Methods for Quantifying Mercury and PCB Loads Reduced From Urban Stormwater Runoff

Assessing municipal stormwater program progress towards TMDL wasteload allocations through control measure implementation

Working Draft Technical Memorandum

Prepared for

Bay Area Stormwater Management Agencies Association (BASMAA)

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List of Abbreviations

BASMAA	Bay Area Stormwater Management Agencies Association
LA	TMDL Load Allocations
MPC	Monitoring and Pollutants of Concern
MRP	Municipal Regional Stormwater NPDES Permit
MS4s	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
PCBs	Polychlorinated Biphenyls
POTWs	Publicly owned Treatment Works
SFEI	San Francisco Estuary Institute
TMDL	Total Maximum Daily Load
WLAs	TMDL Wasteload Allocations

PREFACE

This working draft technical memorandum (TM) was developed under the direction of the Bay Area Stormwater Management Agencies Association (BASMAA) and its associated member agencies. This TM is a working draft that is only intended to demonstrate initial concepts regarding methods for quantifying mercury and PCB loads reduced from urban stormwater runoff in the San Francisco Bay Area. This TM should not be construed as a complete or finalized product, but rather a work-in-progress. Methods discussed in the TM are a result of a preliminary review of applicable literature and initial loads reduced formula development. The literature review will continue and loads reduced formulas will be updated in the future based on comments received from stakeholders.

EXECUTIVE SUMMARY - TO BE COMPLETED

1.0 INTRODUCTION

Municipalities in the San Francisco Bay Area (Bay Area) implement numerous measures at the local level in an attempt to control pollutants (e.g., mercury, PCBs, trash and pesticides) from entering urban stormwater runoff and receiving water bodies (e.g., local creeks, the Bay, and Pacific Ocean). Additionally, through tracking, lobbying and direct participation in task forces and committees, municipalities support and influence the development of pollutant control measures[1] that are implemented at the State or national level through regulatory solid and hazardous waste programs (e.g., mercury product recycling programs). These control measures serve as the best management practices (BMPs) municipalities and flood control agencies can implement to reduce potential adverse impacts to beneficial uses (e.g., fish consumption, recreation, and fisheries habitat) of water bodies in the region.

The effectiveness of these control measures can be evaluated in many ways (CASQA 2007, Strecker et al. 2001), but generally requires the collection and/or tracking of data and information that is directly related to the desired result or outcome of implementing the control. With regard to urban stormwater runoff, the effectiveness of a control measure is generally measured using one or more of following three methods:

1. <u>Increases in Awareness/Behavior</u> - Estimating or quantifying changes in awareness, knowledge or behavior of individuals or populations of individuals;
2. <u>Loads Reduced from Sources</u> - Quantifying reductions in the mass (loads) of pollutants from sources entering stormwater; and
3. <u>Runoff and Receiving Water Improvements</u> - Empirical measurements of water quality (stormwater or receiving water) improvements.

Since stormwater pollution is an issue generally created by the actions of residents or businesses, Bay Area urban stormwater management programs (stormwater programs) have historically used surveys and inspections to assess changes in awareness or behaviors, or water quality monitoring data to evaluate improvements in runoff or receiving water quality. As an alternative approach, this technical memorandum presents preliminary methodologies to quantify the load reductions for priority Pollutants of Concern (POCs) from specific urban stormwater runoff control measures. These methodologies are presented here in preliminary form, as a way to assess progress towards regulatory goals promulgated as Total Maximum Daily Load wasteload allocations for mercury and polychlorinated biphenyls (PCBs) and incorporated into Provisions C.11 and C.12 of the Municipal Regional Stormwater Permit (MRP).

1.1 Regulatory Background

1.1.1 PCBs and Mercury Total Maximum Daily Loads (TMDLs)

Based on a determination of water quality impairment of the San Francisco Bay by Polychlorinated Biphenyls (PCBs) and mercury, the San Francisco Bay Regional Water Quality Control Board (Regional Board) recently developed Total Maximum Daily Loads (TMDLs) for these pollutants. The purpose of the TMDLs is to attain water quality standards that will protect sport fishing, human health, aquatic organisms, wildlife and rare and endangered species in the San Francisco Bay. To attain water quality

[1] For the purpose of this document, control measures defined as pollution prevention practices, source controls and treatment controls that Permittees conduct or cause to be conducted.

standards, the TMDLs set regulatory targets and a maximum total allowable pollutant load from all sources combined (i.e., TMDL). Loads reductions needed to obtain the TMDLs are assigned to sources through wasteload (point sources) and load (nonpoint sources) allocations. Urban stormwater runoff was identified as a pollutant source in both the PCBs and mercury TMDLs and was therefore assigned wasteload allocations accordingly.

On February 12, 2008, the federal Environmental Protection Agency approved a Basin Plan amendment incorporating a Total Maximum Daily Load (TMDL) for mercury in San Francisco Bay (Mercury TMDL) and an implementation plan to achieve the TMDL. The amendment was formerly adopted by the Regional Board, the State Water Resources Control Board, and the state Office of Administrative Law. Mercury TMDL targets include: 1) a Baywide suspended sediment mercury concentration of 0.2 mg mercury per kg dry sediment; 2) a large fish target of 0.2 mg mercury per kg fish tissue that applies striped bass; and, 3) a small fish target of 0.03 mg mercury per kg fish for protection of wildlife (i.e., piscivorous birds).

The U.S. Environmental Protection Agency approved a TMDL for PCBs in the San Francisco Bay on March 29, 2010. The Basin Plan amendment incorporating this TMDL and an implementation plan to achieve the TMDL was formerly adopted or approved by the Regional Board, the State Water Resources Control Board, and the state Office of Administrative Law. The PCBs TMDL includes one target, a fish tissue target of 10 ng of Total PCBs[2] per g of fish tissue (white croaker or shiner surfperch).

TMDL Wasteload Allocations

To reach the TMDL targets described above and obtain water quality standards in the Bay for mercury and PCBs, the pollutant reductions are required from each source causing or contributing to Bay impairment. For mercury, a 43% reduction of total mercury discharged to the Bay from all sources combined is required. The largest mercury reductions are required from the Guadalupe River (legacy mining), Central Valley watershed, and urban stormwater runoff. For PCBs, a 24 kg/yr (~70%) load reduction of total PCBs in discharges to the Bay is required from all sources combined to obtain water quality standards. The largest PCB load reductions are required from the Central Valley watershed and stormwater runoff.

The PCBs and mercury TMDL Staff Reports (Regional Board 2006, 2008) provide estimates of pollutants loads from urban stormwater runoff. Additionally, wasteload allocations (i.e., allowable annual discharges) for urban stormwater runoff are assigned by county to Bay Area stormwater programs. Stormwater programs identified in the TMDLs that represent Permittees to the Municipal Regional Stormwater NPDES Permit (see next section) include:

- Santa Clara Valley Urban Runoff Pollution Prevention Program
- Alameda Countywide Clean Water Program
- Contra Costa Clean Water Program
- San Mateo Countywide Water Pollution Prevention Program
- Fairfield-Suisun Urban Runoff Management Program
- City of Vallejo & Vallejo Sanitation and Flood Control District

[2] Based on the use the term "Total PCBs" in the PCBs TMDL, Total PCBs is defined as either: 1) sum of Aroclors; 2) sum of the individual congeners routinely quantified by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary; or 3) sum of the National Oceanic and Atmospheric Administration (NOAA) 18 congeners converted to total Aroclors.

Mercury and PCB TMDL loads, wasteload allocations (WLA), and load reductions assigned to these stormwater programs are included in Table 1-1. Pollutant load reductions represent the goal that stormwater programs should strive to attain through stormwater control measure implementation.

Table 1-1. Mercury and PCB loads, wasteload allocations and load reduction goals for Bay Area Phase I stormwater programs.

Entity	Mercury (kg/yr)			PCBs (kg/yr)		
	Load (2003)	Wasteload Allocation	Required Load Reduction[4]	Load (2003)	Wasteload Allocation	Required Load Reduction[4]
Santa Clara Valley Urban Runoff Pollution Prevention Program	44	23	**21**	5.5	0.5	**5.0**
Alameda County Clean Water Program	39	20	**19**	4.9	0.5	**4.4**
Contra Costa Clean Water Program	22	11	**11**	2.7	0.3	**2.4**
San Mateo County Water Pollution Prevention Program	16.4	8.4	**8**	2.1	0.2	**1.9**
City of Vallejo and VSFCD[1]	3.2	1.6	**1.6**	1.0[3]	0.1[3]	**0.9**[3]
Fairfield-Suisun Urban Runoff Management Program[2]	3.1	1.6	**1.5**			

[1]Vallejo Sanitation and Flood Control District
[2]Includes the City of Fairfield and Suisun City
[3]The PCB TMDL assigns a combined allocation to "Solano County", which only includes discharges from the cities of Vallejo, Fairfield, Suisun City
[4]Load reductions presented in the table were calculated for each stormwater program by subtracting the applicable WLA (originally based on relative populations) from the pollutant load (originally based on relative population).

Wasteload allocations (WLAs) for urban stormwater runoff programs presented in Table 1-1, implicitly include all current and future permitted discharges within the geographic boundaries of municipalities and unincorporated areas. Permitted discharges include those covered under municipal stormwater NPDES permits, and discharges attributable to the California Department of Transportation (Caltrans) roadways and non-roadway facilities and rights-of-way, atmospheric deposition onto the surface of the watershed, public facilities (e.g., schools), properties adjacent to stream banks, industrial facilities, and construction sites.

1.1.2 Municipal Regional Stormwater Permit Requirements

On December 1, 2009, the Municipal Regional Stormwater NPDES Permit (Order R2-2009-0074), also known as the Municipal Regional Permit (MRP), became effective. The MRP applies to all 76 large and medium municipalities (cities and counties) and flood control agencies in the San Francisco Bay Region. In provisions C.11 and C.12, the MRP requires Permittees to implement a series of control measures at full or pilot-scale that are intended to reduce mercury and PCBs in urban stormwater runoff . These control measures include:

- Collection and Recycling of Mercury-containing Devices (Mercury)
- Investigations and Abatement of Sources in Drainages (Mercury & PCBs)
- Evaluations of Enhanced Municipal Sediment Management Practices (Mercury & PCBs)
- Evaluations of On-Site Stormwater Treatment via Retrofits (Mercury & PCBs)

- Diversions to Publicly Owned Treatment Works (Mercury & PCBs)
- Regional Risk Reduction Program Implementation (Mercury & PCBs)
- Identification of POCs During Industrial Inspections (PCBs)
- Evaluations of PCB-Containing Material Manage Practices during Building Demolition and Renovation (PCBs)

In addition to these, Permittees have historically and continue to implement control measures that provide additional reduction in pollutant loads. These control measures include:

- Street Sweeping;
- Stormwater Drainage System Maintenance (e.g., removal of material and sediments from catch basin, drop inlet and pump stations);
- Sediment Management in Channels and Water Bodies;
- New and Redevelopment Controls (e.g. low impact development);
- Public Outreach and Participation; and,
- Tracking and Participating in Regulatory Processes (e.g., bans and recycling requirements of pollutant-containing devices)

Provisions C.11.g and C.12.g require Permittees to develop and implement a monitoring program to quantify mercury and PCB loads reduced through the implementation of these (and other) control measures. Consistent with the TMDLs, load reductions and progress toward urban stormwater runoff WLAs may be demonstrated through one of three methods:

1. Quantify through estimates the average annual mercury load reduced by implementing pollution prevention, source control and treatment control efforts required by the provisions of this permit or other relevant efforts; or
2. Quantify the mercury load as a rolling five-year average using data on flow and water column mercury concentrations; or
3. Quantitatively demonstrate that the mercury concentration of suspended sediment that best represents sediment discharged with urban runoff is below the target of 0.2 mg mercury/kg dry sediment.

Permittees are moving forward on studies to demonstrate loads reduced and WLA progress using each of the methods described above. Water quality monitoring activities conducted through the *Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP)* and the *Bay Area Stormwater Management Agencies (BASMAA) Regional Monitoring Coalition (RMC)* are currently attempting to estimate changes in pollutant loads (Method #2) and concentrations (Method #3). However, due to the diffuse nature of mercury and PCBs in the San Francisco Bay watershed, observable trends in loads and concentrations in creeks and rivers draining to the Bay could take decades. Quantification of loads reduced through pollution prevention, source controls and treatment controls (Method #1) is the focus of this memorandum.

1.2 Purpose and Scope

Methodologies presented in this document are intended to comply with Provisions C.11.g and C.12.g of the MRP. Additional purposes of the loads reduced quantification methods described in this memorandum include:

- Providing MRP Permittees with methodologies to assess progress towards WLAs assigned to urban stormwater runoff in the PCBs and mercury TMDLs;
- Assessing the effectiveness of pollution prevention programs, source control activities and treatment controls currently implemented in the Bay Area; and,
- Developing concepts for developing baseline levels of control measure implementation and commensurate load reductions, which will allow "new or enhanced" load reduction to be quantified.

1.3 Memorandum Organization

This technical memorandum is organized into four sections: 1) Introduction, background and purpose; 2) Mercury and PCB uses, sources and loadings; 3) Loads quantification methods overview, key assumptions and guiding principles; 4) Factsheets for each control measure that include quantification methods, formulas, assumptions, and data inputs and tracking needs; and, 5) References for all citations.

2.0 MERCURY AND PCB USES, SOURCES AND LOADINGS

2.1 Historical and Current Uses and Sources

2.1.1 Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds (known as congeners). PCBs were manufactured in the United States and used widely from the late 1920s through the 1970s. Due to their non-flammability, chemical stability, high boiling point and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics and rubber products; in pigments, dyes and carbonless copy paper and many other applications. Because of their persistent qualities, and physical and chemical characteristics, PCBs are found in environmental media worldwide, including air, sediment from street sweeping and stormwater conveyance systems, sediment and water from flood control channels and receiving waters, and urban stormwater runoff.

The U.S. total production of PCBs by Monsanto has been reported to be approximately 640,000 metric tones (de Voogt and Brinkman 1989). Production peaked in 1970 at approximately 30,000 tones or about 6% of the total U.S. production (Figure 2-1). Approximately 57% of total production occurred between 1960 and 1974 and 73% of the U.S. production occurred between 1955 and 1977. Overall, it appears that total production is proportional to total consumption in the U.S. (Breivik et al, 2002). However, although total consumption of PCBs in the U.S. (and Bay Area) continues to be at zero due to the ban in 1977, PCBs still remain in use in certain equipment and devices (e.g., transformers) and may possibly continue to contribute to urban stormwater runoff in the near future.

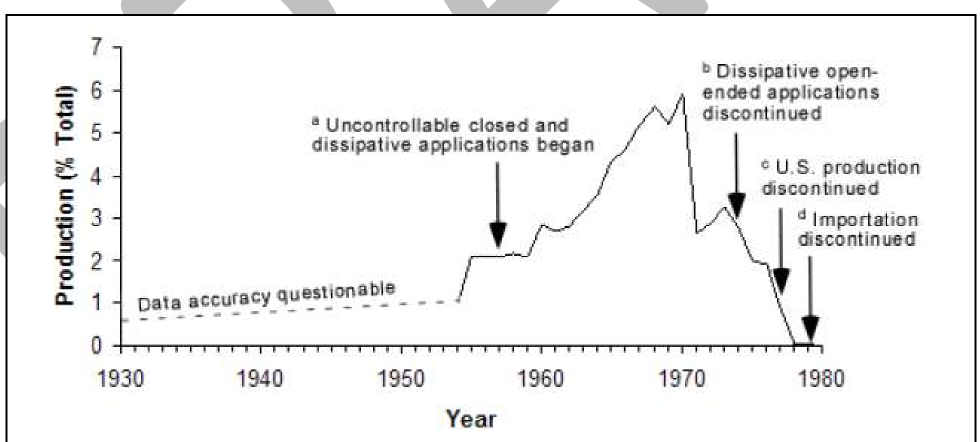

Figure 2-1. Annual production of PCBs in the U.S. from 1930 to 1970 (USEPA 1987).

2.1.2 Mercury

Mercury is a naturally occurring persistent, bioaccumulative metal that can be present in the elemental, inorganic or organic forms in the environment. Historically, mercury has been used in a variety of products. Primary among the over 3,000 historical industrial uses in the U.S. were battery manufacturing and chlorine-alkali production. Paints and industrial instruments have also been among the major uses. Mercury is also used in laboratories for making thermometers, barometers, diffusion pumps, and many other instruments, including mercury switches and other electrical apparatuses. Mercury is used as an electrode in some types of electrolysis and in some types of batteries (mercury cells). Gaseous mercury is used in mercury-vapor lamps (e.g., fluorescent tubes) and advertising signs. Mercury is also the basis of dental amalgams and preparations, and can be a byproduct of burning fossil fuels and refining petroleum.

Mercury production and consumption in the U.S. have decreased dramatically since its use in gold production peaked in the mid/late 1800's (Figure 2-2). In the Bay Area, production was almost entirely from the mercury-rich New Almaden Mining District in Santa Clara County. Consumption of mercury in the U.S. has a similar trend as production. As illustrated in Figure 2-3, mercury consumption has also reduced substantially from 1970 to 2000 (Sznopek 2000), and the mass of mercury in the most current products and devices such as light bulbs and auto switches appear to also be decreasing (NEWMOA 2008). These decreases in mercury uses may assist MRP Permittees in reducing loads of mercury to the Bay.

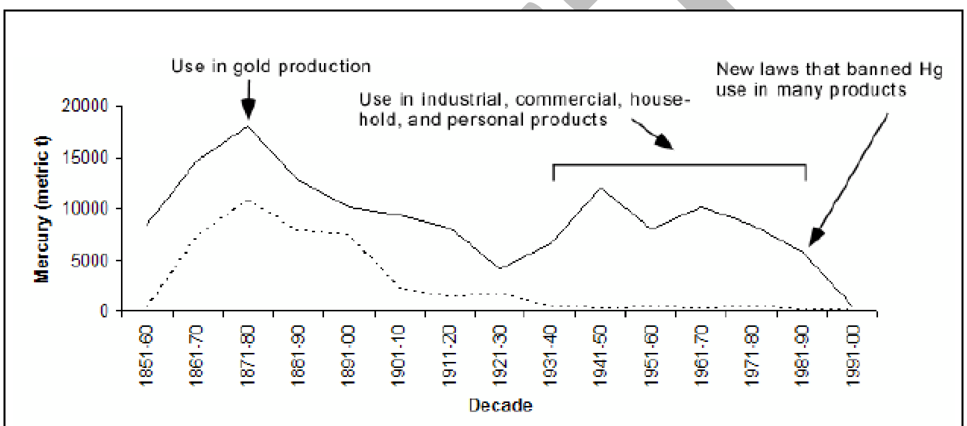

Figure 2-2. Mercury production in the U.S. (dark line) and New Almaden Mining District (dotted line) between 1850 and 2000.

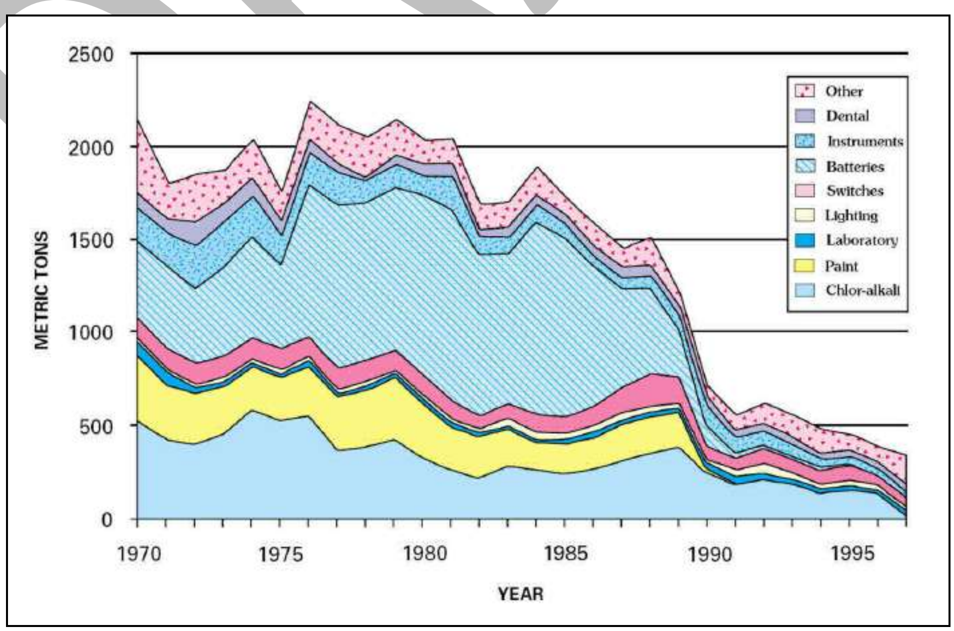

Figure 2-3. Mercury use in the U.S. between 1970 and 2000 (Sznopek 2000).

2.2 Contributions of Pollutant Mass to Stormwater from Sources

In collaboration with BASMAA member agencies, McKee et al. (2006) conducted a thorough literature review on sources and loads of mercury and PCBs entering urban stormwater and developed a mass balance (or conservation of mass) conceptual model based on this information. The intent of the model was to assist managers by providing a framework for identifying the most important mercury and PCBs uses and sources that likely impact Bay Area stormwater runoff. Although disparate information was used to develop the model, it provides the current best estimate of the mass of PCBs and mercury that is contributed to urban stormwater under a steady state scenario. The model also serves as context for management decisions, especially for mercury given its ongoing use (although reduced) in the urban environment and transport via atmospheric deposition. The following sections present the inventory of mercury and PCB sources to urban stormwater runoff based on the current understanding of PCB and mercury uses and linkages to stormwater.

2.2.1 PCBs

As illustrated in Figure 2-4, McKee et al. (2006) estimate that erosion from the surface of the urban watershed is the largest source of PCBs to Bay Area urban stormwater. Watershed surface erosion includes diffuse sources of sediment in urban areas associated with construction sites, vacant lots, unpaved foot paths, and wear debris from road and building surfaces, and represents the mass of PCBs associated with 50+ years of legacy accumulation on the surface of the watershed. Building demolition and remodeling, PCBs that continue to be in use in equipment and devices, and transformers and large capacitors represent the next largest sources. Smaller sources include atmospheric deposition and identified industrial contaminated areas.

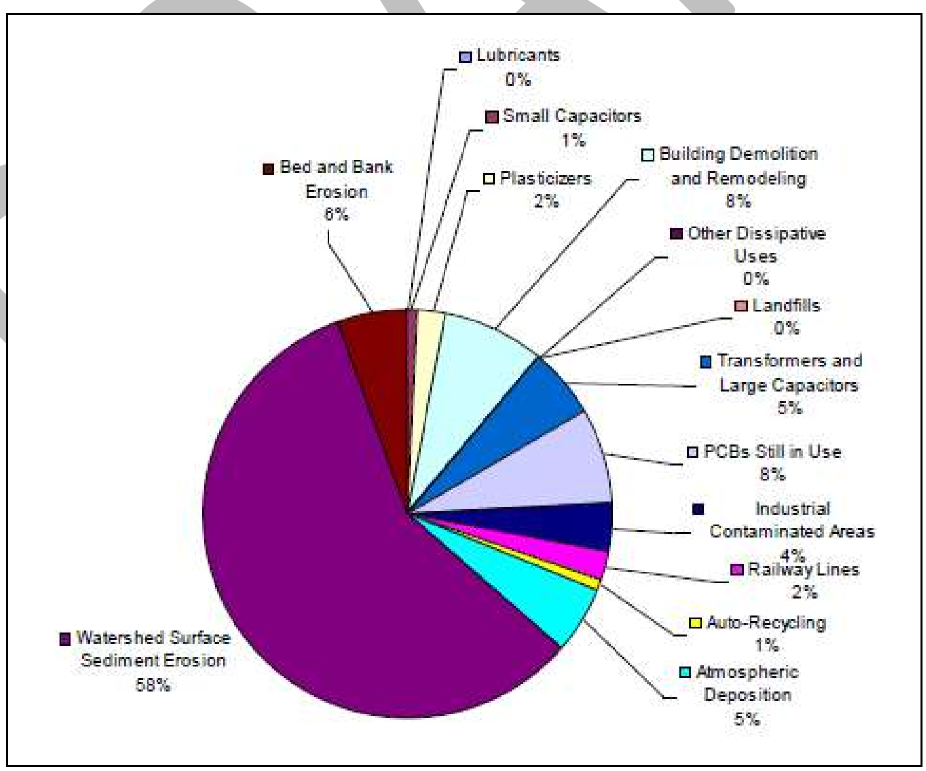

Figure 2-4. Comparison of relative mass inputs of PCBs to Bay Area urban stormwater runoff based on estimates from McKee et al. (2006).

2.2.2 Mercury

Similar to PCBs, McKee et al. (2006) estimate that erosion from the surface of the urban watershed is also the largest source of mercury to Bay Area urban stormwater (Figure 2-5). However, unlike PCBs, atmospheric deposition of mercury to the Bay watershed is estimated to provide a much larger proportion (27%) of the total load to urban stormwater. This suggests that mercury from atmospheric deposition may continue to play an important role in loadings of mercury to the Bay from stormwater. Accidental breakage during transport or disposal of instruments such as barometers, hydrometers, manometers, pyrometers, sphygmomannometers and thermometers, or switches and thermostats that contain relatively large masses of mercury is also suggested to be a large source of mercury to stormwater. Based on these estimates, fluorescent lamps and identified industrial sites with relatively elevated mercury concentrations are far less of a source to stormwater.

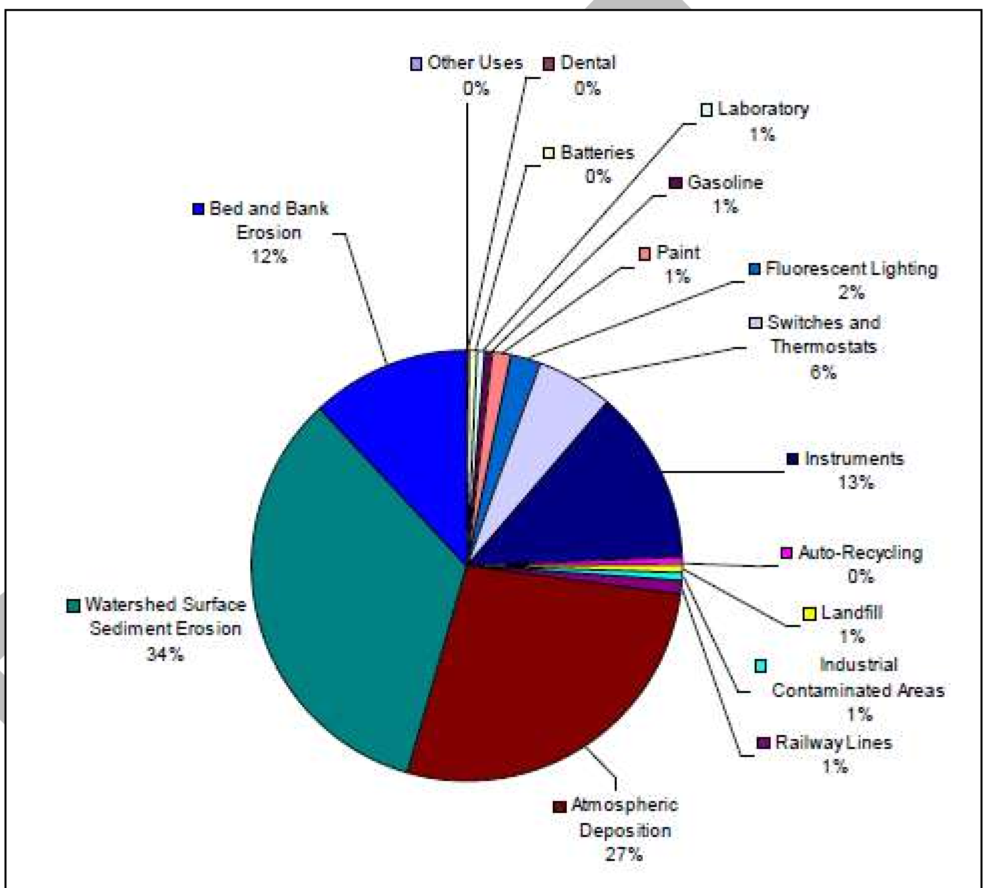

Figure 2-5. Comparison of relative mass inputs of mercury to Bay Area urban stormwater runoff based on estimates from McKee et al. (2006).

One property that distinguishes mercury from PCBs is the fact that mercury bioaccumulation occurs primarily after transformation to methylmercury (methylation). Recent scientific studies have identified monitoring tools to quantify the fraction of mercury most susceptible to methylation – the "reactive mercury" fraction of the total mercury measurement (Marvin-DiPasquale et al. 2009). Studies have also shown that mercury from atmospheric deposition is primarily reactive mercury (Butler 2007). This could mean that stormwater may contain a relatively larger fraction of reactive mercury compared to purely terrestrial sources. If so, water quality benefits could be attained in receiving waters by measures that reduce the fraction of reactive mercury present in the total load. Although there is not sufficient monitoring data at present to make the case for loads reduced or avoided based on reducing the fraction of reactive mercury, that information may be developed over time and submitted to the Water Board for consideration.

3.0 METHODS OVERVIEW, GUIDING PRINCIPLES AND KEY ASSUMPTIONS

This section provides an overview of key concepts, guiding principles and assumptions incorporated into quantitative methods presented in section 4.0 for determining mercury and PCB loads reduced due to control measure implementation. Quantitative methods for evaluating the effectiveness of urban runoff stormwater programs and control measures have been documented by CASQA (2007) and Strecker et al. (2001). These methods were reviewed and incorporated to the extent possible into loads reduced quantification methods presented in the next section. Additionally, information gained through previous evaluations of urban stormwater control measures for PCBs and mercury, sediment and water quality data collected in the Bay Area, and mercury and PCB use and source information described below were heavily utilized.

3.1 Literature Review

3.1.1 Evaluations of Urban Stormwater BMPs for PCBs and Mercury

The San Francisco Estuary Institute (SFEI) received a grant under the Proposition 13 Coastal Nonpoint Source Program to review and evaluate available existing literature on: 1) historical and current PCB and mercury uses, sources, and transport pathways to urban stormwater runoff; 2) PCB and mercury concentrations in stormwater, including considerations of sediment particle sizes; and, 3) current and potential implementation of best management practices (BMPs) used to reduce loadings of sediment-associated contaminants in urban stormwater. In a series of reports completed as part of the project, uses, sources and conceptual models of mercury and PCB in the urban environment and stormwater (McKee et al. 2006; Rothensberg et al. 2010); geographical distributions of mercury and PCBs in Bay Area sediments (Yee and McKee 2010); and realized and potential control measure effectiveness (Mangarella et al. 2008; SFEI 2010) were documented. Additionally, factors that affect the treatability of these pollutants and the efficacy of treatment devices in removing mercury and PCB from stormwater in the drainage network were summarized (Yee and McKee 2010; SFEI 2010). These studies provide the most complete picture on the effectiveness of pollution prevention, source and treatment control measures of control measures to reduce mercury and PCBs in urban stormwater runoff, and therefore associated results and conclusions were heavily relied upon in the development of quantification methods presented in this technical memorandum.

3.1.2 Pollutant Characterization Studies

As described above, geographical distributions in concentrations of mercury and PCBs in watershed sediments throughout the Bay area are summarized in Yee and McKee (2010). A portion of these data were collected by municipal stormwater programs through initial studies (EOA 2002, ACCWP 2002) and follow up case studies focused on PCBs (Citiations), and evaluated during the development of quantification methods. These data were most useful in developing average concentrations of PCBs and mercury in sediment within stormwater drainage systems (e.g., catch basins, drop inlets and pump stations), which were need to quantify average loads of these pollutants removed via drainage system maintenance (i.e., sediment removal).

3.1.3 Street Sweeping Studies

Throughout the past three decades, scientists and engineers have conducted numerous studies designed to assess the effectiveness and efficiencies of municipal street sweeping programs (EOA 2007). These studies have been previously summarized by EOA (2007) as part of a study designed to calculate pollutant loads removed via street sweeping in Contra Costa County, and Mangarella et al. (2008) as part of a desktop evaluation of control measure scenarios to reduced PCBs and mercury in bay Area stormwater. Lessons learned from these studies were incorporated into loads reduced calculations for street sweeping that are presented in section 4.0. Additional information on PCB and mercury concentrations in materials collected by street sweepers in the Bay Area, composition of the material, sediment particle sizes, and geographical distributions based on land uses and age-of-urbanization were also heavily utilized.

3.1.3 Additional Mercury and PCB Use and Source Information

Information on current and historical uses of mercury and PCBs was also obtained during the literature review. Specifically, to develop load reduction estimates for pollution prevention activities (e.g., recycling programs) the number and volume of devices, equipment and materials that contain mercury and PCBs, and the current and historical mass of these pollutants in each device was obtained. Information from reports on mercury flow analyses (Barr Engineering 2001), device recycling rates (ALMR 2003, DTSC 2008, USEPA 2009, CIWMB 2009), content (NEMA 2008, DTSC 2008) and emissions (Barr Engineering 2001, USEPA 2008) were utilized. Bay Area specific air emission and deposition rates of mercury were also obtained (Rothensberg 2010; Tsai and Hoieneke 2001) to assess load reductions due to improved deposition of mercury onto the Bay watershed.

3.2 Control Measures Evaluated

The following sections briefly describe the control measures initially identified by Permittees as those that should be considered for development of loads reduced methodologies. Based on the availability of information on baseline, current and anticipated implementation levels, pollutant concentrations associated with loads removed, and control measure effectiveness, Permittees may choose to develop quantification methods for additional control measures.

3.2.1 Pollution Prevention

Pollution prevention programs and activities are intended prevent pollutants that are present within materials, devices and equipment from entering the environment and contributing to stormwater pollution. Pollution prevention control measures specific to mercury and PCBs are those that reduce the quantities of these pollutants in products and equipment through voluntary or regulatory approaches (e.g., mercury thermometer recycling programs), prevent accidental release or spills into the environment (e.g., industrial facility inspections), or assist in the recycling of materials that contains these pollutants (e.g., fluorescent lamps, switches, thermostats and transformers). These controls are implemented either directly by Permittees and associated solid waste programs in the Bay Area, or by other regulatory programs in which Permittees actively support, advocate or assist in implementing. More specific descriptions of pollution prevention measures anticipated for implementation are included in section 4.0.

Loads reduced quantification methods for the following pollution prevention control measures are included in this document:

- Fluorescent Lamp Recycling (Mercury)
- Thermostat Recycling (Mercury)
- Reduction of Pollutants from Local Atmospheric Sources (Mercury)

The effectiveness of these measures with respect to stormwater runoff is not easily evaluated given that it is difficult to determine to what extent such mercury and PCBs in these materials would enter urban stormwater compared to other disposal options (e.g., landfills, sanitary sewer system). Therefore, uncertainties remain in loads reduced estimates for pollution prevention measures. Additional control measures for which loads reduced quantification methods may be developed in the future include: stormwater inspections at industrial and commercial facilities (PCBs and mercury), thermometer and auto switch recycling (mercury) and building demolition and renovation waste management (PCBs).

3.2.2 Source (Institutional) Controls

There is no universally accepted definition of "source control" as it pertains to stormwater management. Some practitioners refer to source controls as "non-structural controls", and many times they are confused with pollution prevention measures described in the previous section. For the purpose of this document, source controls are defined as institutional non-treatment measures that remove pollutants directly from streets, contaminated properties, stormwater conveyance systems, channels or receiving waters once they have already entered the environment.

For decades, MS4s have implemented source controls that have directly or indirectly helped to improve water quality in the Bay Area. For example, street sweeping on roads and parking lots, although mainly targeted at removing trash and other road related debris, also removes pollutants like PCBs and mercury that strongly attach to particles. Source controls have also helped to establish (and limit) the baseline load condition depicted in the PCB and Mercury TMDLs through load and wasteload allocations. Loads reduced quantification methods for the following source (institutional) control measures are included in section 4.0:

- Street Sweeping (Mercury and PCBs)

Quantification methods will also likely be developed for stormwater conveyance system maintenance, sediment management in channels and water bodies, hydromodification controls and low impact development (LID). Methods for quantifying contaminated property remediation (mercury and PCBs) may also be developed as additional data on the effectiveness of this control measure is evaluated through pilot projects implemented as part of BASMAA's Clean Watersheds for a Clean Bay (CW4CB) project that is intended to comply with MRP requirements.

Because these actions physically remove pollutants from the environment, the process of quantifying the effectiveness of source controls is much more straight-forward and intuitive than pollution prevention activities. Additionally, as described in the previous section, scientist and engineers have conducted many studies aimed at quantifying the effectiveness of source controls. These studies provide numerous datasets and information to base loads reduced quantification tools described in this document.

3.3.3 Treatment Controls

Stormwater treatment controls are engineered devices or systems that can be installed or built in place to enhance the capture of pollutants. Treatment controls have a variety of modes of operation including those that slow down the movement of water, remove sediment and associated contaminants through filtering, settling, or otherwise separating sediment from flowing water, or adsorb and incorporate the substance into some kind of media (e.g. carbon, resin, or living plant material). For the purposes of this document, treatment controls include both those installed or built on-site or within a public right-of-way, and diversions of stormwater (wet and dry weather) runoff to publically owned treatment works (POTWs).

A variety of treatment controls have been implemented throughout the Bay Area to control stormwater impacts on receiving waters (LFR 2004). The impetus for implementation of these controls, however, was not associated with concerns of PCBs or mercury and effectiveness monitoring was generally not conducted in a manner to yield load reduction estimates. Additionally, little to no data are available outside of the Bay Area on the effectiveness of treatment controls to reduce PCBs or mercury in urban runoff (McKee et al. 2006), other than scenarios described in Mangarella et al. (2008) that were based on their current understanding of demonstrated performance of various treatment controls for reductions of total suspended solids (Winer 2000, CASQA 2003, CalTrans 2004, ASCE and USEPA 2008, CalTrans 2010) and PCB and mercury settling studies (Yee and McKee 2010). Based on these sources, Figure 3-1 provides the estimated median BMP effluent concentrations of a number of stormwater treatment controls and is provided here primarily to represent the relative effectiveness of these controls types.

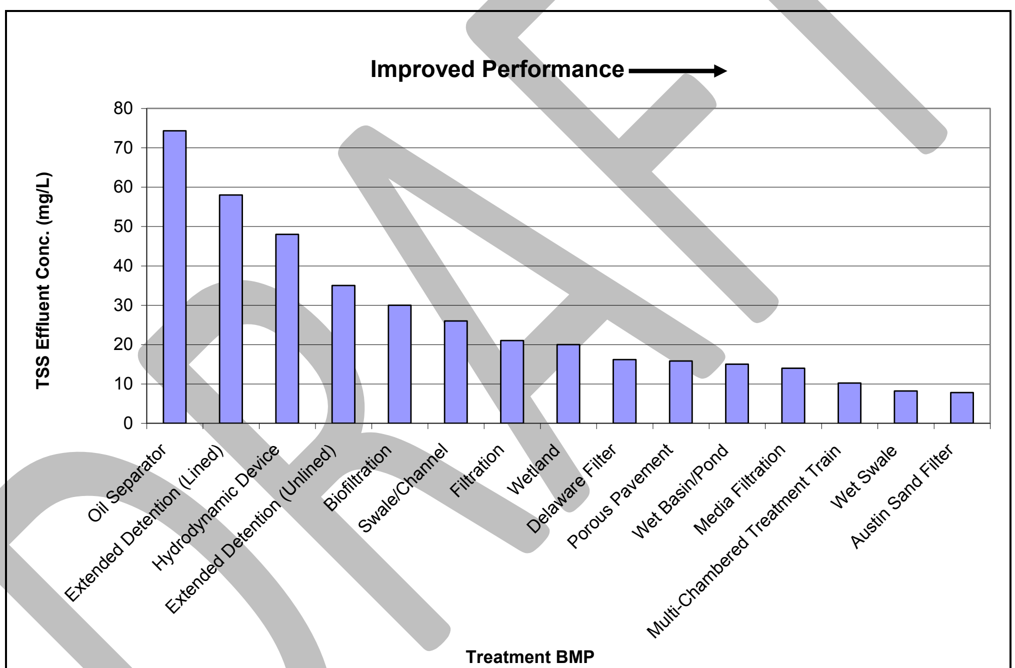

Figure 3-1. Estimated concentrations of total suspended solids (TSS) for various stormwater treatment controls (Mangarella et. al 2008).

Based on the limited data available on treatment controls with regard to their effectiveness in reducing PCB and mercury loads in urban stormwater runoff, quantitative methods for these control measures are not included in this technical memorandum at this time. That said, as described in section 1.1.2, Permittees will be implementing a variety of BMP effectiveness projects, treatment controls and diversions to POTWs at pilot-scales during the term of the MRP through the CW4CB project. Information collected on the effectiveness of these control will assist Permittees in developing load reduction quantification methods. As information becomes available, Permittees, stormwater programs or BASMAA may choose to update section 4.0 with fact sheets describing methods for quantifying the loads reduced via treatment controls.

3.4 Load Reduced Quantification Methods Overview

Quantification methods for assessing mercury and PCBs loads reduced that are presented in section 4.0 were based on a robust review of published and grey literature conducted through this and previous projects (see section 3.1). Quantification methods are intended to assist MRP Permittees in assessing loads of mercury and PCBs reduced through control measures that they have directly implemented (e.g., street sweeping, or assisted in causing the control measure to be implemented (e.g., changes in regulations). This section provides an overview of the guiding principles, key assumptions and concepts behind the methods presented in section 4.0. As quantification methods evolve through trial implementation, assumptions and concepts presented in this section should be adjusted accordingly.

3.4.1 Guiding Principles

Reductions in pollutant loads can be quantified in many ways. To provide transparency in the thought process behind the quantification methods presented in section 4.0, principles that guided the development of these methods are presented below.

- **Quantification methods are constrained by the extent of information available** – Only the information readily available on control measure effectiveness, degree of control measure implementation, concentrations and masses of pollutants in materials/devices/equipment, and baseline loads and loads reduced can be used to develop quantification methods and track annual load reductions. In some cases, information is very limited and assumptions therefore have to be made. Although these assumptions create uncertainties in load reduction calculations, if stated clearly and transparently, assumptions can be tested and revised accordingly as methods evolve.
- **Methods should be as simple and data inputs as tractable as possible** – As a general principle in creating the loads reduced formulas presented in section 4.0, the amount of information that Permittees are required to track as inputs to the formula was considered. In most cases, data that Permittees or stormwater programs will need to track and input into the loads reduced formulas consists of information they collect and submit to the Water Board as part of their Annual Reports. In limited cases, additional information included in reports submitted to State of California by other public agencies or private entities may need to be obtained to provide a complete picture of loads reduced from urban stormwater runoff during a specific year. Such cases are identified in the fact sheets.
- **Pollutant loads reduced targets serve as the goal to achieving WLAs** – The mercury and PCB TMDLs include both baseline loads (circa 2003) and wasteload allocations (WLAs) for urban stormwater runoff. The difference between the two is assumed to be the pollutant load that stormwater programs (and associated Permittees) need to reduce on an annual basis (see section 1.1.1) through control measure implementation. Realistically, however, the pollutant load discharged from urban stormwater runoff to the Bay fluctuates (possibly higher or lower) between years depending rainfall/runoff patterns, pollutant mobility, changes in sales and content of pollutant containing devices, and the degree of control measure implementation. Methods that can be used to estimate annual loads include mass-balances, empirical monitoring and simple or dynamic modeling. That said, given the inherent variability and uncertainties in quantifying urban runoff loads to the Bay on an annual basis, regardless of the method used , it is assumed for the purposes of assessing progress toward WLAs that the annual average loads of PCBs and mercury included in the TMDLs provides the baseline for which loads reduced will be measured, at least until new monitoring and modeling approaches developed through the

Regional Monitoring Program (RMP) Small Tributary Loading Strategy (STLS) yield updated loads information for PCBs and mercury.

- **<u>Baseline levels of control measures implemented at the time loading estimates were developed (i.e., 2003) are implicitly incorporated into pollutant load estimates from urban runoff to the Bay</u>** – Sediment and water quality data used to establish baseline loads in the TMDLs were collected circa 2003. As a simplifying assumption, control measures implemented (at associated pollutant loads reduced) at the time these data were collected are assumed to establish the baseline level of implementation for loads reduced by new or enhanced controls are compared. As described below, future enhancements of control measures implemented in 2003, or new control measures that target products/equipment/material that contain mercury or PCBs that are reasonably liable to enter urban stormwater will help further reduce PCB/mercury loads to the Bay and assist Permittees in addressing WLAs.
- **<u>New and enhanced control measures implemented within the geographical boundaries of the Permittees may be quantified as loads reduced, regardless of the implementing entity</u>** – As described in the PCB and Mercury TMDLs (Water Board 2006, 2008), WLAs for urban runoff implicitly include all current and future permitted discharges within the geographic boundaries of municipalities and unincorporated areas including, but not limited to, California Department of Transportation (Caltrans) roadways and non-roadway facilities and rights-of-way, atmospheric deposition, public facilities, properties proximate to stream banks, industrial facilities, and construction sites. Although implementation of control measures to reduce PCBs and mercury in many of the discharges listed above are outside of the direct jurisdiction of MRP Permittees, load reductions attributable to these control measures need to be accounted for in the context of WLAs assigned to stormwater programs. As such, quantification methods presented in section 4.0 (as well as future methods developed) include actions taken by public agencies and private entities that are assumed to directly affect loads of PCBs and mercury in urban stormwater runoff.

3.4.2 Key Assumptions

In addition to the guiding principles above, the key assumptions described below were included in load reduction quantification methods and results. Control measure specific assumptions are included in each fact sheet presented in section 4.0.

- **<u>Control measures are assumed to be independent of each other</u>** – In some cases, the implementation of one control measure could affect the effectiveness of another. For example, reducing mercury air emissions from local sources could affect pollutant accumulation on streets, which in turn could reduce the mass of pollutants available to source controls such as street sweeping. Evaluating the potential interaction of these controls quantitatively was beyond the level of analysis conducted herein, although potential interactions between control measures are identified and discussed in the fact sheets where appropriate.
- **<u>Baseline conditions and control measure effectiveness are assumed to be geographically uniform</u>**– Conditions vary among the various geographical areas that contribute runoff and pollutants to San Francisco Bay. Thus, projecting results obtained by studies conducted at specific locations may not be representative all areas. As a practical matter, however, we assumed that projections to the whole watershed, based on area, land use, or population, were adequate for the development of the proposed methods. As input data are collected to

populate formulas presented, considerations should be given to the spatial representativeness of these data and disaggregated or aggregated as needed.

4.0 LOADS REDUCED QUANTIFICATION FACT SHEETS

This section includes a series of fact sheets that document preliminary loads reduced quantification methods. Fact sheets were developed for a limited number of pollution prevention and source controls, where a reasonable amount of information was obtained through the literature review to develop methods. As such, methods presented in these fact sheets are based on the most currently available information, and are intended to evolve as additional information becomes available. Much of the information reviewed was collected in the San Francisco Bay Area and therefore is applicable to Permittees. Other information used in quantification method development was collected as part of studies conducted in other areas of the U.S., but appear to be applicable to the Bay Area through scaling based on population.

Each fact sheet in this section includes: 1) a brief description pollutant source, 2) summaries of applicable control measures, 2) loads reduced formulas, 3) assumptions and data inputs, 4) future data tracking needs, and 5) references used to establish the methods. Fact sheets in this section include:

<u>Pollution Prevention</u>

- PP-1: Fluorescent Lamp Recycling (Mercury)
- PP-2: Thermostat Recycling (Mercury)
- PP-3: Reduction of Pollutants from Local Atmospheric Sources (Mercury)

<u>Source (Institutional) Controls</u>

- SC-1: Street Sweeping (Mercury and PCBs)

As this technical memorandum evolves through additional review and revisions, fact sheet for other control measures will be included. In particular, fact sheets for stormwater conveyance system maintenance, sediment management in channels and water bodies, hydromodification and low impact development (LID), stormwater treatment controls, and other controls may be developed to document methods.

PP-1: Fluorescent Lamp Recycling (Mercury)

There are two main categories of lamps (i.e., light bulbs) currently used in large quantities in the United States (U.S.) - incandescent and luminescent gaseous discharge lamps (e.g., fluorescent and low-pressure sodium). Incandescent lamps do not contain mercury. Fluorescent lamps, however, contain mercury and are generally available in two types – tubular or compact. Tubular fluorescent lamps are mostly used in commercial or institutional buildings and usage is believed to have generally remained consistent over time. Compact fluorescent lamps (CFLs), however, are mostly used as energy-saving alternatives to incandescent lamps in homes and have their use has increased substantially in recent years (DTSC 2008).

Recycling of mercury in lamps is the primary control measure used to reduce mercury in the environment from this source. Technologies to reclaim mercury from spent lamps through recycling were developed in the U.S. starting in 1989. However, recycling did not drastically increase until the U.S. EPA announced the addition of lamps to the Universal Waste Rule (UWR) in 1999 (ALMR 2003). The State California's UWR became effective on February 8, 2002 and today prohibits the disposal of fluorescent lamps into landfills, regardless of the waste generator (household or business). The California Department of Toxic Substances Control (DTSC) has adopted regulations that require safe management and recycling of fluorescent lamps.

Applicable Control Measures

Methods describe in this fact sheets are applicable to the following urban stormwater runoff control measures, and as such may be used by Bay Area Permittees to assess progress towards WLA established in TMDLs:

- HHW Collection - Household fluorescent lamp recycling in the Bay Area is available at household hazardous waste (HHW) facilities, which are managed by cities, counties and special districts. A list of Bay Area household hazardous waste facilities that currently (2010) provide fluorescent lamp collection/recycling is attached. Information on the number and types of lamps recycled is available through the HHW facility or the California Integrated Waste Management board (CIWMB).
- Collection at Participating Businesses – Businesses throughout the Bay Area (e.g., IKEA, Home Depot and Orchard Supply) are beginning to accept spent fluorescent lamps from customers. Although tracking may be difficult, recycling provided by these businesses could be quantified by Permittees.
- Private Recycling Contractors - Recycling by small and large businesses occurs through private recycling contractors that coordinate directly with businesses that generate large and small quantities of lamps. The availability of information necessary to quantify loads reduced attributable to this control measure is currently unknown.

Loads Reduced Formula

Based on a review of available data and information gained through literature reviews, the following set equations will allow MRP Permittees to determine the mass of total mercury reduced from stormwater as a result of fluorescent lamps recycling conducted in a given year. Please note that the equations are unit-less and will need to be converted appropriately based on standard conversion rates (e.g., milligrams to kilograms).

$$\mathbf{Reduction_{Lamps} = Current_{Lamps} - Base_{Lamps}}$$

where:

$Reduction_{Lamps}$	=	Mass of total mercury reduced from urban stormwater (above baseline), as a result of fluorescent lamp recycling in year of interest
$Baseline_{Lamps}$	=	Average annual mass of total mercury diverted from Bay Area stormwater during a baseline year(s) due to fluorescent lamp recycling
$Current_{lamps}$	=	Mass of total mercury diverted from Bay Area stormwater due to fluorescent lamp recycling in a year of interest

and;

$$\mathbf{Base_{Lamps}} = Lamps_{Base\#} \bullet Lamps_{BaseMass} \bullet Lamps_{Runoff}$$

$$\mathbf{Current_{Lamps}} = Lamps_{Current\#} \bullet Lamps_{CurrentMass} \bullet Lamps_{Runoff}$$

where:

$Lamps_{Base\#}$	=	Average annual number of fluorescent lamps recycled in baseline year(s)
$Lamps_{BaseMass}$	=	Average mass of total mercury in fluorescent and compact fluorescent lamps recycled in baseline year(s)
$Lamps_{Current\#}$	=	Number of fluorescent lamps recycled in a year of interest
$Lamps_{CurrentMass}$	=	Average mass of total mercury in fluorescent and compact fluorescent lamps recycled in a year of interest
$Lamps_{Runoff}$	=	% of total mercury mass in fluorescent lamps that contributes to the urban stormwater load of mercury to the Bay when the lamp is broken (see below)

and;

$$\mathbf{Lamps_{Runoff}} = Dep_{Lamps} \bullet Trans$$

where:

$Dep_{\mathbf{Lamps}}$	=	Average % of total mercury in fluorescent and compact fluorescent lamps that is deposited onto the surface of the watershed when the lamp is broken
Trans	=	Average % total mercury deposited onto the surface of the watershed when the lamp is broken that is transported by stormwater to the Bay

Assumptions and Data Inputs

Baseline Loads Reduced (2003)

- Baseline Level of Recycling ($Lamps_{Base\#}$) - The average annual number fluorescent lamps recycled from 2000 through 2003 provides the baseline number of lamp that were recycled prior to the TMDL baseline year of 2003. Estimated total number of fluorescent lamps recycled by in the U.S. businesses and households in 2003 are based on estimates by ALMR (2003). Estimates for the U.S. were normalized by population to the geographical area covered by the Municipal Regional Permit (MRP). Table 4-1 provides baseline (2003) recycling rates.

- Baseline Mercury in Lamps ($Lamps_{BaseMass}$) – The mass of mercury (kg) in lamps can vary based on the lamp type, size, manufacturer and date manufactured. Considerations are given to changes in the mass of mercury per bulb that has likely occurred between 2003 and the year of interest by including a baseline concentration ($Lamps_{BaseMass}$) and a concentration for the current year of evaluation ($Lamps_{CurrentMass}$). The mass of total mercury in lamps in 2003 are assumed to average 21 mg per lamp (US EPA 1998).

Table 4-1. Estimated baseline (2000-2003) number of fluorescent lamps recycled in the jurisdictional boundaries of Bay Area MS4s.

Geographical Area/Entity	Households (20%)	Businesses (80%)	Total
United States	*2,680,000*	*150,080,000*	*152,760,000*
Alameda Countywide Clean Water Program	153,393	613,572	766,965
Contra Costa Clean Water Program	105,109	420,436	525,545
San Mateo County Water Pollution Prevention Program	73,226	292,902	366,128
Santa Clara Valley Urban Runoff Pollution Prevention Program	176,217	704,868	881,085
City of Vallejo and VSFCD[1]	12,460	49,841	62,301
Fairfield-Suisun Urban Runoff Management Program[2]	13,494	53,977	67,471

[1]Vallejo Sanitation and Flood Control District
[2]Includes the City of Fairfield and Suisun City

Current Loads Reduced (Year of Interest)

- Current Mercury in Lamps ($Lamps_{CurrentMass}$). The average mass of mercury in a lamp appears to have decreased post-2003 (baseline) due to the increase in CFL usage by households. Specifically, the National Electrical Manufacturers Association (NEMA) announced that under the voluntary commitment, effective April 15, 2007, participating manufacturers will cap the total mercury content in CFLs that are under 25 watts at 5 milligrams (mg) per unit, and CFLs that use 25 to 40 watts of electricity will have total mercury content capped at 6 mg per unit (NEMA 2009). Based on this substantial decrease in mercury mass in CFLs, each bulb recycled is assumed to have an average mass of 5.5 mg. New fluorescent tubes are also assumed to have 5.5 mg on average.
- Current Level of Recycling ($Lamps_{Current\#}$) – The number of fluorescent lamps recycled in the year of interest represents the current level of effort towards meeting WLAs assigned in the TMDL. Recycling efforts are managed by HHWs, participating stores, and private companies for small and large waste generators (US EPA 2009). Recycling efforts are expected to increase substantially over the next decade (US EPA 2009, DTSC 2008).

Baseline and Current Loads Reduced

- % Mercury from Broken Lamps that is Deposited on Watershed (Dep_{Lamps}) – The percentage of mercury in a broken lamp that is assumed to be deposited onto the surface of the watershed is based on a Barr Engineering (2001) study conducted in Minnesota and Wisconsin that focused on the fate of mercury from household products, combined with a partitioning analysis. The authors estimated 37% of the amount of mercury in lamps volatizes into the atmosphere, resulting from breakage, transfer and transit, as well as air emissions following disposal in landfills, combustion, and incineration. For the purposes of loads reduced calculations, we assume that 100% of the mercury that volatilizes into the atmosphere is deposited onto the surface of the watershed.
- % of Mercury Transport by Stormwater (Trans) – the average % imperviousness of Bay Area is an important factor because imperviousness is one of the key mechanisms for stormwater transport. Runoff coefficients are based on the % of imperviousness of a given land use. Based on the literature review conducted in support of this technical memorandum development, there remains a need for an average runoff coefficient for the “urban portion of the Bay” to

complete this variable. As an initial percentage, we suggest using a 32% estimate based on modeling conducted as part of a Mercury Air Deposition Study by Tsai and Hoenicke (2001).

References

ALMR (2003). "National mercury-lamp recycling rate and availability of lamp recycling services in the U.S." Association of Lighting and Mercury Recyclers. September 2003.

ALMR (2007). "Recycling of mercury-containing lighting: alliance formed to promote recycling". Association of Lighting and Mercury Recyclers. December 10, 2007.

Barr Engineering (2001). Substance Flow Analysis of Mercury in Products. Prepared for Minnesota Pollution Control Agency. August 15.

DTSC (2008). AB1109 Lighting Task Force Report to the California Department of Toxic Substance Control. September 1.

NEMA (2008). *Limits on Mercury Content in Self-ballasted Compact Fluorescent Lamps. National Electrical Manufacturers Association.* Standards Publication LL 8-2008. Virginia.

Tsai, P. and Hoenicke, R. (2001). San Francisco Bay atmospheric deposition pilot study Part 1: mercury. Oakland, CA. 45p. San Francisco Estuary Institute (SFEI).

US EPA (2009) Fluorescent Lamp Recycling. United States Environmental Protection Agency. EPA530-R-09-001. February.

PP-2: Thermostat Recycling (Mercury)

Thermostats are commonly used in most homes and commercial facilities to regulate room temperature. Older mechanical thermostats often contained elemental mercury in glass bulbs called ampoules. Through the mishandling of thermostats during demolition and waste transport, ampoules can break and mercury can be emitted to the surface of the watershed. Once in the watershed, mercury is available for transport to the Bay via urban stormwater runoff.

The sale of mercury thermostats was prohibited in California beginning on January 1, 2006 (SB 633). Based on this prohibition, the mass of mercury available to urban stormwater from thermostats is expected to decrease overtime. That said, there are roughly 19.8 million mercury thermostats currently in service in California (TRC 2009), suggesting that near-term contributions of mercury to urban stormwater runoff from thermostats may be important.

Applicable Control Measures

Loads reduced through the implementation of the following urban stormwater runoff control measures may be quantified and used by Bay Area MS4s to assess progress towards WLA established in TMDLs:

- HHW Thermostat Collection - Mercury thermostat recycling has been available through HHW facilities for a number of years and continues to be utilized by residents in the Bay Area.
- Recycling by Wholesalers/Retailers - California's *Mercury Thermostat Collection Act of 2008* (AB 2347) requires that by 2009 manufacturers establish a collection and recycling program for out-of-service mercury-added thermostats. The Thermostat Recycling Corporation (TRC) serves as the collection and recycling program for manufacturers in California (TRC 2010). The TRC provides collection containers to HVAC wholesalers, thermostat retailers, and HVAC contractors for a one-time charge. Collection containers are provided by the TRC to HHW facilities at no cost.
- Other Recycling Efforts – Although likely limited, other recycling activities conducted within the geographical boundaries of the MS4 may be quantified.

For the purposes of assessing progress towards urban stormwater runoff TMDL wasteload allocations, mercury thermostat recycling that occurs through any of these mechanisms described above may be included in loads reduced calculations.

Loads Reduced Formula

Based on a review of available data and information gained through literature reviews, the following set equations will allow MRP Permittees to determine the mass of total mercury reduced from stormwater as a result of thermostat recycling conducted in a given year. Please note that the equations are unit-less and will need to be converted appropriately based on standard conversion rates (e.g., milligrams to kilograms).

$$\mathbf{Reduction_{Therm} = Current_{Therm} - Base_{Therm}}$$

where:

$Reduction_{Therm}$	=	Mass of total mercury reduced from urban stormwater (above baseline), as a result of mercury thermostat recycling in year of interest
$Base_{Therm}$	=	Average annual baseline mass (kg) of total mercury diverted from Bay Area stormwater due to mercury thermostat recycling

$Current_{Therm}$ = Mass of total mercury diverted from Bay Area stormwater due to mercury thermostat recycling in year of interest

and;

$$\textbf{Base}_{\textbf{Therm}} = Therm_{Base\#} \bullet Therm_{BaseMass} \bullet Therm_{Runoff}$$

$$\textbf{Current}_{\textbf{Therm}} = Therm_{Current\#} \bullet Therm_{CurrentMass} \bullet Therm_{Runoff}$$

where:

$Therm_{Base\#}$ = Average annual number of mercury thermostats recycled in baseline year(s)

$Therm_{BaseMass}$ = Average mass of total mercury in mercury thermostats recycled in baseline year(s)

$Therm_{Current\#}$ = Number of mercury thermostats recycled in year of interest

$Therm_{CurrentMass}$ = Average mass of total mercury in mercury thermostats recycled in year of interest

$Therm_{Runoff}$ = % of total mercury mass in mercury thermostat that contributes to the urban stormwater when a mercury thermostat is broken (see below)

and;

$$\textbf{Therm}_{\textbf{Em}} = Dep_{Therm} \bullet Trans$$

where:

Dep_{Therm} = Average % of total mercury in thermostats that is deposited onto the surface of the watershed when the thermostat is broken

Trans = Average % total mercury deposited onto the surface of the watershed that is transported by stormwater

Assumptions and Data Inputs

Baseline Loads Reduced

- Baseline Level of Recycling ($Therm_{Base\#}$) – The average annual number of mercury thermostats recycled from 2000 through 2003 provides the baseline number of thermostats that were recycled prior to the TMDL baseline year (i.e., 2003). The annual average number of mercury thermostats that were recycled by U.S. businesses and households during this time is based on data from TRC (2008). Estimates for the U.S. were normalized by population to the geographical area covered by the Municipal Regional Permit (MRP). Table 1 provides baseline (2000-2003) recycling rates.

Table 4-2. Estimated baseline (2000-2003) number of thermostats recycled in the jurisdictional boundaries of Bay Area MS4s.

Geographical Area	# Recycled
United States	***67,891***
California	***3,420***
Alameda County Clean Water Program	341
Contra Costa Clean Water Program	234
San Mateo County Water Pollution Prevention Program	163
Santa Clara Valley Urban Runoff Pollution Prevention Program	392
City of Vallejo and VSFCD[1]	28
Fairfield-Suisun Urban Runoff Management Program[2]	30

[1]Vallejo Sanitation and Flood Control District
[2]Includes the City of Fairfield and Suisun City

Current Loads Reduced (in Year of Interest)

- Current Level of Recycling ($Therm_{Current\#}$) **–** The number of thermostats recycled in the year of interest represents the current level of effort towards meeting WLAs assigned in the TMDL. Recycling efforts managed by a combination of the TRC, wholesalers and HHWs within areas covered under the MRP may be counted towards this effort.

Baseline and Current Loads Reduced

- Mercury in Thermostats ($Therm_{Base/CurrentMass}$) – the amount of mercury in a thermostat is determined by the number of ampoules. There are generally one or two ampoules per thermostat (average is 1.4) and each ampoule contains an average of 2.8 grams of mercury (TRC 2008). Therefore, each thermostat recycled is assumed to contain approximately 4.0 grams of mercury.
- % Mercury in Thermostats that is Deposited on Watershed (Dep_{Lamps}) – The percentage of mercury in a thermostat that when broken is assumed to be deposited onto the surface of the watershed is based on a Barr Engineering (2001) study conducted in Minnesota and Wisconsin that focused on the fate of mercury from household products, combined with a partitioning analysis. The authors estimated 37% of the amount of mercury in lamps volatizes into the atmosphere, resulting from breakage, transfer and transit, as well as air emissions following disposal in landfills, combustion, and incineration. For the purposes of loads reduced calculations, we assume that 100% of the mercury that volatilizes into the atmosphere is deposited onto the surface of the watershed.
- % of Mercury Transport by Stormwater (Trans) – the average % imperviousness of Bay Area is an important factor because imperviousness is one of the key mechanisms for stormwater transport. Runoff coefficients are based on the % of imperviousness of a given land use. Based on the literature review conducted in support of this technical memorandum development, there remains a need for an average runoff coefficient for the "urban portion of the Bay" to complete this variable. As an initial percentage, we suggest using a 32% estimate based on modeling conducted as part of a Mercury Air Deposition Study by Tsai and Hoenicke (2001).

References

Barr Engineering (2001). Substance Flow Analysis of Mercury in Products. Prepared for Minnesota Pollution Control Agency. August 15.

TRC (2008). Thermostat Recycling Corporation's Annual Report for the U.S. Prepared by the Thermostat Recycling Corporation. http://www.thermostat-recycle.org/files/u3/2008_TRC_Annual_Report.pdf.

TRC (2010). Thermostat Recycling Corporation's Annual Report for California. Prepared by the Thermostat Recycling Corporation. Prepared for the State of California's Office of Pollution Prevention and Green Technology, Department of Toxic Substances Control. March 31.

Tsai, P. and Hoenicke, R. (2001). San Francisco Bay atmospheric deposition pilot study Part 1: mercury. Oakland, CA. 45p. San Francisco Estuary Institute (SFEI).

PP-3: Local Atmospheric Sources (Mercury)

Local (e.g., crematoria) and global (e.g., coal power plants in Asia) emissions of mercury can enter the Bay Area air basin and deposit directly onto the San Francisco Bay or on land surfaces within the local San Francisco Bay watershed. Mercury from air emissions may also be exported beyond the San Francisco Bay Area. The mass of mercury deposited onto the Bay is explicitly accounted for in the Mercury TMDL. Mercury deposited onto the surface of the watershed, however, is included in the urban stormwater load and associated wasteload allocation in the TMDL.

Based on an assessment of local air sources in the Bay Area conducted by the San Francisco Estuary Institute (SFEI) through a Proposition 13 grant, local air sources of mercury (e.g., crematoria and Portland cement plants) may be significant contributors of mercury found in urban stormwater runoff. The total estimated emissions of mercury from all air local sources within the San Francisco air basin are estimated at 214 kg/yr (CARB 2010). The emissions from the one Bay Area portland cement manufacturer (i.e., Lehigh Hanson Permanente Cement Plant) located in western Santa Clara County are estimated at 61 kg/yr (Rothenberg et al. 2010). Annual emissions from the approximately 40 crematoria in the nine county San Francisco Bay Area[3] have been estimated to range from a most probable value of 12 kg/yr to a worst case of 47 kg/yr (Lindquist and Bateman 2000). The primary source of the mercury in the crematoria emissions is assumed to be dental fillings.

Applicable Control Measures

Loads reduced through the implementation of the following control measures that directly affect mercury loads from urban stormwater runoff may be quantified and used by Bay Area MS4s to assess progress towards WLA established in the Mercury TMDL:

- New Emission Standards for Portland Cement Plants – The U.S. EPA has proposed *National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry* that is currently under review. BASMAA and SCVURPPP have provided comment letters to U.S. EPA regarding the proposed adoption regarding the potential nexus between emissions at the plant and mercury in urban stormwater runoff.

- Reduction in Mercury Emissions from Crematoria - Mercury has been widely used in the dental industry in amalgam fillings for teeth for decades. Substantial decreases in the use of mercury in dental amalgam due to increased consumer awareness of mercury use in fillings and the availability of more viable alternatives has been documented since 2003 (IMERC 2010). Continued reductions in the use of dental amalgam over time, may in turn reduce mercury emissions from crematoria/

Load Reduced Formula

Based on a review of available data and information gained through literature reviews, the following set equations will allow MRP Permittees to determine the mass of total mercury reduced from stormwater as a result of reductions in air emissions conducted in a given year. Please note that the equations are unit-less and will need to be converted appropriately based on standard conversion rates (e.g., milligrams to kilograms).

[3] Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma

$$\textbf{Reduction}_{\textbf{AirEm}} = \textbf{Base}_{\textbf{AirEm}} - \textbf{Current}_{\textbf{AirEm}}$$

where:

$Reduction_{AirEm}$	=	Mass of total mercury reduced from urban stormwater baseline attributable to mercury air emission reductions in a year of interest
$Base_{AirEm}$	=	Average annual baseline mass of total mercury in Bay Area stormwater attributable to local mercury air emissions
$Current_{AirEm}$	=	Mass of total mercury in Bay Area stormwater attributable to local mercury air emissions during the year of interest

and;

$$\textbf{Base}_{\textbf{AirEm}} = AirEm_{Base\#} \bullet AirEm_{BaseMass} \bullet Dep_{AirEm} \bullet Trans$$

$$\textbf{Current}_{\textbf{AirEm}} = AirEm_{Current\#} \bullet AirEm_{CurrentMass} \bullet Dep_{AirEm} \bullet Trans$$

where:

$AirEm_{Base\#}$	=	Number of crematory or portand cement manufacturers in baseline year(s)
$AirEm_{BaseMass}$	=	Average annual mass of total mercury emitted from crematory or portand cement manufacturers in baseline year(s)
$AirEm_{Current\#}$	=	Number of crematory or portand cement manufacturers in year of interest
$AirEm_{CurrentMass}$	=	Mass of total mercury (kg) emitted from crematory or portand cement manufacturers in year of interest
Dep_{AirEm}	=	Average % of total mercury mass in emissions from crematory or portand cement manufacturers that is deposited onto the surface of the watershed
Trans	=	Average % of total mercury mass deposited onto the surface of the watershed that runs off into urban stormwater (based on runoff coefficients)

Assumptions and Data Inputs

Baseline Loads

- Baseline Number of Air Emission Facilities ($AirEm_{Base\#}$) – In 2003, there were 31 crematoria (see Table 4-3) and one portand cement manufacturer in the geographical area subject to the MRP.
- Mass of Mercury Emitted from Facilities during Baseline Years ($AirEm_{BaseMass}$) - Emission estimates for crematoria are based on dental statistics and the average amount of mercury used in amalgams. Annual emissions from the approximately 40 crematoria in the nine county San Francisco Bay Area are assumed to be 12 kg/yr (most probable number), or an average of 0.3 kg/yr of mercury per crematoria (Lindquist and Bateman 2000). Mercury emissions from the Lehigh Hanson Permanente Portland Cement Plant located are estimated at 61 kg/yr in 2009 (Rothenberg et al. 2010). For the purposes of establishing baseline, this mass of mercury in 2009 was assumed to also be emitted in 2003.

Current Loads (in Year of Interest)

- Number of Air Emission Facilities in Year of Interest ($AirEm_{Current\#}$) – Due to the closing of crematoria or portland cement manufacturing plants, the number of facilities emitting mercury in the Bay Area may change overtime. Tracking of these businesses should be conducted accordingly to insure the most up-to-date information is used in loads reduced calculations.
- Mass of Mercury Emitted from Facilities during Year of Interest ($AirEm_{CurrentMass}$) – Mercury in crematoria emission may change in the future due to the reduction in the number and size of mercury amalgam fillings used. If literature suggests that the number or size of mercury-based

filling decreases, the estimated 0.3 kg/yr should be refined to account for this decrease. Likewise, if regulations go into place for portland cement manufacturers, the estimated mass of mercury emitted from this source should be revised. In the absence of new information or regulation, the baseline mass of mercury emitted from these facilities should be used to calculate the mass emitted during the year of interest.

Baseline and Current Loads Reduced

- % of Total Mercury in Emitted that is Deposited onto the Watershed (Dep_{AirEm}) – Based on our understanding of air deposition of contaminants, only a percentage of local mercury emissions are deposited onto the surface of Bay watershed. Predicting this percentage through field sampling or modeling, however, is extremely complex and results are typically highly variable and uncertain (USEPA 2001). Therefore, we provide a conservative assumption of 20% of the mercury emitted from these sources is deposited on the surface of the watershed in the Bay Area.
- % of Total Mercury Mass Deposited that Runs Off (Trans) – the average % imperviousness of Bay Area is an important factor because imperviousness is one of the key mechanisms for stormwater transport. Runoff coefficients are based on the % of imperviousness of a given land use. Based on the literature review conducted in support of this technical memorandum development, there remains a need for an average runoff coefficient for the "urban portion of the Bay" to complete this variable. As an initial percentage, we suggest using a 32% estimate based on modeling conducted as part of a Mercury Air Deposition Study by Tsai and Hoenicke (2001).

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Table 4-3. Crematories within the geographic boundaries of MRP Permittees in 2009 (CARB 2010).

CARB ID	County	Name	Address	City	Zip Code	2003	2008
2501	ALA	LIVERMORE CREMATORY	3833 EAST AVENUE	LIVERMORE	94550	X	x
3314	ALA	ROSELAWN CEMETERY	1240 N Livermore Ave	LIVERMORE	94550	X	x
3576	ALA	BAY AREA CREMATORY	1051 HARDER ROAD	HAYWARD	94542	X	x
3786	ALA	CHAPEL OF THE CHIMES	4499 Piedmont Ave	OAKLAND	94611	X	x
3809	ALA	MOUNTAIN VIEW CEMETERY ASSOCIA	5000 PIEDMONT AVE	OAKLAND	94611	X	x
4122	ALA	CEDAR LAWN MEMORIAL PARK & MOR	48800 WARM SPRING BLVD	FREMONT	94539	X	x
4134	ALA	IRVINGTON MEMORIAL CEMETERY	41001 Chapel Way	FREMONT	94538	X	x
4735	ALA	SENTINEL CREMATION SOCIETIES I	4080 Horton Street	EMERYVILLE	94608	X	x
5148	ALA	JESS C SPENCER MORTUARIES INC	21228 Redwood Road	CASTRO VALLEY	94546	X	x
6390	ALA	EVERGREEN CEMETERY	6450 Camden Street	OAKLAND	94605	X	x
8227	ALA	PACIFIC INTERMENT SERVICE	1094 Yerba Buena Ave	EMERYVILLE	94608	X	x
8399	ALA	CHAPEL OF THE CHIMES MEMORIAL	32992 Mission Blvd	HAYWARD	94544	X	x
10794	ALA	WFG-FULLER FUNERALS INC	4647 INTERNATIONAL BLVD	OAKLAND	94601	X	x
19321	ALA	ALAMEDA CREMATIONS	2900 MAIN ST, SUITE 1161	ALAMEDA	94501		x
9712	ALA	DIRECT FUNERAL SERVICES	2900 Main St, Suite 1161	ALAMEDA	94501	X	
2320	CC	OAK VIEW MEMORIAL PARK	2500 E 18th Street	ANTIOCH	94509	X	x
2634	CC	OAKMONT MEMORIAL PARK	2099 RELIEZ VALLEY RD	LAFAYETTE	94549	X	x
7394	CC	SUNSET VIEW CEMETERY ASSOCIATI	101 Colusa Avenue	EL CERRITO	94530	X	x
7564	CC	ROLLING HILLS MEMORIAL PARK	4100 Hilltop Drive	RICHMOND	94803	X	x
11155	CC	HULL'S WALNUT CREEK CHAPEL	1139 Saranap Avenue	WALNUT CREEK	94595	X	x
1426	SCL	GAVILAN HILLS CREMATORY	910 1ST STREET	GILROY	95020	X	x
4205	SCL	OAK HILL MEMORIAL PARK & MORTU	300 Curtner Avenue	SAN JOSE	95125	X	x
11268	SCL	ALTA MESA IMPROVEMENT COMPANY	695 ARASTRADERO ROAD	PALO ALTO	94306	X	x
11459	SCL	VCA JOHNSON ANIMAL HOSPITAL	524 N Santa Cruz Ave	LOS GATOS	95030	X	x
12958	SCL	LOS GATOS MEMORIAL PARK	2255 Los Gatos Almadn Rd	SAN JOSE	95124	X	x
19204	SCL	WYANT & SMITH CREMATORY	174 N SUNNYVALE AVE	SUNNYVALE	94086		x
12867	SCL	WYANT & SMITH FUNERAL HOME	174 N SUNNYVALE AVE	SUNNYVALE	94086	X	
1299	SM	SKYLAWN MEMORIAL PARK	10600 Skyline Blvd	SAN MATEO	94402	X	x
2932	SM	CYPRESS LAWN CEMETERY ASSOCIAT	El Camino Real	COLMA	94014	X	x
5638	SM	OLIVET MEMORIAL PARK	1601 HILLSIDE BLVD	COLMA	94014	X	x
8020	SM	WOODLAWN CEMETERY	1000 El Camino Real	COLMA	94014	X	x
5791	SOL	FAIRMONT MEMORIAL PARK	1901 Union Avenue	FAIRFIELD	94533	X	x
12163	SOL	TWIN CHAPELS MORTUARY	1100 Tennessee St	VALLEJO	94590	X	x

SC-1: STREET SWEEPING (MERCURY AND PCBS)

Street sweeping is conducted by most, if not all, Bay Area municipalities. The traditional purpose of street sweeping is to remove trash and debris that collect in the gutters at the edge of streets. However, street sweeping also removes sediment and associated pollutants such as mercury and PCBs that would otherwise be transported to the Bay via urban stormwater runoff. Although many studies[4] have attempted to assess the effectiveness of street sweeping activities, there continues to be disagreement among stormwater practitioners as to whether sweeping efficiency equates to improvements in the quality of stormwater runoff. Pollutant removal effectiveness of street sweeping may be directly affected by sweeper type, operation (i.e., speed), frequency and inabilities to sweep near curbs due to parked vehicles. Additionally, land uses and proximities to pollutant sources and hot spots may influence the concentration and mass of pollutants removed. These factors make developing pollutant reduction estimates for street sweeping challenging at best. As a practical matter, however, it is difficult to argue from a qualitative perspective that much if not all the material picked up by a sweeper would have otherwise been mobilized and transported by stormwater runoff.

Applicable Control Measures

Pollutant loads reduced through the implementation of the following urban stormwater runoff control measures may be quantified and used by Bay Area MS4s to assess progress towards WLA established in the PCB and Mercury TMDLs:

- Increases in the Pollutants Collected via Standard of Street Sweeping– Permittees may increase the volume of pollutants collected via modification to their existing street sweeping program. Modifications may include: 1) increasing the frequency of street sweeping; 2) enforcing parking violations on street sweeping days; or 3) purchasing new more efficient sweepers.
- Targeted Street Sweeping in Areas with Elevated Pollutants – Based on previous source studies conducted by Permittees, stormwater programs and SFEI, PCB (and to some extent mercury) concentrations are heterogeneous in the Bay watershed. In compliance with the MRP, pilot studies are currently being developed to test control measures (i.e., source investigations, stormwater treatment retrofits, and diversions to POTWs) in selected areas. These areas may also serve as locations where Permittees may chose to target enhanced street sweeping in the future.

Loads Reduced Formula

Based on a review of available data and information gained through literature reviews, the following set equations will allow MRP Permittees to determine the mass of total mercury and PCBs reduced from stormwater as a result of street sweeping conducted in a given year. Please note that the equations are unit-less and will need to be converted appropriately based on standard conversion rates (e.g., milligrams to kilograms).

[4] See citations in the references section and EOA 2007 for a summary of street sweeping studies.

$$\textbf{Reduction}_{\textbf{Streets}} = \textbf{Current}_{\textbf{Streets}} - \textbf{Baseline}_{\textbf{Streets}}$$

where:

$\text{Reduction}_{\text{Streets}}$	=	Mass of total mercury or PCBs reduced from urban stormwater (above baseline), as a result of street sweeping in year of interest
$\text{Base}_{\text{Streets}}$	=	Average annual mass of total mercury or PCBs diverted from Bay Area stormwater due to street sweeping in baseline year(s)
$\text{Current}_{\text{Streets}}$	=	Mass of total mercury or PCBs diverted from Bay Area stormwater due to street sweeping in year of interest

and;

$$\textbf{Base}_{\textbf{Streets}} = \text{Streets}_{\text{BaseMass}} \bullet \text{Streets}_{\%\text{Sed}} \bullet \text{Streets}_{\text{BaseVol}} \bullet F$$

$$\textbf{Current}_{\textbf{Lamps}} = \text{Streets}_{\text{CurrentMass}} \bullet \text{Streets}_{\%\text{Sed}} \bullet \text{Streets}_{\text{CurVol}} \bullet F$$

where:

$\text{Streets}_{\text{BaseMass}}$	=	Average (or measured) concentration of mercury or PCBs in street sweeping sediments collected in baseline year(s)
$\text{Streets}_{\text{BaseVol}}$	=	Average volume of street sweeping material collected in baseline year(s)
$\text{Streets}_{\text{CurrentMass}}$	=	Average (or measured) concentration of mercury or PCBs in street sweeping materials collected in year of interest
$\text{Streets}_{\text{CurrentVol}}$	=	Volume of street sweeping material collected in year of interest
$\text{Streets}_{\%\text{Sed}}$	=	% of “sediment” (by volume) in street sweeping material that has constituent PCBs or mercury attached
F	=	Factor for converting street sweeping sediment volume to dry mass

Assumptions and Data Inputs

Baseline Loads Reduced (2003)

- Concentration of Mercury/PCBs in Street Sweeping Sediment in Baseline Years ($\text{Streets}_{\text{BaseMass}}$) – “Average” concentrations (also called typical concentration values) of PCBs and mercury in street sweeping sediments have been developed through a combination of studies in Contra Costa (EOA 2007), Alameda (Salop and Akashah 2004) and Solano (EOA 2006) counties. Through these studies, pollutant concentrations were compared to sweeper type, land use and age-of-urbanization to determine if significant relationships exist. Based on the results, concentrations of PCBs in street sweeping sediments appear to be dependent upon the very coarse age-of-urbanization categories assigned to cities in Contra Costa and Alameda Counties where street sweeping characterization occurred (Figure 4-1- To be completed). Bay Area age-of-development categories include:
    - Early 20th Century – Represents the earliest and most extensive degree of urbanization/industrialization. May include municipalities where shipping and railways were used extensively for transporting industrial materials. Example cities include Richmond, Hayward, Oakland and Martinez.
    - Mid-Century – Represents the intermediate range in both time and degree of urbanization/industrialization. Example cities include Pinole, Concord, Orinda and Walnut Creek.
    - Late 20th Century – Represents the geographical area with the most recent urbanization. Includes areas where heavy industry never or minimally existed. Example cities include San Ramon, Livermore, Dublin, Brentwood and Clayton.

Other factors appeared to have little to no effect on pollutant concentrations or the particle sizes of sediment collected (EOA 2007). Based on these results, high (75th percentile), average (mean), and low (25th percentile) PCB and mercury concentrations for the three age-of-urbanization categories were developed for use in loads reduced estimates (Table 4-4). To apply these concentrations, Permittees should determine which age-of-urbanization category best fits their municipality based on development patterns and degree of industrialization. Permittees may also choose to use default concentrations of total PCBs (0.094 mg/kg) or mercury (0.14 mg/kg), dry weight, or develop their own average concentrations based on methods similar to those used in Bay Area studies.

Table 4-4. Average (mean), low (25th percentile) and high (75^{h} percentile) estimates for PCBs and mercury in street sweeping material collected by MRP Permittees.

Constituent (mg/kg)	Municipality's Age-of-Urbanization								
	Early 20th Century			Mid-Century			Late 20th Century		
	Low	Ave	High	Low	Ave	High	Low	Ave	High
Total PCBs	0.10	**0.18**	0.22	0.01	**0.03**	0.44	0.01	**0.03**	0.44
Total Mercury	0.17	**0.25**	0.32	0.05	**0.11**	0.14	0.03	**0.05**	0.07

- Average Volume of Street Sweeping Material Collected in Baseline Years ($Streets_{BaseVol}$) - The average volume of street sweeping material collected by Permittees has been reported annually to the Water Board via annual compliance reports for over a decade. Volumes are typically visually estimated by municipal maintenance staff and can be variable from year to year. For each Permittee, the volume of street sweeping material collected from 2000 to 2003 will be used as baseline for the purposes of calculating loads reduced.

Current Loads Reduced (Year of Interest)

- Average (or measured) Concentration of Mercury or PCBs in Street Sweeping Materials Collected in Year of Interest ($Streets_{CurrentMass}$) – Average concentrations of PCBs and mercury in street sweeping sediments based on recent studies are presented in Table 1. These concentrations (or default) concentrations should be used by Permittee as "current" concentrations unless new information is collected. Additionally, average concentrations may be replaced with site specific data collected through field studies.
- Volume of Street Sweeping Material Collected in Year of Interest ($Streets_{CurrentVol}$) - The volume of street sweeping material collected by Permittees should continue to be tracked and reported on an annual basis. To maintain comparability with baseline volumes, volumes should continue to be estimated in a similar manner as in previous years (visually).

Baseline and Current Loads Reduced

- % of Street Sweeping Material that has PCBs or Mercury Attached ($Streets_{\%Sed}$) – It is generally believed that sediment-associated pollutants adsorb to smaller sediment grain sizes due to the increased surface area available. However, it is currently unknown what grain size fractions in street sweeping material constitute the largest percentage of pollutants. This issue continues to be studied and information gained through future investigation will assist in defining the proportion of street sweeping material which is heavily associated with sediment-associated pollutants. For the purposes of developing loads reduced calculations, information gained through EOA (2007) and Salop and Akashah (2004) were utilized to establish that on average 60% of street sweeping material collected is < 2mm and therefore represents a large portion of the pollutant mass in street sweeping material (CH2MHill 1982, Bannerman 1983, Brinkman 1999, Walker and Wong 1999). (Please note that sweeper technology has also advanced considerably over the past 20 years with the emphasis on designing sweepers to remove fine sediments and associated pollutants, if Permittees acquire sweepers that are believed to be significantly more effective at removing fine sediments, this 60% factor presented here should be reconsidered).

- Factor for Converting Street Sweeping Sediment Volume to Dry Mass (F) – The material collected during street sweeping is typically reported in volumes (cubic yards). However, to calculate pollutant loads reduced, a volume to mass conversion factor must be applied. FEECO International developed volume to mass conversion factors for a variety of waste materials in support of the California Integrated Waste Management Act of 1989. These factors continue to be utilized by the California Integrated Waste Management Board (CIWMB 2003). Although the conversion factors may not be representative of every material collected by every Permittee, they are the best currently available. The volume to mass conversion factor is 918.4 kg per cubic yard (CY) of material collected.

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5.0 REFERENCES – TO BE COMPLETED