A REPORT

TO THE GENERAL ASSEMBLY

OF THE STATE OF VERMONT

ON THE MANAGEMENT OF

MERCURY-CONTAINING LAMPS

prepared by

Vermont Agency of Natural Resources
Department of Environmental Conservation

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SUMMARY OF RECOMMENDATIONS

Progressive accumulation of mercury in the Vermont, regional, and global ecosystem is a matter of concern to the Agency of Natural Resources. The underlying issue is not whether a particular source of mercury emission is regulated as a hazardous waste but, rather, its actual contribution to the environment's mercury burden. Accordingly, with respect to the Legislature's specific request for recommendations, the Agency recommends to the General Assembly of the State of Vermont that means be established to promote the environmentally sound management of waste mercury-containing lamps (principally fluorescent and high-intensity discharge bulbs). The goal should be to minimize uncontrolled releases of mercury to the atmosphere from the incineration or uncontrolled breakage of waste mercury-containing lamps. To accomplish these ends, the following short-term and long-term strategies should be pursued:

IN THE SHORT TERM

1. **Technical and financial support should be provided to existing Household Hazardous Waste collection and recycling infrastructures in the state to promote the collection for recycling, or other appropriate processing, of fluorescent and high-intensity discharge lamps from households and conditionally exempt small quantity generators of hazardous wastes. Disposal costs to municipalities for lamp recycling under state-sponsored blanket purchase orders can run as low as $.25 per lamp. (or less than $45,000 per year state-wide, even assuming an 80% recycling rate for lamps from households) If Federal hazardous waste issues could be resolved, regionalized lamp crushing by towns or waste districts could further reduce costs for lamp recycling or responsible solid waste management.**
2. **Source separation of unprocessed waste mercury-containing lamps (with handling, storage and management procedures to minimize lamp breakage) should be required throughout Vermont no later than July 1, 1997. Likely statutory avenues for development of these programs lie in the municipal responsibility for solid waste provisions of Title 24 or the waste management provisions of Title 10, Vermont Statutes.**

IN THE LONGER TERM

1. **It is recommended that the Legislature look beyond just mercury-containing lamps or other mercury containing wastes to enable establishment of infrastructures to ensure appropriate management of all categories of hard to manage wastes, including oil, antifreeze, tires, paint and pesticides.**

These proposed strategies reflect some areas of consensus which emerged from the working group convened to assist in preparation of this report. There was little disagreement that mercury-containing wastes (including lamps) should not be incinerated until the full emission controls mandated under the Federal Clean Air Act are in place. It was also apparent to the group that increased educational and information exchange is needed before either businesses or private citizens will manage waste mercury-containing lamps in more environmentally sound ways than at present. Finally, given that the US Environmental Protection Agency is proposing new regulations for waste mercury-containing lamps, conflicting state legislation should be avoided in order to give the Agency regulatory flexibility it needs to respond to new federal mandates and to accommodate emerging waste management technologies.

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I INTRODUCTION

The purpose of this report to the General Assembly of the State of Vermont is to present recommendations for ensuring environmentally sound management of mercury containing lamps that are being discarded. Concern over the public health and environmental consequences from actual and potential environmental release of mercury due to disposal of fluorescent and high intensity discharge lamps prompted the legislative request for a report. To accomplish the task of preparing this report, the Agency of Natural Resources, in cooperation with the Department of Public Service, held a series of four technical forums from September through December 1994. Representatives from fluorescent bulb manufacturers, public utilities, electrical contractors, industries which generate hazardous wastes, waste management districts and recyclers all participated in these workgroups. Discussions of various technical data points were sometimes lively as differing interpretations and positions were presented to the Agency for consideration. This report also draws heavily on a significant body of data already published on this issue.

MERCURY EXPOSURE LEVELS IN THE ENVIRONMENT

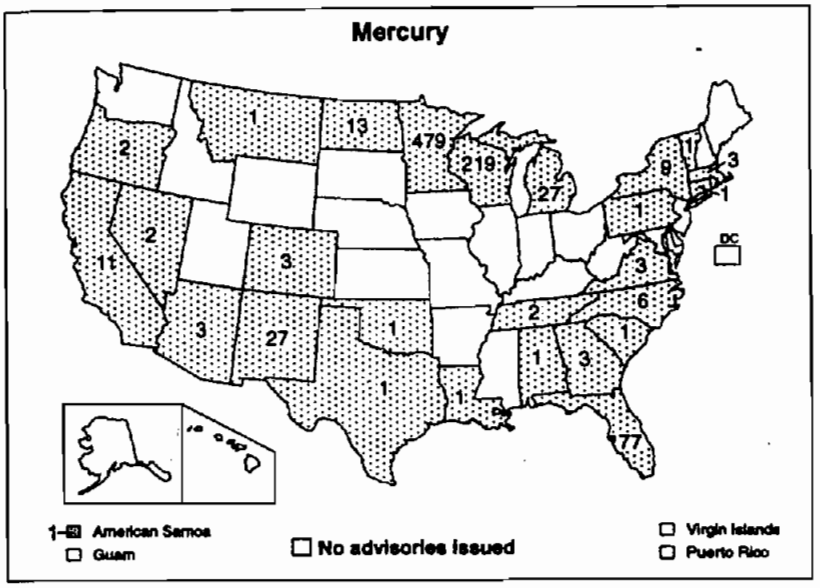
Mercury is a naturally occurring metal that is found in various concentrations almost everywhere in the world. Human uses for the metal and sources of mercury exposure are numerous, including: mining, metallurgy, lighting, electrical equipment, thermometers, barometers, batteries, dental amalgams, paints, medicines and pesticides. Apart from its obvious occupational exposure hazards, mercury also has been recognized as a public health concern over the past 30 years. During these years, at various places in the world, episodes of severe mercury poisoning for entire populations have been reported from ingestion of organic mercury compounds.[e] Regardless of the cause, the effects on human health were profound.

Mercury is unique among the so-called "toxic heavy metals" in that it has a significant vapor pressure and moves easily back and forth between solid, liquid, aqueous, and gaseous forms.[m] Its ability to volatilize also opens a major pathway for rapid environmental dispersion.[m] Consequently, mercury's global distribution is the product of a complex cycle of atmospheric release, deposition, and rerelease. As many as 6,000 metric tons of mercury and mercury compounds are estimated to be released to the atmosphere each year from natural sources such as volcanoes and off-gassing from soils and surface waters.[o] From within a matter of days to as long as two years later, this mercury falls out of the air bound to dust particles or dissolved in rain water. Only a small portion (about 2%)[f] of the mercury deposited annually from the atmosphere is carried through surface water or soils to become sediments and part

of the earth's crust. The remaining mercury is revolatalized or bioaccumulated and stays in the global mercury cycle.
For some years consensus within the scientific community was that global natural atmospheric emissions of mercury were higher than anthropogenic sources. However, more recent estimates suggest that current natural and man-made releases may be roughly equivalent, amounting to as much as an additional 6834 metric tons per year.[o] Increases in atmospheric mercury concentrations over time appear to be linked directly to the rise of industrial activity in society. Studies of ice cores from Greenland indicate a 500-fold increase in atmospheric mercury content since 800 BC.[m] Over the last 140 years these levels have increased by a factor of 3.7 or approximately 2% per year.[s]

Even remote, pristine lakes have become contaminated through atmospheric deposition of mercury compounds and their subsequent biomagnification through the aquatic food chain. Aside from workplace exposures, the most significant environmental pathway for mercury contact with humans is indirect exposure through fish consumption. In this respect Vermont is not immune. Like many other states Vermont has posted fish consumption bans and advisories due to mercury contamination. Recent studies by the Vermont Monitoring Cooperative have estimated a total atmospheric (rainfall and dust) deposition rate for mercury in the Lake Champlain Basin during 1993 to have been 14.6 ug/m^2.[l] If calculated to all of Vermont's land area, the Lake Champlain basin data would suggest that about 800 pounds of mercury fell on Vermont in 1993. Similar deposition rates (12.5 ug/m^2) have been observed in Minnesota where extensive studies of lakes and streams have shown mercury contamination and bioaccumulation of methylmercury in fish so pervasive that the Minnesota Department of Health has placed restrictions on fish consumption in 94% of the lakes surveyed.[f]

NUMBER OF ADVISORIES ISSUED BY STATES FOR MERCURY[c]
(Source: Fisheries, Vol. 19, No. 5, May 1994, p. 21 / cites 1993 US EPA data)



EXPOSURE RISKS FROM MERCURY IN TRASH

The heavy metal content of solid waste disposed in Vermont is already declining because the state has a long legislative history for promoting reduction in the toxicity of its solid waste stream. Laws have been enacted not only for solid waste management and planning but also regarding specific consumer products. With respect to mercury, in 1991, Vermont was one of the first states in the nation to place limits on the mercury content of dry cell batteries sold at retail. That legislation coincided with efforts by battery manufacturers to virtually eliminate added mercury from dry cell batteries. As a result, with less mercury coming from dry cell batteries discarded in the trash today, fluorescent lights, mercury switches, thermostats and thermometers are becoming the major contributors of mercury to the solid waste stream. US EPA reports note similar national trends.°

DISCARDS* OF MERCURY IN PRODUCTS IN THE MUNICIPAL SOLID WASTE STREAM, 1970 TO 2000°

(In percent of total discards)

Products	1970	1980	1989	2000
Household Batteries	73.6	78.4	87.5	57.0**
Electric lighting	4.5	4.4	3.8	23.7
Paint Residues	7.2	4.9	2.6	0.3
Fever Thermometers	2.9	4.7	2.3	9.7
Thermostats	1.3	1.3	1.6	6.0
Pigments	7.7	4.2	1.4	0.9
Dental Uses	2.2	1.3	0.6	1.3
Special Paper Coating	0.0	0.2	0.1	0.0
Mercury Light Switches	0.1	0.1	0.1	1.1
Film Pack Batteries	0.5	0.5	0.0	0.0
TOTAL DISCARDS	100.0	100.0	100.0	100.0

* Discards before recovery

** Includes mercury-containing battery types either banned from landfill disposal or banned from retail sale in Vermont. In Vermont the mercury contribution from batteries should be lower and the other sources higher.

A rough estimate of amount of mercury placed in Vermont's solid wastes from mercury-containing lamps can be made by multiplying the number of lamps discarded in the state each year by the average amount of mercury in each lamp. National production and sales data from lighting industry sources estimate annual discard rates of 2 bulbs per capita with an average of 42 milligrams of mercury per bulb.[b] Using an average population of 560,000 for Vermont, this calculates to 1,120,000 bulbs containing slightly over 103 pounds of mercury being added each year to Vermont's waste streams. At least 80% of these lamps will have been discarded by commercial and industrial users.[c]

The US EPA Green Lights Program recommends managing mercury-containing lamps as a hazardous waste, unless proven otherwise.[a] This practice is relatively uncommon in Vermont. A review of Vermont hazardous waste manifests for the period July 1, 1993 to June 30, 1994 identified shipments totalling only 12 tons (out of a possible 300+ tons) for mercury-containing lamps or lamp components. This may be due partly to the US EPA's proposed rules currently out for public comment which offer two very different approaches to the management of mercury-containing lamps: (1) conditional exemption of the lamps from hazardous waste regulation or (2) somewhat less restrictive hazardous waste accumulation practices under the so-called "Universal Waste Rule".[q] It was a shared concern among workgroup participants that EPA's failure to enforce (or modify in a timely manner) existing RCRA requirements for lamp disposal is putting lamp users and manufacturers in the difficult position of being caught in the conflict between the regulatory requirements on the books and the reality that they are not being enforced.[g] The potential for confusion is also exacerbated by the fact that both federal and Vermont Hazardous Waste Management Regulations allow households and conditionally exempt small quantity generators of hazardous wastes (with prior approval in Vermont) to dispose of their hazardous wastes at solid waste facilities[i].

II LAMP MANAGEMENT PRACTICES AND WHERE MERCURY IS RELEASED

TRANSPORTATION TO DISPOSAL

Fluorescent and high intensity discharge (HID) lamps from homes, businesses, street lighting, tanning booths, etc., traditionally have been discarded along with other municipal solid waste (MSW). These lamps are often put out for transport to resource recovery or land disposal facilities with few precautions taken to prevent breakage. When lamps are discarded in this way, the small amount of mercury (0.04 to 0.1 mg/bulb or 0.1%-.2%) contained in the lamps

as a vapor[h,j] is released immediately when lamps are broken en route to the disposal facility. The remainder of the mercury in the lamp is mixed with other wastes in the truck or shipping container. Of this mercury, from 1%[h,j] to 6.6%[q] (0.4 - 2.8 mg/bulb) are estimated to evaporate from the glass and phosphor before the disposal facility is reached. In most cases, this is still what happens in Vermont. Fates of mercury-containing lamps and their constituents under various waste management scenarios are described below:

DISPOSAL WITH MSW - LANDFILLING

When mercury-containing lamps are disposed in a landfill, almost complete breakage is assured as the waste is dumped in the landfill cell and compacted. The mercury that remains with the waste either stays where it is, is attenuated by soils, makes its way to the groundwater or leachate collection systems, or makes its way to the atmosphere with other landfill gasses.[m] Because the overall mercury concentration in MSW is quantitatively low, at 3.6 parts per million (ppm)°, tracking its distribution within the landfill would be problematic. Nevertheless, appearance of mercury in leachate and gasses collected from landfills provide measures of the rates of its re-release to the environment. Recent reviews conducted for the Unites State Environmental Protection Agency (EPA) indicate that mercury emissions from MSW and incinerator ash landfills are relatively low. Estimates of combined annual re-release of mercury in leachate and landfill gas range from 0.0008% to 0.0037% of the total annual mercury input to the landfill.[m]

DISPOSAL WITH MSW - INCINERATION

When mercury-containing refuse is incinerated, the mercury is distributed among the bottom ash, fly ash and flue gas. The relationship between incinerator type, feed rate and combustion conditions often determines what happens to the mercury. Of particular importance is the carbon content of the fly ash because of carbon's potential for adsorption of mercury. As carbon content increases, it is believed that more mercury in the flue gas is adsorbed onto the ash. This adsorption process is also helped by lower flue gas temperatures. Conversely, the greatest mercury emissions to the air are seen from incinerators that minimize carbon laden fly ash, that operate at higher temperatures and that have less efficient particulate control equipment. Regardless of incinerator type, without appropriate pollution control equipment only 10% to 30%[m] of the waste's mercury content is trapped in the incinerator ash. The remaining 70% to 90% of the mercury is released to the atmosphere in the flue gas. However, MSW facilities equipped with spray dryer/baghouse combination pollution control devices have been able to show greater than 99% collection efficiencies for mercury.[m]

SHIPMENT FOR RECYCLING

A number of companies in the U.S. and abroad currently recycle used fluorescent lamps. Specially constructed, reusable shipping containers designed to minimize lamp breakage during shipment are available from lamp recyclers.[k] Also, original product packaging is often sufficiently protective to allow intact shipment of replaced lamps. Lamp recycling processes generally employ crushing of the lamps with physical separation of the glass and end caps from the phosphor powder coating the lamp interior.[p] The equipment used at these facilities also collects mercury vapors released on lamp crushing through multi-stage active filtering. Phosphor from the lamps, which contains from 85%[b] to 99%[m] of the mercury in the lamps, is then roasted or retorted to recover the mercury by distillation. The mercury is then sold as a commercial product. Once stripped of mercury, the phosphor is discarded in a solid or hazardous waste landfill. The aluminum endcaps may be sent for metal recycling. The separated glass, containing from 1%[m] to 15%[b] of the mercury from the lamp in a tightly bound form, is either discarded in a solid waste landfill or directed to alternative uses such as paving aggregates or the making of new glass. Those glass reuses involving high temperatures will need provision for mercury vapor control because process temperatures above 200° C will effectively release all the mercury bound to the glass.[i]

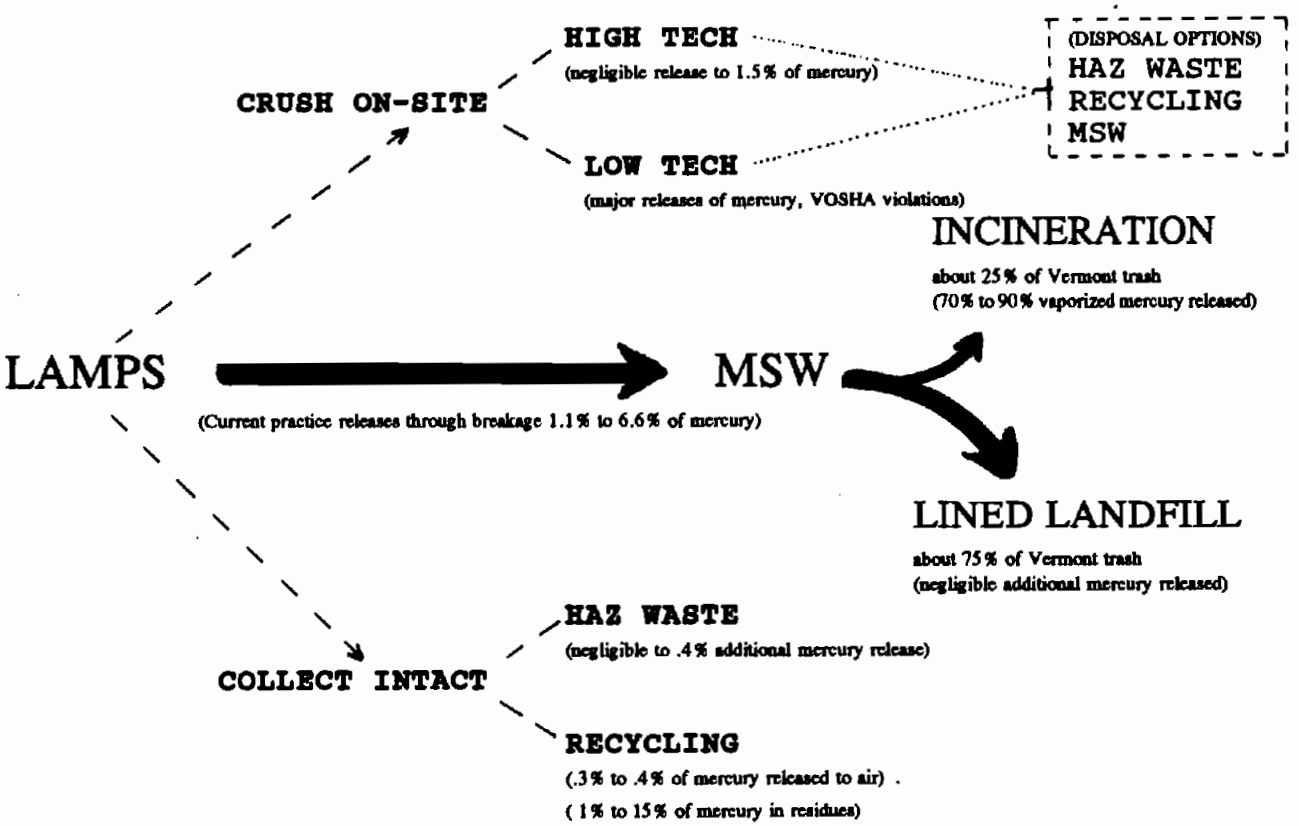
DISPOSAL AS A HAZARDOUS WASTE

Disposal of used fluorescent and HID lamps as a hazardous waste is another management option currently available to homeowners, solid waste districts and businesses. Lamps received by some of these facilities are carefully packaged and handled to minimize bulb breakage in transit while other facilities require that the generator crush the bulbs into 55-gallon drums prior to shipment. Current best demonstrated available technologies for those mercury containing wastes that must be treated before disposal in hazardous waste landfills includes retorting the waste to reclaim the mercury or stabilizing the mercury as an insoluble salt, such as mercuric sulfide. Only some of these measures are equivalent to the technologies used in fluorescent and HID lamp recycling facilities. Also, when mercury-containing lamps are shipped to hazardous waste treatment, storage or disposal facilities (TSDFs), hazardous waste manifests and certified hazardous waste transporters are used to maintain an unbroken chain of custody from the point of generation to the point of disposal.

ON-SITE MANAGEMENT PRIOR TO SHIPMENT

The low weight to volume ratio of intact fluorescent lamps often adds considerable transportation expense when intact bulbs are shipped for recycling or disposal. Although volume reduction equipment does exist for crushing lamps prior to shipment, not all crushing technologies are created equal. Many small crushing operations use a device that fits on top of a 55 gallon drum. Even well-covered crushers of this type may cause mercury concentrations in the air at the unit of about 0.3 mg/m^3, well in excess of VOSHA 8-hour or ceiling exposure limits. Larger well-controlled systems use vacuum collection systems to prevent release of mercury from lamp feed systems. Cyclones, HEPA filters, and carbon absorbers are used to treat emissions. This type of collection and control system can keep emissions well below VOSHA limits and provide 90% or greater reductions in mercury emissions.[P] Even when using a more expensive and sophisticated system, costs for shipping large quantities of lamps to mercury reclamation facilities can be reduced by as much as two-thirds. Use of such systems in Vermont is already allowed by the Agency's Hazardous Materials Management Division on a case-by-case basis.

MERCURY RELEASES FROM VARIOUS LAMP MANAGEMENT PRACTICES



III REGULATORY STATUS OF USED FLUORESCENT LAMPS

Fluorescent and HID lamps are among a group of what are sometimes called "newly identified" hazardous wastes which test hazardous under the EPA's toxicity characteristic leaching procedure (TCLP) test. Previously, the lamps had not failed under an earlier EPA test procedure. EPA's concern over the regulatory status of used mercury-containing lamps originated in 1992 when members of the National Electrical Manufacturers Association (NEMA) began testing their fluorescent lamps using the TCLP. Although the test results were quite variable, some lamps tested as hazardous wastes. These results prompted further studies by both NEMA and EPA into the variability of the TCLP for these materials. Ultimately, EPA, and its contractor, Science Applications International Corporation (SAIC), were able to demonstrate that the TCLP is adequately precise when properly applied to fluorescent lamps and that fluorescent lamps exhibit the toxicity characteristic for mercury as measured by the TCLP.[m]

As a hazardous waste, the management options for mercury-containing lamps are already well defined. Both state and federal hazardous waste management regulations severely restrict how hazardous wastes may be handled and where the wastes may be disposed. A number of states have already adopted regulations or policies concerning the disposal of mercury-containing lamps. Summaries of this information has been disseminated nationally by the US EPA in conjunction with its Green Lights Program.[n]

In Vermont, a few of the larger hazardous waste generators have been managing their mercury-containing lamps as hazardous waste for some time. However, only the Chittenden Solid Waste District currently collects fluorescent lamps for recycling from households and CESQGs. What this means is that most of Vermont's waste mercury-containing lamps are being disposed of as solid wastes, broken and then landfilled or incinerated.

SOLID WASTE ALTERNATIVES TO RECYCLING OR HAZARDOUS WASTE DISPOSAL

Under existing state and federal regulations, if mercury-containing lamps can be shown through testing not to exhibit a hazardous characteristic, they may be disposed as a solid waste. However, unless large numbers of lamps are disposed, the high cost of TCLP testing makes solid waste disposal impractical.

One future option for a mercury-containing lamp management system has been proposed by the US EPA which would create a conditional exemption from hazardous waste regulations and allow disposal of mercury-containing lamps in lined solid waste landfills.[q] A

conditional exemption from full hazardous waste regulation (if consistent with federal rules under the Resource Conservation and Recovery Act [RCRA]) could provide for a mercury-containing lamp management system that avoids the cost and burden of the hazardous waste regulations, and yet still provide for protection of human health and the environment by conditioning the exclusion on areas where there is greatest risk of exposure (breakage, incineration).

REGULATION OF WASTE MERCURY-CONTAINING LAMPS IN OTHER STATES[a]

STATE	COMMENTS
CA	Over 25 lamps per 24 hour period must be disposed as hazardous waste.
FL	After July 1, 1994 lamps may not be burned in any municipal waste incinerator. Generators of more than 10 lamps/month must arrange disposal in permitted lined landfills.
IL	EPA has enforcement authority in IL Lamps exhibiting the toxicity characteristic are subject to hazardous waste management.
IN	Subject to RCRA through TCLP testing and may be regulated as hazardous waste.
KS	Determined on a case by case basis.
LA	Considered hazardous waste.
MA	Can be shipped to a recycler without hazardous waste manifest.
ME	Lamps failing TCLP are handled as hazardous waste, including hazardous waste transporter requirements.
MI	Recommended that lamps are considered hazardous waste and be recycled.
MN	Mercury-containing lamps must be stored according to Minnesota Pollution Control Agency (MPCA) guidelines and shipped to existing recycling facility under MPCA requirements.
NC[k]	Lamps banned from solid waste landfill disposal.
PA	Landfill only when certification shows that waste has passed the TCLP.
RI	Treat as hazardous waste. Log system is used for transporters and generators.
SC	Some landfills ban disposal.
TX	Must be disposed or recycled at a permitted hazardous waste facility.
WI	Hazardous waste lamps and bulbs (including bulbs with high lead concentrations) may not be placed in a solid waste landfill. Lamps and bulbs that are recycled are subject to reduced hazardous waste management requirements.

LIMITATIONS TO REGULATIONS ALONE

Enforcement of existing regulations may provide sufficient incentive to prompt existing hazardous waste generators to properly manage their waste lamps. However, households and small business represent a different problem. Neither have the space nor waste management experience to safely accumulate and store lamps over extended periods of time. Since most lamp transporters and recyclers currently require a minimum pick-up fee for small quantities of lamps, without large numbers of lamps to ship, lamp recycling will remain prohibitively expensive for small users until a collection system that overcomes these consumer barriers is developed.

IV EFFORTS TO REDUCE MERCURY EMISSIONS

SOURCE REDUCTION OF MERCURY IN LAMPS

Unlike the mercury in dry cell batteries, mercury is a vital component in fluorescent lighting. The mechanics of how fluorescent lighting works dictates that there will always be some mercury in these products. Nevertheless, lamp manufacturers have successfully reduced the average mercury content in their bulbs by 14% between 1985 and 1990 (from 48.2 to 41.6 mg/bulb) and predict a further 35% reduction (goal: 27 mg/bulb) by 1995. Additionally, recent product development research has shown that the present practical limits needed for full rated life of a 4-foot fluorescent lamp is about 15 mg/bulb of mercury[i]. In the long term, source reduction efforts such as these will produce major reductions in the total mercury content of the solid waste stream. However, given normal product life expectancy and usage patterns, these newer lower mercury content bulbs will not appear in the waste stream in significant numbers for the next three to five years.

LAMP DISPOSAL UNDER UTILITY EFFICIENCY PROGRAMS

In recent years, Vermont's electric utilities have developed energy efficiency programs, that, among other measures, encourage their customers to save money by replacing inefficient lighting with high-efficiency fluorescent lights. These programs lower the energy consumption by the utility's customers and help the utilities avoid future investments in generating facilities. Also, as an environmental benefit, these programs help reduce discharges of pollutants, including mercury, from existing fossil-fuel fired generating plants. Compared to incandescent lighting, compact

fluorescent lamps will require one-third the power per lumen of light produced.[a] Significant but less dramatic efficiency gains are also found in upgrading conventional fluorescent lighting to high efficiency systems with electronic ballasts.[b]

Generally, utilities have educated their customers about suitable methods of lamp disposal when a commercial or industrial customer installs energy efficient lighting under the utility's program. Given the low levels of documented bulb shipments to hazardous waste management or recycling facilities, the electric utilities may need to consider playing a more active role promoting proper lamp management when their conservation programs are involved.

PROMOTION OF LAMP RECYCLING/COLLECTION INFRASTRUCTURES

The goal of any mercury-containing lamp collection and recycling program is to recapture and prevent environmental release of the greatest amount of mercury from these products. To be effective the system needs to be:

1. easy to use
2. readily accessible (not too far away)
3. consistently available to its users.

While there was broad consensus within the workgroup that mercury-containing wastes should not be incinerated and need to be better managed, there was less agreement about how it should be done and how that activity should be funded. In preparing this report, the workgroup looked at a number of possible program structures. There were three basic program approaches or "incentives" which could be used singly or in combination. Eight possible choices for collection entities were suggested as operators of collection programs who could work independently or jointly. Finally a number of possible program funding sources were identified. These fell into three broad categories: "up front" fees which would likely be reflected in higher purchase prices for what is the environmentally preferred product; "external" sources which would raise the prices of related goods and services; and "back end" costs which would fall directly on the disposer of the waste lamp.

Although a number of program types were suggested, not all permutations of how to establish a possible program were developed in detail. Almost at the outset, concerns about the economic equity for many of these options emerged from workgroup discussions. Two somewhat divergent themes emerged:

1. Not unlike the Declaration of Policy and Purpose to Vermont's waste management law (10 V.S.A. §6601), there was agreement that those who produce a waste should pay for its proper disposal. There was also support for the idea that the costs of operating a lamp collection system to serve households and CESQGs should not fall on those who have already paid for

proper management of their own lamps.

2. Less well defined by the group was the concept that those who enjoy the environmental benefits from others' use of energy efficient lighting (less pollution from the burning of fossil fuels to produce electricity) should also share part of the cost for proper disposal of mercury-containing lamps.

OPTIONS FOR RECYCLING/COLLECTION PROGRAMS

INCENTIVE PROGRAM	COLLECTION ENTITY	FUNDING SOURCE
CONSUMER EDUCATION	TOWN/SW DISTRICT	up front disposal fee at retail level
	STATE	per unit or flat fee on distributors
FINANCIAL INCENTIVES	PUBLIC UTILITIES	per unit or flat fee on manufacturers
	RETAILERS	per unit or flat fee on retailers
REGULATORY REQUIREMENTS	DISTRIBUTORS	flat or variable fee on utilities
	MANUFACTURERS	solid waste surcharges (state or local)
	BULB RECYCLERS	sales or property tax
	WASTE HAULERS	fees on waste haulers
	DISPOSAL FACILITIES	disposal fee

Under existing state and federal hazardous waste regulations, CESQG and household waste fluorescent lamps can be expected to continue finding their way into solid waste disposal facilities. The differential between disposal costs ($.03 per lamp for solid waste landfill disposal vs $.60 per lamp for recycling or over $1.00 per lamp for disposal as a hazardous waste) constitutes a significant barrier to recycling. Nevertheless, in states like Florida and Minnesota where lamp recycling facilities are located and where municipalities may use state purchase contracts, competition has reduced recycling charges to about $.25 per four-foot lamp.[k]

In theory, the cost barrier can be overcome by simple bans on incineration or landfill disposal of waste mercury-containing lamps. However, unless all the costs for management of waste mercury-containing lamps are to fall on the disposers of the lamps, a system to help pay for the collection and recycling of the lamps would have to be developed to ensure their proper management.

MANAGEMENT COST VERSUS MERCURY RELEASE COMPARISON

MERCURY RELEASED		ESTIMATED COST PER LAMP*
GREATEST	INCINERATION	$ .03
	UNCONTROLLED CRUSHING	$ .05
	PRESENT MSW PRACTICES	$ .03
(all below are equivalent)	CONTROLLED CRUSHING	
LEAST	MSW	$ .15
	RECYCLING	$ .30
	HAZARDOUS WASTE	$ .50
	INTACT BULB COLLECTION	
	MSW	$ .15
	RECYCLING	$ .60
	HAZARDOUS WASTE	$1.00+

* Costs may vary widely, does not include TCLP testing or on-site management costs)

V INCENTIVES FOR LAMP COLLECTION/RECYCLING

If money is to be used to entice CESQGs and households to bring in bulbs for collection/recycling, it needs to come from somewhere. Yet, there are no simple ways to create financial incentives to promote lamp collection, recycling or processing. Even the most direct approach of "waste generator pays at the time of disposal" has an inherent disincentive built in. If the cost of processing lamps is too high, the waste lamps will be disposed in the least costly manner.

Alternatively, this management cost could be added "up-front" to the purchase price of the product. Deposits paid on bulbs sold and fees placed on retailers, distributors or manufacturers are all examples of up-front approaches. Because the levy would be immediately reflected in increased prices for an environmentally preferred product, up-front deposits and fees, in this case, could be considered counterproductive. A price disincentive to energy conservation would appear to have been created, since fluorescent and compact fluorescent lamps already have unit costs greater than the less efficient incandescent lamps. On the other hand, any attempt to distribute the cost over all products sold would raise again the equity issue because those businesses which pay for proper management of their own lamps would, in effect, pay twice.

Also, when we look to "deposit-return" approaches, we find that fluorescent lamp recycling is not directly comparable to deposit systems for bottle recycling. Unlike soda bottles, the bulbs are hard to handle and, as manufactured products, cannot be recycled

directly into more lamps. Also, unlike bottles in a deposit system, a mercury-containing lamp can be expected to remain in use an average of five years before it is replaced. With each passing year it becomes less likely that the product on which the tax or deposit was paid will be returned for collection of the deposit or for recycling. The likelihood of system success would be further complicated if it were to be implemented at the retail level because only 10% of the bulbs used in Vermont are sold at retail.

Externalized funding sources do even less well with respect to the equity issue because they are broad based approaches. Whether the funding source is a surcharge on solid waste disposal or a tax levied through an electric utility or a fee placed on a waste hauler, not only do those who have already paid for lamp management contribute, but those who don't even use mercury-containing lamps pay as well. Additionally, because of concerns about placing upward pressure on utility rates, the regulated electric companies should not be seen as a resource for broad-scale lamp collection outside their traditional efficiency programs.

As in earlier Agency reports to the Legislature on dry cell battery and waste paint management, a case could be made for greater lamp industry involvement under the principle of "manufacturer responsibility". A wholly private sector initiative where lamp manufacturers establish a system that pays for the proper management of all tubes could be considered. This would make the manufacturers directly responsible for the hazardous materials in their products. It would also avoid burdening retailers and consumers with deposit fees. The cost of the recycling process would be internalized into the wholesale price of the product regardless of the buyer. However, to be cost effective, programs like this would need to be established on a regional or national scale. Not in a small market like Vermont.

VI FEASIBILITY OF LAMP RECYCLING IN VERMONT

Opportunities for siting a lamp recycling facility in Vermont will be governed by both economic and regulatory considerations. The current classification of most waste fluorescent lamps as a characteristic hazardous waste provides a clear incentive for businesses which produce hazardous wastes to also send their waste lamps to a hazardous waste treatment or recycling facility. The economic bottom line is also relatively straight forward. Potential revenue from the sale of reclaimed mercury, glass and metal bulb components is far less than the costs associated with handling and processing of the bulbs. Lamp manufacturers report that the cost of raw materials in an average four-foot fluorescent lamp is about five cents ($.05).[b] However, the average cost for recycling this same lamp is about sixty cents ($.60). Recycling

charges for high-intensity discharge lamps average $4-5.00.[k] Given that the average start-up cost for a lamp recycling facility in the United States is about $ 600,000.[l], an estimated annual throughput of about one million lamps at an average charge of twelve cents ($0.12) per linear foot would be needed for a mercury-containing lamp facility to break even.[k] Since only an estimated 1.12 million lamps are replaced annually in Vermont, the facility would have to import mercury-containing lamps from other states to remain economically viable.

Under existing regulations siting this facility in Vermont, under most circumstances, would require certification (a permit) to operate as a hazardous waste treatment facility. However, before this permit can be sought a "Certificate of Need" (10 V.S.A. §6606a) must be obtained. This certification must find, among other things, "the lack of adequate current or projected treatment or disposal capacity within the region to handle the hazardous waste generated by Vermont generators which is proposed for the facility". However, there are already lamp recycling facilities in New York, Pennsylvania, and Massachusetts in operation which have the capacity to process all waste lamps produced in Vermont, and may be able to bring new capacity on line as market conditions warrant.[k]

VII RECOMMENDATIONS

THE UNDERLYING PROBLEM: MERCURY IN OUR ENVIRONMENT

Mercury is a classic pollution problem in that, superficially, emissions of mercury appear to cause little or no environmental damage. Because many people have handled liquid mercury metal without health consequences, this seems to contradict concerns about small amounts of methylmercury in fish and wildlife. However, all sources of mercury exposure are not obvious. Like acid rain, much of the mercury that falls in Vermont may have originated thousands of miles away. Consequently, atmospheric deposition of mercury has become the principal route for human exposure. There is no evidence that Vermont is exempt from the global atmospheric mercury cycle. The sum of even small releases of mercury can easily outrace our environment's capacity to cleanse itself of its atmospheric mercury burden. If only 2% (16 pounds) of the 800 pounds of mercury estimated to fall on Vermont annually can be considered effectively "locked up" each year, significant reductions in mercury released from all sources (including waste disposal) will have to be achieved before the state can "break even" in its contributions to the global mercury cycle.

Accordingly, it is the recommendation of the Agency of Natural Resources to the General Assembly of the State of Vermont that means be established to promote environmentally sound management of waste mercury-containing lamps (principally fluorescent and high-intensity discharge lamps). The goal should be to minimize uncontrolled releases of mercury to the atmosphere from the incineration or uncontrolled breakage of waste mercury-containing lamps. To accomplish this and other reductions in the total mercury content of the solid waste stream both short-term and long-term strategies should be pursued.

The fundamental issue, at this time, for Vermont is not whether discarded mercury-containing lamps are a hazardous waste. Rather, the state's efforts should be directed toward finding ways to move these wastes into more environmentally sound management systems.

At a minimum, an educational effort needs to be mounted. Vermont homeowners, businesses and industries need to be told that fluorescent and high-intensity discharge lamps contain mercury and should not be discarded with solid wastes. With respect to developing regulatory and public education program, Vermont does not have to reinvent the wheel. States like Florida and Minnesota have already developed detailed guidance documents for the recycling, storage, transportation, and processing of mercury containing lamps and devices.[d,f]

Consequently, it is recommended that technical and financial support be provided to the existing Household Hazardous Waste collection and recycling infrastructures in Vermont to promote recycling or other equally environmentally sound management options for waste mercury-containing lamps. Source separation of the waste lamps was identified by the workgroup as the preferred means by which to achieve these ends. With adequate funding and guidance, establishing lamp collection capacity should be well within the capabilities of even local, volunteer-based recycling programs. For lamp collection programs, space and equipment requirements are modest. Also, original product packaging is often sufficiently protective to allow intact shipment of replaced lamps to approved destination facilities. Although the final destination for the mercury-containing lamps (be it recycling or solid waste disposal) will largely determine management costs, significant savings can be achieved through group contracts or the sharing of capital equipment. For example, in Florida and Minnesota competition for state purchase contracts has produced recycling charges of $.25 per four-foot lamp, (less than half the national average commercial rate.) Similarly, if Federal hazardous waste management issues can be resolved, regionalized lamp crushing programs operated by municipalities or solid waste management districts might further reduce recycling costs or, if allowable, prepare lamps for even less expensive management as solid wastes.

Therefore, given appropriate legislative mandates and adequate funding, local source separation programs could be implemented throughout much of Vermont in less than two years, presumably before July 1, 1997. However, the key public policy decision to be made is which public or private entities should be charged with carrying out these programs. If municipalities were to be deemed the appropriate party, the municipal responsibility for solid waste provisions of Title 24 may provide the appropriate statutory vehicle. If, on the other hand, the generators of the waste, waste haulers, or waste disposal facilities are selected to carry this burden, the waste management provisions of Title 10, Vermont Statutes, may prove to be effective.

Discussion of issues related to how to direct and fund the proper management of waste mercury-containing lamps is not a new exercise for the Agency. These very same issues were raised in the Agency's January 1992 "Vermont Household Battery Report" and January 1992 "Vermont Waste Paint Report". Therefore, it is recommended that the Legislature look beyond just mercury-containing lamps or other mercury-containing waste to establish infrastructures to ensure appropriate management of all categories of hard to manage wastes. Instead of dealing with one product at a time on a case by case basis, mechanisms such as manufacturers' responsibility, problem materials fees or a state-wide funding mechanism should be seriously investigated.

REFERENCES

a. Begley, K. and Linderson, T., "Management of Mercury in Lighting Products", First European Conference, May 1991

b. Bleasby, Peter A., Director Industry Relations & Standards, Osram Sylvania, Inc., comments at report workgroup meetings on September 20, October 18, November 14, and December 14, 1994.

c. Cunningham, P. A., Smith S.L., Tippett, J.P. and Greene, A., "A National Fish Consumption Advisory Data Base: A Step Toward Consistency", Fisheries, Vol. 19, No. 5, May 1994.

d. Florida Department of Environmental Protection, "Summary and Recommendations on Mercury Containing Lamps and Devices: Review of Recycling, Storage and Transportation Alternatives", July 1994.

e. Minnesota Office of Waste Management, "Report on the Management of Mercury-Containing Lamps", report to the Legislative Commission on Waste Management, January 1993.

f. Minnesota Pollution Control Agency, MPCA Mercury Task Force, "Strategies for Reducing Mercury in Minnesota", 1994.

g. National Electrical Manufacturers Association, "Analysis of Three Regulatory Scenarios for Spent Mercury-Containing Lamps", August 31, 1994.

h. National Electrical Manufacturers Association, "Environmental Risk Analysis: Spent Mercury-Containing Lamps, A Summary of Current Studies: September 6, 1994.

i. National Electrical Manufacturers Association, "Mercury Content of Residues from Lamp Reclamation", September 1994.

j. National Electrical Manufacturers Association, "The Management of Spent Electric Lamps Containing Mercury", (Second Edition), September 1994.

k. Quintal, Robert M., Director of Business Development, Global Recycling Technologies, Inc., comments at report workgroup meetings on November 14, 1994 and December 14, 1994.

l. Scherbatskoy, Tim, University of Vermont School of Natural Resources, personal communication, 1/4/95.

m. Truesdale, Robert S, Beaulieu, Stephen M, Pierson, Terrance K, "Management of Used Fluorescent Lamps: Preliminary Risk Assessment", Research Triangle Institute Project Report to U.S. Environmental Protection Agency, revised May 1993.

n. U.S. Environmental Protection Agency, Global Change Division, Green Lights Program, "Lighting Upgrade Manual" April 1994 update.

o. U.S. Environmental Protection Agency, "Characterization of Products Containing Mercury in Municipal solid Waste in the United States, 1970 to 2000", EPA530-R-92-013, April 1992.

p. U.S. Environmental Protection Agency, "Evaluation of Mercury Emissions from Fluorescent Lamp Crushing", EPA-453/D-94-018, February 1994.

q. U.S. Environmental Protection Agency, "Hazardous Waste Management System; Modification of the Hazardous Waste Program; Mercury-Containing Lamps; Proposed Rule". 59 Federal Register 38283, July 27, 1994.

r. U.S. Environmental Protection Agency, "Report of the National Technical Forum on the Reduction of Heavy Metals in Municipal Solid Waste", September 1993.

s. U.S. Department of Health & Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry "Toxicological Profile for Mercury", TP-93/10, May 1994.

t. Vermont, State of, Agency of Natural Resources, "Hazardous Waste Management Regulations", effective: August 15, 1991.

u. White, Kathleen M., "Handling Difficult Materials: Fluorescent Lamps", Waste Age, November 1994.