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Mercury Stewardship
Storage of Mercury

October 2003

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STORAGE OF MERCURY
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EXECUTIVE SUMMARY

Due to its toxic nature and bioaccumulative properties, mercury is being phased out of use in the United States through local, state, and federal laws, regulations, and policies. As a result of these efforts, mercury recycling has increased and U. S. demand for elemental mercury has decreased dramatically. Both of these trends are expected to continue and, in fact, intensify. Sources of elemental mercury include federal stockpiles of commodity grade mercury, elemental mercury remaining from closing mercury cell chlor-alkali plants, and local and state mercury-containing equipment waste collection programs and mercury retorting facilities. Currently, the U.S. supply of mercury exceeds U.S. demand, and sales of mercury from the federal stockpile have been suspended pending a review of the environmental impacts attendant to such sales. This conjunction of political and economic factors makes it likely that excess mercury may have to be stored in the intermediate term until a permanent storage or disposal option becomes available. However, there is not a national plan or a consensus on who should be storing excess elemental mercury.

This discussion paper describes and evaluates a range of elemental mercury interim storage (10-50 years) options that could be used until a permanent treatment or storage solution is identified. The paper examines and compares a range of potential policy alternatives, such as federal, state, or private party management; and consolidated or decentralized storage. Criteria for evaluating the different options include costs, feasibility, risks, potential environmental impacts, and policy implications. The purpose of the document is not to recommend any particular option, but rather to examine various options and evaluate their relative strengths and weaknesses. Based on the discussion of these factors in this paper, the alternative of federal management of long-term mercury storage appears to be one of the most plausible.

The Department of Defense suspended sales from the US Mercury Stockpile in June of 1994, in response to concerns raised by EPA, Members of Congress, and states. Starting in 1996, ECOS has passed several resolutions calling for establishment of US and international mercury storage policy and programs, coupled with use reductions and phaseouts. The Department of Defense is nearing the completion of an EIS that will address disposition of the US Mercury Stockpile. Despite the fact that stockpile sales were suspended nearly 10 years ago pending resolution of environmental, market, and other concerns, the federal government has not yet developed policies, guidelines, or regulations for long-term storage of elemental mercury. This document provides a framework for federal and state government to take action to address long-term management of US mercury from sources other than the US Mercury Stockpile.

I. INTRODUCTION

The Quicksilver Caucus is a coalition of state government organizations that was formed to collaborate on common concerns about mercury in the environment. The Quicksilver Caucus asked EPA to work with them to analyze storage options, which may be appropriate for addressing excess inventories of elemental mercury nationwide. This Stewardship workgroup agreed to the following charges:

- Develop guidance for mercury storage to ensure safe, interim storage of mercury stock (pending development of viable disposal options at a future date); and
- Develop policy options for the management of excess mercury in the U.S. including: recovery/re-entry into the marketplace, and export/import of mercury as a commodity.

To work towards these charges, three subgroups were formed: Best Management Practices, Markets, and Storage. The Best Management Practices subgroup has focused on developing guidelines for the safe management and handling of mercury. The Markets subgroup has evaluated elemental mercury as a commodity, both here in the U.S. and internationally. This work has involved examining the changes that have occurred in the marketplace based on the efforts of developed nations to reduce or eliminate the use of mercury.

This paper is the work product of the mercury Storage subgroup, comprising representatives from State and Federal government agencies – the EPA, the Department of Defense (DOD), the Department of Energy (DOE), and several State environment departments. The storage subgroup was asked to analyze options for storing mercury, which, for environmental policy reasons, may be kept off the market. In particular, the subgroup was asked to consider the relative merits of consolidated or decentralized storage by a variety of potential custodial entities. The subgroup considered the roles and responsibilities of the various entities (i.e., Federal, State and industry) for different options, and identified barriers that could impede the implementation of particular options. This paper provides an overview of the existing resources available for possible storage of elemental (non-waste) mercury, as well as policy alternatives for storing excess mercury. The federal government already stores mercury owned by the DOD and DOE. The storage options discussed here assume a decision has been made to store excess mercury in the intermediate to long term and to focus on the storage of additional elemental mercury that might be acquired and taken off the market until such time that permanent disposition of this material has been identified.

II. BACKGROUND

Mercury is of concern because it is a Persistent, Bioaccumulative, and Toxic Pollutant (PBT). As a natural element, it cannot be degraded or broken down once released into the environment, and it remains in the biosphere for long periods of time. Some forms of mercury can also bioaccumulate in living organisms, such as fish, to levels that are hundreds of thousands of times greater than the surrounding water. Depending on its precise chemical form, route of exposure, and dose, mercury can damage the brain, kidneys, immune system, nervous system, and cardiovascular system. It can also affect the reproductive system and act as a mutagen.

Mercury's unique properties--high conductivity, high surface tension, and liquidity at room temperature--have made it a useful component in electrical switches, lighting and measuring devices. It also bonds easily with most other metals, has germicidal properties, and can function as a preservative. Hence, it is or has also been used in electrical equipment, hospitals, labs, manufacturing processes for metals, chemicals, and paper, dental amalgams, fluorescent and High Intensity Discharge lamps, agricultural and pharmaceutical applications, and in gold mining.

Because mercury is a commodity that is still being mined and used globally, mercury storage has complicated international economic and environmental impacts that must be considered. (See the Report of the Mercury Stewardship Markets Subgroup). The average price of elemental mercury on the free market over the last five years has been approximately $4,200 per metric ton.[1] If supply constraints lead to additional mining, mercury releases could increase. However, increased stockpile sales could also result in increased usage and more mercury deposition in developing countries, the United States, and European Union from product use, atmospheric transport, and disposal.

Worldwide, mercury is produced from ores as a primary product at a small number of mines owned or subsidized by foreign governments. Since the last dedicated mercury mine closed in 1990, there have been no primary mercury production mines operating in the United States. In addition, mercury is produced at several locations throughout the world as a byproduct of mining of other metals, including at gold mines in Nevada, California, and Utah. The contribution from U.S. byproduct mining is estimated to be between five and 70 tons per year, based on gold production figures.[2]

Another source of mercury is recovery from mercury-containing products and wastes. Recycling of mercury has been spurred by state, regional, and federal laws, regulations, and policies aimed at reducing mercury emissions and use. A specific example is the RCRA regulation that requires certain mercury-bearing hazardous wastes (i.e., wastes with greater than 260 mg/kg total mercury) to be retorted (i.e., thermally treated) to recover the mercury. Such initiatives have resulted in the promulgation of stringent emission control standards for mercury sources and the adoption of legislation/local ordinances that require recycling, reductions in mercury use/sale, and/or disposal restrictions. Some States require industries to recycle mercury from fluorescent bulbs and other products; whereas others have implemented laws that phase out or ban the

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[1] US Geological Survey, *Mineral Commodities Summary 2002*. Available at <http://minerals.usgs.gov/minerals/pubs/commodity/mercury/#pubs>. More recent information puts prices between $4,600 and $5,200 per metric ton, as of September 18, 2002 (see http://www.indianmetals.com/minormtlprices.htm).

[2] Masters, Mining Journal, 2001; John Gilkeson, personal communication

manufacture and/or sale of certain mercury-containing products. Labeling, disclosure of mercury content, and limits on the use of mercury in manufacturing have also been used by States in various policy initiatives.

Mercury-containing products collected from state/local programs are temporarily accumulated until there are sufficient quantities to ship them to private companies that retort the mercury for resale as a commodity. Recovery activities are estimated to yield 40 to 80 tons of mercury per year in the U.S.[3]

Elemental mercury is also currently being stored short-term by private industry. Chlor-alkali factories are the private industries that use the largest amount of mercury in their manufacturing process. These factories use mercury in the mercury cell production of chlorine gas and caustic soda. Alternative chlor-alkali production processes that do not use mercury have been available for many years. With a net energy consumption rate that is lower than mercury cell facilities of comparable production capacity, the new processes have gained popularity as the concerns about mercury use and contamination escalated and the efficiency of their production methods improved. As a result, chlor-alkali plants that use mercury periodically close or retrofit to use other methods. As these factories close or switch away from the mercury cell process, leftover mercury is sold on the global market.

Finally, elemental mercury has been stockpiled by the federal government. The Department of Defense possesses approximately 4,436 metric tons of excess mercury. This stockpile is no longer necessary or viable for defense purposes. In addition, the Department of Energy is housing a mercury inventory of 145 tons, as well as 4.5 tons of mercury-contaminated wastes. This mercury was reclaimed from now discontinued prior uses. In addition to these stocks, DOE's Spallation Neutron Source research center at Oak Ridge, TN, keeps an active inventory of 23 tons of mercury.[4] Sale of the mercury from these stockpiles was suspended in 1994, in response to concerns raised by EPA, Members of Congress, and States, pending review of the environmental impacts of any sales. Since that time, EPA, DOE, and DOD have been studying treatment and storage technologies, and the Defense Logistics Agency has prepared an Environmental Impact Statement for the DOD stockpile's disposition. The federal mercury stockpiles are housed in four locations nationwide.[5]

The use of elemental mercury within the United States has declined by more than 90% from its peak in the 1960s.[6] The reduction in the use of mercury in this country, together with abundant sources of domestic mercury supply, has led to mercury exports from the US. As a result, the Mercury Stewardship Workgroup is discussing the issue and implications of whether some

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[3] E. Weiler, May 2002.

[4] US Environmental Protection Agency, *US Status Report on Mercury Activities*, February 2000.

[5] US Environmental Protection Agency, *US Status Report on Mercury Activities*, February 2000; US Environmental Protection Agency, *Identifying Research and Development Priorities to Reduce Mercury Use and Environmental Release in the United States*, Draft, September 2000; US Environmental Protection Agency, *Preliminary Analysis of Alternatives for the Long-Term Management of Excess Mercury, presentation at Breaking the Mercury Cycle*, Draft Report, April 22, 2002; Cornel Holder, Defense National Stockpile Center*, Mercury Management Environmental Impact Statement*, presentation at Breaking the Mercury Cycle, May 1-3, 2002, Boston, MA.

[6] See Jasinski, Steven (1994) Bureau of Mines Information Circular 9412, p. 11 (http://pubs.usgs.gov/usbmic/ic-9412/mercury.pdf); Johnson, Jeff (2001) "The Mercury Conundrum", *Chemical and Engineering News*, February 5, p. 22.

mercury should be taken off the market and stored, temporarily or permanently, to discourage global mercury use. However, there is not currently a consensus among state and federal policy makers as to whether to store mercury and, if so, who should be responsible for the long-term stewardship of such mercury. Furthermore, there are no federally enforceable standards or regulations to ensure that the elemental mercury is stored safely.

With these issues and sources of mercury in mind, the Storage subgroup began to develop alternative storage scenarios to answer questions such as: who could be responsible for short- and long-term storage of mercury, beyond the current DoD/DoE stockpiles; who might have the best infrastructure for mercury storage; and how could a mercury storage program be managed.

III. STORAGE SCENARIOS

In addition to evaluating the environmental and public health impacts of each storage option, it is necessary to consider the quantity of mercury that may require storage at some point in the future. The federal government currently stores approximately 4,436 metric tons of mercury owned by DOD and DOE. The chlor-alkali industry owns approximately 3,000 tons, and has indicated its potential willingness to donate mercury from closed factories to a government stockpile that could potentially keep the mercury off the market. State and local governments also accumulate mercury devices in the form of wastes collected from households, schools, and businesses prior to sending them to recycling facilities, where the mercury is recovered and returned to commerce. State and local governments' interest in keeping mercury off the market has increased due to their recognition that mercury management is a global problem and mercury pollution crosses state and national borders. The amount of mercury that state and local governments would contribute is uncertain, but it is conceivable that such mercury, together with mercury donated by industry, could equal the amount in the current federal stockpile.

Two main types of mercury storage containers exist: 76 pound flasks, and one metric ton containers. Flasks are typically made of cast iron or stainless steel. At the federal mercury stockpile locations, the flasks are overpacked in closed drums and stored in secure storage buildings.

Interim and Long-term Storage Considerations

The time frame during which mercury will require storage is determined by two main factors: the availability of treatment and disposal technologies for mercury; and whether the decision is made to suspend or ban stockpile sales, based on environmental and economic considerations. Regarding the first factor, there are currently no viable technologies to effectively treat or stabilize large quantities of elemental mercury for landfill disposal. Furthermore, experts disagree on when treatment options will be developed (estimates range from ten to twenty years, to decades). For purposes of this report, interim storage is between 10-50 years, and long-term storage is indefinite. Fifty years was selected as a planning horizon since this is the approximate length of time that the Department of Defense has stored mercury, hence we have experience and records on which to base plans and projections. Any mercury storage policy developed at this time must acknowledge that treatment and disposal are not viable alternatives to storage of mercury, at least in the short or interim term.

The decision of how much, if any, stockpiled mercury should be sold, and under what conditions, is a complex one with significant economic and environmental implications. If all sales of stockpiled mercury are permanently banned, the quantity of mercury in need of storage would obviously increase. However, even if mercury sales are resumed, storage would still be needed for decades because mercury stockpiles could not be sold all at once without undue market disruption. The U.S. government holdings of mercury exceed annual worldwide mercury demand. From 1991 through 1993, when demand was stronger and secondary production was lower, defense stockpile sales averaged less than 12,000 flasks annually.[7]

[7] Kevin Reilly, *Update on Defense Logistics Agency Mercury EIS*, presentation to Binational Toxics Strategy Mercury Workgroup, Windsor, Ontario, May 30, 2002, www.epa.gov/region5/air/mercury/053002.htm.

As part of the Environmental Impact Statement process for the elemental mercury federal stockpile, the Defense National Stockpile Center is currently considering the sale of no more than 5,000 flasks (or 173 metric tons) of mercury annually. At this rate it would take over 25 years to sell the existing defense stockpile. Declining demand and increased supply from closing chlor-alkali facilities in the U.S. and Europe could make it necessary to sell the stockpiles at an even slower rate or not at all.

The quantity of mercury requiring storage may wane in the long term if new mercury treatment and disposal technologies become viable. In the near term, the quantity of mercury requiring storage or treatment/disposal is likely to increase, as mercury use in industrial processes and consumer products is phased out. Adding mercury from the chlor-alkali industry and state/local recycling programs could triple the amount of stored mercury to 15,000 tons. Regardless of its exact initial sizing, it is important that a facility or facilities have significant expansion capacity to accommodate future needs. For planning purposes, this report assumes that only mercury from US sources will be stored. Finally, if mercury stockpile sales are limited, the current stockpile will require storage until treatment, disposal, and/or permanent storage options are available. Even if mercury sales are not banned, it would take several decades to sell stockpiled mercury at the expected rate of 5,000 flasks or fewer annually. Some mercury may never be sold due to declining global demand. Given this confluence of factors, some or all mercury will need to be stored indefinitely. Thus, developing mercury policy that addresses only interim storage is not sufficient; long-term and perhaps even permanent mercury storage may be a necessary feature of any mercury stewardship policy.

Potential Storage Management Entities

Several types of entities could potentially operate mercury storage facilities under a coordinated national mercury plan and storage policy. DOD and DOE manage the federal government stockpile and are currently evaluating the disposition of this stockpile through the Environmental Impact Statement process. While they may continue to store the current stockpile, the mission of these agencies does not include the storage of additional mercury from other sources. However, Congress could change their mission, or other federal agencies might be able to manage or fund the storage of additional surplus mercury (assuming those agencies had a Congressional mandate and the necessary appropriations). The cost to the federal government for managing additional volumes of mercury would not greatly exceed costs of managing the current stockpiles; moreover federal management can more plausibly address the issue of funding needs for an indefinite period of time into the future. Theoretically, local and state governments could take responsibility for temporarily accumulating mercury-containing devices that are collected through recycling programs; however, state and local governments have no experience in long-term storage, and no state/local storage infrastructure currently exists. In addition, state and local governments have extremely limited experience managing liquid elemental mercury since collection programs focus on mercury-containing products and not the elemental mercury, which can be retorted or recovered from those products. While not officially providing mercury storage, a variety of private entities, such as hazardous materials depot operators or private mercury reclamation facilities, have experience storing mercury temporarily for sale or reuse. Such entities could potentially provide more formalized mercury storage. However, any private entity may have to comply with RCRA hazardous waste regulations and liability, as would shippers, if the material in question was defined as hazardous waste. Conversely, state and federal government may have little or no oversight if the material in question was defined as product or commodity. Both states and private entities would face substantial obstacles assuring adequate funds over an indefinite period.

This section analyzes the current mercury storage experience of the above-mentioned entities, their potential suitability for interim and long-term storage, and the tradeoffs between decentralized and consolidated storage. Under a coordinated national plan and storage policy, their roles and responsibilities could change significantly. In addition, depending on the policy, new storage entities may emerge. For example, a policy that mandates storage will increase demand for storage capacity and perhaps attract the interest of commercial facilities or expand involvement of federal facilities.

Federal Facilities

Currently, DOD and DOE have large mercury stockpiles generated from past activities. The Department of Defense possesses approximately 4,436 metric tons of mercury that was once stocked as a protective reserve. The federal government stockpile is housed at four locations nationwide: New Haven, Indiana; Warren, Ohio; Somerville, New Jersey; and Oak Ridge, Tennessee. Table 1 presents information on mercury stores at each facility.

Table 1

MERCURY QUANTITIES IN DOD AND DOE STORAGE FACILITIES

Location	Site Size (Acres)	Current Mercury Storage Space (Square Feet)	Quantity (Metric Tons)	Flasks
New Haven, IN	268	3,885	557	16,151
Somerville, NJ	77	13,750	2,617	75,980
Warren, OH	160	1,812	563	16,355
Oak Ridge, TN	811	4,000	699	20,276
Total		23,447	4,436	128,762

The Defense Logistics Agency (DLA) is the agency responsible for managing the mercury stocks held by the DOD and for representing DOE in selling its mercury holdings. Due to inquiries from Congress and the EPA, and environmental concerns voiced by the States, the DLA suspended its mercury sales in July 1994, pending consideration of their environmental impacts. The quantity of mercury held by DLA and DOE has remained essentially constant for eight years. At present, DLA is not processing the mercury or transporting it between storage facilities.[8] DLA is currently preparing an Environmental Impact Statement to address disposition alternatives, which include status quo, sale, consolidated storage, and treatment and disposal.

[8] US Environmental Protection Agency, *Identifying Research and Development Priorities to Reduce Mercury Use and Environmental Release in the United States*, Draft, September 2000.

If the federal government were required to assume responsibility for mercury storage, it could elect to directly operate the facility or to provide oversight by contracting the facility operations to a private firm. Defense agencies commonly contract hazardous material handling operations to private firms that offer storage management and logistics support for hazardous materials as part of environmental services contracts. Advantages to contracting the operation and maintenance of storage facilities may include potentially lower costs and faster facility construction and more stable funding.

State and local Government Facilities

Though there are State and local government facilities that temporarily accumulate mercury-containing products, there are not currently any State or local governments that store or even temporarily accumulate elemental mercury. State and local collection/recycling efforts generally use private licensed contractors to collect and recycle waste products or devices containing elemental mercury. The licensed contractor transports or arranges for the transport of mercury-containing wastes to retorting facilities, where the mercury is recovered and resold. With the implementation of policies to phase out and recycle mercury-containing products, the number of state and local collection programs has increased. As local government collection programs cover jurisdictions representing limited area and scope, local government mercury storage is not being considered as part of this discussion.

EPA's promulgation of the Universal Waste Rule (UWR) under the Resource Conservation and Recovery Act and its subsequent adoption by most States has encouraged recycling of most mercury-containing devices by easing and streamlining hazardous waste requirements. The adoption of the UWR stimulated the growth of many more State and municipal mercury collection projects targeting businesses, institutions, and households. For example, the northeastern States and the eastern Canadian provinces adopted a Mercury Action Plan with an ambitious long term goal of virtually eliminating manmade mercury emissions and short-term reduction goals of 50 percent by 2003 and 75 percent by 2010 based on 1995 emissions levels. To meet this goal, the New England Governors and Eastern Canadian Premiers Mercury Task Force developed and introduced Model Mercury Reduction Legislation, which includes provisions to ban mercury disposal, restrict the sale of mercury-containing products, and to require labeling of such products. Several States in the northeast have already enacted the comprehensive version of the legislation; others have enacted portions of it. In addition, States across the country have enacted mercury reduction bills that require industries to label and recycle mercury from fluorescent bulbs and other products, as well as phase out mercury use in certain products.

In a survey of 30 States, twenty-two have implemented at least one program that provides for mercury pollution prevention, reduction, removal, collection, or recycling.[9] Such State-sponsored or managed programs may temporarily accumulate waste mercury-containing products on-site prior to recycling. While these programs direct mercury-containing products to recycling or retorting facilities, they do not represent the temporary holding or storage of elemental mercury. Few estimates of mercury quantities collected and stored through these programs are available because estimates tend to be for specific collection events or aggregated by program.

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[9] US Environmental Protection Agency, *Federal, State, and International Mercury Control Efforts: Status and Implications*, prepared by Industrial Economics, Incorporated, July 2002.

If there was a federal mandate endorsing storage as a management option, state government agencies could operate elemental mercury storage facilities provided that the federal government assumed liability for the mercury; federal standards for storage were promulgated; and funds were provided to build, operate, and provide security for such facilities. State and local governments generally lack technical experience in storing mercury, and no state mercury storage infrastructure current exists. Any such infrastructure would have to be established–a potentially expensive, time-consuming, and controversial process. Moreover, State governments are operating under serious budget and staffing constraints and have been forced to cut back on current responsibilities. If each State were required to operate its own storage facility, construction, management, monitoring, security, and liability costs could be prohibitive. There may also not be a sufficient number of qualified private contractors to safely manage 50 facilities. In addition, it may be difficult in many instances to gain public support for expanding State management responsibilities, siting a storage facility in a particular community or State, and assuming increased (perceived) environmental risks. If some states were unwilling or unable to assume storage responsibilities, their mercury may be orphaned because other states are unwilling to accept storage responsibility.

The U.S. Senate passed legislation in September 2002 that would phase out sales of mercury thermometers and provide grant assistance to States or other suitable entities for thermometer collection programs. The legislative proposal also authorizes funding for the EPA for the collection and management of mercury in such a way that the mercury is not released into the environment or reintroduced to commerce.[10] Enactment of this legislation would significantly increase the number of thermometers collected and would expand the need for mercury storage.

Private Facilities

A variety of private entities temporarily accumulate mercury prior to resale, including chlor-alkali plants and reclamation facilities. However, it is important to note that there are no private facilities in existence that operate solely as mercury storage facilities. For the most part, chlor-alkali plants and reclamation facilities treat, recycle and/or sell excess mercury, rather than provide storage as it is discussed in this report. However, implementation of a national storage policy for mercury may stimulate interest among private hazardous materials and waste management firms, reclamation facilities, or chlor-alkali plants to enter the mercury storage business.

As of August 2002, nine mercury-cell chlor-alkali facilities were operating in the U.S. Each of these facilities uses an average of three tons of mercury annually to make up for losses experienced during production processes. Chlor-alkali plants generate wastes and debris contaminated with mercury and either treat it on-site or send wastes off site for treatment and disposal.

Mercury reclamation facilities extract and recycle mercury sent from industrial clients and public collection programs. Use of mercury reclamation centers increased after the passage of the RCRA Universal Waste Rule amendments and implementation of State and local disposal bans and mercury reduction policies. Reclamation facilities now process between 40 and 80 tons of mercury annually. Two main types of facilities are in operation–retorting facilities that accept mercury from

[10] See text of S351, Mercury Reduction Act of 2002 (107th Congress), at:
<http://thomas.loc.gov/cgi-bin/query/z?c107:S.351:> (Note that this link may change in the future.)

all sources, and recycling facilities that address only certain products or restricted ranges of products. Approximately 50 facilities nationwide recover mercury from fluorescent lamps. Some of these facilities also process other mercury and non-mercury-containing products, including ballasts, thermometers, switches, cathode ray tubes, and dental amalgam. Other, more specialized facilities, retort mercury from products, elemental mercury, and mercury-bearing wastes from a variety of sources. Only five of these facilities are in operation as of 2002, down from 12 in 1996. The decline of these facilities has been attributed to the availability of less expensive landfilling options for mercury wastes in Canada, decreased demand, reduced mercury prices, and regulatory inconsistencies. However, recent State legislative initiatives, such as those undertaken in the northeast, may increase the need for additional retorting facilities in the future.

Currently, the duration of mercury storage at reclamation facilities depends on whether the facility is recycling mercury products or mercury waste. While facilities do not have a regulatory time limit for storage of recovered mercury, mercury wastes cannot be stored indefinitely. Facilities that store mercury wastes may be required to obtain RCRA permits, and would be subject to storage time limits regardless of whether they were required to have a permit.

In analyzing incentives for private firms to store mercury, it is important to remember that commodity grade mercury is a saleable asset, although the value of that asset has been dropping annually. Unless storage is mandatory, the government may have to provide economic incentives to store mercury rather than sell it on the market. Even then, companies that shipped the mercury to a private facility would continue to face indefinite liability for the material along with the facility operator.

Depending on economic factors, private facilities may be capable of providing either consolidated or centralized storage. The suitability of private entities for permanent storage may depend on the details of any national storage policy that is developed.

Table 2 presents a summary of the characteristics associated with mercury storage entities.

Table 2

MERCURY STORAGE ENTITY CHARACTERISTICS

Entity	Storage Experience	Suitability for Consolidated/ Decentralized Storage	Suitability for Interim/ Long-term Storage
Defense Agency (DLA)	50 years	Either	Long-term
DOE	Substantial	Either	Long-term
Other Federal Agency	None	Either	Either
Defense/EPA Partnership	Substantial (Defense)	Either	Either
State or Federal Government Contractor	Substantial (but not for all 50 states)	Either	Interim, possibly long-term
State/Local Government	None (some accumulation of mercury-containing products - no formal storage)	Decentralized	Interim

Private Entity	Some (retorting/recycling facilities)	Either	Interim, possibly long-term

Consolidated Versus Decentralized Storage

A discussion of whether or not to store elemental mercury in one facility, a limited number of regionally dispersed facilities, or a more decentralized system, requires consideration of the following factors:

- U.S. policy (i.e., will a policy be developed that requires mercury storage);
- Under what conditions, if any, stored mercury could be sold on the market;
- Quantity expected to be stored;
- Potential adverse environmental and health impacts; and
- Parties responsible for mercury storage.

Mercury storage does not require large amounts of space; the DLA's Somerville, New Jersey site contains 2,617 tons of mercury, more than half the current federal stockpile, in only 13,750 square feet of storage space. Therefore, consolidated storage of a federal stockpile that was double the size of the current stockpile would require less than 55,000 square feet of storage space.

Table 3 outlines the pros and cons of consolidated and decentralized storage facilities. Centralized storage would likely have lower storage costs; however, this may be partially offset by higher transport costs. Transportation costs could in turn be reduced by developing a limited number of regional facilities. With appropriate safeguards in place, the likelihood of a significant mercury release as the result of an accident is considered low in the case of either consolidated storage or decentralized storage. However, it may be easier to ensure the adoption and implementation of appropriate management practices, quality control procedures, training programs for staff, and security safeguards under consolidated storage. On the other hand, the consequences of an extraordinary accident or release could be more serious with consolidated storage.

In evaluating the options of consolidated or decentralized storage, one should consider the type of entity that will assume management and financial responsibility for the mercury. For example, if the Federal government assumes ownership of excess elemental mercury, then most likely the most appropriate form of storage would either be a single facility or several regionally dispersed storage facilities. For purposes of this report, the pros and cons of various storage scenarios are being considered; however, it is difficult to determine whether consolidated or decentralized storage is most appropriate until an agreed national storage policy is developed.[11]

[11] For purposes of the discussion presented here, consolidated is assumed to mean from one to several storage locations, and decentralized is assumed to mean any number greater than that.

Table 3 CONSOLIDATED AND DECENTRALIZED STORAGE		
Types of Storage	**Pros**	**Cons**
Consolidated	Lower management, liability, security costs; Fewer facilities to monitor and inspect; Fewer opportunities for accidents, such as fire; Limited number of EIS needed and limited number of communities to work with; More consistency in management standards	The consequences of an extraordinary release could be more harmful; Potentially higher costs for mercury transport and potentially longer transportation routes unless several sites are regionally dispersed
Decentralized	Lower transportation costs; More flexibility in terms of location (less burden on the source); Less environmental risk if an extraordinary release were to occur	More difficult to site in terms of community acceptance at multiple sites; More expensive to replicate, monitor, securely manage; More opportunities for accidents; Inconsistent environmental standards, implementation, training

IV. OPTIONS FOR STORING MERCURY

The following mercury storage options are considered below:

- Federally-funded co-location of State and private mercury with existing DOD/DOE mercury stock
- Federally-funded and overseen storage of State and private mercury
- State-funded and overseen storage of non-federal mercury
- State-run, federally funded storage of non-federal mercury
- Privately run and funded storage of private sector mercury

1. Federally-funded co-location of State and private mercury with existing DOD/DOE mercury stock

Under this option, funding and final responsibility would lie with DOD/DOE, mercury from the chlor-alkali industry and state collection programs would be co-located with the existing federal stockpile in one or several locations, and management responsibility could lie with either DOD/DOE or a private contractor. This option would draw on the existing federal government experience, infrastructure, and resources for storing mercury and hence might be the simplest to implement. However, storage of additional non-federal mercury is not part of the mission of DOD or DOE; it would probably require a legislative mandate to authorize this option, along with additional appropriations.

Alternatively the entire federal stockpile, including the current stockpile and future additions to it, could be managed by another federal agency. The Environmental Protection Agency, a different federal entity, or a holding corporation created by Congress could be candidates for this role. The EPA has technical expertise in the management of environmentally hazardous materials, but lacks the authority and practical experience for storing mercury. A partnership between DOD and EPA (and maybe DOE) may be a reasonable alternative for storing mercury; however, these federal agencies are operating under budget constraints and funds would have to be appropriated for this service. Use of one or several storage locations would bring the benefits and risks outlined in Table 3. Management of all mercury sources by one entity could facilitate flexible management of the overall stockpile and an eventual transition to permanent storage.

2. Federally-funded and overseen storage of State and private mercury

This is similar to option 1, except that mercury from industry and retorted/recovered from state collection programs would be kept separate from the existing federal stockpile. Under this option, funding and final responsibility would lie with a federal entity, and mercury from industry and state collection programs would be kept in one or several locations but kept separate from the existing government stockpile. Management responsibility could lie with either a federal entity or a private contractor through government-owned, contractor-operated facilities or at privately-owned and operated facilities. Several hazardous materials depots have apparently expressed interest in contracting for the storage of DOD mercury, which may indicate a willingness of private actors to operate mercury storage facilities on a contract basis.

This option would face barriers similar to those facing option 1. A specific legislative mandate and appropriations for storing mercury would have to be given to an existing federal entity, or a new entity would have to be created. Use of one or several storage locations would have the advantages and disadvantages presented in Table 3. Federal oversight would mean that storage policy and possible future arrangements for permanent storage could be relatively easily coordinated with DOD.

3. State-funded and overseen storage of non-federal mercury

This option would leave it to States to oversee and fund the storage of non-federal mercury. In this case, mercury could come from the private sector, such as closed chlor-alkali facilities, or it could be recovered from state mercury-containing product collection programs. Management responsibility could be assumed by the state or contracted to a private party. States could choose to cooperate in this scenario, resulting in several storage locations, or each state could operate independently, resulting in many storage locations.

This option would probably also require some Congressional action, though of a different sort than options 1 and 2. However, Congressional action requiring state storage of mercury might nevertheless be difficult to pass. In addition, States' resources are extremely tight and it is unlikely that States could or would reallocate scarce resources to fund a new, unwanted responsibility. States maintain that they have no experience or expertise in mercury storage and no current storage infrastructure exists. States have clearly indicated, through adoption of ECOS resolutions, that they believe the storage of excess elemental mercury is a federal responsibility. It would be more difficult to coordinate a national mercury policy with multiple storage/management entities and locations. It is not clear what would happen to mercury in states that were unable or unwilling to establish or fund storage facilities. The implications of decentralized storage are outlined in Table 3.

4. State-run, federally funded storage of non-federal mercury

As with the previous option, States would oversee the storage of mercury that is obtained from the private sector and collection programs, but in this case a federal appropriation would pay for the storage. This option could result in several or many storage locations, and different storage facilities could either be run by the states themselves or through private contractors.

The barriers to this option are essentially the same as for option 3, except that funding may be easier because it would be appropriated from the federal budget (assuming sufficient funds are actually allocated).

5. Privately run and funded storage of private sector mercury

Under this option, private generators would manage and be financially responsible for interim term storage of their mercury. Private entities that now own mercury could manage their stocks themselves or contract this responsibility to another party.[12] Given the number and physical locations of private facilities with mercury stocks, it is likely this option would result in several or many storage locations.

This option does not provide a comprehensive solution since it does not address mercury that could be generated through state collection programs, and would therefore perhaps have to be used in conjunction with other policies that consider that portion of the mercury issue. Congressional action would probably be necessary under this option to mandate consistent storage and management practices. This option assumes the continued existence and funding ability of private actors over a 10-50 year time horizon, and it is not clear what would happen to orphaned mercury should either of those assumptions prove to be incorrect. Furthermore, a private for-profit facility may well face economic pressures as quantities of mercury brought to the facility decline as a result of declining mercury usage. Loss of profitability or desire for increased profit margins can lead to cost cutting initiatives that compromise safe management of the surplus mercury. Having mercury stocks independently managed by multiple private entities would make coordination of mercury policy more difficult. The implications of multiple storage locations are discussed above in Table 3.

Evaluation of Options

The criteria that should be used in evaluating these options include feasibility, cost, environmental management, policy implications and likely public acceptance.

Feasibility

Federally-funded management of additional stockpiles, whether by DOD, another federal agency, or States, would require Congressional authorization and appropriations. The state-funded option would similarly require state authorization and appropriations. Federal authorization may be easier to enact than State authorization, given that States have expressed through ECOS resolution 01-3 that storage is a federal responsibility. Limited state budgetary resources could also

[12] For an example of this, see the agreement reached among Natural Resources Council of Maine, Mallinckrodt Inc., and Mercury Waste Solutions Inc., to store 84 metric tons of mercury. Information available at http://www.maineenvironment.org/mercury/holtrachem_sept62002.htm.

make state funding extremely difficult. Under all options, Congressional action would be required to mandate storage of elemental mercury; to promulgate consistent, environmentally protective standards and inspection protocols; to authorize federal assumption of liability; to appropriate sufficient funds; and to address contingencies for orphaned mercury supplies.

Privately-funded storage of small amounts of mercury currently exists, at least on a temporary basis. However, it is uncertain whether sufficient private funding will be available to make this an effective means of safely storing significant quantities of mercury for a long period. Should funding decrease or disappear, orphaned mercury could be created. Decreased funding or pressures to maintain profitability could also impact the ability of private entities to provide adequate interim term storage. Adoption of this option would also require Congressional promulgation of consistent standards and inspection protocols in addition to closure and liability requirements.

Cost

It is difficult to predict which of the options could assure optimum, safe management and environmental protection at a reasonable cost. However, it is likely that the total costs of replicating many storage facilities under a decentralized option would be higher than the total costs of a consolidated storage approach. Consolidated storage, as would likely occur under the federally-run or federally-contracted options, would have lower storage, liability, monitoring, and security costs than decentralized storage under the state-run options. These lower storage costs might be partially offset by higher costs of transporting mercury to a consolidated location; however, higher transportation costs could be offset if there were regionally dispersed facilities, as opposed to one centralized facility. In addition, in terms of overall storage costs, the initial one-time expense of transporting mercury to a storage facility would become proportionally less significant as storage duration increased.

Under any option, a key consideration is the level of funding that would be available from the federal government to support mercury storage. Some cost sharing arrangements would also be possible. For example, states or private entities could fund the storage of mercury-containing devices and/or the costs of transporting elemental mercury to a storage facility, at which point storage expenses could be funded by federal appropriations.

There may also be cost differences between government-run and privately-run (or privately contracted) storage. The workgroup does not have information that would allow it to evaluate the relative costs of these options. In the case of privately-contracted storage, the government would probably assume ownership of and liability for mercury in the storage facility.

There could be more cost control and stability under any federal option because a private facility might increase prices or cut corners to ensure the profitability of the enterprise. Government-ownership would facilitate competition among contractors, since changing the contractor would not necessitate moving the mercury to another facility.

Environmental Management

DOD and DOE are the only entities that currently have experience with safe, long-term mercury storage. Other options would require different Federal agencies, states, or private entities to acquire necessary technical competence in mercury storage.

Federal regulatory standards would have to be developed and implemented to ensure safe storage of mercury. While federal standards would provide a minimum level of acceptable storage practices and procedures, states could adopt regulations to suit their specific circumstances. Though such alterations would result in standards more rigorous than the federally required minimum, they could also vary across states, resulting in inconsistent levels of environmental protection.

Policy Implications

Centralized control of the mercury stockpile (regardless of whether storage is managed by government or private entities) could facilitate a flexible stockpile management policy that strikes a balance between discouraging mercury mining and discouraging mercury use. When necessary, mercury could be sold from the stockpile in an effort to prevent additional mining operations from being undertaken. By the same token, accumulation of mercury in the stockpile would decrease mercury supplies, thereby fostering the transition to substitute materials. It would be difficult for numerous states or private entities to coordinate this sort of market management. Centralized federal control and management may also allow for a more efficient transition to permanent storage or disposal, should this option become feasible.

Consolidated storage of all mercury at one facility would limit or eliminate the ability to move mercury from one facility (or geographic location) to another should the need arise.

For national political considerations, it may be desirable to have more than one facility so that regions of the country feel that there is balance or equity in terms of siting facilities, and one state or region is not asked or required to bear the burden of hosting the single storage facility for the entire country.

Mercury stewardship is a complex issue that is coming under increasing scrutiny both nationally and internationally. As patterns of mercury use change and policies for mercury management are developed, it may become necessary to store mercury in the medium term (10-50 years).

This paper outlined some basic considerations that policy makers would be advised to keep in mind, if a decision is made to store mercury. Any discussion of storage alternatives is complicated by the fact that mercury stewardship is a multifaceted issue. There are several different possible sources of mercury, and many different ways in which storage could be managed and funded. In addition, storage could be physically consolidated in one or a few facilities, or be more decentralized in many facilities. Decisions regarding funding, management, and centralization are interdependent and have significant influence on the feasibility, cost, environmental impacts, and policy implications of any storage policy that might be developed.

In conclusion, for the reasons presented throughout this paper, federal management of surplus mercury is the most plausible policy option. Centralized/consolidated storage of all US mercury stocks can be accomplished through regulatory or statutory means in a manner that drives the market, and allows for comprehensive solution that can flexibly respond to changing conditions. Safe, timely, and consistent protection can be most efficiently provided through federal management and oversight. Liability concerns and long-term financing arrangements are also most effectively addressed by a federal management framework. Next steps should include timely development of specific, reasonable policy suggestions about near and longer term implementation of policy options and improvement of Federal policies.

APPENDIX A

Summary of Management Options for Mercury Storage

Storage Option	**Description**	**Pros**	**Cons**
1.	Federally-funded co-location of State and private mercury with existing DOD/DOE mercury stock	- Addresses mercury storage needs from all sources (chlor-alkali facilities, state collection programs, defense supplies) - DOE/DOD has existing infrastructure and institutional knowledge for safe storage of mercury - States would be highly supportive - Mercury would be managed consistently and safely - Siting difficulties would be reduced - Security concerns more easily addressed - Probably less expensive than decentralized options	- Politically challenging: Would require Congressional Authorization and change of mission statement for Defense Agencies, authorization of funding, assumption of ownership and liability; alternatively, mercury storage could be co-located with DOE/DOD but owned and costs paid by separate federal entity - DOD/DOE currently undergoing a comprehensive EIS process for existing federal stockpiles only - Would require revision to federal regulations (e.g. allowing for long-term storage and to establish federal standards for safe storage) - May take many years to implement due to a complicated bureaucratic process

Storage Option	Description	Pros	Cons
2.	Federally-funded and overseen storage of State and private mercury	- Addresses storage needs from all sources - Contractors currently manage some DOD stockpiles and have relevant experience (is this true?) - States would be highly supportive of this option - Mercury would be managed consistently and safely -Security and monitoring would be better addressed - Would not require revisions to Defense Agencies' missions - Probably less expensive than decentralized options	- Politically challenging: would require Congressional Authorization and change of Agency (EPA, Commerce, etc.) missions (or the creation of a new quasi "mercury holding corporation") - May take many years to implement due to a complicated bureaucratic process - Would require a revision to federal regulations (e.g. allowing for long-term storage and to establish federal standards for safe storage)
3.	State-funded and overseen storage of non-federal mercury	- Enhanced ability to consistently control mercury stockpiles from State and private sources within each State - Would not require Congressional approval (but could require state legislative changes in most cases)	- States do not politically support this option (clearly stated in ECOS Resolutions) - States lack resources and experience in long-term mercury management - Potentially inconsistent standards/ enforcement across various states - Probably more expensive, assuming this option would lead to decentralized storage - May take many years to implement due to differing state legislative processes and local siting opposition, which could lead to orphaned mercury - Would require a revision to federal regulations (e.g. allowing for long-term storage and to establish federal standards for safe storage

Storage Option	Description	Pros	Cons
4.	State-run, federally funded storage of non-federal mercury	- Enhanced ability to consistently control mercury stockpiles from State and private sources within each State - Does not adversely affect state budgets - Could contract out services with state oversight	- Congressional authorization and funding would be required - States do not politically support this option (clearly stated in ECOS Resolutions) - States lack resources and experience in long-term mercury management - Would require promulgation of federal/state standards to ensure consistency (which would accompany a federal appropriation) - Probably more expensive, assuming this option would lead to decentralized storage - May take many years to implement due to differing state legislative processes and local siting opposition, which could lead to orphaned mercury
5.	Privately run and funded storage of private sector mercury	- Some private firms have experience in handling mercury on a short term basis - Private sector capable of operating either centralized or decentralized facilities - Promotes the principle of stewardship of a toxic substance	- Politically difficult: would most likely require federal law and regulations prohibiting sales from mercury slated for storage - Would not address mercury from state collection programs or state's concerns for a national mercury storage strategy - Possible local siting opposition and profitability concerns could create orphaned mercury supplies - Probably more expensive, assuming this option would lead to decentralized storage