



June 21, 2012

Attn: Bruce Wolfe
San Francisco Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Sent via email to bwolfe@waterboards.ca.gov

BACWA's Final Dental Metrics Report

Dear Bruce:

On behalf of our member agencies, please find attached BACWA's final dental metrics report, which is meant to satisfy the June 30, 2012 reporting requirement under the Watershed Permit, Provision V.C.2.b:

"The municipal wastewater Dischargers in Table 1A shall estimate the dental amalgam collected (and describe the basis for its estimation) and describe any other mercury pollution prevention programs that are implemented and maintained by individual municipal wastewater dischargers. The municipal wastewater Dischargers shall provide this information to the Regional Water Board no later than June 30, 2012. The municipal wastewater Dischargers may collaborate to provide this information in a single report to satisfy this requirement for the entire group."

If you have any questions on the submittal, please contact BACWA's Project Manager, Melody LaBella, at (925) 229-7370 or mlabella@centralsan.org.

Sincerely,

A handwritten signature in black ink that reads "James M. Kelly".

Jim Kelly
Executive Director

cc: Robert Schlipf (rschlipf@waterboards.ca.gov)
Bill Johnson (WJohnson@waterboards.ca.gov)
Melody LaBella

Mercury Watershed Permit Dental Metrics – Program Update

For:	Melody LaBella, Project Manager, BACWA Dental Tech Support Project
Prepared by:	Thomas Barron, PE & Stephanie Hughes, PE
Reviewed by:	Tim Potter and Melody LaBella
Date:	May 10, 2012 Final
Subject:	November 2011 - Dental Mercury Metrics

1. Background

The San Francisco Bay Area has a regional mercury watershed permit for its municipal wastewater dischargers.¹ This shared permit identifies two metrics for evaluating the region-wide effort to reduce dental mercury discharges into sanitary sewer systems:

1. The percent of amalgam-using dental practitioners that participate with their local mercury source control program should exceed 85% by March 1, 2013.
2. The amount by which these source control programs reduce mercury discharges from dental offices is to be estimated (with a description of the estimation methodology).

To undertake this regional evaluation, Hughes/Barron worked with BACWA to conduct a survey of all municipal dischargers and develop a methodology to assess progress relative to the two metrics. The survey was conducted in Fall 2009. In October 2010, Hughes/Barron submitted a technical brief to BACWA describing the methodology and the results at that time.² The methodology was approved by the Regional Board in a letter to BACWA dated March 17, 2011. Because the 2009 survey results indicated that dental practitioner participation was at 76%, rather than the minimum of 85%, it was agreed that BACWA would conduct a follow-up survey and present the results by June 2012.

The follow-up survey was completed in November 2011. This technical brief presents the results of that second BACWA survey. As was the case in the original analysis, additional data are taken from published studies of five local dental mercury programs, and from the technical literature.

2. Results Relative to Program Metrics

As of November 2011, both program metrics have been attained. The calculation approach used to make this determination is the same as was presented in the October 2010 technical memo.

¹ Order Number [R2-2007-0077](#)

² “[Mercury Watershed Dental Permit Metrics](#)” October 1, 2010.

2.1 Metric 1 - Participation as Of November 2011

As of the 2011 survey, an estimated 91% of dental practitioners who either remove or place amalgam restorations participated in their local wastewater agency's mercury source control program. These amalgam practitioners have interacted with their local agency through returned surveys, courtesy office visits, self-certification forms, permit applications, or formal inspections. All 91% of amalgam practitioners provided evidence that they adopted the dental amalgam Best Management Practices (BMPs) studied under this project.

Exhibit 1 shows that region-wide the degree of program coverage is fairly high, with 30 agencies having contacted more than 75% of their amalgam practitioners.

Exhibit 1 - Metric #1: Participation Levels By Local Agency

Participation Level	No. of Agencies	Total No. of Practitioners Contacted & Participating [1]	
100% of Practitioners	13	1,275	
75% to 99%	17	3,064	
50% to 74%	3	66	
25% to 49%	4	87	
1% to 25%	1	6	
	<u>38</u>	<u>4,499</u>	91%
Contacted but not using BMPs		328	
Not Yet Contacted		96	
No Implementation	2	8	
Total	<u>40</u> [2]	<u>4,931</u> [3]	

Note [1]: Many of the numbers in this analysis have extra digits to show the arithmetic involved, and should not be taken as an indication of accuracy.

Note [2]: The initial 2009 evaluation included 39 agencies.

Note [3]: The number of amalgam practitioners decreased from the initial total of 5,325 reported for 2009. This more accurate count came about as agencies obtained more site-specific information about the dental practices in their service area after issuing more permits and conducting more inspections.

Exhibit 2 presents a breakdown of the participation into the primary level of activity that has been conducted by individual agencies. For instance, there are 201 dentists listed as "responded to survey". This listing means that a survey was the singular type of contact for those offices. Later, when these dentists participate in a permitting program, then they will be included in the "permit" activity count and no longer included in the "survey" count.

Most amalgam practitioners have been subjected to more than one activity. Exhibit 2 only shows the activity for each practitioner that was used to estimate participation relative to Metric One. For example, if an agency has permitted all its practitioners, and yet has inspected only 50% of their offices then Exhibit 2 includes all of the practitioners within permitting, rather than inspection, to count participation.

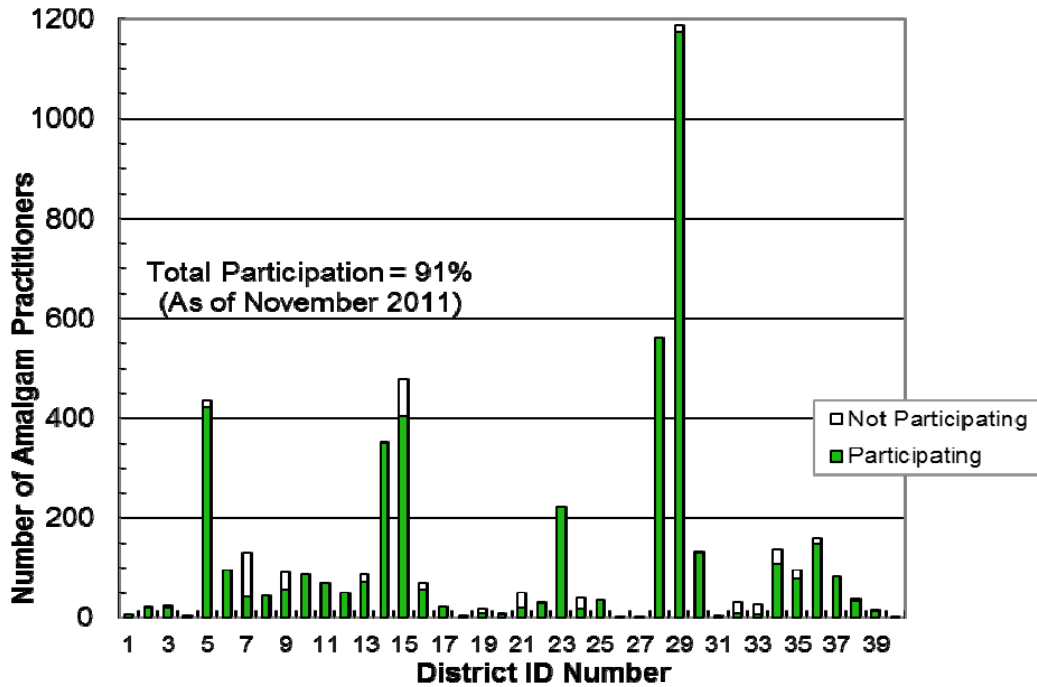
If one were to exclude one-time surveys from overall participation, then that entry would go from 201 down to zero. However, at the same time the entry for Courtesy Visits would increase and the overall total would be 4,366 Participating Dentists, or 89%. That is because some agencies that received a high number of surveys also conducted a smaller number of courtesy visits. Using other assumptions on how to count participation (e.g., not counting instances where best management practices are optional) provides similar results with respect to overall percent participation.

Exhibit 2 - Metric #1: Activities Used To Estimate Participation

Activity	No. of Practitioners	Percent
Responded to Survey	201	4%
Courtesy Visit	205	4%
Self-Certification / Permit	2,771	56%
On-Site Inspection	1,322	27%
Total Participating	4,499	91%
Not Yet Contacted	432	9%
Total	4,931	100%

Exhibit 3 shows how many practitioners in each district are participating in their local source control program. In each agency, the activity with the highest participation is counted. For example, if 100% of the practitioners have a permit while only 10% have been inspected, then the participation is 100%.

Exhibit 3 - Metric #1: Participation in Source Control Programs



2.2 Metric 2 - Diverted Mercury as Of November 2011

Exhibit 4 shows that mercury discharges to wastewater agencies' influent from regional dental offices are estimated to have decreased from a baseline of 119 Kg/yr before the start of regional dental waste programs down to a level of 41 Kg/yr at the end of 2011.

This decrease, amounting to about 66%, is attributed to dental offices:

- implementing best management practices (BMPs); and
- installing amalgam separators.

The widespread trend of dentists performing fewer amalgam placements and removals is believed to cause approximately 1% per year decrease in the generation of amalgam wastes. Although potentially significant over time, this effect is neglected in this evaluation.

Exhibit 4 - Metric #2: Estimated Dental Mercury Discharge Reduction

	Baseline [1]	2009 [2]	2011 [3]
Amalgam Practitioners	4,931	4,931	4,931
Hg Waste Generated (Kg/yr)	411	411	411
Percent Discharged	29%	15%	10%
Hg Discharged (Kg/yr)	119	62	41

Note [1]: The revised Baseline Estimate is an extrapolation from five studies undertaken for specific agencies in the region, together with the 2011 count of amalgam practitioners. The five studies include local data on vacuum system types, BMP use, and separators at individual dental practices before the agencies began their outreach efforts.

Note [2]: This revised estimate for 2009 is jointly based upon the Fall 2009 BACWA survey of participating agencies, and the more recent count of amalgam practitioners developed in 2011.

Note [3]: The estimated net 10% Hg discharge shown for 2011 is the result of higher BMP use and the installation of more amalgam separators than were reported in 2009.



California Regional Water Quality Control Board

San Francisco Bay Region



Linda S. Adams
Acting Secretary for
Environmental Protection

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Edmund G. Brown, Jr.
Governor

March 17, 2011

Bay Area Clean Water Agencies
Attention: Amy Chastain, Executive Director
P.O. Box 24055, MS 702
Oakland, California 94623

SUBJECT: Approval of Mercury Watershed Permit Dental Metrics

Dear Ms. Chastain:

We reviewed the final report entitled *Mercury Watershed Permit Dental Metrics* submitted to us on October 1, 2010, on behalf of the Bay Area Clean Water Agencies (BACWA). We agree that the approach presented in the report meets the requirements of the mercury source control program for municipal dischargers included in the Mercury Watershed Permit (Water Board Order No. R2-2007-0077).

The Mercury Watershed Permit states that municipal wastewater dischargers subject to source control program requirements may collaborate to provide an estimate of dental amalgam collected. We note from the report that BACWA will satisfy this requirement for all municipal dischargers by surveying individual dischargers and implementing the estimation methodology outlined in the report. We appreciate that a metric for measuring the percent of amalgam-using dental practitioners participating in local mercury source control programs is also included; this will assist us in evaluating compliance with the 85% participation target to be met by the end of the permit term. A final report providing the estimate of dental amalgam collected and a description of the methodology is due June 30, 2012.

If you have any questions, please contact Heather Ottaway at 510 622-2116 or via e-mail at hottaway@waterboards.ca.gov.

Sincerely,

Bill Johnson

c: Stephanie Hughes, ChE PE, via email steifehughes@yahoo.com
Thomas Barron, PE, via email tsbarron@attglobal.net
Melody LaBella, Central Contra Costa Sanitary District, via email mlabella@centralsan.dst.ca.us

Preserving, enhancing, and restoring the San Francisco Bay Area's waters for over 60 years

Mercury Watershed Permit Dental Metrics – Executive Summary

For: Melody LaBella, Project Manager
BACWA Dental Tech Support Project

Prepared by: Thomas Barron, PE & Stephanie Hughes, PE

Reviewed by: Brad Eggleston; Tim Potter

Date: October 4, 2010

The San Francisco Bay Area has a regional mercury watershed permit for its 39 municipal wastewater dischargers. This shared permit identifies two metrics for evaluating the region-wide effort to reduce dental mercury discharges into sanitary sewer systems. Both metrics are presented below along with interim regional results that were based on compiling data from a December 2009 survey of municipal dischargers.

Metric 1. The target for this program is that 85% of dental offices that generate amalgam waste participate with their local mercury source control program by March 1, 2013.¹

Region-wide there are about 5,325 amalgam practitioners, of which 4,060 are participating in their wastewater agency's program. This is a 76% participation rate, as of December 2009. These amalgam practitioners have interacted with their local agency through returned surveys, office visits, self-certification forms, permit applications, or formal inspections.

Metric 2. The amount by which these source control programs reduce mercury discharges from dental offices is to be estimated (with a description of the estimation methodology).

Mercury discharges to wastewater agencies' influent from regional dental offices are estimated to have decreased from a baseline of 132 Kg/yr before the start of regional dental waste programs down to a level of 68 Kg/yr at the end of 2009. A technical brief is available that describes the estimation methodology.²

¹ When initiating this analysis, the project team proposed working definitions of the term "dental office" and "participation." Regional Board staff concurred with these definitions: "Dental office" means an individual dentist whose practice includes amalgam restorations. To count as "Participation" an activity must: (1) include some two-way interaction between the dental office and the agency, and (2) be measurable.

² For a complete analysis, see "Mercury Watershed Permit Dental Metrics: Final Report" dated October 1, 2010.

Mercury Watershed Permit Dental Metrics

For:	Melody LaBella, Project Manager BACWA Dental Tech Support Project
Prepared by:	Thomas Barron, PE & Stephanie Hughes, PE
Reviewed by:	Brad Eggleston; Tim Potter
Date:	October 1, 2010
Subject:	December 2009 - Dental Mercury Metrics

1. Background

The San Francisco Bay Area has a regional mercury watershed permit for its 39 municipal wastewater dischargers.

This shared permit identifies two metrics for evaluating the region-wide effort to reduce dental mercury discharges into sanitary sewer systems:

1. The percent of amalgam-using dental practitioners that participate with their local mercury source control program should exceed 85% by March 1, 2013.
2. The amount by which these source control programs reduce mercury discharges from dental offices is to be estimated (with a description of the estimation methodology).

This technical brief evaluates these two metrics based upon a BACWA survey of municipal source control programs conducted in the Fall of 2009. Additional data are taken from published studies of five local dental mercury programs, and from the technical literature.

2. Program Metrics

The results for both program metrics, as of December 2009, are summarized below. Calculation details are presented in Section 3, and references are provided in Section 4.

2.1 Metric 1 - Participation as of December 2009

As of the 2009 survey data, an estimated 76% of dental practitioners who either remove or place amalgam restorations are participating in their local wastewater agency's mercury source control program.

The mercury watershed permit states that the target for participation is that “85% of dental offices that generate mercury amalgam waste ... will be participating in an amalgam program.”

When initiating this analysis, the project team proposed working definitions of the term "dental office" and "participation." Regional Board staff concurred with these definitions:

- For purposes of this study, "dental office" means an individual dentist whose practice includes amalgam restorations. This approach helps the analysis by counting each amalgam-using dental practitioner correctly (e.g., three dentists working out of the same facility count as three practitioners).
- To count as "Participation" an activity must: (1) include some two-way interaction between the dental office and the agency, and (2) be measurable. For instance, a mailing to all dentists in a service area is not by itself considered a program, while a survey of dentists to determine BMP compliance has an sufficient level of interaction to be considered “participation in a program.”

With this guidance, the number of practitioners and their participation levels were evaluated. Exhibit 1 shows that region-wide there are about 5,325 amalgam practitioners, of which 4,060 are participating in their wastewater agency's program. These amalgam practitioners have interacted with their local agency through returned surveys, office visits, self-certification forms, permit applications, or formal inspections.

Exhibit 2 presents a breakdown of the participation into the primary level of activity that has been conducted by individual agencies. For instance, there are 417 dentists listed as “responded to survey”. This listing means that a survey was the singular type of contact for those offices. In the future, if some of those dentists are required to participate in a permitting program, then the accounting of those dentists would move into the “permit” activity and would no longer be counted within “responded to survey.”

Exhibit 2 also shows that of the estimated 4,061 dentists participating in a program as of 2009, about 3,600 (67%) are either self-certified/permited or have been inspected by the local agency.

Exhibit 1 - Participation Levels By Local Agency

Participation Level	No. of Agencies	No. of Practitioners [1]
100% of Practitioners	16	2,592
75% to 99%	2	164
50% to 74%	5	1,256
25% to 49%	3	26
1% to 25%	3	23
	<u>29</u>	<u>4,061</u>
Not Yet Contacted	10	1,264
Total	<u>39</u>	<u>5,325</u>

Note [1]: Many of the numbers in this analysis have extra digits to show the arithmetic involved, and should not be taken as an indication of accuracy.

Exhibit 2 - Activities Used To Estimate Participation

Activity [1]	No. of Practitioners	Percent
Responded to Survey	417	8%
Courtesy Visit	51	1%
Self-Certification / Permit	2,554	48%
On-Site Inspection	1,039	19%
Total Participating	<u>4,061</u>	<u>76%</u>
Not Yet Contacted	1,264	24%
Total	<u>5,325</u>	<u>100%</u>

Note [1]: Most amalgam practitioners have been subjected to more than one activity. This table only shows the activity for each practitioner that was used to estimate participation. For example, if an agency has permitted all its practitioners, and yet has inspected only 50% of their offices then Exhibit 2 includes all of the practitioners, as the permitting, rather than inspection verification was used to count participation.

2.2 Metric 2 - Diverted Mercury as of December 2009

Exhibit 3 shows that mercury discharges to wastewater agencies' influent from regional dental offices are estimated to have decreased from a baseline of 132 Kg/yr before the start of regional dental waste programs down to a level of 68 Kg/yr at the end of 2009.

This decrease, amounting to about -48%, is attributed to dental offices:

- implementing best management practices (BMPs); and
- installing amalgam separators.

The widespread trend of dentists performing fewer amalgam placements and removals is believed to cause a 1±% per year decrease in the generation of amalgam wastes. This effect is neglected in this evaluation.

Exhibit 3 - Estimated Dental Mercury Discharge Reduction

	Baseline [1] (W/out BMPs)	2009 [2]
Amalgam Practitioners	5,325	5,325
Hg Waste Generated (Kg/yr)	443	443
Percent Discharged	28%	15%
Hg Discharged (Kg/yr)	132	68

Note [1]: The Baseline estimate is an extrapolation from five studies undertaken for specific agencies in the region. These studies include local data on vacuum system types, BMP use, and separators at individual dental practices before the agencies began their outreach efforts. See Section 3 for details.

Note [2]: The Year 2009 estimate is based upon the Fall 2009 BACWA survey of participating agencies.

3. Calculation Methods

3.1 Overview

The baseline and recent estimates of dental office mercury wastes are constructed in the following eight steps.

- 1 Practitioner Count - For each service area, determine the number of individual dentists who use amalgam ("amalgam practitioners"). Amalgam use includes either removing or placing amalgam restorations.
- 2 Metric 1: Program Participation - Based upon the Fall 2009 survey of BACWA members, estimate the number of amalgam practitioners who are actively involved with a dental amalgam source control program.
- 3 Amalgam Procedures Performed - Also using survey data, estimate the annual number of placement and removal procedures, on average, that each practitioner performs.
- 4 Amalgam Waste Generation - From data in published studies of dental office wastes, estimate the unit amount of mercury waste generated by each placement or removal procedure.
- 5 BMP Use - From the BACWA survey, determine the average level of BMP and amalgam separator use in each service area, and estimate the net amount of mercury waste that is discharged as a result.
- 6 Regional Waste Total (2009) - Combine the above results into an estimate of mercury waste generated and discharged in each service area, together with a total for the region.
- 7 Regional Waste Total (No BMP Baseline) - Repeat Steps 3 - 6 to estimate mercury waste generated and discharged in the Baseline Year (i.e., before dental source control programs were implemented).
- 8 Metric 2: Waste Reduction - Estimate the reduction in dental office mercury discharges from the Baseline to the current survey year (2009).

Each of these steps is discussed below. Published studies and other references are listed in Section 4.

3.2 Metric #1 - Amalgam Practitioners & Program Participation

Practitioners – Based upon the Fall 2009 BACWA survey, it is estimated that there are about 6,775 general dentists in the 39 POTW service areas, of whom 5,325 place or remove amalgam restorations. A 2009 study published by UCLA indicates a reasonably similar number of general dentists in active practice in the nine Bay Area counties [Ref 1].

Thirty three of the respondents to the Fall 2009 BACWA survey provided a count of dental offices and amalgam practitioners for their sanitary sewer service area. Exhibit 4 is a chart showing the practitioners reported in these 33 service areas, sorted according to residential population.

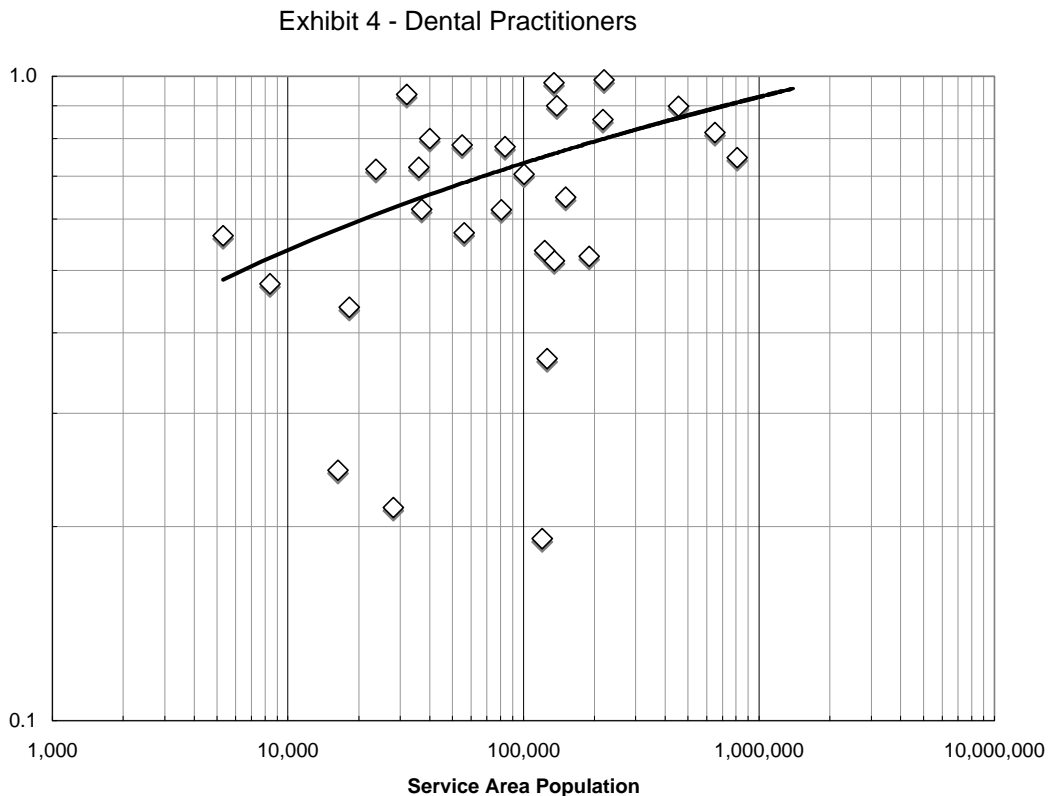
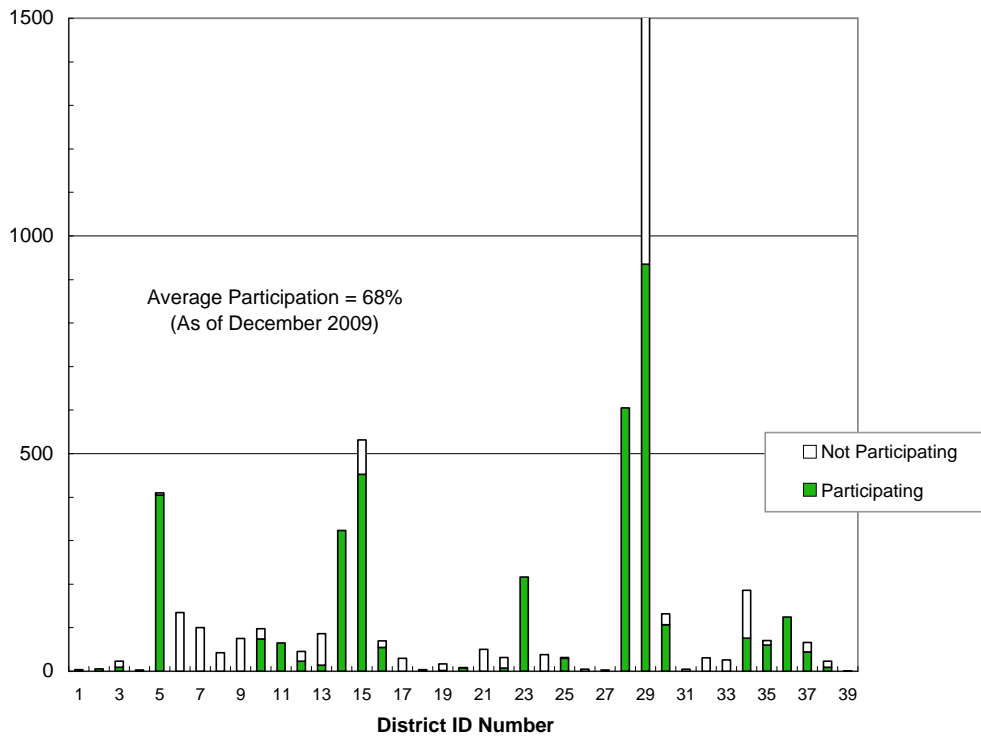


Exhibit 4 was used to estimate the number of practitioners in the six districts that did not furnish these data. For example, a district with 20,000 residents was assumed to have 0.6 amalgam practitioners per 1,000 people, for a total of 12 in the service area. This estimate will be improved by using actual data for each wastewater agency from future surveys.

Program Participation - Exhibit 5 shows how many practitioners in each district are participating in their local source control program.

Participation is defined as: responding to a survey; attending a district-sponsored workshop; receiving an on-site advisory consultation; self-certifying amalgam BMP and separator use; applying for a permit; or receiving a source control inspection. In each district, the activity with the highest participation is counted. For example, if 100% of the practitioners have submitted a permit while only 10% have been inspected, then the participation is 100%.

Exhibit 5 - Metric #1: Participation in Source Control Programs



Overall, an estimated 76% of amalgam practitioners are actively participating in their local source control program. Districts that have just started their outreach efforts, or that did not respond to the Fall 2009 survey, are shown as having "zero" participation.

Meanwhile, it is recognized that participating in a one-time survey is fundamentally different than sustained permitting and inspection programs. Further, not all programs verify the responses of the dentists; it

is difficult to truly understand BMP usage and separator installation from a survey or self-certification program that does not include office visits or inspections. Therefore this metric reflects interactions between dentists and agencies rather than successful adoption of BMPs.

3.3 Metric #2 - Step 1: Amalgam Procedures

Based upon the 2009 survey data, it is estimated that there are about 5,325 amalgam practitioners in the Bay Area. As shown by Exhibit 6, these dentists performed an estimated total of 672,000 amalgam placements and 1,113,000 amalgam removal procedures during 2009.

Exhibit 6 - Amalgam Procedures Per Practitioner

Dist. No.	Amalgam Pract.	Per Practitioner Per Yr		Service Area Per Yr	
		Placements	Removals	Placements	Removals
1					
2	6	2	25	12	150
3	23	24	47	560	1,090
4					
5					
6					
7					
8	43	48	10	2,064	430
9					
10	98	38	67	3,724	6,566
11					
12					
13					
14	323	240	312	77,520	100,776
15					
16	70	156	346	10,920	24,220
17					
18					
19	17	52	255	884	4,335
20					
21					
22	32	74	141	2,364	4,512
23	217	184	291	39,928	63,147
24					
25	32	65	204	2,080	6,528
26					
27					
28	605	102	178	62,004	107,988
29					
30	132	146	184	19,272	24,288
31					
32					
33	26	57	188	1,488	4,896
34	186	47	178	8,723	33,164
35					
36	125	103	180	12,875	22,500
37					
38					
39					
Survey Data	1,935	Weighted Averages 126 209		244,418	404,590
Other Practitioners	3,390	126	209	427,140	708,510
Totals	5,325			671,558	1,113,100

The totals in Exhibit 6 were calculated from individual estimates made for each service area using either their survey data, or by applying a standard rate of procedures per practitioner. Fifteen districts responded to the Fall 2009 survey questions about the numbers of amalgam removals and placements that local practitioners do each year.

The weighted average values of 126 placements and 209 removals were then used to estimate procedure numbers for practitioners in service areas that did not have specific data. In the future, if additional districts are able to provide estimates of amalgam removals and placements, these estimates may be updated.

3.4 Metric #2 - Step 2: Mercury Waste per Procedure

Amalgam waste is generated during each removal and placement procedure. Four published Bay Area studies indicate that removing one average-sized amalgam restoration generates about 0.38 grams of mercury waste at chairside. These studies also indicate that placing one average-sized filling generates about 0.045 grams of Hg waste at chairside [Ref 3 - 6].

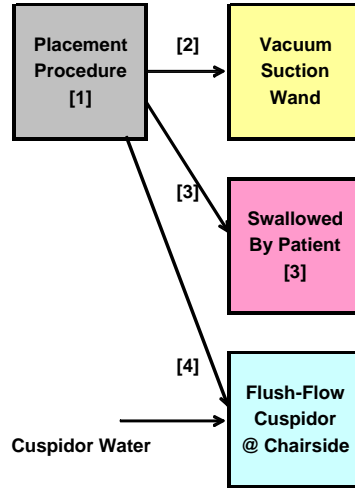
The estimated mercury waste from one removal is similar to that reported from a large study conducted in Ontario, Canada [Ref 2 - Tables 3 & 4].

The relative amount of generated Hg waste that enters the dental office vacuum system depends upon the size and type of filling involved, and upon the dental techniques used.

Interviews with Bay Area dentists suggest that a patient typically swallows an estimated 10% of the waste generated during a placement procedure (See Exhibit 7). The remaining 90% is picked up by the operatory vacuum system, either via a suction wand or cuspidor. Although the unit amount is higher, the fate of waste mercury generated during a removal procedure is similar [Ref 3 - 6].

Exhibit 8 highlights the 2009 estimate of mercury waste generated by dental practices through-out the Bay Area. The amount of this waste that actually is discharged to the sanitary sewer depends on the level of BMP usage, and the presence of an amalgam separator. In addition, swallowed amounts will generally be released into a sewer system within a week, although not necessarily the same system where the dental practitioner is located.

Exhibit 7 - Waste Mercury Generated By One Placement



Location	Flow (l)	Hg Mass (mg)	
		mg	%
[1] One Amalgam Placement	1.0	45.0	100%
[2] Suction Wand	0.9	31.5	70%
[3] Swallowed by Patient	0.1	4.5	10%
[4] Mouthwash into Cuspidor	0.5	9.0	20%

Exhibit 8 - Waste Mercury Generated from Amalgam Procedures (2009)

	Placements	Removals
Waste Hg from One Procedure	0.045 g	0.380 g
Procedures Per Year	671,558	1,113,100
Hg Waste Generated (Kg/yr)	30	423
	453 Combined	
Less 10% Swallowed (Kg/yr)		45
Net Waste Generation (Kg/yr)		408

3.5 Metric #2 - Step 3: Mercury Discharge vs. BMPs Use

The relative amount of mercury wastes that a dental practice actually discharges to the sanitary sewer depends upon several key factors:

- successful use of best management practices;
- operation of an amalgam separator; and
- the type of vacuum system.

This study first estimates the use of available dental amalgam controls, and then forecasts how much mercury is: (1) captured using BMPs and amalgam separators; and (2) discharged in each wastewater agency's service area.

Best Management Practices (BMPs) - Four waste management techniques are used here to estimate how much amalgam waste is captured by the typical vacuum system. These are:

1. avoid use of vacuum line cleaners that contain bleach;
2. do not rinse chairside traps into a sink;
3. do not rinse vacuum system pump screens into a sink; and
4. collect, store, and dispose of wastes properly.

The Fall 2009 BACWA survey provides data on BMP use in 19 sanitary sewer districts. Exhibit 9 shows these data for BMP #1, "Avoid Use of Bleach Line Cleaners", compared to the level of outreach effort that each district has accomplished. Charts for the other BMPs are similar.

Exhibit 9 shows a weak but noticeable relationship between BMP use and the level of sanitary district outreach effort. This relationship, summarized by the high and low trend lines, is used to extrapolate probable BMP use in districts for which data are not yet available. The upper trend line assumes that BMP use is 100% at the time of inspection. The lower trend line (dashed) reflects sites not yet adopting a BMP before being inspected.

Amalgam Separator Operation - Installation and proper use of an amalgam separator can divert additional waste amalgam beyond what is captured by using BMPs. The Fall 2009 BACWA survey provides data on separator use in 32 of the sanitary sewer districts. Exhibit 10 shows these data with trend curves for separator use compared to the level of outreach effort that each district has accomplished.

As with BMPs, the approximate relation between program level and separator installation was used to extrapolate placeholder numbers for districts for which there are as yet no data.

Exhibit 9 - Reported Use of BMP#1 (Avoid Bleach Line Cleaner)

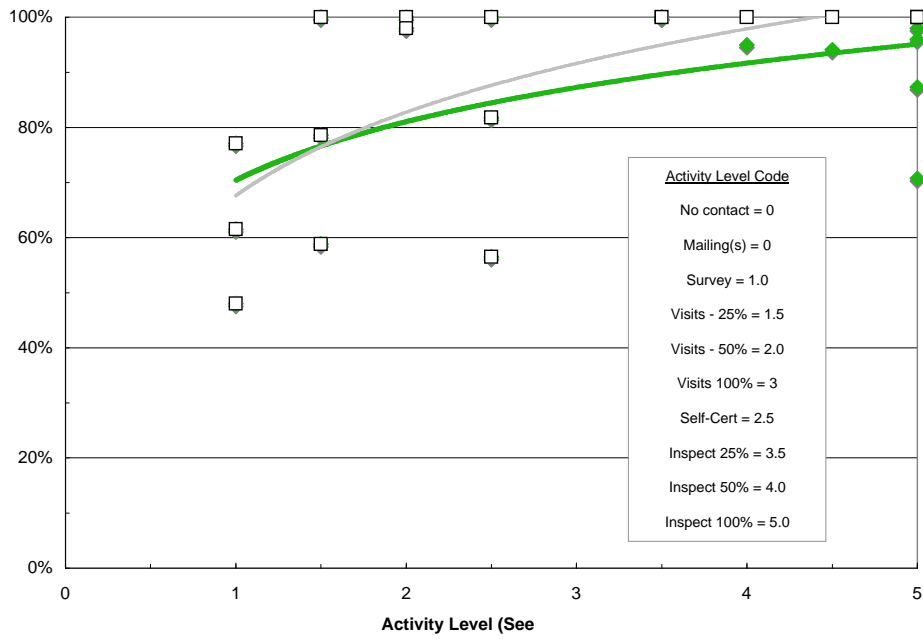
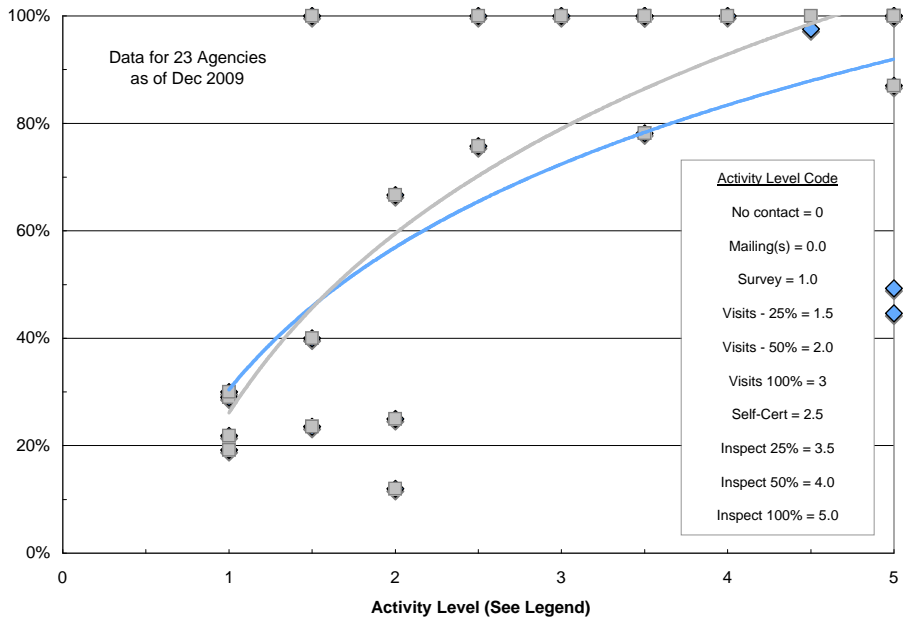


Exhibit 10 - Reported Separator Installations (2009)



Vacuum System Types - Until an amalgam separator is installed, a dry turbine vacuum system will tend to discharge a greater fraction of amalgam wastes than will a comparable wet vacuum pump. This disparity arises because the latter has a fine mesh screen that collects amalgam particles, while the former does not. About 75% of dental practices are served by this kind of vacuum [Ref 3, 4].

Amalgam waste studies published by San Mateo and San Francisco quantify these differences between vacuum systems, and base their overall mercury discharge estimates on detailed data for each dental practice [Ref 3, 4]. These two studies are used here to extrapolate the capture and discharge of waste mercury in other service areas.

Mercury Discharge For One Procedure - Exhibits 11 and 12, taken together, show a mass balance for one placement procedure in a dental office equipped with a wet-seal vacuum pump.

Exhibit 11 presents a mass balance diagram that shows how waste mercury moves from chairside, through the vacuum system, and into the sanitary sewer. This diagram includes a cuspidor that flows into the vacuum system, an arrangement that is typical but not universal.

In order to estimate the mercury discharges to each collection system, a set of 6 different cases was developed, each one relating to a different level of BMP use. Exhibit 12 presents the 6 cases (labeled A through F), and shows how using one or more of the four BMPs and having an amalgam separator captures more of the waste mercury so that less is discharged into the sewer.

A similar approach was used to estimate mercury waste discharges for individual removal procedures, and for both kinds of procedures in offices served by dry vacuum systems.

Case F, which represents dental offices that have an amalgam separator, assumes that during typical office operations, such a separator attains 90% removal efficiency. This assumed removal efficiency is less than the 95% and greater efficiencies attained during ISO 11143 laboratory tests because it has been documented that, in practice, amalgam separator removal efficiency is generally less than that calculated under lab test conditions [Ref 7]. This assumption has a fairly significant impact upon the estimate of mercury discharged

Exhibit 11 - Dental Waste Mercury Mass Balance Diagram

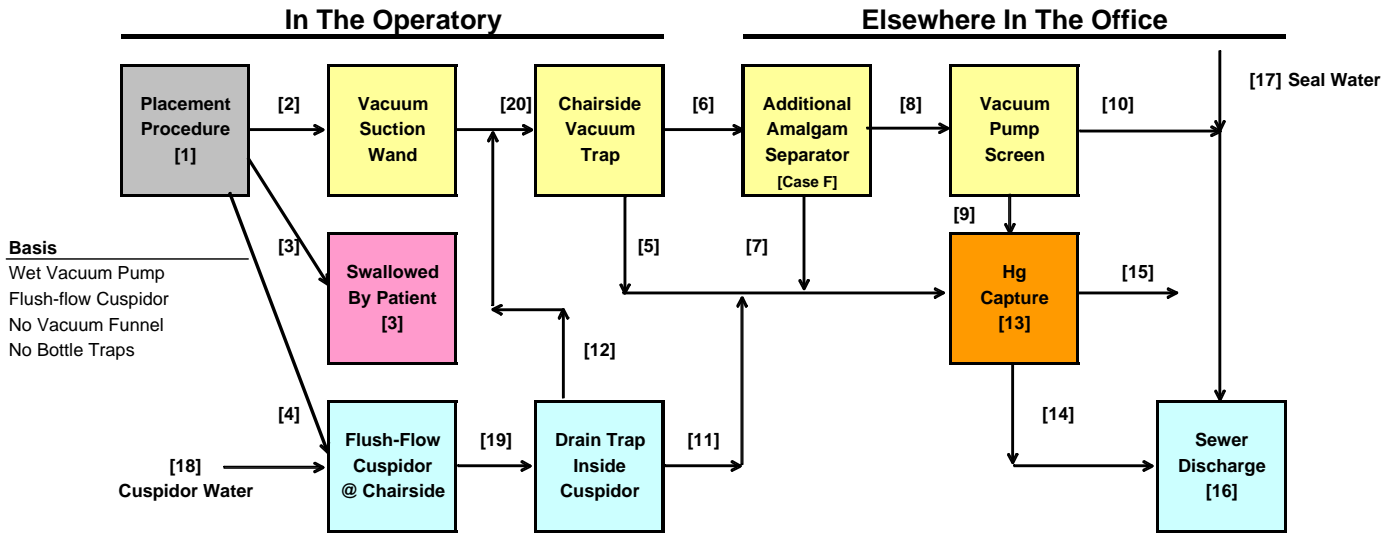


Exhibit 12 - Dental Mercury Discharges for Various BMP Use Levels
[See larger version in the appendix]

Location	Flow (l)	A: No BMPs or ARE		B: BMP 1 Only		C: BMP 1 & 2 Only		D: BMP 1, 2, & 3 Only		E: All BMPs		F: All BMPs & ARE	
		Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%
[1] One Amalgam Placement	1.0	45.0	100%	45.0	100%	45.0	100%	45.0	100%	45.0	100%	45.0	100%
[2] Suction Wand	0.9	31.5	70%	31.5	70%	31.5	70%	31.5	70%	31.5	70%	31.5	70%
[3] Swallowed by Patient	0.1	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%
[4] Mouthwash into Cuspidor	0.5	9.0	20%	9.0	20%	9.0	20%	9.0	20%	9.0	20%	9.0	20%
[5] Vacuum Trap Capture	0.0	23.2	60%	23.2	60%	23.2	60%	23.2	60%	23.2	60%	19.4	50%
[6] Pass Vacuum Trap	1.4	15.5	40%	15.5	40%	15.5	40%	15.5	40%	15.5	40%	19.4	50%
[7] Amal. Separator Capture	0.0	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	17.4	90%
[8] Pass Amalgam Separator	1.4	15.5	100%	15.5	100%	15.5	100%	15.5	100%	15.5	100%	1.9	10%
[9] Vacuum Screen Capture	0.0	3.9	25%	7.7	50%	7.7	50%	7.7	50%	7.7	50%	0.4	20%
[10] Pass Vacuum Pump Screen	1.4	11.6	75%	7.7	50%	7.7	50%	7.7	50%	7.7	50%	1.5	80%
[11] Cuspidor Trap Capture	0.0	1.8	20%	1.8	20%	1.8	20%	1.8	20%	1.8	20%	1.8	20%
[12] Pass Cuspidor Trap	0.5	7.2	80%	7.2	80%	7.2	80%	7.2	80%	7.2	80%	7.2	80%
[13] Total Capture	0.0	28.9		32.8		32.8		32.8		32.8		39.0	
[14] Release to Sinks	0.0	27.4		30.7		8.2		1.6		0.0		0.0	
[17] Vacuum Pump Seal Water	2.5	0.0		0.0		0.0		0.0		0.0		0.0	
[18] Cuspidor Water Flow	1.0	0.0		0.0		0.0		0.0		0.0		0.0	
[19] Cuspidor Wastes into Trap	1.5	9.0		9.0		9.0		9.0		9.0		9.0	
[20] Waste into Vacuum Trap	1.4	38.7		38.7		38.7		38.7		38.7		38.7	
[3] Swallowed by Patient	0.1	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%
[15] Diverted from Sewer	0.0	1.4	3%	2.0	5%	24.5	55%	31.1	69%	32.8	73%	39.0	87%
[16] Sewer Discharge	4.9	39.1	87%	38.5	86%	16.0	35%	9.4	21%	7.7	17%	1.5	3%

Note: "ARE" = Amalgam removal equipment", another term for amalgam separator.

Exhibit 13 summarizes the six alternative cases in which the estimated mercury discharge from the average dental practice is tied to its level of BMP use. In this analysis, Case A results in the most waste mercury discharge, while Case F results in the least. This table shows that amalgam practitioners discharge from 3% to 87% of the waste mercury that they generate, depending upon their level of BMP use.

At the end of 2009, about two-thirds of the dental practices in the Bay Area can be characterized by Cases D, E, or F. In the Baseline Year, i.e., before dental amalgam source control programs, most dental practices fit into the range of Cases C and D.

Exhibit 13 - Waste Mercury Discharge from One Amalgam Procedure

	One Placement	One Removal
Hg Waste	0.045 g	0.380 g
Less what patient swallows	- 0.0045 g	- 0.038 g
Net Operatory Waste	0.0405 g	0.342 g
Case	Net Hg Discharge [1]	Net Hg Discharge [1]
A: No BMPs or Separator	87% .039 g	87% .33 g
B: Using BMP #1 Only	86% .039 g	86% .33 g
C: BMP #1 & #2 Only	35% .016 g	35% .13 g
D: BMP #1 - #3 Only	21% .009 g	21% .08 g
E: All Four BMPs	17% .008 g	17% .06 g
F: All Four BMPs & Separator	3% .001 g	3% .01 g

[1] These discharge percentages are of the total amount of waste generated by one procedure (i.e., 0.045g for a placement, and 0.38g for a removal).

3.6 Metric #2 - Step 4: Estimated Mercury Discharges - 2009

As of December 2009, it is estimated that 68 Kg/yr (15%) of the 453 Kg/yr of mercury wastes generated by amalgam practitioners are discharged directly to the sanitary sewer. The remaining 85% are: swallowed by patients (10%); or are captured by traps, screens, and amalgam separator units in the vacuum system (75%).

These results were estimated by combining the applicable discharge cases ("A" through "F") with the specific BMP and separator use levels reported in the Fall 2009 survey by each sanitary sewer district. Exhibit 14 summarizes the outcome of this process.

Exhibit 14 - Dental Waste Mercury Discharges For Each District (2009)

Dist. No.	Generated Hg		Captured Hg		Discharged Hg	
	g/yr		g/yr	Pct	g/yr	Pct
1	340		-330	-97%	10	3%
2	58		-53	-92%	4	8%
3	439		-380	-87%	59	14%
4	255		-223	-87%	33	13%
5	34,887		-33,432	-96%	1,455	4%
6	11,487		-6,425	-56%	5,062	44%
7	8,509		-4,918	-58%	3,591	42%
8	256		-170	-66%	87	34%
9	6,382		-3,689	-58%	2,693	42%
10	2,663		-2,049	-77%	613	23%
11	5,531		-4,936	-89%	595	11%
12	3,914		-3,797	-97%	117	3%
13	7,318		-7,098	-97%	220	3%
14	41,783		-40,530	-97%	1,253	3%
15	45,268		-37,255	-82%	8,012	18%
16	9,695		-7,299	-75%	2,396	25%
17	2,553		-1,690	-66%	863	34%
18	340		-259	-76%	82	24%
19	1,687		-845	-50%	843	50%
20	681		-603	-89%	78	11%
21	4,255		-2,816	-66%	1,438	34%
22	1,821		-1,389	-76%	432	24%
23	25,793		-25,019	-97%	774	3%
24	3,278		-1,895	-58%	1,383	42%
25	2,574		-2,331	-91%	243	9%
26	414		-239	-58%	175	42%
27	213		-123	-58%	90	42%
28	43,826		-42,511	-97%	1,315	3%
29	136,144		-112,047	-82%	24,097	18%
30	10,097		-8,400	-83%	1,696	17%
31	425		-246	-58%	180	42%
32	2,638		-1,709	-65%	929	35%
33	1,927		-1,121	-58%	807	42%
34	12,995		-9,837	-76%	3,158	24%
35	6,041		-4,934	-82%	1,108	18%
36	9,129		-8,689	-95%	440	5%
37	5,616		-4,542	-81%	1,074	19%
38	1,957		-1,474	-75%	483	25%
39	43		-25	-58%	18	42%
	453,231				67,904	
	453	Kg			68	Kg

Note: Extra digits included to show arithmetic, not to imply accuracy.

3.7 Metric #2 - Step 5: Estimated Mercury Discharges - Baseline

The second program metric calls for an estimate of mercury discharge reductions.

A necessary step in making that estimate is to establish a "baseline" that quantifies discharges before local source control programs had started their efforts.

Detailed pre-program data are available for five sewer systems: Palo Alto, San Mateo, San Francisco - Oceanside, San Francisco - Southeast, and Union Sanitary District [Ref 3 - 6]. These data include practitioners, procedures done, BMP use, separator installations, and vacuum system types for dental offices in the respective service areas.

It was decided to use a weighted average of these pre-program data to represent conditions at other Bay Area agencies, as shown by Exhibit 15. Note that the mercury waste generated in the San Francisco Oceanside service area is included in developing the baseline discharge percentage, even though this district does not discharge into the Bay.

Exhibit 15 - Waste Mercury Discharges For Five Districts (Baseline)

District	Practitioners	Hg Waste		Captured Hg		Discharged Hg	
		(g/yr)	Pct.	(g/yr)	Pct.	(g/yr)	
Palo Alto	221	25,875	-69%	-17,854	31%	8,021	
San Francisco - SE	510	47,439	-73%	-34,582	27%	12,856	
San Francisco - OS	192	16,074	-71%	-11,405	29%	4,668	
San Mateo	83	10,773	-56%	-6,066	44%	4,707	
Union Sanitary Dist	267	27,819	-79%	-21,977	21%	5,842	
		<u>127,980</u>	<u>-72%</u>	<u>-91,883</u>	<u>28%</u>	<u>36,094</u>	

The average discharge of 28% is used as a baseline for the other agencies in this study, except where the 2009 estimated discharge for an agency is more than this percentage (Exhibit 14). In these cases the 2009 percentage was assumed to be the baseline. This assumption affects about 10% of the amalgam practitioners in the Bay Area.

3.8 Metric #2 - Step 6: Estimated Reduction in Mercury Discharges

Exhibits 16 and 17 combine information from the Baseline and 2009 estimates to indicate the amount of mercury discharge reduction that has occurred through the programs in each service area. Exhibit 16 shows the estimated change for each district, while Exhibit 17 shows overall totals.

Overall the decrease in dental mercury discharges as of 2009 is about -64 Kg/yr (i.e., from 132 Kg/yr down to 68 Kg/yr), which is about -48%.

Exhibit 16 – Estimated Change in Dental Waste Mercury Discharges For 39 Districts

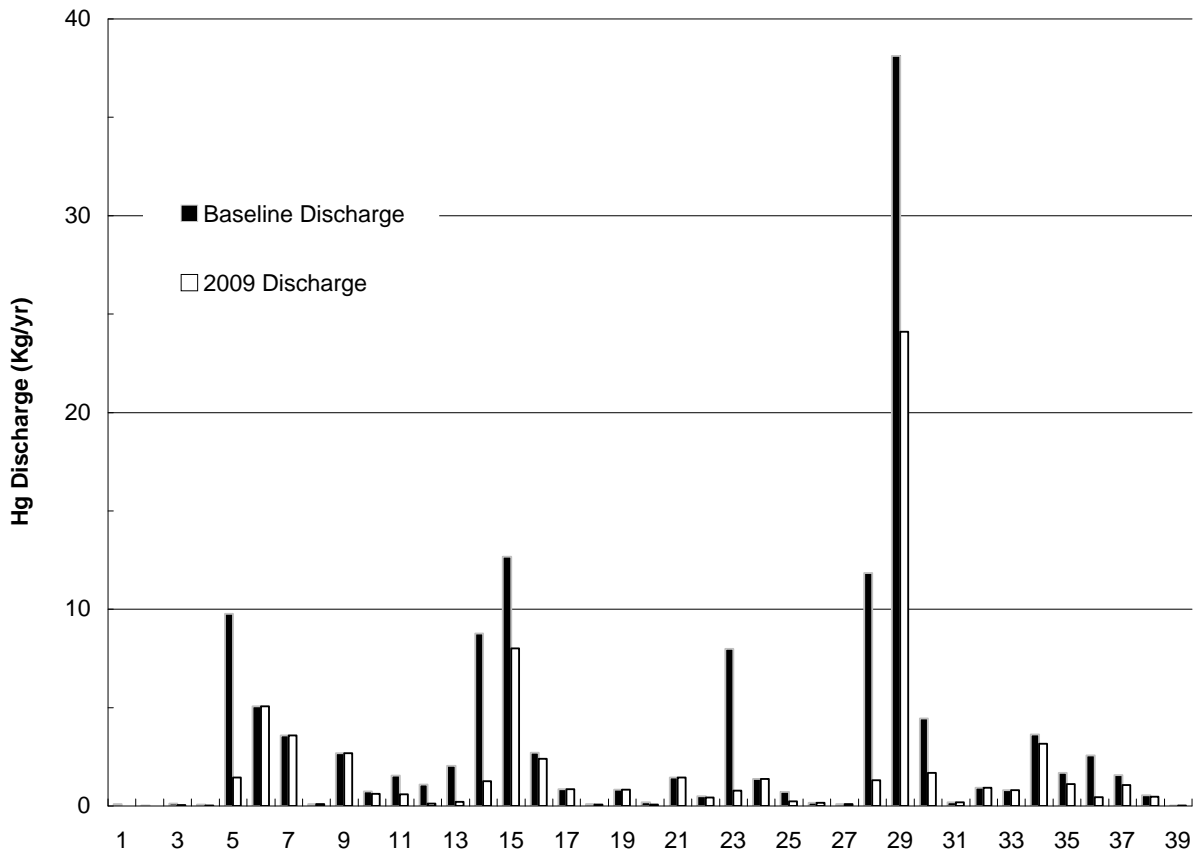


Exhibit 17 - Estimated Change in Waste Mercury Discharges

Hg Discharge Before Programs

Waste Gen (Kg/yr)	453
Pct. Disch	29%
Waste Disch (Kg/yr)	132

Present Hg Discharge (2009)

Waste Gen (Kg/yr)	453
Pct. Disch	15%
Waste Disch (Kg/yr)	68

Discharge Reduction (2009)

Reduced Waste Disch (Kg/yr)	-64
Pct Reduction	-48%

As discussed above, this estimate assumes amalgam practitioners in each district have the same average baseline in which they discharge 28% of their generated waste mercury to the sanitary sewer (per Exhibit 15).

The current (2009) level shown for each district is based upon data from the Fall 2009 survey. The best level attained to date is an estimated reduction in net mercury discharge down to 3±% of the baseline amount generated by dental practices in the district.

3.8 Metric #2 - Step 7: Compare Results with Agency Effluent Reporting Data

As a quality assurance check, the estimates of dental mercury discharges to the sanitary sewer (Exhibit 14) were correlated back to the agency effluent results reported in the BACWA 2009 Mercury Group Report. In order to correlate dental mercury discharges with effluent data, one needed to have information about the percent removal at each individual facility. This information was obtained for 6 agencies. For each of these 6 agencies, their mercury influent was calculated from their reported 2009

effluent data and their percent removal efficiency. This estimated influent mass was compared to the results in Exhibit 14. In each case the numbers compared favorably. For each of the 6 agencies, the values in Exhibit 14 were lower than total estimated influent. On average the dental discharge estimated in this analysis was 32 percent of the estimated influent, with that fraction fluctuating from a much higher percentage for agencies with new dental programs to a much lower percentage for agencies with long-standing programs. This provides confidence in the relative accuracy of this analysis.

4. References

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- 3 Palo Alto RWQCP Hg Source Study
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http://sfwater.org/Files/Reports/Hg_Tech_Memo_2.pdf
- 6 Union Sanitary District Hg Source Study
<http://www.unionsanitary.com/environmentalprograms/commercial/moreInfoMercuryPollution.htm>
- 7 Fan, P.L., et al., "Laboratory Evaluation of Amalgam Separators", J. American Dental Assoc 2002; 133 (5): 577.
<http://www.ada.org>

Appendix - Example Mass Balances (Enlarged from Exhibit 12)

Location	Flow (l)	A: No BMPs or ARE		B: BMP 1 Only		C: BMP 1 & 2 Only		D: BMP 1, 2, & 3 Only		E: All BMPs		F: All BMPs & ARE	
		Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%	Hg Mass (mg)	%
[1] One Amalgam Placement	1.0	45.0	100%	45.0	100%	45.0	100%	45.0	100%	45.0	100%	45.0	100%
[2] Suction Wand	0.9	31.5	70%	31.5	70%	31.5	70%	31.5	70%	31.5	70%	31.5	70%
[3] Swallowed by Patient	0.1	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%
[4] Mouthwash into Cuspidor	0.5	9.0	20%	9.0	20%	9.0	20%	9.0	20%	9.0	20%	9.0	20%
[5] Vacuum Trap Capture	0.0	23.2	60%	23.2	60%	23.2	60%	23.2	60%	23.2	60%	19.4	50%
[6] Pass Vacuum Trap	1.4	15.5	40%	15.5	40%	15.5	40%	15.5	40%	15.5	40%	19.4	50%
[7] Amal. Separator Capture	0.0	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	17.4	90%
[8] Pass Amalgam Separator	1.4	15.5	100%	15.5	100%	15.5	100%	15.5	100%	15.5	100%	1.9	10%
[9] Vacuum Screen Capture	0.0	3.9	25%	7.7	50%	7.7	50%	7.7	50%	7.7	50%	0.4	20%
[10] Pass Vacuum Pump Screen	1.4	11.6	75%	7.7	50%	7.7	50%	7.7	50%	7.7	50%	1.5	80%
[11] Cuspidor Trap Capture	0.0	1.8	20%	1.8	20%	1.8	20%	1.8	20%	1.8	20%	1.8	20%
[12] Pass Cuspidor Trap	0.5	7.2	80%	7.2	80%	7.2	80%	7.2	80%	7.2	80%	7.2	80%
[13] Total Capture	0.0	28.9		32.8		32.8		32.8		32.8		39.0	
[14] Release to Sinks	0.0	27.4		30.7		8.2		1.6		0.0		0.0	
[17] Vacuum Pump Seal Water	2.5	0.0		0.0		0.0		0.0		0.0		0.0	
[18] Cuspidor Water Flow	1.0	0.0		0.0		0.0		0.0		0.0		0.0	
[19] Cuspidor Wastes into Trap	1.5	9.0		9.0		9.0		9.0		9.0		9.0	
[20] Waste into Vacuum Trap	1.4	38.7		38.7		38.7		38.7		38.7		38.7	
[3] Swallowed by Patient	0.1	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%	4.5	10%
[15] Diverted from Sewer	0.0	1.4	3%	2.0	5%	24.5	55%	31.1	69%	32.8	73%	39.0	87%
[16] Sewer Discharge	4.9	39.1	87%	38.5	86%	16.0	35%	9.4	21%	7.7	17%	1.5	3%