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OPTIONS FOR DENTAL MERCURY REDUCTION PROGRAMS: INFORMATION FOR STATE/PROVINCIAL AND LOCAL GOVERNMENTS

A REPORT OF THE BINATIONAL TOXICS STRATEGY
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Preface

Much of the information contained in this report was presented at a meeting held on December 2, 2002, to discuss options for reducing the environmental impact of dental mercury. Many thanks to all of the participants at this meeting, and to others who commented on the draft report, including: Keith Linn, Jerry Bowman, Peter Berglund, Gail Savina, Pat Magnuson, Abigail Jarka, Grace Scott, and Tim Tuominen. They are not responsible for any errors or omissions in the final report.

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1.0 INTRODUCTION/BACKGROUND

Through the Great Lakes Binational Toxics Strategy (GLBTS), Canada and the United States have committed to reduce the use and release of mercury. A Mercury Workgroup, led by Environment Canada and the U.S. Environmental Protection Agency (USEPA), promotes activities that will reduce mercury releases to the Great Lakes Basin, utilizing the GLBTS analytical framework for achieving virtual elimination of mercury from the Great Lakes. This analytical framework involves a four-step process of 1) information gathering; 2) analysis of current regulations and programs; 3) identification of cost-effective options to achieve further reductions; and 4) implementation of actions to work toward the goal of virtual elimination. This report is an effort by the Mercury Workgroup co-chairs to contribute toward the process of utilizing this analytical framework, with a focus on steps 2 and 3.

This report is meant to facilitate a dialogue about options that state and local governments have for addressing mercury releases from dental offices, which has become a growing concern in both Canada and the United States as larger sources of mercury are controlled and efforts to reduce mercury focus on smaller sources. It is based in large part, though not entirely, on a meeting that the Mercury Workgroup hosted on December 2, 2002, in Chicago, to discuss the issue of dental mercury and ways of reducing the environmental impact of dental amalgam.

Approximately 50 percent of dental amalgam is mercury.[1] Mercury in dental amalgam can enter the environment in a variety of ways. Dental amalgam waste that is generated (for instance, excess amalgam that is not placed in a tooth, or amalgam that is captured by traps and filters in the dental office) can release mercury into the environment if it is not managed properly. When amalgam restorations are placed in or removed from teeth during dental work, amalgam can enter dental wastewater; when it reaches a wastewater treatment plant, a small percentage of the mercury in the amalgam will be discharged by the plant. A study by the Association of Metropolitan Sewerage Agencies found that dental offices are the largest source of mercury to publicly owned treatment works (POTWs), contributing more than 35 percent of mercury influent to the POTWs studied (AMSA, 2002). While amalgam has very low solubility in water, a small percentage can be released in a bioavailable form, and be converted to methylmercury, the form that accumulates in the food chain, presenting potential health risks to humans and wildlife who consume contaminated fish.

Most of the mercury that reaches sewage treatment plants (in excess of 90 percent) is likely to be captured by the treatment plant and enter the sewage sludge, or biosolids. Once mercury is in sewage sludge, it is likely to be released if the sludge is incinerated. Some of the mercury can also be released when sludge is landfilled, or especially when it is land applied (see section 2.0).

In the United States, dentists use an estimated 35 tons of mercury annually (ENVIRON), which may be placed in teeth, recycled, discharged into wastewater, or disposed as waste. In Canada, approximately 0.6 tonnes of mercury in new dental filling material is placed each year

[1] The remaining constituents commonly include copper, tin, and silver.

(CCME). Mercury use by this industry, as the number of amalgam restorations, has declined (a 29 percent reduction in the United States between 1990 and 1999).

While the use of dental amalgam has decreased, amalgam is still considered a safe, durable, long-lasting, and cost-effective restoration. Due to these properties, amalgam continues to be used for dental restorations. While alternatives to amalgam are available and are used increasingly, most dentists wish to have the option of continuing to use amalgam, particularly for restorations of posterior teeth. Research into viable substitutes continues. However, even as amalgam use declines, old amalgam restorations will be removed for years to come.

In some areas, measures have been implemented to reduce the amount of mercury flowing from dental offices to wastewater treatment plants. Both voluntary and regulatory approaches have been undertaken. This report describes the efforts of four dental mercury reduction programs and collates the lessons learned from these case studies into a discussion of factors that state/provincial or local agencies should consider in implementing their own dental mercury reduction programs.

2.0 POTENTIAL BENEFITS

There are many reasons for initiating a mercury reduction program for dental offices. Reducing concentrations of mercury in dental wastewater can have the following potential benefits: reduce mercury loadings to POTWs, decrease the environmental impact of dental mercury wastes, help a POTW or municipality comply with local and/or state discharge limits, and improve the quality of POTW biosolids.[2] For instance, in King County, Washington, the wastewater treatment agency considers high-quality biosolids a priority because these biosolids are land applied. Although King County charges a fee for its biosolids based on their fertilizer value (that is, their nitrogen value, not their mercury content), public perception of biosolids safety is critical to maintaining a market for them. For that reason, King County wished to proactively reduce mercury discharges into the wastewater treatment system. Recycling the amalgam waste collected through a reduction program (for metal constituents, including silver) provides an added benefit of reduced mercury releases from improper waste handling. Also, for dental offices, installation of state-of-the-art amalgam separator equipment can offer a marketing edge for environmentally aware patients.

POTWs in the Great Lakes states are coming under pressure to meet the water quality standards developed under the 1995 Great Lakes Water Quality Initiative. Mercury is one of 22 “Bioaccumulative Chemicals of Concern” identified in the Great Lakes Water Quality Guidance with water quality criteria of 3.1 ng/L for protection of human health[3] and 1.3 ng/L for

[2] Biosolids are the nutrient-rich organic product of wastewater treatment. Biosolids are a valuable resource containing essential plant nutrients and organic matter and can be recycled as a fertilizer and soil amendment.

[3] The water quality criterion for protection of human health initially set by the Great Lakes Water Quality Guidance was 1.8 ng/L. However, subsequent to publication of the Guidance, USEPA published a reference dose for methylmercury which, if used, would result in a criterion for mercury of 3.1 ng/L. Great Lakes States’ adoption of

protection of fish-eating wildlife. While mercury at these levels was previously difficult to detect, or was undetectable for some analytical methods, in 1999 USEPA adopted Method 1631, which uses oxidation, purge and trap, and cold vapor atomic fluorescence to detect mercury levels in water as low as 0.2 ng/L. Method 1631 has demonstrated that POTW effluent mercury levels are exceeding the stringent effluent limitations set by the Great Lakes Water Quality Initiative. This has caused an increased focus on the dental sector as a source of mercury contributing to levels in POTW effluent.

Wastewater treatment plants are a source of mercury to water bodies, fish, crops, and the atmosphere. A dental mercury reduction program captures amalgam waste and reduces the amount of mercury moving into municipal sewers and being disposed of improperly. Dental mercury reduction programs have been clearly shown to reduce mercury in POTW influent and sludge, which in turn should limit releases from sludge incineration, use, and disposal. The impact of these reductions on effluent has not been determined. The results of a Community-Wide Dental Mercury Study, undertaken by the Metropolitan Council of Environmental Services, in partnership with the Minnesota Dental Association, showed that the use of amalgam separators at dental clinics in two Minnesota cities achieved reductions in mercury levels in sludge of 29 percent to 44 percent in just three months, as monitored at two wastewater treatment plants (Berglund, 2002 – Study coordinated by Claude Anderson, MCES). Preliminary data have shown reductions in mercury levels in sludge at Toronto's wastewater treatment plants of 40 percent to 70 percent following implementation a "Sewer Use By-law" requiring the installation of an amalgam separator and imposing a discharge limit on dental offices in Toronto.

Comprehensive mercury reduction efforts by POTWs can have a significant impact on mercury releases. Reductions of 80 to 90 percent in mercury levels in the influent, effluent, and sludge at the Western Lake Superior Sanitary District (WLSSD) in Duluth, Minnesota, have been achieved as a result of WLSSD's many pollution prevention efforts, along with changes in plant operations. The contribution to WLSSD's success of dental mercury reduction, as compared with other reductions, is not known.

The impact of dental amalgam discharge on the environment is a subject of debate. The mercury contained in amalgam is elemental mercury, not methylmercury, the organic form that can bioaccumulate in fish and animal tissue and that is therefore considered "bioavailable." Amalgam can break down, however, and release mercury into the environment, where it can be transformed into methylmercury. Nonetheless, since some percentage of amalgam discharges are likely to be buried in sediments before methylation can occur, environmental releases of amalgam probably are less environmentally damaging than releases of other forms of mercury.

3.1 ng/L as the water quality criterion for protection of human health for mercury was therefore considered consistent with the Guidance and was approved by USEPA.

In addition to amalgam releases, dental offices release some dissolved mercury and, in at least some cases, methylmercury. A recent study has shown that methylmercury is actually formed within dental effluent at large clinics. Methylmercury levels can be higher in the holding tanks of large dental clinics by an order of magnitude in comparison with levels seen in the natural environment (though still a small fraction of the total mercury). The high levels in holding tanks are likely the result of methylation by bacteria and fungi (Stone, et al., 2003). Effluent from smaller dental clinics, without effluent holding tanks, have not been studied, and may contain lower concentrations of methylmercury.

Assessments of the potential benefits of reducing the discharge of amalgam can be difficult, given the uncertainties surrounding:

- the typical dental office wastewater discharge stream (due to the daily variation in the amount of dental amalgam discharged and the differences between dental practices);
- the fate of mercury in amalgam (whether it is captured in traps or filters, dissolves, settles in lines, reaches the treatment plant, etc.); and
- the percentage of elemental mercury that is released from amalgam, thereby becoming available for possible methylation, under different circumstances.

Dr. Phillip Watson, of the University of Toronto College of Dentistry, conducted a study to measure the percentage of amalgam waste entering dental office wastewater from the removal of dental amalgam restorations. A typical office system was replicated in a laboratory setting, and 160 amalgam restorations were removed in four test runs. The study found that approximately 40 percent of the amalgam removed was captured by a chair-side trap and a filter screen placed just upstream from the vacuum pump; the remaining amalgam, approximately 60 percent, was released to wastewater. The study also showed that, for the study's set-up, the average concentration of mercury in wastewater was 31.15 mg/L without an amalgam particle separator and 0.18 mg/L with an amalgam separator, a difference of 99.4 percent (Watson, 2002).

ENVIRON International has developed an "Assessment of Mercury in the Form of Amalgam in Dental Wastewater in the United States" for the American Dental Association (ADA). ENVIRON estimates that dental offices release approximately 29.7 tons of mercury into their internal wastewater annually, and that capture by existing equipment in the dental office (chair-side traps and vacuum filters) reduces the amount discharged annually to sewage treatment plants to 6.5 tons. This assessment utilizes estimates that chair-side traps capture 68 percent of amalgam, and that 80 percent of U.S. dental facilities are equipped with vacuum filters that capture 40 percent of the remaining mercury. Based on studies showing an average of greater than 95 percent capture efficiency for mercury at sewage treatment plants, the ENVIRON study estimates that POTWs discharge to the water 0.3 tons of the dental mercury that they receive from dental offices, with the remaining 6.2 tons ending up in sludge.

These estimates effectively demonstrate that a significant portion of dental mercury ends up either in waste that must be managed by the dental office or in sewage sludge that must be managed by sewage treatment plants. While mercury discharges to surface waters may also be significant in many local circumstances, dental mercury reduction efforts should not focus exclusively on that fraction (Drummond, 2002).

The ENVIRON study also makes estimates of the fate of some of the estimated 6.2 tons of mercury in sludge. It estimates that approximately 1 ton of dental mercury in sludge is managed via incineration, resulting in air emissions of 0.2 tons of mercury, based on USEPA estimates that emissions controls at sewage sludge incinerators reduce mercury releases by 79 percent. It was further estimated that approximately half of these emissions would deposit in the United States. ENVIRON made no estimate of releases from the remaining 5.2 tons of mercury in sludge, which are either landfilled, or applied to land as a soil amendment.

The fate of mercury in sludge, or biosolids, that are land applied is an important area of uncertainty. More than half of sewage sludge generated in the United States is land applied. USEPA sets a pollutant concentration ceiling of limit for mercury of 57 mg/kg in any land applied sludge; "exceptional quality" biosolids, which have fewer restrictions on their use, can have no more than 17 mg/kg. Typically, sewage sludge concentrations are well below these limits. EPA's 1988-1989 National Sewage Sludge Survey found only a small number of sewages sludges that had concentrations above 17 mg/kg, and mercury levels in sludge have declined since then. For instance, a study of trace metal levels in New England sludge found average levels of 1 to 2 mg/kg in 1999 and 2000 (NEBRA). A 2003 National Academy of Sciences report found no evidence that USEPA's regulation of land applied sewage sludge has failed to protect public health, but recommended that the regulations be updated using current scientific data and risk assessment methods, including consideration of the species of mercury that might be present in sludge, or released from sludge. While there has been no evidence of local water quality problems as a result of mercury sludge applications, the total mass of mercury in land applied sludge is large (likely more than three tons per year), and could represent a meaningful contribution of mercury to the environment if a significant portion of this mercury is volatilized.

While emissions of mercury from land applied sludge need further study, there have been some efforts to quantify these mercury releases. Carpi and Lindberg measured mercury emissions from two sites that had been newly amended with sewage sludge, and two additional sites where sludge had been applied repeatedly over five to ten years. They found that sludge-amended soil releases elemental mercury vapor, and that emissions increase by a factor of 10 to 100 above the releases from freshly-amended soils. Only a fraction of the mercury was emitted to the air; most seems to stay in the soil. Mercury was emitted only from the top few millimeters of soil, and emissions were higher with increased sunlight and temperature, and lower with increased soil moisture. Carpi and Lindberg estimated that average summertime mercury air emissions from sludge-amended soils exposed to sunlight, would be 100 ng/m^2/hour, or approximately 0.06 percent per day of the mercury in the sludge applied.

A study prepared for the Canadian Council of Ministers of the Environment used this research as the basis for a calculation that in Canada an estimated 357 kg of mercury in sludge are applied to the land annually, and that approximately 32 kg of this amount is emitted to the air. Thus, approximately nine percent of mercury in land applied sewage sludge is estimated to be released to the air in Canada. Mercury releases are likely higher in warmer climates. These studies do not attempt to determine the share of these releases that can be attributed to mercury discharged by dental offices. It is likely that the rate of mercury release from amalgam contained in land-applied sewage sludge is lower than the rate of release from other forms of mercury.

Dental offices release less mercury to the environment than many other industries (electric utilities release an estimated 48 tons of mercury to the air annually, for instance). Moreover, air deposition accounts for most of the mercury input to most water bodies in the United States and Canada. Addressing dental mercury releases is still important, for the following reasons:

- Sanitary sewers release mercury directly to water bodies, and dental offices are thought to be the largest contributers of mercury to sanitary sewers. When the receiving waters have mercury impairments, such discharges are of greater local concern than an equivalent amount of air emissions, which are dispersed broadly. While sewage treatment plants remove more than 90 percent of the mercury discharged to them, a fraction is discharged directly to the impaired water.[4] POTWs have strict mercury discharge limits in many parts of the country (including the Great Lakes region), which will in most cases require them to implement Pollutant Minimization Programs addressing all sectors that release mercury to water, including dental offices.
- In addition to mercury discharges to POTWs, dental offices generate substantial amounts of mercury-containing solid waste, which may potentially be discharged to the environment if improperly managed.
- Successfully reducing mercury contamination requires reductions from numerous different source sectors which are collectively responsible for a significant share of the mercury in the environment, even though individually they do not account for a large share of the problem.

To address these releases, municipalities and POTWs have initiated programs to reduce mercury releases from dental offices, and have achieved reductions of mercury at the wastewater treatment plant. The U.S. Navy is in the process of installing advanced mercury removal equipment in all dental facilities, including clinics, ships, and field units in the U.S. and abroad.

3.0 ISSUES OF TECHNOLOGY AND INFRASTRUCTURE

The removal of mercury from dental office wastewater involves several issues of technology and infrastructure. This section discusses best management practices, amalgam removal systems, residual mercury in lines, the action of line cleaners, and disposal of dental mercury waste.

[4] The percentage of mercury that POTWs remove from dental discharges is not known. Since these discharges are primarily in particulate form, rather than dissolved mercury, it is possible that POTWs remove an even greater percentage of dental mercury discharges than of other mercury discharges.

3.1 BEST MANAGEMENT PRACTICES

Best management practices (BMPs) for dental amalgam waste are procedures that have been found by experience to effectively reduce the release of mercury into the environment. BMPs can prevent the release into the environment of excess amalgam that is never placed into a patient's teeth, as well as amalgam that is discharged to the internal dental wastewater system, through the proper use of chair-side traps and vacuum filters and by recycling excess amalgam.

Dental BMPs include procedures for training of staff, good housekeeping, proper disposal, and recycling of mercury-containing material. In some places, use of amalgam separators is now considered a BMP. A few suggested practices for BMPs are described below. Section 3.2 will describe amalgam separator technologies. The following practices are a combination of BMPs from various sources (e.g., the ADA, the Northeast Ohio Regional Sewer District, and the Sustainable Hospitals Project).

Training of Staff

Dental office staff should be instructed in proper techniques for the storage, handling, and disposal of amalgam and amalgam wastes. Employees should also be made aware of relevant environmental and waste management regulations and human safety concerns related to mercury-containing materials. Mercury spill kits, or materials to clean up a mercury spill, should be kept on hand and staff members should be trained in how to properly clean up a spill of mercury-containing material. The development of training programs or educational curricula can help to keep dental office staff trained. Section 5.2 discusses a program at Kansas State University to develop and present a dental BMP curriculum to dentists and dental assistants.

Good Housekeeping

Proper housekeeping can reduce spills and contamination of additional materials. Suggested BMPs for housekeeping include:

- Keep amalgam and mercury-bearing wastes out of solid waste ("regular trash") and out of infectious waste. (Solid wastes may be incinerated in some areas, and infectious wastes may be incinerated or autoclaved, thus possibly releasing mercury.)
- Clean or replace under-sink traps and sumps, taking care to avoid spillage of the contents from plumbing parts. Remove sludge that may contain mercury, and have it recycled.
- Avoid using sodium hypochlorite (bleach) to disinfect vacuum lines or other line cleaners that could dissolve mercury out of amalgam.

- Acids that are used to clean equipment, such as x-ray processors, have the potential to release mercury from old amalgam in clinic sewer lines. Acids should be neutralized before going down the drain or be disposed in an alternate manner, such as shipping to a waste handler.
- Inspect containers of mercury-containing materials regularly.
- Store amalgam waste in covered, segregated, and clearly labeled airtight plastic containers.

Product Substitution and Use

A variety of practices can reduce the use of mercury in dental offices. For example:

- Eliminating the use of bulk elemental mercury (also referred to as liquid or raw mercury);
- Using pre-encapsulated dental amalgam;
- Limiting the amount of amalgam generated to what is needed for each restoration;
- Salvaging and store all scrap amalgam in appropriate containers.
- Using substitutes to amalgam, such as gold, ceramic, porcelain, composites, polymers, glass ionomers, cold silver or gallium, if appropriate. The choice of dental treatment rests solely with dental professionals and their patients. As fewer mercury-containing dental amalgams are provided as treatment, they will become less of a source of mercury in the environment.

Disposal and Recycling

Studies have shown that following BMPs for disposal and recycling of dental mercury and waste amalgam can significantly reduce the amount of mercury released into the waste stream. BMPs for disposal and recycling of dental mercury include:

- Use disposable chair-side traps;
- Use vacuum pump filters and change regularly;
- Inspect chair-side amalgam traps frequently and remove or clean as necessary;
- Collect used amalgam for recycling regularly;
- Use a professional amalgam recycler or certified hazardous waste transporter to dispose or recycle scrap amalgam; do not rinse it down the drain or dispose of in biohazard bags.
- Participate in bulk mercury collection programs and events.

A checklist of dental BMPs can help dental offices identify areas where they could change procedures and reduce amalgam waste. The ADA has recently published a set of BMPs that it encourages all of its members to use (see Appendix A). The Northeast Ohio Regional Sewer District (NEORSD) provides a checklist of mandatory and recommended BMPs that, when completed, signed and returned, may serve as the required BMP plan for a dental office (see Appendix B.)

3.2 AMALGAM REMOVAL SYSTEMS

Separator technologies that remove amalgam may be used in addition to filters and traps in chair-side dental units and vacuum lines (WEF, 1999). According to MCES, approximately three-fourths of the amalgam generated in a dental office can be removed by chair-side traps and a vacuum filter (MDA and Metropolitan Council, 2003). With the installation of an amalgam separator, greater than 99 percent of amalgam waste can be captured.

An International Organization for Standardization (ISO) standard has been developed for amalgam separators, ISO-11143. Published in 1999, the *International Standard ISO-11143 Dental Equipment - Amalgam Separators* document defines amalgam separators as "an item of dental equipment designed to remove amalgam particles from the waste water from the dental treatment centre, so as to reduce the number of amalgam particles and therefore the mass (amount) of amalgam entering the sewage system" (ISO, 1999).[5]

ISO-11143 certification is based on 95 percent or greater efficiency, when tested using the ISO protocol established in the above document. Some U.S. programs may call for higher removals, up to 99 percent, such as in the Minneapolis/St. Paul, Minnesota, metropolitan area. Not all commercially available amalgam separators have been verified to meet the ISO standard.

Mercury removal equipment for dental offices is widely available on the market. Systems range from particulate removal to systems with oxidation and affinity resins (sorbents) that remove ionic mercury. Removal of mercury from dental-unit wastewater to below parts-per-billion levels is possible with commercial systems. However, current technology will not eliminate all mercury.

The ADA has evaluated the efficiency of commercially available amalgam separators (Fan et al., 2002). The ADA evaluated the amalgam removal efficiency of 12 amalgam separators according to ISO-11143. The removal technologies evaluated include sedimentation, filtration, chemical removal, centrifugation, and combinations of removal technologies. The results showed that all 12 amalgam separators evaluated exceeded the ISO 11143 requirement of 95 percent amalgam removal efficiency. In accordance with the ISO standard, the maximum flow rates used by the ADA were those provided by the manufacturers. Table 1 presents the efficiencies of the amalgam separators evaluated by the ADA (Fan, 2002).

[5]The copyrighted ISO 1143 test procedure may be obtained through the American National Standards Institute, at www.ansi.org. Corrections to the test method may be downloaded for free. Go to http://webstore.ansi.org/ansidocstore/find.asp? and look up "amalgam separator".

Table 1. Amalgam Separators Evaluated by the ADA

Amalgam Separator	Removal Efficiency	Maximum Flow Rate (L/min)	Removal Technology
Hg 10	99.99%	0.95	Sedimentation/filtration/ ion exchange
MRU (Mercury Recovery Unit)	99.95%	0.75	Sedimentation/filtration/ ion exchange
Rasch 890-4000	99.90%	4	Sedimentation/filtration/ ion exchange
Amalgam Collector	99.89%	0.5	Sedimentation
RME 2000	99.66%	1	Sedimentation
Hg 5	99.28%	0.05	Sedimentation/filtration/ ion exchange
Asdex	99.10%	0.5	Filtration
MSS 2000	98.94%	2.5	Sedimentation/filtration
BullfroHg	98.88%	0.75	Sedimentation/filtration
Durr 7800	97.66%	12	Centrifugation
ECO II	97.51%	3	Sedimentation
A1000*	96.09%	3	Sedimentation

*This separator has been retested by the manufacturer since the time that ADA published its results:
Data for the A1000 (now called the Guardian) indicate 99.3% removal at 3 L/minute (testing performed by a contract lab for Air Techniques, Inc.).

The total price of an amalgam separator includes the costs to purchase, install, and maintain the separator and to remove amalgam wastes. Separators may be purchased or secured through lease agreements. **Typical costs are estimated to range from $300 to $2,000 in purchase price or $300 to $1,800 annually for a lease agreement, approximately $200 for installation (or included in purchase price), and $75 to $750 in annual maintenance (including waste disposal). In some cases, installation costs can be higher.** Table 2 presents the reported costs and features of selected amalgam separators.

Table 2. Costs and Features of Selected Amalgam Separators

Product Name	Manufacturer/ Distributor	Costs[a]	Est. Annual Cost Averaged Over 3 Years[b]	Features
Amalgam Collector	R&D Services	CH12: $495/unit; $100/installation; $75/year waste collection fees (unit can be emptied and reused)	$270	Chair-side unit; One unit serves one chair
		CE18: $695/unit; $125/installation; $75/year waste collection fees (unit can be emptied and reused)	$350	Centrally-located unit; one unit serves up to 6 chairs
		CE24: $1,250/unit; $250/installation; $75/year waste collection fees (unit can be emptied and reused)	$580	Centrally-located unit; one unit serves up to 12 chairs
Asdex[c]	Avprox	AS-9: $229/unit; $200/installation; $790/year for replacement filters; amalgam disposal not included	$930 (plus filter disposal cost)	One filter unit per chair
BullfroHg	DRNA Dental Recycling North America	$200/installation; $600/year service plan includes: equipment and amalgam disposal; $100/year cartridge; $200/year cleaner; repairs not included	$970	Standard unit serves 1-6 chairs. Uses 120V AC (to pump treated effluent)
		$200/installation; $1,200/year service plan includes: equipment, amalgam disposal, cartridge replacement, and repairs; $200/year cleaner	$1,470	
Durr 7800	Air Techniques	This product is no longer available in the United States (February, 2003)		
ECO II	Metasys	$260/installation; $288/year service plan includes: equipment, amalgam disposal, cartridge replacement, and repairs; $100/year cleaner	$470	One unit serves up to 6 chairs
Guardian Amalgam Separator (formerly known as A1000)	Air Techniques	A1100 or A1200 (for use with a dry vacuum system): $1,500/unit (includes 2 collectors, cleaner, and recycling of first collector); $200/installation; $750/year replacement kit	$1,320	Number of chairs serviced depends on type and size of vacuum system
		A1300 (for use with a single pump liquid ring vacuum system and 4 gallon tank): $2,995/unit (includes 2 collectors, cleaner, and recycling of first collector); $200/installation; $750/year replacement kit	$1,820	
		A1400 (for use with a dual pump liquid ring vacuum system and 8 gallon tank): $3,255/unit (includes 2 collectors, cleaner, and recycling of first collector); $200/installation; $750/year replacement kit	$1,900	
Hg 10	SolmeteX	$7,450/unit; $1,000/installation; $2,100/year filter replacement (2 per year)	$4917	One unit serves 10 or more chairs; Used to meet a specific discharge limit

Table 2. Costs and Features of Selected Amalgam Separators (continued)

Hg 5	SolmeteX	$695/unit; $200/installation; $500/year filter replacement (2 per year), includes recycling; $200/year cleaner; repairs not included	$965	One unit serves up to 10 chairs
		$720/year service plan includes: equipment, amalgam disposal, cartridge replacement, and repairs; $200/year cleaner	$920	
MRU	DRNA Dental Recycling North America Inc.	$200/installation; $1,800/year service plan includes: equipment, amalgam disposal, cartridge replacement, and repairs; $200/year cleaner	$2,070	One unit serves 1-6 chairs
MSS 1000	Maximum Separation Systems	$968/unit; $200/installation; $165/year replacement settle tank; $185/year tank waste management fees	$740	One unit serves up to 11 chairs
MSS 2000	Maximum Separation Systems	$1,395/unit; $200/installation; $165/year replacement settle tank; $185/year tank waste management fees	$880	One unit serves up to 20 chairs
Rasch 890-1000	AB Dental Trends	$1,190/unit; $200/installation; $397/year replacement canister (1 every 18 months)	$860	One unit serves 12 chairs
		Rasch 890-1000 with Rasch 890-4000 add-on unit: costs for Rasch 890-1000 plus $718/add-on unit (15-year life span; no maintenance required for add-on unit)	$1,100	Add-on unit used to meet stringent requirements
RME 2000	Rebec	$1,895/unit and installation; $395/year cartridge replacement includes amalgam disposal and repairs; $200/year cleaner	$1,230	One unit serves 8 chairs

a Taxes not included in costs. The cost of a "typical" installation is estimated at $200 unless estimated otherwise by the manufacturer/distributor. Most installations take about an hour ($50-$100), but some have taken several hours. Also, replacement/maintenance costs may vary significantly depending on use. Costs as reported by the Massachusetts Strategic Envirotechnology Partnership (STEP) (Oct. 2002) or by Battelle through personal communication with manufacturers (Feb. 2003).

b A typical service plan length is 3 years.

c Asdex cost from Minnesota Dental Association, Revised–Features of Approved Amalgam Separators (October 14, 2003), http://www.mndental.org/professionals/amalgam_recovery/revised_chart/

3.3 RESIDUAL MERCURY IN LINES

Mercury and dental amalgam particles that are trapped in existing plumbing present a potential source of continuing mercury release. Mercury can build up in low-lying plumbing areas (e.g., sink traps and sumps) and can be discharged at any time, releasing a "slug" of mercury to the sewer system.

A recent study by the U.S. Naval Dental Research Institute found considerable amounts of residual mercury in dental wastewater lines from large dental clinics. Analysis showed that these wastewater lines were capable of leaching mercury at levels that would make them subject to hazardous waste disposal regulations in the United States under the Resource Conservation and Recovery Act (Stone et al., 2003). A 2001 study done for Environment Canada found that sediments in sewer lines from dental facilities contained high levels of mercury, with mercury concentrations of 17 percent by weight in Vancouver, 20 percent in Calgary, and 1.2 percent in Toronto (C.D. Sonter).

The Sustainable Hospitals Project, sponsored by the Lowell Center for Sustainable Production (at the University of Massachusetts-Lowell), provides technical support to the healthcare industry for selecting products and work practices that eliminate or reduce occupational and environmental hazards. The project recommends that dentists clean or replace mercury-containing pipes and plumbing fixtures, especially when new amalgam management practices are adopted, because trapped particles can continue to be a source of dissolved mercury in wastewater for years (Sustainable Hospitals, 1998).

Despite this concern, experience in Duluth, the Twin Cities, and Toronto seems to indicate that reductions of current releases through the use of amalgam separators can bring about immediate reductions in the amount of mercury reaching the POTW.

3.4 ACTION OF LINE CLEANERS

Some oxidizing line cleaners used to clean suction lines can mobilize mercury from amalgam and create a potential environmental hazard. Bleach (sodium hypochlorite) is one of the most notable line cleaners for mobilizing mercury. Figure 1 illustrates the effect of bleach and other line cleaners on the mobilization of mercury from amalgam (Stone et al., 1999).

However, many cleaners on the market do not mobilize mercury. Line cleaners that do not appear to mobilize mercury from amalgam particulate include the following (McManus, 2002):

All-In-One	Green and Clean	Super-Dent
E-Vac	MAXI-EVAC	Turbo Vac Line
Evacuation	ProE-Vac	Flush
Cleaner	Purevac	VacuCleanse
EZ-Zyme	Sani-Treet Plus	VAC-U-EZ
Gobble Plus	Stay-Clean	

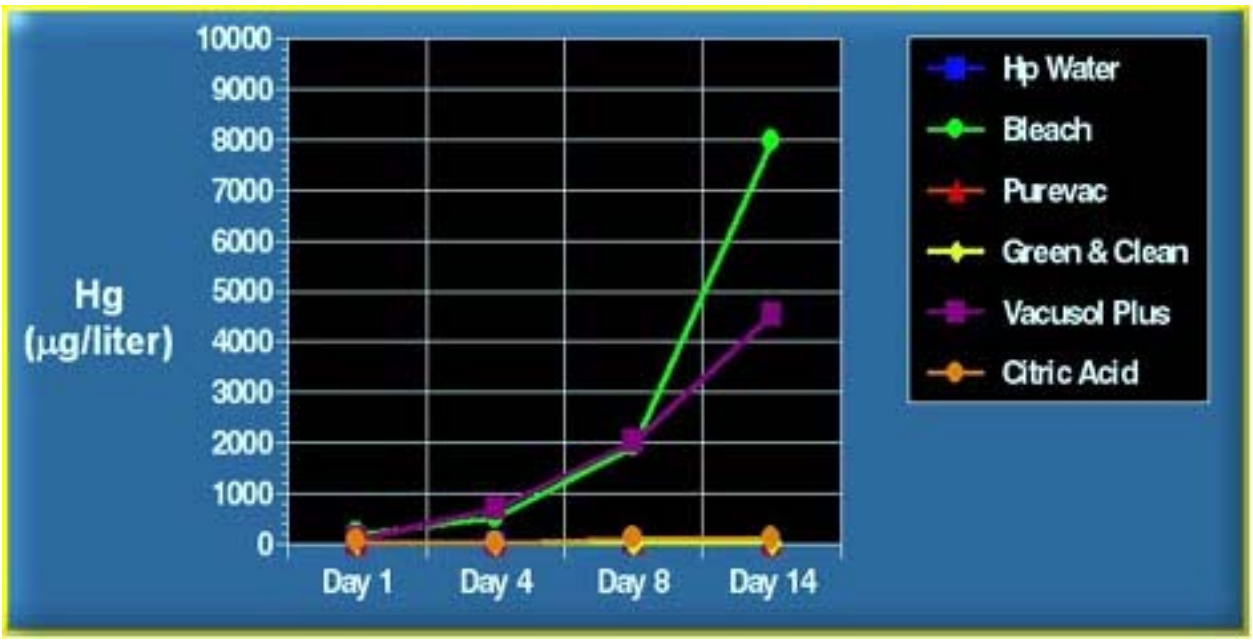

Figure 1. Effect of Some Oxidizing Line Cleaners on Mobilizing Mercury from Amalgam

3.5 DISPOSAL OF DENTAL MERCURY WASTE

A plan for the proper disposal of dental mercury waste can minimize the entry of mercury into the sewer system, medical waste, or ordinary trash. Dental mercury waste typically includes:

- Non-contact amalgam (scrap);
- Contact amalgam (e.g., extracted teeth containing amalgam);
- Amalgam/sludge captured by chair-side traps, vacuum pump filters, screens, and other devices;
- Used amalgam capsules that visibly contain mercury;
- Leaking or unusable amalgam capsules.

While the ADA has recommended that dental offices eliminate the use of bulk dental amalgam mercury, some dentists may continue to use bulk elemental mercury, also known as liquid or raw mercury, for the preparation of amalgam. The Ohio Dental Association, and other state and local agencies, have sponsored bulk mercury collection and recycling programs as incentives for dentists to recycle mercury-containing material.

In the United States, amalgam waste is considered hazardous waste only it fails a test that determines that it is likely to leach mercury in a landfill and (in most states), if it is not recycled. Amalgam wastes pass the toxicity characteristic leachate procedure (TCLP) test only about half of the time, so testing is required to determine if a particular amalgam waste is hazardous. In

most states, if amalgam waste is recycled, it is exempt from hazardous waste status (and considered a scrap metal or reclaimed commercial chemical product), eliminating the need for TCLP testing. In Ontario, all amalgam waste is considered hazardous.

Amalgam waste should not be disposed in the regular trash, with infectious waste (red bag), or down the drain. Amalgam-containing traps, filters, or screens should not be rinsed over drains or sinks. Amalgam that is collected in separators, chair-side traps, and vacuum filters should be sent to a licensed treatment, storage, disposal, or recycling (TSDR) facility. To facilitate recycling and disposal, POTWs or other local organizations may maintain lists of dental amalgam recycling companies. The State of Vermont, for instance, maintains a "Dental Amalgam Recycler/Processor" list that describes the costs, services provided, and other information about dental amalgam recyclers.

A lack of feasible options may be a barrier to the proper disposal of amalgam waste. For example, regulations requiring that service contractors carry certification to haul mercury-containing wastes might affect the cost and availability of dental amalgam recycling/disposal services in a locality. It may be costly for large waste haulers to pick up small amounts of dental waste from a dental office (Samek, 2002). Improvements in infrastructure, as well as outreach and education, may be needed to lower barriers and improve the rate of amalgam disposal and recycling. State or local agencies could introduce central collection depots that collect and recycle amalgam waste or, as described above, publish a list of amalgam recycling companies. Dentists may not be aware that amalgam waste can be shipped through a delivery service (e.g., FedEx or UPS) to recycling companies or that disposal of amalgam waste may be included in the price of replacement cartridges or amalgam separator service agreements.

Documentation of a dental practice's amalgam waste recycling and disposal activities may be a requirement of a mercury reduction program. Documentation may be obtained from the recycler or hazardous waste hauler.

4.0 CASE STUDIES

This section presents four case studies of dental mercury reduction programs. Each subsection describes the dental community (e.g., number of dentists in area), type of approach taken, the partners involved, the voluntary or regulatory nature of the program and related issues, budgetary and staff resources needed for the program, type of outreach conducted, results of the program (e.g., changes in mercury influent, effluent, or sludge levels), who installed separators, who collects amalgam waste, type of monitoring and enforcement required, and "next steps."

Note that there are other programs going on as well. The case studies presented here are just a sample. Descriptions and contact information about other programs are provided in Appendix C.

4.1 KING COUNTY, WASHINGTON

Background

The King County wastewater treatment system in the State of Washington serves a population of 1.4 million in the urban areas of King and Southern Snohomish Counties. Treatment plant effluent is discharged into Puget Sound. One hundred percent of King County's biosolids are recycled through land application to croplands and forests or composting. No biosolids are incinerated or landfilled. There is pressure to maintain high-quality biosolids which the public will accept for use in land application.

An estimated 1,500 to 1,800 dentists operate in King County's service area. Approximately 1,000 to 1,300 dentists handle amalgam fillings, and 85 percent belong to a local dental society. From 1995 to 2000, King County engaged in a voluntary program to manage dental waste. In 2001, King County announced a mandate for dentists to meet local sewer discharge limits.

Initial Approach

In 1991 King County conducted a study which concluded that the dental sector was a "significant and identifiable" source of mercury to the wastewater system. During 1991-1994, King County underwent a review process, examining available separation units and developing a set of considerations to evaluate separation units. King County published its findings in a guidebook for dentists.

In 1994, King County proposed a rule requiring dental offices to install amalgam separation equipment to control discharge of mercury-bearing amalgam. This first rule was vigorously resisted by the dental community at the local, state, and national levels. In 1995, King County postponed the rule and agreed to work with the dental community to meet mercury discharge limits voluntarily. The reasons for undertaking a voluntary program included:

- Intense resistance to regulation from organized dentistry;
- An offer by organized dentistry to collaborate on the issue;
- An immature supply infrastructure of amalgam separators and waste haulers (few choices, high prices);
- Ability to allow dentists to comply in a more leisurely fashion, without disrupting operations.

Voluntary Program 1995-2000

In 1995, the Seattle-King County Dental Society set up a standing committee to work with King County on a voluntary basis. These partners met several times a year and pursued a number of activities, including:

- developing a poster and a handbook for dentists,
- writing articles for a dental journal,

- mailing information to all members,
- co-sponsoring a free waste pick-up event,
- presenting a "Green Dentistry" session at two Pacific Northwest Dental Conferences.

The Seattle-King County Dental Society won a regional environmental achievement award for its efforts to educate member dentists concerning mercury in dental wastewater. The participation of the Washington State Dental Association (WSDA) was notably absent from these efforts.

Other efforts undertaken independently by King County include:

- advertisements seeking to educate dentists;
- outreach to dental supply houses;
- outreach to vocational/technical programs for dental assistants;
- cash rebates for purchase of amalgam separators (up to $500);
- technical assistance visits to dental offices; and
- promotion of dentists as "EnviroStars".

Figure 2 presents an example of King County's efforts to promote dentists as "EnviroStars."

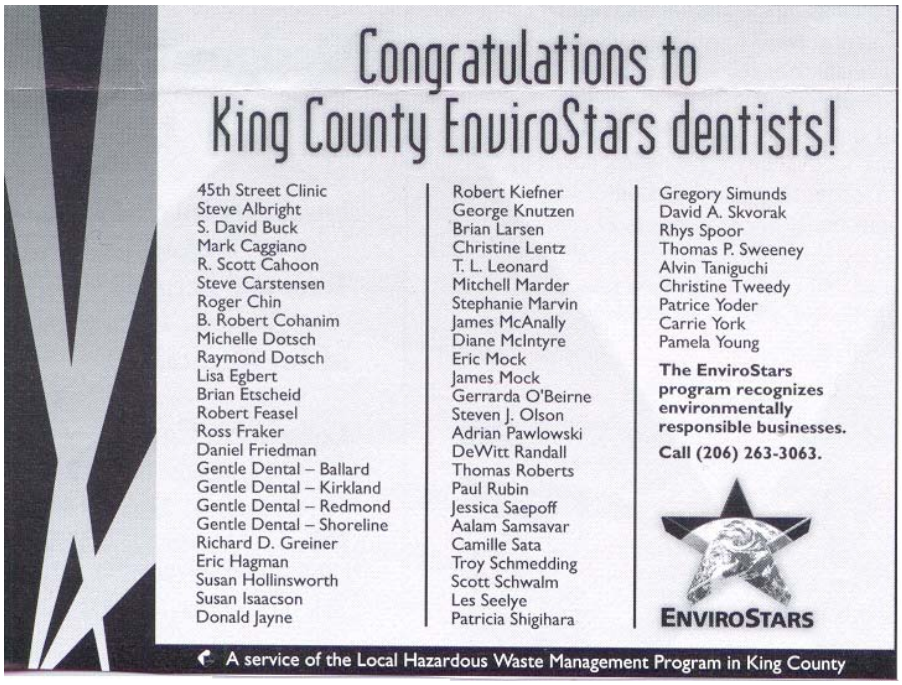

Figure 2. As Part of King County's Voluntary Program, Dentists Were Promoted As EnviroStars

Evaluation of the Voluntary Program

During the fall of 1999 and spring of 2000, King County performed an evaluation of its voluntary dental program. King County staff conducted random visits to 212 dental offices and collected data on the disposal of amalgam scrap, trap amalgam, pump filter sludge, and fixer. Information was also obtained by 1) contacting three manufacturers who sold amalgam separators in 1999 and 2000 and obtaining lists of dental offices that had purchased and installed separators; and 2) contacting waste haulers and mail-away firms and obtaining lists of dental offices with waste management contracts.

King County's evaluation showed that the six-year voluntary program achieved the following results:

- While the state dental association was not involved, the local dental society cooperated in the program.
- Less than half of dentists in the King County service area properly managed scrap amalgam.
- Less than 25 percent of dentists properly managed chair-side trap and pump filter waste.
- 25 dental offices installed amalgam separators (2.5 percent of those estimated to place and/or remove amalgam).
- About 10 percent of dental offices contracted with waste haulers and/or mail-away firms.
- Hundreds of pounds of mercury from dental amalgams were still being disposed of annually to garbage, 'red bag',[6] sewer, and 'unknown' places.

The costs for King County's voluntary program totaled over $250,000. During 1995-2001, an estimated $4,500 was spent on advertisements, $24,000 on the production of a poster and handbook, $65,000 on equipment rebates, $63,500 on field visits, and $100,000 for staff time.

Mandatory Program

In July 2001, King County informed dental offices within their service area that they must meet the local discharge limit for mercury of 0.2 parts per million (ppm). This limit applies to process water only; it does not include sanitary waste from the facility. The compliance deadline given for this mandate was July 1, 2003. New dental practices were required to be in compliance with the local limits when they opened. The enforcement protocol for violation of the 0.2 ppm limit consists of a notice of violation, a compliance schedule, and escalating penalties for non-compliance. In addition, the names of businesses that are fined are published in the *Seattle Times*.

King County advised dentists that to demonstrate compliance with the local limits they

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[6] "Red bag" refers to the container used for infectious waste. This waste is typically incinerated.

could:

- install and maintain a King County-approved amalgam separator; or
- apply for a wastewater discharge permit and show that they can consistently meet the limit without a separator.

Dental offices that place or remove amalgam no more than three days each year or belong to an "exempt" specialty, which includes orthodontics, periodontics, oral and maxillofacial surgery, radiology, oral pathology or oral medicine, and some endodontics and prosthodontics, need only comply with established BMPs for amalgam. These offices do not need to install an amalgam separator or apply for a permit. However, they need to be able to demonstrate that they place or remove amalgam three days or less each year. This may include keeping a record, with dates, of each procedure performed that involves dental amalgam.

King County provides a "Dental Wastewater Discharge Fact Sheet" for dentists and a list of approved amalgam separators. King County's fact sheet for dentists can be found at http://dnr.metrokc.gov/wlr/indwaste/dentists.htm. This fact sheet describes how to meet the wastewater discharge limit. The list of amalgam separators approved by King County is presented in Appendix D. All King County approved separators are certified as meeting or exceeding ISO-11143 as verified by an ISO testing laboratory.

Dental offices that have installed an amalgam separator that is not on the approved amalgam separator list maintained by King County, or that use another method of metals pretreatment, must obtain a permit. The cost of a King County dental wastewater discharge permit ranges from $130 to $1,335, renewable every five years (per 2003 fee schedule).

King County identified dental office practices that would result in dental offices meeting King County's discharge limit for mercury (0.2 ppm). King County offered to accept adherence to these practices as proof of compliance and not require an office to collect and analyze wastewater samples or to obtain a permit to dispose of wastewater into the sewer system. The dental office practices identified are the following:

1. Follow Best Management Practices for amalgam wastes

    - Keep amalgam out of sinks and never rinse amalgam waste down the drain.
    - Clean or replace chair-side traps on a regular schedule and properly dispose of amalgam waste.
    - Clean vacuum pump filters regularly, according to the manufacturer's recommendations, and properly dispose of amalgam waste.
    - Send amalgam wastes to a licensed TSDR (treatment, storage, disposal, or recycling facility). (King County provides a list of companies that transport waste to a TSDR.)
    - Maintain all disposal records on site for 3 years.

2. Install amalgam separators at each chair or in a central location where amalgam is removed or placed

- Separators must be approved by King County. (King County provides a fact sheet and comparison chart for King County approved amalgam separators.)
- Maintain the unit and dispose of wastes according to manufacturer's recommendations.
- Keep installation, maintenance, and disposal records on site for 3 years.

Through its web site, King County provides information about the regulation, how to comply, and who to contact (see http://dnr.metrokc.gov/wlr/indwaste/dentists.htm).

Beginning in 2001 and continuing through 2003, King County field staff, along with Public Health - Seattle, performed initial, non-regulatory inspections of dental offices to explain the dental office practices recommended for meeting the mercury discharge limit and to assist with implementation of these practices. (Public Health also inspected dental offices for its own program goals, including solid waste and hazardous waste issues.)

King County offered the following informational workshops periodically through April 2003:

- The King County Approved Amalgam Separator Workshop
- The King County Dental Practice Wastewater Discharge Permit Orientation
- The King County Dental Practice Wastewater Discharge Permit Workshop

The Seattle-King County Dental Association sponsored technology fairs in the fall of 2001 and 2002 to display amalgam separators (over 100 dentists attended these fairs).

King County continues to sponsor a Voucher Incentive Program that reimburses qualified businesses for the cost of purchasing and installing pollution prevention equipment like amalgam separators. The program reimburses half of what a business spends, up to a total of $500. This program discontinued offering vouchers for required amalgam separators in 2003.

Next Steps

After the July 1, 2003, compliance deadline, King County investigators began inspecting dental offices for compliance with the mercury discharge limit (0.2 ppm) and taking enforcement action with offices that are not in compliance.

Results

In response to King County's mandatory program, the Washington State Dental Association and their attorneys met with King County. WSDA was concerned with how to exempt those offices that do not need a separator. King County clarified that there were alternatives for demonstrating compliance (e.g., belonging to an 'exempt' specialty or applying for a permit and demonstrating continued compliance).

King County reports that dentists are complying with the mandate. While 25 dentists installed amalgam separators during the voluntary program (1995-2000), after the mandate,

between July and December 2001, 53 dental offices in King County's service area installed amalgam separators. Another 131 dental offices installed separators during the period from January to June 2002. During the period from July 1 to December 31, 2002, 286 dental offices installed separators, based on data reported by 7 manufacturers (not all manufacturers report data). As of December 2002, a total of 520 offices, out of 1,000 estimated to place or remove amalgam in King County's service area, had purchased amalgam separators. King County reports that, in general, dentists subject to the mandatory program are not complaining; they are asking how to buy separators (not why).

The mandated program is thought to have created a certainty within the profession about what is required by putting all dental offices on a "level playing field." The mandated program has also brought wider choices in technology and waste hauling options to the area, and prices have stabilized. No current data are available on mercury levels in wastewater influent and effluent. King County does track mercury levels in their biosolids but has not analyzed data for any trends which may be a result of King County's mandatory program.

Costs

The estimated cost for King County's mandatory program from startup in October 2000 through the end of 2001 was approximately $150,000. In 2002, approximately $145,000 (including overhead) was spent implementing the program. While initial inspections of dental offices were conducted in partnership with Public Health - Seattle from 2001 through 2003, King County's estimated share of these visits was about $35,000 to $50,000. In 2003, the cost for inspections and program maintenance was approximately $55,000. Depending on compliance rates, this figure is expected to remain the same for 2004. Ultimately, King County's goal is to decrease the cost of the program each year as it becomes more established and the time spent per inspection is reduced (Magnuson, 2003).

4.2 SEWER USE BY-LAW IN TORONTO, ONTARIO

The City of Toronto has an estimated 1,700 dental practices, including general and specialty practices. After examining regulations to prevent dental waste from entering the sewer, City Council decided to employ a discharge standard, rather than an equipment-based standard, with an information requirement. In July 2000, Toronto enacted a "Sewer Use By-law" that required the city's dental offices to:

- submit pollution prevention plans by December 31, 2001;
- install and maintain dental waste amalgam separators (type not specified) by January 1, 2002;
- limit mercury discharges to concentrations less than 0.01 mg/L (0.01 ppm), effective June 30, 2002 (which was extended to November 1, 2002).

A standard "pollution prevention plan" form was developed with requirements for each dental office to specify the type of separator installed; frequency of servicing; plumbing connections; handling of waste from the separator; procedures for amalgam preparation; and methods for storage, handling, and disposal of scrap amalgam.

The 0.01 mg/L limit is called a "total facility limit," which is applied at the property line rather than at the separator. Penalties for non-compliance range from $10,000 to $100,000 a day.

Monitoring

As a method of monitoring compliance, the by-law requires dentists to submit a four-page information form every two years. Toronto City Council also approved the hiring of four new enforcement officers to monitor compliance with the by-law. Inspections at every dental office in Toronto were expected to be completed by November 2003. A sampling protocol has been developed to sample wastewater after the vacuum pump.

Results

Some equipment manufacturers have modified their separators and offered a guarantee to meet the discharge limit or to pay the fine. In some cases the discharge limit may have delayed installation of separator equipment because dentists were not certain that the equipment would be able to meet the limit.

As of January 2003, approximately 1,200 dentists in Toronto had installed separators. Preliminary data collected by the City of Toronto indicated that mercury levels in Toronto's wastewater treatment plants (biosolids) decreased by 40 percent to 70 percent between 2001 and 2002 (Krauel, 2002). This reduction coincides with implementation of the dental regulations, but it is not certain whether other factors also contributed to this decrease.

Further Issues

Additional issues that the City of Toronto has identified for further potential action include:

- historic contamination of amalgam in plumbing and drains, and the effectiveness of remediation strategies;
- the ultimate disposal of scrap plumbing from dental offices, which is likely to contain waste amalgam; and
- concerns expressed on the part of dentists about their ability to comply with the numerical limit and a possible preference for the clarity of a technology standard.

4.3 WESTERN LAKE SUPERIOR SANITARY DISTRICT, DULUTH, MINNESOTA

Background

The Western Lake Superior Sanitary District (WLSSD), located in Duluth, Minnesota, is a regional wastewater treatment plant designed to treat an average daily flow of 43 million gallons of wastewater. WLSSD collects wastewater from cities and industries covering a 50-mile network of interceptor sewers. WLSSD produces biosolids that are used for land application. Since 1985, WLSSD has worked with local businesses to monitor industrial discharges, and major industrial contributors are regulated under the Industrial Pretreatment Program through a series of routine monitoring, self-monitoring and reporting, and on-site inspections. WLSSD also operates a nationally recognized pollution prevention program.

Western Lake Superior Dental Waste Management Program

In 1992, WLSSD, in cooperation the local dental society, began the Western Lake Superior Dental Waste Management Program, a voluntary program aimed at reducing the amount of amalgam waste being disposed into the sewer by approximately 50 dental practices in the WLSSD service area. WLSSD conducted a survey of waste management practices among area dentists. A cooperative environmental team was formed between WLSSD and the Northeast District Dental Society. An informational brochure on managing special wastes from dental practices was developed. Also, a reduction of mercury at a major dental facility was achieved by identifying and abandoning the practice of cleaning out traps by washing down the drain.

In 1995, an audit of 10 dental practices showed that much amalgam was being disposed in incinerated waste streams (infectious waste and solid waste). WLSSD developed a program to increase the amount of amalgam being recycled (going to mercury recovery facilities). WLSSD developed an educational program that trained staff on how to recycle amalgam waste. The program included training at all dental offices in WLSSD's service area, presentations at local dental society meetings, presentations at dental assistant and hygienist schools, continuing education classes for dentists and staff, and written materials. Some presentations were given by dentists and dental assistants (e.g., to demonstrate how to dispose of amalgam waste).

In 1996, WLSSD began testing three different amalgam capture devices. In 2000, WLSSD installed 11 devices in the area's largest dental building. In 2001, WLSSD and the local dental society received a local grant to purchase additional devices. As a result, another 31 dental practices had devices installed by WLSSD, for a total 45 practices with amalgam capture devices. All devices were ISO-certified. Seven practices in WLSSD's service area remain without amalgam capture devices. One practice refused to install the equipment, three have not been contacted, and three need some re-design of vacuum systems before equipment could be installed.

Dental offices may dispose of dental amalgam and other mercury-bearing waste at low-cost through WLSSD's "Clean Shop" Program. Clean Shop is designed to help small businesses and other organizations find responsible and cost-effective ways to dispose of very

small quantities of hazardous waste. Participants can dispose of up to 660 pounds of hazardous waste annually through the program at minimal cost.

Program Costs

Over the 10 year period 1992-2002, approximately 10 percent of a full-time staff member was devoted to the dental waste management project. About $20,000 of grant money was used to purchase equipment at $500/unit (all ISO-certified). Some equipment was also donated by the equipment manufacturers. About $100,000 of national grants (from USEPA Great Lakes National Program Office and the Great Lakes Protection Fund) was used for the development of "Best Management Practices" materials locally and for the Great Lakes states dental associations.

Results

The Western Lake Superior Dental Waste Management Program has been a voluntary, cooperative effort between WLSSD and the local dental society. A number of factors appear to have contributed to the success of this program:

- the leadership of the local dental society;
- peer-to-peer interaction with area dentists, including explaining the need to properly manage amalgam waste to prevent mercury from entering the environment and demonstrating the proper methods for doing this;
- incentives to install amalgam capture equipment (the devices were purchased through grants, and WLSSD performed the installations);
- a discount waste disposal option (through WLSSD's "Clean Shop" Program); and
- the smaller community (~50 dental practices) allowed a collaborative relationship to be built.

As a result of the Western Lake Superior Dental Waste Management Program, approximately 100 pounds of raw mercury (no longer in use) were collected from dentists in the WLSSD service area. Dentists who collect excess mix, chair-side trap amalgam, vacuum pump trap sludge, and separator sludge are estimated to recycle 1-2 pounds of mercury per dentist per year.

In addition to these program results, levels of mercury reaching WLSSD have declined steadily. Many other factors, however, may have contributed to this decline. Figure 3 shows the declining trend in the levels of mercury in WLSSD's influent (pounds per day) from 1993 to 2002. Figure 4 shows the declining trend in the levels of mercury in WLSSD's sludge, and the times when separators were installed in dental offices. Figure 5 shows the decline in mercury levels in WLSSD effluent after amalgam separators were installed in 2000 and 2001. However, the relationship between the dental mercury reduction program and the changes in influent, effluent and sludge is difficult to determine. Other mercury reduction efforts took place during this period, and mercury concentrations in effluent may have dropped partly as a result of operational changes at the plant, including closure of an incinerator.

Next Steps

WLSSD would like to involve amalgam vendors on a statewide basis in Minnesota. WLSSD has obtained letters from dental offices that describe their experiences in installing amalgam capture equipment. These letters explain that installation of equipment that reduces the amount of mercury released into the sewer does not disrupt a practice's operations and, thus, are intended to help convince other dental offices to install such equipment.

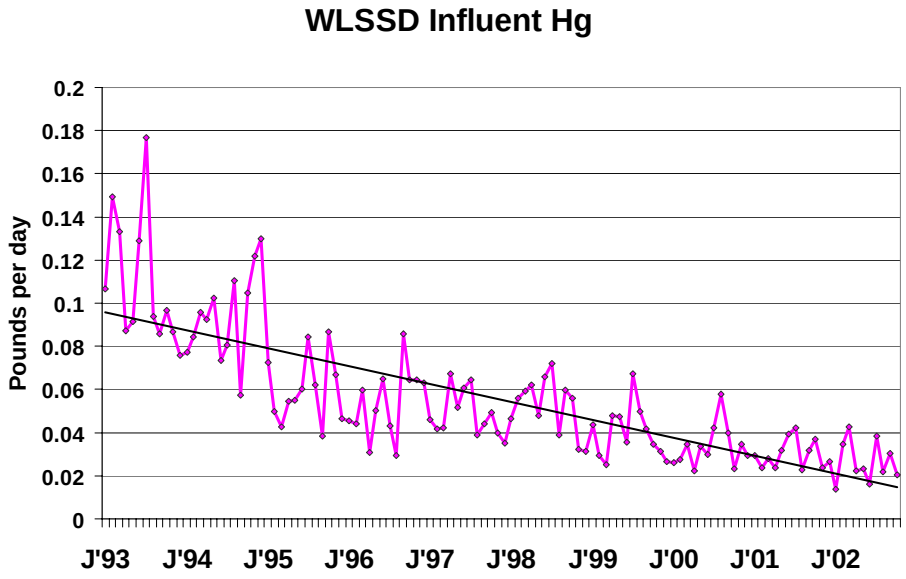

Figure 3. Mercury Levels in WLSSD Influent (pounds per day) from 1993 to 2002 (Source: Tuominen, 2002)

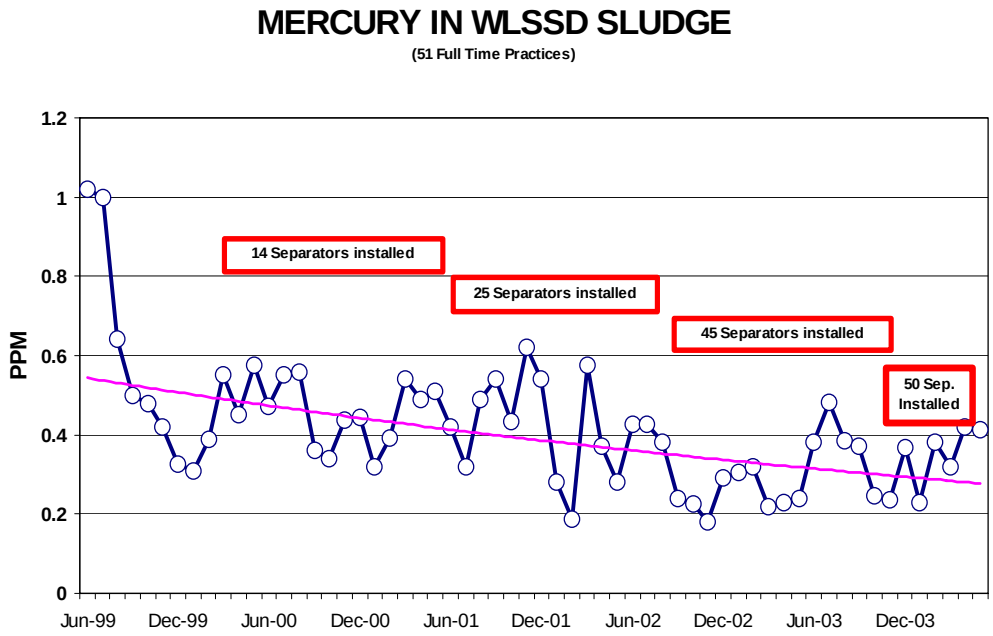

Figure 4. Mercury Levels in WLSSD Sludge (PPM dry) from 1999 to 2003 (Source: Tuominen, 2004)

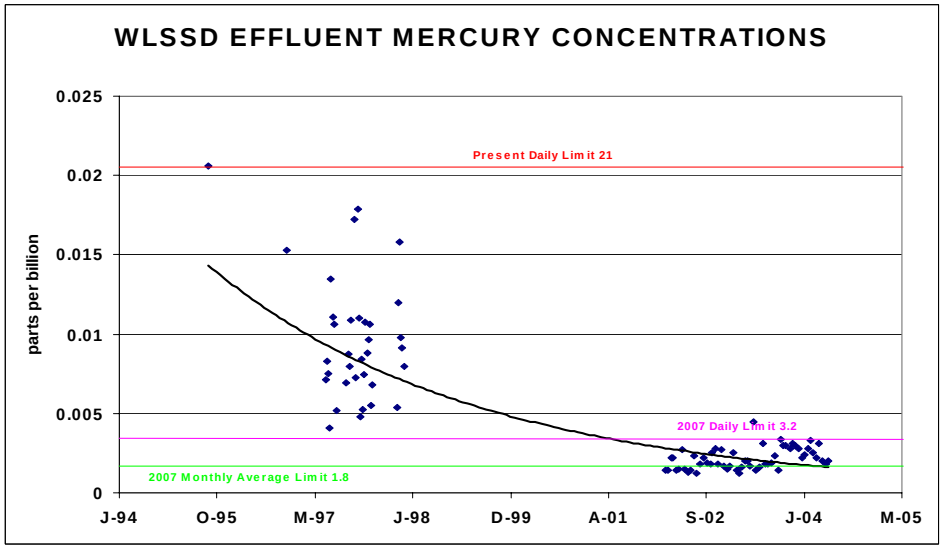

Figure 5. Mercury Levels in WLSSD Effluent (parts per billion) from 1994 to 2004 (Source: Tuominen, 2004)– All measurements using Method 1631

4.4 NORTHEAST OHIO REGIONAL SEWER DISTRICT

Background

The Northeast Ohio Regional Sewer District (NEORSD) serves most of Greater Cleveland. NEORSD is governed by a board of trustees appointed by city, county, and suburban governments. Operation is funded by local sewer use charges. NEORSD owns and operates combined-sewer overflow (CSO) facilities, major intercepting sewers, and three wastewater treatment plants. It is the pretreatment control authority in its service area.

In 1997, Ohio EPA revised the Ohio water quality rules to be consistent with USEPA's 1995 Great Lakes Water Quality Guidance. The revised rules apply to the entire Lake Erie drainage basin in Ohio. Mercury is one of 22 "Bioaccumulative Chemicals of Concern" identified in the Great Lakes Water Quality Guidance with water quality criteria of 1.8 ng/L for protection of human health and 1.3 ng/L for protection of fish-eating wildlife.

Evaluating data obtained using the newer, sensitive EPA Method 1631, the Ohio EPA found mercury concentrations exceeding 1.3 ng/L (the Great Lakes water quality criterion for protection of fish-eating wildlife) in 98 percent of treated wastewater samples. An *Ohio EPA Economic Impact Assessment* reported that end-of-pipe removal of mercury to less than 12 ng/L would cost "$10 to $100 million per pound of mercury removed" and "… would result in substantial and widespread social and economic impact." As a result of this assessment, the Ohio EPA adopted into its rules a variance from water quality-based effluent limits for mercury. One of the requirements for an NPDES[7] permittee who is granted the variance is implementation of a pollutant minimization program (PMP) for mercury.

In anticipation of the PMP requirement, NEORSD assisted in planning an Ohio Dental Association (ODA) statewide bulk mercury collection and recycling program in 1997. In 1998, NEORSD served as a drop-off site, collecting 103 pounds of bulk mercury for the ODA program. In May 1998, NEORSD conducted a mercury regulation/disposal seminar for dentists, with cooperation from ODA and the Greater Cleveland Dental Society. In September 1998, NEORSD conducted a seminar at the ODA Annual Conference in Columbus, Ohio, and in Fall 1998, NEORSD authored an article on mercury regulation/disposal, which was published in the Greater Cleveland Dental Society Bulletin.

In 2000, NEORSD was issued an NPDES permit that required the establishment of a local pretreatment limit to prevent levels of mercury passing through the NEORSD treatment plant from exceeding 1.3 ng/L. NEORSD estimated the relative contributions of sources of mercury to

[7]The National Pollutant Discharge Elimination System (NPDES) permit program was established by USEPA, as directed by the Clean Water Act, to control point source discharges. The NPDES permit program defines the conditions and effluent limitations under which a facility may make a discharge into the waters of the United States. Monitoring requirements may also be specified in an NPDES permit.

its system. Due to mercury contributions from domestic/background sources and a safety factor, a numeric local limit for mercury was calculated to be a negative value. Dental offices were estimated to be the largest class of sources of mercury, contributing 41 percent of the total mercury influent to NEORSD wastewater treatment plants.

Also in 2000, Ohio EPA issued pretreatment guidance on the use of Best Management Practices (BMPs) as industrial local pretreatment limits. Ohio EPA advised that "… local limits … may be numeric or narrative … ." NEORSD chose to adopt a narrative limit for mercury.

Administrative Orders

In 2002, NEORSD set the following narrative local limit for mercury:

> *"All industrial [i.e., non-residential] users that are sources of mercury shall implement best management practices (BMPs) … to minimize discharges of mercury to the System. Certain industrial users and/or classes of industrial users identified by the District as significant … shall comply with District-issued administrative orders requiring submittal and implementation of BMP plans … ."*

In cooperation with representatives of ODA and the Greater Cleveland Dental Society, NEORSD developed BMP plans for dentists in the NEORSD service area. In February 2002, NEORSD held a meeting with ODA and leaders of the Greater Cleveland Dental Society to inform them of its intent to issue administrative orders to area dentists. A list of area dentists was obtained from the Ohio Dental Board. In March 2002, NEORSD began a series of free seminars for dentists, with continuing education credits provided by the Greater Cleveland Dental Society.

By April 1, 2002, NEORSD sent administrative orders by certified mail to 1,100 service area dentists. These orders required submission of a BMP plan and implementation at each office no later than December 31, 2002. The administrative orders included both mandatory and recommended BMPs. Appendix B presents the administrative order issued to dental practitioners and a document provided to dental offices that, when completed, could serve as the required BMP plan. The goal of the BMP plan is to maintain wastewater effluent total mercury concentrations below 0.2 nanograms per liter (parts per trillion).

Table 3 summarizes the mandatory BMPs developed by NEORSD for dental mercury discharge minimization. Table 4 summarizes NEORSD's recommended BMPs for dental mercury discharge minimization. Installation of amalgam separators is a recommended BMP.

In addition to a BMP plan, NEORSD requires each dental office to submit an annual report describing the implementation status of its BMP plan, updates to the plan, an updated inventory of potential sources of mercury; copies of any correspondence that indicates compliance (e.g., waste hauling documentation), and any available information on wastewater monitoring results or the effectiveness of the BMP plan. The first annual reports to NEORSD were due by March 1, 2003.

Program Costs

Through 2002, several NEORSD personnel have been involved in the dental mercury program to constantly varying degrees as parts of their jobs in the Water Quality & Industrial Surveillance department. Currently, no staff are fully devoted to mercury issues. NEORSD's estimate of the total cost of staff salaries and benefits attributable to the dental mercury program during 2002 is approximately $115,000. Estimates of the percent of time that NEORSD staff have contributed to the program during 2002 are the following: one superintendent (10%), one specialist (50%), two supervisors (10%, 5%), and four investigators (85%, 6%, 4%, 2%). Costs for the program to date are expected to change as the program begins to be more fully implemented. NEORSD had planned to hire two full-time staff devoted to mercury issues in 2003 (Linn, 2003).

Once the two-person mercury crew is in place, NEORSD estimates that the total cost of salaries and benefits attributable to the dental mercury program will be approximately $125,000 per year. Estimates of the percent of time NEORSD staff will contribute to the program are as follows: one manager (5%), one specialist (30%), one supervisor (10%), and two investigators (80%, 80%). In 2002, the total cost to NEORSD of sampling and analysis for mercury to comply with NPDES permit requirements and to support the mercury program was approximately $65,000. Costs associated with sampling and analysis for mercury are expected to increase as the NEORSD mercury program intensifies its efforts in the future (Linn, 2003).

Next Steps

NEORSD anticipates that the two-person mercury crew will each devote 80 percent of their time to the dental mercury program. These staff will be responsible for performing field inspections to verify BMP plan implementation at dental offices, hospitals, and other dischargers that, as significant sources of mercury in the sewer system, have been issued administrative orders. These staff will also be responsible for identifying additional significant sources of mercury and for other mercury-related projects such as sampling to quantify mercury levels and public education on mercury use reduction.

Depending on the results of the program in reducing mercury effluent levels, NEORSD will evaluate the potential need for additional reductions. If additional reductions are necessary, NEORSD may consider issuing new administrative orders that make mandatory some of the measures that are currently only recommended.

Table 3. NEORSD Mandatory Best Management Practices for Dental Mercury Discharge Minimization

NEORSD Mandatory BMPs for Dental Mercury Discharge Minimization
■ Eliminate all use of bulk elemental mercury. ■ Use only precapsulated dental amalgam. ■ Any bulk mercury must be recycled or hauled away as hazardous waste. ■ Bulk mercury must never be placed into the regular trash, in with infectious waste, or down the drain. ■ Limit amount of amalgam used to smallest appropriate size for each restoration. ■ Keep a variety of amalgam capsule sizes on hand. ■ Change or clean chair-side amalgam traps frequently. ■ Flush the vacuum system before changing the trap. ■ Change vacuum pump filters and screens at least once per month or as directed by the manufacturer. ■ All amalgam waste[a] must either be recycled (preferable) or hauled away as hazardous waste (acceptable). ■ Amalgam waste must never be placed in regular trash, placed in infectious waste, or flushed down the drain. ■ Traps, filters, or screens must never be rinsed over drains or sinks. ■ Store amalgam waste in covered, segregated, and clearly labeled airtight plastic containers or as directed by the recycler. ■ Maintain a log of amalgam waste generation and recycling/disposal. ■ Documentation must be obtained from recycler or waste hauler, kept on file, and made available to NEORSD upon request. ■ Train all staff that handles or may handle mercury-containing material in its proper use and disposal.

[a] NEORSD defined amalgam waste as contact amalgam (e.g., extracted teeth containing amalgam); amalgam/sludge captured by chair-side traps, vacuum pump filters, screens, etc.; non-contact amalgam (scrap); used capsules visibly containing mercury; or leaking or unusable capsules.

Table 4. NEORSD Recommended Best Management Practices for Dental Mercury Discharge Minimization

NEORSD Recommended BMPs for Dental Mercury Discharge Minimization
■ Use, when appropriate, mercury-free alternatives to amalgam: - Gold - Composite resins - Ceramic - Porcelain - Polymers - Glass ionomer, etc.
■ Clean or replace under-sink traps and sumps.
■ Take care to avoid spillage of contents from plumbing parts.
■ Remove sludge that may contain mercury, and have it recycled or hauled away as hazardous waste.
■ Use disposable chair-side amalgam traps in cuspidor and vacuum system.
■ Have used disposable traps recycled or hauled away as hazardous waste.
■ Maximize use of the high-speed suction system.
■ Remove wet cuspidors from service during amalgam restoration/extraction procedures.
■ Avoid using sodium hypochlorite (bleach) to disinfect vacuum lines.
■ Be knowledgeable about amalgam separators employing enhanced sedimentation, fine particle filtration, and/or other technologies.
■ Install and properly maintain such technologies that are determined to be feasible and effective.

5.0 ESTABLISHING A MERCURY REDUCTION PROGRAM

As illustrated by the case studies presented in the previous chapter, a number of different approaches have been employed in dental mercury reduction programs. In the United States, there are no national regulations imposing mercury controls on dental offices, so state and local governments are free to determine the best program for their local circumstances, within the requirements set by discharge permits and pollutant minimization plans, in the case of sewage treatment authorities. In Canada, provinces are committed to the use of best management practices to achieve a 95 percent national reduction in mercury releases from dental amalgam waste discharges to the environment, by 2005, from a baseline of 2000. Within this framework, provincial and local governments in Canada have considerable freedom to choose the approach they will take.

This section discusses factors that state/provincial and local governments should consider in establishing a mercury reduction program, whether voluntary or regulatory.

5.1 LEADERSHIP AND RESOURCES

There are different options for leadership of a mercury reduction program, including different levels of local government or local POTWs. Case studies have shown that successful mercury reduction programs can be implemented at the local level by involving the dental community, through professional dentistry organizations or individual dental practices. The local dental society and the local POTW can be powerful partners in a collaborative effort to reduce mercury from dental office wastewater.

Incentives may be offered to motivate dentists to participate. Free installation, discount waste collection, technical assistance, equipment rebates, and free seminars with continuing education credits are some of the incentives that may be used to encourage dentists to participate in a mercury reduction program.

Costs of a mercury reduction program can vary. Costs include staff time for operation of a program, including field visits, web site maintenance, educational presentations, compliance and evaluation, as well as costs of outreach materials, incentives (e.g., rebates for equipment installed), and wastewater sampling. Discounts may be available from equipment manufacturers in lieu of rebates offered by a POTW or municipality. Local or regional grants may offer opportunities to help offset some costs.

In Canada, the federal and provincial governments have also provided leadership through the Canada Wide Standards process. A national standard for dental amalgam has been established requiring that dentists reduce environmental releases by 95 percent by 2005. This standard is expected to be achieved by the collection of dental amalgam waste through the installation of an advanced amalgam separator and the adoption of BMPs to ensure the appropriate management of the collected amalgam waste. In addition, the Professional licensing body in Ontario has established a requirement to install an amalgam separator as a regulatory standard in order to be licensed to practice dentistry in the province.

5.2 OUTREACH

A successful program will most likely involve some type of outreach to the dental community. State and local dental societies can be useful partners in such outreach. The outreach may serve multiple purposes. Outreach may seek to educate or inform dentists, to request their involvement, to promote a reduction program, or to share results. Potential methods of outreach include:

- advertisements
- educational curricula, letters, and handbooks
- presentations at dental assistant/hygienist schools or dental society meetings
- seminars or workshops
- technical assistance
- technology fairs
- visits to dental offices
- web sites

Outreach to dentists can be facilitated by the fact that the American Dental Association has taken the position that all dental offices in the United States should voluntarily follow ADA BMPs (see Appendix A). Where local environmental conditions warrant going beyond voluntary BMPs, ADA believes that a graduated approach is preferable, whereby additional steps (such as bulk mercury and scrap amalgam recycling programs, mandatory BMPs, etc.) are undertaken and given a chance to work before moving on to more burdensome measures. The ADA believes that mandatory dental office controls should be considered only when they will make an environmentally significant difference and when local limits are being exceeded.

Educational programs for dentists and dental assistants can be a useful outreach tool. The Pollution Prevention Institute at Kansas State University has undertaken a mercury educational effort. Through this effort, an amalgam waste fact sheet has been developed and a dental waste education curriculum has been presented to dental schools and dental assistance programs (Larson, 2002). For more information about KSU's program, visit www.sbeap.org.

Some initial sensitivity and defensiveness from the dental sector can be expected. However, case studies have shown that dentists can be willing partners once they understand the issue. King County's initial efforts to gain the participation of dentists in reduction actions were disappointing; however, these efforts took place in a period when many dentists had little familiarity with environmental concerns about mercury. Subsequent efforts, including in Duluth, Witchita, and Milwaukee, have been more successful in getting cooperation with dentists. Educational materials may be best accepted by dentists when they include scientific facts to explain the problem with mercury in dental office wastewater. Thus, outreach materials should aim to educate dentists on the wastewater issue, about which they may be unaware, rather than place blame. Outreach materials may also need to recognize that, while it must be properly managed, dental amalgam remains a valuable restorative material to the practicing dentist.

Sensitive outreach may also facilitate the cooperation of the dental community, whether the program is a voluntary or regulatory effort. Language should be non-judgmental. For example, materials might use the term "non-compliant" instead of "illegal" to describe the manner in which dental wastes are being disposed. Care should be taken to recognize specialty and other practices (orthodontics, periodontics, oral surgery, maxillo-facial, some endodontics and prosthodontics) whose mercury discharge levels are not expected to be significant.

5.3 REGULATORY VS. VOLUNTARY APPROACH

In some areas, the problem of mercury in dental office wastewater can be addressed through voluntary, collaborative efforts. In other areas, particularly where significant reductions in mercury discharges by a sewage treatment plant are required for compliance with permit requirements, a regulatory approach may be needed to ensure compliance by the dental community. In some cases, the *potential* for regulation may be sufficient to induce effective, voluntary action, although a threatening approach could engender resistance from dentists.

The voluntary approach may be easier to implement than regulation. Voluntary efforts tend to sustain an attitude of "we're in it together" and avoid an "us vs. them" relationship between the dental community and the regulating agency, which could hinder cooperation or

cause ill-will in a community. A voluntary approach may require dental office visits, outreach materials, and/or technical assistance that incur significant costs. If the goal is to have dentists voluntarily install amalgam separation equipment, it may be necessary to secure grants or public funds to offset or defray the cost of equipment. However, a voluntary approach avoids the regulatory process of deciding upon an appropriate standard, writing the regulation, issuing the mandate, and monitoring and enforcing compliance.

Even when the goal is ambitious, for instance to encourage dentists to adopt separators, voluntary programs can work, particularly if there is potential for regulation in the absence of successful voluntary efforts. The Minnesota Dental Association (MDA) has begun to implement a statewide voluntary mercury reduction program, with assistance from the Metropolitan Council of Environmental Services (MCES). While this program is voluntary, it has regulatory backing, because of the potential that MCES and other sewage treatment authorities in Minnesota might impose regulations in the absence of a successful voluntary program. The MDA, through this proactive voluntary program, encourages dentists to use best management practices for managing mercury wastes, and to install amalgam separators by February 2005. To date, two-thirds of Minnesota dentists have committed to participate in the program, and 15 percent have installed separators. For more information about this program, see http://www.mndental.org/professionals/amalgam_recovery/.

The regulatory approach often requires numerical data as a basis of support for a statute that imposes a cost upon society. The level of mercury in dental wastewater is highly variable, changing daily within each office. As a result, obtaining consistent numerical data can be difficult. The regulatory approach also requires terms and processes to be defined. Regulation can also be expensive for both the regulating agency and the regulated audience. On the other hand, the regulatory approach presents a clear requirement for all affected dental offices, typically with a definite time frame for achieving compliance, and a means for measuring outcomes. In some cases, a mandate may be less costly than a protracted period of attempts to obtain cooperation from the dental community. Regulation may also result in a more competitive market for mercury removal equipment, bringing better products and services, wider choices, and lower prices.

If a regulatory approach is chosen, regulators should be sure to provide exemptions for dental specialties that do not handle amalgam.

A regulation may set a narrative standard (e.g., a requirement that dentists use BMPs, or install control technologies) or a numeric limit (on mercury concentration in wastewater discharges). There are advantages and disadvantages to each type of requirement. The cost of each approach will vary depending on the requirements that are included. Each approach will likely require outreach to educate dentists and monitoring of compliance with the requirement(s).

A narrative standard may require that dentists use BMPs to minimize releases of dental mercury, and the use and maintenance of amalgam separators could be a required BMP. This may be the easiest type of requirement for a dental office to comply with, and compliance can be monitored through inspections, reports, or other documentation.

One advantage of a narrative standard is that compliance is straightforward and easy to monitor (a practice must install the technology or document use of the BMPs). While it may be uncertain whether the required practices and technologies will sufficiently lower mercury levels in the wastewater, if separators are required, this uncertainty can be partly alleviated by requiring that the separator meet the ISO 11143 efficiency requirement and that certain maintenance procedures are performed. A narrative standard does not mean that a particular device will be required, only that a device that has been proven effective will be required.

Setting a numerical discharge limit might seem appealing, since it would avoid the need to specify technologies or practices. However, this approach requires determination of an appropriate limit and, once the regulation is in effect, testing to ensure that discharges are below the limit. A numerical limit may incur significant costs for a dental practice to be able to meet the limit and to perform testing. Morever, since dental office wastewater is highly heterogeneous, it is extremely difficult to collect a representative sample using traditional composite sampling methods. For these reasons, dentists are likely to prefer narrative standards to a numerical discharge limit, and regulatory authorities are likely to find a technology or narrative standard easier to implement.

5.4 MONITORING AND ENFORCEMENT

While monitoring and enforcement are typically associated with a regulatory approach, a voluntary program will probably include some type of follow-up with dental offices as well, for example, to ensure that filters are being cleaned properly and that waste materials are being disposed in an appropriate manner. Participation and results of both voluntary and regulatory programs may be monitored through surveys, visits to dental offices, purchase information from amalgam separator vendors (information on offices that have installed units), information from waste management firms (information on offices that have amalgam waste hauled away), mandatory reports from dental offices, sludge measurements, and tests of discharge and influent/effluent levels.

For regulatory programs, the need for monitoring and enforcement will vary with the type of mandate issued, as discussed in the preceding section. Monitoring compliance with a technology standard or narrative limit might be accomplished through office visits or reporting requirements. Monitoring compliance with a numerical limit will likely involve testing dental office discharges. Sampling may be difficult if it includes collecting a sample under vacuum conditions and obtaining a representative sample of a heterogeneous waste. Digestion and analytical methods may be difficult when amalgam is part of the waste. In addition, a number of variables are associated with testing wastewater discharges, such as when the test should be performed (e.g., on a typical day or while amalgam is being handled), where the test should be performed (e.g., at the vacuum filter or at the property line), and how often the test should be performed (e.g., one time or once a month and the results averaged over the year).

Regulatory enforcement protocols may include a notice of violation, a mandated compliance schedule, and escalating penalties for continued non-compliance. Compliance with a voluntary program might be encouraged through correspondence or an office visit to determine the reason for non-participation and offer technical assistance to help dentists meet the objectives

of the program.

5.5 PRACTICAL ISSUES

The decision to install amalgam separator equipment involves many practical issues from a dentist's point of view. Consideration of these factors can affect the success of a mercury reduction program. Several issues are presented below, as factors to consider, but are not described at length. (Much of the information presented in this section is from McManus, 2002, and McManus and Fan).

Selection Factors

There are several factors to consider in selecting amalgam separator equipment, including:

- Cost, including installation, operation, maintenance, and amalgam waste disposal
- Whether to purchase or lease a unit
- Installation considerations (e.g., available space)
- Discounting of future costs
- Ease of installation
- Ease of operation
- Field performance (beyond ISO 11143)
- Recycling options
- Frequency/ease of maintenance
- Volume of wastewater flow

Installation

Several installation factors should be considered before the type and location of a separator are chosen. If office space is leased, tenant-landlord issues may affect the type and location of a separator that can be installed. For example, a gravity unit would require the use of basement space and access to water and sewer lines.

A common question of dental offices is who should install a separator. A licensed plumber is recommended. A licensed electrician may also be needed for systems utilizing pumps (depending upon the application). Installation may be arranged by the equipment manufacturer/distributor (depending upon local code requirements, and lease requirements).

Table 5 presents a checklist of installation factors for dentists to consider in selecting and installing amalgam separator equipment.

Issues Encountered with Various Field Installations

Issues that have been encountered during the installation of amalgam removal equipment include:

- Insufficient space or access to preferred installation location (e.g., basement vs. office level, access to centralized plumbing locations);
- Compatibility with, and condition of, existing piping;
- Tenant/landlord issues;
- Local plumbing code interpretations;
- Impacts on vacuum system operation;
- Warranty impacts (for existing in-situ equipment);
- Maintenance and repair responsibilities;
- Multi-chair installation requirements.

Space and Utility Requirements

The physical dimensions of a typical amalgam separator are 9-28 inches in height, 3-12 inches in width/diameter, and 8-24 inches in length. The preferred location for gravity separators is below grade, if possible. The preferred location for separators upstream of the vacuum system is as close as possible to the vacuum pump (to minimize vacuum impacts). Many separators do not require electric power. Some may need 110 volts of electricity for pumping wastewater.

Recycling and Disposal

There are a wide variety of amalgam handling/disposal techniques and options for recycling. Spent amalgam can be a waste or a resource, if recycled. Classification and handling requirements for amalgam wastes vary by state.

Maintenance and Cleaning

Equipment maintenance and cleaning procedures are specified by the manufacturer, and are important factors to the efficiency and effectiveness of amalgam separator systems. The frequency of maintenance needs to be monitored on the basis of individual office activities (e.g., number of amalgam restorations removed daily and use of polishing compound - “prophy paste” by hygienists). Some units recommend daily application of cleansers. Some systems require the use of special cleaning products. Training may be needed for dental office staff to ensure that proper maintenance and cleaning procedures are followed. Records of maintenance may need to be kept as a requirement of a program.

Table 5. Installation Factors Checklist for Dentists

Installation Factors Checklist for Dentists
✓ Total # of operatories/chairs? ✓ How many amalgam fillings are placed or removed per day? ✓ How many days a week does your facility operate? ✓ Other dental practices located within your building? - Number and type? ✓ Is dental office space leased or owned? - If leased, what terms are included for utilities maintenance? ✓ Are you responsible for the following activities in your building: - Equipment servicing? - Water/sewer/utilities? - Amalgam collection/recycling? ✓ Does the separator require electrical power? ✓ Is there access to 110V electrical power at proposed location? ✓ Is there access to a floor drain or other plumbing to hook into? ✓ Do you operate wet/dry cuspidors? ✓ Can the separator be installed to operate under vacuum? (To operate without being under vacuum, the separator must be installed below the air/water separator tank check valve.) - If not, it may need to be installed 1) after the liquid-ring pump (If after liquid-ring pump, is an air/water separator necessary? An air/water separator routes the air to an outside vent, rather than into the drain line.) Or 2) at wastewater outlet of air/water separator of turbine (dry) vacuum system. ✓ Do you operate a wet or dry vacuum system? Could an amalgam separator handle the flow of water from a wet system, and not exceed its ISO-rated maximum flow? ✓ Is vacuum system dedicated to your office? - Is this system under warranty? If yes, is the warranty voided by third-party installations? ✓ Is vacuum system located at office level or in the basement? ✓ Available space adjacent to vacuum system? ✓ Access to chair-side drain line and sewer connection location? - Is it a single connection or combined connection? ✓ Size/material of existing sewer connection line? ✓ What is the expected flow rate of wastewater, such as during vacuum system flushing? (To compare to an amalgam separator's ISO-rated maximum flow.) ✓ What is the quantity of wastewater generated on a daily basis? (To compare to the volume of amalgam separators that treat wastewater on a daily batch basis and to the capacity of the air/water separator tank used in a turbine "dry" vacuum system.) ✓ What happens if the incoming flow exceeds ISO-rated maximum? - Does wastewater back up? - If wastewater backs up into the clinic vacuum system plumbing, will there be a problem of solids build-up in the pipes, especially if pump is on the same floor as the operatories? ✓ Does the separator hold wastewater (by backing it up within the separator surge tank) while it continues to treat? ✓ Does the separator allow backed up wastewater to overflow, untreated? ✓ Is there a mechanism (e.g., flow restrictor) by which the separator will retain and slow the wastewater flow as it treats? If not, does the separator allow excess flow to pass through the separator? ✓ What is the overall capacity of the surge tank? ✓ What is the "working" capacity of the surge tank so the air can still pass through, without drawing (vacuuming) out wastewater that would be untreated?

5.6 CONCLUSIONS

While dentists are not the largest source of mercury to the environment, they are a contributor. Out of concern for public health, dentists have a responsibility to do their part to manage dental waste properly (Kuehne, 2002). Technology is available to significantly reduce the rate of removal of mercury from dental office wastewater, and costs are likely to decrease as technology and efficiency improve. Although practicing dentists are faced with a number of concerns affecting a dental office (e.g., tax laws, requirements for employee safety and health, hygienists' union, regulations concerning privacy of patient records), they are generally willing to take the necessary steps to control mercury releases, once they understand the problem (Suchy, 2002).

The problem with dental mercury is complex. This report has attempted to describe many of the issues and present case studies relaying the approach, cost, results, and experience of actual programs that have been implemented. For state/provincial or local agencies considering implementing a dental mercury reduction program, the following steps summarize information presented in this report:

1. *Involve the dental community*. The local dental society is a good place to start. Maintaining communication with the dental community, along with other stakeholders who are interested in mercury control, will be key throughout the program.

2. *Identify issues and define terms*. Obtain understanding and acceptance from the dental community on key issues and common terms (e.g., the definition of amalgam).

3. *Decide upon the means for resolving the issues*. Determine the type of approach to be taken, regulatory or voluntary, and the goal to be achieved–narrative standard or numeric limit. Also, investigate whether feasible recycling and disposal options are available.

4. *Outreach to the dental community*. Educate dentists about the problem, the goal of the program, and how to participate or comply.

5. *Evaluate the program*. Evaluate whether the results of the program are achieving the objective and make modifications as necessary.

Case studies have shown that dental mercury programs implemented at the local level with the support of the local dental community can be effective. However, the type of approach appropriate for a particular state or community will likely vary with the circumstances of each locality (e.g., number of dentists, levels of mercury discharge, local ordinances). The type of approach taken will most likely be determined in cooperation with the dental community and/or developed through trial and error.

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Websites to Visit for More Information:

Subject	Website
American Dental Association	http://www.ada.org
American National Standards Institute	http://www.ansi.org and http://webstore.ansi.org/ansidocstore/find.asp?
Canadian Council of Ministers of the Environment (Canada Wide Standard - amalgam)	http://www.ccme.ca/initiatives/standards.html
Canadian Dental Association (MOU on dental amalgam)	http://www.cda-adc.ca/english/news_events/news_releases/2002/02_18/2002.asp
Kansas State University Dental Curriculum	http://www.sbeap.org
King County's voluntary dental program	http://www.metrokc.gov/hazwaste/pubs/studies/
King County's mandatory dental program	http://dnr.metrokc.gov/wlr/indwaste/dentists.htm
Minnesota Dental Association	http://www.mndental.org/professionals/amalgam_recovery/
Naval Dental Research Institute	http://www.dentalmercury.com/home.html
Royal College of Dental Surgeons of Ontario (Amalgam regulation and BMPs)	http://www.rcdso.org
Sustainable Hospitals Project	http://www.sustainablehospitals.org/HTMLSrc/IP_Merc_BMP_DentalAmalgam.html
Toronto Sewer Use By-law	http://www.city.toronto.on.ca/wes/techservices/involved/wws/nbylaw/index.htm

APPENDIX A:

ADA BEST MANAGEMENT PRACTICES FOR AMALGAM WASTE

see www.epa.gov/region5/air/mercury/dentalbmps.pdf

APPENDIX B:

NEORSD ADMINISTRATIVE ORDER AND BEST MANAGEMENT PRACTICES

APPENDIX B. NEORSD ADMINISTRATIVE ORDER AND BEST MANAGEMENT PRACTICES

Administrative Order Issued to
[Dental Care Practitioner]

In accordance with Section 2.0603 of the Northeast Ohio Regional Sewer District (NEORSD) Code of Regulations:

[Dental Care Practitioner]
[Address]
[City, State, Zip Code]

Administrative Order No. 8021-SEQ

This Administrative Order grants to **[Dental Care Practitioner]** the authority to discharge dental wastewater from the above identified facility into the NEORSD's sewerage collection and treatment system. This authority is granted in accordance with the conditions set forth in this Administrative Order. All discharges from the above-mentioned practice, requirements, and reports relating thereto shall be in accordance with the terms and the conditions of this Administrative Order. Compliance with this Order does not relieve **[Dental Care Practitioner]** of the obligation to comply with any and all applicable regulations, standards, requirements, or laws that may become effective during the term of this Administrative Order.

All dischargers to the NEORSD sewerage system must comply with all applicable laws, regulations, standards, and requirements contained in the NEORSD Code of Regulations.

Following is the local limit for mercury under Section 1.0915 of the NEORSD Code of Regulations:

"Except where application of the most sensitive analytical method approved under 40 CFR Part 136 for mercury in wastewater demonstrates to the District's satisfaction that no mercury is detectable in the user's discharge to the System, all Industrial Users are, for the purpose of this section, sources of mercury. All Industrial Users that are sources of mercury shall implement Best Management Practices (BMPs), as defined under section 1.0203 of this Title of the Code of Regulations, to minimize discharges of mercury to the System. Certain Industrial Users and/or classes of Industrial Users identified by the District as significant sources of mercury shall comply with District-issued administrative orders requiring submittal and implementation of BMP plans for mercury discharge minimization. Any Industrial User that is a source of mercury failing to implement BMPs in a manner and to an extent satisfactory to the District and/or failing to fully comply with requirements in an administrative order shall be subject to charges as indicated under Section 1.0924 and/or refusal of service as indicated under Section 1.0907."

Following is the definition of an Industrial User under Section 1.0225 of the NEORSD Code of Regulations:

" 'Industrial User' – shall mean a discharger of any liquid, solid, or gaseous substance or form of energy, or combination thereof, resulting from any process of industrial, commercial, governmental, and institutional concerns, manufacturing, business, trade or research, including the development, recovery and processing of natural resources, or from sources other than those described in Section 1.0217 (Domestic Sewage)."

Following is the definition of best management practices (BMPs) under Section 1.0203 of the NEORSD Code of Regulations:

" 'Best Management Practice (BMP)' – Methods determined by the Director to be the most effective, practical means of preventing or reducing pollution, including but not limited to: substitution of materials; reformulation or redesign of products; modification of equipment, facilities, technology, processes, and procedures; and improvement in management, inventory control, materials handling or general operation of a facility."

Administrative Orders are issued to dental care practitioners as they have been determined by the NEORSD to be a class of Industrial Users that is a significant source of mercury into the sewerage system. Pursuant to Section 1.0915 of the NEORSD Code of Regulations, offices employed in practicing dental care are required to submit and implement a BMP plan as described below.

Part One – Process/Operational Description

A. **[Dental Care Practitioner]** is employed in practicing dental care. The discharge from this process is regulated by the NEORSD Code of Regulations.

Part Two – BMPs

A. The goal of the BMP plan is to maintain wastewater effluent total mercury concentrations below 0.2 nanograms per liter (parts per trillion). Any facility discharging mercury into the NEORSD's sewerage system shall make reasonable progress in developing, incorporating, and continuously improving BMPs to minimize the facility's discharge of mercury. During the term of this Administrative Order, implemented BMPs shall not be altered in any manner that would be expected to result in a net increase in the overall quantity of mercury entering the sewerage system. The NEORSD must be notified prior to any alteration of implemented BMPs that has not been specified in the approved BMP plan.

By December 31, 2002, **[Dental Care Practitioner]** shall develop a BMP plan and submit it to the NEORSD for review and approval. The objective of this plan is to identify pollution prevention opportunities and implement those opportunities that are technically and economically feasible. The plan shall include the following.

1. A list of individuals responsible for developing, implementing, and practicing under the BMP plan. The list must include the name of one individual designated as primarily responsible.
2. An inventory of potential sources of mercury. The inventory shall include a description of each potential source.
3. A description of any current and past BMPs for mercury and any information on the effectiveness of such BMPs.
4. Identification and any technical/economical evaluation of new BMPs.
5. A schedule for implementation of economically feasible BMPs.
6. Any methods used for measuring progress towards the BMP goal and updating the BMP plan.

Required BMPs and examples of other possible BMPs are listed in the Appendix A.

C. **[Dental Care Practitioner]** will be subject to periodic, unannounced monitoring by the NEORSD and will be responsible for reimbursing the NEORSD for certain expenses associated with this monitoring.

Part Three – Reporting Requirements

A. By March 1 of 2003 and each year thereafter, **[Dental Care Practitioner]** shall submit an annual report to the NEORSD. The annual report must include:
1. Any BMP plan monitoring results for the year;
2. An updated inventory of potential sources of mercury;
3. A summary of any information indicating the effectiveness of all BMPs implemented to meet the BMP plan goal;
4. Any updates to the BMP plan;
5. Copies of any correspondence that indicates compliance, including but not limited to hazardous waste hauling manifests or bills of lading.

B. **[Dental Care Practitioner]** must notify the NEORSD immediately upon occurrence of an accidental discharge of mercury-containing material or any other slugload or spill that has potential to enter the NEORSD's sewerage system. Notifications are to be made to the District by telephone at (216) 641-6000, Monday through Friday from 8:00 a.m. until 4:30 p.m., or at any other time by telephone at (216) 641-3200.

C. **[Dental Care Practitioner]** must report any outage or malfunction of any pretreatment system for mercury removal (e.g., amalgam traps, filters, screens, and/or separators) within twelve (12) hours of discovery of such outages or malfunction.

Part Four – Violation Charges

A. Any failure to comply with this Administrative Order and/or the provisions set forth in the NEORSD Code of Regulations may result in charges and/or damages as stipulated necessary by the NEORSD.

Part Five – Special Conditions

A. Reopener Clause

1. This Order may be reopened and modified to incorporate any new and/or revised requirements contained in the NEORSD Code of Regulations.

2. This Order may be reopened and modified to incorporate any new or revised requirements resulting from the District's reevaluation of local limits or to ensure POTW compliance with applicable sludge management requirements promulgated by EPA (40 CFR 503).

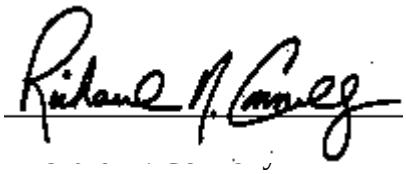
B. Compliance Schedule

1. **[Dental Care Practitioner]** shall contact the NEORSD within thirty (30) days of receipt of this correspondence to negotiate any modifications to the enclosed Administrative Order. Pursuant to Section 5.1 of the NEORSD Code of Regulations, "Rules and Procedure for Administrative Determinations"; failure to petition for reconsideration of the Administrative Order within the allotted 30 days is deemed a waiver by the receiver of any right to challenge for modification of the terms of this Administrative Order.
2. A complete BMP plan must be submitted to the NEORSD by December 31, 2002.
3. Implementation of the BMP plan should begin as soon as possible but must be in place by December 31, 2002.

Noncompliance with any term or condition of this Administrative Order shall constitute a violation of the NEORSD Code of Regulations. This Administrative Order shall become effective on April 1, 2002 and shall expire on April 1, 2007. Upon expiration, the provisions of this Administrative Order shall remain in effect until a new Order is effective. The NEORSD may reevaluate the facility prior to the expiration date of this Order; an updated Order may be issued prior to the expiration date.

Issued this 27th day of March, 2002.

Respectfully yours,



Superintendent of Environmental Services
Northeast Ohio Regional Sewer District

DENTAO
2/12/02

Best Management Practices ("BMPs")

for Minimization of Mercury Discharges from Dental Offices to the Sewerage System

Prepared by the Northeast Ohio Regional Sewer District
in Cooperation with Representatives of
the Ohio Dental Association and the Greater Cleveland Dental Society

By making a check mark in the appropriate boxes (to indicate which, if any, of the recommended BMPs will be implemented at your office) and providing the requested information below, a signed copy of this document may be submitted to the Northeast Ohio Regional Sewer District ("NEORSD") as the required BMP Plan for this office. Additional pages may be attached, as necessary, to supplement this document. (Send a request to LinnK@neorsd.org *if you would prefer to be e-mailed a Microsoft Word version of this document.)*

❑ If the practice at this office does not handle dental amalgam, you may make a check mark in this box and proceed directly to page 7 of this document. (*If the practice at this office handles dental amalgam in any form, such as extractions of amalgam or extractions of teeth that contain amalgam, do not make a check mark in this box*.)

Mandatory BMPs

✓ Eliminate all use of bulk elemental mercury (also referred to as liquid or raw mercury). Use only precapsulated dental amalgam. Any bulk elemental mercury must be recycled or hauled away as hazardous waste. *It must never be poured into the regular trash, in with infectious waste (red bag), or down the drain.* (You may contact NEORSD Mercury Program staff at 216-641-6000 or the Ohio Dental Association at 614-486-2700 for information on recycling bulk elemental mercury or dental amalgam.)

✓ Limit the amount of amalgam used to the smallest appropriate size for each restoration. Keep a variety of amalgam capsule sizes on hand to more closely match the amount triturated to the amount needed in the restoration.

✓ Change or clean chairside amalgam traps frequently. Flush the vacuum system before changing the chairside trap.

✓ Change vacuum pump filters and screens at least once per month or as directed by the manufacturer.

✓ All amalgam waste must be either recycled (preferred method) or hauled away as hazardous waste (acceptable alternative). Included are:

- Non-contact amalgam (scrap);
- Contact amalgam (e.g., extracted teeth containing amalgam);
- Amalgam/sludge captured by chairside traps, vacuum pump filters, screens, and other devices;
- Used amalgam capsules that visibly contain any mercury;
- Leaking or unusable amalgam capsules.

Amalgam waste must never be put in the regular trash, put in with infectious waste (red bag), or flushed down the drain. Amalgam-containing traps, filters, or screens must never be rinsed over drains or sinks.

✓ Store amalgam waste in covered, segregated, and clearly labeled airtight plastic containers or as directed by your recycler.

✓ Maintain a log of amalgam waste generation and recycling/disposal. Documentation of all amalgam waste recycling and disposal must be obtained from your recycler or hazardous waste hauler, kept on file, and made available to the NEORSD upon request.

✓ Train all staff that handles or may handle mercury-containing material in its proper use and disposal.

Recommended BMPs

❑ Use, when appropriate, mercury-free alternatives to amalgam (e.g., gold, ceramic, porcelain, composites, polymers, glass ionomers, cold silver, gallium).

- [ ] Clean or replace under-sink traps and sumps, taking care to avoid spillage of the contents from plumbing parts. Remove sludge that may contain mercury, and have it recycled or hauled away as hazardous waste.

- [ ] Install clear plastic, easily removable under-sink P-traps, and have the contents recycled or hauled away as hazardous waste if they may contain inadvertently spilled mercury-containing material.

- [ ] Use disposable chairside amalgam traps instead of reusable traps in your cuspidor and vacuum system, and have the disposable traps recycled or hauled away as hazardous waste.

- [ ] Maximize the use of the high-speed suction (vacuum) system, because it captures more of the amalgam waste than does the coarse screen in a cuspidor.

- [ ] During amalgam restoration/extraction procedures, remove wet cuspidors from service and rely solely upon the high-speed suction (vacuum) system to remove debris and saliva.

- [ ] Avoid using sodium hypochlorite (bleach) to disinfect vacuum lines, because it dissolves mercury out of amalgam.

- [ ] Be knowledgeable about amalgam separators employing enhanced sedimentation, fine particle filtration, and/or other technologies. Install and properly maintain such technologies that are determined to be feasible and effective.

- [ ] Obtain mercury spill kits, place them in appropriate easy-to-access locations, and immediately use them as directed by the manufacturer for any spill of mercury-containing material. All spilled mercury-containing material must be recycled or hauled away as hazardous waste.

❑ Implement a program to have mercury-containing thermostats, switches, and fluorescent light bulbs recycled when they are replaced. Thermostats and switches should be replaced with mercury-free alternatives.

❑ Describe below any additional BMPs for mercury discharge minimization that you may have identified and plan to implement.

Please provide the following information to the best of your ability.

1. List the individuals, including all the dental care practitioners at your office, who are responsible for developing, implementing, and practicing under this BMP plan, and designate one individual who has the primary responsibility for it:

2. List and describe all identified potential sources of mercury or mercury-containing materials that could enter the sewerage system from this office:

3. Describe any BMPs that you may have implemented in the past and/or may be currently implementing for mercury discharge minimization. (See previous pages of this document for examples.) Also, please provide any information that you may have obtained regarding the effectiveness of the BMPs:

4. Provide information from any technical/economical evaluation that you may have performed on BMPs for mercury discharge minimization:

5. Provide a schedule for implementation of the BMPs that you have indicated will be implemented for mercury discharge minimization at this office. Implementation of all mandatory BMPs should begin as soon as possible and must begin no later than December 31, 2002.

6. Describe any methods that you may have identified for measuring progress toward the BMP Plan goal and updating this BMP Plan (e.g., documenting increased utilization of mercury-free alternatives, researching new BMPs, etc.):

Your Name:
Mailing Address:

Office Address (if different from Mailing Address):

Telephone Number:

_____ _____

Your Signature Date

If this document is to serve as your required BMP Plan for mercury discharge minimization, send one completed copy of it for each office at which you practice no later than December 31, 2002 to the address below:

Northeast Ohio Regional Sewer District
4747 East 49th Street
Cuyahoga Heights, OH 44125-1011
Attention: Mercury Program

DENTBMPs
2/12/03

APPENDIX C:

OTHER DENTAL MERCURY PROGRAMS

APPENDIX C. OTHER DENTAL MERCURY PROGRAMS

Los Angeles, California

The City of Los Angeles, and six other cities who contract with Los Angeles for wastewater treatment, have a formal regulatory program for dental offices. This program requires dental offices to comply with specific BMPs, but it does not require amalgam separators.
Point of Contact: Teresa Pichay, California Dental Association (209) 257-1935, TeresaP@cda.org

Massachusetts

The Massachusetts Executive Office of Environmental Affairs is performing a study of ISO test and available separators. There is currently no regulatory plan in effect.
Point of Contact: Charles Bering (617) 788-2309, Charles.Bering@mwra.state.ma.us

Minneapolis & St. Paul Metropolitan Area and the State of Minnesota

The Metropolitan Council (Council) and the Minnesota Dental Association (MDA) have implemented a voluntary Amalgam Recovery Program in the Minneapolis-St. Paul metropolitan area. Clinics participating in the program are issued a "Certificate of Compliance" for installing an approved amalgam separator and properly managing amalgam wastes generated by the clinic. Approved separators must remove 99% of the amalgam (by ISO testing). Clinics maintain certification by properly operating and maintaining the separator, implementing Best Management Practices, and submitting a statement annually to the Council certifying that the separator is in place, operating, and that "Best Management Practices" are being implemented. The MDA is extending this program beyond the Council's metropolitan area and promoting separator installation to all of Minnesota. Prior to implementing the program, the Council and the MDA completed two dental mercury studies which showed that amalgam separators are effective at removing amalgam from dental office wastewater and that the use of amalgam separators will reduce the amount of mercury present in wastewater treatment plant sludge. More information about the amalgam recovery program and the studies can be obtained from the point of contact.
Point of Contact: Peter Berglund, Metropolitan Council Environmental Services (651) 602-4708; peter.berglund@metc.state.mn.us

New Hampshire

The state passed legislation requiring its environmental agency to promulgate regulations for all dental offices. This is expected to be accomplished in 2003.

New York

Effective March 16, 2003, the State of New York added a law that bans the use of non-encapsulated elemental mercury in dental offices and requires dentists to recycle any

mercury or dental amalgam waste generated in their offices in accordance with regulations established by the New York State Department of Environmental Conservation (DEC). DEC is in the process of developing regulations to assist dentists with implementation of this law. More information can be found at http://www.dec.state.ny.us/website/dshm/redrecy/mercdent.htm
Point of Contact: Jim Honan, Environmental Program Specialist, NYSDEC, 625 Broadway, Albany, NY 12233; (518) 402-8704; jphonan@gw.dec.state.ny.us

Richmond, California, San Francisco Bay area

Nine dentists in the service area must comply with a 5 ppb discharge limit. Dentists have worked cooperatively with the city of Richmond for the past 2-3 years. All dentists have been cited for violating the limit at least once, but the fines have been waived. The city has tried numerous methods to reduce the mercury discharge. The best results were achieved when a dentist implemented BMPs *and* installed a separator, although the local discharge limit was still exceeded.
Point of Contact: Teresa Pichay, California Dental Association (209) 257-1935; TeresaP@cda.org

U.S. Navy

The U.S. Navy is in the process of installing amalgam separators in all dental facilities. Installed systems remove particulate and "dissolved mercury." Separators will be installed in all U.S. and overseas dental treatment facilities. The program is managed by the Naval Dental Research Institute (NDRI) with funding from the Department of Defense, Health Affairs.

Wichita, Kansas

Wichita has a metropolitan area of 500,000 in southeast Kansas. There are 200 dental clinics in the metro area, 150 of which are general practice dentists (thought to handle amalgam). Phase 1 of a regulation passed by the city requires installation of technology greater than already in an office by October 2001. If a 50 percent reduction to the wastewater treatment plant is not obtained by June 2003, then Phase 2 will be implemented. Phase 2 requires the mandatory installation of ISO 11143 certified separators. The city maintains a list of approved separators. Each dental clinic samples wastewater annually and submits an annual self-monitoring report. The city also inspects and samples clinics on an annual basis. Sludge from the city's wastewater treatment plant is land-applied.
Points of Contact: Jamie Belden (316) 303-8775 or Rebecca "Becky" Gagnon (316) 303-9900

The Pollution Prevention Institute at Kansas State University has undertaken a mercury educational effort. Through this effort, an amalgam waste fact sheet has been developed and a curriculum presented to dental schools and to hygiene and dental assistance programs.
Point of Contact: Nancy Larson (800) 578-8898 or Nlarson@ksu.edu.

APPENDIX D:

AMALGAM SEPARATORS APPROVED BY KING COUNTY

APPENDIX D. AMALGAM SEPARATORS APPROVED BY KING COUNTY (REVISED 4/9/03)

The following amalgam separators are approved by King County for discharge of dental wastewater to the King County sewer system. Dental practices must install an amalgam separator approved by King County's Industrial Waste Program. Main page: http://dnr.metrokc.gov/wlr/indwaste/dentists.htm. Information from manufacturers is still being received and evaluated by King County. If a dental practice is considering an amalgam separator not on this list, please contact Bruce Tiffany (206-263-3011) or bruce.tiffany@metrokc.gov to check on the status of amalgam separator evaluations.

Amalgam Separators Approved by King County

Company	Phone	Model [Maximum Flow Rate From ISO-11143 Testing In mL/min or L/min] [5]
AB Dental Trends, Inc.	360-354-4722	Rasch 890 System [4 L/min]
American Dental Accessories, Inc.	800-331-7993	ASDEX Amalgam Separator with: ASDEX Premium Filter No.: AS-9 [250 mL/min] (No.: AS-9-1[1]) [NA]
		ASDEX Super Premium Filter No.: AS-9-2[1] [NA]
Bio-Sym Medical Corporation	800-947-7550	MERC II [2 L/min]
Dental Recycling North America [DRNA)	800-360-1001	SRAB 99 [1] [NA]
		BullfroHg (No.: BUI0) [750 mL/min]
		MRU (Nos.: MRU10c & MRU100v) [750 mL/min]
Hygenitek, Inc. - Canada Bio-Med Process - USA Distributor	866-494-3648 or 905-494-2054 866-510-7082	ARU-10 [750 mL/min]
Maximum Separation Systems, Inc.	800-799-7147	MSS Model 1000 [1 L/min]
		MSS Model 2000 [2.5 L/min]
Metasys [Pure Water Development, L.L.C.)	877-METASYS	MST-1 [1, 2] [NA]
		ECO II [2 L/min]
R&D Services	206-525-4995 or 800-816-4995	The Amalgam Collector, Design I [1, 3] [NA]
		The Amalgam Collector, Design II [1, 4] [NA]
		The Amalgam Collector, CH - Series (Nos.: CH9, CH12, CH15 and CH18) [NA]
		The Amalgam Collector, CE - Series (Nos.: CE15, CE18 and CE24) [NA]

Rebec Environmental	425-745-4177 or 800-569-1088	RME 2000/Catch hg	[1 L/min]
SolmeteX	508-393-5115 or 800-216-5505	Hg5	[50 ml/L]

1. This unit is no longer being marketed
2. Approved only for water-driven vacuum & chair-side location
3. Approved only for water-driven vacuum
4. Approved only for turbine "dry" vacuum
5. ISO - International Standards Organization maximum flow rate at which separator efficiency was tested and is reported as either milliliters per minute [mL/L]; liters per minute [L/min]; or not applicable [NA].

King County provides no guarantees or warranties for purchase, installation, operation, and maintenance of King County approved amalgam separators. The purchase, installation, operation, and maintenance of a King County approved amalgam separator does not relieve the owner of meeting other applicable federal, state, or local codes, ordinances, regulations, or statutes.

International Standards Organization (ISO) Certification:

Beginning July 1, 2003, King County will only approve amalgam separators that have been certified as meeting or exceeding ISO-11143 as verified by an ISO-certified testing laboratory. Any amalgam separator manufacturer that has not previously initiated King County (formerly Metro) testing will need to test its amalgam separator by ISO-11143. All amalgam separators sampled and tested according to the King County protocols will remain on the King County list of approved separators and are approved for use in dental facilities tributary to the King County sewer system.

Choosing the right amalgam separator for a dental practice

The type of amalgam separator to choose depends on several factors.

Does the practice want individual chair-side separators or a central unit that will handle all the chairs?

What type of vacuum pump services the office? Choose an amalgam separator that doesn't interfere with the practice's vacuum. Some amalgam separators are approved only for chair-side use or for use with a particular type of vacuum pump.

King County's list of approved amalgam separators notes whether there are King County restrictions on the use of each model. The practice's vendor should be able to recommend units that will best serve the office configuration.

If a practice is in a building that contains many dental offices, it should check with the building manager before installing the unit, to make sure it will be compatible with the central vacuum.

What maintenance is required?

Ask whether the vendor provides regular maintenance for the unit or if it is the practice's choice. Questions include: How often does one need to dispose of accumulated waste sludge? Is the sludge collected in a canister that can be replaced or in one that must be emptied?

If the vendor maintains the unit, find out: who the vendor contracts with to haul the waste away; where the contractor sends it, and what waste documentation the vendor provides as part of the service fee.

Review the operation and maintenance

manual for items one needs to keep track of while using the unit.

How much will the amalgam separator cost?

Costs range from several hundred dollars to a few thousand dollars, depending on whether the practice: leases the unit with required maintenance included in the fee; purchases the unit and contract with a company to maintain it, or purchases the unit and maintains it. A practice should ask if the price includes installation or if the practice will have to arrange for it. There are also costs for disposing of sludge.

When comparing costs, consider costs of the unit, installation, maintenance, and waste disposal.

Choosing a vendor

Although practices may rely on others for maintenance and waste disposal, they are legally responsible for the waste until its final disposal. In choosing a vendor, practices should consider reliability as well as cost.

What documentation and other paperwork are provided?

Manifests and receipts track dental practices' waste from the site, to hauler, to the receiving facility. Vendors may help the
papers, but practices should be careful to ensure their accuracy. While small quantity
generators do not need to manifest the waste
shipped, manifests provide added protection.

How much will the services cost?

The total cost of handling a practice's waste
can include a number of fees: a waste profile
or lab fee, a hauling charge, a disposal fee, and a container replacement charge. Practices should: ask vendors what they charge for each of these items; ask which charges are one-time and which are ongoing,
and find out if there are any other fees.

For more information visit:

http://dnr.metrokc.gov/wlr/indwaste/dentists.htm

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division
Industrial Waste Program
130 Nickerson Street, Suite 200
Seattle, WA 98109-1658
206-263-3000 Fax 206-263-3001