercury supply and demand is multi-faceted. An examination of the global mercury cycle includes international consideration and knowledge of trade flows, storage, primary mining, by-product generation and other issues. For purposes of this panel, the international context should not be ignored; rather, it is one of many considerations impacting a domestic policy on the long-term management of commodity grade mercury in the U.S.

U.S. MERCURY SUPPLY

Overview

Mercury supply refers to the movement of mercury into the market over a given time frame (i.e., the "flow" of the commodity as it is mined, recovered as by-product, or recovered from waste) and also to certain static "stocks" or inventories of mercury.

Mercury stocks in the U.S. include military stockpiles and reservoirs of mercury contained in products and in active mercury cells at chlor-alkali plants. Stocks are an important consideration because they represent potential sources of supply. In the United States, the vast majority of stocks are found in Federal government stockpiles and in

[5] Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.
[6] Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.
[7] Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.

eight mercury-cell chlor-alkali manufacturing plants. Currently known U.S. mercury stocks total at least 8,010 metric tons, of which 70% are owned and stored by DOD and DOE, and the remaining 30% are owned and used by the chor-alkali industry. In addition, unknown (but assumed to be relatively small) quantities of mercury are stored for use by laboratories and individuals. Finally, mercury contained in consumer products can be considered a "reservoir" that is a continuing source of supply over time as these products are recycled. (See "Summary of Current U.S. Mercury Supply and Use" in the Appendix.)

Mercury supplies produced annually in the United States are estimated to be, on average, about 255 metric tons (see Appendix), which is fairly small compared to existing domestic stocks, and also small relative to global mercury supplies produced annually. Mercury production is also highly variable from year to year. U.S. sources of mercury supplies fall into two categories:

- **By-Product Production:** In the U.S., by-product production consists of recovery of mercury as a by-product from mining other metals, primarily gold. There has been no primary mercury mining as a principal product in the United States since the McDermitt Mine in Nevada closed in 1990.
- **Secondary (Recovered) Mercury:** Secondary mercury includes mercury that is recovered via a retorting (thermal) process from mercury-containing industrial process wastes, mining or industrial site remediation wastes, scrap consumer products, and decommissioned mercury cells at chlor-alkali plants.

Domestic annual production of mercury supplies is highly variable. Unfortunately there have been no publicly available data on U.S. by-product or secondary mercury production since 1997, because as domestic demand for mercury has declined, the number of domestic firms supplying mercury has fallen below the minimum number needed to allow the U.S. Geological Survey (USGS) to report basic production without revealing proprietary information.

In 2002, an industry source estimated that the total amount of U.S. by-product mercury from mining was in the range of 70-100 metric tons per year.[8] The amount of by-product mercury appears to be increasing somewhat over time as mining facilities strive to capture more mercury in order to decrease the amount released to the air during purification activities, and also as gold mining activities increase in response to increasing gold prices.

Based on USGS estimates, U.S. mercury supplies during the six-year period from 1991 to 1997 were predominantly from secondary (i.e., recovered) sources rather than from by-product mining. In 1997, for example, secondary production was about 389 metric tons compared with 72 metric tons for by-product mining. This secondary mercury was thought to originate from three sources: closure of mercury cell chlor-alkali plants; retorting of scrap mercury from discarded mercury-containing products and

[8] Lawrence, Bruce. Bethlehem Apparatus Company, Inc. Personal communication to EPA, July 2002.

devices; and recovery of elemental mercury from contaminated soil and debris.[9] In 2002, a recycling industry source estimated that 75% or more of secondary mercury production was from dismantling of chlor-alkali plants, with minor amounts from lamp recycling and retorting facilities.[10] This 2002 estimate no doubt reflected several recent closures of chlor-alkali plants: one in 2000 in Maine, and two in 2002 in Kentucky and Texas.

U.S. secondary (recovered) mercury is produced primarily by two major metals retorting facilities in the U.S. These companies remove the mercury from a variety of secondary sources, and then heat the mercury in a closed vessel called a retort. The mercury is turned into a gas, and then condensed back into its natural, liquid-metal form. This purification process continues until the metal is brought to the stage where it meets industry standards for reuse. It is then sold on the world commodity market, either directly or through metals brokers.

Any prediction of the amount of secondary supply produced from recycling in the U.S. is complicated by the option for industry to export some mercury-containing waste to Canada under the 1986 Canada-USA Agreement on the Transboundary Movement of Hazardous Waste. It appears that some portion of mercury-containing waste is exported to Canada for disposal in a regulated landfill instead of being retorted and recovered in the U.S., due to differences in government restrictions on landfilling mercury.[11]

Once mercury is sold, it is very difficult to track the end use. Many experts believe, however, that mercury is sold mostly to customers in developing nations, and is used primarily for small-scale and artisanal gold mining, followed by use for chlor-alkali manufacturing and various mercury-containing products.[12] In 2004, the U.S. estimates it exported about 278 metric tons of mercury to countries such as Mexico, Vietnam, Peru and Brazil.[13]

Attached is a table that summarizes the amount of mercury in current U.S. inventories and estimated amounts of mercury produced and consumed annually in the U.S. (See Table 1 in the Appendix.)

U.S. Government Mercury Stockpiles

The U.S. Government currently holds approximately 5,642 metric tons of mercury in stockpiles that were used in the 1950s and 1960s in the production of enriched lithium, a product used in the atomic weapons program. These military stockpiles account for 70% of all currently known mercury stocks in the U.S. During the early and mid-1990s, both DOD and DOE authorized the sale of mercury from their stockpiles.

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[9] EPA. Mercury Market Background Report, May 2005.
[10] Lawrence, Bruce. Bethlehem Apparatus Company, Inc. Presentation at Breaking the Mercury Cycle Conference, Boston, MA. May 1-3, 2002.
[11] EPA. Mercury Market Background Report, May 2005.
[12] Maxson, Peter. Mercury Flows and Safe Storage of Surplus Mercury, August 2006. Report for the European Commission.
[13] U.S. International Trade Commission.

Sales of DOD stockpile mercury were suspended in 1994 in response to environmental concerns.

DOD has 4,436 metric tons of mercury stored in its strategic stockpiles. In 2004, DOD decided to continue to store its mercury for the next 40 years, and to consolidate its stockpiles in above-ground storage at one site in Nevada. Under this management strategy, DOD mercury supplies will not enter the market and will remain as reserves until 2044.[14] Should a treatment technology become available, another decision may be considered.

DOE has approximately1,206 metric tons of stored mercury, which the department decided in late 2006 to continue to store rather than sell.[15] The DOE stockpile is currently stored at its National Nuclear Security Administration (NNSA) Y-12 facility in Oak Ridge, Tennessee. DOE has no future plans to sell its mercury stockpile, and will continue to store it at the Y-12 facility while investigating its options for alternative long-term storage. In evaluating these options, DOE will take into account a number of factors, including the annual storage costs of about one million dollars.

Chlor-alkali Manufacturing Plants

In the U.S., the chlor-alkali industry is currently the largest private-sector source of stored and in-use mercury, and therefore the largest private-sector source of potential new supplies as a result of future closures or conversions of mercury cell chlor-alkali equipment or plants.

There are currently eight chlor-alkali plants still using mercury cell technology. A plant in Louisiana is expected to convert to non-mercury technology in 2007, and an Alabama plant is expected to close in 2008. A third plant in Wisconsin has indicated it is seeking a favorable electrical contract that would make conversion a viable option, but negotiations with the state are still on-going. The remaining five plants have not announced any plans to discontinue use of mercury. The eight plants are located in seven states in the South and Midwest:

1) PPG, Lake Charles, LA (is expected to convert to non-mercury process by mid-2007)
2) Occidental Chemicals, Muscle Shoals, AL (is expected to close in 2008)
3) ERCO Worldwide (USA) Inc., Port Edwards, WI (considering conversion)
4) Ashta Chemical, Ashtabula, OH
5) PPG, New Martinsville, WV
6) Olin, Charleston, TN
7) Olin, Augusta, GA
8) Pioneer, St. Gabriel, LA

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[14] DOD. Defense Logistics Agency, Defense National Stockpile Center, Final Mercury Management *Environmental Impact Statement*, March 2004. 69 Federal Register 23733, 4/30/04.
[15] Letter from DOE to Senator Obama, December 2006.

The most recent Chlorine Institute report[16] indicates that at the end of 2005 these eight plants together contained a total inventory of 2,368 metric tons (2,605 short tons) in mercury cell process equipment and on-site storage, of which 1,814 are considered to be recoverable as new supplies. When these operating plants reach the end of their useful lives, the mercury remaining in process equipment or storage will require recycling.

In recent decades, the chlor-alkali industry has been a major contributor to U.S. mercury supplies, as the industry has transitioned to using mercury-free processes. This trend is expected to continue as firms still using mercury cell technology slowly phase out the use of this process. Alternative chlor-alkali processes have similar or slightly lower costs than mercury cell production, and they do not face the environmental concerns associated with the mercury cell process.[17] No new mercury cell plant has been constructed in the U.S. since 1970.

Mercury cell plants typically have a working life of 40 to 60 years, and currently all U.S. mercury-cell plants are over 30 years old. Hence, it is reasonable to expect that mercury cell operations will be shut down sometime over the next three decades as the remaining plants reach the end of their useful lives.[18] Since 1980, available information suggests that 17 U.S. mercury cell chlor-alkali plants have closed.

The rate at which the remaining mercury cell plants will close is uncertain. Under the current regulatory regime, individual plant economics and chlorine industry market conditions will probably be the major factors driving the closure rate. Prospective investments in mercury control equipment needed for compliance with new air emissions regulations may be partially responsible for some recent decisions to shut or convert mercury cell plants. Moreover, higher electricity costs could promote shutdowns or conversions, since membrane cell plants have lower electricity requirements than mercury cell plants. Reasonable assumptions for the disappearance of mercury cells in the U.S. range from 10 to 30 years, given the current age of plants and recent industry trends. However, companies may choose to run their plants at the upper end of this range because they have identified ways to minimize mercury losses. By adding more mercury to the cells in a one-time upgrade, the cells can be operated at lower temperatures, which reduce energy consumption and fugitive mercury emissions.[19] Planned mercury cell upgrades were expected to be completed by 2005.[20]

Historically, mercury from chlor-alkali closures has re-entered mercury commodity markets, although in recent years the chlor-alkali industry has reused its own mercury to a great extent. This mercury is then either re-sold to users of comparable grade mercury, such as other chlor-alkali facilities, or dealers may distill the recovered mercury to produce a higher-grade product. Sale of mercury back into commodity markets reduces the costs of dismantling or converting chlor-alkali plants.[21]

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[16] Chlorine Institute, The. Ninth Annual Report to EPA, May 15, 2006.
[17] Chlorine Institute, The. Written communication to EPA, October 7, 2002.
[18] EPA. Mercury Market Background Report, May 2005.
[19] EPA. Mercury Market Background Report, May 2005.
[20] Chlorine Institute, The. Sixth Annual Report to EPA. May 12, 2003.
[21] EPA. Mercury Market Background Report, May 2005.

While there is some local political pressure for these plants to convert to non-mercury technology or to close because of the plants' mercury emissions, there are no requirements for existing U.S. plants to close or convert to non-mercury processes. U.S. regulations limit mercury emissions from chlor-alkali plants, and effectively prohibit the new construction of mercury-cell chlor-alkali plants.

By-Product Mercury from Metals Mining

Mercury is recovered as a by-product from mining other metals, primarily gold. Mercury occurs naturally as a constituent of gold ore, and is an impurity during the smelting process for purifying the gold. By-product mercury is recovered from gold-processing precipitates and from the calomel[22] collected from pollution control devices at gold smelters, mainly in Nevada. Mercury present in the ore of these other minerals that is not recovered is generally emitted to the air, water, or land. This industrial gold mining process is different from artisanal and small-scale gold mining activities, where elemental mercury is added to the process to aid in the gold recovery.

While by-product mercury production in the United States is most commonly associated with gold mining, some by-product mercury is also generated from other metals mining, including copper, zinc, lead and silver mining.

Production of by-product mercury appears to have been relatively stable from 1990 through the early 2000s. Estimates derived by calculating by-product mercury as a function of gold production range from 59 to 73 metric tons of mercury per year from 1990 to 2002.[23] An industry source estimated in 2002 that between 70 and 100 metric tons of by-product mercury are produced annually.[24] However these estimates remain uncertain, given the lack of recent published data on the amount of by-product mercury mined in the U.S. Moreover, by-product recovery may be increasing because Nevada gold mines have recently begun to use new mercury control technology for environmental reasons, resulting in recovery of more mercury.

The USGS reported in January 2003 that there were still a small number of gold mines located in western states that continue to produce limited quantities of mercury by-product.[25] The most recent USGS Minerals Yearbook reports that in 2005, by-product mercury and calomel were produced at several gold and silver mines in Nevada. In addition, by-product mercury was imported to the U.S. from gold mines in Chile and Peru, then further refined and sold for domestic use or export. Calomel was also captured by pollution-control devices at ore roasters at domestic smelters to recover mercury for resale.[26]

[22] Calomel is the ancient name, often still used, for mercurous chloride (Hg_2Cl_2). It is a heavy, white or yellowish-white, tasteless and odorless powder which in the past was used medicinally as a cathartic.
[23] EPA. Mercury Market Background Report, May 2005
[24] Lawrence, Bruce. Bethlehem Apparatus Company, Inc. Personal communication to EPA, July 2002.
[25] USGS. Mineral Commodity Summaries: Mercury, 2003. Prepared by W.E. Brooks.
[26] USGS. Minerals Yearbook: Mercury, 2005. Prepared by W.E. Brooks.

Because mercury recovery represents a small fraction of income from gold mining, future domestic production of by-product mercury will depend primarily on environmental management strategies of mining firms and on levels of U.S. gold production. Gold prices in recent years have been hundreds of times higher than mercury prices and gold is produced at approximately five times the quantity of by-product mercury. The difference in production rates and prices for these two commodities is so great that gold ultimately will drive any decision about by-product production levels from industrial scale mines.[27]

The amount of by-product mercury recovered from mining is expected to increase over time, as more mining facilities strive to decrease the amount of mercury pollution released to the air during mining activities, and as the amount of gold mining increases due to increasing world gold prices.

Product Recycling

The recovery of mercury from industrial and consumer products represents another source of secondary mercury supply. Mercury can be drained directly from products and also recovered via retorting. Historically, this source of supply has been less significant than the chlor-alkali sector, in part because the transaction costs of collecting products and the costs of retorting are higher.

Estimates in 2002 indicated that mercury recovered from products in the United States totaled about 35 metric tons per year, with most of this mercury recovered from measuring devices such as industrial gauges.[28] Roughly 3.5 metric tons was estimated to come from recycling of mercury in fluorescent bulbs.[29] Other products such as thermometers and laboratory instruments contributed a modest quantity of mercury.[30]

These estimates of product recycling address only a portion of the total mercury discarded in products each year. EPA's Toxics Release Inventory (TRI) data suggest that almost 42 metric tons of mercury were disposed in 2002.[31] In addition, EPA estimated that the reservoir (i.e., stock) of mercury in products still in use is about 2,000 metric tons.[32] Many of these products have long working lives, and therefore only a relatively small portion of this reservoir might be expected to enter the waste stream in any given year. Assuming a 10 to 20 year period for the current reservoir of about 2,000 metric

[27] EPA. Mercury Market Background Report, May 2005.
[28] Lawrence, Bruce. Bethlehem Apparatus Company. Personal communication to EPA, July 2002.
[29] NEMA (National Electrical Manufacturers Association. Written communication to EPA, September 17, 2002.
[30] EPA. Mercury Market Background Report, May 2005.
[31] EPA. Toxics Release Inventory (TRI) Program, 2005. The TRI data do not distinguish between mercury derived from product recycling or waste recovery. Consequently, TRI estimates reported in the "Product Recycling" category also represent mercury supplies from the "Industrial Waste Recovery" category.
[32] EPA. Mercury Market Background Report, May 2005.

tons to flow into the waste stream, approximately 100 to 200 metric tons of material potentially would be available for recovery annually.[33]

Many state and local governments have for several years promoted public and private collection programs for both bulk elemental mercury (e.g., from schools, laboratories and dentists) and discarded mercury-containing products such as thermometers. Some businesses are also collecting unwanted mercury or mercury-containing products, such as thermostats and, more recently, fluorescent light bulbs.

The National Vehicle Mercury Switch Recovery Program, which was launched in 2006, is a new voluntary program to remove and collect mercury-containing switches from scrap (or retired) vehicles manufactured prior to 2003. This national program is the result of a two-year collaboration involving EPA, States, environmental organizations, and several industry sectors. The program complements existing state mercury switch reduction efforts, and will help to reduce up to 75 tons of mercury emissions over the next 15 years.[34]

It is unclear how much mercury is being collected through these various voluntary collection programs, but it is likely that supplies of recovered mercury may increase over time due to the increasing number of collection programs.

Industrial Waste Recovery

Information on mercury recovered from hazardous industrial wastes and from contaminated soil and debris is limited. Lawrence[35] estimates that treatment of contaminated soil and debris produces approximately 35 metric tons of mercury per year.[36] This quantity, however, is likely to be quite variable from one year to the next. Treatment of hazardous industrial process wastes is also a potential source of secondary mercury, although it does not appear to be significant in quantity. Analysis of EPA's Biennial Reporting System for hazardous wastes does not provide data on quantities of mercury recovered, but it does indicate that the majority of waste that is recovered goes to large retorting operations for treatment and is thus captured in Lawrence's estimates of total mercury recovery.

Another potential source of secondary mercury is cleanup of mine sites. Many western U.S. States have abandoned mercury mines and gold and silver mines contaminated with mercury. California alone has more than 300 such mines. EPA is undertaking efforts to characterize abandoned mine sites, and to the extent that a sizeable number of cleanups occur, the amount of mercury from soil and debris could increase.

[33] Note that the mercury in products includes mercury that is imported into the U.S. as products (*e.g.*, lights) as well as commodity mercury used to manufacture products domestically.
[34] EPA. Fact Sheet: National Vehicle Mercury Switch Recovery Program, August 2006. EPA's Mercury Website: www.epa.gov/mercury/switchfs.htm
[35] Lawrence, Bruce. Bethlehem Apparatus Company. Personal communication to EPA, July 2002.
[36] Mercury recovered from waste is separate from and in addition to quantities recycled from mercury-containing products.

In addition, many States are in the process of regulating indirect dischargers to surface waters (e.g., dental offices). In the future, these efforts may result in recoverable elemental mercury, especially from discarded dental amalgams. According to a recent study commissioned by the American Dental Association, dental offices currently release approximately 6.5 metric tons of mercury each year. Of this quantity, approximately 0.3 metric tons are emitted annually to surface waters after processing at wastewater treatment facilities; the remaining mercury is transferred to grit solids or bio-solids at the treatment facility.[37]

Mercury may also be recovered from contaminated soil in proximity to natural gas pipelines. These pipelines use mercury manometers for metering flow. Over time, routine maintenance activities on these meters have released mercury into the soil, and contamination is now prevalent at many of these sites.

U.S. Imports and Exports

Imports of elemental mercury represent a potential source of supply for domestic mercury needs. The U.S. imported almost 2,000 metric tons of mercury from 1989 to 2002. In the same period, however, exports totaled over 4,733 metric tons of elemental mercury.[38] Moreover, exports exceeded imports in the majority (nine of 14) of the years reported. The United Nation Environment Program estimated that in 2004 the U.S. exported more than 400 metric tons of mercury.[39]

The overall pattern of imports and exports suggests that a considerable portion of U.S. trade in mercury is not driven by domestic use or production, but is instead purchased by distillers or dealers for subsequent sale to other markets. The wide variety of nations of origin and quantities that comprise the mercury imports to the U.S. are also indications that trade is not a major source of supply to domestic users.[40] If U.S. imports were specifically targeting domestic demand, one would expect a pattern of more consistent imports over time reflecting consistent domestic demand. In addition, recent secondary production estimates indicate that the U.S. has been able to meet, and in some cases exceed, its own demand.[41]

While imports do not appear to be a primary source of mercury for domestic producers, they may perform a necessary smoothing role at times when other sources of supply are unavailable to meet demand. For example, a recent lull in chlor-alkali plant closures has reduced secondary production since 2003. Non-domestic trade considerations (i.e., brokering) also drive imports, especially when enough secondary mercury is produced to meet demand in the U.S. This suggests that future imports will

[37] ADA (American Dental Association). Assessment of Mercury in the Form of Amalgam in Dental Wastewater in the United States, 2003. Prepared by ENVIRON International Corporation.
[38] For years 1989 through 2001, U.S. Customs data as compiled by ITC; for 2002, data provided by USGS, Mineral Commodity Summaries: Mercury, 2003. Prepared by W.E. Brooks.
[39] UNEP; Summary of Supply, Trade and Demand Information on Mercury 2006.
[40] U.S. Customs data show eight different "top" suppliers to the U.S. over the 14 year period from 1989 to 2002: Canada, Spain, Germany, Australia, United Kingdom, Russia, Kyrgyzstan, and Chile.
[41] EPA. Mercury Market Background Report, May 2005.

continue to be driven primarily by the need to smooth out unevenness in domestic supplies from secondary and by-product sources, or by non-domestic trade considerations.[42] [43]

Overview of Firms in the U.S. Mercury Supply Sector

The U.S. supply sector comprises two major players—Bethlehem Apparatus Company, Inc. and D.F. Goldsmith Chemical and Metal Corporation—who supply virtually all commodity mercury to U.S. consumers. Bethlehem Apparatus operates 29 advanced high vacuum mercury waste retorts, two continuous feed fluorescent lamp glass retorts, and eight quadruple distillation systems in continuous operation. The company also provides mercury waste management services. Bethlehem estimated in 2002 that it supplied about 70 percent of U.S. mercury demand. Bethlehem is the major purchaser of mercury by-products from U.S. mines, and estimates that it has 40 percent of the U.S. mercury recycling and recovery market share. Bethlehem Apparatus has a relatively small group of large-volume customers who typically purchase mercury under six to twelve-month supply contracts. Approximately 80 percent of the company's sales come from these long-standing customers.[44]

D.F. Goldsmith likely accounts for virtually all remaining mercury sales to end-users in the U.S. These sales represent approximately one-third of Goldsmith's total sales volume. Goldsmith has a long-standing relationship with the chlor-alkali industry and appears to be the major buyer of mercury from closed chlor-alkali plants in the United States.[45] Goldsmith is not permitted to treat hazardous wastes, and therefore acts as a broker of mercury recovered by others (e.g., Mercury Waste Solutions, Inc.).

Other firms that might be counted as part of the mercury supply sector in the U.S. are recyclers, such as Mercury Waste Solutions (MWS) of Mankato, Minnesota, Onyx Special Services of Fond du Lac, Wisconsin (a division of Veolia), and AERC Recycling Solutions, Inc. of Allentown, Pennsylvania. MWS does not have high-level purification equipment, and therefore sells very little mercury directly to customers. Instead, MWS

[42] In addition to trade in elemental mercury, the U.S. imports a variety of mercury-based compounds. At present, imports of these compounds have fallen to relatively low levels due to the phase-out of various uses of mercury in pesticides, paint, and other products. The exceptions are mercuric chloride and organo-mercury compounds. Mercury chlorides (HTS Code 28273920) are occasionally imported by mercury distillers in the form of calomel (also written as mercury (1) chloride), for recovery and resale of elemental mercury. From 1989 to 2001, the U.S. imported a total of 411 metric tons of mercury chlorides, potentially representing as much 330 metric tons of distilled mercury (if all imports are calomel). In 2001, the imports of mercury chlorides totaled 22 metric tons. Imports of organo-mercury compounds (used in fungicides, bactericides, and pharmaceuticals) were 37 metric tons in 2001. Mercury compounds are generally included in production data (either produced in mines or, in the case of calomel, as a secondary source). However, the fact that these compounds are traded in quantity is an important consideration in developing any policy that would track or restrict imports or exports of mercury.

[43] EPA. Mercury Market Background Report, May 2005.

[44] Lawrence, Bruce. Bethlehem Apparatus Company. Personal communication to EPA, July 2002.

[45] Lawrence, Bruce. Bethlehem Apparatus Company. Personal communication to EPA, July 2002.

sells mercury to either Bethlehem Apparatus or D.F. Goldsmith[46] for additional refinement and resale.[47]

U.S. MERCURY USE

Use of elemental mercury for products and processes has declined significantly over the last several decades, in the U.S. and globally. These declines are attributable both to the phase-out of certain mercury uses and to reductions in the quantity of mercury used in individual products.

In 1980, the three largest U.S. industrial uses of mercury were in batteries (1,052 metric tons), the chlor-alkali manufacturing process (358 metric tons), and paint (326 metric tons).[48] Between 1980 and 2001, there was a dramatic 83 percent drop in annual mercury use by industries, from 2,225 metric tons to 274 metric tons.[49] This reduction in use was due in large part to state and congressional limits placed on mercury use in batteries, EPA's cancellation of pesticide registrations for using mercury as a fungicide in paint, closure of some mercury-cell chlor-alkali manufacturing plants, and voluntary reductions made under the United States-Canada Great Lakes Binational Toxics Strategy.

By 2001, mercury use in batteries had decreased significantly, use in paint had ended, and annual use by the chlor-alkali industry had decreased to 38 metric tons or 12 percent of overall mercury use by U.S. industry. Since then, further progress has been made by the chlor-alkali industry. As a result of a voluntary commitment to mercury reduction made by the U.S. Chlorine Institute under the Great Lakes Binational Toxics Strategy, the chlor-alkali industry reduced its annual use of mercury by 91 percent between 1995 and 2005, after adjusting for shut down facilities. The chlor-alkali industry reported its annual usage in 2005 to be 9 metric tons.[50]

Estimated mercury use in products in 2001 was 245 metric tons. The dominant use was in switches and wiring devices at 42 percent (103 metric tons), followed by measuring and control devices at 28 percent (69 metric tons), dental amalgam at 14 percent (34 metric tons), and electrical lighting at 9 percent (21 metric tons). All other smaller uses accounted for 7 percent (17 metric tons).[51]

Over time, the distribution of mercury used across various sectors has changed significantly as environmental regulations have limited some uses (e.g., paint) and new technology has increased mercury use in other sectors (e.g., high intensity discharge

[46] Cornwell, J. Mercury Waste Solutions, Inc. Personal communication to EPA, June 2001.
[47] Information on mercury recycling firms viewed at the following websites: <http://www.aercmti.com>; <http://www.bethlehemapparatus.com>; <http://www.dfgoldsmith.com>; <http://mercurywastesolutions.com>; <http://superspecial.com/index.html>.
[48] Jasinski, S.M. The Materials Flow of Mercury in the United States. U.S. Bureau of Mines, Information Circular 9412, 1994.
[49] For 1980 to 1997: USGS Minerals Yearbook: Mercury, 1994-2001. For 2001: Lawrence Bruce, 2001 and The Chlorine Institute, 2006.
[50] Chlorine Institute, The. Ninth Annual Report to EPA, May 15, 2006.
[51] Lawrence, Bruce. Bethlehem Apparatus Company. Personal communication to EPA, June 2001.

lamps in the lighting sector). These shifts are projected to continue as chlor-alkali use decreases and alternatives to mercury-containing devices become more prevalent. Most of these uses are expected to decline in the future. However, future demand for mercury in switches and relays is uncertain given the lack of viable alternatives for certain applications. In addition, mercury use is expected to continue in the lighting sector as new applications are evolving, although the amount of mercury used per unit may continue to decline. Although alternatives exist, dental amalgam remains the most widely used and least costly option available for tooth fillings. The current expectation is that use of mercury in dental amalgams will decline, but more slowly than some other uses.[52]

MERCURY MANAGEMENT

Mercury Treatment/Storage Requirements Under RCRA

There is currently no cost-effective or proven environmentally safe treatment and disposal method for elemental mercury,[53] and current regulations under the Resource Conservation and Recovery Act (RCRA) require high concentration mercury wastes be retorted for mercury recovery and reuse rather than be disposed of in a landfill.[54]

How elemental mercury is characterized (i.e., as a waste or as a commodity) is relevant to discussions of domestic mercury management. Industry has raised the issue of limitations and liability that RCRA laws place on the storage of mercury.

Under RCRA, elemental mercury that is not declared a waste (i.e., is a commercial chemical product), or that results from retorting of wastes, is not considered a RCRA waste if it is put back into commerce or is intended to be put back in commerce. However, when there is no longer any intention of using or selling the mercury, it is considered to be a waste, and therefore the RCRA Land Disposal Restriction (LDR) requirements apply. The LDR standard for "high mercury wastes" (greater than 260 mg/kg total mercury) is retorting, which is obviously not necessary for mercury that is already in the pure, elemental state. A long-term disposal facility for elemental mercury that has been declared a waste must have a Subtitle C, hazardous waste RCRA disposal permit. The mercury placed in such a facility will have met the LDR requirements if it is in the pure, elemental state.

Mercury Storage Methods and Protocols

DOD's Defense National Stockpile Center (DNSC) provides one of the best examples of a successful approach to safe storage of elemental mercury. This section provides a brief summary of methods and protocols that have been used by the DNSC.

[52] EPA. Mercury Market Background Report, May 2005.
[53] EPA. Economic and Environmental Analysis of Technologies to Treat Mercury and Dispose in a Waste Containment Facility, 2005.
[54] EPA. Mercury Laws and Regulations. For information on how mercury is regulated under RCRA, see: www.epa.gov/epaoswer/hazwaste/mercury/regs.htm.

Flask Management

Storage of mercury may require large amounts of space. For example, at DOD's Somerville, New Jersey depot, 2,617 tons of mercury has been stored in a warehouse in 80,000 square feet of space.[55]

There are various technical options for safely storing elemental mercury. For example, mercury managed by the DNSC is stored in 76-pound flasks, which are in turn sealed in airtight 30-gallon drums. There are six flasks per drum and five drums per pallet. Inside the drums, the flasks are individually sealed in plastic bags, separated by dividers, and placed on an absorbent mat that doubles as cushioning material. The drums rest on catch trays on wooden pallets on sealed floors. The pallets are not stacked in order to facilitate inspection and air monitoring. As a result, leakage of mercury in an amount sufficient to escape the warehouse is unlikely.[56]

While DNSC mercury is stored in 76-pound flasks, there are other storage options in use by other entities. Some mercury is stored in metric ton flasks, and some in plastic bottles.

Storage Facility Management

DNSC has safely stored mercury for over 50 years. Periodic inspections ensure that mercury storage containers are in good condition and leak free. Any defects in the packaging are quickly corrected. Inspections are conducted by appropriately trained DNSC or contract personnel. Warehouses are locked except for inspections and other periodic maintenance work. Additionally, perimeter fencing and controlled access (taking into consideration the potential for the most unlikely scenarios) are handled by appropriately trained personnel.[57]

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[55] Quicksilver Caucus. Stewardship of Mercury: Storage of Mercury, October 2003.
[56] DOD. Defense Logistics Agency, Defense National Stockpile Center, Final Mercury Management *Environmental Impact Statement*, March 2004.
[57] DOD. Defense Logistics Agency, Defense National Stockpile Center, Final Mercury Management *Environmental Impact Statement*, March 2004.

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12. UNEP. Global Mercury Assessment, 2002. Report of the United National Environment Programme.

APPENDIX

Table 1: Summary of Current U.S. Mercury Supply and Use

Current U.S. Mercury Inventories	***Total Metric Tons***
DOD stockpile (excess supply)	4,436
DOE stockpile (excess supply)	1,206
8 mercury-cell chlor-alkali plants (in process equipment and on-site storage)	2,368 (2,605 tons)*
Laboratories (schools, universities, research & commercial)	No data available. Assumed to be a relatively small amount.
Individuals (dentists, scientists)	No data available. Assumed to be a relatively small amount.
Total	At least 8,010

Annual U.S. Mercury Supply (Domestic Production)	***Metric Tons Per Year***
By-product production: metals mining (especially from gold mining)	Variable (est. range: 70-100)**
Recovered from chlor-alkali plants either closed or converted to non-mercury process.	Variable (avg. plant: 300)* Depends on how many plants close/convert in any year
Recovered through retorting from waste, scrap, soil, debris, product collection programs	Variable (est.: 70 or more)**
Total	Highly variable

Annual U.S. Use (Domestic Consumption)	***Metric Tons Per Year***
Hg-cell chlor-alkali plants (8)	9 (10 tons)*
Products manufacturing (lights, switches, measuring/control devices, dental materials, etc.)	245**
Laboratories (schools, universities, research & commercial)	No data available. Amount assumed to be relatively small.
Total	Approx. 250 or more

References:
*The Chlorine Institute, Inc., 2006. Ninth Annual Report to EPA for the Year 2005. Accessible at: www.epa.gov/region5/air/mercury/7thcl2report.pdf.

** Lawrence, Bruce, 2002. Bethlehem Apparatus Company, Inc. Personal communications to EPA in July 2002.