Appendix C

Staff Report

Mercury in San Francisco Bay

Total Maximum Daily Load (TMDL) Proposed Basin Plan Amendment and Staff Report

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Summary

This staff report provides the technical background and basis for a proposed amendment to the *Water Quality Control Plan, San Francisco Bay Region* (Basin Plan). Appendix A contains the text of the proposed Basin Plan Amendment. If adopted, portions of Basin Plan Chapter 4 (Implementation Plan) would be revised (1) to establish a mercury Total Maximum Daily Load (TMDL) for all segments of San Francisco Bay pursuant to Section 303(d) of the Clean Water Act, and (2) to establish an implementation strategy to achieve and support the TMDL. The TMDL is necessary because all San Francisco Bay segments are impaired (i.e., they do not meet water quality standards). This report contains the results of staff analyses of mercury impairment and sources, recommends mercury load reduction allocations, and sets forth a plan to implement the allocations.

TMDL Components

Mercury is a persistent, bioaccumulative, toxic metal. Its organic form, methylmercury, readily enters the food web. Mercury concentrations in San Francisco Bay fish are high enough to threaten human health and the beneficial use of sport fishing. The California Office of Environmental Health Hazard Assessment has issued an interim fish consumption advisory for San Francisco Bay. In addition, mercury concentrations in some bird eggs harvested from the shore of San Francisco Bay are high enough to account for high rates of eggs failing to hatch; therefore, mercury threatens wildlife and rare and endangered species. Because controllable water quality factors cause detrimental mercury concentrations in sediment, aquatic organisms, and wildlife, the narrative water quality objective for bioaccumulative substances is not met in San Francisco Bay.

The sources of mercury entering San Francisco Bay convey mercury originating from mining legacies and contemporary mercury uses. Table S.1 lists these sources and their estimated loads. The sources include net bed erosion, the Central Valley watershed, urban storm water runoff, the Guadalupe River watershed, direct atmospheric deposition, non-urban storm water runoff, and wastewater discharges. San Francisco Bay also loses mercury as sediment is transported to the ocean through the Golden Gate (about 1,400 kilograms per year [kg/yr]), mercury evaporates from the bay's surface (about 190 kg/yr), and dredged material is removed and disposed of (about 150 kg/yr, net).

Numeric targets are measurable conditions that demonstrate attainment of water quality standards. To protect sport fishing and human health, the concentration of mercury in fish tissue must be reduced by about 40% to 0.2 parts per million (ppm). To protect wildlife and rare and endangered species, the concentration of mercury in bird eggs must be reduced by at least 25% to below 0.5 ppm. To achieve the fish tissue and bird egg targets, the concentration of mercury in sediment must be reduced by about 50%; the median concentration of mercury in sediment should be 0.2 ppm. These proposed targets are consistent with water quality standards and antidegradation policies.

TABLE S.2: Existing Loads and Proposed Allocations By Source Category

Source	Existing Mercury Load (kg/yr)	Allocation (kg/yr)
Bed Erosion (net)	460	220
Central Valley Watershed	440	330
Urban Storm Water Runoff	160	82
Guadalupe River Watershed (mining legacy)	92	2
Atmospheric Deposition	27	27
Non-Urban Storm Water Runoff	25	25
Wastewater (municipal and industrial)	20	20
Sediment Dredging and Disposal	net loss	0 ≤ ambient concentration
Total	***1,220***	***706***

By linking the targets to the sources, this report demonstrates how actions taken to control mercury sources will achieve the proposed targets and ensure attainment of water quality standards. Methylmercury accumulation in aquatic organisms depends on sediment mercury concentrations, methylmercury production, and the structure of the food web. Reductions in sediment mercury concentrations are assumed to result in proportional reductions in fish tissue and bird egg mercury concentrations. Reducing net methylmercury production will further reduce mercury in fish and wildlife. Assuming that the amount of mercury in San Francisco Bay needs to be reduced by about 50% to meet the proposed targets, the assimilative capacity of the bay is about 32,000 kilograms.

Table S.1 lists proposed load and wasteload allocations for each source. Achieving these allocations is necessary to reach the proposed sediment target and attain water quality standards. The allocation scheme is based on the assumption that mercury from all sources is similarly available to be converted to methylmercury and taken up into the food web. By implementing the proposed allocations, the average San Francisco Bay sediment mercury concentration will likely decrease from about 0.44 ppm and reach the target of 0.2 ppm after roughly 120 years. Conservative assumptions used to develop the proposed numeric targets and allocations provide an implicit margin of safety, and the proposed implementation plan provides a further measure of safety.

Implementation Plan

The implementation plan has four objectives: (1) reduce total mercury loads to the bay, (2) reduce methylmercury production, (3) perform monitoring and focused studies to track progress and improve technical understanding of the system, and (4) encourage actions that address multiple contaminants. An adaptive implementation approach is proposed, which means taking immediate actions based on available information and defining a process by which to incorporate technical information as the plan is adapted in the future.

The Central Valley Regional Water Quality Control Board is developing mercury TMDLs expected to reduce mercury loads from Central Valley watersheds sufficiently to be able to ensure that sediment from Central Valley rivers eventually meets the sediment target of 0.2 ppm. Likewise, the mercury load that is a legacy of mercury mining in the Guadalupe River watershed will be reduced to about 2 kg/yr over the next 20 years. A separate TMDL effort for this watershed will be the primary regulatory driver for actions to achieve this reduction.

Urban storm water loads are expected to be reduced from about 160 kg/yr to about 82 kg/yr over a course of 20 years. This will be achieved through a combination of source control and targeted sediment removal and storm water treatment. Atmospheric deposition is thought to contribute about 27 kg/yr directly to the bay surface and about 55 kg/yr through deposition on the local watershed and then conveyance to the bay. Available data suggest that this source is not easily controlled because the majority of atmospheric mercury emissions take place in Asia.

Municipal wastewater dischargers, as a group, will be held to current mercury loads. Likewise, industrial wastewater dischargers will be held to current loads. Existing information is insufficient to estimate loads for sources like local mines and bay margin contaminated sites. The proposed plan requires investigation of these sites to determine their impacts and reasonable next steps to reduce loads, if necessary.

Wetlands are not a source of new mercury, but they are important to the cycling of methylmercury in the bay. The plan encourages and supports studies to develop ways in which wetlands can be designed and managed so as to minimize the production of methylmercury. If wetlands are being restored and come under the jurisdiction of the San Francisco Bay Regional Water Quality Control Board (Water Board), the plan requires a demonstration that the project does not result in a net increase in the production of methylmercury.

As these actions are underway, TMDL implementation will also include working with the California Office of Environmental Health Hazard Assessment and the California Department of Health Services to manage the human health risk from consumption of mercury-contaminated bay fish.

These immediate actions are commensurate with available data and information. The implementation plan also includes monitoring to assess the effectiveness of these actions and progress toward meeting proposed targets. In addition, the strategy calls for reviewing information obtained through ongoing scientific studies every five years and revising the TMDL and implementation plan as appropriate.

Regulatory Analyses

Many Basin Plan provisions are considered regulations, and many of the changes contained in the proposed Basin Plan Amendment add regulatory provisions to the Basin Plan. To adopt these changes, the Water Board must complete several analyses pursuant to the Administrative Procedures Act. This report contains these analyses, and explains the following conclusions: (1) the proposed Basin Plan Amendment is preferable to other options because it best meets the project objectives, (2) adopting the Basin Plan Amendment would not result in any significant adverse environment effects, and (3) implementing the Basin Plan Amendment could place substantial economic burdens on the regulated community to meet existing water quality standards.

1. Introduction

This staff report provides the technical background and basis for a proposed amendment to the *Water Quality Control Plan, San Francisco Bay Region* (Basin Plan) (SFBRWQCB 1995). Appendix A contains the text of the proposed Basin Plan Amendment. This staff report contains results of staff analyses of mercury impairment and sources, recommended mercury load reduction allocations, and the plan to implement the allocations. If adopted, the Basin Plan amendment would (1) establish a mercury Total Maximum Daily Load (TMDL) in all segments of San Francisco Bay pursuant to Section 303(d) of the Clean Water Act, and (2) establish an implementation strategy to achieve and support the TMDL. If adopted, portions of Basin Plan Chapter 4 (Implementation Plan) will be revised.

The Basin Plan contains water quality standards applicable to the San Francisco Bay region. A water quality standard defines the water quality goals for a water body by designating the uses to be made of the water, by setting the numeric or narrative water quality objectives necessary to protect the uses, and by preventing degradation of water quality through antidegradation provisions. The Basin Plan delineates these standards by identifying beneficial uses of the bay, numeric and narrative water quality objectives to protect those uses, and provisions to enhance and protect existing water quality.

Section 303(d) of the Clean Water Act requires states to compile a list of "impaired" water bodies that do not meet water quality standards. All segments of San Francisco Bay appear on the list because mercury impairs the bay's established beneficial uses, including sport fishing, preservation of rare and endangered species, and wildlife habitat (SWRCB 2003a). For these "impaired" waters, states are required to establish TMDLs for the pollutants responsible for impairment. TMDLs are to be established at a level necessary to attain water quality standards. They are to account for seasonal variations and include a margin of safety that accounts for uncertainties.

This report provides a rationale for why the TMDL and associated implementation plan are necessary for San Francisco Bay. It discusses background conditions and current mercury loads. It also describes how the TMDL ensures attainment of water quality objectives, protects beneficial uses of San Francisco Bay, and is consistent with state and federal antidegradation policies.

This staff report meets the requirements of the California Environmental Quality Act (CEQA) for adopting Basin Plan Amendments. CEQA authorizes the California Resources Agency Secretary to exempt a state agency's regulatory program from preparing an Environmental Impact Report or Negative Declaration if certain conditions are met. The Resources Agency has certified the basin planning process to be "functionally equivalent" to the CEQA process. Therefore, this report is a Functional Equivalent Document and fulfills CEQA environmental documentation requirements.

Report Organization

The process for establishing a TMDL includes compiling and considering available data and information, conducting appropriate analyses relevant to defining the impairment problem, identifying sources, and allocating responsibility for actions to resolve the impairment. This staff report is organized into sections that reflect the key elements of the TMDL process. The first eight sections present the technical basis of the proposed Basin Plan Amendment and the ninth section presents the regulatory analyses required to adopt the amendment.

1. *Introduction*—provides background on this report and the TMDL process.
2. *Project Background*—describes the basis for concluding that mercury impairs San Francisco Bay, and describes and defines the proposed Basin Plan Amendment and its objectives.
3. *Mass Budget Approach*—describes some of the basic concepts and assumptions underlying the analysis.
4. *Source Assessment*—identifies and quantifies the various contributions of San Francisco Bay mercury sources.
5. *Numeric Targets*—expresses the condition desired for San Francisco Bay by proposing numeric targets, which, if met, would ensure attainment of water quality standards.
6. *Linkage Analysis*—describes the relationship between mercury sources and the proposed targets, and estimates the bay's capacity to assimilate mercury while still meeting water quality standards.
7. *Allocations*—proposes wasteload allocations for mercury sources with permits and load allocations for other sources, and describes the margin of safety afforded by the analysis.
8. *Implementation Plan*—proposes mercury pollution prevention and control actions necessary to reach the targets, specifies monitoring mechanisms to evaluate progress, and describes how new information will be gathered and considered as it becomes available.
9. *Regulatory Analyses*—summarizes the conclusions of the environmental impact assessment, evaluates alternatives to the proposed Basin Plan Amendment, and considers economic factors relating to the amendment.
10. *References*—lists all the information sources cited and relied upon to prepare this report.

Next Steps

Staff of the San Francisco Bay Regional Water Quality Control Board (Water Board) will respond to public comments on the proposed Basin Plan Amendment and consider changes to the amendment. Staff will then present the revised draft Basin Plan Amendment to the Water Board for consideration and possible adoption (authorized under California Water Code §13240). If adopted, the State Water Resources Control Board will consider the Basin Plan Amendment for adoption (authorized under California

Water Code §13170), and if approved, the California Office of Administrative Law will review the amendment. If the Office of Administrative Law approves the amendment, the U.S. Environmental Protection Agency will consider this TMDL for final approval. Stakeholder comments and concerns will continue to be considered at key milestones throughout the process.

Key Points

- Section 303(d) of the Clean Water Act requires states to compile a list of "impaired" water bodies that do not meet water quality standards.
- San Francisco Bay is impaired because mercury adversely impacts established beneficial uses, including sport fishing, preservation of rare and endangered species, and wildlife habitat.
- This report contains Water Board staff analyses and findings pertaining to mercury impairment of San Francisco Bay and staff recommendations for an implementation plan to address the impairment.
- This staff report supports a proposed Basin Plan Amendment, which, if adopted, will establish the TMDL for mercury in San Francisco Bay, including related implementation actions.
- If adopted by the Water Board, the amendment will be forwarded to the State Water Resources Control Board for consideration. If approved, the amendment will be sent to Office of Administrative Law and finally to the U.S. Environmental Protection Agency.

2. Project Background

This report focuses on mercury in San Francisco Bay. Mercury is a persistent, bioaccumulative, toxic metal and does not degrade in the environment. It exists in elemental, inorganic, and organic forms. Natural processes transform mercury between the elemental and inorganic forms, and between the inorganic and organic forms. The organic form, methylmercury, is the most toxic. Small aquatic organisms take in methylmercury, allowing it to enter the food web. As methylmercury moves through the food web, it accumulates and concentrates in organisms at the top of the food web.

While the focus of this report is mercury contamination in San Francisco Bay, mercury is a pollutant of global concern. Natural and human processes release mercury into the environment. Atmospheric transport carries mercury around the globe, including areas relatively unaffected by human activity (USEPA 1997b). Mercury has been found in fish and other aquatic organisms throughout the United States and the rest of the world (USEPA 1997a).

Physical Setting

For purposes of this report, "San Francisco Bay" refers to the following water bodies, as shown in Figure 2.1:

- Sacramento/San Joaquin River Delta (within San Francisco Bay region)
- Suisun Bay
- Carquinez Strait
- San Pablo Bay
- Richardson Bay
- Central San Francisco Bay
- Lower San Francisco Bay
- South San Francisco Bay (including the Lower South Bay)

This report also addresses the following mercury-impaired waters that exist within the water bodies listed above:

- Castro Cove (part of San Pablo Bay)
- Oakland Inner Harbor (part of Central San Francisco Bay)
- San Leandro Bay (part of Central San Francisco Bay)

San Francisco Bay is a natural embayment in the Central Coast of California. With an average depth of six meters, the bay is broad, shallow, and turbid, which makes sediment an important factor in the fate and transport of pollutants. The movement of sediment within the bay is driven by daily tides, the spring-neap tide cycle, and seasonally variable wind patterns. About 150 years ago, during the California Gold Rush, hydraulic mining and dredging substantially altered the floor of the bay and mercury concentrations in bay

FIGURE 2.1: Map of San Francisco Bay Estuary

Eight unique segments of San Francisco Bay appear on the 303(d) list of impaired water bodies: Sacramento/San Joaquin River Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, Richardson Bay, Central San Francisco Bay, Lower San Francisco Bay, and South San Francisco Bay. Three additional mercury-impaired water bodies exist within these segments: Castro Cove, Oakland Inner Harbor, and San Leandro Bay.

sediment. While still rebounding from those historic changes, the bay is now affected by a growing metropolitan population of about 6.5 million people (USCB 2001).

The bay is divided into two major hydrographic units, which are connected by the Central Bay to the Pacific Ocean. The northern reach is relatively well flushed because more than half of California's freshwater flows into the bay through the Sacramento and San Joaquin Rivers. In contrast, the southern reach receives more limited flushing from local watersheds.

Problem Statement

Three lines of evidence define the problem of mercury contamination in San Francisco Bay: the high concentrations of mercury in bay fish; the high concentrations in bird eggs representing a threat to wildlife, including rare and endangered species; and exceedance of the narrative water quality objective for bioaccumulation.

Fish Consumption and Human Health

In humans, mercury is neurotoxic, affecting the brain and spinal cord, and interfering with nerve function. Pregnant women and nursing mothers can pass mercury to their fetuses and infants through the placenta and breast milk. In children, particularly those under age six, mercury can decrease brain size, delay physical development, impair mental abilities, cause abnormal muscle tone, and result in coordination problems. Substantial mercury exposure is also associated with birth defects and infant mortality. Adults exposed to mercury may experience abnormal sensations in their hands and feet, tiredness, or blurred vision. Higher levels of mercury exposure can impair hearing and speech. Long-term exposure can damage the kidneys (D'Itri 1991; Davies 1991; COEHHA 1997; USDHHS 1999; USEPA 1997c).

In humans, the principal route for mercury exposure is through the consumption of mercury-containing fish (USEPA 2001). San Francisco Bay is used for recreational sport fishing and subsistence fishing, but San Francisco Bay sport fish contain elevated mercury concentrations (SFEI 2003a,b,c). As shown in Figure 2.2, mercury concentrations in many San Francisco Bay fish exceed the U.S. Environmental Protection Agency's (USEPA's) fish tissue residue criterion of 0.3 milligrams mercury per kilogram fish tissue (i.e., parts per million, ppm) (USEPA 2001). Because of elevated mercury levels in bay fish, the California Office of Environmental Health Hazard Assessment issued the following interim fish consumption advisory for San Francisco Bay (COEHHA 1999):

- Adults should consume no more than two meals per month of sport fish from the bay, including sturgeon and striped bass.
- Adults should not eat striped bass over 35 inches long.

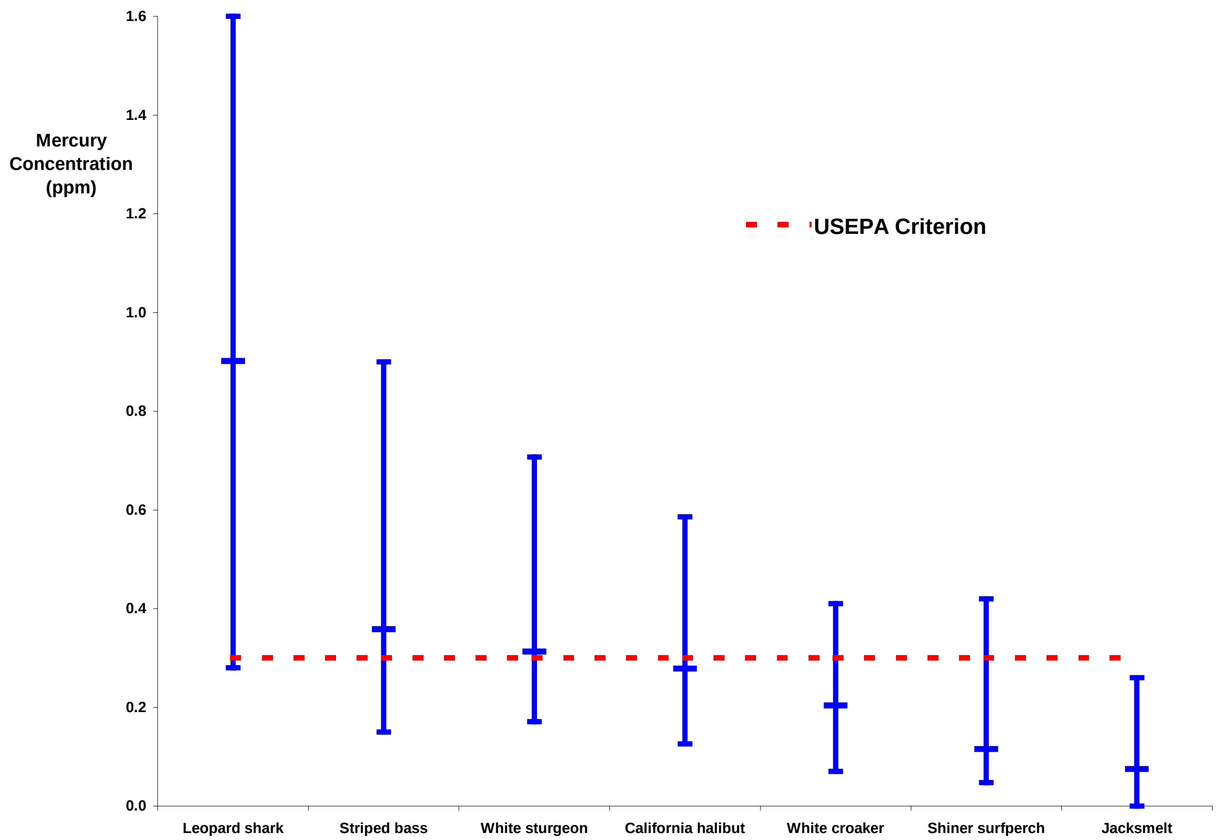

FIGURE 2.2: San Francisco Bay Fish Tissue Mercury Concentrations Compared to USEPA Criterion

Figure shows mean and range of San Francisco Bay fish tissue mercury concentrations (ppm, wet weight) measured in 1994, 1997, and 2000 (SFEI 2003a,b,c). USEPA's criterion is 0.3 ppm (USEPA 2001).

- Pregnant women, nursing mothers, and children under age six should limit their consumption of sport fish to one meal per month.
- Pregnant women, nursing mothers, and children under age six should not eat striped bass over 27 inches long or shark over 24 inches long.

The interim advisory does not apply to salmon, anchovies, herring, and smelt caught in the bay; fish caught in the delta or ocean; or commercial fish (San Francisco Bay supports commercial bait shrimp, herring, and Dungeness crab fisheries).

Since the human health risks associated with eating San Francisco Bay fish warrant a fish consumption advisory, mercury in San Francisco Bay impairs the beneficial use of sport fishing.

Wildlife and Rare and Endangered Species

Mercury poses potential hazards to birds, mammals, and other wildlife. Birds and mammals that consume fish and other aquatic organisms can be exposed to significant quantities of mercury. In birds, mercury can adversely affect survival. It can affect cell development and reproductive success, and cause developmental problems in the young. It can cause reduced feeding, weight loss, lack of coordination, hyperactivity and hypoactivity, and liver and kidney damage. In mammals, mercury can reduce speed and agility, making it more difficult to obtain food and avoid predation (USEPA 1997d). The embryos of birds and other vertebrates are more sensitive to mercury exposure than adults (Wiener et al. 2003).

Bird eggs representing species that consume bay fish and other aquatic organisms have been harvested from the shoreline of San Francisco Bay. Studies have shown that these eggs have higher mercury concentrations than eggs from the same species in other regions of the country (CDFG 2002; Davis et al. 2003; Schwarzbach et al. 2000). As shown in Figure 2.3, mercury concentrations in eggs from the San Francisco Bay region occur at levels above those shown to cause reproductive harm in laboratory tests involving mallards (Fimreite 1971; Heinz 1979). These mercury concentrations may account for unusually high numbers of San Francisco Bay bird eggs failing to hatch (CDFG 2002; Davis et al. 2003; Schwarzbach et al. 2000; Schwarzbach et al. 1996). Mercury toxicity appears to be one of the primary causes of mortality in the eggs of the endangered California clapper rail, which eats aquatic organisms. Because of the small foraging range of the California clapper rail, elevated methylmercury concentrations may affect its eggs to a greater degree than those of other local bird species. The observed high bird egg mercury concentrations indicate that birds and other wildlife, including rare and endangered species are threatened. Consequently, mercury impairs the beneficial uses of wildlife habitat and protection of rare and endangered species.

Compliance with Water Quality Objectives

Federal Clean Water Act regulations and the Basin Plan contain water quality standards that identify beneficial uses of the bay, numeric and narrative water quality objectives to protect those uses, and provisions to enhance and protect existing water quality (SFBRWQCB 1995). Several water quality objectives apply to mercury in San Francisco Bay:

- *Basin Plan Numeric Objectives*. The Basin Plan limits total mercury in water north of the Dumbarton Bridge to a one-hour average concentration of 2.1 micrograms per liter (µg/l, parts per billion) and a four-day average concentration of 0.025 µg/l (Basin Plan Table 3-3).

- *California Toxics Rule Numeric Objective*. Regulations implementing the Federal Clean Water Act limit total mercury in water to 0.051 µg/l south of the Dumbarton Bridge (Code of Federal Regulations, Title 40, §131.38).

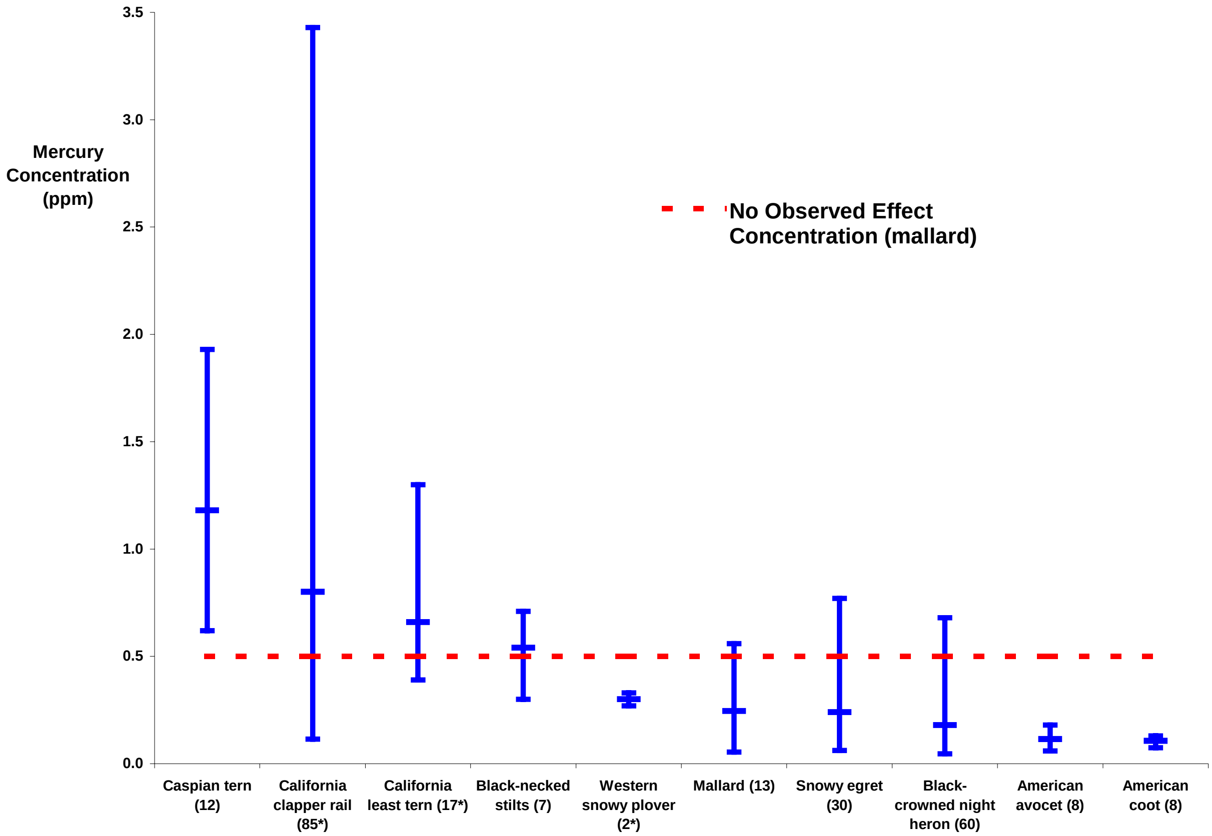

FIGURE 2.3: San Francisco Bay Bird Egg Mercury Concentrations
Figure shows mean and range of San Francisco Bay bird egg mercury concentrations (ppm, wet weight) (Davis et al. 2003). Adverse effects have been observed when mallard egg mercury concentrations were 0.5 micrograms of mercury per gram of egg (parts per million, ppm, wet weight) and greater (Fimreite 1971). The number of eggs represented is given in parentheses. Only fail-to-hatch eggs were collected where marked by an asterisk (*).

- *Basin Plan Narrative Objective*. The Basin Plan limits bioaccumulative substances as follows:

> Many pollutants can accumulate on particles, in sediment, or bioaccumulate in fish and other aquatic organisms. Controllable water quality factors shall not cause a detrimental increase in concentrations of toxic substances found in bottom sediments or aquatic life. Effects on aquatic organisms, wildlife, and human health will be considered.

To monitor pollutant concentrations in water, sediment, and fish and shellfish tissue, the San Francisco Estuary Institute administers the San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP). Monitoring began in 1993. San Francisco Bay water samples are collected two times a year to capture seasonal variability. Two dozen sampling stations are located throughout the bay and at its major tributaries. More than 100 individual chemical parameters are measured, including mercury concentrations.

The Basin Plan one-hour average total mercury objective of 2.1 µg/l, which is intended to protect against acute effects to aquatic life, has never been exceeded in any RMP sample collected in San Francisco Bay (SFEI 2003b). With respect to the Basin Plan's four-day numeric objective, RMP data do not represent four-day averages. The samples are collected over periods of less than one hour (SFEI 2001a). Figure 2.4 shows total mercury concentrations in water reported by the RMP for 1993 through 1999. Measured mercury concentrations in San Francisco Bay exceed 0.025 µg/l in roughly 21% of the samples, although four-day average concentrations are believed to exceed the numeric Basin Plan objective infrequently, as discussed in Section 4, Numeric Targets. Therefore, available information does not suggest that mercury directly threatens San Francisco Bay aquatic life. However, mercury levels in San Francisco Bay exceed the narrative water quality objective for bioaccumulative substance because, as described in the fish consumption and wildlife discussions above, mercury accumulates in sediment, fish, and other aquatic organisms at levels detrimental to human health, wildlife, and rare and endangered species, and some of the water quality factors responsible for these conditions are controllable (see Section 3, Source Assessment; Section 7, Allocations; and Section 8, Implementation Plan).

Project Description

Project Necessity and Definition

The project is the adoption of a proposed Basin Plan Amendment (see Appendix A) to establish a TMDL and an implementation plan to attain mercury water quality standards in San Francisco Bay. The Water Board is obligated under Section 303(d) of the Clean Water Act to develop a TMDL for San Francisco Bay to address mercury impairment. The following components form the basis of the proposed regulatory provisions and define the project:

1. Numeric targets for mercury concentrations in suspended sediment, fish tissue, and bird eggs.
2. Total maximum yearly mercury load to San Francisco Bay of 706 kg, on average, which is roughly 60% of the existing load.
3. Allocation of the total maximum yearly mercury load among the various San Francisco Bay mercury sources.
4. Plan to implement the TMDL that includes actions to reduce mercury loads to achieve allocations, and actions to reduce methylmercury production.
5. Monitoring program that evaluates progress in meeting the established targets, ensures conformity with the allocations, and includes studies to improve technical understanding relevant to the mercury TMDL and implementation plan.
6. Plan and schedule for reviewing progress toward meeting targets, implementing proposed actions, and evaluating continued appropriateness and effectiveness of proposed actions.

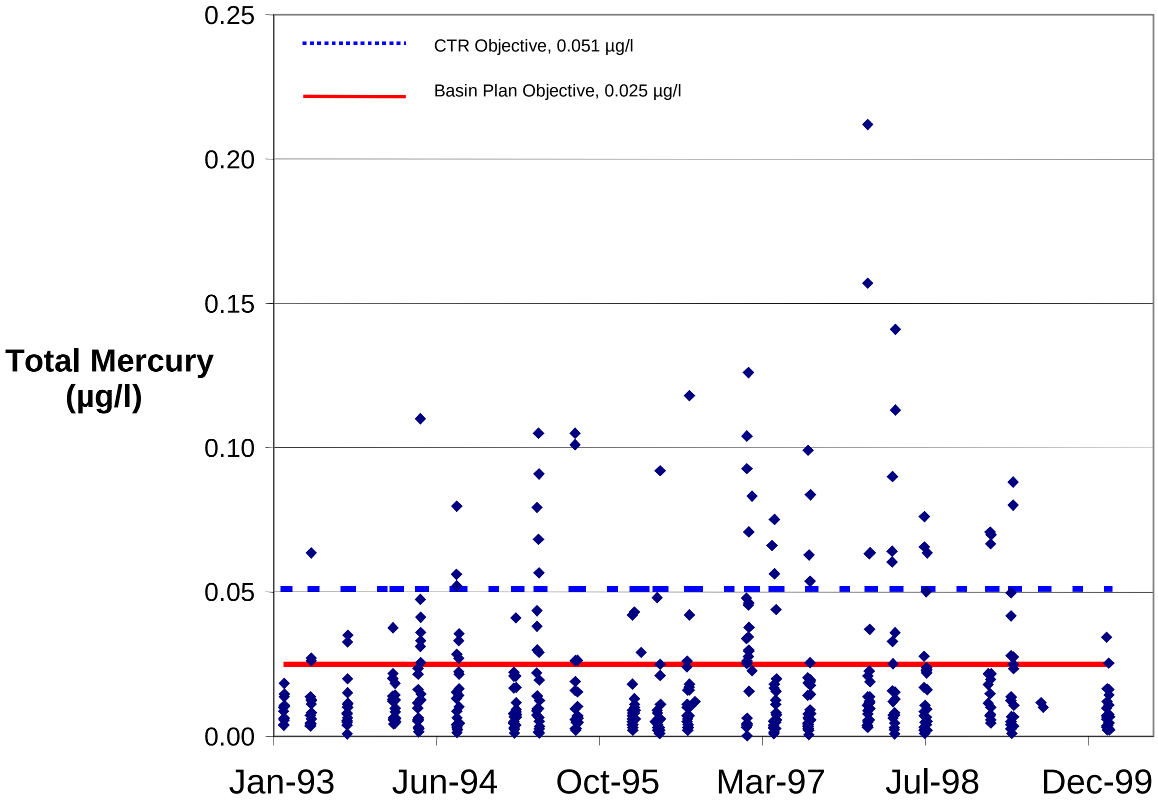

FIGURE 2.4: Total Mercury Concentrations in San Francisco Bay Water
Total mercury concentrations have been measured in San Francisco Bay water since 1993. From 1993 through 2000, short-term (less than one hour) mercury concentrations often exceeded the Basin Plan objective that applies to four-day averages (SFEI 2003b). The number of samples shown is 465. Two extreme values from the Guadalupe River in 1997 and 1998 are not shown because they are off the scale of the figure: 0.622 µg/l (4/7/97) and 0.730 µg/l (2/5/98).

These regulatory provisions are necessary to reduce mercury discharges to and mercury methylation within San Francisco Bay. Such reductions are necessary to reduce mercury concentrations in suspended sediment, fish, and bird eggs, and thereby attain water quality standards and protect beneficial uses. Specifically, the necessity of each regulatory provision of the project is as follows.

1. Numeric targets for mercury concentrations in suspended sediment, fish tissue, and bird eggs are needed to translate water quality objectives into monitoring metrics that reflect the beneficial uses to be protected.
2. The total maximum yearly load of mercury to San Francisco Bay is needed to form the basis of mercury load and wasteload allocations.
3. Mercury allocations for each identified source are needed to ensure that discharges from all sources combined do not exceed the mercury loading capacity of the bay.
4. The implementation plan is needed to ensure that mercury load and wasteload allocations, and therefore the established numeric targets, are met.

5. A monitoring program is needed to evaluate implementation progress, improve technical information about the system, and inform the review of effectiveness and appropriateness of proposed implementation actions.
6. Progress reviews are needed on a recurring schedule to ensure that actions are implemented as planned and the appropriateness of these actions is reviewed in light of new information.

Project Objectives

The proposed Basin Plan Amendment is intended to reduce existing and future mercury discharges to San Francisco Bay associated with controllable water quality factors. Controllable water quality factors are those resulting from human activities that can influence water quality and be reasonably controlled through prevention, mitigation, or restoration. The amendment is also intended to reduce the amount of mercury converted to methylmercury, the form of mercury most readily available for uptake by organisms and the most toxic. Specific objectives of the project are as follows:

1. Attain water quality objectives established for the bay.
2. Protect beneficial uses of San Francisco Bay related to sport fishing and wildlife habitat, including rare and endangered species habitat.
3. Set targets to attain relevant water quality standards in all parts of the bay.
4. Continue to make use of the experience and expertise of the San Francisco Bay Regional Water Quality Control Board and its stakeholder community regarding local watersheds and mercury sources.
5. Initiate actions to reduce mercury discharges and mercury methylation, while continuing to accommodate new information on mercury fate and effects.
6. Establish a decision-making framework where management actions evolve to adapt to future knowledge or conditions.
7. Favor actions that have a multi-contaminant benefit and promote efficiencies in water quality regulation and resource management.
8. Avoid actions that will have unreasonable costs relative to their environmental benefits.
9. Comply with the antidegradation requirements of State Board Resolution No. 68-16 and federal antidegradation regulations (40 CRF 131.12).
10. Base decisions on readily available information on ambient conditions, mercury loads, fish consumption patterns, and mercury fate and effects.
11. Consider site-specific factors relating to mercury sources, ambient conditions, watershed characteristics, and response to management actions.
12. Avoid arbitrary decisions and speculation when computing loads, setting targets, setting allocations, determining implementation actions, and defining a margin of safety.
13. Include an explicit or implicit margin of safety in setting allocations.
14. When selecting from a range of options, select an environmentally protective option as a means of building an implicit margin of safety into the TMDL.
15. Consider natural, seasonal, and inter-annual variability in determining the manner of implementing the load allocations.

16. Avoid imposing regulatory requirements more stringent than necessary to meet the targets designed to attain water quality standards.
17. Provide details of an implementation plan that includes:
    a. A description of the nature of actions necessary to meet targets and thereby achieve the existing water quality objectives;
    b. A schedule for actions to be taken; and
    c. A description of monitoring to be undertaken to determine progress toward meeting targets and water quality objectives.

Key Points

- Mercury concentrations in San Francisco Bay fish are high enough to threaten human health and the beneficial use of sport fishing. The California Office of Environmental Health Hazard Assessment has issued an interim fish consumption advisory for San Francisco Bay.
- Mercury concentrations in some bird eggs harvested from the shore of San Francisco Bay are high enough to account for abnormally high rates of eggs failing to hatch; therefore, mercury threatens wildlife and rare and endangered species.
- Because controllable water quality factors cause detrimental mercury concentrations in sediment, aquatic organisms, wildlife, and humans, the narrative water quality objective for bioaccumulative substances is not met in San Francisco Bay.
- The Water Board is obligated under Section 303(d) of the Clean Water Act to develop a TMDL for San Francisco Bay to address mercury impairment.
- The proposed project is a Basin Plan Amendment to adopt the mercury TMDL and associated implementation plan for San Francisco Bay.

3. Mass Budget Approach

A Workable Approach to a Complex Situation

San Francisco Bay is the largest estuary in western North America. Located at the mouth of the Sacramento/San Joaquin River Delta, its watershed encompasses about 60,000 square miles, or 40% of California (STB et al. 2000). Water and sediment circulation patterns are especially complex as a result of the bay's elongated shape, the large volume of water that passes through its northern reach, its narrow connection to the Pacific Ocean at the Golden Gate, and the relatively low freshwater inputs from local tributaries, especially those in South San Francisco Bay.

As described in Section 2, Project Background, mercury poses a significant threat to San Francisco Bay wildlife and humans who consume bay fish. Mercury cycling in the environment, coupled with the bay's complexity, make solving the mercury problem a challenge. Studies of mercury transport, fate, and effects in the bay will continue for decades; however, the severity of the environmental threat warrants immediate action. The problem solving approach set forth below is commensurate with available data and adequate to identify and prioritize measures to attain water quality standards.

Mercury fate and transport processes within the bay vary significantly throughout time and space, and available data are insufficient to support detailed analyses without over-interpreting the limited data. Therefore, this report relies on simple models to represent San Francisco Bay and some of its basic processes. The advantages of simplicity—the ability to identify and prioritize reasonable actions without over-interpreting available data—outweigh the apparent realism that could be attainable with more complex models (Harte 1988). The following discussion describes a key assumption that forms the basis for this analytical approach—the bay is a simple box.

One-Box Models

A complex system can be simplified by treating it as a simple "box." A one-box model relates primarily to inputs and outputs, not specific processes that occur within a system. When inputs equal outputs, the amount of material in the box stays the same, and the system is considered to be at steady state. When a system is at steady state, the net sum of missing information about inputs and outputs can often be derived from available information. Box models can also be used to predict how a system may change if inputs or outputs change.

This report uses two one-box models for San Francisco Bay: (1) a steady-state model for sediment and (2) a non-steady-state model for mercury. Both models treat the entire bay as one large container consisting of two compartments, water and active sediment. Active sediment is sediment on the bay floor that is regularly resuspended and deposited as a result of tides, waves, and wind and is located in the biologically active zone of the bay floor. In San Francisco Bay, the active sediment layer is estimated to average approximately 15 centimeters (about six inches) in depth (SFEI 2002d). Buried sediment, or sediment beneath the active layer, is not included in the box, but can enter if sediment in the active layer erodes. Because the active layer is assumed, for model purposes, to have a fixed depth, its mass cannot change. Therefore, the amount of sediment entering the box must roughly equal the amount of sediment leaving the box. In other words, the mass of sediment in the bay is at steady state.

Figure 3.1 identifies sediment sources to San Francisco Bay (inputs to the box). Sediment inputs include erosion of buried sediment and flows from the Central Valley watershed, the Guadalupe River watershed, and other local watersheds (urban and non-urban storm water runoff). Sediment and mercury losses (outputs from the box) include net discharges to the Pacific Ocean through the Golden Gate and dredged material disposal at upland or ocean disposal sites. (Dredging is a loss to the extent that it removes a portion of the active layer. Maintenance dredging is relatively shallow; dredging below the active layer removes sediment not considered to be in the box.) The sediment inputs are assumed to equal the sediment outputs.

The sediment steady state assumption does not imply that mercury is at steady state. Figure 3.2 identifies mercury sources (inputs to the box), which include all the sediment sources, plus atmospheric deposition and wastewater discharges. Mercury losses (outputs from the box) include all the sediment losses, plus evaporation from the bay's surface. (The term "evaporation" is used here to refer to any loss to the atmosphere.)

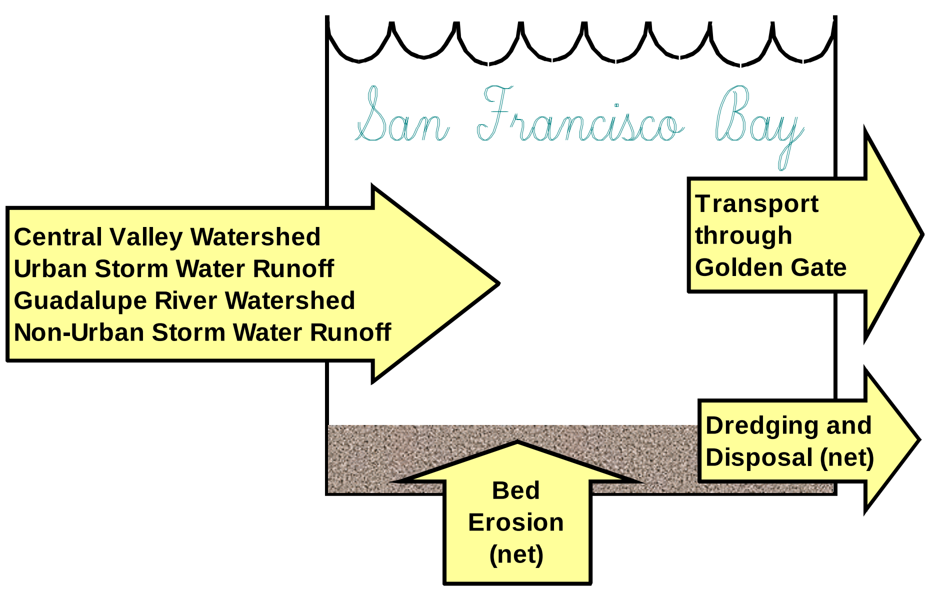

FIGURE 3.1: San Francisco Bay Sediment Sources and Losses
Sediment enters and exits San Francisco Bay. For purposes of this report, a simple one-box model assumes sediment is at steady state (i.e., sediment loads and losses are equal). The shaded area at the bottom of the figure represents the active sediment layer, which is included within the box. The box does not contain sediment buried below the active layer.

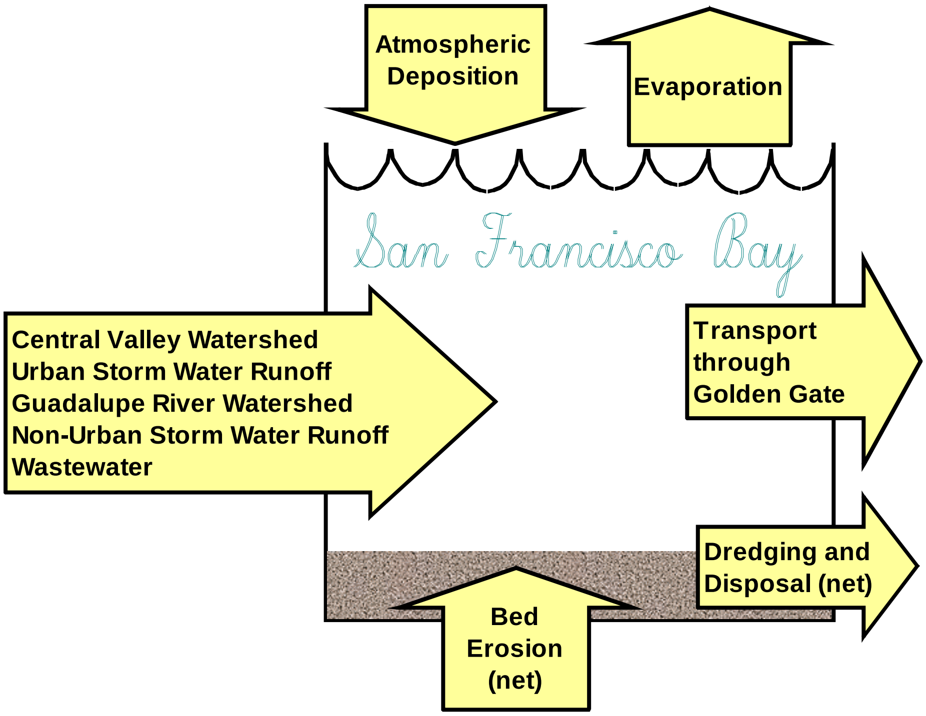

FIGURE 3.2: San Francisco Bay Mercury Sources and Losses
Mercury enters and exits San Francisco Bay. For purposes of this report, a simple one-box model does not assume that mercury is at steady state. Mercury sources and losses are the same as sediment sources and losses, with the addition of wastewater discharges, atmospheric deposition, and evaporation. The shaded area at the bottom of the figure represents the active sediment layer, which is included within the box.

The assumptions associated with these one-box models affect the conclusions expressed in this report's various sections. Section 4, Source Assessment, describes estimated mercury loads for each source and loss category (inputs and outputs). The sediment steady state assumption is used to fill critical information gaps. Section 5, Numeric Targets, proposes a sediment mercury concentration target that defines the goal to be achieved within the box. Section 6, Linkage Analysis, explores processes most relevant to mercury's fate in the bay and estimates the amount of mercury San Francisco Bay (the box) can assimilate while still meeting water quality standards. Section 7, Allocations, proposes load reductions and, using the one-box mercury model, illustrates how San Francisco Bay may respond if the proposed allocations are implemented. Section 8, Implementation Plan, explains how the proposed adaptive management strategy will be used to monitor progress toward meeting the sediment target and to refine the models as more information about sediment and mercury transport, fate, and effects becomes available.

Key Points

- Relying on simple models allows the identification and prioritization of reasonable solutions without over-interpreting limited available data.
- Although one-box models underlie much of the analysis presented in this report, Section 8, Implementation Plan, explains plans to refine the models as more information about sediment and mercury transport, fate, and effects becomes available.

4. Source Assessment

Mercury Sources and Methodology

During the California Gold Rush, cinnabar mines in the Central Coast Ranges produced the mercury used to extract gold from the Sierra Nevada foothills (Dorrance 2002; USGS 2000a). Mercury was later mined and used to produce munitions, electronics, and health care and commercial products. Today, the sources of mercury entering San Francisco Bay convey mercury originating from mining legacies and contemporary mercury uses.

Each source and loss pathway is discussed below. Table 4.1 summarizes each mercury load estimate. Figure 4.1 displays the loads graphically. Mercury and sediment loads vary from year to year; therefore, these estimates are intended to represent long-term averages. The estimates are based on available information; more study may allow refinement in the future.

Most mercury in the water column is particle-bound (see Section 6, Linkage Analysis). Therefore, the magnitude of many mercury sources can be estimated on the basis of sediment loads and mercury concentrations in suspended sediment, as shown in Equation 1.

Equation 1:

$$L_{mercury} = L_{sediment} \times [Hg]_{sediment}$$

where:

$L_{mercury}$ = mercury load (kilograms per year, kg/yr)
$L_{sediment}$ = sediment load (million kilograms per year, M kg/yr)
$[Hg]_{sediment}$ = mercury concentration in sediment (milligrams mercury per kilogram dry sediment, or parts per million, ppm)

For purposes of this source assessment, mercury and sediment load estimates and mercury concentrations are rounded to two significant figures. All calculations were completed prior to rounding.

Calculations and Assumptions

Bed Erosion

The erosion of mercury-enriched sediment from the floor of the bay is estimated to be the largest source of mercury to the bay. From the 1850s through the 1880s, hydraulic mining in the Sierra Nevada involved spraying large volumes of water on hillsides and stripping them of soil, sand, and gravel (USGS 2000a). The resulting sediment slurries

TABLE 4.1: San Francisco Bay Mercury Sources and Losses

	Mercury Load (kg/yr)	Sediment Load (M kg/yr)	Mercury Concentration in Sediment (ppm)
Sources			
Bed Erosion	460	1,100	0.42
Central Valley Watershed	440	1,600	0.26
Urban Storm Water Runoff	160	410	0.38
Guadalupe River Watershed	92	44*	2.1*
Direct Atmospheric Deposition	27	*NA*	*NA*
Non-Urban Storm Water Runoff	25	400	0.06
Wastewater	20	*NA*	*NA*
Total	***1,220***	***3,600***	
Losses			
Transport through Golden Gate	1,400	3,200	0.44
Dredging and Disposal (net)	150	400	0.37
Evaporation	190	0	*NA*
Total	***1,730***	***3,600***	

* The estimates for the Guadalupe River Watershed do not include mercury associated with storm water. The sediment load associated with the Guadalupe River is a subset of the sediment load estimated for urban and non-urban storm water runoff and is not double counted. The sediment mercury concentration in this table reflects only the mercury enrichment due to the Guadalupe River's mining legacy. The actual sediment mercury concentration, including storm water runoff, is about 2.4 ppm.
NA = Not available or not applicable
Note: Most of these mercury and sediment load estimates are rounded to two significant figures. Because calculations were completed prior to rounding, some columns may not add to totals, and in some cases, estimated mercury loads may not exactly equal the product of sediment loads times sediment mercury concentrations.

were directed to sluices lined with mercury, where gold was extracted. Many of the finer mercury and gold particles washed through the sluices and were discharged downstream. Along with mercury, hydraulic mining activities released a substantial mass of sediment, which flowed through the Central Valley to San Francisco Bay. Much of this mercury-laden sediment accumulated on the bay floor. After hydraulic mining ended, sediment loads to the bay decreased. Dams constructed in the Central Valley watershed further reduced sediment loads. However, mercury mining in the Central Coast Ranges continued to release mercury into the bay.

Although sediment burial and erosion are ongoing natural processes throughout San Francisco Bay, San Pablo Bay and Suisun Bay studies indicate that more erosion is occurring than burial (USGS 2001a,b). The status of other San Francisco Bay segments is unknown. During the 48 years from 1942 to 1990, Suisun Bay experienced a net loss of about 61,000,000 cubic meters of sediment, averaging a net loss of 1,300,000 cubic meters per year (USGS 2001b). During the 32 years from 1951 to 1983, San Pablo Bay experienced a net loss of about 7,000,000 cubic meters of sediment, averaging a net loss of 220,000 cubic meters per year (about one sixth of what eroded from Suisun Bay each year) (USGS 2001a). Combining these losses from Suisun Bay and San Pablo Bay, the total net loss is about 1,500,000 cubic meters per year.

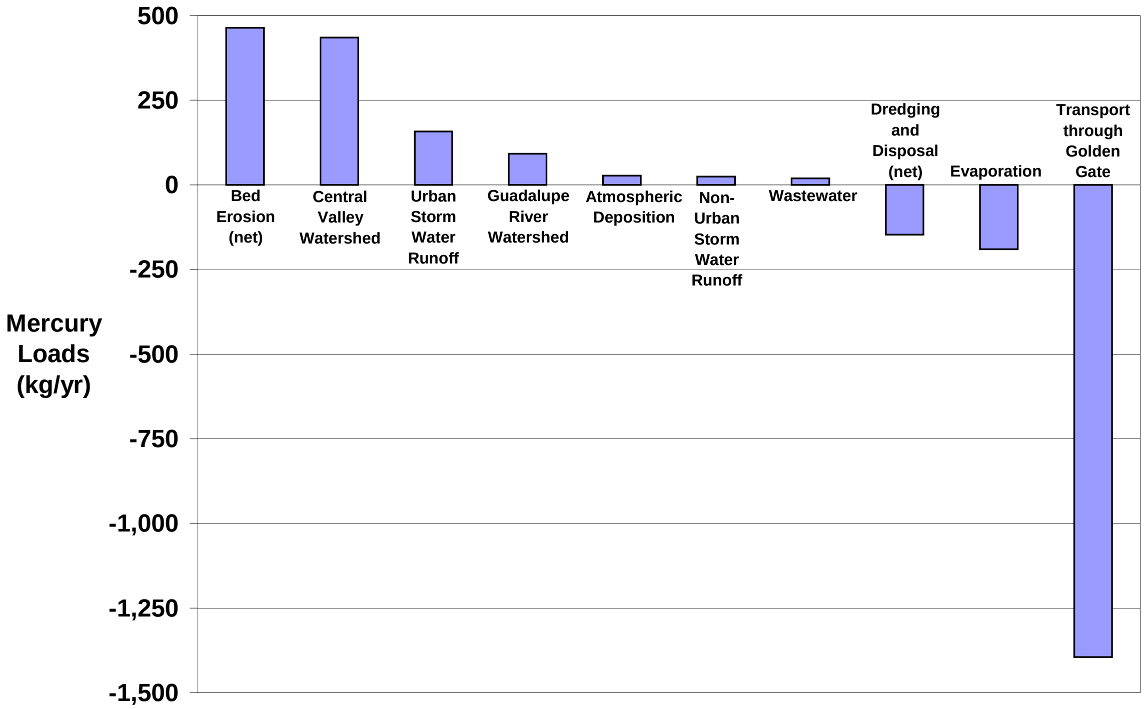

FIGURE 4.1: San Francisco Bay Mercury Source and Loss Loads
The largest sources of mercury are bed erosion and the Central Valley watershed. The greatest loss is transport through the Golden Gate.

Assuming that the eroding sediment is 50% water and 50% sediment by weight (a common assumption for dredging operations [USACE 2002b]), and based on the densities of water and sediment (1.03 grams per milliliter [g/ml] and 2.65 g/ml [Weast 1981; Elert 2002]), there are about 740 kilograms of dry sediment per cubic meter of wet volume. The annual net sediment loss is therefore about 1,100 M kg.

As sediment is lost from the floors of San Pablo Bay and Suisun Bay, buried sediment enters the active layer (the top 0.15 meters). This newly introduced sediment likely contains higher mercury concentrations. Mercury concentrations are available for sediment cores from San Pablo Bay, Grizzly Bay (north of Suisun Bay), and Richardson Bay (Hornberger et al. 1999). Mercury concentrations in buried sediment increase with depth, then decrease substantially below about 1 meter. This gradient is most extreme in Grizzly Bay, as shown in Figure 4.2, which shows mercury concentrations within the top 2 meters of the sample core. The San Pablo Bay and Grizzly Bay sediment cores can be used to estimate the mercury concentration of sediment eroding from the floor of San Pablo Bay and Suisun Bay. (The Richardson Bay core is less likely to be representative of conditions where net bed erosion is known to occur because it is farther away from San Pablo Bay and Suisun Bay.) The depth-weighted average mercury concentration in the top 1.3 meters of sediment (the sediment with elevated mercury concentrations) is about 0.42 ppm (SFBRWQCB 2003c). Because the floor of the bay is not eroding evenly (some areas are eroding more than others and burial is occurring at some locations), some

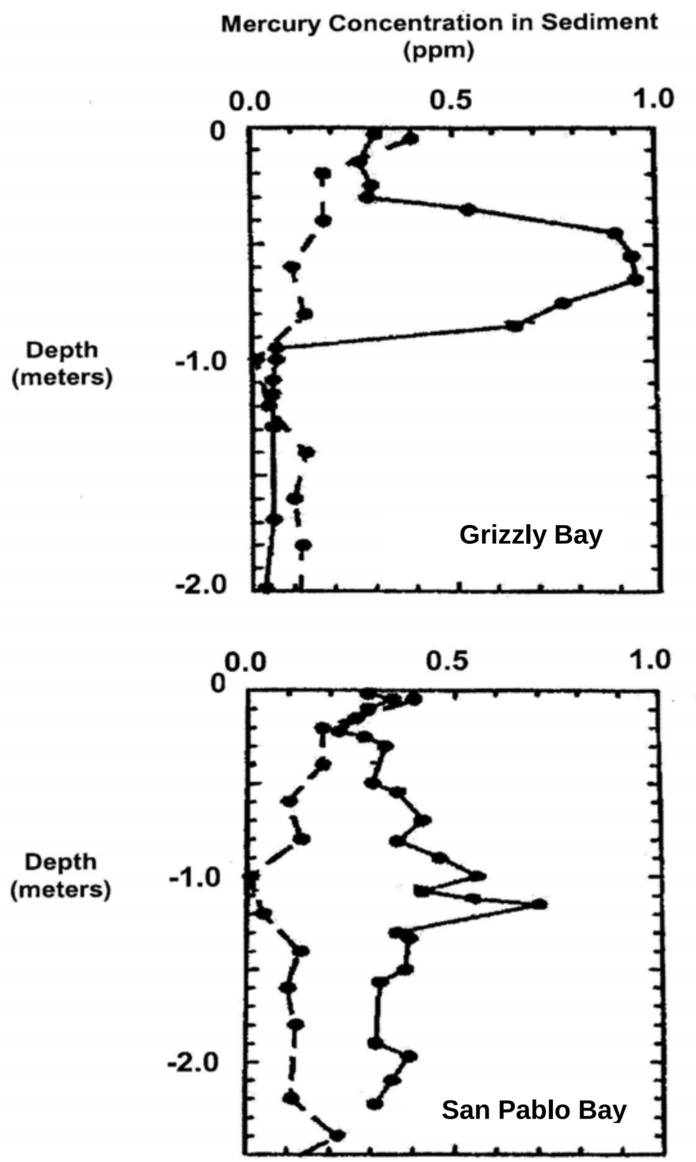

FIGURE 4.2: Mercury Concentrations in Buried Sediment
Solid lines represent mercury concentrations at various depths. Dotted lines represent equivalent concentrations within a reference core collected from Tomales Bay (Hornberger et al. 1999).

newly exposed sediment could contain higher mercury concentrations, and some could contain lower concentrations.

For purposes of this report, mercury loads from bed erosion from bay segments other than Suisun Bay and San Pablo Bay are assumed to be negligible because flows from the Central Valley watershed have their greatest influence on Suisun Bay, the Carquinez Strait, and San Pablo Bay. A recent study concluded that the bay's southern reach experienced net erosion from 1956 to 1983, but has gone through periods of net erosion and net deposition since 1858 (USGS 2004b). Another study concluded that sedimentation patterns fluctuated during the 1980s and 1990s (URS 2003).

Regarding mercury concentrations in sediment buried in the southern reach, studies of Lower San Francisco Bay and South San Francisco Bay sediment cores reported that mercury concentrations buried at 0.7 meters and greater depths are about 0.1 ppm or less. The mercury concentration pattern in a core from Triangle Marsh (at the southernmost end of the bay, downstream from historic mercury mines) closely resembles that of the Grizzly Bay core shown in Figure 4.2 (SFBRWQCB 2003f). However, because the core was collected from a stable marsh (a depositional environment), it is probably not representative of sediment erosion in the bay's southern reach.

Using Equation 1, assuming that eroding sediment from the bay floor contains about 0.42 ppm mercury, and assuming that the net annual sediment loss is about 1,100 M kg/yr, the mercury load associated with newly exposed sediment is roughly 460 kg/yr. This represents about 38% of the total estimated mercury load entering San Francisco Bay. This estimate could be refined if additional sediment cores or more information about how different parts of the bay floor are eroding were to become available in the future.

Central Valley Watershed

San Francisco Bay receives runoff from the Central Valley watershed. The two primary Central Valley rivers, the Sacramento River and the San Joaquin River, drain an area of about 60,000 square miles, equivalent to about 40% of California (STB et al. 2000). These rivers carry mercury-laden sediment from Central Valley mines, urban and non-urban storm water, wastewater, and atmospheric deposition from local and global mercury emissions. The Central Valley watershed is beyond the jurisdiction of the San Francisco Bay Regional Water Quality Control Board. It is under the authority of the Central Valley Regional Water Quality Control Board.

On the basis of suspended sediment concentrations measured near Mallard Island (shown in Figure 2.1) during the six years from October 1994 through September 2000, the amount of sediment entering San Francisco Bay from the Central Valley watershed appears to be about 1,600 M kg/yr, with an uncertainty of ±300 M kg/yr (SFEI 2002a). This closely matches other estimates (Krone 1979; USACE 1992). By establishing a linear relationship between total mercury concentrations in water and total suspended sediment concentrations for this period, the Central Valley mercury load was estimated to be about 440 kg/yr, with an uncertainty of ±100 kg/yr (SFEI 2002a). This estimate represents about 36% of the bay's total mercury sources. The estimate was derived by extrapolating mercury concentrations measured from March 2000 through October 2001 at "X2," the estuary location where the water's salinity is 0.2%. X2 represents the most downstream portion of the river not greatly affected by upstream marine currents; its location moves up and down the estuary, depending on the amount of freshwater flow through the delta. Inserting the estimated sediment and mercury loads into Equation 1, the average concentration of mercury in Central Valley sediment is about 0.26 ppm, with a propagated uncertainty of ±0.075 ppm.

The Central Valley watershed mercury load estimate could be overstated. Recent studies suggest that the mercury load entering the freshwater side of the delta may be smaller than the load leaving at X2. This apparent enrichment may result from the relative lack of sediment data for freshwater entering the delta, available only for 2001 and 2002, when freshwater flows were unusually low (SFEI 2002a). The delta may temporarily retain sediment from year to year, so the amount of sediment entering the delta in any particular year may not equal the amount of sediment leaving the delta. Alternatively, unidentified mercury sources could exist in the delta, or sediment erosion in Suisun Bay (USGS 2001b) could be contributing to mercury observed at X2.

Storm Water

For purposes of this report, "storm water" includes urban and non-urban runoff, which may include flows not directly associated with precipitation (e.g., storm water can include urban irrigation runoff and base flows). Urban runoff includes runoff from developed areas throughout municipalities, industrial sites, and rights of way (e.g., California Department of Transportation highways).

The federal Clean Water Act requires National Pollutant Discharge Elimination System (NPDES) permits for storm water discharges. In the Bay Area, the Water Board issues and administers storm water permits. Dischargers representing the largest populations were the first to receive permits. The Water Board issued four countywide permits shared by municipalities in Alameda County, Contra Costa County, San Mateo County, and Santa Clara County. The Water Board issued individual permits to American Canyon, the Fairfield-Suisun Urban Runoff Management Program, and the Vallejo Sanitation and Flood Control District. As listed in Table 4.2, many smaller dischargers operate under a statewide general permit. In the future, the Water Board will likely require additional entities to operate under the statewide general permit issued by the State Board. These entities include California community colleges, California State University campuses, University of California campuses, national laboratories, U.S. Department of Defense facilities, school districts, and many other facilities (SWRCB 2003b).

Storm water mercury loads can be estimated using Equation 1. To determine mercury concentrations in storm water sediment, several urban runoff management agencies collected 113 bed sediment samples from storm water conveyance systems in Contra Costa County, Marin County, San Mateo County, Santa Clara County, and the cities of Fairfield, Suisun, and Vallejo (Kinnetic Laboratories 2002). The sample locations were selected to represent storm water conduits for different land uses. Because the results from industrial, commercial, and residential land uses were not significantly different from one another, these data were combined under one "urban" land use category. Runoff from open space contained significantly lower mercury concentrations; therefore, open space data were handled separately. Agricultural drainages were not sampled. Agricultural land was assumed to be like open space in terms of mercury loads. Therefore, for purposes of estimating mercury loads, agricultural land was treated as open space. The agricultural and open space land uses were combined under a "non-urban" land use category. The urban runoff management agencies estimated mercury loads to be about 83 kg/yr from all urban areas within the Region that drain to the bay and about

TABLE 4.2: Storm Water Dischargers with NPDES Permits

Permit Type	Entity		NPDES Permit
Countywide [a]	Alameda Countywide Clean Water Program		CAS029831
	Contra Costa Clean Water Program		CAS029912
	San Mateo County Stormwater Pollution Prevention Program		CAS029921
	Santa Clara Valley Urban Runoff Pollution Prevention Program		CAS029718
Individual [b]	American Canyon		CAS612007
	Fairfield-Suisun Urban Runoff Management Program		CAS612005
	Vallejo Sanitation and Flood Control District		CAS612006
Statewide General Permit [c]	Alameda County Port of Oakland Marin County [d] County of Marin City of Belvedere Black Point-Green Point Town of Corte Madera Town of Fairfax City of Larkspur City of Mill Valley City of Novato Town of Ross City of San Rafael City of Sausalito City of Tamalpais-Homestead Valley City of Tiburon Woodacre	Napa County County of Napa City of Calistoga City of St. Helena City of Napa Town of Yountville Solano County County of Solano City of Benicia Sonoma County County of Sonoma City of Petaluma City of Sonoma Town of San Anselmo Sonoma County Water Agency San Francisco County City and County of San Francisco [e] Port of San Francisco	CAS000004

[a] The Water Board has issued countywide permits for urban runoff management programs in Alameda, Contra Costa, San Mateo, and Santa Clara counties. Municipalities within these counties are not listed individually.
[b] The Water Board has issued individual permits to American Canyon, Fairfield, Suisun City, and Vallejo. Fairfield and Suisun City discharge under a single permit.
[c] Other entities operate under a statewide general permit from the State Water Resources Control Board. This list includes those already operating under the general permit and those that will definitely operate under the permit in the near future. It does not include all those anticipated to covered in the future.
[d] Although Marin County municipalities operate under the statewide general permit, their programs are coordinated through the Marin County Stormwater Pollution Prevention Program.
[e] Only areas of San Francisco not served by the combined sewer system are subject to an urban storm water runoff permit.

24 kg/yr from non-urban areas within the region draining to the bay (Kinnetic Laboratories 2002). However, for purposes of this report, these loads have been adjusted for the reasons explained below (SFBRWQCB 2003b).

- This report uses mean (average) sediment mercury concentrations to estimate loads, whereas the urban runoff management programs used medians. When calculating total loads from a number of samples, the mean concentration is more useful than the median (USGS 2002). Averaging the concentration data is equivalent to creating a single composite sample from all the individual samples and using its concentration to estimate loads. In this case, the median mercury concentration was relatively insensitive to data at the low and high ends of the data range, lowering the significance of the mercury concentrations at several locations where measured concentrations were about 10 times higher than the median.

- This report estimates total sediment loads—i.e., suspended loads plus bed loads (some sediment is transported along the bottom without being suspended). In contrast, the urban runoff management agencies estimated suspended sediment loads. The total sediment load is likely to be about 10% greater than the suspended sediment load due to bed load transport (USGS 1980; SFEI 2002c). The U.S. Geological Survey estimated the total sediment load for the local San Francisco Bay tributaries (excluding the Central Valley watershed) to be about 810 M kg/yr on the basis of data representing 1909 to 1966 conditions (USGS 1980). Water resources have not been substantially modified since that estimate was made (USACE 1992). The U.S. Geological Survey total sediment estimate is about four times greater than the urban runoff management agency suspended sediment estimate, which was based on available rainfall data and approximate runoff fractions, typical suspended sediment concentrations, and estimated area covered by each land use. However, the method the urban runoff management agencies used to estimate suspended sediment loads may understate loads by a factor of two to three (SFEI 2002c). The U.S. Geological Survey total sediment estimate is within the range of several others, which range from 600 to 1,400 M kg/yr (USACE et al. 1998; Krone 1979). The sediment load associated with urban and non-urban areas can be estimated by assuming the same ratio estimated by the urban runoff management agencies (Kinnetic Laboratories 2002); about 50% of the total sediment load is discharged from urban areas and about 50% is discharged from non-urban areas. Therefore, of the total sediment load of 810 kg/yr (USGS 1980), about 410 M kg/yr is from urban areas and about 400 M kg/yr is from non-urban areas.

- This report uses sediment mercury concentration data not normalized to percent fines (primarily silt and clay particles less than 62.5 microns). Because the finer particles typically contain more mercury, normalization is common. Normalization eliminates differences attributable only to variations in the particle size distribution of the different samples. However, normalization could overstate mercury concentrations in urban runoff management runoff if the particle size distribution of the sampled sediment is more like that of total sediment than suspended sediment. The urban runoff management agencies reported mean non-normalized mercury concentrations of 0.38 ppm for urban areas and 0.06 ppm for non-urban areas (SCVURPPP 2003; EOA 2003a).

Using Equation 1 to multiply the total sediment load estimates derived from the U.S. Geological Survey's study (410 M kg/yr for urban areas and 400 M kg/yr for non-urban areas) by the mean non-normalized sediment mercury concentrations (0.38 ppm for urban areas and 0.06 ppm for non-urban areas) results in mercury loads of about 160 kg/yr for urban areas and about 25 kg/yr for non-urban areas. These represent about 13% and 2% of the bay's total mercury load.

Guadalupe River Watershed (Mining Legacy)

Operations at the New Almaden mercury mines within the Guadalupe River watershed began in 1846. The mines were the most productive in North America, producing over 40,000 tons of mercury (Bulmore 1953). However, mining left a mercury legacy in piles of waste rock, surface soils, and stream sediment (SFBRWQCB 1998). This waste contributes substantially to mercury enrichment of Guadalupe River sediment (Thomas et al. 2002). The Guadalupe River also carries mercury in storm water from urban and non-urban areas (discussed above). As shown by Equation 2, to estimate the mercury load for the mining legacy, the load for Guadalupe River storm water is subtracted from the load for the entire Guadalupe River watershed, as estimated below.

Equation 2:

Mining Legacy Load = Entire Watershed Load – Storm Water Load

Entire Watershed Load

The Guadalupe River watershed's suspended sediment load has been estimated using available rainfall data and approximate runoff fractions, typical suspended sediment concentrations, and relative land use areas. Using this method, the load is 6 to 7 M kg/yr (Kinnetic Laboratories 2002; URS and Tetra Tech 2000). However, this method is believed to underestimate sediment loads by a factor of 2 to 3 (SFEI 2002c). The U.S. Geological Survey has estimated the total Guadalupe River watershed sediment load (suspended plus bed loads) to be about 44 M kg/yr on the basis of field measurements (USGS 1980). This may overstate the sediment load discharged into the bay because substantial amounts of sediment settle in the lower portion of the Guadalupe River, which is regularly dredged. However, because tides also carry bay sediment into the lower reaches of the Guadalupe River (SCVWD 2000), available information is insufficient to determine the relative proportion of watershed sediment dredged from the river. This estimate is reasonably close to a Santa Clara Valley Water District estimate of about 34 M kg/yr (SCVWD 2000).

Near downtown San Jose at a U.S. Geological Survey sample station, Guadalupe River bed sediment mercury concentrations in 16 samples collected between 1980 and 1989 ranged from 0.03 to 10 ppm. The average concentration was 2.4 ppm (SCVNSCP 1992). These data represent the Guadalupe River watershed better than data for sediment collected at the mouth of the Guadalupe River (Alviso Slough) because, although Alviso Slough sediment contains about 1 ppm mercury (SFEI 2002b), Alviso Slough is subject to tidal mixing, which tends to dilute the mercury concentration in Guadalupe River sediment (SFBRWQCB 2003d). Also, as indicated above, the Santa Clara Valley Water District dredges upstream portions of the Guadalupe River, which distorts the apparent watershed sediment mercury concentrations when measured downstream.

Using Equation 1, and assuming the sediment load is 44 M kg/yr (USGS 1980) and the average mercury concentration is 2.4 ppm, the total mercury load associated with the Guadalupe River watershed is about 106 kg/yr.

Storm Water Load

Storm water mercury loads are estimated above for all tributaries flowing directly to San Francisco Bay. Like the other tributaries, the Guadalupe River carries urban and non-urban storm water runoff. It also carries storm water runoff from mine sites. To avoid double counting the storm water loads when estimating the Guadalupe River watershed mining legacy load, the urban and non-urban storm water runoff loads (not including the mine site runoff load) must be subtracted from the total watershed load. The result is the runoff load associated with the mining legacy.

In the Guadalupe River watershed, the ratio of urban storm water sediment to non-urban storm water sediment can be estimated using rainfall data, estimated runoff fractions, typical suspended sediment concentrations for various land uses, and approximate land use areas. Taking into account such factors, about 81% of the total Guadalupe River sediment load is from urban areas and about 19% is from non-urban areas (Kinnetic Laboratories 2002). Since the total sediment load is about 44 M kg/yr (estimated above) (USGS 1980), the urban sediment load is about 36 M kg/yr, and the non-urban sediment load is about 8.5 M kg/yr. This approach assumes that all sediment discharged from the Guadalupe River would be discharged with or without the mining legacy.

As discussed above, the estimated average mercury concentrations in storm water sediment is about 0.38 ppm in urban areas and about 0.06 ppm in non-urban areas (Kinnetic Laboratories 2002; SCVURPPP 2003; EOA 2003a). Using Equation 1, the urban storm water contribution to the Guadalupe River watershed load is about 14 kg/yr. The non-urban contribution is about 0.5 kg/yr. Together, these loads, which are not attributed to the watershed mining legacy, amount to about 14 kg/yr.

Mining Legacy Load

Using Equation 2 and subtracting the storm water loads (14 kg/yr) from the entire Guadalupe River watershed load (106 kg/yr) yields a load representing the watershed's mining legacy—about 92 kg/yr. This represents about 7% of the bay's mercury inputs.

Atmospheric Deposition and Evaporation

Atmospheric Deposition

Mercury in the atmosphere enters San Francisco Bay during dry weather (dry deposition) and rainy weather (wet deposition). To determine the mercury load associated with dry and wet deposition, the Regional Monitoring Program for Trace Substances (RMP) collected ambient air and precipitation samples at three Bay Area sites. The study estimated the average dry deposition rate to be 19 micrograms of mercury per square meter per year ($\mu g/m^2/yr$). The study estimated the average wet deposition rate to be

4.2 μg/m^2/yr. The report concluded that atmospheric deposition of mercury on the bay surface is about 27 kg/yr, "with an error of two to five fold" (SFEI 2001b). This is about 2% of the bay's mercury sources.

This load estimate does not include mercury deposited on the bay's watershed and carried to the bay by runoff. The load associated with such indirect deposition is included in the storm water and Central Valley watershed load estimates. The RMP study estimated the load associated with this indirect deposition on the local watershed (not including the Central Valley) to be about 55 kg/yr (SFEI 2001b). Therefore, of the roughly 180 kg/yr of mercury from storm water (urban and non-urban runoff), about 55 kg/yr could result from atmospheric deposition.

Evaporation

The loss of mercury from the bay surface, referred to here as "evaporation," can be estimated on the basis of measured dissolved elemental mercury concentrations, atmospheric mercury concentrations, and estimated wind speeds (Conaway et al. 2003). Bay Area winds vary greatly depending on the season. In summer, they are typically much stronger than in winter and temperatures are higher; therefore, more mercury evaporates during summer. Summer evaporation rates range from 100 to 400 μg/m^2/yr. Winter evaporation rates range from 20 to 100 μg/m^2/yr. Assuming a surface area for San Francisco Bay of 1.24 x 10^9 square meters (SWRCB 2003a), summer conditions result in mercury losses of 120 to 500 kg/yr. Winter conditions result in mercury losses of 27 to 120 kg/yr. Although meteorological conditions vary substantially, for purposes of this report, the midpoints of these ranges (the value most likely to be representative of overall conditions)—310 kg/yr for summer and 75 kg/yr for winter—are used to estimate summer and winter evaporation rates. Assuming that summer conditions prevail for half the year and winter conditions prevail for the other half, the typical mercury load lost from the bay's surface each year is roughly the average of the summer and winter evaporation rates, or about 190 kg/yr. This is about 11% of the bay's mercury losses. When considered with direct atmospheric deposition on the bay (estimated above to be about 27 kg/yr), there is a net loss to the atmosphere of about 160 kg/yr.

Wastewater

The federal Clean Water Act requires NPDES permits for wastewater discharges. In the Bay Area, the Water Board issues and administers these permits, which impose requirements on wastewater quality and monitoring. Wastewater treatment plants collect and analyze mercury in their effluent using "ultra-clean" methods capable of detecting extremely low mercury concentrations. The NPDES program covers municipal wastewater treatment plants (see Table 4.3) and industrial dischargers (see Table 4.4).

In the Bay Area, municipal wastewater treatment plants provide secondary treatment, which includes settling, filtration, and biological treatment. Some plants also provide advanced treatment, which removes additional solids. Removing additional solids

TABLE 4.3: Municipal Wastewater Dischargers to San Francisco Bay and its Tributaries*

Permit Holder	Permit Number
American Canyon, City of	CA0038768
California Department of Parks and Recreation, Angel Island State Park	CA0037401
Benicia, City of	CA0038091
Burlingame, City of	CA0037788
Calistoga, City of	CA0037966
Central Contra Costa Sanitary District	CA0037648
Central Marin Sanitation Agency	CA0038628
Delta Diablo Sanitation District	CA0038547
East Bay Dischargers Authority	CA0037869
Dublin-San Ramon Services District (CA0037613)	
Hayward Shoreline Marsh (CA0038636)	
Livermore, City of (CA0038008)	
Union Sanitary District, wet weather (CA0038733)	
East Bay Municipal Utilities District	CA0037702
East Brother Light Station	CA0038806
Fairfield-Suisun Sewer District	CA0038024
Las Gallinas Valley Sanitary District	CA0037851
Marin County Sanitary District, Paradise Cove	CA0037427
Marin County Sanitary District, Tiburon	CA0037753
Millbrae, City of	CA0037532
Mountain View Sanitary District	CA0037770
Napa Sanitation District	CA0037575
Novato Sanitary District	CA0037958
Palo Alto, City of	CA0037834
Petaluma, City of	CA0037810
Pinole, City of	CA0037796
Contra Costa County, Port Costa Wastewater Treatment Plant	CA0037885
Rodeo Sanitary District	CA0037826
Saint Helena, City of	CA0038016
San Francisco, City and County of, San Francisco International Airport WQCP	CA0038318
San Francisco, City and County of, Southeast Plant	CA0037664
San Jose/Santa Clara WPCP	CA0037842
San Mateo, City of	CA0037541
Sausalito-Marin City Sanitary District	CA0038067
Seafirth Estates	CA0038893
Sewerage Agency of Southern Marin	CA0037711
Sonoma Valley County Sanitary District	CA0037800
South Bayside System Authority	CA0038369
South San Francisco/San Bruno WQCP	CA0038130
Sunnyvale, City of	CA0037621
US Naval Support Activity, Treasure Island WWTP	CA0110116
Vallejo Sanitation & Flood Control District	CA0037699
West County Agency, Combined Outfall	CA0038539
Yountville, Town of	CA0038121

* Does not include wastewater dischargers outside the jurisdiction of the San Francisco Bay Regional Water Quality Control Board.

TABLE 4.4: Industrial Wastewater Dischargers to San Francisco Bay and its Tributaries*

Permit Holder	Permit Number
C&H Sugar Co.	CA0005240
Chevron Products Company	CA0005134
ConocoPhillips	CA0005053
Crockett Cogeneration	CA0029904
The Dow Chemical Company	CA0004910
General Chemical	CA0004979
GWF Power Systems, Site I	CA0029106
GWF Power Systems, Site V	CA0029122
Hanson Aggregates, Amador Street	CA0030139
Hanson Aggregates, Olin Jones Dredge Spoils Disposal	CA0028321
Hanson Aggregates, Tidewater Ave. Oakland	CAA030147
Pacific Gas and Electric, East Shell Pond	CA0030082
Pacific Gas and Electric, Hunters Point Power Plant	CA0005649
Rhodia, Inc.	CA0006165
San Francisco, City and Co., SF International Airport Industrial WTP	CA0028070
Martinez Refining Co. (formerly Shell)	CA0005789
Southern Energy California, Pittsburg Power Plant	CA0004880
Southern Energy Delta LLC, Potrero Power Plant	CA0005657
Ultramar, Golden Eagle	CA0004961
United States Navy, Point Molate	CA0030074
USS-Posco	CA0005002
Valero Refining Company	CA0005550

* Does not include wastewater dischargers outside the jurisdiction of the San Francisco Bay Regional Water Quality Control Board.

removes additional pollutants, like mercury, that adhere to particles. Municipal wastewater treatment plants remove over 90% of the mercury in their influent (AMSA 2000). While the removed mercury is not directly discharged to water, some is returned to the environment through landfills, incinerators, or soil amendments. The primary sources of mercury in municipal wastewater are human waste and medical and dental facilities (Palo Alto RWQCP 1999).

Industrial dischargers include petroleum refineries, chemical plants, and other large industrial facilities. Their mercury loads depend on the types of activities in which these dischargers engage. Because wastewater dischargers regularly monitor and report their discharges, their combined loads can be estimated more precisely than any of the other loads estimated in this report. Available data are sufficient to allow statistical analyses that quantitatively characterize variations from year to year. Current load estimates were computed using available data on effluent mercury concentrations and effluent discharge volumes from 2000 through 2003. In order to account for the inter-annual variability of discharge given the relatively short data period, current loading for the two wastewater discharge groups (municipal and industrial) was estimated as the upper 99% confidence intervals about the mean. The combined mercury load for all municipal wastewater discharges to San Francisco Bay and its tributaries is about 17 kg/yr. The combined load of the industrial dischargers and petroleum refineries is about 3 kg/yr (LWA 2004; SFBRWQCB 2004b,c).

Together, these municipal and industrial wastewater discharges account for a load of about 20 kg/yr, or about 2% of the bay's total mercury load. These loads do not reflect wastewater discharged in the Central Valley, which is included in the estimate for the Central Valley watershed, above.

Sediment Dredging and Disposal

From time to time, sediment is dredged from San Francisco Bay channels to accommodate navigation. Some dredging is routine channel maintenance, and some is construction-related. Beginning in the 1970s, most dredged material was disposed of near Alcatraz Island. Other in-bay disposal sites are in San Pablo Bay, Carquinez Strait, and Suisun Bay. Sediment disposed of near Alcatraz Island was expected to disperse, but a sizeable mound grew, posing potential navigation problems. To improve dredged material management and disposal, the Water Board joined the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, San Francisco Bay Conservation and Development Commission, and State Water Resources Control Board in developing the Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS). The LTMS seeks to reduce the volume of dredged material disposed of in San Francisco Bay by shifting disposal to ocean and upland disposal sites (USACE et al. 2001).

Available data include the volumes of material dredged for channel maintenance disposed of at in-bay disposal sites and at sites outside the bay. As shown in Table 4.5, between 1991 and 1999, the amount of dredged material disposed of each year at in-bay disposal sites averaged 2,300,000 cubic yards (USACE et al. 2001). In 1999, 2000, and 2001, the average out-of-bay dredged material disposal volume was 700,000 cubic yards (USACE 2002a). Volumes vary substantially from year to year because channels do not need to be dredged every year. Dredging occurs when needed and when funds are available, or when special projects are needed. The total amount of material dredged from the bay is the sum of the in-bay and out-of-bay disposal volumes, or about 3,000,000 cubic yards per year.

TABLE 4.5: Dredged Material Volumes, Sediment Masses, and Mercury Loads

	Average Volume (yd^3/yr)	Average Sediment Mass (M kg/yr)*	Average Estimated Mercury Load (kg/yr)
Material dredged (loss)	3,000,000	1,700	640
In-bay disposal (source)	2,300,000	1,300	490
Out-of-bay disposal (net loss)	700,000	400	150

* Assumes dredged material is 50% water and 50% sediment by weight (USACE 2002b) and there are about 570 kilograms of dry sediment per cubic yard of wet dredged material based on relative densities of water and sediment (Weast 1981; Elert 2002).

Dredged material consists of sediment and water. Assuming that dredged material is 50% water and 50% sediment by weight (USACE 2002b), there are about 570 kilograms of dry sediment per cubic yard of wet dredged material based on the relative densities of water and sediment (Weast 1981; Elert 2002). Therefore, the amount of sediment dredged from the bay (a loss) is about 1,700 M kg/yr. The amount of sediment returned to the bay for disposal (a source) is about 1,300 M kg/yr. The net sediment loss is about 400 M kg/yr.

In 2000 and 2001, mercury concentrations were measured in samples representing about 73% of the dredged material disposed of in the bay. On a volume-weighted basis, the average mercury concentration was about 0.37 ppm (SFBRWQCB 2002d). Inserting this concentration into Equation 1, the mercury load from in-bay dredged material disposal is about 490 kg/yr. Assuming that the concentration of mercury in sediment disposed of at out-of-bay sites is the same as that disposed of in-bay, the mercury loss from dredging is about 640 kg/yr. The net loss from the combined processes of dredging and disposal is about 150 kg/yr. This represents about 8% of the mercury leaving San Francisco Bay each year.

Transport Through Golden Gate to Ocean

The net sediment discharge through the Golden Gate to the ocean is difficult to estimate because sediment moves back and forth through the Golden Gate with tides and weather conditions. Several estimates exist, ranging from 1,900 to 4,600 M kg/yr (USACE et al. 1998; USACE 1992; Krone 1979). With the steady state one-box model described in Section 3, Mass Budget Approach, sediment loads leaving through the Golden Gate can be estimated from the sediment loads estimated for the other sources and losses discussed above. Assuming the sediment load entering the bay equals the sediment load leaving the bay, the Golden Gate load equals the sum of the sediment loads entering the bay minus the other sediment losses. The major sediment source loads are as follows:

- Bed Erosion—1,100 M kg/yr
- Central Valley Watershed—1,600 M kg/yr
- Urban Storm Water—410 M kg/yr
- Non-Urban Storm Water—400 M kg/yr

The total of all sediment sources is about 3,600 M kg/yr. (Because sediment associated with the Guadalupe River watershed is a subset of the total sediment load estimated for storm water, this sediment load is not counted twice in the calculation.) Dredging and disposal involves a net sediment loss of about 400 M kg/yr. Subtracting this loss results in the net sediment transported to the ocean through the Golden Gate—3,200 M kg/yr. This estimate is within the range of other available estimates (USACE et al. 1998; USACE 1992; Krone 1979).

The mercury in exported sediment is assumed to come from all over San Francisco Bay. On the basis of data from the RMP, the overall concentration of mercury in bay suspended sediment averages 0.44 ppm (SFBRWQCB 2002c). Using Equation 1, the mercury load lost through the Golden Gate is about 1,400 kg/yr. This represents about 81% of the mercury exiting the bay through all routes.

Other Potential Sources

In addition to the mercury sources and losses quantified above, there may be other less well understood sources that are yet to be discovered. These may include mining sources in local tributaries other than the Guadalupe River watershed (SFBRWQCB 1998) and contaminated sites within and in the vicinity of the bay (SWRCB 1999). The potential mercury loads that could be associated with these potential sources are unknown.

Table 4.6 lists mines that could be potential sources of mercury to San Francisco Bay (SFBRWQCB 1998). Implementing the Water Board's mines program as described in the Basin Plan involves inspecting these mine sites, identifying and contacting the property owners, notifying local agencies, implementing site management plans, assessing loads and risks, identifying previous owners, issuing permits or orders, initiating remediation, and following up with monitoring (SFBRWQCB 1995). Existing information is insufficient to estimate the potential loads from these mines. However, the margin of safety discussed in Section 7, Allocations, is intended to account for this uncertainty. Moreover, Section 8, Implementation Plan, includes measures to investigate and address potential mercury discharges from Bay Area mines.

Sediment at some sites along the margins of San Francisco Bay contains elevated mercury concentrations. Some sites have been identified through the RMP, the Bay Protection and Toxic Cleanup Program, the State Mussel Watch Program, and individual site investigations. Other sites may remain to be discovered. Table 4.7 provides some examples of known bay margin contaminated sites. At each of these sites, at least one sediment sample contained a mercury concentration above the non-regulatory screening value 0.71 ppm. This value is the Effects Range Median (ERM) concentration, which is the mercury concentration at which adverse biological effects have been reported in 50% of National Oceanic and Atmospheric Administration data. Sites that exceed this

TABLE 4.6: Bay Area Mercury Mines

Mine	County	Drainage
Bella Oaks	Napa	Napa River
Borges	Napa	American Canyon Creek
Challenge	San Mateo	Arroyo Ojo de Agua
Corda	Marin	San Antonio Creek
Hastings	Solano	Sulphur Springs Creek
La Joya	Napa	Dry Creek / Napa River
New Almaden / Guadalupe *	Santa Clara	Guadalupe River
Saint Johns	Solano	Rindler Creek
Silver Creek	Santa Clara	Silver Creek

* The New Almaden Mining District encompasses a number of mines that drain into the Guadalupe River watershed. Associated mercury loads are accounted for in the Guadalupe River Watershed load estimate and, therefore, are not "other potential sources."
Source: SFBRWQCB 1998

TABLE 4.7: Examples of Bay Margin Sites with Elevated Mercury Concentrations

Site	Average Mercury Concentration (ppm)	Estimated Mercury Mass (kg)
Treasure Island Air Station – Area B	0.62	4.8
Treasure Island Air Station – Area E	0.51	1.0
Hamilton Army Air Field	0.6	3.0
U.C. Berkeley Richmond Field Station	16	130
Zeneca – Stege Marsh	5.2	22
Alameda Seaplane Lagoon	1.0	36
Castro Cove	2.3	4.4
Point Potrero	4.7	3.1
Pacific Dry Dock	1.3	*NA*
San Leandro Bay	0.77	3.0
San Francisco International Airport	1.9	*NA*

Source: URS 2002
NA = not available

threshold represent some of the most contaminated bay margin sites. Table 4.7 estimates the mass of mercury at each site (URS 2002). The extent to which this mercury enters San Francisco Bay and affects beneficial uses or influences mercury concentrations in the bay is unknown. However, the margin of safety discussed in Section 7, Allocations, is intended to account for this uncertainty. Moreover, Section 8, Implementation Plan, includes measures to investigate and address potential mercury effects from bay margin contaminated sites.

Key Points

- About 1,220 kg of mercury enters San Francisco Bay each year.
- The sources of mercury in San Francisco Bay include bed erosion (about 460 kg/yr), the Central Valley watershed (about 440 kg/yr), urban storm water runoff (about 160 kg/yr), the Guadalupe River watershed (about 92 kg/yr), direct atmospheric deposition (about 27 kg/yr), non-urban storm water runoff (about 25 kg/yr), and wastewater discharges (about 20 kg/yr).
- San Francisco Bay loses mercury as sediment is transported to the ocean through the Golden Gate (about 1,400 kg/yr), mercury evaporates from the bay surface (about 190 kg/yr), and dredged material is removed and disposed of (about 150 kg/yr, net).

5. Numeric Targets

Numeric targets are measurable conditions that demonstrate attainment of water quality standards. A numeric target can be a numeric water quality objective, a numeric interpretation of a narrative objective, or a numeric measure of some other parameter necessary to meet water quality standards. For a complex problem, such as mercury bioaccumulation in a large estuary, multiple targets may be needed. This report proposes targets for mercury concentrations in San Francisco Bay fish tissue, bird eggs, and suspended sediment. In Section 7, Allocations, the sediment target serves as a basis for allocating loads for several mercury sources. In Section 8, Implementation Plan, the fish tissue and bird egg targets serve to guide management actions needed to minimize mercury methylation and bioaccumulation. The proposed targets are intended to protect the beneficial uses of San Francisco Bay. The targets are based on available information and are intended to be at least as protective as established water quality objectives. Other targets could also be protective of beneficial uses and could be considered in the future through the adaptive management process described in Section 8, Implementation Plan.

Human Health Target

The method used to develop a target for San Francisco Bay fish tissue is derived from the method the U.S. Environmental Protection Agency (USEPA) used to develop its national criterion for mercury in fish tissue (USEPA 2001). To protect human health, USEPA developed a criterion of 0.3 milligrams mercury per kilogram fish tissue (i.e., parts per million, ppm) using Equation 3:

Equation 3:

$$\text{Criterion} = \frac{\text{Body Weight x (Reference Dose - Relative Source Contribution)}}{\text{Fish Intake}}$$

USEPA assumed an adult body weight of 70 kilograms. The reference dose in the equation is 0.0001 milligrams mercury per kilogram body weight per day (mg/kg-day). It represents a lifetime daily exposure level at which no adverse effects would be expected. It is derived from mercury levels that studies have shown cause toxic effects in children exposed to mercury prior to birth. Adverse developmental effects are the most sensitive indicator of mercury effects. USEPA's approach for developing its fish tissue criterion includes several additional conservative assumptions, including incorporating a factor of 10 in the reference dose to account for uncertainties related to mercury's health effects and its metabolism within the body. The relative source contribution (0.000027 mg/kg-day) accounts for other sources of mercury exposure (USEPA 2001).

USEPA recommends that states adopt their own water quality criteria using local consumption data (USEPA 2001). USEPA used 0.0175 kilograms per day as a default fish intake rate. This rate represents the 90th percentile of the U.S. population, including those who do and do not consume fish. However, Bay Area sport fishers (anglers) and subsistence fishers have different fish consumption patterns than the general U.S. population.

To protect the bay's beneficial use of sport fishing, mercury concentrations in bay fish should be low enough so people who choose to eat bay fish can do so on a regular basis. Roughly 170,000 sport and subsistence fishers currently choose to consume bay fish (USEPA 1997e). According to a survey of these fishers, 95% eat less than 0.032 kilograms of fish per day (CDHS and SFEI 2000). Substituting this fish intake rate into the equation above results in a fish tissue criterion of 0.2 ppm mercury. Therefore, 0.2 ppm mercury in fish tissue is proposed as a target to protect human health.

The estimated 170,000 Bay Area sport and subsistence fishers (USEPA 1997e) represent about 3% of the roughly 6.5 million people who live in the Bay Area (CDFFP 1999; CDF 2000). Because the proposed target protects the 95th percentile of these fishers, it protects well over 99% of the Bay Area's existing population.

According to surveys of contaminant levels in fish conducted by the Regional Monitoring Program for Trace Substances (RMP) in 1994, 1997, and 2000, many San Francisco Bay fish that humans consume contain greater than 0.2 ppm mercury, as shown in Figure 5.1. An individual fish consumer's mercury exposure is a function of the type of fish consumed, the amount consumed, and the frequency of consumption. Because the target is derived from a level of daily exposure assumed to occur over an entire lifetime, some fish above the target could be consumed if others were well below it. Therefore, the fish tissue target applies to the average mercury concentration in a collection of fish representing typical consumption patterns.

Striped bass is among the fish species with the highest observed mercury tissue concentrations. Surveys indicate that about 78% of sport and subsistence fishers report consuming striped bass, although the relative proportion of striped bass within their diet is unknown (CDHS and SFEI 2000). This contrasts with 20% reporting leopard shark consumption. Because consumers favor striped bass and striped bass contain relatively high mercury concentrations, achieving 0.2 ppm mercury in striped bass would likely achieve the proposed target in bay fish that represent typical consumption patterns. To lower the current average striped bass mercury concentration of about 0.36 ppm (SFEI 2003b) to 0.2 ppm, fish tissue mercury concentrations would need to be reduced by about 40%.

Wildlife Target

Whereas fish consumption accounts for only a portion of most human diets, some wildlife depend entirely on bay fish or other aquatic organisms for their food. Numerous studies document mercury accumulation within the aquatic food web and its toxic effects on birds (Wiener et al. 2003). In the Bay Area, birds feeding on fish and other aquatic organisms are among the most sensitive wildlife mercury receptors (CDFG 2002;

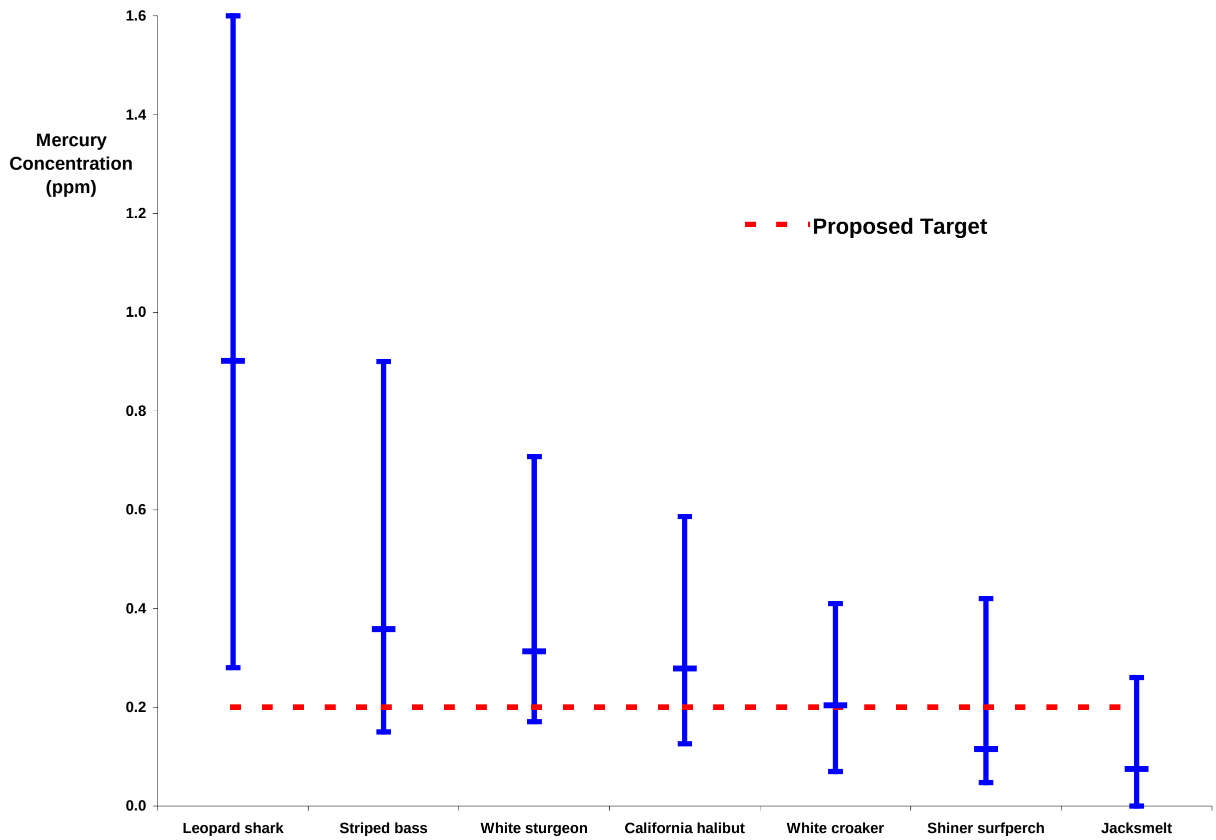

FIGURE 5.1: San Francisco Bay Fish Tissue Mercury Concentrations Compared to Proposed Target
Figure shows mean and range of San Francisco Bay fish tissue mercury concentrations (ppm, wet weight) measured in 1994, 1997, and 2000 (SFEI 2003a; SFEI 2003b; SFEI 2003c).

Davis et al. 2003). A wildlife target that protects birds is also expected to protect other wildlife reliant on the bay for food (USFWS 2003).

The U.S. Fish and Wildlife Service (USFWS) evaluated USEPA's fish tissue residue criterion to determine if the criterion developed to protect human health would also protect wildlife, including rare and endangered wildlife (USFWS 2003). USFWS concluded that, if predatory fish at the top of the food web were to contain 0.3 ppm mercury (USEPA's criterion), most San Francisco Bay wildlife species would be protected. The one exception could be the California least tern. Based on a number of assumptions (e.g., nationwide mercury bioaccumulation data are representative of California estuarine food webs), USFWS concluded that the California least tern would be protected if mercury concentrations in top predator fish were to be 0.12 ppm or less. USFWS also concluded that mercury concentrations of about 0.03 ppm in smaller prey fish comprising the California least tern diet would be protective. (The California least tern generally consumes fish less than 5 centimeters long.) The mercury content of smaller fish more closely relates to California least tern mercury exposure than the mercury content of larger fish. Fewer assumptions are needed to derive the 0.03 ppm for smaller fish than the 0.12 ppm for larger fish. However, mercury concentration data for California least tern prey in San Francisco Bay are unavailable for comparison purposes.

California least tern egg mercury concentrations are a more direct measure of California least tern mercury risks than prey concentrations. To protect the California least tern (and therefore all wildlife), a bird egg mercury target is proposed in addition to the proposed fish tissue target. For the California least tern, like all birds, the life stage most vulnerable to mercury toxicity is the developing embryo (CDFG 2002). Dietary concentrations of mercury that significantly impair bird reproduction are about one-fifth of those that produce overt toxicity in adults (Wiener et al. 2003). Egg mercury concentrations reflect the pre-laying diet of the parent and are predictive of reproduction risks (Davis et al. 2003). The bird egg target does not rely on assumptions about how mercury concentrations in fish at the top of the food web relate to California least tern mercury exposure.

Egg concentrations of 0.5 micrograms of mercury per gram of egg (parts per million, ppm, wet weight) and higher have been associated with toxic effects (CDFG 2002; USEPA 1997d). In a study of common terns, egg mercury concentration between 1.0 and 3.6 ppm adversely affected nesting success (Fimreite 1974). In a ring-necked pheasant feeding study, egg mercury concentrations from 0.5 to 1.5 ppm significantly reduced hatching success (Fimreite 1971). In a study of mallard ducks fed a diet containing 0.5 ppm mercury, egg mercury concentrations were about 0.8 ppm and sublethal effects were observed (Heinz 1979). The lowest observed adverse effect mercury concentration in a bird's diet was about 0.064 micrograms per gram body weight per day, which corresponded to average egg mercury concentrations of about 0.86 ppm (Davis et al. 2003). These studies support the conclusion that bird egg concentrations at or above 0.5 ppm could be associated with toxic effects, but they do not provide a specific concentration at which no toxic effects would occur. In the absence of this information, USEPA has suggested estimating a no-effects level by dividing 0.5 ppm by two or three. However, USEPA concluded that, because of the substantial uncertainties in estimating a no-effects level, neither two nor three can be considered the only correct value (USFWS 2003). Research is needed to develop a site-specific factor for San Francisco Bay or to determine a bird egg mercury concentration that corresponds to no adverse effects.

Because available information suggests that the bird egg mercury concentration at which no adverse effects would occur is below 0.5 ppm, a bird egg target of less than 0.5 ppm mercury (wet weight) where no observable adverse effects occur is proposed. This target will be refined when a mercury toxicity threshold for the California least tern or a more sensitive species is developed. The goal of refining the target would be to establish a concentration that fully protects beneficial uses. Such a refinement would protect all wildlife, including rare and endangered species that nest and feed in the vicinity of San Francisco Bay.

According to San Francisco Bay bird egg studies, average mercury concentrations in California least tern eggs collected in the northern bay region are about 0.66 ppm (Davis et al. 2003). The potential for local conditions to affect typical mercury concentrations is unknown. For California least tern egg mercury concentrations to drop below 0.5 ppm, existing concentrations will need to be reduced by more than 25%. A 40% reduction (roughly the same reduction required to meet the fish tissue target) would result in egg mercury concentrations of about 0.4 ppm. A 50% reduction would result in average egg mercury concentrations of about 0.3 ppm.

Sediment Target

This report proposes a target for suspended sediment mercury concentrations (particle-bound mercury mass divided by sediment mass). Sediment mercury concentrations are closely linked to mercury sources (see Section 6, Linkage Analysis). A suspended sediment mercury target is preferable to a water column mercury target because sediment mercury concentrations relate better to the amount of mercury in the bay and are less subject to short-term fluctuations. The amount of suspended sediment in the water column fluctuates greatly throughout the bay with seasonal and tidal changes (SFEI 1997). Likewise, water column mercury concentrations fluctuate in response to suspended sediment changes. The proposed suspended sediment mercury target is not subject to these confounding factors. The proposed suspended sediment mercury target is useful in allocating mercury loads, as done in Section 7, Allocations.

RMP data collected from 1993 through 2000 can be used to determine the current median suspended sediment mercury concentration. As shown in Equation 4, the dissolved mercury concentration for each RMP sample is subtracted from the total mercury concentration. The difference (the particle-bound mercury concentration) is divided by the total suspended sediment concentration to obtain the suspended sediment mercury concentration.

Equation 4:

$$[Hg]_{sediment} = \frac{10^6 \times [Hg]_{total} - [Hg]_{dissolved}}{[suspended\ sediment]}$$

where:

$[Hg]_{sediment}$ = mercury concentration in suspended sediment (milligrams mercury per kilogram dry sediment)

$[Hg]_{total}$ = total mercury concentration in water (milligrams mercury per liter water)

$[Hg]_{dissolved}$ = dissolved mercury concentration in water (milligrams mercury per liter water)

[suspended sediment] = suspended sediment concentration (milligrams suspended sediment per liter water)

The current median suspended sediment mercury concentration is about 0.33 milligrams mercury per kilogram dry sediment (parts per million, ppm) (SFBRWQCB 2002c). The median is the most robust central tendency measure of the RMP data because the data are skewed and not normally distributed.

To meet the proposed fish tissue and bird egg targets, a 40 to 50% reduction is needed in the amount of mercury in San Francisco Bay sediment. (Section 6, Linkage Analysis, discusses the relationship between mercury in sediment and mercury in fish tissue and bird eggs.) If each individual RMP sample's sediment mercury concentration were reduced by 50%, the median suspended sediment mercury concentration would decrease to about 0.2 ppm (assuming the fraction of dissolved mercury in each sample were to remain the same and rounding to one significant figure). Reducing each individual sample's suspended sediment mercury concentration by 50% would imply a 50% reduction in the total amount of mercury in the system. Therefore, a median sediment mercury concentration of 0.2 ppm is proposed as the suspended sediment mercury target.

Consistency with Numeric Objectives

The proposed targets are consistent with (i.e., at least as strict as) the Basin Plan and California Toxics Rule water quality objectives (see Section 2, Project Background):

- One-hour average total mercury concentration of 2.1 micrograms of mercury per liter of water (µg/l, or parts per billion) north of the Dumbarton Bridge (Basin Plan Table 3-3).
- Four-day average total mercury concentration of 0.025 µg/l north of the Dumbarton Bridge (Basin Plan Table 3-3).
- Total mercury concentration of 0.051 µg/l (Code of Federal Regulations, Title 40, §131.38).

The 0.025 µg/l Basin Plan objective is the lowest of these objectives. It is derived from the U.S. Food and Drug Administration's action level for mercury in commercial fish and shellfish (1.0 ppm) and a bioconcentration factor of 40,000 (the relative methylmercury concentration found in the Eastern oyster compared to the total mercury concentration in the water the Eastern oyster lives in) (USEPA 1985). Because the proposed fish tissue target of 0.2 ppm is substantially lower than the U.S. Food and Drug Administration action level of 1.0 ppm, it is consistent with the lowest applicable numeric objective.

The bird egg target is intended to protect the most sensitive wildlife (i.e., the California least tern) from bioaccumulation. Detrimental effects are unlikely to occur when bird egg concentrations drop to some unknown concentration below 0.5 ppm (Fimreite 1971). The proposed bird egg target will be reviewed as new information becomes available, as discussed in Section 8, Implementation Plan. The stated goal for refining the target—no detrimental mercury concentrations—is stricter than the Basin Plan's narrative objective for bioaccumulation, which states, "Controllable water quality factors shall not cause a detrimental *increase* in concentrations of toxic substances found in bottom sediments or aquatic life" [emphasis added].

As described below, the suspended sediment target is also consistent with the numeric objectives. Under existing conditions, the Basin Plan one-hour average total mercury objective of 2.1 µg/l has never been exceeded in any RMP sample collected in San Francisco Bay (SFEI 2003b). Because reaching the suspended sediment target will require reductions in existing sediment mercury concentrations, attaining the target makes exceedances of the objective even less likely. Figure 2.4 shows that about 21% of RMP water samples from 1993 through 2000 exceeded 0.025 µg/l. However, because the RMP's instantaneous grab samples do not represent four-day averages, they do not establish that the Basin Plan's four-day average objective was exceeded. Suspended sediment levels can fluctuate by as much as 100 milligrams per liter or more on a daily basis (Schoellhamer 1996), and total mercury concentrations fluctuate significantly over four-day periods. Nevertheless, as illustrated in Figure 5.2, if all sediment mercury

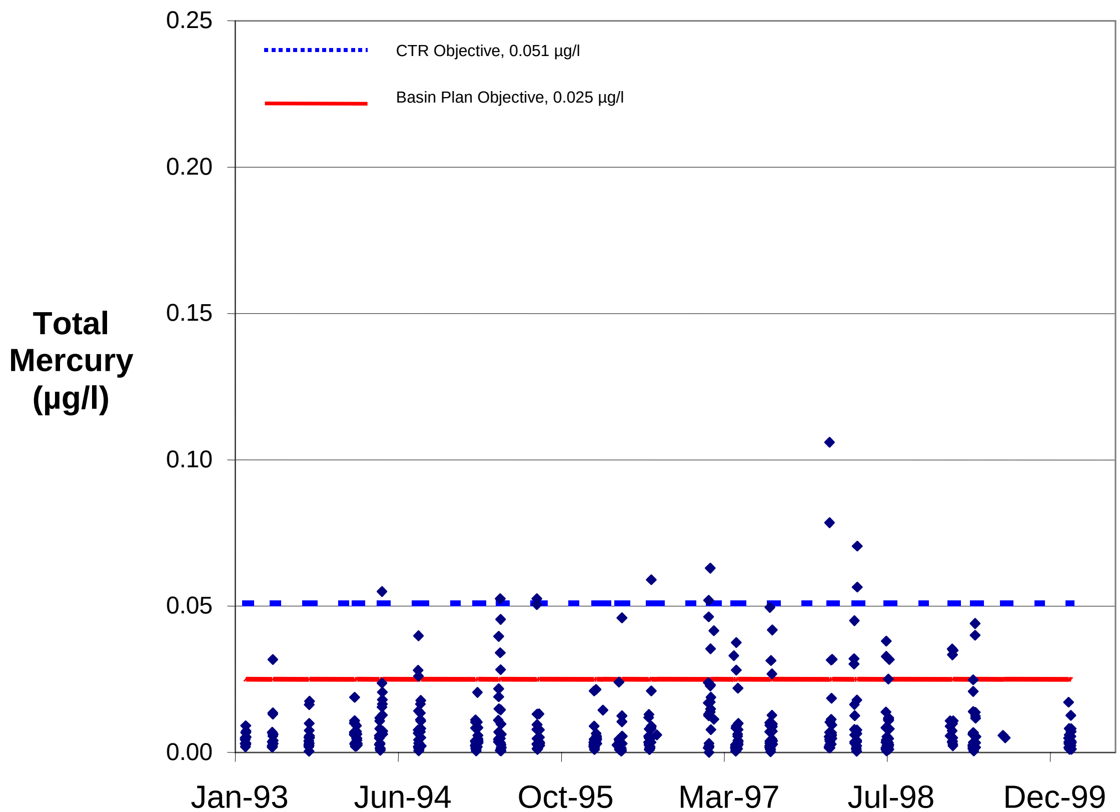

FIGURE 5.2: Predicted Total Mercury Concentrations in Water with 50% Reduction in Sediment Mercury Concentrations

Much of the mercury in San Francisco Bay is bound to suspended sediment. By reducing sediment mercury concentrations by 50%, total mercury concentrations would decrease as illustrated (compare with Figure 2.4). The number of samples shown is 465. Two extreme values from the Guadalupe River are not shown in this figure because they are beyond the scale. The median mercury concentration would be 0.00475 µg/l. The value 0.025 µg/l would be exceeded 46 times during this eight-year period. These data do not represent four-day averages; therefore, they do not indicate that the Basin Plan objective would be exceeded.

concentrations measured from 1993 through 2000 were reduced by 50%, the proposed suspended sediment target of 0.2 ppm would be met, and only 46 out of 465 RMP instantaneous grab water samples (about 10%) would exceed 0.025 µg/l during this eight-year period—but again, these instantaneous samples do not correlate to violation of the Basin Plan objective, which is expressed as a four-day average. Reducing the frequency of total mercury concentrations exceeding 0.025 µg/l illustrates the benefit of achieving the proposed suspended sediment target, but this comparison does not suggest that the target is inconsistent with the 0.025 µg/l Basin Plan objective.

As an illustration of the variability in suspended sediment concentrations over a four-day period, a time series of these concentrations, beginning March 16, 1997, is shown in Figure 5.3 (SFBRWQCB 2002e). In that time period, 22% of the short-term estimated sediment mercury concentrations exceeded 0.025 µg/l. The bottom curve is the calculated total mercury concentration in the water column that would have resulted if the suspended sediment had a mercury concentration of 0.2 ppm (the proposed target). However, the four-day average water concentration is 0.021 µg/l, well below the Basin Plan objective of 0.025 µg/l and the California Toxics Rule objective of 0.051 µg/l. This scenario illustrates that, with a suspended sediment mercury target of 0.2 ppm, occasional

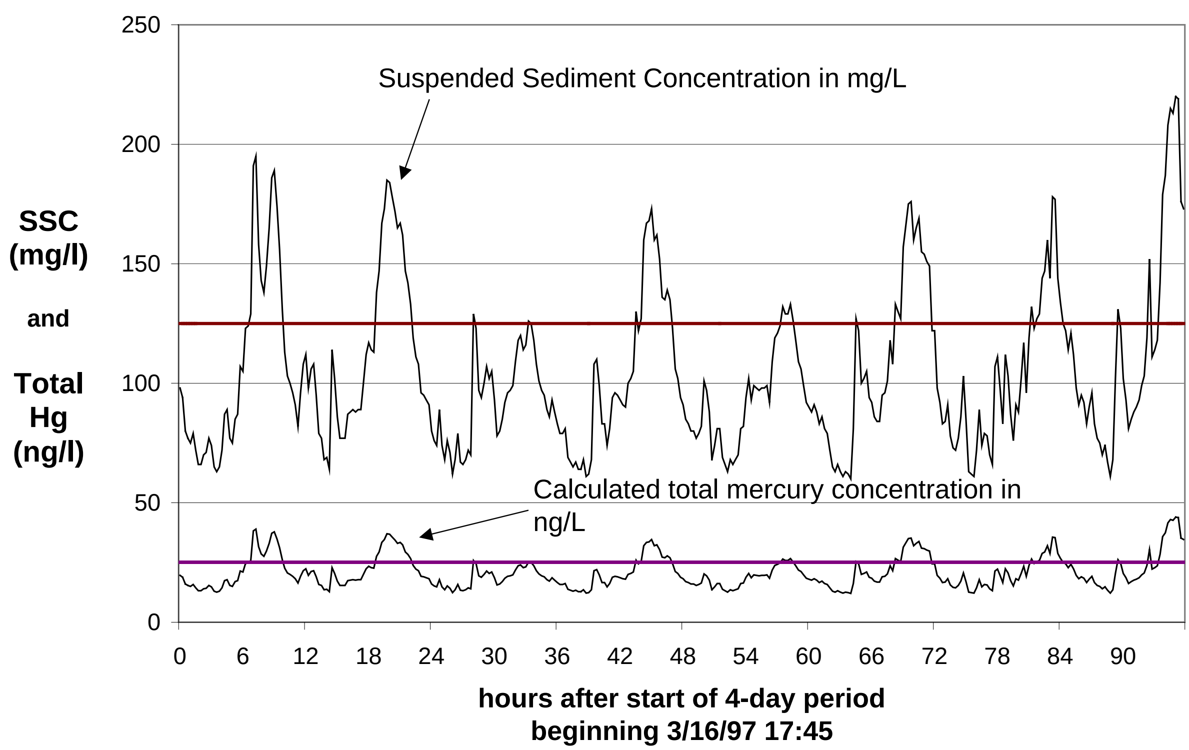

FIGURE 5.3: Suspended Sediment and Estimated Mercury Concentrations for a Four-Day Period

Data (upper plot) represent four days of continuous 15-minute average, mid-depth, suspended sediment concentrations (SSC) at the Dumbarton Bridge as measured by the U.S. Geological Survey. Calculated total mercury concentration (lower plot) is computed from an assumed mercury concentration of 0.2 ppm (the proposed target) on suspended particles.

short-term (less than four-day) excursions above 0.025 µg/l total water column mercury may continue, but such excursions do not necessarily imply actual violation of the Basin Plan objective.

To further explore the relationship between suspended sediment concentrations and the Basin Plan's four-day average mercury objective, multi-day water column total mercury concentrations were simulated (SFBRWQCB 2004a) using USGS 15-minute suspended sediment concentration data from the fixed bay stations from 1993 to 2000 (USGS 2004). The simulation estimated the total water column mercury concentration as the 4-day, 14-day, 21-day, and 30-day average suspended sediment concentration multiplied by the suspended sediment target of 0.2 mg/kg. The simulation computes running multi-day average water column mercury concentrations and the number of computed multi-day averages that would exceed the Basin Plan total mercury objective of 0.025 µg/l (0.051 µg/l for stations south of the Dumbarton Bridge). The simulations show that exceedances of the water quality objectives occur when results are averaged over periods of up to 21 days, but do not occur when averaged over 30 days. Exceedances of the water quality objectives do not occur in Central San Francisco Bay for any averaging period.

Mercury accumulation in upper levels of the food web is a process that operates over relatively long time scales. The concentration of mercury in top predator fish reflects the ambient baywide mercury concentration over periods much longer than four days. Therefore, the longer averaging periods of this simulation should better reflect the bay conditions with respect to mercury impairment. No exceedances of the relevant water quality objectives occur for any of the simulated 30-day average mercury concentrations.

Antidegradation

The numeric targets must be consistent with antidegradation policies. Title 40 of the Code of Federal Regulations (§131.12) contains the federal antidegradation policy. State Water Resources Control Board Resolution 68-16 contains California's antidegradation policy. These antidegradation policies are intended to protect beneficial uses and the water quality necessary to sustain them. When water quality is sufficient to sustain beneficial uses, it cannot be lowered unless doing so is consistent with the maximum benefit to the citizens of California. Even then, water quality must sustain existing beneficial uses.

The proposed numeric targets are designed to implement the narrative water quality objective for bioaccumulation and the Basin Plan and California Toxic Rule numeric water quality objectives for mercury in water. The targets are essentially translations of the narrative and numeric objectives, which have already been established. To be consistent with the antidegradation policies, these targets, taken together, cannot be less stringent than the existing water quality objectives. The proposed combination of the numeric targets is as protective as the objectives. Since mercury concentrations already exceed the bioaccumulation objective, meeting the numeric targets would improve current water quality conditions. Therefore, the proposed targets are consistent with the antidegradation policies and the protection of water quality and beneficial uses.

Key Points

- To protect sport fishing and human health, the concentration of mercury in fish tissue must be reduced by about 40% to 0.2 ppm.
- To protect wildlife and rare and endangered species, the concentration of mercury in bird eggs must be reduced by at least 25% to below 0.5 ppm.
- To achieve the fish tissue and bird egg targets and to attain water quality standards, the concentration of mercury in sediment must be reduced by about 50% consistent with assumptions explained in Section 6, Linkage Analysis; the median concentration of mercury in suspended sediment should be 0.2 ppm.
- The proposed targets are consistent with water quality objectives and antidegradation policies.

6. Linkage Analysis

In Section 5, Numeric Targets, the proposed numeric targets are linked to water quality standards. The proposed targets are intended to ensure attainment of water quality objectives and protection of beneficial uses. This linkage analysis links the proposed targets to the sources of mercury in San Francisco Bay. By linking the targets to the sources, this report demonstrates how actions taken to control mercury sources will achieve the proposed targets and ensure attainment of water quality standards. This analysis also estimates San Francisco Bay's capacity to assimilate mercury while still attaining water quality standards.

Links between Sources and Targets

As discussed in Section 3, Mass Budget Approach, mercury fate and transport within San Francisco Bay is complex. Figure 6.1 simplifies the system to illustrate the primary links between the mercury sources and the proposed sediment, fish tissue, and bird egg targets. The principal steps are as follows:

1. Most mercury in San Francisco Bay binds to sediment.

2. Water movement within the bay transports mercury-laden sediment throughout the bay, depositing some in wetlands, mudflats, and sloughs, where conditions favor methylmercury formation.

3. Small aquatic organisms, such as plankton, take in methylmercury and pass it up through the food web to higher organisms, such as fish.

4. Wildlife and birds at the top of the food web consume mercury in fish and other aquatic organisms (e.g., clams, snails, crabs, and worms).

Mercury Sources and Sediment

The proposed suspended sediment target is closely linked to the sources of mercury in San Francisco Bay because mercury exhibits a high affinity for particles. Most mercury in the aquatic environment is sediment-bound (Morel et al. 1998). The sediment-to-water partition coefficient (K_{db}) for inorganic mercury is typically between 16,000 and 990,000 milliliters per gram (USEPA 1997b) (at equilibrium, a mass of sediment contains roughly 16,000 to 990,000 times more inorganic mercury than an equal mass of water). Therefore, assuming a typical San Francisco Bay suspended sediment concentration of 100 milligrams per liter (see Figure 5.3), between 62% and 99% of the mercury in San Francisco Bay water is bound to particles.

As explained in Section 4, Source Assessment, tributaries, such as the Sacramento and San Joaquin Rivers, the Guadalupe River, and other local tributaries carrying storm water runoff, are the largest sources of new mercury in San Francisco Bay. These tributaries

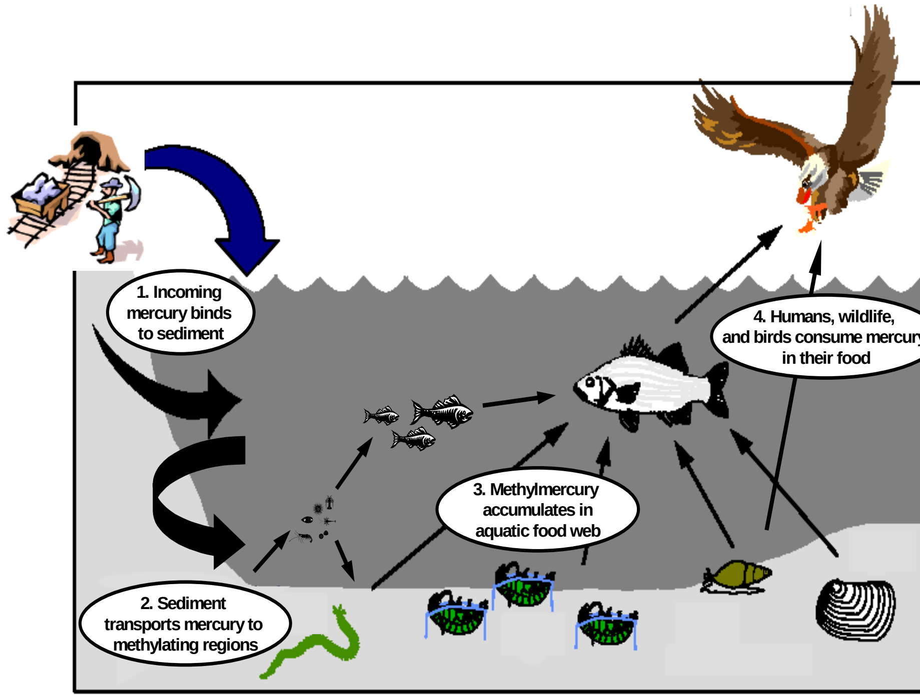

FIGURE 6.1: Simple Conceptual Model
Much of the mercury from the various sources binds to sediment. Some of this mercury is converted to methylmercury, which accumulates in the aquatic food web. Humans, wildlife, and birds are exposed to mercury in the fish and other aquatic organisms they consume.

carry substantial sediment loads, and most of the mercury they deliver is bound to sediment by the time it arrives at the bay. In contrast, the relatively small mercury load from wastewater is primarily dissolved because treatment processes trap and remove most particles (AMSA 2000). The relatively small atmospheric deposition load (roughly 2% of the total) is typically inorganic and may be either particle-bound or not (Morel et al. 1998). Although a relatively small amount of mercury enters the bay not bound to sediment, because of mercury's affinity for sediment, most of this mercury likely binds to sediment after it arrives. Because the amount of mercury in bay sediment is closely related to the mercury loads from the various mercury sources, reducing mercury loads will reduce mercury concentrations in sediment.

Methylmercury Production

The bay is a dynamic system, where water and sediment are mixed by tides, wind, and tributary flows (STB et al. 2000). Mercury is transported with sediment. As sediment moves through the bay, a portion may be transported to areas that favor methylmercury production. Mercury methylation is the conversion of inorganic mercury to organic methylmercury. Demethylation is the opposite process. Both methylation and demethylation occur in San Francisco Bay, and the term "methylation" often refers to net methylmercury production (as in this report).

In 2000, the Regional Monitoring Program for Trace Substances measured methylmercury concentrations in 20 San Francisco Bay water samples. Concentrations ranged from 0.002 nanograms per liter (ng/l, or parts per trillion) to 0.32 ng/l. The median concentration was 0.034 ng/l (SFEI 2003b).

Different bay regions can vary considerably in their methylation potential. Areas that favor methylmercury production include wetlands, marshes, and brackish areas, such as sloughs. Factors that facilitate methylation include the presence of organic matter, low-oxygen sediment, high microbial activity, and water-level fluctuations (Wiener et al. 2003). Methylation rates also depend on pH, temperature, and oxygen levels (DTMC and SRWP 2002). For example, low-oxygen waters can inhibit demethylation, thereby increasing net methylation (DTMC and SRWP 2002; Morel et al. 1998). A study by a Bay Area advanced wastewater treatment plant reported that the ratio of methylmercury to total mercury (fraction methylated) increases when dissolved oxygen decreases below 7 milligrams per liter (FSSD 2002) (the current Basin Plan water quality objective for dissolved oxygen [SFBRWQCB 1995]). Because the factors that affect methylmercury production vary throughout San Francisco Bay, methylation rates also vary.

Sulfate-reducing bacteria are considered to be among the most important methylating agents in aquatic systems (Gilmour et al. 1992). Sulfate-reducing bacteria are most active at the interfaces of water high in oxygen and water low in oxygen, and in sediment and wetlands. In sediment, the microbial methylation of mercury is most rapid in the uppermost 5 centimeters (Wiener et al. 2003). Mercury buried below surface sediment is not readily converted to methylmercury because microbial activity is lacking (Rudd et al. 1983).

Methylmercury production at any particular site is strongly influenced by total mercury in local surface sediment (Rudd et al. 1983). At any particular location, the mercury methylation rate in surface sediment is probably roughly proportional to mercury concentrations in the sediment when sediment concentrations are less than 1 ppm (USGS 2003b). The median concentration of mercury in bay sediment is about 0.3 ppm (SFBRWQCB 2002c). Therefore, methylmercury production is linked to sediment mercury, which, as discussed above, is linked to mercury sources. Reducing mercury loads is expected to reduce methylmercury production.

Mercury Accumulation in Aquatic Food Web

Methylmercury in San Francisco Bay is available for accumulation within the food web. Aquatic organisms take up methylmercury from food, water, and sediment. Higher organisms acquire methylmercury primarily through food ingestion (Rudd et al. 1983; Morel et al. 1998). Methylmercury is the predominant form of mercury found in these organisms (Morel et al. 1998). The amount of mercury that organisms contain varies considerably and does not depend solely on mercury concentrations in water. Relying exclusively on total water column mercury data can mislead efforts to assess potential methylmercury risks (Wiener et al. 2003). Sediment methylmercury concentrations can be a key variable in mercury accumulation within the food web (Schwarzbach et al. 1996). Methylmercury concentrations in water can correlate even more directly with accumulation in aquatic organisms. Both sediment and water methylmercury concentrations more closely relate to concentrations in the food web than total mercury concentrations in water (USGS 2000b).

While the amount of methylmercury in a water body influences the rate at which methylmercury enters the food web, the structure of the food web (what eats what) determines the efficiency of transfer among organisms (Morel et al. 1998). Methylmercury has a high affinity for sulfur-containing proteins, and since upper-level consumers tend to retain the protein components of their food, tissue concentrations of mercury increase at higher levels of the food web (Mason et al. 1995). Fish assimilate about 65 to 80% of the methylmercury in their food (Wiener et al. 2003). With continued exposure, methylmercury concentrations rise within aquatic organisms because elimination is typically slow relative to the rate of uptake. The relative positions of different organisms within the food web account for much of the variation in methylmercury concentrations within and among species (Wiener et al. 2003).

Mercury sources are linked to the proposed fish tissue target via sediment mercury, mercury methylation, and mercury accumulation within the food web. Most modeling in support of mercury TMDLs has been based on an assumption that reducing mercury loads to the environment will have a proportional effect in reducing fish tissue concentrations (DTMC and SRWP 2002). As discussed above, factors relating to mercury methylation and accumulation within the food web are complex and not fully understood. In the absence of additional information, reductions in mercury loads are assumed, for purposes of this report, to result in proportional reductions in fish tissue residues. Additional study is needed to better quantify the relationships between mercury in San Francisco Bay sediment, methylation, and accumulation in aquatic organisms.

The San Francisco Estuary Institute is modeling striped bass growth, diet, and mercury accumulation by estimating fish growth over time as a function of energy inputs and outputs. A fish's change in size is a function of energy input due to food consumption and energy loss though metabolic processes. Pollutant uptake is a function of the rate of food consumption, pollutant concentrations in food, and assimilation rates. The model assumes the rate of predator uptake is linearly related to prey mercury concentrations, the rate of fish growth is unrelated to prey mercury concentrations, and the rate of mercury elimination is linearly related to fish concentrations. Therefore, according to the model, when prey mercury concentrations are cut in half, striped bass mercury concentrations are cut in half. Preliminary model results show that striped bass mercury concentrations closely track mercury levels in prey (SFEI 2002e).

Mercury Accumulation in Birds and Wildlife

Many wildlife and bird species obtain essentially all of their diet from San Francisco Bay. The bay is the feeding and nesting ground for numerous birds, mammals, and other animals. Mercury accumulation in the aquatic food web leads to the mercury exposure of wildlife and birds that eat fish and other aquatic organisms. In birds, methylmercury readily passes from mother to eggs. When transferred to eggs, nearly 100% of the mercury is methylmercury, and about 85 to 95% is deposited in the whites of the eggs (Wiener et al. 2003; CDFG 2002).

The mercury exposure of birds that catch prey throughout the bay likely reflects overall bay conditions. Birds, such as the endangered California clapper rail, that eat organisms from the bay floor often forage in sediment where methylmercury production may be high. California clapper rails are non-migratory, spending their entire lives in marshes. During the breeding season, they have a range of only a few acres and rarely move between marshes. As a result, their eggs reflect local methylmercury production (Davis et al. 2003).

As discussed above, mercury sources are linked to the proposed bird egg target via mercury in sediment, methylation, accumulation within the aquatic food web, and bird exposure. Additional study is needed to quantify the relationship between the aquatic food web and bird eggs. Available information does not fully explore exposure (e.g., diet), mercury transfer to eggs, and the relationship between mercury levels in eggs and reproduction, particularly for the California least tern. In the absence of additional information, however, reductions in bird egg concentrations are assumed, for purposes of this report, to be proportional to reductions in fish tissue mercury. Reducing mercury loads is expected to reduce bird egg mercury concentrations. Because birds annually eliminate much of their body burden of methylmercury through the formation of new feathers (Wiener et al. 2003; CDFG 2002), mercury concentrations in adult birds would be expected to respond relatively quickly to changes in dietary mercury concentrations.

Assimilative Capacity

San Francisco Bay's capacity to assimilate mercury is the maximum amount of mercury that could be in the bay while meeting the proposed targets. Section 5, Numeric Targets, explains that a roughly 50% decrease in sediment, fish tissue, and bird egg mercury concentrations is necessary for the bay to meet water quality standards. As discussed above, reductions in sediment mercury concentrations are assumed, for purposes of this report, to result in proportional reductions in fish tissue and bird egg mercury concentrations. Since most mercury in San Francisco Bay is attached to sediment, reducing sediment mercury concentrations by 50% will reduce the total amount of mercury in San Francisco Bay by 50%.

The amount of mercury currently in San Francisco Bay can be estimated by adding up the amount of mercury in the active sediment layer (sediment where physical mixing and biological activity occurs) and the water column. The amount of mercury in the active sediment layer can be estimated by multiplying the average concentration of mercury in bay sediment, 0.44 ppm (SFBRWQCB 2002c), by the amount of sediment in the active layer. The depth of the active layer varies by time and location within the bay; a reasonable bay-wide estimate ranges from 0.05 to 0.25 meters (SFEI 2002d). Assuming the active layer is about 0.15 meters deep and the area of the bay is about 1.3×10^9 square meters (SWRCB 2003a), the volume of the active layer is about 1.9 x 10^8 cubic meters. Assuming the active layer is 50% water and 50% sediment, there are about 740 kilograms of dry sediment per cubic meter of volume based on the relative densities of water and sediment (Weast 1981; Elert 2002). Therefore, the amount of sediment in the active layer is about 1.4 x 10^{11} kilograms. Using Equation 1 from Section 4, Source Assessment, the total mass of mercury in the active layer is about 63,000 kilograms.

The amount of mercury in the water column can be estimated by multiplying the average total mercury concentration in San Francisco Bay, 0.022 µg/l (SFBRWQCB 2003e), by the amount of water in the bay, 6.66 x 10^9 cubic meters (Conomos et al. 1985). This is about 140 kilograms, an inconsequential mass when compared to the 63,000 kilograms of mercury in the bay's active layer. Therefore, assuming that the amount of mercury in San Francisco Bay needs to be reduced by about 50% to achieve the proposed targets, the bay's assimilative capacity for mercury is about half of 63,000 kilograms, or about 32,000 kilograms.

Key Points

- Efforts to reduce mercury loads are expected to help achieve targets and attain water quality standards because the targets are linked to the sources.
- Most mercury in San Francisco Bay is bound to sediment; reducing mercury loads will reduce sediment mercury concentrations.
- Methylmercury accumulation in aquatic organisms depends on methylmercury production and the structure of the food web.
- Reductions in sediment mercury concentrations are assumed to result in proportional reductions in fish tissue and bird egg mercury concentrations.
- Reducing net methylmercury production will further reduce mercury exposures.
- Assuming that the amount of mercury in San Francisco Bay needs to be reduced by about 50% to meet the proposed targets, the assimilative capacity of the bay is about 32,000 kilograms.

7. Allocations

This section presents recommended allocations for mercury reduction among San Francisco Bay's mercury sources. A TMDL need not be stated as a daily load (Code of Federal Regulations, Title 40, §130.2[i]). Other measures are allowed if more appropriate. The allocation scheme proposed below is expressed in terms of annual mercury loads in kilograms per year (kg/yr) because the adverse effects of mercury occur through long-term bioaccumulation. The loads are intended to represent long-term averages and account for long-term variability, including seasonal variability.

Load and Wasteload Allocations

Allocations are divided among "wasteload allocations" for point sources and "load allocations" for nonpoint sources. The TMDL is the sum of these:

Equation 5:

$$\text{TMDL} = \text{Wasteload Allocations} + \text{Load Allocations}$$

As discussed below, the proposed allocation scheme involves an implicit margin of safety. No explicit margin of safety is proposed.

Table 7.1 presents the proposed load and wasteload allocations by source category. For the Central Valley watershed, the Guadalupe River watershed, and urban storm water runoff, the allocations are derived from the suspended sediment target of 0.2 ppm and each source's estimated sediment load. Assuming that sediment loads do not change, the allocations for these sources could also be expressed as a suspended sediment mercury concentration equal to or less than the proposed suspended sediment target of 0.2 ppm. For bed erosion, atmospheric deposition, non-urban storm water runoff, and wastewater, reasonable goals are proposed either to achieve load reductions or to maintain current loads. Figure 7.1 compares current loads to the proposed allocations.

The proposed allocations are based on the assumption that the mercury from all sources is equally available to be converted to methylmercury and incorporated within the food web. However, a recent study suggests, "The input of wastewater into [San Francisco Bay's] southern reach could be both an external source of methylmercury and an important contributor to mercury methylation through the supply of organic carbon and nutrients to the system" (Conaway et al. 2003). On the other hand, evidence also suggests that mercury in municipal wastewater effluent tends to be present as extremely strong complexes that may be less amenable to methylation (Hsu and Sedlak 2003). Evidence from chemical extraction and incubation experiments indicates that mercury in sediment from different geographic locations can differ in terms of its ability to enter the food web (CDFG 2001). Some recent mercury experiments suggest that mercury newly

TABLE 7.1: Proposed Load and Wasteload Allocations By Source Category

Source	2003 Mercury Load (kg/yr)	Allocation (kg/yr)	Reduction (%)[c]
Bed Erosion	460	220	53
Central Valley Watershed	440	330	24
Urban Storm Water Runoff	160	82	48
Guadalupe River Watershed (mining legacy)	92[a]	2	98
Atmospheric Deposition	27	27	0
Non-Urban Storm Water Runoff	25	25	0
Wastewater (municipal and industrial)	20	20	0
Dredging and Disposal[b]	net loss	0 ≤ ambient concentration	
Total	***1,220***	***706***	

[a] This load does not account for mercury captured in sediment removal programs conducted in the watershed.
[b] Sediment dredging and disposal often moves mercury-containing sediment from one part of the bay to another. The dredged sediment mercury concentration generally reflects ambient conditions in San Francisco Bay sediment. This allocation is concentration-based. The mercury concentration of dredged material disposed in the bay must be at or below the baywide ambient mercury concentration. This allocation will ensure that this source category continues to represent a net loss of mercury.
[c] The 2003 mercury load for each source is rounded from calculated values. The percent reduction for each source was calculated prior to rounding.

deposited in the environment is more readily methylated than existing mercury already in the system (Benoit et al. 2003). This suggests that, although most of the mercury in San Francisco Bay results from historical sources (Dorrance 2002; USGS 2000a), recent mercury additions may be proportionally more responsible for human and wildlife mercury exposure (USGS 2003a).

Available information is insufficient to weight the allocation scheme to account for the relative bioavailability of mercury from different sources. Therefore, these factors have not been explicitly incorporated into the proposed allocation scheme. As more information becomes available, a more refined allocation scheme may be possible. The recent studies underscore the need to consider all sources to be potentially important, even if they are relatively small compared to other sources and the amount of mercury already in the bay. Studies to address the relative bioavailability of mercury from different sources are proposed as part of the adaptive implementation strategy described in Section 8, Implementation Plan.

Bed Erosion

The erosion of sediment buried below San Francisco Bay is a natural process due to uncontrollable factors. Nevertheless, the amount of buried sediment containing elevated mercury concentrations is finite. Eventually, the mercury-laden sediment may completely erode, or alternatively, the erosive process could change such that buried mercury-laden sediment remains buried and sediment loads decline from the estimated

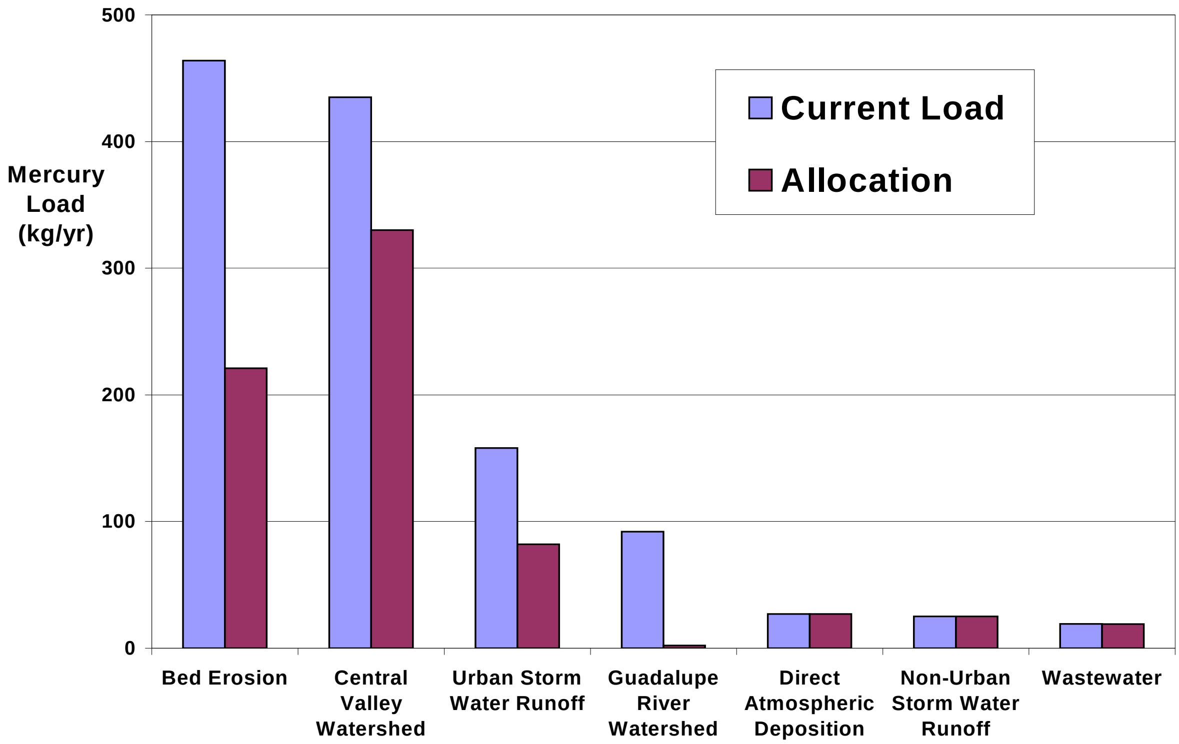

FIGURE 7.1: Current Loads and Proposed Allocations
The proposed allocations call for substantial load reductions from bed erosion, the Central Valley watershed, urban storm water runoff, and the Guadalupe River watershed.

existing 1,100 M kg/yr. In either case, a long-term reduction in mercury loads is foreseeable. This report conservatively assumes that the same amount of bed erosion will continue indefinitely. It also assumes that the mercury concentration of eroding sediment will drop to 0.2 ppm (as discussed later in this section, this is the depth-weighted average mercury concentration observed below 1.3 meters in San Pablo Bay and Grizzly Bay sediment cores [Hornberger et al. 1999]). As a result, the mercury load will eventually drop to about 220 kg/yr without any specific implementation measures.

Central Valley Watershed

Using Equation 1 from Section 4, Source Assessment, the Central Valley watershed mercury load is estimated as the product of the concentration of mercury in sediment times the amount of sediment delivered to the bay. Central Valley watershed sediment contains 0.26 ppm mercury. The Central Valley watershed sediment load is 1,600 M kg/yr. The proposed load allocation for Central Valley watershed is based on the sediment leaving this watershed meeting the proposed target of 0.2 ppm mercury and the sediment load staying the same. Multiplying 0.2 ppm times the sediment load results in a load allocation of 330 kg/yr.

Urban Storm Water Runoff

The mercury load associated with urban storm water runoff has been estimated as 160 kg/yr (see Section 4, Source Assessment). The mercury in urban storm water sediment results in part from controllable urban sources, such as improperly discarded fluorescent lights, electrical switches, thermometers, other mercury-containing devices, and historical and ongoing industrial activities. Atmospheric deposition and natural background also contribute to the mercury in urban runoff. These contributions are assumed to be difficult to control.

Currently, the urban sediment load is estimated to be about 410 M kg/yr, and its mercury concentration is estimated to be about 0.38 ppm. The proposed allocation is based on urban storm water suspended sediment meeting the proposed target of 0.2 ppm mercury. The proposed allocation is 82 kg/yr, which requires a reduction of 78 kg/yr from current conditions. To achieve this reduction, urban runoff management programs can reduce either sediment loads or mercury concentrations in sediment.

Under the proposed allocation scheme, urban storm water dischargers will receive a combined allocation of 82 kg/yr. Table 7.2 breaks this allocation down by urban runoff management program and geographic area. Individual allocations are computed on the basis of populations, not including populations not residing in watersheds draining to San Francisco Bay). The total population residing within the San Francisco Bay Regional Water Quality Control Board's jurisdiction and within watersheds draining to San Francisco Bay (not the Pacific Ocean) was determined using year 2000 census data (CDF 2000) and the CALWATER 2.2 watershed boundary database (CDFFP 1999). Santa Clara, Alameda, Contra Costa, and San Mateo counties have countywide urban runoff management programs, and Table 7.2 lists an individual allocation for each program based on its population. A few municipalities within the other Bay Area counties have their own urban runoff programs, and they have been assigned allocations based on their populations. The portion of the total urban storm water runoff allocation remaining is divided among the otherwise not represented geographic areas of Sonoma, Solano, San Francisco, Napa, and Marin counties according to the fraction of the Bay Area population residing in those areas. The wasteload allocations for these areas are computed by subtracting from each county's total population the populations of municipalities within that county that have an explicit load allocation. The allocation for each municipality or county program implicitly includes any load contribution from current or future permitted discharges from public facilities, California Department of Transportation (Caltrans) roadways and non-roadway facilities and rights-of-way, and industrial facilities and construction sites located in the program area.

Guadalupe River Watershed (Mining Legacy)

Of the 44 M kg/yr of sediment coming from the Guadalupe River watershed, 8.5 M kg/yr is from non-urban areas and the remainder is from urban areas (see Section 4, Source Assessment). Mercury from the Guadalupe River watershed mines originates in non-urban areas and is transported by the sediment originating from non-urban areas.

TABLE 7.2: Proposed Individual Wasteload Allocations for Urban Storm Water Runoff Discharges

Entity	NPDES Permit	Percent of Program Area Population (2003)*	Allocation (kg/yr)[a]	Load Reduction (kg/yr)[b]
Santa Clara Valley Urban Runoff Pollution Prevention Program	CAS029718	27.54	23	21
Alameda Countywide Clean Water Program	CAS029831	24.79	20	19
Contra Costa Clean Water Program	CAS029912	13.59	11	11
San Mateo County Stormwater Pollution Prevention Program	CAS029921	10.27	8.4	8.0
Vallejo Sanitation and Flood Control District	CAS612006	2.01	1.6	1.6
Fairfield-Suisun Urban Runoff Management Program [c]	CAS612005	1.93	1.6	1.5
American Canyon	CAS612007	0.17	0.14	0.13
Sonoma County area [d]	CAS000004	1.97	1.6	1.5
Napa County area [d]	CAS000004	1.93	1.6	1.5
Marin County area [d]	CAS000004	4.05	3.3	3.2
Solano County area [d]	CAS000004	0.98	0.81	0.77
San Francisco County area[d,e]	CAS000004	10.76	8.8	8.4
Total		***100***	***82*** [f]	***78*** [f]

* Source: Year 2000 census data (CDA 2000) and CALWATER 2.2 watershed boundary data (CDFFP 1999).
[a] Allocations 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.
[b] This column contains calculated load reductions relative to the estimated 2003 urban storm water runoff annual load that would result in attaining the wasteload allocation.
[c] The Fairfield-Suisun program area population was adjusted by subtracting the population of Travis Air Force Base, about 10,000 people in 2002 (BASMAA 2003).
[d] Includes unincorporated areas and all municipalities in the county that are in the San Francisco Bay Region and drain to the bay. The statewide municipal storm water general permit issued by the State Water Resources Control Board covers these municipalities.
[e] The urban stormwater runoff load estimate does not account for treatment provided by San Francisco's combined sewer system. The treatment provided by the Bayside facilities (NPDES permit CA0037664) will be credited toward meeting the allocation and load reduction.
[f] Total differs slightly from the column sum due to rounding.

Applying the suspended sediment target of 0.2 ppm mercury to this sediment load results in a load allocation of 1.7 kg/yr.

Atmospheric Deposition

As discussed in Section 4, Source Assessment, atmospheric deposition of mercury is responsible for about 82 kg/yr throughout the local San Francisco Bay watershed (not including the Central Valley). About 27 kg/yr of the 82 kg/yr is deposited directly on the surface of San Francisco Bay, and the remainder is deposited to the watershed. This load allocation concerns only direct deposition. It is the same as the current 27 kg/yr load because the potential to reduce deposition by controlling local sources is believed to be limited. Section 8, Implementation Plan, includes actions to address this source.

Non-Urban Storm Water Runoff

The proposed allocation for non-urban storm water runoff is the same as the current estimate of 25 kg/yr (see Section 4, Source Assessment). The load was estimated using information on sediment loads and mercury concentrations in sediment originating from open space. The estimated mercury sediment concentration of 0.06 ppm is well below the suspended sediment target of 0.2 ppm and close to the estimated pre-mining background concentration of 0.08 ppm (SFBRWQCB 2003f). For this reason, no load reduction is proposed.

Wastewater

Municipal Wastewater

The proposed wasteload allocation requires that, as a group, municipal wastewater dischargers discharge no more than their current combined load of 17 kg/yr (LWA 2004, SFBRWQCB 2004b,c). As a group, municipal wastewater treatment plants perform well. Additional load reductions would incur substantial costs and contribute little to the overall load reductions needed to meet the proposed targets (LWA 2002). However, municipal wastewater discharges need to be managed to minimize the potential for methylmercury production in receiving waters and possible adverse local effects. Table 7.3 lists individual wasteload allocations for municipal wastewater treatment plants. These allocations are computed on the basis of each facility's fraction of the entire municipal wastewater category mercury load from 2000 through 2003. Individual wasteload allocations may be useful in identifying potentially responsible facilities if the combined allocation were ever to be exceeded.

Industrial Wastewater and Petroleum Refineries

The proposed wasteload allocation for industrial wastewater discharges and petroleum refineries requires that, as a group, the petroleum refinery and industrial wastewater dischargers discharge no more than their current combined load of 3 kg/yr (LWA 2004, SFBRWQCB 2004b). As a group, industrial wastewater dischargers perform well. Additional load reductions would incur substantial costs and contribute little to the overall load reductions needed to meet the proposed targets (LWA 2002). However, industrial wastewater dischargers need to be managed to minimize the potential for methylmercury production in receiving waters and possible adverse local effects. Table 7.4 lists individual wasteload allocations for industrial dischargers. These allocations were computed on the basis of each facility's fraction of the total average mercury load from 2000 through 2003 (SFBRWQCB 2004b). Table 7.4 includes all industrial dischargers that discharge directly to the bay. Any industrial facility that does not discharge directly to the bay is implicitly included in the urban storm water runoff allocation for the appropriate county or municipality where the facility is located.

TABLE 7.3: Proposed Individual Wasteload Allocations for Municipal Wastewater Discharges

Permitted Entity	NPDES Permit	Allocation (kg/yr)
American Canyon, City of	CA0038768	0.12
California Department of Parks and Recreation, Angel Island State Park	CA0037401	0.013
Benicia, City of	CA0038091	0.088
Burlingame, City of	CA0037788	0.089
Calistoga, City of	CA0037966	0.016
Central Contra Costa Sanitary District	CA0037648	2.23
Central Marin Sanitation Agency	CA0038628	0.18
Delta Diablo Sanitation District	CA0038547	0.31
East Bay Dischargers Authority Dublin-San Ramon Services District (CA0037613) Hayward Shoreline Marsh (CA0038636) Livermore, City of (CA0038008) Union Sanitary District, Wet Weather (CA0038733)	CA0037869	3.67[a]
East Bay Municipal Utilities District	CA0037702	2.57
East Brother Light Station	CA0038806	0.001
Fairfield-Suisun Sewer District	CA0038024	0.22
Las Gallinas Valley Sanitary District	CA0037851	0.17
Marin County Sanitary District, Paradise Cove	CA0037427	0.001
Marin County Sanitary District, Tiburon	CA0037753	0.01
Millbrae, City of	CA0037532	0.052
Mountain View Sanitary District	CA0037770	0.034
Napa Sanitation District	CA0037575	0.28
Novato Sanitary District	CA0037958	0.079
Palo Alto, City of	CA0037834	0.38
Petaluma, City of	CA0037810	0.063
Pinole, City of,	CA0037796	0.055
Contra Costa County, Port Costa Wastewater Treatment Plant	CA0037885	0.001
Rodeo Sanitary District	CA0037826	0.06
Saint Helena, City of	CA0038016	0.047
San Francisco, City and County of, San Francisco International Airport WQCP	CA0038318	0.032
San Francisco, City and County of, Southeast Plant	CA0037664	2.68
San Jose/Santa Clara WPCP	CA0037842	1.0
San Mateo, City of	CA0037541	0.32
Sausalito-Marin City Sanitary District	CA0038067	0.078
Seafirth Estates	CA0038893	0.001
Sewerage Agency of Southern Marin	CA0037711	0.13
Sonoma Valley County Sanitary District	CA0037800	0.041
South Bayside System Authority	CA0038369	0.53
South San Francisco/San Bruno WQCP	CA0038130	0.29
Sunnyvale, City of	CA0037621	0.15
US Naval Support Activity, Treasure Island WWTP	CA0110116	0.026
Vallejo Sanitation & Flood Control District	CA0037699	0.57
West County Agency, Combined Outfall	CA0038539	0.38[c]
Yountville, Town of	CA0038121	0.04
Total		***17*** [b]

[a] This allocation includes wastewater treatment and all wet weather facilities.
[b] Totals differs slightly from the column sum due to rounding. Allocations were rounded up to the nearest gram.
[c] Monitoring data quality concerns pertaining to this discharger will need to be addressed when the TMDL is next reviewed.

TABLE 7.4: Proposed Individual Wasteload Allocations for Industrial (Non-Petroleum Refinery) Wastewater Discharges

Permitted Entity	NPDES Permit	Allocation (kg/yr)[a]
C&H Sugar Co.	CA0005240	1.56
Crockett Cogeneration	CA0029904	0.005
The Dow Chemical Company	CA0004910	0.044
General Chemical	CA0004979	0.23[b]
GWF Power Systems, Site I	CA0029106	0.002
GWF Power Systems, Site V	CA0029122	0.003
Hanson Aggregates, Amador Street	CA0030139	0.001
Hanson Aggregates, Olin Jones Dredge Spoils Disposal	CA0028321	0.001
Hanson Aggregates, Tidewater Ave. Oakland	CAA030147	0.001
Pacific Gas and Electric, East Shell Pond	CA0030082	0.001
Pacific Gas and Electric, Hunters Point Power Plant	CA0005649	0.022
Rhodia, Inc.	CA0006165	0.012
San Francisco, City and Co., SF International Airport Industrial WTP	CA0028070	0.055
Southern Energy California, Pittsburg Power Plant	CA0004880	0.008
Southern Energy Delta LLC, Potrero Power Plant	CA0005657	0.003
United States Navy, Point Molate	CA0030074	0.013
USS-Posco	CA0005002	0.047
Total		***2.0***[c]

[a] Allocations were rounded up to the nearest gram.
[b] Monitoring data quality concerns pertaining to this discharger will need to be addressed when the TMDL is next reviewed.
[c] Total differs slightly from the column sum due to rounding.

Table 7.5 lists individual wasteload allocations for petroleum refineries. The allocations were computed as the average of each facility's fractional mercury load and fractional effluent volume for the period 2000 through 2003 (SFBRWQCB 2004b).

Individual wasteload allocations may be useful in identifying potentially responsible facilities if the combined allocation were ever to be exceeded.

Sediment Dredging and Disposal

Dredging and disposal operations move mercury-containing sediment from one part of the bay to another. Dredged sediment mercury concentrations generally reflect ambient San Francisco Bay sediment conditions. As ambient mercury concentrations decline, the mercury load from dredged material disposal will decline. The mass of sediment disposed of in the bay is also expected to decline as the Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region is implemented (USACE et al. 2001). To ensure that dredging and dredged material disposal (which always occur together) continue to represent a net loss of mercury from the bay, both a mass-based and a concentration-based allocation are proposed. The mercury concentration of dredged material disposed of in the bay must be at or below the baywide ambient mercury concentration. The ambient threshold concentration is the 99th percentile mercury concentration of the previous 10 years of bed sediment samples

TABLE 7.5: Proposed Individual Wasteload Allocations for Petroleum Refinery Wastewater Discharges

Permitted Entity	NPDES Permit	Allocation (kg/yr)
Chevron Products Company	CA0005134	0.38
ConocoPhillips	CA0005053	0.15
Martinez Refining Co. (formerly Shell)	CA0005789	0.25
Ultramar, Golden Eagle	CA0004961	0.13
Valero Refining Company	CA0005550	0.09
Total		***1.0***

collected through the RMP. The current value of this percentile is 0.55 ppm. Each year, a new 10-year data window will be analyzed to determine this threshold. Because dredged material comes from the bay, RMP stations outside the bay (e.g. Sacramento River, San Joaquin River, Guadalupe River, and Standish Dam stations) will not be considered for determining the Bay ambient threshold. We do not expect that this disposal determination threshold will conflict with any existing suitability determinations utilized by the Dredged Material Management Office (DMMO) because specific numeric sediment quality criteria have not been developed for the Bay Area (USACE 2001).

Other Potential Sources

Available information is insufficient to determine whether local mines or bay margin contaminated sites are sources of San Francisco Bay mercury. Therefore, no load allocations are proposed. Section 8, Implementation Plan, sets forth a strategy for evaluating these potential sources and refining the allocation scheme if appropriate.

Projected Recovery

San Francisco Bay's assimilative capacity for mercury is the amount of mercury it can receive without exceeding water quality standards. As discussed in Section 6, Linkage Analysis, San Francisco Bay's assimilative capacity for mercury is about 32,000 kilograms. To reach the assimilative capacity, about 32,000 kilograms of mercury must be removed from the bay (50% of the existing mercury mass).

A simple model was developed to predict the effects of the proposed allocations on bay sediment mercury concentrations and the time needed to reach the suspended sediment target (SFBRWQCB 2003g). The model is based on the one-box mercury model described in Section 3, Mass Budget Approach. The model accounts for San Francisco Bay mercury inputs and outputs, and relies on assumptions about how sources and losses will change over time.

The model greatly simplifies the complexity of mercury movement throughout the bay and foreseeable changes in sources and losses. The model assumes that bay sediment and mercury are well mixed. Each mercury atom, regardless of its form (i.e., inorganic, elemental, chemically bound, or not bound), is assumed to have an equal chance of being converted to methylmercury and entering the food web. New mercury entering the bay is treated the same as mercury already in the bay. Even with these simplifications, the model provides a useful illustration of foreseeable relative changes in sediment mercury concentrations in San Francisco Bay. Figure 7.2 illustrates the results for two scenarios evaluated.

1. *Current Loads*. In this scenario, no implementation measures are assumed. All mercury inputs (about 1,220 kg/yr) remain the same throughout the simulation, with one exception. The bed erosion mercury load is assumed to decrease from 460 kg/yr to 220 kg/yr after about 110 years. The depth of the elevated mercury concentrations in Suisun Bay and San Pablo Bay sediment is about 1.3 meters (see Figure 4.2) (Hornberger et al. 1999). Suisun Bay, which is eroding more than San Pablo Bay, is eroding at a rate of about 0.012 meters per year (USGS 2001b). Therefore, the time it will take for the mercury-laden sediment to erode completely is assumed to be about 110 years (1.3 meters ÷ 0.012 meters per year). In this scenario, all mercury outputs (about 1,730 kg/yr) remain the same, except that the mercury concentration in sediment leaving through the Golden Gate is adjusted over time to account for decreasing sediment mercury concentrations throughout the bay. The result is that the average sediment mercury concentration in the bay declines from about 0.44 ppm to about 0.22 ppm over more than 200 years and never reaches the proposed suspended sediment target.

2. *Proposed Allocations*. This scenario is like the first; however, additional load reductions of about 280 kg/yr (consistent with the proposed allocations) are phased in over 20 years. Under these conditions, the average bay sediment mercury concentration declines from about 0.44 ppm to about 0.15 ppm, reaching the target of 0.2 ppm after about 120 years and continuing to decline. Significant improvement

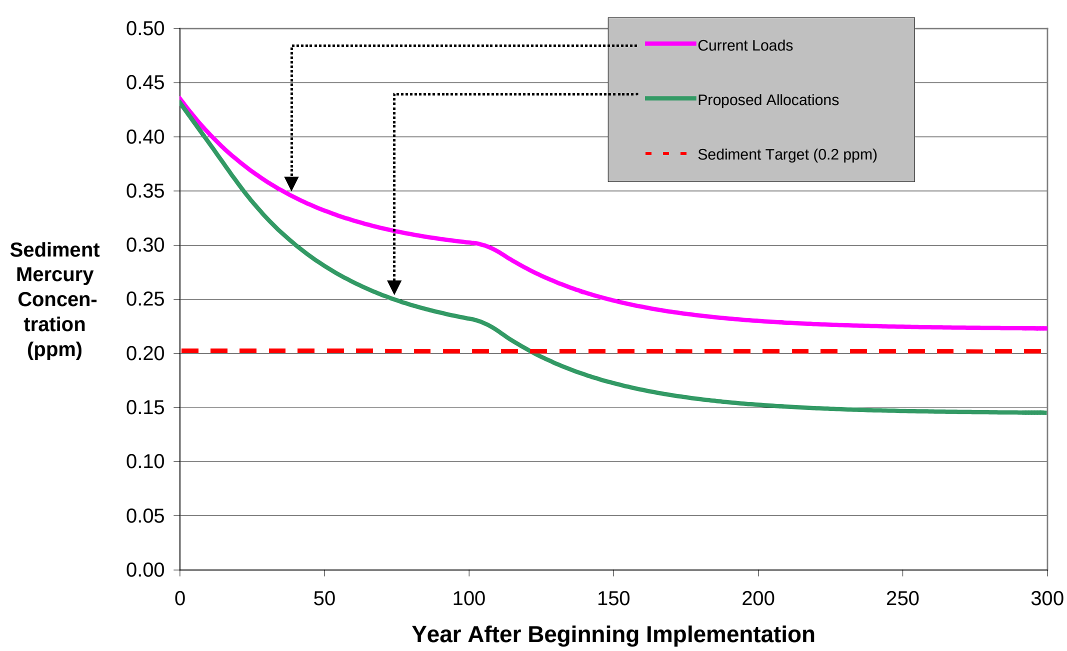

FIGURE 7.2: Recovery Model Results

A simple model was used to estimate changes in average sediment mercury concentrations under two scenarios: (1) current loads and (2) proposed allocations. The shape of the recovery profiles changes after 110 years when mercury-contaminated sediment eventually erodes.

could be observable much sooner, however. The average sediment mercury concentration could decline to about 0.3 ppm after about 40 years. This 30% reduction could significantly reduce the risks mercury poses to humans and wildlife, including rare and endangered species.

Margin of Safety

TMDL analyses must incorporate a margin of safety to address potential uncertainties. The margin of safety is intended to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality.

The margin of safety can be derived either explicitly or implicitly. Providing an explicit margin of safety would involve reserving a specific mercury load allocation for the margin of safety. Alternatively, an implicit margin of safety involves using conservative assumptions (assumptions more likely to be over-protective than under-protective) throughout the analysis. This report relies on several conservative assumptions to derive targets and allocations, and thereby provides the margin of safety implicitly. The proposed adaptive implementation strategy described in Section 8, Implementation Plan, offers an additional margin of safety. The proposed plan involves measuring progress toward meeting the proposed targets and, as necessary, re-evaluating the validity and appropriateness of the assumptions underlying the analysis. Implementation actions will be revised as new information becomes available.

Conservatism in Targets

The assimilative capacity and the mercury reductions that the allocations entail are derived from the reductions needed to meet the proposed targets. In developing the targets, several conservative assumptions were made:

- The fish tissue target is based on the 95th percentile of local fish consumption (not including the vast majority of Bay Area residents that do not eat bay fish). In contrast, when USEPA developed its fish tissue criterion, it used the 90th percentile of national consumption estimates and included data for non-consumers (USEPA 2001). As a result, the proposed fish tissue target is one third less than the USEPA criterion and therefore more conservative.

- The method USEPA used to develop its fish tissue criterion (upon which the fish tissue target is derived) includes several conservative assumptions, including the incorporation of a factor of 10 in the reference dose to account for uncertainties related to mercury's health effects and its metabolism within the body. These conservative assumptions were retained for the fish tissue target; therefore, the target reflects a conservative estimate of the lifetime daily exposure level at which no adverse effects would be expected (USEPA 2001).

- USEPA calculated fish mercury concentrations necessary to protect wildlife using a water column concentration of 0.050 ng/l and mean bioaccumulation factors (USEPA

1997d). The calculated fish tissue mercury concentrations were 0.077 ppm for small fish and 0.35 ppm for larger predator fish that humans more typically consume. The TMDL fish tissue target proposed to protect human health, 0.2 ppm, is substantially lower than USEPA's estimated concentration, 0.35 ppm.

- Based on a U.S. Fish and Wildlife Service review of USEPA's fish tissue residue criterion, the proposed fish tissue target is protective of wildlife (except for the California least tern). The U.S. Fish and Wildlife Service included safety factors to account for interspecies variability and the lack of information about exposure levels causing no observed adverse effects (USFWS 2003).

- The bird egg target is intended to protect the most sensitive wildlife endpoint and the most sensitive resident birds (CDFG 2002). The bird egg target will be refined as more information becomes available. The goal of "controllable water quality factors shall not cause a detrimental increase in mercury concentrations in San Francisco Bay bird eggs" is conservative.

- The suspended sediment target is conservative because it is derived from the fish tissue and bird egg targets, which are conservative. Moreover, whereas a 40% reduction in striped bass mercury concentrations is needed to meet the fish tissue target and a greater than 25% reduction in California least tern egg mercury concentrations are needed to meet the bird egg target, the suspended sediment target calls for a 50% reduction in sediment mercury concentrations.

Conservatism in Allocations and Implementation

The proposed allocations are intended to reduce mercury bioaccumulation in fish and wildlife. Conservative assumptions are used to derive proposed allocations and implementation measures:

- In addition to plans to meet the allocations, the adaptive implementation strategy described in Section 8, Implementation Plan, calls for additional actions to reduce mercury in fish and wildlife. For example, it calls for investigating ways to control atmospheric deposition, even though the allocation scheme does not assume specific load reductions for atmospheric deposition. To the extent that atmospheric deposition can be controlled, all watershed sources will be reduced. Likewise, the implementation plan addresses potential mercury mines and bay margin contaminated sites even though these possible sources have not been confirmed.

- The implementation plan also calls for investigating ways to control mercury methylation. The allocation scheme assumes that all methylmercury reductions in fish and wildlife must come from total mercury reductions in bay sediment. To the extent that methylmercury production can be controlled or managed, the proposed targets will be met more quickly, reducing mercury concentrations in fish tissue and bird eggs.

Although this report provides an implicit, rather than an explicit, margin of safety, Figure 7.2 demonstrates that this analysis is probably conservative. The proposed load and wasteload allocations will likely result in an average sediment mercury concentration of roughly 0.15 ppm, which is 0.05 ppm below the proposed target of 0.2 ppm.

Seasonal Variability and Critical Conditions

Federal regulations require TMDLs to account for seasonal variations and critical conditions. The possible factors to consider for seasonal variability include pollutant loads, beneficial use impairment, and ambient concentrations of total mercury and methylmercury in water and sediment. Seasonal variability in loads is discussed below. Data are limited with respect to seasonal variability in beneficial use impairment and most ambient condition metrics. Data from Regional Monitoring Program sampling are sufficient to investigate seasonal variability of total mercury in the water column. Figure 7.3 shows that there is very little month-to-month variability in total water column mercury despite the probable monthly variability in total mercury loads to San Francisco Bay. Mercury contamination in San Francisco Bay does not appear to be worse at any particular time of year (as would be the case, for example, for oxygen depletion in a lake during summer months). Therefore, concern about seasonal variability is not critical to this analysis or implementation actions related to load reductions, and the proposed allocation scheme does not have a seasonal component.

There is substantial inter-annual variability in the amount of Bay Area rainfall (SFEI 2003b), however, and variability in rainfall means the amount of sediment and water delivered from tributaries varies among years. Furthermore, rainfall variability affects the amount of water that infiltrates into wastewater collection systems. Increases in the volume of water or mass of sediment delivered could increase the amount of mercury delivered to the bay. The proposed yearly load and wasteload allocations represent long-term averages of annual loads. Section 8, Implementation Plan, acknowledges and accommodates long-term inter-annual variability by evaluating whether sources are meeting allocations on a multi-year basis. Long-term averages help smooth out differences among high and low rainfall years.

Some evidence exists that rates of mercury methylation vary according to season. If this is shown to be the case, then there may be a seasonal component to wetland management to minimize mercury methylation in managed wetland areas.

Key Points

- To reach the proposed suspended sediment target and attain water quality standards, the proposed load and wasteload allocations are as follows: bed erosion, 220 kg/yr; Central Valley watershed, 330 kg/yr; urban storm water runoff, 82 kg/yr; Guadalupe River watershed (mining legacy), 2 kg/yr; atmospheric deposition, 27 kg/yr; non-urban storm water, 25 kg/yr; wastewater, 20 kg/yr; and dredging and disposal, 0 kg/yr.

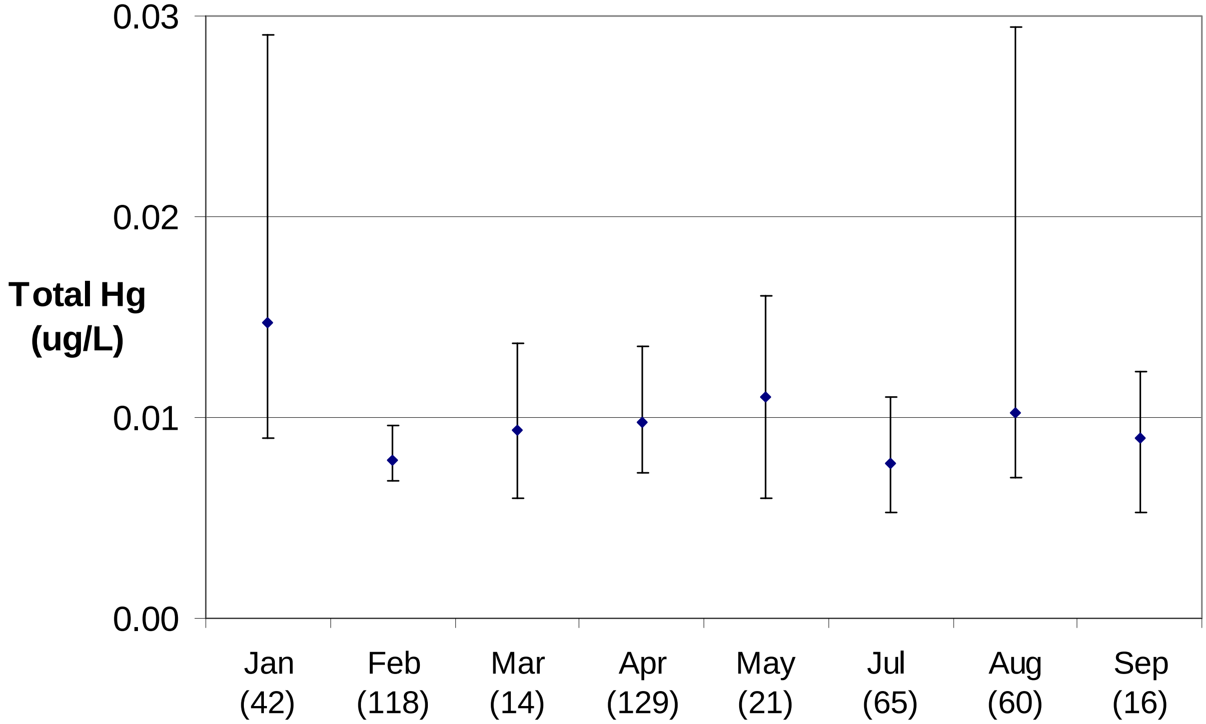

FIGURE 7.3: Monthly Variability in Total Water Column Mercury
The central diamonds represent the median water column total mercury concentration for all Regional Monitoring Program samples collected for the given month from 1993 to 2000. The number in parentheses below the month is the number of samples collected during that month. The bars represent the lower and upper 95% confidence interval for the median.

- The proposed allocation scheme is based on the assumption that mercury from all sources is similarly available to be converted to methylmercury and taken up into the food web.
- By implementing the proposed allocations, the average sediment mercury concentration in the bay will likely drop from about 0.44 ppm to the target of 0.2 ppm after roughly 120 years and to continue dropping to about 0.15 ppm.
- Conservative assumptions used to develop the proposed numeric targets and allocations provide an implicit margin of safety.

8. Implementation Plan

This section describes the plan to implement the load and wasteload allocations specified in Section 7, Allocations. This plan addresses all sources for which there is an explicit allocation as well as other factors relevant to mercury management in the bay.

Objectives

This proposed implementation plan has four objectives. The first is to reduce existing and future discharges of mercury to San Francisco Bay that are due to controllable water quality factors. The goal of such reductions is to attain the proposed load and wasteload allocations and numeric targets. Meeting the allocations and targets will result in attainment of applicable water quality standards. Not all mercury discharges are due to controllable factors, and controllable discharges cannot necessarily be controlled with complete effectiveness. In developing implementation actions for various sources, this plan takes into consideration the relative magnitude of the source and the quantity and quality of data on which the source estimate is based, and the potential cost of control.

In addition to controlling mercury loads, a second objective of the implementation plan is to reduce the amount of mercury transformed to methylmercury, the most toxic form of mercury and the form most readily available for uptake by organisms and consequent risk to humans and wildlife exposed to methylmercury. Based on the discussion presented in Section 6, Linkage Analysis, intervention is possible at three points along the linkage between sources and targets. One point of intervention is the reduction of sources of mercury to San Francisco Bay. The second point of intervention is the reduction of the amount of mercury transformed to methylmercury. Improving our understanding and control of methylation will be important if load reduction efforts are to be effective. Controlling methylation should also guard against locally enhanced biological uptake near discharge locations. A third point of intervention is possible with respect to human risk in that methylmercury exposure can be reduced by limiting consumption of fish containing high concentrations of mercury.

A third objective of this plan is to improve our technical understanding of mercury in San Francisco Bay and source control effectiveness, and then use this information to guide future decisions. Although available data are sufficient to support the TMDL analysis and implementation plan, an adaptive approach is proposed for TMDL implementation. This approach consists of a program of immediate actions to control known sources of mercury with high potential for reduction; a program of monitoring to determine progress toward meeting targets and effectiveness of early actions; special studies to refine our understanding of mercury fate and effects; and a scheme to adapt the strategy in the future as new information becomes available. The actions to be taken immediately are described first, followed by the manner and timeframe for obtaining, reviewing, and incorporating information.

A fourth objective arises from the recognition that water quality programs are most efficient when they address more than one pollutant. Therefore, to the extent possible, this plan seeks to encourage implementation actions that reduce loads of multiple pollutants and not mercury alone.

Implementation Actions

This implementation plan proposes actions to reduce mercury loads and mercury methylation and suggests monitoring needs, where appropriate, for each mercury source. No implementation actions are proposed for bed erosion and non-urban storm water runoff because more information is needed before control strategies can be identified for these sources

Central Valley Watershed

Existing Load:	440 kg Hg /yr
Allocation:	330 kg Hg /yr
Required Actions:	Develop and implement San Francisco Bay Delta and Central Valley Tributary mercury TMDLs

The Central Valley Regional Water Quality Control Board (Central Valley Water Board) is in the process of developing mercury TMDLs for the portions of the Sacramento / San Joaquin River Delta within its jurisdiction and mercury-impaired tributaries draining to San Francisco Bay (Cache Creek, Harley Gulch, Sulphur Creek, Bear Creek, and Sacramento River). The TMDLs will be designed, in part, to meet the Central Valley watershed load allocation. The mercury load reductions necessary to meet Central Valley TMDL targets and achieve applicable water quality standards will likely reduce Central Valley watershed loads to San Francisco Bay sufficiently to meet the requirements of the San Francisco Bay Mercury TMDL. The Central Valley Delta mercury TMDL is scheduled for Central Valley Water Board consideration as a Basin Plan Amendment by December 2005.

Attainment of the load allocation will be assessed as a five-year average annual mercury load. A minimum averaging period of five years is intended to account for the region's substantial inter-annual rainfall variability (SFEI 2003b), which affects the quantity of sediment and mass of mercury delivered. One of two methods may be used to make the attainment demonstration. First, attainment may be demonstrated by documentation provided by the Central Valley Water Board that shows a net 110 kilograms per year (kg/yr) decrease in total mercury entering the Delta from within the Central Valley region. Alternatively, attainment of the load reduction may be demonstrated by multiplying the flow-weighted suspended sediment mercury concentration by the sediment load measured at the Regional Monitoring Program (RMP) Mallard Island monitoring station. If sediment load estimates are unavailable, the sediment load will be assumed to be 1,600 million kilograms of sediment per year (see Section 4, Source Assessment). The mercury load fluxing past Mallard Island will be less than or equal to 330 kg/yr after allocation attainment.

The Mallard Island sampling location may be subject to confounding physical processes, however, in which mercury-laden Suisun Bay or Grizzly Bay sediment is transported upstream by incoming tides and transported downstream again past Mallard Island. The San Francisco Bay Water Board will work with the Central Valley Water Board to refine this source estimate.

Implementation actions likely to be employed in the Central Valley watershed include mine remediation and targeted sediment capture. Other actions may be similar to those outlined for San Francisco Bay in this report. The benefit of control efforts may be difficult to detect and slow to manifest because of the size of this watershed and the distribution of mercury sources. The Central Valley watershed allocation should be achieved within 20 years after the Central Valley begins implementing its TMDLs. Studies need to be conducted to evaluate the time required between the remediation of mercury sources and the time for Delta loads to be reduced. As a way to measure progress, it is expected that the load will be reduced to an interim loading milestone of 385 kg mercury per year, halfway between the current load and the allocation, 10 years after implementation of the Central Valley Delta TMDL. This schedule will be reevaluated as the load reduction plans are implemented.

Urban Storm Water Runoff

Existing Load:	160 kg Hg /yr
Allocation:	82 kg Hg /yr
Required Actions:	Comply with NPDES permits, implement pollution prevention and control programs, and evaluate mercury bioavailability of discharge and feasibility of minimizing mercury uptake into the food web

The wasteload allocations shown in Table 7.2 will be implemented through the NPDES storm water permits issued to urban runoff management agencies and the California Department of Transportation (Caltrans). The urban stormwater runoff allocations implicitly include all current and future permitted discharges, not otherwise addressed by another allocation, and unpermitted discharges within the geographic boundaries of urban runoff management agencies (collectively, "source category") including, but not limited to, Caltrans roadway and non-roadway facilities and rights-of-way, atmospheric deposition, public facilities, properties proximate to stream banks, industrial facilities, and construction sites.

Urban runoff management agencies can reduce urban mercury loads by preventing urban mercury sources from enriching sediment or by reducing the amount of enriched sediment discharged to the bay. Urban runoff management agencies can prevent enrichment through various source control and pollution prevention activities, including fluorescent light bulb, electrical switch, and thermometer collection and disposal programs, and other household hazardous waste collection programs. In addition, urban storm water mercury loads can be reduced through capture, detention, and removal of highly contaminated sediment, and possibly by urban storm water treatment. Substantial infrastructure improvements are expected to result from implementation of construction and new development runoff permit requirements. These requirements, which promote controls such as planting vegetative buffers around impervious surfaces, may effectively control urban sediment discharges. Many of these actions also have the potential benefit of reducing other particle-associated pollutant loads in addition to mercury. The proposed plan will recognize loads reduced by implementing pollution prevention and control programs as credit toward attaining the TMDL allocation. Therefore, the benefit of these measures needs to be carefully quantified.

How rapidly watershed loads and sediment concentrations will respond to control efforts is unknown. Detectable effects will likely lag source control efforts by several years because mercury bound to particulates can be stored in stream beds, banks, and floodplains for several years, particularly during drought years (SFEI 2003b). As such, we propose to implement the allocation in phases using an interim 10-year mercury loading milestone for this source category of 120 kg/yr, which is halfway between the current load and the allocation. The allocations for this group of discharges should be achieved within 20 years.

Loads reduced by diverting urban storm water runoff otherwise destined for San Francisco Bay to treatment facilities will also be recognized as credit toward attaining the allocation. If this is accomplished with the assistance of wastewater treatment facilities, credit for mercury loads reduced may be shared by cooperating agencies. In addition, if storm water dischargers help to reduce loads from another source category (e.g., mining legacies), credit for loads reduced can be shared by the cooperating entities.

The NPDES permits for urban runoff management agencies will require the implementation of best management practices and control measures designed to achieve the allocations or accomplish the load reductions derived from the allocations. In addition to controlling mercury loads, best management practices or control measures will include actions to reduce mercury-related risks to humans and wildlife. Examples of risk-related actions are: efforts to reduce production of methylmercury, efforts to reduce uptake of methylmercury by biota, efforts to reduce human exposure to methylmercury, as well as efforts to improve the quality and management wildlife habitat.

Requirements in each permit issued or reissued and applicable for the term of the permit shall be based on an updated assessment of control measures intended to reduce pollutants in stormwater runoff to the maximum extent practicable and remain consistent with the section of the Basin Plan in Chapter 4 titled "Surface Water Protection and Management—Point Source Control - Stormwater Discharges."

This plan proposes incorporating the following additional requirements into urban runoff (storm water) programs covered by NPDES permits issued or reissued by the Water Board.

i) Evaluate and report on the spatial extent, magnitude, and cause of contamination for locations where elevated mercury concentrations exist.
ii) Develop and implement a mercury source control program.
iii) Develop and implement a monitoring system to quantify either mercury loads or the loads reduced through treatment, source control, and other management efforts.
iv) Conduct or cause to be conducted studies aimed at better understanding mercury fate, transport, and biological uptake in San Francisco Bay and tidal areas. This requirement can be satisfied by supporting or conducting efforts that result in this information being made available to the Water Board beginning with the first adaptive implementation review.
v) Develop an equitable allocation-sharing scheme in consultation with Caltrans (see below) to address Caltrans roadways and non-roadway facilities in the program area and report the details to the Water Board.
vi) Prepare an annual report that documents compliance with the above requirements and documents either mercury loads discharged or loads reduced through ongoing pollution prevention and control activities.
vii) Demonstrate compliance with the allocations shown in Table 7.2 using one of the following methods.

- Quantify the annual average mercury load reduced by implementing (a) pollution prevention activities, and (b) source and treatment controls. The benefit of efforts to reduce mercury-related risks to wildlife and humans should also be quantified. The Water Board will recognize such efforts as progress toward achieving the interim milestone and the mercury-related water quality standards upon which the allocations and corresponding load reductions are based. Loads reduced as a result of actions implemented after 2001 (or earlier if actions taken are not reflected in the 2001 load estimate) may be used to estimate load reductions. New mercury load reductions need to be distinguished from those currently being achieved because the benefit of existing control programs is accounted for in the baseline load estimates on which the allocations are based.
- Quantify the mercury load as a rolling five-year annual average mercury load using data on flow and water column mercury concentrations.
- Quantitatively demonstrate that the mercury concentration of suspended sediment that best represents sediment discharged from program areas is below the suspended sediment target.

An urban runoff management agency that complies with these permit requirements shall be deemed to be in compliance with receiving water limitations relative to mercury. Once the Water Board accepts that a requirement has been completed by an urban runoff management agency, it need not be included in subsequent permits for that agency. These requirements apply to municipalities covered by the statewide municipal stormwater general permit (issued by the State Water Resources Control Board) five years after the effective date of this Mercury TMDL.

Urban runoff management agencies have a responsibility to oversee various sources. However, if it is determined that a source is substantially contributing to mercury loads to the bay or is outside the jurisdiction or authority of an agency, the Water Board will consider a request from an urban runoff management agency that may include an allocation, load reduction, and/or other regulatory requirements for the source in question.

Within the jurisdiction of each urban runoff management agency, Caltrans manages and is responsible for discharges associated with California roadways and non-roadway facilities. Caltrans has a statewide permit issued by the State Water Resources Control Board that requires, among other things, submittal of a work plan that explains how the program will be implemented in each region. The permit also requires Caltrans to develop a program for communication with local agencies and coordination with other municipal urban runoff management programs where the programs overlap geographically with Caltrans roadways and non-roadway facilities. We propose that the following elements be incorporated into the Caltrans regional work plan for the San Francisco region:

- Develop and implement a system to quantify mercury loads or loads reduced through control actions;
- Prepare an annual report that documents mercury loads or loads reduced through control actions; and
- Develop an equitable allocation-sharing scheme that reflects Caltrans load reduction responsibility in consultation with the urban runoff management agencies, and report the details to the Water Board. Alternatively, Caltrans may choose to implement load reduction actions on a watershed or regionwide basis in lieu of sharing a portion of an urban runoff management agency's allocation, and the Water Board will consider a separate allocation for Caltrans. Caltrans may demonstrate progress toward attaining an allocation or load reduction in the same manner mentioned previously for municipal programs.

Guadalupe River Watershed (Mining Legacy)

Existing Load:	92 kg Hg /yr
Allocation:	1.7 kg Hg /yr
Required Actions:	Develop and implement the Guadalupe River Watershed Mercury TMDL

The Guadalupe River Watershed Mercury TMDL will provide a watershed-wide mercury management strategy and will be the primary regulatory vehicle for achieving water quality goals in the watershed and reducing loads to the bay. Implementation measures will likely include mining waste removal actions and extensive slope stabilization measures in the New Almaden Mining District (a steeply sloped upper watershed area); creek restoration activities throughout the watershed, including removal of overbank mining waste deposits; removal of accumulated sediment from surface water conveyance facilities (which will likely reduce loads to the bay of multiple pollutants in accumulated sediment); a monitoring program to evaluate methylation controls; methylation control measures in reservoirs and possibly in other portions of the watershed; measures intended to reduce mercury-related risks to humans and wildlife; and monitoring programs to refine our understanding of sources and effects. Ultimately, the Water Board expects the implementation plan for the Guadalupe River Watershed Mercury TMDL to integrate implementation efforts relative to that TMDL with the implementation efforts for the San Francisco Bay Mercury TMDL.

Control efforts will not be implemented immediately, and the benefit of control efforts may be difficult to detect and slow to manifest because of the size of the watershed and the distribution of mercury sources within the watershed. As such, we propose that the sources of mercury from the Guadalupe River watershed mining legacy be reduced to achieve the load allocation within 20 years, and as a way to measure progress, an interim loading milestone of 47 kg/yr mercury, halfway between the current load and the allocation, should be achieved within 10 years. During the first 10 years of implementation, the dischargers identified through the Guadalupe River Watershed Mercury TMDL process should make reasonable and measurable progress toward the ten-year load reduction through implementation of the watershed-wide strategy.

The Guadalupe River Watershed Mercury TMDL is being developed via a collaborative process between the Santa Clara Valley Water District and the San Francisco Bay Water Board, with active stakeholder involvement. The Santa Clara Valley Water District and the Water Board signed a memorandum of understanding in spring 2003 that describes the scope, schedule, and collaborative process for TMDL development. For the purpose of the San Francisco Bay Mercury TMDL, assessing progress toward reducing mercury loads is critical. Therefore, the adaptive implementation requirements for the Guadalupe River watershed focus on periodic loading studies to assess progress toward achieving the targets and load allocation.

We propose that dischargers identified through the Guadalupe River Watershed Mercury TMDL demonstrate progress toward (a) the interim loading milestone, or (b) attainment of the allocation by using one of the methods listed below.

1. Quantify the annual average mercury load reduced by implementing (a) pollution prevention activities, (b) source and treatment controls, and (c) if applicable, other efforts to reduce methylation or mercury-related risks to humans and wildlife consistent with the watershed-based strategy. The Water Board will recognize loads reduced resulting from activities implemented after 1996 (or earlier if actions taken are not reflected in the 2001 load estimate) to estimate load reductions.
2. Quantify the mercury load as a five-year annual average mercury load using data on flow and water column mercury concentrations.
3. Quantitatively demonstrate that the mercury concentration of suspended sediment that best represents sediment discharged from the watershed to San Francisco Bay is below the suspended sediment target.

Atmospheric Deposition

Existing Load:	27 kg Hg /yr
Allocation:	27 kg Hg /yr
Required Actions:	Support and track national efforts such as the Clear Skies Act and the Quicksilver Caucus

In view of the degree to which global (non-local) sources appear to dominate Bay Area air concentrations and presumably deposition, mandated load reductions do not appear appropriate at this time. A key management issue to be resolved through the adaptive approach to implementing the TMDL is determining the significance of atmospheric deposition and potential pollution prevention and source control options, especially for local sources.

Estimating the local contribution to atmospheric deposition is difficult. Mercury can be transported long distances in the atmosphere, and the Bay Area is downwind of heavily industrialized countries in Asia. In 1996, the California Air Resources Board estimated that Bay Area mercury emissions total about 500 kg/yr (Tetra Tech 2002). Coal combustion in China accounts for about 10% of the global anthropogenic contribution of mercury to the atmosphere, and the United States' contribution is about 5% of the global total (Steding and Flegal 2002). Although it is unknown exactly how much of this mercury is deposited locally, air concentration modeling can provide a starting point to estimate such contributions.

The REgional Lagrangian Model of Air Pollution (RELMAP) mercury model was developed to simulate the emission, transport, dispersion, atmospheric chemistry, and deposition of mercury across the continental United States. This model was used in the development of the Mercury Study Report to Congress to estimate the magnitude and pattern of mercury deposition throughout the United States from domestic emissions and from the global average concentration of elemental mercury from sources around the world (USEPA 1997b). Table 8.1 shows the results of this modeling effort for the counties in the San Francisco Bay region. As shown in the table, the modeled local contribution represents 10% to 59% of the total average air concentration. The mass of mercury deposited is proportional to the air concentration.

TABLE 8.1: Modeled Local Source and Background Contributions to Bay Area Mercury Concentrations in Air (ng/m^3)

County	Average Air Concentration	Background Contribution	Local Source Contribution
Alameda	2.26	1.5	0.76
Contra Costa	1.81	1.5	0.31
Marin	1.68	1.5	0.18
Napa	1.70	1.5	0.20
San Francisco	3.66	1.5	2.16
San Mateo	1.92	1.5	0.42
Santa Clara	1.89	1.5	0.39
Solano	1.67	1.5	0.17
Sonoma	2.00	1.5	0.50

ng/m^3, nanograms per cubic meter
Source: Tetra Tech 2002

The cement industry is a significant stationary air source in the Bay Area (Tetra Tech 2002). USEPA studied the cement industry and determined that treatment would not be cost effective (BAAQMD 2003). Reducing mercury from cement kilns requires a pretreatment step involving carbon adsorption. Costly carbon treatment is probably the most effective option for reducing mercury emissions because existing controls involving cooling exhaust gases do not readily control mercury emissions.

Crematoria emit mercury into the air from dental fillings. The Bay Area Air Quality Management District estimated crematoria emissions to be about 12.2 kg/yr (BAAQMD 2000). Crematoria air emissions permits focus on clean combustion and do not consider mercury. The American Dental Association has reported a 30% decrease in the number of mercury amalgam fillings used between 1990 and 1999 (Berthold 2002). If this trend continues, crematoria emissions will likely decrease proportionally.

National mercury reduction efforts are underway. The Great Lakes Binational Toxics Strategy (Environment Canada and USEPA 1997) calls on the United States to reduce by 50% its anthropogenic mercury inputs to the atmosphere by 2006. However, it is difficult to predict whether reduction efforts within the United States and Canada, along with reductions in local sources, will offset potential increases from combustion sources in Asia. The U.S. Congress is currently considering the Clear Skies Act of 2003. If passed, it would cut mercury emissions by 69% from 1999 levels by establishing a cap of 15 tons of mercury emissions from power plants by 2018 (USEPA 2003). The Quicksilver Caucus was formed in May 2001 by a coalition of state environmental associations to develop comprehensive approaches for reducing mercury in the environment and is currently engaged in two interrelated efforts. In partnership with USEPA, the Quicksilver Caucus is developing a mercury stewardship program to identify best management practices for management, handling, and storage of mercury, and assess market policy options and review mercury commodity markets with a view toward limiting mercury in the marketplace. A second effort of the caucus is to define a national strategy to achieve reduction in mercury loads to surface waters to attain water quality standards (ECOS 2003a,b).

Recent scientific studies suggest that mercury newly deposited from the atmosphere may be more available for biological uptake than mercury already present in an aquatic system (USGS 2003a; Benoit et al. 2003). Chemical extraction and incubation experiments suggest that mercury in sediment from different geographic locations can differ substantially both in its chemical availability and potential to produce methylmercury (CDFG 2001). Therefore, mercury entering the bay from atmospheric deposition could be more available for methylation and biological uptake than mercury derived from legacy sources, such as mining operations.

The following implementation efforts need to be undertaken to evaluate the significance of atmospheric deposition and the feasibility of load reductions:

- USEPA should investigate the significance of atmospheric deposition and actively pursue national and international efforts to reduce the amount of mercury released through combustion of fossil fuels; and
- The Bay Area Air Quality Management District should conduct a local mercury emissions inventory, investigate the significance of local mercury air emissions, evaluate the effectiveness of existing control measures, and the feasibility of additional controls.

If local air sources are found to contribute substantially to atmospheric deposition loading to the Bay and its surrounding watershed, the Water Board will consider assigning allocations and load reductions to individual air sources and work with the Bay Area Air Quality Management District to ensure allocations are achieved.

The key information needs for this source are refining the atmospheric deposition load estimate, assessing the contribution and controllability of local sources, and investigating the relative availability of deposited mercury for methylation and biological uptake. These are discussed in more detail in the subsection on Adaptive Implementation later in this section.

Wastewater

Wastewater loads from municipal and industrial dischargers are addressed separately below.

Municipal Discharges

Existing Load:	17 kg Hg /yr
Allocation:	17 kg Hg /yr (group total to be implemented)
Required Actions:	Comply with NPDES permits, implement pollution prevention programs to assure no net increase in load, evaluate mercury bioavailability of discharge and feasibility of minimizing mercury uptake into the food web

The Water Board proposes to issue a San Francisco Bay watershed NPDES permit for mercury to all dischargers in Table 7.3. We propose to implement the total wasteload allocation as a group mass limit equivalent to the sum of the individual wasteload allocations shown in Table 7.3. The watershed NPDES permit will explicitly prohibit the aggregate municipal wastewater mercury load from exceeding the group allocation of 17 kg/yr.

We propose to evaluate compliance with the group mass limit by comparing the annual load from all municipal wastewater facilities to the group mass limit. The annual mass load for each facility will be computed according to methods described in the Standard Provisions and Reporting Requirements for NPDES Surface Water Discharge Permits (SFBRWQCB 1993). The total annual municipal wastewater load is defined as the sum of the annual loads for each facility. If the annual load exceeds the group mass limit, the Water Board will consider enforcement against those facilities that exceeded their individual allocation.

The potential availability of wastewater mercury for methylation and biological uptake, and possible local effects of such discharges, is not well understood. We propose that dischargers undertake or otherwise support studies to evaluate local impacts and bioavailability. If evidence of local effects from wastewater effluent is discovered, or if municipal wastewater facilities significantly contribute to mercury concentrations in the food web, the Water Board may impose discharge restrictions aimed at minimizing or avoiding adverse impacts. To facilitate implementation and tracking of this and other TMDL efforts, we will encourage municipal dischargers to participate in the Electronic Reporting System already in place. We also encourage expansion of water re-use programs because such programs result not only in conservation of water resources, but also result in reduced loads to the bay of mercury and other pollutants.

We propose that the group mass limit and the following requirements be incorporated into a watershed NPDES permit for municipal wastewater dischargers:

- Develop and implement effective programs to control mercury sources and loading and reduce mercury-related risks to humans and wildlife (the level of effort will be commensurate with the mercury load and performance of the facility) and quantify the mercury load avoided or reduced and risk reductions resulting from the activities;
- Comply with water quality-based effluent limitations, elaborated through the permit, that are consistent with the assumptions and requirements of the wasteload allocation;
- Track individual facility and aggregate wastewater loads and the status of source control and pollution prevention activities;
- Conduct or cause to be conducted studies to better understand mercury fate, transport, and biological uptake in San Francisco Bay and tidal areas (this requirement can be satisfied by supporting or conducting investigations that result in this information being made available to the Water Board beginning with the first adaptive implementation review);
- Conduct or cause to be conducted studies to evaluate the presence or potential for local effects on fish, wildlife, and rare and endangered species in the vicinity of wastewater discharges; and
- Prepare an annual report that documents mercury load data from each facility, including mercury loads avoided through control actions.

The watershed NPDES permit for municipal facilities will put in place a set of triggered actions that would apply individually to each facility. The triggers for such actions are the individual facility mass allocation and a specific effluent mercury concentration. These triggered actions are intended to minimize the potential for adverse effects in the immediate vicinity of discharges and to ensure that municipal wastewater facilities maintain their ongoing operation, maintenance, and performance.

There are two broad categories of municipal facilities—those that provide secondary treatment, and those that provide advanced treatment. Facilities providing advanced treatment have better performance, hence lower effluent concentrations than those providing secondary treatment, so the trigger concentrations for advanced facilities are lower than those for secondary treatment facilities. Proposed effluent mercury concentration trigger values for secondary treatment facilities are a daily maximum of 0.065 µg/l total mercury (derived from the 99th percentile concentration of effluent data collected from January 2000 to September 2002) and a monthly average of 0.041 µg/l total mercury (derived from the 95th percentile concentration of effluent data collected from January 2000 to September 2002) (SFBRWQCB 2002a). For facilities providing advanced treatment, the proposed concentration triggers are a daily maximum of 0.021 µg/l total mercury (the 99th percentile concentration) and a monthly average of 0.011 µg/l total mercury (the 95th percentile concentration). If a facility exceeds both the applicable mass and concentration triggers, it will be required to report the exceedance in its individual Self-Monitoring Report, and to submit a report that:

- Evaluates the cause of the trigger exceedances;
- Evaluates the effectiveness of existing pollution prevention or pretreatment programs and methods for preventing future exceedances;
- Evaluate the feasibility and effectiveness of technology enhancements to improve plant performance.

Industrial Discharges, including Petroleum Refineries

Existing Load:	3.0 kg Hg /yr (major dischargers)
Allocation:	3.0 kg Hg /yr (major dischargers)
Required Actions:	Compliance with NPDES permits, evaluate mercury bioavailability of discharge and feasibility of minimizing mercury uptake into the food web, pollution prevention

We propose that the wasteload allocations for the industrial wastewater discharges, including the five Bay Area petroleum refineries (Chevron, ConocoPhilips, Shell, Ultramar Golden Eagle, and Valero), be implemented as a group mass limit of 3 kg/yr combined for these discharges. The annual mass load for each facility will be computed according to methods described in the Standard Provisions and Reporting Requirements for NPDES Surface Water Discharge Permits (SFBRWQCB 1993). If the annual group mass load exceeds the group mass limit, the Water Board will consider enforcement against those dischargers that exceeded their wasteload allocations (shown in Tables 7.4 and 7.5).

The wasteload allocations for the other industrial wastewater facilities will be implemented as individual mass limits. The individual facility annual loads will be computed in the same fashion as indicated for the petroleum refineries. If the annual load for any non-refinery discharge in Table 7.4 exceeds the wasteload allocation, the Water Board will consider a range of enforcement options.

The potential availability of mercury in industrial wastewater (including petroleum refinery wastewater) for methylation and biological uptake, and the possible local effects of such discharges, are not well understood. We propose that dischargers be required to undertake studies to evaluate local impacts and bioavailability. If evidence of local effects from industrial effluent is discovered, or if industrial dischargers significantly contribute to mercury concentrations in the food web, the Water Board may impose discharge restrictions aimed at minimizing or avoiding adverse impacts. To facilitate implementation and tracking of this and other TMDL efforts, we encourage dischargers of this category to participate in the Electronic Reporting System already in place.

We propose that the mass limits and the following requirements be incorporated into NPDES permits for all industrial wastewater facilities:

- Develop and implement effective programs to control mercury sources and loading and reduce mercury-related risks to humans and wildlife (the level of effort will be commensurate with the mercury load and performance of the facility) and quantify the mercury load avoided or reduced and risk reductions resulting from the activities;
- Comply with water quality-based effluent limitations, to be elaborated through the permit, that are consistent with the assumptions and requirements of the wasteload allocation;
- Conduct or cause to be conducted studies to understand mercury fate, transport, and biological uptake in San Francisco Bay and tidal areas (this requirement can be satisfied by supporting or conducting investigations that result in this information being made available to the Water Board beginning with the first adaptive implementation review);
- Conduct or cause to be conducted studies to evaluate the presence or potential for local effects on fish, wildlife, and rare and endangered species in the vicinity of industrial wastewater discharges; and
- Prepare an annual report that documents mercury loads from each facility, mercury effluent concentrations, and ongoing source control activities, including mercury loads avoided through control actions.

Another proposed requirement in the NPDES permits for industrial facilities is to put in place a set of triggered actions that would apply individually to each facility. The triggers for such actions will be the individual facility mass allocation and a specific effluent mercury concentration. Proposed effluent trigger concentrations are a daily maximum of 0.062 µg/l total mercury (derived from the 99th percentile concentration of effluent data collected from January 2000 to September 2002) and a monthly average of 0.037 µg/l total mercury (derived from the 95th percentile concentration of effluent data collected from January 2000 to September 2002) (SFBRWQCB 2003a). If a facility exceeds both the applicable mass and concentration triggers, it will be required to report the exceedance in its individual Self-Monitoring Report, and to submit a report that:

- Evaluates the cause of the trigger exceedances;
- Evaluates the effectiveness of existing pollution prevention or pretreatment programs and methods for preventing future exceedances;
- Evaluates feasibility and effectiveness of technology enhancements to improve plant performance.

The fate of mercury originally contained in crude oil is not well understood. This mercury may be emitted directly to the air from the refinery, in refinery product, in wastewater, or in solid waste (Wilhelm 2001). The amount of mercury in Bay Area processed refinery crude oil is about 400 kg/yr (SFBRWQCB 2003k; CEC 2002; CARB 2001; NHTSA 2001). Based on refinery wastewater monitoring data, a very small amount of this mercury (less than 1 kg/yr) is discharged in wastewater effluent (SFBRWQCB 2003a). Air emissions from petroleum refineries could be depositing mercury locally on the bay surface and surrounding watershed such that the wastewater contribution from petroleum refineries calculated for this report understates the impact these facilities have on bay mercury concentrations. We propose that, in addition to the requirements above, Bay Area petroleum refineries shall be required to work collaboratively with the Water Board to investigate the environmental fate of mercury in crude oil and report findings to the Water Board within five years of the effective date of this Mercury TMDL implementation plan. These requirements may be implemented via the Water Board’s authority under Section 13267 of the California Water Code or via petroleum refinery wastewater NPDES permits. The report shall address the following two key questions:

1. What are the potential pathways by which crude oil mercury could be discharged to the Bay from Bay Area refining facilities?
2. What are the annual mercury loads associated with these discharge pathways?

Sediment Dredging and Disposal

Existing net loss:	- 150 kg Hg /yr
Allocation:	0 kg Hg /yr
Required Actions:	Comply with applicable dredging permits, implement Long Term Management Strategy for the Disposal of Dredged Material (LTMS), and investigate effect of dredging activities on mercury uptake into food web.

The proposed allocation for sediment dredging and disposal is both mass-based and concentration-based. The mercury concentration in dredged material disposed of in the bay must not exceed the 99th percentile mercury concentration of the previous 10 years of sediment samples collected through the RMP (excluding stations outside the bay, for example, Sacramento River, San Joaquin River, Guadalupe River and Standish Dam stations). Prior to disposal, the material should be sampled and analyzed according to the procedures outlined in available guidance (USEPA et al. 2001).

We also propose that permitted dredging and disposal operations demonstrate that dredging is accomplished in a manner that does not increase bioavailability of mercury. Dredging and disposal activity must continue to conform to the Dredging and Disposal of Dredged Sediment Program described in the Basin Plan. A key component of this program is the Long Term Management Strategy for the Disposal of Dredged Material in the San Francisco Bay Region (LTMS). The program calls for decreased reliance on in-bay disposal of dredged material, and increased reliance on open ocean disposal and beneficial reuse of dredged material for wetland restorations, levee maintenance, and other upland uses. The LTMS seeks to reduce the total volume of in-bay disposal from the approximately 2,400,000 cubic yards per year (yd^3/yr) to approximately 1,000,000 yd^3/yr within about 10 years (USACE et al. 2001). At that time, the amount of mercury placed back in the bay after removal by dredging will be approximately 210 kg/yr. The amount of material removed is assumed to remain essentially the same as current, 640 kg/yr. Thus, upon full implementation of the LTMS, San Francisco Bay dredging will accomplish a net removal of about 430 kg/yr. This removal rate will diminish as sediment mercury concentrations decrease because sediment removed via dredging and out-of-bay disposal will contain less mercury over time as bay sediment mercury concentrations decline (SFBRWQCB 2003j). Because dredging activities involve removal and transport of a large volume of mercury-containing sediment, there is concern regarding the degree to which dredging activities may enhance mercury uptake into the food web. Thus, we propose requirements in the dredging permits to investigate the potential for dredging to enhance mercury uptake. The requirements can be satisfied by supporting or conducting investigations that result in this information being made available to the Water Board beginning with the first adaptive implementation review.

Other Potential Sources

Existing Load:	Unknown
Allocation:	To be determined, if necessary
Required Actions:	Identify and quantify sources, implement mercury and methylmercury control measures as appropriate.

Section 4, Source Assessment, identifies potential sources for which mercury loads have not been confirmed, including potential contributions from mercury mines other than those in the Guadalupe River and Central Valley watersheds, and industrial and military sites along the bay margins that are contaminated by mercury. Wetlands also produce methylmercury, although they are not sources of new inorganic mercury to San Francisco Bay. These potential sources are addressed below.

Mercury Mines

To address mercury mines requires continued implementation of the Mines and Mineral Producers Discharge Control Program (Mines Program) described in the Basin Plan. The key regulatory component of this established program is that property owners of inactive and active mine sites are required to comply with NPDES industrial storm water regulations. Under the Mines Program, the Water Board has the authority to issue individual industrial permits or allow the discharger to obtain coverage under the industrial storm water general permit issued by the State Water Resources Control Board.

Approximately seven small mercury mines located in the North Bay are not meeting the conditions set forth in the Mines Program. Responsible parties must attain compliance within five years of the adoption of the TMDL implementation plan. Water Board staff will work with each mine site property owner to determine the details and sufficiency of monitoring, and necessary source control actions.

Bay Margin Contaminated Sites

A number of former industrial and military sites that contain mercury-enriched sediment surround the bay. While some data are available to estimate the amount of mercury at these sites, loads leaving these sites and entering San Francisco Bay are unknown. While the load these sites contribute to the bay may be small relative to known sources, these sites may pose a threat if biological uptake is taking place in these areas. As such, cleanup of these contaminated sites is a Water Board priority and many cleanups are underway.

The Water Board's approach to cleanup of contaminated sites is detailed in the Basin Plan. We do not propose imposing new cleanup standards for these sites. However, the TMDL implementation plan will require responsible parties to provide data to help assess risks to the bay's ecosystem, evaluate local effects on humans and wildlife, and consider mercury TMDL wildlife and suspended sediment targets when determining site cleanup goals. In particular, we propose that responsible parties be required to do the following:

1. Quantify mercury mass on site such that the upper 95% confidence limit of the mean value is no more than 20% higher than the estimated mean;
2. Determine seasonal and spatial patterns of total and methyl mercury in sediment on site;
3. Estimate future mercury mass on site and patterns of contamination after planned remediation efforts are complete;
4. Determine seasonal patterns of total mercury and methylmercury in the water column at the site;
5. Collect prey items for local fish and birds and assess their mercury concentrations; and
6. Quantify rate of sediment accretion or erosion at the site.

These requirements will be incorporated into all relevant site cleanup plans within five years of TMDL adoption, and the actions will be fully implemented within 10 years of TMDL adoption. The details of monitoring programs to address these information needs will need to take into account site-specific features of the site. We will work with the responsible parties to determine the sufficiency of the monitoring and data collection efforts.

Wetlands

Although wetlands are not a source of inorganic mercury to the bay, they may contribute substantially to methylmercury production and biological exposure. Plans for extensive restoration of wetlands in the San Francisco Bay region raise the concern that mercury methylation may increase, thereby increasing the amount of mercury entering the food web (LFR 2002). On the other hand, such restoration presents a potential opportunity to accelerate achievement of TMDL targets and to reduce ecological risks through carefully considered sequestration of mercury-laden sediment in restored wetlands. Implementation tasks related to wetlands focus on managing existing wetlands and ensuring that new constructed wetlands are designed such that methylmercury production and subsequent transfer to the food web are minimized.

How and where methylation takes place in wetlands and the significance of wetland methylmercury production to the mercury observed in fish and wildlife are unknown. An improved understanding of factors that control methylmercury production and biological uptake is needed as wetlands restoration projects move forward. The Basin Plan details the Water Board's regulatory authority and programs aimed at restoring and protecting wetlands. The Water Board routinely issues Waste Discharge Requirements or Clean Water Act Section 401 certifications that set forth conditions related to the fill or construction and management of wetlands.

To implement the mercury TMDL, we propose that requirements for wetland projects include provisions that the restored wetland region be designed and operated to minimize methylmercury production and biological uptake, and result in no net increase in mercury or methylmercury loads to the bay. We propose pre- and post-restoration monitoring requirements to demonstrate compliance. For managed wetland areas not subject to permit requirements, we will evaluate ways to encourage management to meet the objectives of this TMDL.

We will support and promote projects and studies aimed at evaluating methods to minimize mercury methylation in new and existing wetlands. The following list of wetland design and management options suggests the types of studies or pilot projects needed.

- **Pretreatment—**Capture and detention of mercury-laden sediment prior to transport into wetlands can reduce the amount of mercury available for methylation.
- **Sediment cover requirements—**If wetlands are constructed with fill material, any more heavily contaminated sediment should be placed below less contaminated cover material.
- **Types of wetlands—**The salinity, tidal regime, and vegetation type may greatly influence methylation. Evidence from study of freshwater wetlands suggests that abundant emergent vegetation may favor mercury methylation (UC Davis 2002). This result may or may not be applicable to saltwater marshes.
- **Redox Control—**Mercury methylation is a process that takes place in a particular oxidation-reduction regime, and management options may be available for controlling this factor (Mehrotra et al. 2003).
- **Nutrient Control—**Control of nutrients entering a wetland may be an efficient way to control redox reactions and the amount and type of emergent vegetation. The type and temporal and spatial variability of algae may also play a significant role in methylmercury production and biological uptake (Knapp 2002).
- **Competitive process control—**Recent research suggests that it is possible to affect the balance between different chemical forms of inorganic mercury to minimize the chemical form most readily taken up by methylating bacteria. This approach offers promise in reducing the amount of mercury converted to methylmercury. This has been accomplished in pilot wetland studies by adding iron to a wetland (Horne 2003; Steding 2003).

Risk Management

Another implementation activity is to collaborate with other California agencies to help manage the risk to consumers of mercury-contaminated fish from San Francisco Bay. We envision a multi-phase process to develop a regional risk management strategy. The first phase should focus on identifying specific risk-management needs, the appropriate measures to address those needs, and the associated costs and mechanisms to implement the measures. In this effort, we will work with the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, and other organizations including dischargers that pursue risk management as part of their mercury-related programs. The risk management activities will include the following:

1. Providing multilingual fish-consumption advice to the public. Fish-consumption advisories can be effective for reducing exposure of humans to methylmercury. Existing and future monitoring data should be analyzed to determine what species of fish contain the highest amount of methylmercury. It may even be appropriate to develop information on replacement food sources for those subsisting on Bay fish. The fish consumption advice prepared using such information should be communicated through a variety of mechanisms: direct outreach to the community, broadcast and print media, and signs posted at popular fishing locations.

2. Regularly informing the public about monitoring data and findings of environmental health professionals about the hazards of eating mercury-contaminated fish. It may be appropriate also to distribute information to health care providers serving impacted communities about how to recognize mercury-related health impacts. Monitoring data, combined with information from special studies, can be used to identify priority areas and target groups for outreach and education efforts, which should also communicate the health benefits of eating fish that contain less mercury. Here too the information needs to be conveyed to consumers of Bay fish through a variety of media and languages.
3. Performing special studies needed to support health-risk assessment and risk communication. These studies may include estimation of rates and patterns of fish consumption, characterization of groups with potentially high levels of exposure, identification of effective methods for communicating advice, and evaluation of effectiveness of fish-consumption advisories.

Adaptive Implementation

Adaptive implementation entails applying the scientific method to the TMDL. A National Research Council review of the TMDL program strongly suggested that the key to improving the application of science in the TMDL program is to apply the scientific method to TMDL implementation (NRC 2001). For a TMDL, applying the scientific method involves taking immediate actions commensurate with available information, defining and implementing a program for refining the information on which the immediate actions are based, and modifying actions as necessary based on new information. Taking immediate actions based on currently available information allows the bay to make progress toward attaining water quality standards while we simultaneously improve our understanding of the system through research and by observing how it responds to the immediate actions.

Overview of Adaptive Implementation

The adaptive implementation plan has the following features:

1. Immediate actions commensurate with available data and information. These have been described above for each source category.
2. Monitoring to assess effectiveness of immediate actions and progress toward TMDL targets.
3. Statement of management questions, associated scientific hypotheses, and a framework and schedule for addressing the management questions.
4. A process for reviewing and incorporating into the TMDL information obtained through the studies and monitoring.

The Water Board will adapt the TMDL to incorporate new and relevant scientific information such that effective and efficient actions can be taken to achieve TMDL goals. At a minimum, we propose that the San Francisco Bay Mercury TMDL for be reviewed approximately every five years to evaluate findings from early implementation actions, monitoring, special studies, and relevant scientific literature. The five-year reviews will be coordinated through the Water Board’s water quality Basin Planning Program, and any modifications to the TMDL elements will be incorporated into the Basin Plan. At a minimum, the following focusing questions will be used to conduct the reviews. Additional focusing questions will be developed in collaboration with stakeholders prior to each review.

1. Is the bay progressing toward TMDL targets as expected? If it is unclear whether there is progress, how should monitoring efforts be modified to improve our ability to detect trends? If there has not been adequate progress, how might the implementation actions or allocations be modified?
2. What are the loads for the various source categories, how have these loads changed over time, and how might source control measures be modified to improve load reduction?
3. Is there new, reliable, and widely accepted scientific information that suggests modifications to targets, allocations, or implementation actions are appropriate? If so, how should the TMDL elements be modified?
4. Are effective risk management activities in place to reduce human and wildlife exposure to methylmercury? If not, how should these activities be modified or enhanced?

The load and wasteload allocations were determined, using available data, on the basis of their sufficiency to achieve water quality standards. As part of the adaptive implementation process and in collaboration with dischargers and interested stakeholders, the Water Board will review the TMDL as a whole and determine whether new evidence suggests revisions of specific load and wasteload allocations that will result in more strategic, efficient, and cost effective achievement of water quality standards. For example, as reliable information becomes available regarding methylation control or the relative bioavailability of sources, the Water Board will consider adjusting allocations to implement the TMDL more effectively. The Water Board may also consider revising implementation requirements or resulting permit requirements if such changes are consistent with the assumptions and requirements of the allocations and the cumulative effect of such changes will ensure attainment of water quality standards. During the review, the Water Board will encourage dischargers to share relevant feasibility, effectiveness, and cost information about implementation actions being performed.

Achievement of the allocations for three of the largest source categories (Central Valley Watershed, Urban Stormwater Runoff, Guadalupe River Watershed) is projected to take 20 years, with an interim 10-year milestone of fifty percent achievement. Approximately 10 years after the effective date of the TMDL or any time thereafter, the Water Board will consider modifying the schedule for achievement of the load allocations for a source category or individual discharger provided that they have complied with all applicable permit requirements and all of the following have been accomplished relative to that source category or discharger:

- A diligent effort has been made to quantify mercury loads and the sources of mercury and potential bioavailability of mercury in the discharge;
- Documentation has been prepared that demonstrates that all technically and economically feasible and cost effective control measures recognized by the Water Board as applicable for that source category or discharger have been fully implemented (the Water Board will express recognition of such measures through a variety of regulatory mechanisms [e.g., NPDES permits, Waste

Discharge Requirements, Board Orders, Adoption of TMDLs, etc.], all of which allow for public participation**)**, and evaluates and quantifies the comprehensive water quality benefit of such measures;
- A demonstration has been made that achievement of the allocation will require more than the remaining 10 years originally envisioned; and
- A plan has been prepared that includes a schedule for evaluating the effectiveness and feasibility of additional control measures and implementing additional controls as appropriate.

At approximately 20 years after the start of implementation and after taking the steps regarding schedule modification listed above, if a source category or individual discharger cannot demonstrate achievement of its allocation, despite implementation of all technically and economically feasible and cost effective control measures recognized by the Water Board as applicable for that source category or discharger, the Water Board will consider revising the allocation scheme provided that any resulting revisions ensure water quality standards are attained.

Load and wasteload allocations have been assigned to individual entities. However, assigning loads to watersheds could be a useful future approach for managing pollutant loads, particularly if net environmental benefits can be realized. Such a program would only involve watersheds in the San Francisco Bay region that drain to the bay. Such an approach could involve urban runoff management programs, wastewater facilities, and other responsible parties in a watershed accepting joint responsibility for load reductions. For example, credit for mercury loads reduced by diverting urban storm water to treatment facilities may be shared by cooperating agencies. Trading pollution credits to another bay-draining watershed and establishing credit for removal or sequestration of mercury already in the bay may also be possible. However, no such program currently exists. Interested parties may submit detailed proposals for such an approach, including recommendations for establishing appropriate credit for straightforward load reduction activities like treatment and water re-use and for more difficult-to-quantify activities that result in reduced mercury loads (e.g., collection of household hazardous waste containing mercury). An acceptable credit program may include incentives for agencies to implement load reduction activities and account for avoided mercury loads. Credits could be used to offset annual loads and attain allocations for multiple sources. In addition, the Water Board could encourage and consider a pilot mercury mass offset program if it is demonstrated that such a program is a more cost effective and efficient means of achieving water quality standards and the potential for mercury from different sources to enter the food web and the potential for adverse local impacts have been evaluated. These programs should recognize and reward ongoing efforts that are above and beyond those required by this TMDL.

New Sources of Mercury

As the TMDL is implemented, new sources of mercury may emerge either as the result of a new facility applying for a discharge permit or as a result of a new source being discovered. The Water Board will consider establishing a load or wasteload allocation for a new mercury source under any of the following circumstances:

- The allocation from one or more existing sources of the same category (e.g., municipal wastewater) will be reduced by an amount equal to the new allocation; or
- The Water Board finds that the magnitude of the new allocation is negligible compared to load reductions from all sources that will have been realized prior to establishing the new allocation; or
- The allocation is for a previously unquantified discharge of mercury from a source category that does not already have an allocation.

Monitoring Framework

This report proposes a suspended sediment target of 0.2 ppm (dry weight), a fish tissue target of 0.2 ppm (wet weight), and an interim bird egg mercury target of less than 0.5 ppm (wet weight). The RMP performs the monitoring necessary to evaluate progress toward the sediment and fish tissue targets, and the U.S. Fish and Wildlife Service (USFWS) is collecting information on bird egg mercury concentrations necessary to evaluate progress toward the bird egg target. We anticipate that this bird egg collection and analysis will continue in the future, possibly as a regularly scheduled RMP component.

Evaluation of Suspended Sediment Target

The RMP typically collects water samples at more than 30 locations each year. We propose to evaluate progress toward the sediment mercury target by comparing it to the central tendency mercury concentration on suspended sediment particles collected at all bay locations. The mercury concentration on suspended sediment particles is computed as the difference between total and dissolved mercury in a water sample (at a specific location) divided by the suspended sediment concentration for that same sample.

Evaluation of Fish Tissue Target

The RMP conducts fish tissue sampling and analysis in San Francisco Bay every three years. The program catches and analyzes a number of different fish species from all parts of the bay. For the purpose of evaluating progress toward attainment of the fish tissue target, we propose to focus on striped bass for reasons discussed in the targets section. Striped bass are routinely caught in three size ranges: 45-59 centimeters (cm) (small), 60-82 cm (medium), and larger than 82 cm (large). In the past, it has been relatively easy to catch bass in the small and medium size ranges. It has been difficult to catch fish in the large size category so there is the concern that not enough could be caught in the future to provide a large enough sample size.

To provide sufficient data to evaluate the mercury target, we propose that several striped bass in the small and medium size ranges (about 15 in each category) be caught and analyzed individually for mercury. Because the amount of mercury in fish has been shown to be proportional to the length of the fish, a reasonable approach is to establish this relationship by plotting mercury concentration against fish length and computing the equation of the best fitting line through the data (Wiener et al. 2003; SFEI 1999). Once this best linear relationship between mercury concentration and length has been established for the fish caught as part of the sampling program, the equation for the linear fit will be evaluated at 60 cm (the size associated with the current average striped bass mercury concentration) to compute the mercury concentration to compare to the fish tissue target. When the mercury concentration in striped bass of this size is below the mercury target, the average concentration of all bay fish consumed by sport fishers will likely be below the mercury fish tissue target.

Evaluation of Bird Egg Target

The Water Board and the California Bay Delta Authority (CALFED, which implements a cooperative effort of state and federal agencies and local communities to improve the quality and reliability of California's water supplies and revive the San Francisco Bay-Delta ecosystem) have contracted with USFWS to conduct a pilot study of contaminant concentrations in bird eggs in San Francisco Bay. USFWS will continue sampling for a couple more years. The RMP is collaborating with USFWS to conduct a separate pilot study to select appropriate bird species for long-term monitoring and analysis. Based on preliminary project results, candidate species include the California clapper rail, Caspian tern, California least tern, Forster’s tern, and the cormorant.

In the long term, eggs will likely be collected from at least one of the marsh bird species listed above and the cormorant (a non-marsh species). We anticipate that this sampling program will be repeated once every 3 years. The eggs will be collected at several locations throughout San Francisco Bay. The bird egg target will be compared to the computed 99th percentile mercury concentration in the marsh bird species eggs. The 99th percentile is appropriate for comparison to the target because adverse effects are associated with mercury concentrations of 0.5 ppm. Therefore, essentially no eggs should have a mercury concentration higher than the bird egg target concentration. If the bird egg mercury concentrations do not follow a normal distribution, the data will be transformed appropriately to obtain a distribution that most closely approaches normality (verified through a statistical test of normality or a symmetry plot) prior to estimating the 99th percentile. Once the percentile is computed, the result will be transformed back to the original data scale before comparison to the bird egg target (e.g., if the data were squared to obtain a normal distribution, the square root of the computed percentile would be used for comparison to the target).

In addition to measuring mercury concentrations in bird eggs directly, it is also useful to measure the amount of mercury in bird prey. We will encourage the RMP to collect and analyze prey typically consumed by birds. These prey should include benthic invertebrates and small fish, like anchovy and topsmelt, of a size that could be consumed by piscivorous birds. According to the USFWS, the sensitive and endangered California least tern will be protected if the average concentration of mercury in the fish it consumes does not exceed 0.03 milligrams of mercury per kilogram of fish tissue (wet weight).

This prey fish concentration is an alternative method of demonstrating protection of wildlife (the purpose of the bird egg target).

Evaluating Effectiveness of Actions Already Taken

In addition to monitoring to assess progress toward targets, it is important to assess the effectiveness of actions to control mercury loads and methylation. Where our permitting authority allows, we propose to encourage dischargers to conduct effectiveness studies as they implement specific control measures so that more effective actions can be taken in the future. The range of actions to be taken is quite large so it is impossible to describe in detail the manner in which such evaluations should be conducted. In general, however, effectiveness evaluations should document the degree to which an action results in reduced mercury loads or methylation and the cost of the action, along with any information about site-specific factors relevant to applicability of the action throughout the region.

Management Questions

The purpose of this section is to identify the management questions relevant to improving our understanding of mercury sources, fate, and effects in the San Francisco Bay system such that we can better manage the mercury water quality problem. We do not need to fully understand everything about mercury in San Francisco Bay to make management decisions. We are focusing attention on those questions that are most relevant to solving the water quality problem. The relevant management questions deal with San Francisco Bay system processes and effects, source loads and implementation of control strategies, and TMDL targets. In the following discussion of each question, we briefly describe current hypotheses about the question; the proposed manner in which the question would be addressed (by whom and when), why the question is important, and how the information will be incorporated into the TMDL process.

San Francisco Bay System Processes and Effects

<u>Where is methylation occurring in the system and what are the controlling factors?</u>
This question must be addressed to develop management or design strategies to suppress methylation. Currently available information suggests that methylation is occurring in tidal wetlands connected to the bay and fringe mudflat areas. These areas have the necessary physical, chemical, and biological conditions required for methylation, and wetland habitats in general have been noted as likely areas of high methylation because of the maintenance of these conditions. Methylmercury may also be produced in bay sediment, and there may be some methylmercury input to the bay from tributaries.

This question can be addressed through a program of observation and controlled laboratory and field experiments. Studies are underway to measure methylmercury production in multiple locations in the bay and its margins at various times along with a survey of candidate chemical, biological, and physical controlling factors. These candidate controlling factors will then be further tested through controlled laboratory and field investigations. With this information, options for management and design of such areas can be explored. This observational program will be accomplished through a variety of programs including the RMP, grant-funded projects, and discharger-funded studies. We anticipate having a preliminary answer to this question within five years of TMDL adoption. We may be able to incorporate this information in a number of ways: (1) there may be more stringent measures to reduce mercury inputs to such areas, (2) we may be able to suggest management or design options for such areas aimed at controlling methylation, and (3) we may be able to remove mercury from these areas if feasible.

<u>Will erosion of mercury-laden sediment from certain regions of the bay affect water quality?</u>
The source assessment estimates that 460 kg/yr of mercury that was buried below the active layer is introduced into the system via erosion of overlying sediment. In Section 7, Allocations, this process was estimated to continue for about 110 years at its current rate before exhausting the excess mining legacy mercury in bay sediment. If this source continues for many decades, it will impede progress toward TMDL targets because of its magnitude. It is particularly important to focus attention on regions of the bay that contain high mercury concentrations subject to physical conditions that could mobilize sediment, and where mobilized sediment could be transported to methylating regions. The U.S. Geological Survey has ongoing modeling and observational studies looking into this question, and we expect an improved answer within ten years. Resolution of this management question will influence estimates concerning how long it will take to reach TMDL targets, and this may influence decisions regarding frequency of certain monitoring activities as well as decisions about actions to control ongoing sources.

<u>Are there local methylation or bioaccumulation effects at the point of discharge?</u>
Based on available information, we hypothesize that every molecule of mercury entering San Francisco Bay has an equal chance of becoming methylated and incorporated into the food web such that there are no discernible local impacts at the point of discharge of storm water and wastewater. The information on which these hypotheses is based needs to be refined by measuring methylmercury production in the vicinity of discharges to determine if the discharge itself is enhancing methylation in the receiving water. If there is evidence of local effects at the point of discharge, we may compel dischargers to manage their discharge so as to minimize methylation in receiving waters. We may also modify discharge limits to better manage local effects. We anticipate that discharger-funded investigations will provide a preliminary answer to this question within five years of TMDL adoption.

<u>What is the mercury and sediment export out the Golden Gate?</u>
This report estimates mercury and sediment export out the Golden Gate indirectly using information about other sources to the bay. Better estimates of sediment and mercury export may enable refinement of estimates of the time it will take for the bay to attain targets. There is active research into this question. We anticipate having a better estimate within ten years of TMDL adoption.

What is the timeframe for recovery of the system and attainment of targets?
The simple modeling exercise discussed in Section 7, Allocations, suggests that, under the proposed allocation scheme, bay sediment will attain the suspended sediment target in about 120 years. This model is based on the following simplifications:

- *The bay system is composed of two compartments—bay waters and the active sediment layer.* The active sediment layer is the topmost layer of sediment that is subject to routine resuspension by wind, waves, currents, and tides and most available to organisms living in the bay. This two-compartment structure is a simplification of the complex structure of San Francisco Bay, but it is useful for modeling how the system might respond to load reductions.

- *The depth of the active sediment layer is 0.15 meters.* This is a simplification of a dynamic and complex process. The active sediment layer depth may vary by location, salinity, season, and a number of other factors. Since the TMDL is concerned with long-term changes and consequences, it is reasonable to reduce this process to an overall average that estimates what portion of San Francisco Bay sediment is likely to be resuspended into the water column.

- *Mercury below the active sediment layer is not considered in the bay system, but can enter the system when overlying sediment erodes.* The mercury in sediment below the active sediment layer (below 0.15 meters) can enter the active layer through the erosion of overlying sediment. This process does not occur everywhere in the bay but, it is well documented (USGS 2001a,b).

- *The active sediment layer is completely well-mixed.* This is a reasonable assumption given that, by definition, the sediment in this layer is subject to re-suspension and mixing.

- *The mass of sediment leaving the bay balances the mass of sediment entering the bay either naturally or via dredged material disposal out of the bay.* Although there are some portions of the bay that appear to be eroding, the active layer within the bay is considered neither to be losing nor gaining sediment. Assuming that the depth of the active layer is constant, the sediment mass in the active layer is constant.

There are already efforts underway by the San Francisco Estuary Institute and the U.S. Geological Survey to help develop a more sophisticated model of sediment transport in the bay that will provide a more refined and realistic answer to the question of bay recovery. Results are expected within five years of TMDL adoption.

Source Loads and Implementation of Control Strategies

How much of the direct and indirect atmospheric deposition to San Francisco Bay is from California sources and Bay Area sources?
To evaluate options for controlling atmospheric deposition, we need information concerning the degree to which local sources of mercury to the atmosphere are

contributing to deposition that reaches the bay directly or indirectly through runoff. There are studies that suggest that upwind air emissions in Asia dominate the mercury concentrations in California (Steding 2002). This question is relevant because, if we find that local sources contribute substantially to deposition reaching the bay, then we may seek to control those sources. We propose to collaborate with the Bay Area Air Quality Management District to determine the contribution and controllability of local sources. We intend to improve our estimates of direct and indirect atmospheric deposition loads through a combination of monitoring and modeling studies. We anticipate having an improved estimate of atmospheric deposition and the contribution of local sources within ten years of TMDL adoption.

<u>What is the relative bioavailability of mercury from different sources to San Francisco Bay?</u>
Based on currently available information, we employ the simplification that mercury from all sources to the bay is equal in terms of bioavailability. Moreover, the mercury already in the system is just as bioavailable as mercury recently introduced. There is emerging evidence that mercury newly-deposited from the atmosphere is more bioavailable than mercury already in the system (Benoit et al. 2003, USGS 2003a) and that watershed mercury sources vary in chemical availability (CDFG 2001). Factors such as particle size of mercury-containing sediment as well as mineral composition of the sediment may influence biological uptake of mercury. We have not taken into account relative bioavailability in allocating loads because, at present, information is insufficient to base allocations or to adjust allocations according to bioavailability. We also recognize that some mercury sources are more likely than others to enter methylating regions in and around the bay, but information is insufficient at present to account for this potential in the allocation scheme.

Resolution of this management question is important in that it can help guide efforts to control the most bioavailable sources. If sources differ substantially in bioavailability, then allocations could be adjusted by reducing the allocation for the most bioavailable sources. This question will be addressed through careful observational programs involving field studies and laboratory investigations, some of which CALFED, dischargers, and others will perform in the bay and support through a variety of ongoing research efforts. We anticipate having a preliminary answer to this question within five years of TMDL adoption.

<u>What is the mercury load from the Central Valley rivers?</u>
A large source of mercury to San Francisco Bay is the amount delivered to the bay from the Sacramento and San Joaquin Rivers. It is important to have an accurate estimate of this source and track its change through time to predict the rate at which the bay will achieve TMDL targets. It is possible that mercury eroding from Suisun and Grizzly Bay may be confounding attempts to measure mercury loads from the Central Valley rivers. The San Francisco Bay Water Board and Central Valley Water Board will work cooperatively to investigate this issue over the next five to ten years. There is already work being performed through the RMP that will help resolve the question.

How much mercury is stored in San Francisco Bay tributaries?

There may be a large amount of mercury stored in stream channels and bank deposits that may be delivered to San Francisco Bay over time. It is important to locate, quantify, and characterize channel and bank storage. If it is localized, it may be possible to remove it before it reaches the bay. If we can estimate the amount and determine the factors controlling its transport downstream, we may be able to reduce loads to the bay, and we will have better information about when the bay will reach TMDL targets.

What is the relationship between mercury concentrations in sediment and mercury concentrations in the food web?

The linkage analysis proposes a linear relationship between the concentration of mercury in sediment and the concentration in fish tissue and bird eggs. In other words, if sediment mercury concentrations are reduced by 50%, then fish tissue and bird egg mercury concentrations will be reduced by 50%. A related hypothesis is that the fraction of total mercury in the bay that is transformed to methylmercury will remain essentially constant. This hypothesis is based on the assumption that there are regions of the bay and its margins where the majority of mercury methylation takes place. Assuming that the overall fraction of total mercury transformed to methylmercury is proportional to the aerial extent of these various regions, and that the spatial extent of such regions does not change substantially, then reducing mercury inputs should proportionally reduce methylmercury production. A reduction in methylmercury production will result in a reduction in the amount of mercury entering food web. To refine the linkage analysis, we need information about where and how mercury methylation occurs and how mercury concentrations in sediment relate to mercury concentrations in the food web. These are challenging areas of research being pursued by many investigators. It is difficult to anticipate the pace of completion or specific outcomes of such studies, but we intend to incorporate any new information that helps us manage the mercury problem more effectively.

What is the fate of mercury contained in crude oil refined in the Bay Area?

The fate of mercury originally contained in crude oil is not well understood. The amount of mercury in Bay Area processed refinery crude oil is about 400 kg/yr, but less than 1 kg/yr is discharged in wastewater effluent. Air emissions from petroleum refineries could be depositing mercury locally on the bay surface and surrounding watershed. We will require that petroleum refineries evaluate the significance of their atmospheric emissions by providing a more precise estimate of the amount of mercury contained in Bay Area refined crude oil and investigating the ultimate fate of the mercury originally contained in crude oil. We expect to have this information within five years and will take it into consideration as we adapt implementation actions for petroleum refineries commensurate with their mercury loads to the bay.

What are the implications of residence time of different source loads?

We know from modeling studies that water and sediment entering San Francisco Bay from different locations likely have different residence times and that there is a need to better understand the hydrodynamics and sediment transport in the bay. Understanding the implications of residence time is important because a molecule of mercury that has a very short residence time in the bay may be less likely to undergo methylation and be incorporated into fish and wildlife. There are efforts underway through the San Francisco Estuary Institute and the U.S. Geological Survey to help develop a more sophisticated model of sediment transport in the bay. Such a model will provide a tool to begin to evaluate this management question.

TMDL Targets

Are the fish tissue, bird egg, and suspended sediment targets appropriate?
Based on currently available information, striped bass is an appropriate target species because people who eat bay fish frequently consume it. There are complications with using striped bass to assess the condition of San Francisco Bay because striped bass live only a portion of their lives in the bay. Monitoring and field investigations are needed to learn more about this species.

Based on currently available information, bird eggs represent the most sensitive wildlife endpoint, and bird eggs are distinctly more prone to hatch failure at a certain threshold level (at some unknown point below 0.5 ppm). Data on endangered bird species are currently limited in terms of the level of mercury that would cause hatch failures. USFWS is currently conducting field and laboratory studies to determine how mercury impacts bird egg development. We expect to have these data within five years. We will incorporate into the TMDL any new and relevant information that becomes available, potentially adjusting the value of the numeric target or the approach we use to evaluate the target.

The proposed suspended sediment target is derived from the fish tissue and bird egg targets. As information is gathered regarding San Francisco Bay processes and effects, we will consider the need to refine the suspended sediment target.

Conclusion

The mercury problem in San Francisco Bay may take decades to control to the point where beneficial uses are not impaired. The currently proposed regulatory strategy relies on simplifications of a complex environmental system. There is much yet to learn about mercury and how the bay will respond to control efforts. Much research is underway, and more is planned for the future to shed light on the remaining questions. We have an obligation to adapt the regulatory program in the future as relevant information becomes available, and we intend to do so. We also have an obligation to protect water quality by taking actions now based on the information currently available. To fulfill these two obligations, we propose the adaptive implementation plan of the San Francisco Bay Mercury TMDL.

Key Points

- The implementation plan has four objectives: (1) reduce total mercury loads to the bay, (2) reduce methylmercury production, (3) perform monitoring and focused studies to track progress and improve technical understanding of the system, and (4) encourage actions that address multiple contaminants.

- An adaptive implementation approach is proposed, which means taking immediate actions based on available information and defining a process by which to incorporate technical information as the plan is adapted in the future.
- The Central Valley Water Board is developing mercury TMDLs expected to sufficiently reduce mercury loads from the Central Valley watershed to ensure that sediment from Central Valley rivers eventually meets the suspended sediment target.
- We expect that the Guadalupe River Watershed Mercury TMDL will be the primary regulatory driver for actions to reduce the mining legacy load over the next 20 years.
- Urban storm water runoff wasteload allocations will be achieved over a course of 20 years through a combination of source control, targeted sediment removal, and storm water treatment.
- Available data suggest that atmospheric deposition is not easily controlled because the majority of atmospheric mercury emissions take place in Asia.
- Municipal wastewater dischargers, as a group, will be held to current mercury loads. Exceedance of proposed triggers will compel investigation of causes and consideration of enhanced treatment.
- Existing information is insufficient to confirm whether local mines and bay margin contaminated sites are sources of mercury to San Francisco Bay. We propose to require investigation of these sites to determine their impacts and reasonable next steps to reduce loads, if necessary.
- Wetlands are not a source of new mercury, but they are important to the cycling of methylmercury in the bay. We are encouraging and supporting studies to develop ways in which wetlands can be designed and managed so as to minimize methylmercury production. If wetlands are being restored and come under our jurisdiction, we propose to require a demonstration that the project does not result in a net increase in methylmercury production.
- We will work with the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, and others to manage human health risks from consumption of mercury-contaminated bay fish.
- The proposed actions are commensurate with available data and information. The proposed implementation plan also includes monitoring to assess the effectiveness of the actions and progress toward meeting the proposed targets. The strategy calls for reviewing and incorporating into the TMDL information obtained through ongoing scientific studies and monitoring. The plan is to review this TMDL about every five years through the Water Board's water quality Basin Planning Program.

9. Regulatory Analyses

This section includes the analyses required pursuant to the Administrative Procedures Act to adopt or modify a regulation. Many Basin Plan provisions are considered regulations, and many of the changes contained in the proposed Basin Plan Amendment add regulatory provisions to the Basin Plan. To adopt these changes, the Water Board must complete an environmental checklist pursuant to the California Environmental Quality Act (CEQA), consider reasonable alternatives to the proposal, and consider economic factors relating to compliance with any new regulatory requirements.

Environmental Checklist

CEQA requires agencies to review the potential for their actions to result in adverse environmental impacts. CEQA further requires agencies to adopt feasible measures to mitigate potentially significant impacts. Appendix B contains the environmental checklist for the proposed Basin Plan Amendment. An explanation follows the environmental checklist and provides details concerning the environmental impact assessment. The analysis concludes that adopting the proposed Basin Plan Amendment will not have any significant adverse environmental effects.

Alternatives

To illustrate how some of the choices made in developing the proposed Basin Plan Amendment affect its foreseeable outcomes, this analysis considers a range of alternatives to the Basin Plan Amendment. It discusses how each alternative would affect foreseeable outcomes and the extent to which the alternative would achieve the goals of the proposed Basin Plan Amendment. As discussed in Appendix B, Environmental Checklist, the Basin Plan Amendment does not pose any significant adverse environmental impacts; therefore, the alternatives would not avoid or lessen any significant adverse impacts. The alternative scenarios considered below involve different targets, allocations, and implementation strategies. They include the following: (1) proposed Basin Plan Amendment, (2) no Basin Plan Amendment, (3) higher fish tissue target, (4) lower fish tissue target, (5) no sediment target, (6) proportional allocations, (7) lower allocations, (8) methylmercury allocations, and (9) faster implementation.

Proposed Basin Plan Amendment

The proposed project is the adoption of the Basin Plan Amendment presented in Appendix A. The Basin Plan Amendment is based on the technical analyses described in Sections 2 through 8 of this report. The Basin Plan Amendment includes target mercury concentrations for San Francisco Bay sediment (0.2 ppm), fish (0.2 ppm), and bird eggs (less than 0.5 ppm), and assigns load and wasteload allocations to the various mercury sources to achieve the targets. The proposed total maximum yearly load is 706 kg/yr. The Basin Plan Amendment implementation plan calls for phasing in the allocations over

20 years. Then, as shown in Figure 7.2, the sediment mercury concentrations are expected to decline from about 0.44 ppm to about 0.15 ppm over a period of more than 120 years.

No Basin Plan Amendment

Under this alternative, the San Francisco Bay Regional Water Quality Control Board (Water Board) would not amend the Basin Plan to adopt the proposed mercury TMDL. Neither the proposed targets nor the proposed allocations would be adopted, and no new implementation activities would be initiated. Assuming no action were ever taken to address the bay's mercury impairment, sediment mercury concentrations would likely decrease eventually due to existing processes, including foreseeable changes in the bed erosion mercury load. However, the bay-wide sediment mercury concentration would probably not reach the proposed target of 0.2 ppm. As shown in Figure 7.2, the sediment mercury concentration would decline from about 0.44 ppm to about 0.22 ppm over a period of more than 200 years.

If the Water Board were to decline to adopt a mercury TMDL, the Clean Water Act requires the U.S. Environmental Protection Agency (USEPA) to complete a TMDL for San Francisco Bay. How USEPA's TMDL would differ from the TMDL described in the proposed Basin Plan Amendment is unknown. USEPA would likely rely, at least in part, on analyses completed to date; however, USEPA would be free to develop its own TMDL in any manner it deemed appropriate, within legal constraints. USEPA would identify targets and allocate mercury loads. USEPA would not impose an implementation plan directly. However, the Water Board would be expected to incorporate USEPA's TMDL and appropriate implementation actions into the Basin Plan through the continuing planning process.

This alternative would not meet all the Basin Plan Amendment's objectives, as listed in Section 2, Project Background. It would involve the Water Board declining to exercise the authority and responsibility delegated to it by USEPA to implement Section 303(d) of the Clean Water Act. The Water Board would not maintain responsibility for developing and implementing the San Francisco Bay mercury TMDL. The regional expertise of the Water Board and the stakeholders in the TMDL process may not be incorporated as effectively into a TMDL developed and imposed by the federal government.

Higher Fish Tissue Target

Under this alternative, the fish tissue target would be set equal to the USEPA fish tissue residue criterion of 0.3 ppm, instead of 0.2 ppm. As discussed in Section 5, Numeric Targets, the target would be based on nationwide fish consumption data, not local Bay Area fish consumption data representing people known to eat San Francisco Bay fish. As shown in Figure 5.1, to meet this alternative target, striped bass tissue mercury concentrations would need to decrease by about 20%. However, the sediment target used to derive many of the allocations is derived from both the fish tissue and bird egg targets. Achieving the bird egg target will require mercury concentrations to decline at least 25%.

A 50% reduction would ensure that bird egg mercury concentrations fall far below the target of some concentration less than 0.5 ppm. To be consistent with such a reduction, the sediment target would remain unchanged; mercury levels would need to decrease by about 50%. Therefore, raising the fish tissue target would not necessarily affect the proposed allocations or the implementation plan.

This alternative would not meet the Basin Plan Amendment's objectives in that it would not make the best use of available information about local Bay Area fish consumption and would not be as conservative as the proposed project in that it would not protect as many local fish consumers. Although the higher fish tissue target would not, by itself, be as protective of human health as the proposed target, because the sediment target would probably not change, there would be no actual difference in human health risks because the sediment mercury concentration reduction would drive fish tissue mercury concentrations down to the same levels anyway. The sediment target, allocations, and implementation plan would be driven by the need to protect wildlife, and be the same as proposed.

Lower Fish Tissue Target

Under this alternative, the fish tissue target would be reduced from the proposed 0.2 ppm to 0.1 ppm in predatory fish at the top of the food web. While the proposed target is protective of human health and appears to be protective of all wildlife except the California least tern, this alternative could ensure additional protection for the most sensitive San Francisco Bay birds, including the California least tern (USFWS 2003). Reducing the fish tissue target could eliminate the need for a bird egg target. Because the proposed sediment target was derived, in part, from the proposed fish tissue target, the sediment target would need to be lower under this scenario. The sediment target would need to be reduced from 0.2 ppm to 0.1 ppm. As shown in Figure 7.2, the simple model described in Section 7, Allocations, indicates that the proposed allocations will eventually result in a bay-wide sediment mercury concentration of about 0.15 ppm. Therefore, the allocations would need to be reduced to achieve these lower fish tissue and sediment targets. This could necessitate additional TMDL implementation actions.

To achieve the lower sediment target, all sources discharging mercury-laden sediment to San Francisco Bay would need to meet the lower target. This would require reducing the allocations for watershed sources, which are derived from the sediment target. The allocations for the Central Valley watershed, urban storm water runoff, and Guadalupe River watershed would need to be roughly half of what is proposed. Additional load reductions could also be needed from atmospheric deposition and wastewater treatment plants. If feasible, these combined reductions could reduce sediment mercury concentrations in the bay further and more quickly than the proposed allocations.

This alternative would not, however, meet the Basin Plan Amendment's objectives. Meeting the lower allocations would require substantial additional effort to reduce mercury loads and would likely be less feasible than meeting the proposed allocations. Because the costs of achieving these far greater mercury reductions may be disproportionately large when compared to the costs of the proposed reductions, the added costs may be unreasonable relative to the environmental benefits. Moreover, this alternative would be based on an over-interpretation of limited available information and could result in regulatory requirements more stringent than necessary to address the known water quality problem. The relationship between the fish tissue target, which applies to large predatory fish at the top of the food web, and the considerably smaller fish consumed by California least terns has not yet been established for San Francisco Bay. Likewise, the relationship between mercury in the California least tern diet and its effects on California least terns is unclear. Therefore, this alternative could result in unnecessary implementation activities. The proposed bird egg target, which is expressed numerically and narratively, is a more direct measure of the potential effects of mercury on the California least tern and better accounts for site-specific conditions.

No Sediment Target

Under this alternative, the sediment target of 0.2 ppm would not be proposed. The sediment target is derived from the proposed fish tissue and bird egg targets, which are intended to protect human health, wildlife, and rare and endangered species. While the sediment target is useful for setting allocations, the other two targets are sufficient for TMDL purposes. The same allocations could be proposed without actually adopting the sediment target. The linkage analysis adequately links the mercury sources to the fish tissue and bird egg targets. Therefore, the sediment target could be eliminated without affecting human health, wildlife, or rare and endangered species. However, this alternative would be less clear than the proposed Basin Plan Amendment because the basis for deriving many of the proposed allocations would not be adopted as a regulatory provision.

Proportional Allocations

Under this alternative, the proposed total maximum yearly load of 706 kg/yr would be allocated proportionally among the mercury sources. Unlike the proposed allocation scheme, which was derived largely by setting sediment concentrations at the proposed sediment target, this alternative would distribute the allocations among the sources in proportion to their current loads. Urban storm water runoff and the Guadalupe River watershed would receive higher allocations; the Central Valley watershed, atmospheric deposition, non-urban storm water runoff, and wastewater would receive lower allocations. The allocation for bed erosion, a natural process due to essentially uncontrollable factors, would remain 220 kg/yr as proposed. Table 9.1 lists the alternative allocations, and Figure 9.1 illustrates differences among current loads, proposed allocations, and the proportional alternative.

Unlike the proposed allocation scheme, which results in sediment mercury concentrations discharged from each source being no greater than the proposed sediment target (0.2 ppm), this alternative would result in sediment mercury concentrations from some sources being greater than the sediment target. Allocating 100 kg/yr to urban storm water runoff would allow the 410 M kg/yr of related sediment (see Table 4.1) to reach a

TABLE 9.1: Proposed Allocations Versus Proportional Alternative

Source	Current Mercury Load (kg/yr)	Proposed Allocations (kg/yr)	Proportional Alternative (kg/yr)
Bed Erosion	460	220	220
Central Valley Watershed	440	330	280
Urban Storm Water Runoff	160	82	101
Guadalupe River Watershed	92	2	59
Atmospheric Deposition	27	27	17
Non-Urban Storm Water Runoff	25	25	16
Wastewater	20	20	13
Total	***1,220***	***706***	***706***

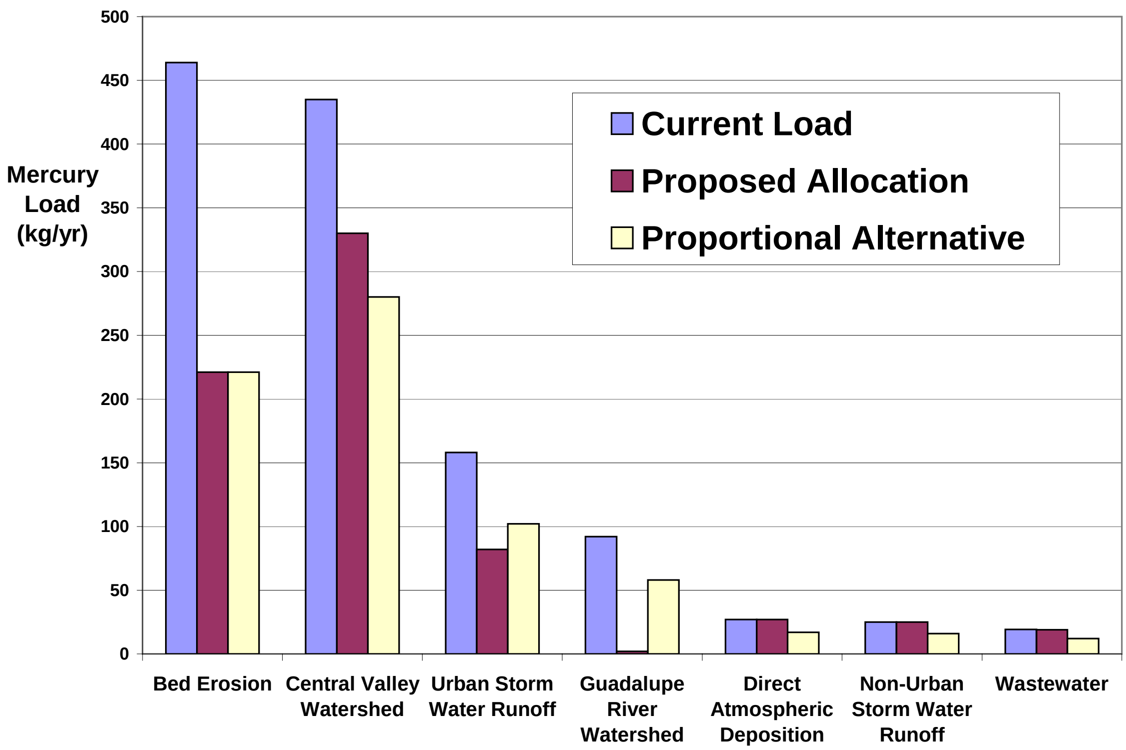

FIGURE 9.1: Proposed Allocations Versus Proportional Alternative
The Proportional Allocations alternative would result in lower allocations for the Central Valley watershed, direct atmospheric deposition, non-urban storm water runoff, and wastewater. Allocations would be higher for urban storm water runoff and the Guadalupe River watershed. Bed erosion would remain the same as proposed.

sediment mercury concentration of 0.25 ppm (100 kg/yr ÷ 410 M kg/yr, using Equation 1 from Section 4, Source Assessment). Similarly, allocating 59 kg/yr to the Guadalupe River watershed would allow the 44 M kg/yr of related sediment (see Table 4.1) to reach a sediment mercury concentration of 1.3 ppm (59 kg/yr ÷ 44 M kg/yr). Not withstanding the additional mercury associated with urban and non-urban storm water runoff in the Guadalupe River watershed, this mining legacy contribution to the river's sediment mercury concentration significantly exceeds the proposed sediment target. If the urban storm water runoff and Guadalupe River watershed sediment mercury concentrations were to exceed the proposed sediment target, then local bioaccumulation effects could occur near the mouths of the Guadalupe River and other creeks entering San Francisco Bay.

To accommodate the higher urban storm water runoff and Guadalupe River watershed allocations, lower allocations would be assigned to the Central Valley watershed, atmospheric deposition, non-urban storm water runoff, and wastewater. However, the feasibility of achieving these lower allocations is unknown. The feasibility of reducing the non-urban storm water runoff load is particularly doubtful because this source closely reflects pre-mining conditions (SFBRWQCB 2003f).

To reduce the combined wastewater allocation by 6 kg/yr could require additional pollution prevention, reclamation, and advanced treatment at most Bay Area facilities. Along with the treatment plant upgrades, the facilities could reach the alternative allocation by reclaiming about 125,000 acre-feet of water per year. All this could cost about $170 million per year. The facilities could also possibly reach the alternative allocation without additional advanced treatment by reclaiming about 240,000 acre-feet of water per year. This could cost about $250 million per year (LWA 2002).

This alternative would not meet the Basin Plan Amendment's objectives. The proportional allocations are not based solely on water quality concerns. Some parts of San Francisco Bay could be left unprotected, particularly at locations of urban storm water runoff and Guadalupe River watershed discharges. This could pose unacceptable health risks to individuals who eat fish from these areas, and unacceptable risks to wildlife and rare and endangered species that consume organisms that forage in these areas. Therefore, this alternative may not be consistent with water quality standards. In addition, this alternative could involve unreasonable costs for relatively little environmental benefit.

Lower Allocations

Under this alternative, the allocations would be lowered so as to reach the targets more quickly. With the proposed allocations, reaching the proposed sediment target will take roughly 120 years or more (see Figure 7.2). Lowering the allocations would speed the recovery. In the most extreme case (which is infeasible), the allocations would be lowered to zero for all sources except bed erosion, which, as a natural process due to essentially uncontrollable factors, would eventually decline to its allocation of 220 kg/yr. As shown in Figure 9.2, assuming all other sources could be eliminated immediately, this

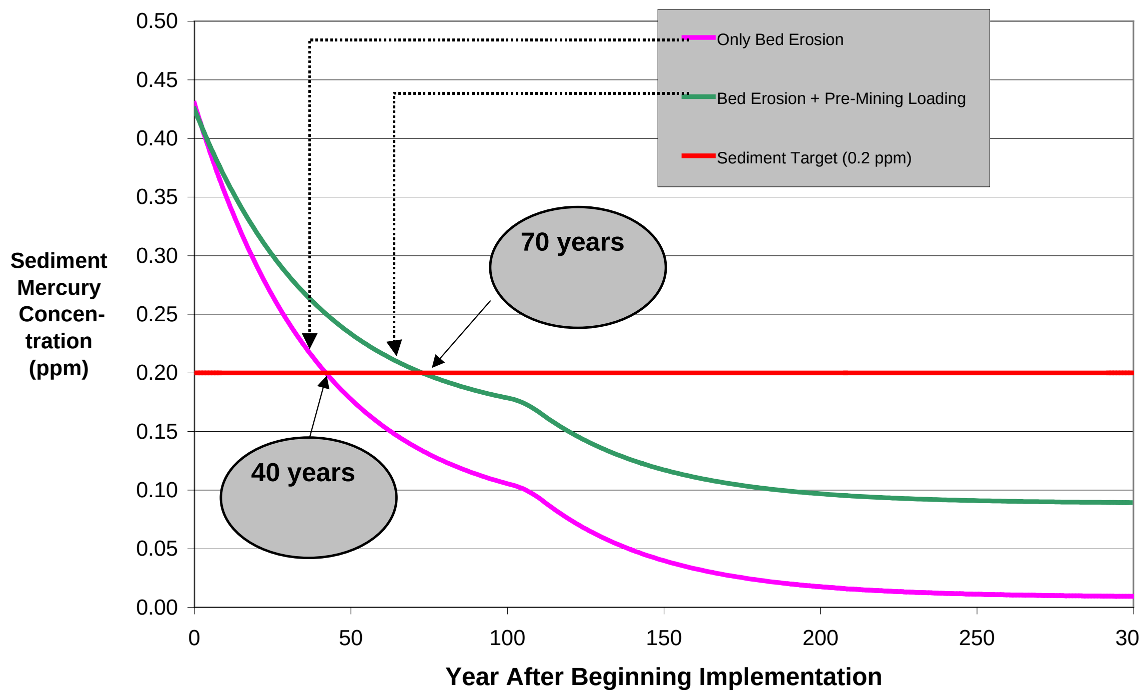

FIGURE 9.2: Sediment Mercury Concentrations with Lower Allocations
The Lower Allocations alternative would attain sediment targets faster than the proposed allocation and implementation scheme. However, such extreme reductions in mercury loads would be infeasible to achieve.

extreme scenario could lead to reaching the sediment target sometime after roughly 40 years and reaching an eventual sediment mercury concentration of about 0.01 ppm (SFBRWQCB 2003h).

In a less extreme case (which is also infeasible), the allocations for watershed sources (i.e., the Central Valley and Guadalupe River watersheds and urban storm water runoff) could be lowered to pre-mining background conditions. Pre-mining sediment mercury concentrations were about 0.08 ppm (SFBRWQCB 2003f). Bed erosion, as a natural process due to essentially uncontrollable factors, would decline to its allocation of 220 kg/yr. The wastewater and atmospheric deposition allocations would be zero. As shown in Figure 9.2, assuming these reductions could occur immediately, this scenario could lead to reaching the sediment target sometime after roughly 70 years and reaching an eventual sediment concentration of about 0.08 ppm (SFBRWQCB 2003h). Therefore, a lower allocations scenario would take more than 70 years to meet the targets and would reduce long-term sediment mercury concentrations from those anticipated with the proposed allocation scheme.

Achieving allocations significantly lower than those proposed would be less feasible than meeting the proposed allocations. The proposed allocations require reducing Central Valley watershed, urban storm water runoff, and Guadalupe River watershed mercury loads by 25%, 49%, and 98%. Further reducing Central Valley watershed loads would require additional efforts on the part of the Central Valley community. Because of the large volume of water coming from the Central Valley, the effects of individual efforts are diluted substantially prior to reaching San Francisco Bay. Urban runoff management agencies may be able to reduce their loads further, but doing so would require substantial additional effort with diminishing returns. Because the proposed allocation for the Guadalupe River watershed is a 98% reduction, lowering this allocation further may not substantially increase the considerable implementation efforts required to achieve the proposed targets.

This alternative would require load reductions from atmospheric deposition, non-urban storm water runoff, and wastewater. The potential to reduce atmospheric deposition loads is unknown, but is limited by the contribution of global sources to atmospheric mercury concentrations. The proposed implementation plan includes actions to study the feasibility of reducing atmospheric sources. Reducing non-urban storm water runoff loads is probably infeasible because the sediment mercury concentrations from this source are already near pre-mining levels (SFBRWQCB 2003f). Reducing wastewater loads is feasible, but it could require additional pollution prevention, reclamation, and treatment. Wastewater loads could be reduced by more than 50% by reclaiming about 125,000 acre-feet of water per year and providing advanced treatment at nearly all plants. This could cost about $170 million per year (LWA 2002).

This alternative would not meet the Basin Plan Amendment's objectives. It could result in regulatory requirements more stringent than necessary to address the water quality problem and require possibly unnecessary implementation activities. Moreover, this alternative may be less feasible than the proposed Basin Plan Amendment. To the extent that lower allocations are actually feasible, this alternative could be unreasonably costly for limited environmental benefit. For example, reducing wastewater discharges could cost from $87 million to almost $1 billion (LWA 2002) and fail to detectibly accelerate target attainment.

Methylmercury Allocations

The mercury from different sources may be converted to methylmercury at different rates. Therefore, mercury from some sources may be more susceptible to uptake and accumulation within the food web. Under this alternative, the allocation scheme would be weighted to account for differences in mercury methylation among sources. Despite what is known about the links between mercury sources, sediment, mercury methylation, biological uptake within the food web, and mercury accumulation in humans, birds, and wildlife, available information is insufficient to weight the allocations quantitatively to account for these complex processes (see Section 6, Linkage Analysis). Therefore, this alternative cannot meet the Basin Plan Amendment's objectives because it cannot be accomplished with existing information. It would require substantial over-interpretation of limited available data.

Faster Implementation

Under this alternative, the allocations would be phased in over 10 years instead of 20 years as proposed. The proposed Basin Plan Amendment will take more than 120 years to achieve the target. This alternative could reach the target about 10 years earlier. The eventual sediment mercury concentration would be the same, about 0.15 ppm.

Implementing the allocations faster may be infeasible, particularly for the Central Valley and Guadalupe River watersheds, where additional TMDL work is underway. Completing these TMDLs and developing detailed implementation plans for these watersheds may take several years. In addition, the best approach for reducing mercury loads from urban storm water runoff has not been determined. The implementation plan requires gathering information that facilitates development of strategic options. Due to the size of the San Francisco Bay watershed and natural variability in watershed loads, load reductions will take time to implement and time is needed to observe the effects. This alternative would not meet the Basin Plan Amendment’s objectives because faster implementation without improved understanding could be unreasonably costly for limited environmental benefit.

Preferred Alternative

Because the proposed Basin Plan Amendment will not pose any significant adverse environmental impacts, the alternatives would not avoid or lessen any significant impacts. Some alternatives could be considered environmentally superior because, conceptually, they could involve lower allocations and greater implementation efforts. In this way, they could result in lower mercury concentrations in San Francisco Bay. These alternatives are the lower fish tissue target and lower allocations scenarios. Both could be less feasible to implement than the proposed Basin Plan Amendment, and both would fail to meet some of the essential objectives of the Basin Plan Amendment listed in Section 2, Project Background. The faster implementation scenario could also be incrementally superior to the proposed Basin Plan Amendment, but the difference would be negligible. The proposed Basin Plan Amendment is the preferred alternative.

Economic Considerations

The California Environmental Quality Act requires that whenever a Water Board adopts a rule that requires the installation of pollution control equipment or establishes a performance standard or treatment requirement, it must conduct an environmental analysis of reasonably foreseeable methods of compliance. This analysis must take into account a reasonable range of factors, including economics. The proposed Basin Plan

Amendment includes performance standards (i.e., targets and allocations) and therefore requires the consideration of economic factors.*

Economic Costs

The economic costs of implementing the proposed Basin Plan Amendment are considered below. The discussion is organized by mercury source and monitoring and other data collection activities. All costs discussed below are only rough estimates. Expected costs are difficult to estimate because, although the proposed Basin Plan Amendment explains how the TMDL will be implemented, it does not prescribe the exact actions the parties responsible for implementing the TMDL must take to meet the allocations. A menu of options exists from which entities can choose. In many instances, selecting the most appropriate action will require obtaining information that is currently unavailable. Therefore, this economic analysis is primarily qualitative. The word "substantial" is used to refer to major economic burdens (e.g., on the order of $1 million or more). Quantitative information is included where available.

Bed Erosion. Because bed erosion is a natural process due to uncontrollable factors, the Basin Plan Amendment does not prescribe any implementation actions to reduce the bed erosion mercury load. Therefore, there are no economic costs associated with reducing this load.

Central Valley Watershed. To achieve the Central Valley watershed's proposed load allocation, the proposed Basin Plan Amendment relies primarily on mercury TMDL projects being completed for mercury in Central Valley impaired water bodies. The costs of preparing and implementing these TMDLs will likely be substantial. For example, the Central Valley watershed contains a number of water bodies affected by mining, and remediating them could be costly. In addition, the costs of controlling urban storm water runoff in the Central Valley could be similar to those for the Bay Area (see below) because the populations and urbanization of the two regions are similar (USCB 2001). As shown in Table 9.2, the Central Valley Regional Water Quality Control Board has estimated unit costs for a number of mercury reduction options (USGS 2003c). The Central Valley Regional Water Quality Control Board has not yet estimated how many units of each type of activity will be needed.

The Clean Water Act requires that the Central Valley TMDLs be completed whether or not the proposed Basin Plan Amendment for mercury in San Francisco Bay is approved. Therefore, the substantial costs associated with preparing and implementing the Central Valley TMDLs will occur with or without this proposed Basin Plan Amendment.

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* California's Porter-Cologne Water Quality Control Act requires a Water Board to consider economics when it adopts water quality objectives. The analysis typically identifies available methods to comply with the water quality objective and the costs of compliance. If the costs are substantial, the staff report must state why the objective is necessary despite the potential adverse economic consequences. The proposed Basin Plan Amendment does not include any new water quality objectives. It implements the existing bioaccumulation objective to protect beneficial uses. Therefore, these economic analysis requirements do not apply to the Basin Plan Amendment.

TABLE 9.2: Mercury Reduction Unit Costs

Activity	Unit Cost Estimate Low End	Unit Cost Estimate High End	Unit
Mercury Mine Site Cleanup	$0.93	$16	per cubic yard
Mercury Control (i.e., keeping mercury out of water body)	$0.32	$2,200	per ton
	$2.70	$60	per pound
	$320	$8,600	per kilogram mercury
Erosion Control (i.e., keeping sediment out of water body)	$760	$900,000	per acre
	$41	$200	per cubic meter
Ecosystem Modification	$2,500	$22,000	per gallon/minute
	$300,000	$3,900,000	per study
	$2,800	$150,000	per acre
Wastewater Treatment Plant Activities (i.e., pollution prevention or treatment)	$75,000	$3,600,000	per million gallons/day

* These costs may or may not be representative of mercury site cleanup costs.
Source: CVRWQCB 2003

Whether implementing the Central Valley TMDLs will cost more than they otherwise would because of the San Francisco Bay mercury TMDL is unknown. Economic considerations related to the Central Valley TMDLs will be evaluated when those TMDLs are proposed for adoption.

Urban Storm Water Runoff. The specific means by which urban storm water runoff management agencies will achieve their proposed wasteload allocations are unknown. Representatives of the Santa Clara Valley Urban Runoff Pollution Prevention Program have estimated that mercury TMDL-related activities will cost Santa Clara County municipalities roughly $0.33 per capita to initiate and roughly $0.42 per capita per year for ongoing operations (EOA 2003b). The Bay Area population is about 6.5 million (USCB 2001). If the Santa Clara Valley costs are representative of the Bay Area as a whole, mercury TMDL-related costs could exceed $2 million to initiate programs and roughly $3 million per year for ongoing operations. These estimates do not include waste disposal costs (e.g., disposal of mercury-containing sediment or consumer wastes) or costs for environmental monitoring. In addition, these estimates do not account for the potentially greater relative costs of newer and smaller urban runoff management programs. According to Santa Clara Valley Urban Runoff Pollution Prevention Program staff, actual costs could be roughly 10 times higher (EOA 2003b).

The costs of existing urban storm water runoff management programs are substantial. Assuming that they cost up to $18 per household (LARWQCB 2003), and that there are about 2.5 million households in the Bay Area (ABAG 2003), the Bay Area currently spends roughly $45 million per year specifically to manage urban storm water runoff (not including related activities that would occur with or without urban runoff permits). Although the costs associated with the proposed Basin Plan Amendment are unknown, they would likely be a fraction of existing costs, which cover a range of pollutants, including mercury. In accordance with existing storm water permits, urban runoff management agencies have already begun to implement mercury reduction measures. Many TMDL implementation activities could be accommodated within existing budgets by reprioritizing some activities. The extent to which this is possible is unknown.

Guadalupe River Watershed (Mining Legacy). To achieve the Guadalupe River watershed's proposed load allocation, the Basin Plan Amendment relies primarily on the TMDL project currently underway for mercury in the Guadalupe River. The costs of preparing and implementing this TMDL will likely be substantial because significant reductions are needed. However, the Clean Water Act requires that the Guadalupe River TMDL be completed whether or not the proposed Basin Plan Amendment for San Francisco Bay is approved. Therefore, the substantial costs associated with preparing and implementing the Guadalupe River TMDL will occur with or without the proposed San Francisco Bay Basin Plan Amendment. Whether the Guadalupe River TMDL will cost more than it otherwise would because of the San Francisco Bay TMDL is unknown. Economic considerations related to the Guadalupe River TMDL will be evaluated when that TMDL is proposed for adoption.

Atmospheric Deposition. The Basin Plan Amendment does not include any implementation actions to control atmospheric deposition. The Basin Plan Amendment calls for additional study, and if appropriate, specific actions could be considered. The costs of undertaking such studies are discussed below.

Non-Urban Storm Water Runoff. The Basin Plan Amendment does not include any implementation actions to address non-urban storm water runoff because this is a natural process and sediment mercury concentrations are already close to pre-mining conditions (SFBRWQCB 2003f). Therefore, there are no economic costs to address non-urban storm water runoff.

Wastewater. Wastewater facilities are already meeting their wasteload allocations; therefore, the cost of implementing the Basin Plan Amendment would essentially be limited to the costs of implementing new pollution prevention measures. Most wastewater facilities are already implementing mercury pollution prevention programs. The cost of implementing these and additional programs has been estimated to be greater than $8 million (LWA 2002); however, this estimate may be high considering similar estimates for urban storm water runoff programs (discussed above).

Sediment Dredging and Disposal. The Basin Plan Amendment assumes that the Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS) will be implemented with or without the Basin Plan Amendment. The LTMS is expected to result in substantial costs as less dredged material is disposed of in the bay and more is disposed of in the ocean or at upland sites. These costs, however, would not result from any requirements contained in this proposed Basin Plan Amendment.

Mercury Mines. The Basin Plan's mines program will be implemented with or without this proposed Basin Plan Amendment. There are no new economic costs to address mercury mines.

Bay Margin Contaminated Sites. The Basin Plan's toxic site cleanup program will be implemented with or without this proposed Basin Plan Amendment. There are no economic costs to address bay margin contaminated sites.

Wetlands. Opportunities may exist to minimize mercury methylation in wetlands. Additional study is necessary before the most effective options can be determined. The costs of undertaking pilot studies could be substantial.

Risk Management. The Basin Plan Amendment calls for enhancing risk management efforts to minimize human exposure to mercury from San Francisco Bay fish. These efforts could be coordinated with the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, and other entities. Assuming that this coordination could require as much as 0.2 person-years each year, the cost could be roughly $20,000 per year. This investment in staff time could yield dividends by securing grant funds.

Adaptive Management. The Basin Plan Amendment calls for the Water Board to refine and reconsider the mercury TMDL about every five years. Adaptively managing the TMDL in this way will require Water Board staff time, monitoring, and scientific studies. The Basin Plan Amendment calls for a number of studies to help refine the TMDL through adaptive management. The costs of the studies will depend, in part, on available resources and the results of the initial studies. The 2004-2005 Clean Estuary Partnership budget contains over $170,000 specifically for mercury-related studies (AMS 2003). The Basin Plan Amendment calls for continued monitoring through the Regional Monitoring Program for Trace Substances (RMP). The 2003 RMP budget is about $3.4 million, with $1.7 million allotted for status and trends monitoring and $0.5 million allotted for pilot and special studies (SFBRWQCB 2003i). The RMP already measures mercury in sediment and fish tissue; therefore, the additional monitoring costs associated with implementing the Basin Plan Amendment would be minimal. Pilot projects and special studies could probably be accommodated within the existing budget. The U.S. Fish and Wildlife Service already measures mercury in bird eggs; therefore, the additional costs of implementing the proposed Basin Plan Amendment would be minimal.

Economic Benefits

When all foreseeable Basin Plan Amendment actions are considered together, the potential costs could be several million dollars each year. However, attaining water quality standards also offers economic benefits. The Basin Plan Amendment's economic benefits relate to San Francisco Bay's improved potential to support sport and subsistence fishing and the potential benefits of reducing the potential health risks associated with consuming bay fish. Improving the bay's ability to support wildlife and rare and endangered species provides additional benefits.

USEPA estimated the benefits of implementing the California Toxics Rule, including the 0.051 total mercury water quality objective (USEPA 1997e). Implementing the proposed Basin Plan Amendment would advance the goals of the California Toxics Rule, providing some of the same benefits. USEPA concluded that, in addition to improving human health and wildlife habitat, California Toxics Rule implementation would improve how well San Francisco Bay recreational fishers appreciate their fishing experience. The value of the improved experience would be between $3 and $17 million. Moreover, the value of additional participation in San Francisco Bay recreational fishing would be between $1 and $11 million. Less tangible benefits would include intergenerational equity, environmental stewardship, reduced wildlife sickness and mortality and increased reproductive success, improved conditions for rare and endangered species recovery, and improved ecosystem integrity. In addition to mercury in San Francisco Bay, other pollutants will need to be addressed to benefit fully from the California Toxics Rule.

Key Points

- Adopting the proposed Basin Plan Amendment would not result in any significant adverse environment effects.
- The proposed Basin Plan Amendment is the preferred alternative because it best meets the project objectives.
- Implementing the Basin Plan Amendment could place substantial economic burdens on the regulated community to meet existing water quality objectives and protect human health, wildlife, and rare and endangered species.

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Appendix A

Proposed Basin Plan Amendment

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PROPOSED BASIN PLAN AMENDMENT

This proposed Basin Plan Amendment consists of two changes to the existing Basin Plan. The first change would insert the following text in its entirety into Chapter 4, immediately after the introduction of the section entitled "TOXIC POLLUTANT MANAGEMENT IN THE LARGER SAN FRANCISCO BAY ESTUARY SYSTEM." Because this text would be added in its entirety, it is not shown below in underline/strikeout. The second change (found on the last page of this appendix) modifies the existing Basin Plan text relating to continuing planning. It is shown in underline/strikeout.

San Francisco Bay Mercury TMDL

The following sections establish the allowable annual mercury load (Total Maximum Daily Load [TMDL]) to San Francisco Bay, and actions and monitoring necessary to implement the TMDL. The numeric targets, allocations, and associated implementation plan will ensure that all San Francisco Bay segments attain applicable water quality standards established to protect and support beneficial uses.

The TMDL allocations and implementation plan focus on controlling the amount of mercury that reaches the Bay and identifying and implementing actions to minimize mercury bioavailability. The organic form of mercury (methylmercury) is toxic and bioavailable, but information on ways of controlling methylmercury production is limited. However, this is an area of active research and strategies for controlling this process are forthcoming. The effectiveness of implementation actions, monitoring to track progress toward targets, and the scientific understanding pertaining to mercury will be periodically reviewed and the TMDL may be adapted as warranted.

Problem Statement

San Francisco Bay is impaired because mercury contamination is adversely affecting existing beneficial uses, including sport fishing, preservation of rare and endangered species, and wildlife habitat. Mercury concentrations in San Francisco Bay fish are high enough to threaten the health of humans who consume them. In addition, mercury concentrations in some bird eggs harvested from the shores of San Francisco Bay are high enough to account for abnormally high rates of eggs failing to hatch.

In the context of this TMDL, "San Francisco Bay" refers to the following water bodies:

- Sacramento/San Joaquin River Delta (within San Francisco Bay region)
- Suisun Bay
- Carquinez Strait
- San Pablo Bay
- Richardson Bay
- Central San Francisco Bay
- Lower San Francisco Bay
- South San Francisco Bay (including the Lower South Bay)

This TMDL also addresses the following mercury-impaired water bodies that exist within the water bodies listed above:

- Castro Cove (part of San Pablo Bay)
- Oakland Inner Harbor (part of Central San Francisco Bay)
- San Leandro Bay (part of Central San Francisco Bay)

Numeric Targets

TMDL numeric targets interpret narrative and/or numeric water quality standards, including beneficial uses and water quality objectives. To protect sport fishing and human health, the average fish tissue mercury concentration for typically consumed fish shall not exceed 0.2 mg mercury per kg fish tissue (wet weight). To protect wildlife and rare and endangered species, the concentration of mercury in bird eggs shall be less than 0.5 mg mercury per kg wet weight. The goal of this target is that controllable water quality factors not cause detrimental mercury concentrations in San Francisco Bay bird eggs, which is consistent with the bioaccumulation objective in Chapter 3. To achieve the fish tissue and bird egg targets and to attain water quality standards, the Baywide suspended sediment mercury concentration target is 0.2 mg mercury per kg dry sediment.

The Regional Monitoring Program (RMP) conducts monitoring relevant to evaluating progress toward meeting the sediment and fish tissue targets, and the U.S. Fish and Wildlife Service collects information on bird egg mercury concentrations useful to evaluate progress toward meeting the bird egg target. The following passages describe acceptable approaches to evaluate progress toward meeting the targets. Other approaches can be considered during adaptive implementation reviews.

Suspended Sediment Target

The suspended sediment target (0.2 mg mercury per kg dry sediment) shall be compared to the annual median Bay suspended sediment mercury concentration found through RMP monitoring. The suspended sediment mercury concentration shall be computed as the difference between total and dissolved mercury concentration in a water sample (at each location) divided by the suspended sediment concentration for that same sample.

Human Health Target

The human health target is a fish tissue mercury concentration (0.2 mg mercury per kg fish tissue – wet weight). The RMP conducts fish tissue sampling and analysis in San Francisco Bay every three years. Progress toward attainment of the human health target shall be evaluated by tracking mercury concentrations in striped bass, a frequently consumed sport fish with relatively high mercury concentrations. Striped bass are routinely caught in three size ranges: 45-59 cm (small), 60-82 cm (medium), and larger than 82 cm (large). To provide sufficient data to evaluate the target, striped bass in the small and medium size ranges should be caught and analyzed. The best functional relationship between mercury concentration and length shall be established for the fish caught, and the resulting equation of fit shall be evaluated at 60 cm to compute the mercury concentration to compare to the human health target. The RMP tracks mercury concentrations in other San Francisco Bay sportfish, such as halibut and jack smelt. This information will be used to assess overall trends and human health risks.

Wildlife Target

The wildlife target is expressed as a bird egg mercury concentration (less than 0.5 mg mercury per kg - wet weight). The RMP is collaborating with the U.S. Fish and Wildlife Service on long-term monitoring and analysis of bird eggs. Eggs will be collected at several locations throughout San Francisco Bay. The wildlife target will be compared to the computed 99^{th} percentile mercury concentration in eggs.

In addition to measuring mercury concentrations in bird eggs directly, it is also useful to measure the amount of mercury in bird prey. The Water Board will work with the RMP to develop a long term monitoring program to evaluate mercury concentrations in prey typically consumed by birds. Prey species should include benthic invertebrates and small fish that are typically consumed by piscivorous birds. According to the U.S. Fish and Wildlife Service, the sensitive and endangered California least tern will be protected if the average mercury concentration in the fish it consumes does not exceed 0.03 mg per kg fish tissue (wet weight). Achieving this prey fish concentration is an alternative method of demonstrating attainment of the wildlife target.

Sources and Losses

During the California Gold Rush, cinnabar mines in the Central Coast Ranges produced the mercury used to extract gold from the Sierra Nevada foothills. Mercury was later mined and used to produce munitions, electronics, and health care and commercial products.

The year 2003 estimate of total mercury inputs to the San Francisco Bay is about 1220 kg/yr. The sources of mercury in San Francisco Bay include bed erosion (about 460 kg/yr), the Central Valley watershed (about 440 kg/yr), urban stormwater runoff (about 160 kg/yr), the Guadalupe River watershed (about 92 kg/yr), direct atmospheric deposition (about 27 kg/yr), non-urban stormwater runoff (about 25 kg/yr), and wastewater discharges (about 20 kg/yr). There is a potential that mercury may enter the Bay from Bay margin contaminated sites and abandoned mercury mines outside the

Guadalupe watershed. An evaluation of these potential sources is addressed below under Mercury TMDL Implementation.

Using box models for sediment and mercury inputs and outputs to and from San Francisco Bay, the 2003 estimate for San Francisco Bay mercury losses is approximately 1700 kg/yr. Mercury leaves the Bay by transport to the Pacific Ocean via the Golden Gate, the net result of dredging and disposal (in-Bay and upland), and other losses.

Allocations

Tables 4-v through 4-z present load and wasteload allocations for San Francisco Bay mercury sources. Table 4-v presents load and wasteload allocations by source category and the 2003 estimated annual loads. Tables 4-w through 4-z contain wasteload allocations for individual wastewater and urban stormwater discharges to San Francisco Bay. When summed, the individual allocations equal the category totals for urban stormwater and wastewater shown in Table 4-v.

TABLE 4-v: Mercury Load and Wasteload Allocations By Source Category

Source	2003 Mercury Load (kg/yr)	Allocation (kg/yr)
Bed Erosion[a]	460	220
Central Valley Watershed	440	330
Urban Stormwater Runoff	160	82
Guadalupe River Watershed (mining legacy)	92 [b]	2
Atmospheric Deposition	27	27
Non-Urban Stormwater Runoff	25	25
Wastewater (municipal and industrial)	20	20
Sediment Dredging and Disposal[c]	net loss	0 ≤ ambient concentration

[a] Bed erosion occurs as mercury buried in Bay sediment becomes available for biological uptake when overlying sediment erodes.
[b] This load does not account for mercury captured in ongoing sediment removal programs conducted in the watershed.
[c] Sediment dredging and disposal often moves mercury-containing sediment from one part of the Bay to another. The dredged sediment mercury concentration generally reflects ambient conditions in San Francisco Bay sediment. This allocation is both mass-based and concentration-based. The allocation will be implemented by confirming both that the combined effect of dredging and disposal continues to be a net loss and that the mercury concentration of dredged material disposed in the Bay must be at or below the Baywide ambient mercury concentration. This allocation ensures that this source category continues to represent a net loss of mercury.

Total Maximum Daily Load

The mercury TMDL for San Francisco Bay is the sum of the load and wasteload allocations, 706 kg/yr. The Bay will attain applicable water quality standards for mercury when the overall mercury load is reduced to the TMDL and mercury methylation control measures are implemented.

A TMDL must include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. This TMDL's targets and allocations rely on conservative assumptions, which thereby

TABLE 4-w: Individual Wasteload Allocations for Urban Stormwater Discharges

Entity	NPDES Permit	Allocation (kg/yr)[a]	Load Reduction (kg/yr)[b]
Santa Clara Valley Urban Runoff Pollution Prevention Program	CAS029718	23	21
Alameda Countywide Clean Water Program	CAS029831	20	19
Contra Costa Clean Water Program	CAS029912	11	11
San Mateo County Stormwater Pollution Prevention Program	CAS029921	8.4	8.0
Vallejo Sanitation and Flood Control District	CAS612006	1.6	1.6
Fairfield-Suisun Urban Runoff Management Program	CAS612005	1.6	1.5
American Canyon	CAS612007	0.14	0.13
Sonoma County area [c]	CAS000004	1.6	1.5
Napa County area [c]	CAS000004	1.6	1.5
Marin County area [c]	CAS000004	3.3	3.2
Solano County area [c]	CAS000004	0.81	0.77
San Francisco County area [c,d]	CAS000004	8.8	8.4
Total		***82*** [e]	***78*** [e]

[a] Allocations 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.
[b] This column contains calculated load reductions relative to the estimated 2003 urban stormwater runoff annual load that are consistent with attaining the wasteload allocation. Demonstration of such load reductions is an alternative manner of showing compliance with the allocations.
[c] Includes unincorporated areas and all municipalities in the county that are in the Region and drain to the Bay. The statewide municipal stormwater general permit issued by the State Water Resources Control Board covers these municipalities.
[d] This urban stormwater runoff load estimate does not account for treatment provided by San Francisco's combined sewer system. The treatment provided by the Bayside facilities (NPDES permit CA0037664) will be credited toward meeting the allocation and load reduction.
[e] These totals differ slightly from the column sum due to rounding.

provide an implicit margin of safety. The adaptive approach to implementation provides an additional margin of safety.

There is no evidence that mercury contamination in San Francisco Bay is worse at any particular time of year. Therefore, the TMDL and allocation scheme do not have a seasonal component.

Mercury TMDL Implementation

The San Francisco Bay mercury TMDL implementation plan has four objectives: (1) reduce mercury loads to achieve load and wasteload allocations, (2) reduce methylmercury production and consequent risk to humans and wildlife exposed to methylmercury, (3) conduct monitoring and focused studies to track progress and improve the scientific understanding of the system, and (4) encourage actions that address multiple pollutants. The plan establishes requirements for dischargers to reduce or control mercury loads and identifies actions necessary to better understand and control methylmercury production. In addition, it addresses potential mercury sources and

TABLE 4-x: Individual Wasteload Allocations for Municipal Wastewater Discharges

Permitted Entity	NPDES Permit	Allocation (kg/yr)
American Canyon, City of	CA0038768	0.12
California Department of Parks and Recreation, Angel Island State Park	CA0037401	0.013
Benicia, City of	CA0038091	0.088
Burlingame, City of	CA0037788	0.089
Calistoga, City of	CA0037966	0.016
Central Contra Costa Sanitary District	CA0037648	2.23
Central Marin Sanitation Agency	CA0038628	0.18
Delta Diablo Sanitation District	CA0038547	0.31
East Bay Dischargers Authority	CA0037869	3.67[a]
Dublin-San Ramon Services District (CA0037613)		
Hayward Shoreline Marsh (CA0038636)		
Livermore, City of (CA0038008)		
Union Sanitary District, wet weather (CA0038733)		
East Bay Municipal Utilities District	CA0037702	2.57
East Brother Light Station	CA0038806	0.001
Fairfield-Suisun Sewer District	CA0038024	0.22
Las Gallinas Valley Sanitary District	CA0037851	0.17
Marin County Sanitary District, Paradise Cove	CA0037427	0.001
Marin County Sanitary District, Tiburon	CA0037753	0.01
Millbrae, City of	CA0037532	0.052
Mountain View Sanitary District	CA0037770	0.034
Napa Sanitation District	CA0037575	0.28
Novato Sanitary District	CA0037958	0.079
Palo Alto, City of	CA0037834	0.38
Petaluma, City of	CA0037810	0.063
Pinole, City of	CA0037796	0.055
Contra Costa County, Port Costa Wastewater Treatment Plant	CA0037885	0.001
Rodeo Sanitary District	CA0037826	0.06
Saint Helena, City of	CA0038016	0.047
San Francisco, City and County of, San Francisco International Airport WQCP	CA0038318	0.032
San Francisco, City and County of, Southeast Plant	CA0037664	2.68
San Jose/Santa Clara WPCP	CA0037842	1.0
San Mateo, City of	CA0037541	0.32
Sausalito-Marin City Sanitary District	CA0038067	0.078
Seafirth Estates	CA0038893	0.001
Sewerage Agency of Southern Marin	CA0037711	0.13
Sonoma Valley County Sanitary District	CA0037800	0.041
South Bayside System Authority	CA0038369	0.53
South San Francisco/San Bruno WQCP	CA0038130	0.29
Sunnyvale, City of	CA0037621	0.15
US Naval Support Activity, Treasure Island WWTP	CA0110116	0.026
Vallejo Sanitation & Flood Control District	CA0037699	0.57
West County Agency, Combined Outfall	CA0038539	0.38[c]
Yountville, Town of	CA0038121	0.04
Total		***17***[b]

[a] This allocation includes wastewater treatment and all wet weather facilities.
[b] Total differs slightly from the column sum due to rounding.
[c] Mercury monitoring data quality concerns pertaining to this discharger will need to be addressed during the next review.

TABLE 4-y: Individual Wasteload Allocations for Petroleum Refinery Wastewater Discharges

Permitted Entity	NPDES Permit	Allocation (kg/yr)
Chevron Products Company	CA0005134	0.38
ConocoPhillips	CA0005053	0.15
Martinez Refining Co. (formerly Shell)	CA0005789	0.25
Ultramar, Golden Eagle	CA0004961	0.13
Valero Refining Company	CA0005550	0.09
Total		***1.0***

TABLE 4-z: Individual Wasteload Allocations for Industrial (Non-Petroleum Refinery) Wastewater Discharges

Permitted Entity	NPDES Permit	Allocation (kg/yr)
C&H Sugar Co.	CA0005240	1.56
Crockett Cogeneration	CA0029904	0.005
The Dow Chemical Company	CA0004910	0.044
General Chemical	CA0004979	0.23[a]
GWF Power Systems, Site I	CA0029106	0.002
GWF Power Systems, Site V	CA0029122	0.003
Hanson Aggregates, Amador Street	CA0030139	0.001
Hanson Aggregates, Olin Jones Dredge Spoils Disposal	CA0028321	0.001
Hanson Aggregates, Tidewater Ave. Oakland	CAA030147	0.001
Pacific Gas and Electric, East Shell Pond	CA0030082	0.001
Pacific Gas and Electric, Hunters Point Power Plant	CA0005649	0.022
Rhodia, Inc.	CA0006165	0.012
San Francisco, City and Co., SF International Airport Industrial WTP	CA0028070	0.055
Southern Energy California, Pittsburg Power Plant	CA0004880	0.008
Southern Energy Delta LLC, Potrero Power Plant	CA0005657	0.003
United States Navy, Point Molate	CA0030074	0.013
USS-Posco	CA0005002	0.047
Total		***2.0*** [b]

[a] Data quality concerns pertaining to this discharger will need to be addressed during the next review.
[b] Total differs slightly from the column sum due to rounding.

describes actions necessary to manage risks to Bay fish consumers. The adaptive implementation section describes the method and schedule for evaluating and adapting the TMDL and implementation plan as needed to assure water quality standards are attained.

Mercury Source Control Actions

This section, organized by mercury source categories, specifies actions required to achieve allocations and implement the TMDL.

Central Valley Watershed

The Central Valley Regional Water Quality Control Board (Central Valley Water Board) is developing mercury TMDLs for several mercury-impaired water bodies in its region that drain to San Francisco Bay. The Central Valley Water Board staff is currently developing a mercury TMDL for portions of the Delta within the Central Valley region designed to meet the Central Valley watershed's load allocation. This Delta mercury TMDL is scheduled for consideration as a Basin Plan Amendment by the Central Valley Water Board by December 2005.

Attainment of the load allocation shall be assessed as a five-year average annual mercury load by one of two methods. First, attainment may be demonstrated by documentation provided by the Central Valley Water Board that shows a net 110 kg/yr decrease in total mercury entering the Delta from within the Central Valley region. Alternatively, attainment of the load allocation may be demonstrated by multiplying the flow-weighted suspended sediment mercury concentration by the sediment load measured at the RMP Mallard Island monitoring station. If sediment load estimates are unavailable, the load shall be assumed to be 1,600 million kg of sediment per year. The mercury load fluxing past Mallard Island will be less than or equal to 330 kg/yr after attainment of the allocation.

The allocation for the Central Valley watershed should be achieved within 20 years after the Central Valley Water Board begins implementing its TMDL load reduction program. Studies need to be conducted to evaluate the time lag between the remediation of mercury sources and resulting load reductions from the Delta. An interim loading milestone of 385 kg/yr of mercury, halfway between the current load and the allocation, should be attained ten years after implementation of the Central Valley Delta TMDL begins. This schedule will be reevaluated as the load reduction plans are implemented.

Urban Stormwater Runoff

The wasteload allocations shown in Table 4-w shall be implemented through the NPDES stormwater permits issued to urban runoff management agencies and the California Department of Transportation (Caltrans). The urban stormwater runoff allocations implicitly include all current and future permitted discharges, not otherwise addressed by another allocation, and unpermitted discharges within the geographic boundaries of urban runoff management agencies (collectively, "source category") including, but not limited to, Caltrans roadway and non-roadway facilities and rights-of-way, atmospheric deposition, public facilities, properties proximate to stream banks, industrial facilities, and construction sites.

The allocations for this source category should be achieved within 20 years, and, as a way to measure progress, an interim loading milestone of 120 kg/yr, halfway between the current load and the allocation, should be achieved within ten years. If the interim loading milestone is not achieved, NPDES-permitted entities shall demonstrate reasonable and measurable progress toward achieving the 10-year loading milestone.

The NPDES permits for urban runoff management agencies shall require the implementation of best management practices and control measures designed to achieve the allocations or accomplish the load reductions derived from the allocations. In addition to controlling mercury loads, best management practices or control measures shall include actions to reduce mercury-related risks to humans and wildlife. Requirements in each permit issued or reissued and applicable for the term of the permit shall be based on an updated assessment of control measures intended to reduce pollutants in stormwater runoff to the maximum extent practicable and remain consistent with the section of this chapter titled “Surface Water Protection and Management—Point Source Control - Stormwater Discharges”. The following additional requirements are or shall be incorporated into NPDES permits issued or reissued by the Water Board for urban runoff management agencies.

i) Evaluate and report on the spatial extent, magnitude, and cause of contamination for locations where elevated mercury concentrations exist;
ii) Develop and implement a mercury source control program;
iii) Develop and implement a monitoring system to quantify either mercury loads or loads reduced through treatment, source control, and other management efforts;
iv) Conduct or cause to be conducted studies aimed at better understanding mercury fate, transport, and biological uptake in San Francisco Bay and tidal areas;
v) Develop an equitable allocation-sharing scheme in consultation with Caltrans (see below) to address Caltrans roadway and non-roadway facilities in the program area, and report the details to the Water Board;
vi) Prepare an annual report that documents compliance with the above requirements and documents either mercury loads discharged, or loads reduced through ongoing pollution prevention and control activities; and
vii) Demonstrate progress toward (a) the interim loading milestone, or (b) attainment of the allocations shown in Table 4-w, by using one of the following methods:

    1) Quantify the annual average mercury load reduced by implementing (a) pollution prevention activities, and (b) source and treatment controls. The benefit of efforts to reduce mercury-related risk to wildlife and humans should also be quantified. The Water Board will recognize such efforts as progress toward achieving the interim milestone and the mercury-related water quality standards upon which the allocations and corresponding load reductions are based. Loads reduced as a result of actions implemented after 2001 (or earlier if actions taken are not reflected in the 2001 load estimate) may be used to estimate load reductions.
    2) Quantify the mercury load as a rolling five-year annual average using data on flow and water column mercury concentrations.
    3) Quantitatively demonstrate that the mercury concentration of suspended sediment that best represents sediment discharged with urban runoff is below the suspended sediment target.

An urban runoff management agency that complies with these permit requirements shall be deemed to be in compliance with receiving water limitations relative to mercury. Once the Water Board accepts that a requirement has been completed by an urban runoff management agency, it need not be included in subsequent permits for that agency. These requirements apply to municipalities covered by the statewide municipal stormwater general permit (issued by the State Water Resources Control Board) five years after the effective date of this Mercury TMDL.

Urban runoff management agencies have a responsibility to oversee various discharges within the agencies’ geographic boundaries. However, if it is determined that a source is substantially contributing to mercury loads to the Bay or is outside the jurisdiction or authority of an agency the Water Board will consider a request from an urban runoff management agency which may include an allocation, load reduction, and/or other regulatory requirements for the source in question.

Within the jurisdiction of each urban runoff management agency, Caltrans is responsible for discharges associated with roadways and non-roadway facilities. Consequently, Caltrans shall be required to implement the following actions:

i) Develop and implement a system to quantify mercury loads or loads reduced through control actions;

ii) Prepare an annual report that documents mercury loads or loads reduced through control actions; and
iii) Develop an equitable allocation-sharing scheme that reflects Caltrans load reduction responsibility in consultation with the urban runoff management agencies, and report the details to the Water Board. Alternatively, Caltrans may choose to implement load reduction actions on a watershed or regionwide basis in lieu of sharing a portion of an urban runoff management agency's allocation. In such a case, the Water Board will consider a separate allocation for Caltrans for which they may demonstrate progress toward attaining an allocation or load reduction in the same manner mentioned previously for municipal programs.

Guadalupe River Watershed (Mining Legacy)
In the near term, the effort underway to develop the Guadalupe River Watershed Mercury TMDL will be the mechanism used to implement and track progress toward achieving the load allocation. Ultimately, the Water Board expects the implementation plan for the Guadalupe River Watershed Mercury TMDL to integrate implementation efforts relative to that TMDL with those implementation efforts for the San Francisco Bay Mercury TMDL.

The Guadalupe River Watershed Mercury TMDL will provide a watershed-wide mercury management strategy. Efforts are already underway in the watershed to take early actions to reduce mercury loads, and more are planned. A high priority for the watershed-based strategy is to control upper watershed sources associated with the mining legacy to avoid compromising actions taken in the lower watershed. The strategy will include measures that prevent mercury-laden sediment from reaching the Bay, either by removal or by preventing their transport to the Bay. The strategy will also feature measures intended to reduce methylmercury production and risks to human health and wildlife. An essential component of the strategy will also involve testing and evaluation of new techniques and control measures, the benefits of that may apply throughout the Bay. As the mercury load, methylation, and reductions resulting from these efforts are quantified by the dischargers identified through the Guadalupe River Watershed Mercury TMDL process, the Water Board will consider how the reductions achieved will be counted toward fulfillment of the load reductions required to meet the Guadalupe River watershed load allocation.

The Guadalupe River watershed mining legacy mercury load allocation is expected to be attained within 20 years after the Water Board begins implementing the Guadalupe River Watershed Mercury TMDL. As a way to measure progress, an interim-loading milestone of 47 kg/yr of mercury, halfway between the current load and the allocation, should be achieved within ten years. If the interim loading milestone is not achieved, dischargers shall make reasonable and measurable progress toward achieving the ten-year load reduction through implementation of the watershed-wide strategy.

Progress toward (a) the interim loading milestone, or (b) attainment of the allocation, shall be demonstrated by the dischargers identified through the Guadalupe River Watershed TMDL using one of the methods listed below:

1. Quantify the annual average mercury load reduced by implementing (a) pollution prevention activities, (b) source and treatment controls, and (c) if applicable, other efforts to reduce methylation or mercury-related risks to humans and wildlife consistent with the watershed-based strategy. The Water Board will recognize loads reduced resulting from activities implemented after 1996 (or earlier if actions taken are not reflected in the 2001 load estimate) to estimate load reductions.
2. Quantify the mercury load as a rolling five-year annual average using data on flow and water column mercury concentrations.
3. Quantitatively demonstrate that the mercury concentration of suspended sediment that best represents sediment discharged from the watershed to San Francisco Bay is below the suspended sediment target.

Municipal Wastewater

The individual municipal wastewater wasteload allocations shall be implemented as a group mass limit. The Water Board will issue a San Francisco Bay watershed mercury NPDES permit to all dischargers listed in Table 4-x. The group mass limit is the sum of the individual allocations for these facilities, 17 kg/yr. If the group mass limit is exceeded, the Water Board will pursue enforcement actions against those individual dischargers whose mass emissions exceed their individual wasteload allocations.

The group mass limit and the following requirements shall be incorporated into the watershed NPDES permit for municipal wastewater dischargers:

- Develop and implement effective programs to control mercury sources and loading and reduce mercury-related risks to humans and wildlife (the level of effort shall be commensurate with the mercury load and performance of the facility) and quantify the mercury load avoided or reduced and risk reductions resulting from these activities;
- Comply with water quality-based effluent limitations, to be elaborated through the permit, that are consistent with the assumptions and requirements of the mercury wasteload allocation;
- Track individual facility and aggregate wastewater loads and the status of source control and pollution prevention activities;
- Conduct or cause to be conducted studies aimed at better understanding mercury fate, transport, and biological uptake in San Francisco Bay and tidal areas;
- Conduct or cause to be conducted studies to evaluate the presence or potential for local effects on fish, wildlife, and rare and endangered species in the vicinity of wastewater discharges; and
- Prepare an annual report that documents mercury loads from each facility, mercury effluent concentrations, and ongoing source control activities, including mercury loads avoided through control actions.

The watershed NPDES permit shall also specify conditions that apply to each individual facility. These conditions are intended to minimize the potential for adverse effects in the immediate vicinity of discharges and to ensure that municipal wastewater facilities maintain proper operation, maintenance, and performance. If a facility exceeds its individual mercury load allocation and an effluent mercury trigger concentration, it shall be required to report the exceedance in its individual Self-Monitoring Report, and to submit a report that:

- Evaluates the cause of the trigger exceedances;
- Evaluates the effectiveness of existing pollution prevention or pretreatment programs and methods for preventing future exceedances;
- Evaluates the feasibility and effectiveness of technology enhancements to improve plant performance.

Effluent mercury trigger concentrations for secondary treatment facilities are a daily maximum of 0.065 µg/l total mercury and monthly average of 0.041 µg/l total mercury. For advanced treatment facilities, effluent mercury trigger concentrations are a daily maximum of 0.021 µg/l total mercury and a monthly average of 0.011 µg/l total mercury.

Industrial Wastewater

The individual wasteload allocations for the industrial wastewater discharges from the five Bay Area petroleum refineries (Chevron, ConocoPhillips, Shell, Ultramar Golden Eagle, and Valero) are shown in Table 4-y. The individual wasteload allocations for all other industrial wastewater facilities are listed in Table 4-z. The total group allocation for industrial and refinery wastewater facilities is 3 kg/yr and shall be implemented as a group mass limit. If the group mass limit is exceeded, the Water Board will pursue enforcement actions against those individual dischargers whose mass emissions exceed their individual wasteload allocations.

The group mass limit and the following requirements shall be incorporated into NPDES permits for all industrial wastewater dischargers:

- Develop and implement effective programs to control mercury sources and loading and reduce mercury-related risks to humans and wildlife (the level of effort will be commensurate with the mercury load and performance of the facility) and quantify the mercury load avoided or reduced and risk reductions resulting from these activities;
- Comply with water quality-based effluent limitations, to be elaborated through the permit, that are consistent with the assumptions and requirements of the mercury wasteload allocation;
- Conduct or cause to be conducted studies aimed at better understanding mercury fate, transport, and biological uptake in San Francisco Bay and tidal areas;
- Conduct or cause to be conducted studies to evaluate the presence or potential for local effects on fish, wildlife, and rare and endangered species in the vicinity of wastewater discharges; and
- Prepare an annual report that documents mercury loads from each facility, mercury effluent concentrations, and ongoing source control activities, including mercury loads avoided through control actions.

The NPDES permits for industrial facilities shall also specify conditions that apply to each individual facility. These conditions are intended to minimize the potential for adverse effects in the immediate vicinity of discharges and to ensure that industrial facilities maintain proper operation, maintenance, and performance. If a facility exceeds its individual mercury load allocation and an effluent mercury trigger concentration, it shall be required to report the exceedance in its individual Self-Monitoring Report, and to submit a report that:

- Evaluates the cause of the trigger exceedances;
- Evaluates the effectiveness of existing pollution prevention or pretreatment programs and methods for preventing future exceedances;
- Evaluates the feasibility and effectiveness of technology enhancements to improve plant performance.

Effluent mercury trigger concentrations are a daily maximum of 0.062 µg/l total mercury and monthly average of 0.037 µg/l total mercury.

Bay Area petroleum refineries shall be required to work collaboratively with the Water Board to investigate the environmental fate of mercury in crude oil and report findings to the Water Board within five years of the effective date of this Mercury TMDL implementation plan. These requirements may be implemented via the Water Board's authority under Section 13267 of the California Water Code or petroleum refinery wastewater NPDES permits. The report shall address two key questions:

1. What are the potential pathways by which crude oil mercury could be discharged to the Bay from Bay Area petroleum refining facilities?
2. What are the annual mercury loads associated with these discharge pathways?

Sediment Dredging and Disposal

The allocation for sediment dredging and disposal is both mass-based and concentration-based. The mercury concentration in dredged material disposed of in the Bay shall not exceed the 99^{th} percentile mercury concentration of the previous 10 years of Bay sediment samples collected through RMP (excluding stations outside the Bay like the Sacramento River, San Joaquin River, Guadalupe River and Standish Dam stations). Prior to disposal, the material shall be sampled and analyzed according to the procedures outlined in the 2001 U.S. Army Corps of Engineers document "Guidelines for Implementing the Inland Testing Manual in the San Francisco Bay Region."

The process of dredging and disposing of dredged material in the Bay may enhance biological uptake and methylmercury exposure. To address this concern, permitted dredging and disposal operations shall demonstrate that their activities are accomplished in a manner that does not increase bioavailability of mercury. As part of this demonstration, the Waste Discharge Requirements for such operations shall include requirements to conduct or cause to be conducted studies to better understand how their operations affect mercury fate, transport, and biological uptake.

Atmospheric Deposition

Mercury that deposits directly on the Bay surface and the surrounding watershed is attributed to both remote and local sources. The extent to which these sources can be controlled is unknown and the Water Board's authority to control such sources is limited. The load allocation does not allow an increase of current loads, and does not require a reduction from this source category at this time. Recent scientific studies suggest that mercury newly deposited from the atmosphere may be more available for biological uptake than mercury already present in an aquatic system. As such, the following implementation efforts need to be undertaken to evaluate the significance of atmospheric deposition and the feasibility of load reductions:

- The U.S. Environmental Protection Agency should investigate the significance of atmospheric deposition and actively pursue national and international efforts to reduce the amount of mercury released through combustion of fossil fuels; and
- The Bay Area Air Quality Management District should conduct a local mercury emissions inventory, investigate the significance of local mercury air emissions, evaluate the effectiveness of existing control measures and the feasibility of additional controls.

If local air sources are found to contribute substantially to atmospheric deposition loading to the Bay and its surrounding watershed, the Water Board will consider assigning allocations and load reductions to individual air sources and work with the Bay Area Air Quality Management District to ensure allocations are achieved.

New Mercury Sources

As the TMDL is implemented, new sources of mercury may emerge either as the result of a new facility applying for a discharge permit or as a result of a new source being discovered. The Water Board will consider establishing a load or wasteload allocation for a new mercury source under any of the following circumstances:

- The allocation from one or more existing sources of the same category (e.g., municipal wastewater) will be reduced by an amount equal to the new allocation; or
- The Water Board finds that the magnitude of the new allocation is negligible compared to load reductions from all sources that will have been realized prior to establishing the new allocation; or
- The allocation is for a previously unquantified discharge of mercury from a source category that does not already have an allocation.

This section specifies actions required for sources that are potentially either discharging mercury or enhancing methylmercury production in the Bay.

Mercury Mines

Local inactive mercury mines shall be addressed through continued implementation of the Mines and Mineral Producers Discharge Control Program (Mines Program) described later in this chapter. The key regulatory component of this established program is that property owners of inactive and active mine sites that discharge stormwater contaminated by contact with any overburden, raw material, intermediate products, finished products, byproducts, or waste products are required to comply with NPDES industrial stormwater regulations. Under the Mines Program, the Water Board has the authority to issue individual industrial permits or allow the discharger to obtain coverage under the industrial stormwater general permit issued by the State Water Resources Control Board. For those mines that are not currently meeting the conditions set forth in the Mines Program, responsible parties shall attain compliance within five years of the effective date of this Mercury TMDL implementation plan.

Bay Margin Contaminated Sites

A number of former industrial and military sites that contain mercury-enriched sediment surround the Bay. Available data are insufficient at this time to determine whether these sites may be discharging to the Bay. While the load these sites contribute to the Bay may be small relative to known sources, these sites may pose local threats. As such, cleanup of these sites is a Water Board priority and many cleanups are underway. The Water Board will require parties responsible for Bay margin contaminated sites to:

1. Quantify mercury mass on site such that the upper 95% confidence limit of the mean value is no more than 20% higher than the estimated mean;
2. Determine seasonal and spatial patterns of total mercury and methylmercury in sediments on site;
3. Estimate future mercury mass on site and patterns of contamination after planned remediation efforts are complete;
4. Determine seasonal patterns of total mercury and methylmercury in the water column at the site;
5. Collect prey items for local fish and birds and assess mercury concentrations; and
6. Quantify rate of sediment accretion or erosion at the site.

These requirements shall be incorporated into relevant site cleanup plans within five years of the effective date of this mercury TMDL, and the actions shall be fully implemented within ten years of the effective date of this TMDL.

Wetlands

Wetlands may contribute substantially to methylmercury production and biological exposure to mercury within the Bay. Plans for extensive wetland restoration in the San Francisco Bay region raise the concern that mercury methylation may increase, thereby increasing the amount of mercury entering the food web. Implementation tasks related to wetlands focus on managing existing wetlands and ensuring that new constructed wetlands are designed to minimize methylmercury production and subsequent transfer to the food web.

The Water Board issues Waste Discharge Requirements and Clean Water Act Section 401 certifications that set forth conditions related to Bay filling and the construction and management of wetlands. To implement the mercury TMDL, the Waste Discharge Requirements and Section 401 certifications for wetland projects shall include provisions that the restored wetland region be designed and operated to minimize methylmercury production and biological uptake, and result in no net increase in mercury or methylmercury loads to the Bay. Additionally, projects must include pre- and post-restoration monitoring to demonstrate compliance. There is much active research on mercury cycling in wetlands. Information about how to manage wetlands to suppress or minimize mercury methylation will be adaptively incorporated into this implementation plan as it becomes available.

Risk Management

The mercury problem in San Francisco Bay may take decades to solve. However, there are activities that should be undertaken immediately to help manage the risk to consumers of mercury-contaminated fish. In this effort, the Water Board will work with the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, and dischargers that pursue risk management as part of their mercury-related programs. The risk management activities will include the following:

- Providing multilingual fish-consumption advice to the public to help reduce methylmercury exposure through community outreach, broadcast and print media, and signs posted at popular fishing locations;
- Regularly informing the public about monitoring data and findings regarding hazards of eating mercury-contaminated fish; and
- Performing special studies needed to support health risk assessment and risk communication.

Adaptive Implementation

The Water Board will adapt the TMDL to incorporate new and relevant scientific information such that effective and efficient actions can be taken to achieve TMDL goals. Approximately every five years, the Water Board will review the San Francisco Bay

Mercury TMDL and evaluate new and relevant information from monitoring, special studies, and scientific literature. The reviews will be coordinated through the Water Board's continuing planning program and will provide opportunities for stakeholder participation. Any necessary modifications to the targets, allocations, or implementation plan will be incorporated into the Basin Plan. At a minimum, the following focusing questions will be used to conduct the reviews. Additional focusing questions will be developed in collaboration with stakeholders during each review.

1. Is the Bay progressing toward TMDL targets as expected? If it is unclear whether there is progress, how should monitoring efforts be modified to detect trends? If there has not been adequate progress, how might the implementation actions or allocations be modified?
2. What are the loads for the various source categories, how have these loads changed over time, and how might source control measures be modified to improve load reduction?
3. Is there new, reliable, and widely accepted scientific information that suggests modifications to targets, allocations, or implementation actions? If so, how should the TMDL be modified?
4. Are effective risk management activities in place to reduce human and wildlife exposure to methylmercury? If not, how should these activities be modified or enhanced?

Using available data, the load and wasteload allocations were determined on the basis of their sufficiency to achieve water quality standards. As part of the adaptive implementation process, the Water Board will review the TMDL as a whole and determine whether new evidence suggests revisions of specific load and wasteload allocations that will result in more strategic, efficient, and cost effective achievement of water quality standards. For example, as reliable information becomes available regarding methylation control or the relative bioavailability of sources, the Water Board will consider adjusting allocations to implement the TMDL more effectively. The Water Board may also consider revising implementation requirements and/or resulting permit requirements if such changes are consistent with the assumptions and requirements of the allocations and the cumulative effect of such changes will ensure attainment of water quality standards.

Achievement of the allocations for three of the largest source categories (Central Valley Watershed, Urban Stormwater Runoff, Guadalupe River Watershed) is projected to take 20 years, with an interim 10-year milestone of fifty percent achievement. Approximately 10 years after the effective date of the TMDL or any time thereafter, the Water Board will consider modifying the schedule for achievement of the load allocations for a source category or individual discharger provided that they have complied with all applicable permit requirements and all of the following have been accomplished relative to that source category or discharger:

- A diligent effort has been made to quantify mercury loads and the sources of mercury and potential bioavailability of mercury in the discharge;

- Documentation has been prepared that demonstrates that all technically and economically feasible and cost effective control measures recognized by the Water Board as applicable for that source category or discharger have been fully implemented, and evaluates and quantifies the comprehensive water quality benefit of such measures;
- A demonstration has been made that achievement of the allocation will require more than the remaining 10 years originally envisioned; and
- A plan has been prepared that includes a schedule for evaluating the effectiveness and feasibility of additional control measures and implementing additional controls as appropriate.

At approximately 20 years after the start of implementation and after taking the steps regarding schedule modification listed above, if a source category or individual discharger cannot demonstrate achievement of its allocation, despite implementation of all technically and economically feasible and cost effective control measures recognized by the Water Board as applicable for that source category or discharger, the Water Board will consider revising the allocation scheme provided that any resulting revisions ensure water quality standards are attained.

Load and wasteload allocations have been assigned to individual entities. However, assigning loads by watersheds could be a useful approach for managing pollutant loads, particularly if net environmental benefits can be realized. A watershed-based allocation program would only involve watersheds in the San Francisco Bay region that drain to the Bay. Such an approach could involve urban runoff management programs, wastewater facilities, and other dischargers in a watershed accepting joint responsibility for load reductions. An acceptable watershed allocation program may include incentives for agencies to implement load reduction activities and account for avoided mercury loads as well as incentives for strategic removal or sequestration of mercury already in the system. Credits could be used to offset annual loads and attain allocations for multiple sources. In addition, the Water Board will encourage and consider a pilot mercury mass offset program if it is demonstrated that such a program is a more cost effective and efficient means of achieving water quality standards, and the relative potential for mercury from different sources to enter the food web and the potential for adverse local impacts have been evaluated. These programs should recognize and reward ongoing efforts that are above and beyond those required by this TMDL. Until such programs are established, the Water Board will consider mercury source control and risk reduction activities on a case-by-case basis to determine how they contribute toward achievement of TMDL goals.

The following changes, shown in redline/strikeout, apply to the section at the end of Chapter 4 entitled “CONTINUING PLANNING.”

REGIONAL BOARD RESOURCE ALLOCATION

The items indicated below have been identified in this review as specific areas for which ~~Regional Board~~Water Board planning resources should be allocated. The items are divided into categories and each item is followed by an estimate of the frequency at which the item will be reviewed or the staff time and/or contract dollars needed to complete the item. Resolution of these items may result in future Basin Plan amendments.

TOTAL MAXIMUM DAILY LOAD	
Review the San Francisco Bay Mercury TMDL and evaluate new and relevant information from monitoring, special studies, and scientific literature. Determine if modifications to the targets, allocations, or implementation plan are necessary.	Every 5 years

Appendix B

Environmental Checklist

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ENVIRONMENTAL CHECKLIST

1.	**Project Title:**	Mercury in San Francisco Bay Total Maximum Daily Load (TMDL) Basin Plan Amendment
2.	**Lead Agency Name and Address:**	California Regional Water Quality Control Board, San Francisco Bay Region 1515 Clay Street, Suite 1400 Oakland, California 94612
3.	**Contact Person and Phone Number:**	Bill Johnson (510) 622-2354 Richard Looker (510) 622-2451
4.	**Project Location:**	San Francisco Bay and San Francisco Bay Region
5.	**Project Sponsor's Name and Address:**	California Regional Water Quality Control Board, San Francisco Bay Region 1515 Clay Street, Suite 1400 Oakland, California 94612
6.	**General Plan Designation:**	Not Applicable
7.	**Zoning:**	Not Applicable

8. **Description of Project:**

   The project is a proposed Basin Plan Amendment to adopt a TMDL for mercury in San Francisco Bay. The project would involve numerous actions to reduce mercury concentrations in San Francisco Bay sediment, fish, and bird eggs. Additional details are provided in the explanation attached.

9. **Surrounding Land Uses and Setting:**

   The proposed Basin Plan Amendment would affect all segments of San Francisco Bay. Implementation would involve specific actions throughout the Bay Area and Central Valley. Bay Area and Central Valley land uses include a mix of residential, commercial, industrial, municipal, agricultural, and open space.

10. **Other public agencies whose approval is required** (e.g., permits, financing approval, or participation agreement.)

    The California State Water Resources Control Board, the California Office of Administrative Law, and the U.S. Environmental Protection Agency must approve the proposed Basin Plan Amendment.

ENVIRONMENTAL IMPACTS:

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
I. AESTHETICS -- Would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☒
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☐	☒
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☒
II. AGRICULTURE RESOURCES -- In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. **Would the project:**				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	☐	☐	☐	☒
III. AIR QUALITY -- Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. **Would the project:**				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
III. AIR QUALITY -- (cont.):				
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☐	☒	☐
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☐	☐	☐	☒
d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☒
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☒
IV. BIOLOGICAL RESOURCES -- Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☒	☐
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☒	☐
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☒	☐
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☒	☐

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
IV. BIOLOGICAL RESOURCES -- (cont.):				
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒
V. CULTURAL RESOURCES -- Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?	☐	☐	☒	☐
b) Cause a substantial adverse change in the significance of a unique archaeological resource pursuant to §15064.5?	☐	☐	☒	☐
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☒	☐
d) Disturb any human remains, including those interred outside of formal cemeteries?	☐	☐	☒	☐
VI. GEOLOGY AND SOILS -- Would the project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
ii) Strong seismic ground shaking?	☐	☐	☐	☒
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☒
iv) Landslides?	☐	☐	☐	☒
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
VI. GEOLOGY AND SOILS -- (cont.):				
c) Be located on geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☐	☒
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☒
e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒
VII. HAZARDS AND HAZARDOUS MATERIALS -- Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☒	☐
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☒	☐
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☒
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
VII. HAZARDS AND HAZARDOUS MATERIALS -- (cont.):				
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☒
VIII. HYDROLOGY AND WATER QUALITY -- Would the project:				
a) Violate any water quality standards or waste discharge requirements?	☐	☐	☐	☒
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☐	☒
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion of siltation on- or off-site?	☐	☐	☒	☐
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☐	☐	☐	☒
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
VIII. HYDROLOGY AND WATER QUALITY -- (cont.):				
f) Otherwise substantially degrade water quality?	☐	☐	☐	☒
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☐	☐	☐	☒
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☐	☒
j) Inundation of seiche, tsunami, or mudflow?	☐	☐	☐	☒
IX. LAND USE AND PLANNING -- Would the project:				
a) Physically divide an established community?	☐	☐	☐	☒
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☒
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☒
X. MINERAL RESOURCES -- Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
XI. NOISE -- Would the project result in:				
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☒
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☒	☐
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☒
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☒	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
XII. POPULATION AND HOUSING -- Would the project:				
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☒
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
c) Displace substantial numbers of people necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
XIII. PUBLIC SERVICES --				
a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services:				
Fire protection?	☐	☐	☐	☒
Police protection?	☐	☐	☐	☒
Schools?	☐	☐	☐	☒
Parks?	☐	☐	☐	☒
Other public facilities?	☐	☐	☐	☒
XIV. RECREATION --				
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☒
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☐	☐	☐	☒
XV. TRANSPORTATION / TRAFFIC -- Would the project:				
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume-to-capacity ratio on roads, or congestion at intersections)?	☐	☐	☐	☒
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☐	☐	☐	☒
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
XV. TRANSPORTATION / TRAFFIC – (cont.):				
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☒
e) Result in inadequate emergency access?	☐	☐	☐	☒
f) Result in inadequate parking capacity?	☐	☐	☐	☒
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☒
XVI. UTILITIES AND SERVICE SYSTEMS -- Would the project:				
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☒
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☒	☐
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☒
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☒
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☒
g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒

Issues:	*Potentially Significant Impact*	*Less Than Significant With Mitigation Incorporation*	*Less Than Significant Impact*	*No Impact*
XVII. MANDATORY FINDINGS OF SIGNIFICANCE				
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☐	☒
b) Does the project have impacts that are individually limited, but cumulative considerable? ("Cumulative considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☐	☒	☐
c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☒

EXPLANATION

PROJECT DESCRIPTION

The proposed project is a Basin Plan Amendment to adopt a Total Maximum Daily Load (TMDL) for mercury in San Francisco Bay (see Appendix A). The goal of the Basin Plan Amendment is to improve environmental conditions. The Basin Plan Amendment would include target mercury concentrations for sediment, fish, and bird eggs, and assign load and wasteload allocations to the various mercury sources to achieve the targets. The Basin Plan Amendment implementation plan would involve numerous actions to achieve the targets and allocations. The Basin Plan Amendment would affect all segments of San Francisco Bay, and implementation actions would occur throughout the Bay Area and Central Valley.

The proposed targets and allocations are measures of performance. The implementation plan outlines the San Francisco Bay Regional Water Quality Control Board's (Water Board's) approach to meeting these measures of performance. The plan describes actions the Regional Board would take and how the Water Board would compel, as necessary, other entities to do their parts to reduce mercury concentrations in San Francisco Bay. The Water Board would not directly undertake any actions that could physically change the environment, but adopting the proposed Basin Plan Amendment could indirectly result in other entities (e.g., cities, counties, and special districts) undertaking projects to satisfy requirements derived from the Basin Plan Amendment. These projects could physically change the environment. The environmental impacts of such physical changes are evaluated below to the extent that they are reasonably foreseeable. Changes that are speculative in nature do not require environmental review.

Until the parties that must comply with requirements derived from the Basin Plan Amendment propose specific projects, many physical changes cannot be anticipated. These projects would be subject to environmental review under the California Environmental Quality Act (CEQA), and CEQA compliance would be the responsibility of the lead agency for each project. The environmental reviews would identify any potentially significant adverse environmental impacts of the specific proposals, along with appropriate mitigation measures. Until such projects are proposed, however, identifying specific impacts and mitigation measures would require inappropriate speculation. Moreover, any mitigation deemed necessary by the lead agencies for those projects would not be within the jurisdiction of the Water Board to require.

Direct and Indirect Physical Changes

Table B.1 summarizes the actions that could conceivably be undertaken if the proposed Basin Plan Amendment were adopted, and explains the rationale for including them or not including them in this environmental review. As shown in the table, the physical changes that require evaluation are those associated with (1) minor construction, (2) earthmoving operations, and (3) waste handling and disposal. Although these activities are reasonably foreseeable, the implementation plan does not specify the nature of these actions. Therefore, this analysis considers these actions in general programmatic terms. To illustrate the possible nature of these activities, some examples are described below.

- *Minor Construction.* Basin Plan Amendment-related construction activities would generally be small in scale. Most would relate to storm water treatment facilities intended to remove

TABLE B.1: Implementation Actions Subject to Environmental Review

	Possible Actions	Environmental Change Subject to Review
Central Valley Watershed	Pollution prevention	Waste handling & disposal
	Storm water treatment	Minor construction/waste handling & disposal
	Storm sewer maintenance	Waste handling & disposal[1]
	Additional wastewater treatment	None—Speculative
	Additional water reclamation	None—Speculative
	Mine site remediation	Earthmoving operations/waste handling & disposal[2]
	Slope stabilization	Earthmoving operations/waste handling & disposal[2]
	Channel maintenance and restoration	Earthmoving operations[2]
	Contaminated site remediation	Earthmoving operations/waste handling & disposal[2]
	Methylation control	None—Speculative
	Central Valley emissions controls	None—Speculative
Urban Storm Water Runoff	Pollution prevention	Waste handling & disposal
	Storm water treatment	Minor construction/waste handling & disposal
	Storm sewer maintenance	Waste handling & disposal[1]
	New development permit provisions	None—Not a Basin Plan Amendment effect
	Methylation control	None—Speculative
Guadalupe River Watershed (mining legacy)	Mine remediation	Earthmoving operations/waste handling & disposal[2]
	Slope stabilization	Earthmoving operations[2]
	Channel maintenance and restoration	Earthmoving operations/waste handling & disposal[2]
	Methylation control	None—Speculative
Atmospheric Deposition	Bay Area emissions controls	None—Speculative
	Global actions	None—Not a Basin Plan Amendment effect
Wastewater	Pollution prevention	Waste handling & disposal
	Additional treatment	None—Speculative
	Additional reclamation	None—Speculative
	Methylation control	None—Speculative
Sediment Dredging and Disposal	Additional upland disposal	None—Not a Basin Plan Amendment effect
	Methylation control	None—Speculative
Mercury Mines	Mine site remediation	None—Not a Basin Plan Amendment effect[3]
	Slope stabilization	None—Not a Basin Plan Amendment effect[3]
	Creek maintenance and restoration	None—Not a Basin Plan Amendment effect[3]
	Methylation control	None—Speculative
Bay Margin Contaminated Sites	Site remediation	None—Speculative
	Methylation control	None—Speculative
Wetlands	Methylation control	None—Speculative
Risk Management	Risk communication	None—No physical environmental change
Monitoring and Studies	Data collection and analysis	Earthmoving operations[4]

[1] The Basin Plan Amendment may not increase maintenance, but maintenance activities may be targeted to maximize mercury removal.
[2] Earthmoving could include grading, sediment removal, capping, or other actions taken to remediate a site.
[3] The Basin Plans for the San Francisco Bay Region and Central Valley Region already include implementation plans for mines.
[4] Most studies would result in no physical environmental change; however, some studies (e.g., wetlands studies) could involve small pilot projects, which could require some small-scale earthmoving operations.

mercury-containing sediment from urban storm water runoff. For example, new treatment facilities could include retention or detention basins, separators, infiltration basins, or vegetated swales. Construction could also be undertaken to divert storm water flows. For example, if a wastewater treatment facility were to treat storm water, a connection between the storm water and wastewater systems would need to be constructed. Additionally, minor construction, such as fence construction, could occur at remediation sites.

- *Earthmoving Operations.* The Basin Plan Amendment could result in the use of heavy equipment to move soils from one place to another. For example, site remediation (and possibly construction activities) could include grading, soil removal and disposal, soil containment, capping, slope stabilization, or landscaping. Recontouring and restoring creeks could involve temporarily diverting creeks or other less disruptive soil movement. Routine channel maintenance could entail removing sediment periodically on an ongoing basis. Pilot projects associated with special studies (e.g., experimental wetlands) could also require earthmoving.

- *Waste Handling and Disposal.* Contaminated soil associated with site remediation could require disposal. In some cases, disposal could be arranged on site (e.g., by constructing a containment facility on site). In others, the soil could be sent for disposal as solid or hazardous waste, depending on its properties. While implementation projects would reasonably generate contaminated soil for disposal, the possible amount of this waste stream is unknown. This waste would, however, be generated only on a temporary basis.

  Pollution prevention and outreach activities could encourage proper disposal of mercury-containing wastes, which could increase hazardous waste generation. For example, new programs could support the collection and disposal of mercury-containing thermometers, switches, and fluorescent bulbs as hazardous waste. Pollution prevention and outreach could also decrease overall mercury waste generation by discouraging the use of mercury in commercial products. For example, implementation projects could encourage alternatives to mercury thermometers and switches, and promote the use of low-mercury fluorescent bulbs. Mercury pollution prevention and outreach would be a long-term commitment, and the effects would continue indefinitely.

These examples are not intended to be exhaustive or exclusive. As specific implementation proposals are developed and proposed, lead agencies would undertake environmental review and identify specific environmental impacts and appropriate mitigation measures.

Changes Likely With or Without the Basin Plan Amendment

The implementation plan relies on some actions that will occur with or without the proposed Basin Plan Amendment. Because these actions do not result from the Basin Plan Amendment, environmental review is not included in this analysis. Many Central Valley actions are likely to occur with or without the Basin Plan Amendment because scheduled mercury TMDLs will be completed and implemented for Central Valley water bodies. Because these TMDLs have not been completed yet, specific implementation details are unknown, but these actions would likely be similar to those foreseeable in the Bay Area. Additional environmental review will occur as the Central Valley TMDLs are completed. This analysis considers some Central Valley watershed actions because the proposed Basin Plan Amendment could potentially require more actions than the Central Valley TMDLs would otherwise require on their own.

Like the Central Valley watershed, many implementation actions for the Guadalupe River watershed are likely to occur with or without the proposed Basin Plan Amendment because a mercury TMDL is already being developed for the Guadalupe River. Because the TMDL is not yet complete, however, specific implementation details are unknown. This analysis considers some Guadalupe River watershed actions because the proposed Basin Plan Amendment could potentially require more actions than the Guadalupe River TMDL would otherwise require. Additional environmental review will occur as the Guadalupe River TMDL is completed.

Other actions likely to occur with or without the Basin Plan Amendment include implementing existing urban storm water runoff permit provisions regarding new development, participation in global mercury-reduction efforts, maintaining storm sewers, cleaning up Bay Area mine sites (the Basin Plan already specifies the Water Board’s approach for remediating mine sites), and implementing the Long-Term Management Strategy for the Disposal of Dredged Materials (LTMS) (a certified EIS/EIR already covers the environmental effects of the LTMS, which has been considered and adopted by a number of agencies). All these activities are already underway.

Changes Too Speculative to Evaluate

Several conceivable actions that could be taken as a result of the Basin Plan Amendment require speculation and cannot be evaluated in this environmental review. Among these are wastewater treatment, water reclamation, methylation control, air emissions control, and bay margin site remediation. The need for new or expanded wastewater treatment or reclamation facilities is speculative because the need for such facilities is not foreseeable given existing capacity and population growth projections (LWA 2002). Although the proposed Basin Plan Amendment includes plans to study ways to control methylmercury production and mercury emissions, more information is needed before actual controls can be considered. Therefore, these actions are too speculative consider. Similarly, more information is needed before concluding that any particular bay margin contaminated site contributes substantially to the mercury impairment of San Francisco Bay. Until such information becomes available, bay margin contaminated site remediation options remain too speculative for environmental review. As discussed above, even in cases where some physical changes are foreseeable, the exact nature of these changes is often speculative pending specific project proposals to be put forth by those subject to requirements derived from the Basin Plan Amendment.

ENVIRONMENTAL ANALYSIS

The proposed Basin Plan Amendment does not define the specific actions local agencies could take to comply with requirements derived from the Basin Plan Amendment. As discussed above, physical changes resulting from the Basin Plan Amendment are foreseeable, but the attributes of specific implementation actions (e.g., location, extent, etc.) are unknown, pending local agencies proposing actions to comply with Basin Plan Amendment requirements. CEQA requires lead agencies to review the potential for their actions to result in adverse environmental impacts. CEQA further requires lead agencies to adopt feasible measures to mitigate potentially significant impacts. Therefore, the analysis below assumes that lead agencies would adopt mitigation measures necessary to address potentially significant impacts as long as appropriate measures are readily available. As explained below, mitigation measures are readily available to address all the foreseeable impacts of the Basin Plan Amendment, including possible local agency actions to the extent that they can be anticipated. Therefore, the potential impacts of the proposed Basin Plan Amendment would be less-than-significant.

An explanation for each box checked on the environmental checklist is provided below:

I. Aesthetics

a-d) Any physical changes to the aesthetic environment as a result of the Basin Plan Amendment would be small in scale. The Basin Plan Amendment would not substantially affect any scenic resource or vista, or degrade the existing visual character or quality of any site or its surroundings. It would not create any new source of light or glare.

II. Agriculture Resources

a-c) The Basin Plan Amendment would not involve the conversion of farmland to non-agricultural use. It would not affect agricultural zoning or any Williamson Act contract.

III. Air Quality

a) Because the Basin Plan Amendment would not cause any change in population or employment, it would not generate ongoing traffic-related emissions. It would also not involve the construction of any permanent emissions sources. For these reasons, no permanent change in air emissions would occur, and the Basin Plan Amendment would not conflict with applicable air quality plans.

b) The Basin Plan Amendment would not involve the construction of any permanent emissions sources or generate ongoing traffic-related emissions. Construction that would occur as a result of Basin Plan Amendment implementation, including earthmoving operations, would be of short-term duration. Fine particulate matter (PM_{10}) is the pollutant of greatest concern with respect to construction. PM_{10} emissions can result from a variety of construction activities, including excavation, grading, demolition, vehicle travel on paved and unpaved surfaces, and vehicle and equipment exhaust. If specific construction projects were proposed to comply with requirements derived from the proposed Basin Plan Amendment, local agencies would require any necessary mitigation through their environmental reviews. The Bay Area Air Quality Management District has identified readily available measures to control construction-related air quality emissions (BAAQMD 1999). These measures include watering active construction areas; covering trucks hauling soil; paving, applying water, or applying soil stabilizers on unpaved areas; sweeping paved areas; and sweeping public streets. Lead agencies would ensure that appropriate emissions control measures are implemented. Therefore, the Basin Plan Amendment would not violate any air quality standard or contribute substantially to any air quality violation, and its temporary construction-related air quality impacts would be less-than-significant.

c) Because the Basin Plan Amendment would not generate ongoing traffic-related emissions or involve the construction of any permanent emissions sources, it would not contribute considerably to cumulative emissions.

d-e) Because the Basin Plan Amendment would not involve the construction of any permanent emissions sources, it would not expose sensitive receptors to ongoing pollutant emissions posing health risks or creating objectionable odors.

IV. Biological Resources

a-b) The Basin Plan Amendment is designed to benefit biological resources, including wildlife and rare and endangered species. If, pursuant to the proposed Basin Plan Amendment, specific projects were proposed that were to involve construction and earthmoving activities that could modify habitats, adversely affect special-status species, or disturb riparian habitat or sensitive natural communities, then local agencies would conduct environmental review and identify necessary mitigation measures. Through the CEQA and permitting processes, lead agencies would ensure that readily available mitigation measures are implemented, such as avoiding or, if feasible, relocating or replacing sensitive habitat. Therefore, the Basin Plan Amendment would not substantially affect habitats, special-status species, or sensitive communities, and its impacts would be less-than-significant.

c) Basin Plan Amendment-related studies could indirectly result in wetlands (e.g., marshes etc.) being managed differently so as to minimize methylmercury production; however, to anticipate the management changes that could occur would require speculating on the possible conclusions of studies that have not yet begun. If, pursuant to requirements derived from the proposed Basin Plan Amendment, specific projects were to be proposed involving construction or earthmoving activities that could adversely affect wetlands, then local agencies would require necessary mitigation measures through their environmental reviews. Lead agencies would ensure that readily available measures are implemented, such as avoiding sensitive wetland and riparian habitat or mitigating for unavoidable fill. Therefore, the Basin Plan Amendment would not adversely affect wetlands, and its impacts would be less-than-significant.

d) If, pursuant to Basin Plan Amendment requirements, specific projects were proposed that were to involve construction or earthmoving activities that could interfere with fish or wildlife movement, migratory corridors, or nurseries, then local agencies would require necessary mitigation through their environmental reviews. Lead agencies would ensure that readily available measures are implemented, such as avoiding construction during the breeding season, avoiding sensitive habitat areas, and minimizing disturbances. Therefore, the Basin Plan Amendment would not substantially affect fish or wildlife movement, migratory corridors, or nurseries, and its impacts would be less-than-significant.

e-f) If, pursuant to Basin Plan Amendment requirements, specific projects were proposed that were to involve construction or earthmoving activities, then local agencies would develop such proposals in accordance with their own local policies and ordinances, including any applicable habitat conservation plans, natural community conservation plans, or other plans intended to protect biological resources. Therefore, the Basin Plan Amendment would not conflict with local policies, ordinances, or adopted plans.

V. Cultural Resources

a-d) Local agencies could propose specific projects involving earthmoving or construction to comply with requirements derived from the proposed Basin Plan Amendment. Construction would generally be small in scale, and earthmoving would likely occur in areas already disturbed by recent human activity. If necessary to protect historical, archaeological, or paleontological resources, local agencies would require mitigation through their environmental reviews. Lead agencies would ensure that readily available measures are implemented, such as requiring a trained professional to observe major earthmoving work and stop the work if evidence of cultural resources is discovered. Therefore, the Basin Plan Amendment would not adversely affect any cultural resource, and its impacts would be less-than-significant.

VI. Geology and Soils

a) The Basin Plan Amendment would not involve the construction of habitable structures; therefore, it would not involve any human safety risks related to fault rupture, seismic ground-shaking, ground failure, or landslides.

b) Local agencies could propose specific projects involving earthmoving or construction activities to comply with requirements derived from the proposed Basin Plan Amendment. To meet the proposed Basin Plan Amendment targets, construction would be designed to reduce overall soil erosion and mercury loads associated with erosion. However, temporary earthmoving operations could result in short-term erosion. Local agencies would require necessary mitigation measures through their environmental review and grading permit processes. Lead agencies would ensure that readily available measures are implemented, such as dust suppression (e.g., spraying water), use of erosion control best management practices, and proper construction site management. In addition, construction projects over 1 acre in size would require a general construction National Pollutant Discharge Elimination System permit and implementation of a storm water pollution prevention plan. Therefore, the Basin Plan Amendment would not result in substantial soil erosion, and its impacts would be less-than-significant.

c-d) The Basin Plan Amendment would not involve the construction of habitable structures, and any construction would be relatively small in scale. Local agencies proposing construction to comply with requirements derived from the Basin Plan Amendment would undertake engineering and environmental studies to ensure that they do not locate structures on unsuitable soil, including expansive soil. Construction would be designed to minimize any potential for landslides, lateral spreading, subsidence, liquefaction, or collapse. Therefore, the Basin Plan Amendment would not create safety or property risks due to unstable or expansive soil.

e) The Basin Plan Amendment would not require wastewater disposal systems; therefore, affected soils need not be capable of supporting the use of septic tanks or alternative wastewater disposal systems.

VII. Hazards and Hazardous Materials

a-b) Remediation actions could require the disposal of mercury-contaminated soils, but such waste streams would be generated for a limited, short-term duration. The California Department of Toxic Substances Control oversees hazardous waste handing and disposal. The U.S. Department of Transportation specifies requirements for hazardous materials transportation. Proper handling in accordance with relevant laws and regulations would minimize hazards to the public or the environment, and the potential for accidents or upsets. Therefore, hazardous waste transport and disposal would not create a significant public or environmental hazard, and impacts would be less-than-significant.

Pollution prevention and outreach could increase the amount of ongoing mercury-containing waste generation, which could slightly increase routine hazardous waste disposal volumes throughout the Bay Area and Central Valley. Such efforts would divert mercury-containing wastes from sewers and solid waste landfills, and reduce breakage that could release mercury into the atmosphere. Outreach efforts could also decrease demand for mercury-containing consumer products and ultimately reduce the amount of mercury waste. To the extent that mercury-containing wastes are diverted from inappropriate waste streams, the Basin Plan Amendment would benefit the environment.

c-f) Because many common consumer products, such as fluorescent light bulbs, contain mercury, these wastes could be handled within 0.25 mile of a school, on a contaminated site included on the Cortese List, or near an airport or airstrip. However, mercury waste handling near such sites would not create a significant public or environmental hazard beyond the hazards already inherent in the use of the mercury-containing consumer products.

g) Hazardous waste management activities resulting from the Basin Plan Amendment would not interfere with any emergency response plans or emergency evacuation plans.

h) The Basin Plan Amendment would not affect the potential for wildland fires.

VIII. Hydrology and Water Quality

a) The project would amend the Basin Plan, which articulates applicable water quality standards; therefore, it would not violate standards or waste discharge requirements.

b) The Basin Plan Amendment would not decrease groundwater supplies or interfere with groundwater recharge. Construction of facilities such as retention or detention basins, infiltration basins, or vegetated swales could increase groundwater recharge.

c) Local agencies could propose specific projects involving earthmoving or construction activities to comply with requirements derived from the proposed Basin Plan Amendment. Such projects could affect existing drainage patterns. However, to meet the proposed Basin Plan Amendment targets, they would be designed to reduce overall soil erosion and mercury loads associated with erosion. Nevertheless, temporary earthmoving operations could result in short-term erosion. If necessary to address specific impacts, local agencies would require mitigation measures through their environmental reviews. Lead agencies would ensure that readily available measures are implemented, such as dust suppression (e.g., spraying water), use of erosion control best management practices, and proper construction site management. In addition, construction projects over 1 acre in size would require a general construction National Pollutant Discharge Elimination System permit and implementation of a storm water pollution prevention plan. Therefore, the Basin Plan Amendment would not result in substantial erosion, and its impacts would be less-than-significant.

d) The Basin Plan Amendment could involve some earthmoving operations that could affect existing drainage patterns, but Basin Plan Amendment-related activities would not substantially increase the amount of impervious surfaces in any watershed. Therefore, the Basin Plan Amendment would not increase the rate or amount of runoff, or result in flooding.

e-f) Basin Plan Amendment-related activities would not substantially increase the amount of impervious surfaces in any watershed. Therefore, the Basin Plan Amendment would not increase the rate or amount of runoff, or exceed the capacity of storm water drainage systems. Because the proposed Basin Plan Amendment is intended to reduce mercury-laden runoff, it would not be a source of new polluted runoff, or degrade water quality.

g-i) Basin Plan Amendment-related construction would be small in scale and would not include housing or structures that would pose or be subject to flood hazards.

j) Basin Plan Amendment-related construction would not be subject to substantial risks due to inundation by seiche, tsunami, or mudflow.

IX. Land Use and Planning

a) Basin Plan Amendment-related construction would be too small in scale to divide any established community.

b-c) The Basin Plan Amendment would not conflict with any land use plan, policy, or regulation, and would not conflict with any habitat conservation plan or natural community conservation plan.

X. Mineral Resources

a-b) Basin Plan Amendment-related excavation and construction would be relatively small in scale and would not result in the loss of availability of any known mineral resources.

XI. Noise

a) Earthmoving and construction could temporarily generate noise. Projects that local agencies propose to comply with requirements derived from the Basin Plan Amendment would be consistent with the local agencies' own standards.

b) To comply with requirements derived from the Basin Plan Amendment, local agencies could propose specific projects involving earthmoving or construction, which could result in temporary groundborne vibration or noise. If necessary, local agencies could require mitigation measures through their environmental reviews. Lead agencies would ensure that readily available measures are implemented, such as restricting the hours of operations and ensuring that earthmoving equipment is equipped with mufflers to reduce noise. Therefore, the Basin Plan Amendment would not result in substantial noise, and its impacts would be less-than-significant.

c) The Basin Plan Amendment would not cause any permanent increase in ambient noise levels. Any noise would be short-term in nature.

d) To comply with requirements derived from the Basin Plan Amendment, local agencies could propose specific projects involving earthmoving or construction, which could result in temporary increases in ambient noise levels in excess of noise levels without the Basin Plan Amendment. Noise-generating operations would comply with local noise minimization requirements, including local noise ordinances. If necessary, local agencies could require that noise reduction mitigation measures are implemented, such as restricting the hours of noise-generating operations. Therefore, the Basin Plan Amendment would not result in substantial noise, and its impacts would be less-than-significant.

e-f) The Basin Plan Amendment would not cause any permanent increase in ambient noise levels, including aircraft noise. Therefore, it would not expose people living within an area subject to an airport land use plan or in the vicinity of a private airstrip to excessive noise.

XII. Population and Housing

a-c) The Basin Plan Amendment would not affect the population of the Bay Area, Central Valley, or California. It would not induce growth through such means as constructing new housing or businesses, or by extending roads or infrastructure. The Basin Plan Amendment would also not displace any existing housing or any people that would need replacement housing.

XIII. Public Services

a) The Basin Plan Amendment would not affect populations or involve construction of substantial new government facilities. The Basin Plan Amendment would not affect service ratios, response times, or other performance objectives for any public services, including fire protection, police protection, schools, or parks.

XIV. Recreation

a-b) Because the Basin Plan Amendment would not affect population levels, it would not affect the use of existing parks or recreational facilities. No recreational facilities would need to be constructed or expanded.

XV. Transportation / Traffic

a-b) Because the Basin Plan Amendment would not increase population or provide employment, it would not generate any ongoing motor vehicle trips. Earthmoving and construction would be temporary, and related traffic would be of short-term duration. Therefore, the Basin Plan Amendment would not substantially increase traffic in relation to existing conditions. Levels of service would be unchanged.

c) The Basin Plan Amendment would not affect air traffic.

d) Because the Basin Plan Amendment would not affect any roads or the uses of any roads, it would not result in hazardous design features or incompatible uses.

e) The small-scale construction that could occur as a result of the Basin Plan Amendment would not likely restrict emergency access. Local agencies would confirm that specific proposals would not restrict emergency access through their environmental reviews.

f) Because the Basin Plan Amendment would not increase population or provide employment, it would not affect parking demand or supply.

g) Because the Basin Plan Amendment would not generate ongoing motor vehicle trips, it would not conflict with adopted policies, plans, or programs supporting alternative transportation.

XVI. Utilities and Service Systems

a) The project would amend the Basin Plan, which is the basis for wastewater treatment requirements in the Bay Area; therefore, the Basin Plan Amendment would be consistent with such requirements.

b) Because the Basin Plan Amendment would not affect water demands or supplies, it would not require the construction of new or expanded water or wastewater treatment facilities.

c) To comply with requirements derived from the proposed Basin Plan Amendment, local agencies could propose to construct some new or expanded urban storm water runoff management facilities. However, such construction would not pose any adverse impacts not otherwise discussed in this analysis. Local agencies could require necessary mitigation measures through their environmental reviews, and as described throughout this analysis, all potential impacts can be mitigated to less-than-significant levels. Because lead agencies would ensure that readily available measures are implemented, the impacts of constructing storm water facilities would be less-than-significant.

d-e) Because the Basin Plan Amendment would not increase population or provide employment, it would not require an ongoing water supply. It would also not require ongoing wastewater treatment services.

f-g) Basin Plan Amendment implementation would comply with federal, state, and local solid waste requirements. Although the Basin Plan Amendment could generate some mercury-containing waste, such waste would typically be considered hazardous and would generally not be sent to municipal solid waste landfills. Pollution prevention and outreach activities could divert mercury-containing waste from municipal landfills. For these reasons, the

Basin Plan Amendment would not substantially affect municipal solid waste generation or landfill capacities.

XVII. Mandatory Findings of Significance

a) When taken as a whole, the Basin Plan Amendment would not degrade the quality of the environment. The proposed Basin Plan Amendment is intended to benefit wildlife and rare and endangered species by decreasing mercury concentrations in San Francisco Bay aquatic organisms to levels where wildlife that consume aquatic organisms do not experience any harm.

b) As discussed above, the Basin Plan Amendment could pose some less-than-significant adverse environmental impacts related to earthmoving and construction operations. These impacts would be individually limited, and most would be of short-term duration. As specific implementation proposals are developed and proposed, lead agencies would undertake environmental review and identify specific environmental impacts and appropriate mitigation measures. In cases where potential impacts could be significant, local lead agencies would adopt readily available mitigation measures to ensure that possible impacts would be less-than-significant. Therefore, the incremental effects of the Basin Plan Amendment would be negligible when viewed in the context of the overall environmental changes foreseeable in the Bay Area and Central Valley as California's population grows and urban development occurs. For this reason, the Basin Plan Amendment's cumulative effects would be less-than-significant, and adopting the Basin Plan Amendment would require no mandatory findings of significance.

c) The Basin Plan Amendment would not cause any substantial adverse effects to human beings, either directly or indirectly. The Basin Plan Amendment is intended to benefit human beings (particularly sport and subsistence fishers) by decreasing San Francisco Bay fish tissue mercury concentrations to levels where humans can consume as much fish as they desire without experiencing adverse health effects.

REFERENCES

Bay Area Air Quality Management District (BAAQMD) 1999. *BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans*, December, pp. 13-20.

Larry Walker Associates (LWA) 2002. "CEP Project Hg-IP-1: Technical Assistance in Support of Mercury TMDL Implementation Plan for San Francisco Bay—Wastewater Facilities," prepared for Applied Marine Sciences on behalf of the Clean Estuary Partnership, September 3 (draft).