Guadalupe River Watershed

Mercury
Total Maximum Daily Load (TMDL)
Project Report

Carrie M. Austin, P.E.

California Regional Water Quality Control Board
San Francisco Bay Region

January 2006

SUMMARY

Overview

This report provides the technical background and basis for a future amendment to the Water Quality Control Plan, San Francisco Bay Region, addressing mercury contamination in the Guadalupe River watershed, a 170-square-mile region containing numerous creeks and reservoirs and draining the historic New Almaden mercury mining district into San Francisco Bay (see Figures S-1 and S-2). This report contains analyses by staff of the San Francisco Bay Regional Water Quality Control Board (Water Board) of mercury impairment and sources, recommends mercury load allocations, and proposes a preliminary plan to implement the allocations. If adopted as a future Basin Plan amendment, it would 1) establish a Total Maximum Daily Load (TMDL) for mercury in the Guadalupe River Watershed pursuant to Section 303(d) of the Clean Water Act, and 2) establish an implementation strategy to achieve and support the TMDL.

This summary highlights and explains four central points that have emerged from the technical studies and regulatory work undertaken in drafting this TMDL:

- The largest source of mercury contamination in this watershed is mining waste—which can be reduced by "low-tech" erosion control methods.
- Most of the production of methylmercury, the chemical form of mercury most harmful to fish, and to the humans and wildlife that eat them, occurs in summer in the oxygen-depleted depths in impoundments (engineered structures such as reservoirs that cause water to pond) in the watershed.
- There is a link between the amount of contamination in the fine sediments at the bottom of these impoundments and the amount of methylmercury present in the tissues of the fish living in them. This link provides the basis of the allocation of loads to the New Almaden Mining District proposed in this TMDL.
- Curbing the production of methylmercury in the watershed—primarily by innovative changes in reservoir management currently under development by engineers at the Santa Clara Valley Water District—will help solve the problem of bioaccumulation in fish and protect human health and wildlife.

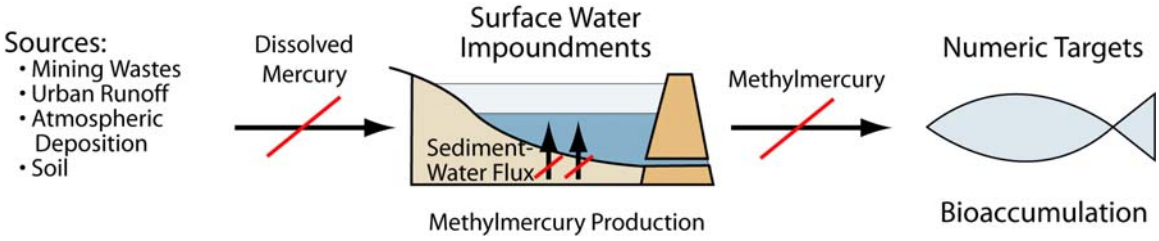

Figure S-1 Solving the Mercury Problem

Citation: prepared by Tetra Tech under contract to Water Board

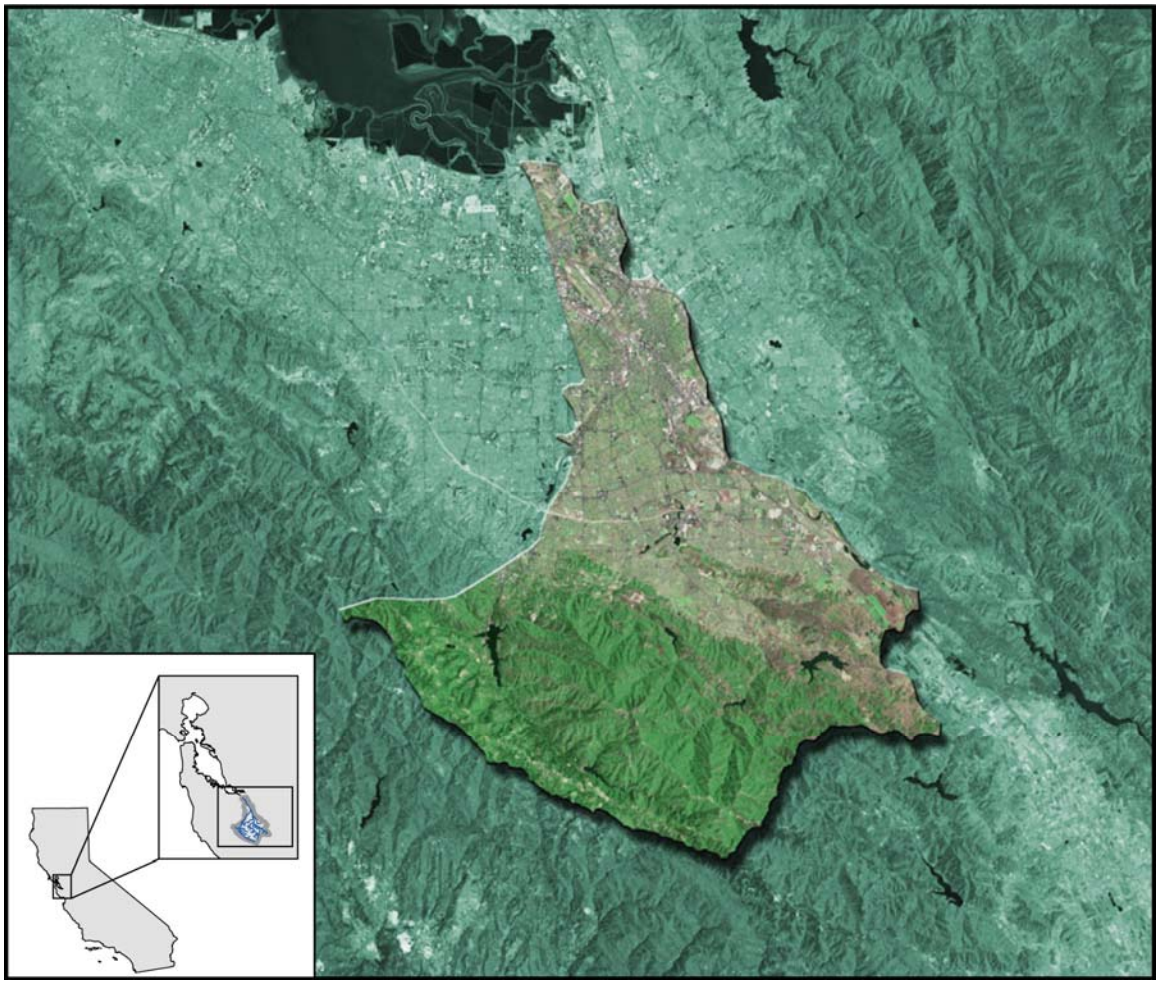

Figure S-2 Location of Guadalupe River Watershed

Citation: Figure ES-1 Final Conceptual Model Report (Tetra Tech 2005c)

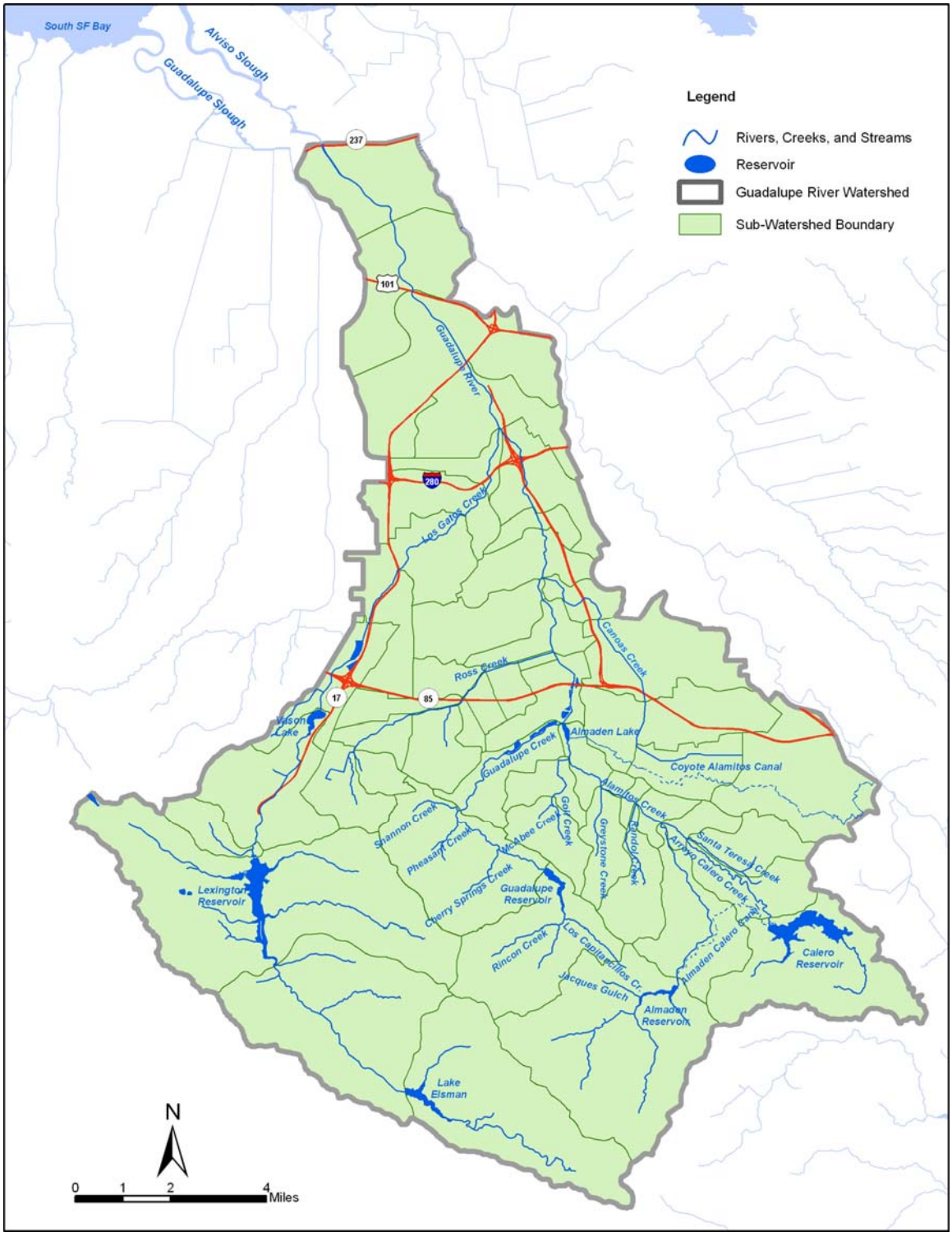

Figure S-3 Guadalupe River Watershed

Citation: Figure 2-2 Final Conceptual Model Report (Tetra Tech 2005c)

Background

Mercury, also known as "quicksilver," is a naturally occurring metal commonly found in such items as thermometers, was also used as an amalgam in dental fillings, industrial processes, and gold mining. California's miners placed mercury in their gold sorting and washing trays because it forms a heavy amalgam with the gold, making it easier to separate the gold from the waste rock. The U.S. Geological Survey estimates that gold mining activities added an estimated 13 million pounds of mercury to the creeks, rivers, and delta draining into San Francisco Bay.

Additions to the Bay's mercury load also came from the south. The South Bay's New Almaden Mining District, located in the hills above San Jose (Figures S-2 and S-3), was the fifth-largest mercury mine in the world. Between 1845 and 1975, New Almaden produced 38.4 million kilograms of mercury, about five percent of all the mercury mined on the planet. Only four other mines worldwide extracted more mercury than New Almaden, top among these being its namesake in Spain.

New Almaden included five large and numerous small mine sites and tunnels, one big furnace yard, and a number of other yards, retorts, and mobile furnaces used to roast and process the ore. Miners placed most of the roasted waste, called calcines, in or near creeks so winter flows would sweep the materials downstream—a mining practice common at the time. As a result of such practices, a substantial amount of waste material and mercury ended up in the district's myriad creeks and the 19-mile-long Guadalupe River, as well as in two reservoirs and several other artificial ponds and lakes.

Production of the specific form of mercury most easily passed up to humans through fish is particularly significant in the watershed's reservoirs and other impoundments. It is in the oxygen-depleted depths of these impoundments that bacteria convert garden-variety (inorganic) mercury into (organic) methylmercury in a process called "methylation." Methylmercury is of much greater concern than other chemical forms of the metal because it concentrates as it moves up the food chain from algae to zooplankton to prey fish and to predator fish (concentrations in fish can be millions of times higher than in the water in which they live). This astonishing intensification of methylmercury as it moves up the food chain is among the largest "biomagnifications" of all known chemical compounds (see Section 6, Figure 6.8).

Studies leading up to this TMDL compared mercury levels in fish from reservoirs and lakes downstream of the New Almaden Mining District to those from elsewhere in the San Francisco Bay Area. Although largemouth bass from many of the Bay region's water bodies have elevated mercury concentrations (in the range of 0.8-1.4 parts per million, ppm), the concentrations are markedly higher in Guadalupe and Almaden reservoirs and Almaden Lake (2.1-5.8 ppm). In reservoirs inhabited by fish considered safe for human consumption, such as nearby Lexington Reservoir and Alameda County's Lake Chabot, levels are closer to 0.6 ppm.

Comparisons were also made between the Guadalupe watershed and another stretch of the Central Coast Range mined for mercury—the Cache Creek watershed about 80 miles upstream of the Bay. Cache Creek is one of the largest contributors of mercury to the Sacramento River system. Comparing 40-cm-long largemouth bass (a size large enough to be consumed by humans) from both watersheds, the Guadalupe Reservoir's bass had

more than 10 times (6.1 ppm) the amount of methylmercury in their bodies as Cache Creek's Clear Lake bass (0.6 ppm). Such data show that the Guadalupe watershed is a larger producer and bioaccumulator of methylmercury than Cache Creek and other Bay Area watersheds, and therefore should be of concern to the State and to Bay Area residents, and particularly to local anglers putting fish from this watershed on their family dinner plates.

Consumption of fish containing mercury is the principal route of human exposure to this metal. 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. In summary, the main human health concern is for the fetus and young children. The young, and reproductive problems, are also of concern for wildlife consuming mercury-laden fish. In and around the Guadalupe River, wildlife sensitive to mercury include ducks, kingfishers, herons, terns, osprey, mink, and otter; among them the least tern is the only listed rare and endangered species.

Contamination

Within the Guadalupe River watershed, those waterways listed as impaired by mercury under section 303(d) of the Clean Water Act are: Almaden Reservoir, Alamitos Creek, Calero Reservoir, Guadalupe Reservoir, Guadalupe Creek, and the Guadalupe River. Other water bodies in and downstream of the historic New Almaden Mining District are also considered impaired due to the presence of mining wastes but have not yet been listed—these water bodies are, however, addressed by this TMDL.

For those waters listed as impaired, states are required to establish TMDLs. This report provides the basis for the TMDL. It discusses background conditions and current mercury loads. It also describes how the TMDL will ensure attainment of water quality objectives and protect beneficial uses of water bodies in the Guadalupe River watershed consistent with state and federal antidegradation policies. Of the many beneficial uses recognized by the State (which range from municipal water supply to recreation and groundwater recharge), only human and wildlife consumption of fish are impaired by mercury. It is for this reason that mercury in fish is the focus of the Guadalupe River Watershed TMDL.

Warnings about not eating the fish from the Guadalupe region's reservoirs and lakes pre-date this TMDL. In 1987, Santa Clara County issued an advisory warning anglers and their families not to consume any fish from water bodies containing mining wastes. During the same year, the state ordered a Superfund cleanup of the New Almaden mines property, which the County had purchased in 1975 to create the 4,000-acre Almaden Quicksilver County Park. The County began cleanup in 1990, and worked to bury, cover, and re-vegetate waste piles, and to control erosion and runoff at five sites that posed the greatest threat to people visiting the park. Although progress was made in the effort to clean up New Almaden's mercury legacy, a great deal more remains to be done both

within and downstream of the New Almaden Mining District. This TMDL offers some next steps.

As a first step, the Water Board, together with stakeholders, commissioned and conducted many technical studies examining the sources and effects of current mercury contamination in the watershed. These studies provide a strong scientific basis for the TMDL (the more technically inclined readers are urged to read both the *Data Collection Report* and the *Final Conceptual Model Report*).

TMDL studies identified four sources of mercury in the Guadalupe River watershed: mining wastes, urban runoff, naturally occurring mercury in the soil, and atmospheric deposition. Whatever the source, once mercury enters the water column, most of it is bound to particles. Studies suggest that not every source contributes to every water body. Lexington Reservoir, for example, does not receive mining wastes or urban runoff and therefore serves as the "reference reservoir" indicative of natural background conditions. Based on measurements of total mercury transported downstream during the 2003-2004 wet season, mining waste is by far the largest source (see Section 4, Figures 4.1 and 4.2, and Tables 4.1 and 4.3).

Mercury loads are not only influenced by their primary source of origin and physical form (solid, suspended, liquid, or airborne), but also by seasonal changes and the resulting changes in water chemistry from thermal stratification (layering) within reservoirs. TMDL studies indicate that the wet season is largely a time of transport of the garden-variety inorganic particulate mercury, whereas the more problematic methylation and bioaccumulation largely occur in the dry season. As explained above, this is because during the dry season, oxygen levels in the water become very low (anoxic) down in the deeper waters of impoundments (a layer known as the "hypolimnion") and in the upper few centimeters of sediment—conditions that enhance methylation.

A 2004 study of Guadalupe and Almaden reservoirs indicates that large amounts of methylmercury were produced in the dry season, and more was transported downstream to Guadalupe and Alamitos creeks and the Guadalupe River than was retained in these reservoirs (see Section 4, Figure 4.8). Although there may be sites for methylation in the stream and river channels, their total contribution to methylmercury production is much smaller than the exports from the reservoirs and Almaden Lake during the dry season. This suggests that reducing methylmercury production in impoundments in the New Almaden Mining District and Almaden Lake will likely also reduce contamination of downstream waters.

Once produced in the depths of the watershed's reservoirs, and/or discharged downstream, the methylmercury may find its way into resident fish. TMDL studies found that mercury concentrations in fish samples collected in 2004 were greatest in Guadalupe and Almaden reservoirs located immediately downstream of the mining district. In contrast, adult largemouth bass in nearby Lexington Reservoir are safe for human consumption (see Section 2, Figure 2.1 for results of fish samples collected from throughout the watershed in 2004).

Proposed Targets

To demonstrate attainment of water quality standards, TMDLs must specify "numeric targets" that reflect measurable conditions. Targets are the amount of mercury (solid, suspended, liquid, or airborne) allowed in a certain amount of water, fish tissue, or sediment. For the Guadalupe River Watershed TMDL, the Water Board proposes three targets for methylmercury in fish to protect human health and wildlife, as shown in Table S-1 below.

Table S-1 Fish Targets (ppm methylmercury, wet weight)

Protection of Wildlife	Protection of Wildlife	Protection of Human Health
TL3 Fish* 50 – 150 mm	TL3 Fish* 150 – 350 mm	Typical Size and Species of Fish Consumed
0.05 ppm	0.10 ppm	0.3 ppm

** TL3 refers to the two sizes of smaller fish considered to be at the third trophic level (TL3) in the aquatic food web.*

The fish targets for wildlife are more stringent than the human health targets and therefore provide additional protection of human health (strong controls on smaller fish at the base of the food chain will reduce accumulation in the larger fish that humans consume). Achieving these targets will protect the Guadalupe River Watershed's wildlife and recreational (fishing) beneficial uses, attain the Basin Plan narrative objective for bioaccumulation, and attain all applicable numeric water quality objectives.

Proposed TMDL and Allocations

The Guadalupe River Watershed proposed TMDL consists of concentration- and mass-based allocations, which are not strictly additive but in combination protect against the adverse effects of mercury that occur through long-term bioaccumulation. The allocations are based on the goals of a) eliminating inputs of mercury caused by human activities, particularly mining and urban runoff, and b) minimizing the transformation of mercury to methylmercury caused by human activities, particularly the construction and operation of impoundments.

The allocations are listed on Table S-2 (see next page).

Table S-2 Allocations

Concentration-based allocations

Impoundment Methylmercury Allocation

- 3.0 ng/l (parts per trillion) seasonal maximum of methylmercury in the hypolimnion of Guadalupe, Almaden, and Calero reservoirs and Almaden Lake

Mining Waste Total Mercury Allocations

- 0.1 ppm mercury (annual median, dry weight) in erodable soil fines transported from the portion of the New Almaden Mining District that drains to Guadalupe, Almaden, and Calero reservoirs and Almaden Lake; and
- 0.2 ppm mercury (annual median, dry weight) in erodable soil fines transported from the remaining 10 percent of the New Almaden Mining District; and from sediments suspended from Guadalupe, Alamitos, and Calero creeks and the Guadalupe River

Definition of impoundments: engineered structures that pond water. They include dams (i.e., reservoirs), former quarries (i.e., lakes and percolation ponds), flood control structures, other engineered features (such as drop structures), and non-native invasive vegetation that ponds water.

Definition of erodable soil: soil that is transported by storm runoff ***to receiving waters***; soil fines (i.e. particulates, suspended sediment) are less than 63 microns in diameter.

Mass-based allocations

Urban Runoff Total Mercury Allocation

- 11 kilograms per year of total mercury to be attained within 10 years, and 7.2 kilograms per year of total mercury to be attained within 20 years

Background Soil Total Mercury Allocation

- 0.5 kilograms per year of total mercury

Atmospheric Deposition Total Mercury Allocation

- 0.1 kilograms per year of total mercury

Outreach and Implementation

This TMDL report represents a major step forward in the state's efforts to address public concerns about mercury contamination in their fish and waterways, and to implement the broader 2004 San Francisco Bay Mercury TMDL. It also offers an opportunity for the public to provide input and feedback on the regulatory direction. As it has at all key milestones in the TMDL process, the Water Board will actively solicit and consider stakeholder comments and concerns on this report.

The Water Board also extends an opportunity to the Guadalupe Mercury Work Group to provide detailed, specific feedback and suggestions on the Implementation, Adaptive Implementation, Risk Management, and Monitoring Plans for this TMDL. Implementation to reduce methylmercury production and bioaccumulation requires innovative measures—currently underway for the first time ever in the world by engineers at the Santa Clara Valley Water District—to adapt reservoir nutrient controls for methylation. Other implementation actions will likely entail erosion control in areas where mining waste is present, removal of contaminated sediments from stream beds, banks, and floodplains, and storm drains. Monitoring to document progress made in reducing mercury methylation, transport, and discharge into the Bay, and uptake by fish and wildlife, will also be critical to the success of cleaning up and managing mercury within the Guadalupe River watershed.

Conclusion

Based on the large body of data collected and technical analysis undertaken in support of this TMDL, the Water Board is now prepared to take regulatory action. The Guadalupe River Watershed Mercury TMDL will be the primary regulatory vehicle for achieving water quality goals in the watershed and will simultaneously reduce the load of mercury to the Bay in accordance with the San Francisco Bay Mercury TMDL.