REGIONAL MERCURY LOAD REDUCTION EVALUATION
CENTRAL VALLEY, CALIFORNIA

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ACRONYMS AND ABREVIATIONS

APCD	Air pollution control district
AQMD	Air quality management district
Basin Plan	Water Quality Control Plan for the Sacramento River and San Joaquin River Basins
Bay	San Francisco Bay
BLM	U.S. Department of the Interior, Bureau of Land Management
BMP	Best management practice
CBDA	California Bay Delta Authority
CEQA	California Environmental Quality Act
cfs	Cubic feet per second
CVP	Central Valley Project
CWA	Clean Water Act
CY	Cubic yard
Delta	Sacramento-San Joaquin Delta
DLM	Designated Level Methodology
DWR	Department of Water Resources
DWQ	Division of Water Quality
EIS/EIR	Environmental impact statement/environmental impact report
EPA	U.S. Environmental Protection Agency, Region 9
Forest Service	U.S. Department of Agriculture Forest Service
GCL	Geosynthetic clay liner
GRA	General response action
HDPE	High density polyethylene
I-5	Interstate-5
kg	Kilogram
kg/day	Kilogram per day
kg/yr	Kilogram per year
m^3	Cubic meters
mg/kg	Milligram per kilogram

ACRONYMS AND ABREVIATIONS (Continued)

mg/L	Milligram per liter
MKg	Million kilogram
MKg/yr	Million kilogram per year
MS4	Municipal separate storm sewer systems
NAWQA	National Water Quality Assessment
NPDES	National Pollutant Discharge Elimination System
OEHHA	Office of Environmental Health Hazard Assessment
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Administration
PG&E	Pacific Gas and Electric
RCRA	Resource Conservation and Recovery Act
Regional Board	California Regional Water Quality Control Board—Central Valley Region
SMCRA	Surface Mining Control and Reclamation Act
SMARA	California Surface Mining and Reclamation Act
State	State of California
STLC	Soluble threshold limit concentration
SWP	California's State Water Project
SWRCB	State Water Resources Control Board
Tetra Tech	Tetra Tech EM, Inc.
TMDL	Total Maximum Daily Load
TSS	Total suspended solids
USGS	United States Geological Survey
WQO	Water quality objective
WY	Water year

EXECUTIVE SUMMARY

Methyl mercury concentrations in fish in the Bay, Delta, and tributary watersheds to the Delta exceed levels that protect humans and wildlife species that consume fish from the Delta. Because of elevated methyl mercury in fish, the beneficial uses of fishing and wildlife habitat are not attained within surface waters of the Delta. For these reasons, the California State Water Resources Control Board (SWRCB) and the Regional Board identified the Delta waterways as impaired due to mercury content; therefore, Delta waterways are identified on the Clean Water Act (CWA) 303(d) list. Once a water body is identified on the 303(d) list, the State is required to develop a control program to address the impairment.

Total Maximum Daily Load (TMDL) estimates for mercury prepared by the Regional Board (2008) have identified a total mercury load of 440 kilogram per year (kg/yr) to the Delta from the Sacramento and San Joaquin River watersheds. The San Francisco Bay Regional Board has prepared a TMDL estimate that requires a reduction of mercury loading from Delta tributaries of 110 kg/yr.

Reducing the methyl mercury content of fish in the region will require local, waterway-specific solutions because each waterway has its own unique set of mercury sources. To reduce fish methyl mercury levels in the Delta subareas, inorganic mercury and methyl mercury from sources within and upstream of the Delta must be reduced. In general, methyl mercury production in open water sediments can be reduced by two methods: (1) control the activities/conditions that enhance the production of methyl mercury in the sediment and (2) reduce the amount of inorganic mercury available in the sediment to be converted to methyl mercury. This project focuses on evaluating potential methods of reducing inorganic mercury loads to the Delta and involves the second method of control.

Inorganic mercury is present in at least three different forms (cinnabar, free liquid, and adsorbed to sediment particles) and in several different types of settings (channel deposits, over bank deposits, channels, concentrated, dispersed, etc.) throughout the Delta watershed. Recognition of the different forms of mercury within the Delta watershed and the differing modes of mercury occurrence within each subwatershed implies that there is no one single control action that is likely to succeed in reducing the loading of total mercury to the Delta and Bay. Instead, a set of control actions implemented at different scales within the watershed will be necessary to achieve the desired mercury load reduction.

The goal of this study is to identify potential mercury load control actions and candidate projects that could be undertaken to reduce the loading of total mercury to the Delta and ultimately the Bay. More than 96 percent of the identified total mercury loading to the Delta comes from major tributary inputs; within-Delta sources are a very small component of overall loading. The Sacramento Basin (Sacramento

River and Yolo Bypass) contributes approximately 86 percent or more of the total mercury load to the Delta. Of the watersheds in the Sacramento Basin, Cache Creek and upper Sacramento River (above Colusa) watersheds contribute the most mercury. Cache Creek, Feather River, American River and Putah Creek watersheds in the Sacramento Basin each have relatively large mercury loadings and high mercury concentrations in suspended sediment.

Potential project areas were identified and retained for detailed evaluation based on total mercury load contribution and the ratio of total mercury to total suspended solids. Project areas with ratios above 0.2 mg/kg and total mercury loads above 10 kg/yr were generally retained. A summary of retained project areas is provided by watershed below.

Project Areas Retained for Detailed Evaluation

Watershed	Total Hg Load (kg/year)	Total Hg/TSS Ratio	Retained Project Areas
Feather River	76 ±2	0.30	• Active channel and floodplain of Feather River near confluence with Yuba River • Active channel and floodplain of Feather River near confluence with Bear River • Active channel and floodplain of Feather River from Nicolaus to Verona • Active channel and floodplain of Feather River near confluence with Sacramento River
Yuba River	42.91	0.30	• South Fork Yuba River at Englebright Reservoir • Active channel and floodplain of Feather River near confluence with Yuba River
Cache Creek	119 ±5	0.46	• Mercury mines in Sulphur Creek watershed • Floodplain containing mine waste on Sulphur Creek and Bear Creeks • Floodplain containing mine waste on Harley Gulch • Active channel and floodplain on Lower Cache Creek from Capay to Yolo • Cache Creek Settling Basin
Yolo Bypass	162±9	0.16	• Yolo Bypass at confluence of Sacramento and Feather Rivers • Yolo Bypass at outlet of Cache Creek Settling Basin • Yolo Bypass at Putah Creek
Sacramento River	183±1	0.21	• Active channel and floodplain of Sacramento River from Verona to Freeport, including confluence with American River

Recognition of the different forms of mercury within the Delta watershed and the differing modes of mercury occurrence within each subwatershed implies that there is no one single control action that is likely to succeed in reducing the load of total mercury to the Delta and the Bay. In order to facilitate the selection of the appropriate load reduction alternative(s) for each project area, the following four steps were followed: 1) identification and description of general response actions (GRA), control actions, and process options; 2) initial screening of control actions and development of load reduction alternatives; 3) detailed analysis of load reduction alternatives; and 4) comparative analysis of load reduction alternatives. GRAs are divided into control actions and process options for land based and stream based project areas. Land based control actions are applicable at the original sources of mercury and to project areas outside of the existing levee system. Stream based control actions are applicable to projects within active channels, active floodplains, and potentially mobile sediment within the confines of the existing levee system. Those control actions potentially capable of meeting TMDL goals for the land based and stream based project areas were combined into load reduction alternatives and are listed below.

Load Reduction Alternatives for Land Based Source Areas

Alternative	Description
1	No action
2	Institute land use restrictions and ensure implementation of existing BMPs to limit practices that may disturb soils with elevated levels of mercury
3	Grade, revegetate, and install run-on and run-off controls/diversions for intact mine waste or soils with elevated levels of mercury
4	Consolidate non-hazardous mine waste and/or basin sediment, revegetate, and install run-on and run-off controls
5	Place an earthen cover over intact or consolidated mine waste and/or basin sediment, revegetate, and install run-on and run-off controls
6	Excavation, process aggregate as a commodity, and on- or off-site disposal of non-hazardous fines
7	Excavation, process aggregate as a commodity, and on-site fixation/stabilization of hazardous fines
8	Excavation, process aggregate as a commodity, and placement of hazardous fines in an on-site mine waste repository or an off-site Class I repository
9	Excavation, process aggregate as a commodity, and off-site retorting of hazardous fines
10	Construct check dams and settling basins to capture solids eroding from mine site
11	Install in channel erosion and flood controls; construct setback levees to isolate mine waste from streams

Load Reduction Alternatives for Stream Based Source Areas

Alternative	Description
1	No action
2	Ensure implementation of existing programs; coordinate flood control operations, water transfers, and irrigation management; and improve levee and control structure maintenance activities
3	Modify existing sediment control structures to improve capture efficiency
4	Stabilize stream banks, flood plains, and settling basin surfaces
5	Construct flood control bypasses and/or settling basins to promote solids settling
6	Construct levees to isolate mercury and mine waste contained in floodplain sediment from adjacent active stream channel
7	Capture sediment using low dams and weirs within small creeks and streams
8	Dredge, process aggregate as a commodity, and dispose of fines (farmland, Delta islands, construction sites)

The retained load reduction alternatives were evaluated for applicability to different types of general project areas utilizing the following criteria: 1) effectiveness, 2) implementability, and 3) range of costs. The eleven land based load reduction alternatives were evaluated for the following types of land based project areas: upstream hydraulic and hard rock mines, upstream mercury mines, active channels, active floodplains, eroding stream banks, and historic floodplains. The eight stream based load reduction alternatives were evaluated for the following types of stream based project areas: active channels, active floodplains, eroding stream banks, historic floodplains, flood control bypasses/basins, Delta islands and marshlands, reservoirs, and upstream hydraulic and hard rock mines. The results of the evaluation were used to focus selection of load reduction alternatives for project areas retained for this study as list above. The results can also be used to identify load reduction alternatives for other project areas identified in the future.

The retained load reduction alternatives were comparatively evaluated for each of the retained project areas for this study. For each project area, the best alternative was selected based on its projected load reduction and comparative cost (cost efficiency). Based on this comparative analysis the following load reduction alternatives were selected for land based project areas:

- Mercury Mines in Sulphur Creek Watershed – Alternative 8
- Floodplain Containing Mine Waste on Sulphur Creek – Alternative 3
- Floodplain Containing Mine Waste on Bear Creek – Alternative 3
- Floodplain Containing Mine Waste on Harley Gulch – Alternative 10

Based on this comparative analysis the following load reduction alternatives were selected for stream based project areas:

- South Fork Yuba River at Englebright Reservoir – Alternative 2
- Active Channel and Floodplain of Yuba River within the Yuba Goldfields – Alternatives 2 and 4
- Active Channel and Floodplain of Feather River near confluence with Yuba River - Alternative 4
- Active Channel and Floodplain of Feather River near confluence with Bear River – Alternative 4
- Active Channel and Floodplain of Feather River from Nicolaus to Verona - Alternative 4
- Active Channel and Floodplain of Sacramento River Upstream of Feather River - Alternative 2
- Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo – Alternative 4
- Cache Creek Settling Basin - Alternative 3
- Yolo Bypass from Fremont Weir to Putah Creek - Alternative 3
- Lower Putah Creek Upstream of Yolo Bypass - Alternative 2
- Active Channel and Floodplain of Sacramento River from Verona to Freeport - Alternative 2

The best load reduction alternatives were ranked based on their projected load reduction and cost efficiencies, and the following projects are recommended for future implementation;

- **Active Channel and Floodplain of Yuba River within the Yuba Goldfields:** Alternatives 2 and 4 - Coordinate Reservoir Release And Improve Control Structure Management (4.8 kg/yr load reduction at $6.85 million) and Stabilize Stream Banks and Floodplain Surfaces (16 kg/yr load reduction at $62.8 million)

- **Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo:** Alternative 4 - Stabilize Stream Banks and Floodplain Surfaces (78 kg/yr load reduction at $42.9 million)

- **Cache Creek Settling Basin:** Alternative 3 - Modify Existing Settling Basin to Improve Capture Efficiency (59 kg/yr load reduction at $44.7 million)

The next steps required to implement the recommend alternatives in the three project areas involve meeting with stakeholders to discuss 1) scope of preliminary studies required for environmental impact evaluation and project design, 2) required environmental documentation, and 3) property acquisition or property easements potentially required to gain access to and begin construction activities at each project area.

1.0 INTRODUCTION

This report describes work necessary to reduce the loading of total mercury in surface water to the San Francisco Bay (or Bay). Control actions that could potentially reduce the load of total mercury from the Central Valley through the Sacramento-San Joaquin Delta (Delta) and into the Bay were identified and evaluated.

Tetra Tech EM Inc. (Tetra Tech) performed this evaluation in support the U.S. Environmental Protection Agency, Region 9 (EPA) and California Regional Water Quality Control Board—Central Valley Region (Regional Board) under Delivery Order No. 0922, Contract No. GS-10F-0268K. This evaluation specifically addresses the total mercury load reduction goal identified in Total Maximum Daily Load (TMDL) estimates prepared by the Regional Board (Regional Board 2008).

1.1 BACKGROUND

Figure 1-1 shows the location of the Delta, and the Sacramento-San Joaquin Delta watershed in relation to the Bay. Methyl mercury concentrations in fish in the Bay, Delta, and tributary watersheds to the Delta exceed levels that protect humans and wildlife species that consume fish from the Delta. Concerns about human consumption of fish from the Bay and Delta have existed for many years. In 1971, the State of California (State) issued an advisory recommending that pregnant women and children not eat striped bass from the Delta and Bay. In 1994, the Office of Environmental Health Hazard Assessment (OEHHA) issued an advisory against consumption of sturgeon and continuing the warning for striped bass. In 2007, OEHHA released a draft of safe consumption guidelines covering the Central and South Delta subareas for other species of fish. Because of elevated methyl mercury in fish, the beneficial uses of fishing and wildlife habitat are not attained within surface waters of the Delta. For these reasons, the California State Water Resources Control Board (SWRCB) and the Regional Board identified the Delta waterways as impaired due to mercury content; therefore, Delta waterways are identified on the Clean Water Act (CWA) 303(d) list. Once a water body is identified on the 303(d) list, the State is required to develop a control program to address the impairment.

Mercury is a regional problem because fish methyl mercury levels throughout the Delta and many of the tributary waterways (including the Yolo Bypass) have levels that are higher than safe for wildlife and human consumption. This is because inorganic mercury and methyl mercury sources are present throughout these areas. Reducing the methyl mercury content of fish in the region will require local, waterway-specific solutions because each waterway has its own unique set of mercury sources. To reduce fish methyl mercury levels in the Delta subareas, inorganic mercury and methyl mercury from sources within and upstream of the Delta must be reduced. Reducing inputs from any particular source (for example, the Cache Creek Settling Basin) may directly benefit immediate downstream conditions but may not result in improvements in other subwatersheds.

In general, methyl mercury production in open water sediments can be reduced by two methods: (1) control the activities/conditions that enhance the production of methyl mercury in the sediment and (2) reduce the amount of inorganic mercury available in the sediment to be converted to methyl mercury. This project focuses on evaluating potential methods of reducing inorganic mercury loads to the Delta and involves the second method of control.

TMDL estimates for mercury prepared by the Regional Board (2008) have identified the total mercury load to the Delta from the Sacramento and San Joaquin River watersheds. In addition, the San Francisco Bay Regional Board has prepared a TMDL estimate that identifies the load of mercury from the Delta to the Bay. The San Francisco Bay TMDL allocates a reduction of mercury loading from Delta tributaries of 110 kilogram per year (kg/yr). Thus, the project location consists of the watersheds for both the Sacramento and San Joaquin Rivers (Delta watershed). Subwatersheds on the west side of the Central Valley contain mercury mines and geologic materials that are naturally enriched in mercury through geologic processes. Subwatersheds on the east side of the Central Valley were the site of historic gold mining activity that involved the use of elemental mercury for gold recovery. Investigations have indicated that as much as 4.5 million kilograms (MKg) of mercury may have been released to Sierra Nevada foothill watersheds as a result of historic gold mining practices (Churchill 1999). Investigations of historical mercury mines and soils containing naturally enriched mercury in the Coast Range have concluded that these sources contribute hundreds of kilograms of mercury to the Delta watersheds each year (Churchill and Clinkenbeard 2002).

Regional scale investigations indicate that reservoirs retain much of the total mercury transported by their tributaries (Brooks and Slotton 1996, United States Geological Survey [USGS] 2003). Thus, the focus of this evaluation is on project areas located downstream from such reservoirs, on subwatersheds that are not controlled by reservoirs, or on projects that are expected to improve the settling capability of such reservoirs.

1.2 PROBLEM DESCRIPTION

Mercury occurs within each subwatershed in a variety of forms. These forms include cinnabar associated with natural geologic materials and mine wastes in Coast Range subwatersheds; elemental mercury associated with former retorts and furnaces at historic mercury mines in the Coast Range subwatersheds;

elemental mercury associated with former mills, dredge tailings and hydraulic gold mines in the Sierra Nevada subwatersheds; and sediment bound mercury within in-channel and overbank deposits throughout the Delta watershed (primarily Sacramento Basin). In addition, accumulations of mine waste related cinnabar are present within stream sediment in Coast Range subwatersheds affected by mercury mining, and occurrences of liquid elemental mercury are documented within channels of Sierra Nevada subwatersheds. Thus, inorganic mercury is present in at least three different forms (cinnabar, free liquid, and adsorbed to sediment particles) and in several different types of settings (channel deposits, over bank deposits, channels, concentrated, dispersed, etc.) throughout the Delta watershed.

As mentioned above, reservoirs trap or retain mercury, though mercury may remobilize from the sediment within reservoirs to the water column within the reservoir and then be released to the watershed below reservoirs (USGS 2003). Thus, the focus of this evaluation is upon those watersheds without reservoirs, areas down stream from reservoirs, or within those watersheds where reservoirs no longer provide sufficient residence time to trap mercury containing particles.

Recognition of the different forms of mercury within the Delta watershed and the differing modes of mercury occurrence within each subwatershed implies that there is no one single control action that is likely to succeed in reducing the loading of total mercury to the Delta and Bay. Instead, a set of control actions implemented at different scales within the watershed will be necessary to achieve the desired mercury load reduction.

1.3 PROJECT GOALS AND OBJECTIVES

The goal of this evaluation is to identify potential mercury load control actions and candidate projects that could be undertaken to reduce the loading of total mercury to the Delta and ultimately the Bay.

1.3.1 Regulatory Framework

Section 303(d) of the federal CWA requires the State to meet the following requirements:

- Identify waters not attaining water quality standards (referred to as the “303(d) list”).
- Set priorities for addressing the identified pollution problems.
- Establish a TMDL for each identified water body and pollutant that will attain water quality standards.

In 1990, the SWRCB Division of Water Quality (DWQ) adopted the 303(d) List that identified Delta waterways as impaired with respect to mercury because of the presence of a fish consumption advisory (SWRCB-DWQ 1990). The 1998 303(d) List identified the TMDL control program for mercury in the Delta as a high priority (SWRCB-DWQ 2003).

A TMDL represents the maximum load (usually expressed as a rate, such as kilogram per day [kg/day] or other appropriate measure) of a pollutant that a water body can receive and still meet water quality objectives (WQO). A TMDL describes the load reductions needed to meet WQOs and allocates those reductions among the sources in the watershed. TMDLs must include the following elements: description of the problem, numerical water quality target, analysis of current loads, and load reductions needed to eliminate impairments.

The State of California Porter-Cologne Water Quality Control Act (Section 13240) requires the Regional Board to develop a water quality control plan for each water body in the Central Valley that does not meet its designated beneficial uses. The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) is the legal document that describes the beneficial uses of all water bodies in these basins, WQOs to protect them, and an implementation program to correct impairments. The Regional Board has prepared a draft TMDL and is currently conducting a public process to adopt amendments to the Basin Plan that prescribe WQOs for the Delta and an implementation plan to achieve the objectives.

1.3.2 Related Total Maximum Daily Loads

Mercury TMDLs have been prepared for San Francisco Bay; Cache Creek (a tributary to the Sacramento River), Clear Lake (a tributary to Cache Creek), Bear Creek (a tributary to Cache Creek), Harley Gulch (a tributary to Cache Creek); and are being prepared for Sulphur Creek (a tributary to Bear Creek), and the Delta.

The SWRCB recently adopted a mercury TMDL for San Francisco Bay (SWRCB 2007). To calculate the Bay mercury TMDL, mercury loads were assessed from various sources to the Bay and the load reductions necessary to meet WQOs for the Bay were identified. For the Bay mercury TMDL, the SWRCB concluded that approximately 1,220 kg/yr of mercury entered the Bay based on 2003 data. Sources for this mercury were bed erosion (460 kg/yr), the Delta watershed (440 kg/yr), the Guadalupe River watershed (92 kg/yr), atmospheric deposition (27 kg/yr), non-urban storm water runoff (25 kg/yr), and wastewater discharges (18 kg/yr). The Bay mercury TMDL allocated an annual mercury load of 330 kg/yr to the Delta (SWRCB 2007, Attachment 2). This load allocation requires a 110 kg/yr reduction of the total mercury load from the Delta.

Staff from the Regional Board has recently prepared a draft TMDL report for the Delta Estuary (Regional Board 2008). Sources of total mercury to the Delta were identified as including tributary inflows from upstream watersheds, atmospheric deposition, urban runoff, and municipal and industrial wastewater. Most of the total mercury loading to the Delta (greater than 96 percent) was identified as coming from tributary inputs. Within-Delta sources for total mercury were concluded to be a very small component of overall loading. The Sacramento Basin (Sacramento River + Yolo Bypass) was concluded to contribute approximately 80 percent or more of the total mercury load migrating through the Delta. The Cache Creek and upper Sacramento River (above Colusa) watersheds were identified as contributing the most mercury to the Sacramento Basin. The staff report identified the Cache Creek, Feather River, American River and Putah Creek watersheds of the Sacramento Basin as having both relatively large mercury loads and high mercury concentrations in suspended sediment, which makes these watersheds likely candidates for load reduction efforts.

The Cache Creek, Bear Creek, and Harley Gulch TMDL calculation for mercury (Regional Board 2004) estimated the average total mercury load exported from the Cache Creek Settling Basin to be approximately 119 kg/yr. Sources of mercury to Cache Creek were identified as including waste rock and tailings from historic mercury mines, erosion of naturally mercury-enriched soils, geothermal springs and atmospheric deposition.

1.3.3 Relationship with Other Programs

The relationship of the Regional Board TMDL to EPA programs under the CWA is described above. The Regional Board TMDL was based in part on information gathered as part of the CBDA (California Bay Delta Authority [formerly CALFED]) Environmental Restoration Program. In addition, dredging programs within the Delta contribute to removal of mercury, and statewide abandoned mine land programs administered by federal agencies have also generated relevant information and resulted in remediation of mercury sources within the Delta watershed. These programs are briefly described below.

1.3.3.1 CBDA Program

The CBDA Bay Delta Program is a collaborative effort of 25 state and federal agencies. CBDA’s mission is to improve California’s water supply and the ecological health of the San Francisco Bay/Sacramento-San Joaquin River Delta. Two of CBDA’s program objectives are ensuring California’s water quality and restoration of ecosystems within the Delta watershed. CBDA’s Ecosystem Restoration Program has supported several regional studies to evaluate the occurrence, fate and transport of mercury throughout the Delta watershed. Particular emphasis has been placed on understanding the cycling of mercury from sources to water and the food chain, and the relationship between mercury cycling and restoration efforts such as wetland restoration and wetland creation. This study resulted in the development of a mercury strategy (California Bay Delta Authority 2005). The mercury strategy was intended to provide a framework for understanding and responding to mercury issues. Following are the three basic management approaches recommended by the strategy:

1. Identify sources of bioavailable mercury and remediate them.
2. Assess the risks to human health and provide advice to the public on how to reduce the risks.
3. Manage the landscape to reduce methyl mercury bioaccumulation and exposure.

The TMDL reports prepared by the Regional Board incorporated information obtained through CBDA investigations. In addition, CBDA goals regarding water quality are consistent with the Regional Board responsibility to reduce mercury loading from the Delta to the Bay. CBDA restoration efforts are increasing the area of wetlands, which are known to be the site for methylation of mercury. Thus, there is a need to coordinate restoration efforts by CBDA with TMDLs prepared by the Regional Board and the resulting mercury control actions.

As part of the CBDA water supply reliability program, a Delta water conveyance is being studied. This water conveyance would divert water from the north Delta and convey it to California's State Water Project (SWP) and the federal Central Valley Project (CVP). Diversion of water from the north Delta would also have the potential to divert suspended sediment and associated mercury. Thus, such a north Delta diversion could result in an increase in the export of total mercury as compared to current exports through diversion at the existing south Delta pumping plants operated by the SWP and CVP.

1.3.3.2 Delta Dredging Programs

Sediment is dredged from waterways in the Delta to maintain the design depth of ship channels and marinas. The Port of Sacramento and Port of Stockton maintain annual deep water channel dredging programs. Dredging occurs at other Delta locations when needed, when funds are available, or when special projects take place. Approximately 533,000 cubic yards (CY) of sediment are removed annually with about 199,000 CY from the Sacramento Deep Water Ship Channel and about 270,000 CY from the Stockton Deep Water Channel (Regional Board 2008). Other minor dredging projects, mostly at marinas, remove an additional 64,000 CY per year. The amount of mercury exported from the Delta through dredging projects could be increased above current levels through partnering and collaboration with the ports and other project proponents.

1.3.3.3 Abandoned Mine Land Programs

Federal and state programs have identified abandoned mines as significant sources for mercury to the Delta watershed. Mercury mines in the Coast Range are sources of cinnabar (mercury sulfide) and elemental mercury to the Delta watershed. Gold mines in the Sierra Nevada foothills are sources of elemental mercury to the Delta watershed (though most of these foothill sources are located upstream of reservoirs). Land management agencies, particularly the U.S. Department of the Interior, Bureau of Land

Management (BLM), and the U.S. Department of Agriculture Forest Service (Forest Service) have undertaken regional studies of mercury in western Sierra Nevada watersheds, the Shasta-Trinity Mountains, and portions of the Coast Range through funding of USGS research projects. In addition, BLM and Forest Service have remediated mercury mines and gold mines that were identified as sources of mercury. As BLM and Forest Service continue to remediate abandoned mines, these sources will contribute less mercury to the Delta watershed, resulting in a gradual reduction of the associated mercury loading to the Delta.

2.0 MERCURY AND TOTAL SUSPENDED SOLIDS LOADS

The following sections provide a general description of the Delta watershed, describe mercury sources and summarize mercury loading. This information is summarized from the Draft Regional Board Staff Report: *Sacramento—San Joaquin Delta Estuary Total Maximum Daily Load for Mercury* (Regional Board 2008).

Identified sources of total mercury in the Delta watershed include point and non-point sources. Point sources include municipal separate storm sewer systems (MS4), and municipal and industrial dischargers. Non-point sources include urban and rural runoff, atmospheric deposition, and erosion of naturally mercury-enriched soils. Historic mercury and gold mining sites, along with associated impacted waterways downstream, may contribute a substantial portion of the mercury in the tributary discharges to the Delta. Total mercury and total suspended solids (TSS) are considered together because much of the total mercury load in the Delta watershed is associated with suspended solids. This is likely due to the association of much of the mercury within the watershed with mine wastes from historic mercury and gold mining.

More than 96 percent of the identified total mercury loading to the Delta comes from tributary inputs; within-Delta sources are a very small component of overall loading. The Sacramento Basin (Sacramento River and Yolo Bypass) contributes approximately 86 percent or more of the total mercury load to the Delta. Of the watersheds in the Sacramento Basin, Cache Creek and upper Sacramento River (above Colusa) watersheds contribute the most mercury. Cache Creek, Feather River, American River and Putah Creek watersheds in the Sacramento Basin each have relatively large mercury loadings and high mercury concentrations in suspended sediment.

2.1 WATERSHED DESCRIPTION

The Delta, along with the Bay, forms the largest estuary on the west coast of North America. The Delta encompasses a maze of over 1,100 miles of river channels surrounding about 738,000 acres (1,153 square miles) of reclaimed islands and tracts in Alameda, Contra Costa, Sacramento, San Joaquin, Solano and Yolo Counties (Figure 2-1). Many of the Delta waterways follow natural courses while others have been constructed to provide deep-water navigation channels, to improve water circulation, or to obtain material for levee construction (California Department of Water Resources [DWR] 1995). The legal boundary of the Delta is defined in California Water Code Section 12220. The Delta and its source watersheds comprise nearly 40 percent of the landmass of the State (Regional Board 2008). The Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras Rivers all flow into the Delta, carrying approximately 47 percent of the State's total runoff (DWR 2005). During the period 1984 through 2003, the average annual water input to the Delta was 23.5 million acre feet. Approximately 18.8 million acre feet of water was from the Sacramento River watershed (including the Yolo Bypass); and approximately 3 million acre feet was from the San Joaquin River watershed. The remaining 1.7 million acre feet were from the Mokelumne, Cosumnes, and Calaveras Rivers and small creeks. During a typical water year (WY), the Delta receives runoff only from the Sacramento and San Joaquin Basins in the Central Valley (Figure 1-1). During infrequent flood events, the Tulare Basin in the southern Central Valley is connected to the San Joaquin River system and contributes water to the Delta.

The major Delta tributary from the Sacramento Valley is the Sacramento River. Flow in the Sacramento River and its major tributaries (American, Feather, and Yuba Rivers) is controlled by releases from federal and state reservoirs including Shasta, Oroville, and Folsom lakes. Flooding is also prevented by operation of a system of weirs at five locations along the river (DWR 2003). The weirs are designed to prevent flows that exceed the downstream channel capacity by diverting excess flow to bypasses and/or basins. At a river stage of 27.5 feet as measured at the I Street bridge in Sacramento, the Sacramento weir is opened to divert flow from the Sacramento River through the Sacramento Bypass and into the Yolo Bypass to protect Sacramento from flooding. The Yolo Bypass flows into the Delta at Prospect Slough.

The major Delta tributary from the San Joaquin Valley is the San Joaquin River. Flow in the San Joaquin River and its major tributaries (Merced, Stanislaus, and Tuolumne Rivers) is controlled by releases from federal and state reservoirs, including New Don Pedro Reservoir, Lake McClure, and Millerton Lake. The San Joaquin River is often dry in the upper reaches within the San Joaquin Valley due to agricultural and municipal diversions.

Flow in the Sacramento and San Joaquin Rivers and their tributaries generally follows a seasonal cycle with low flows occurring during the dry season (July through October), and increasing flows during the rainy season (November through March) associated with significant rainfall events. High flows due to rain on snow melt events also occur in the spring and early summer months (April through June). Figure 2-2 shows a hydrograph for the Sacramento River at the Fremont Weir gauging station during WY2005-2006 that illustrates this seasonal pattern.

2.2 MERCURY SOURCES

This section describes potential sources for mercury loading, including municipal and industrial sources, urban runoff, abandoned mines, and soils naturally enriched with mercury. Atmospheric deposition (dry and wet) is not described because the data are sparse and the estimated loads are thought to be very small (approximately 1 percent or less of the total annual mercury load) (Regional Board 2008).

2.2.1 Municipal and Industrial Sources

Municipal and industrial sources include those facilities with National Pollutant Discharge Elimination System (NPDES) permits located in the Delta. There are 18 municipal and industrial dischargers with NPDES permits within the Delta. These dischargers include 13 waste water treatment plants, two power plants, two heating/cooling related discharges, and one dewatering discharge. The total mercury load contributed by these dischargers is approximately 2.4 kg/yr or approximately 1 percent of the annual total mercury load to the Delta (Regional Board 2008).

Permitted facilities located outside of the Delta were not evaluated; however, the associated loads are incorporated into the existing load estimates through their inclusion in the waters sampled to assess mercury loads. Further, the total mercury loading is believed to be small compared to other sources based on similarity to permitted facilities within the Delta and permit requirements that minimize discharge of mercury.

2.2.2 Urban Runoff

Urban runoff was evaluated by considering the total mercury contained in discharges from permitted MS4 systems in the Delta. There are 12 MS4 permits that cover nearly 60,000 acres of urbanized land within the Delta. The average annual total mercury load from urban runoff is approximately 2.6 kg/yr or about 1 percent of the total mercury load to the Delta. To evaluate the potential contributions of urban areas outside of the Delta, the total load from the Sacramento and Stockton MS4 areas (including areas located outside of the Delta) was calculated. An urban runoff load of approximately 7.8 kg/yr was estimated representing approximately 3.5 percent of the annual total mercury load to the delta.

The Sacramento and Stockton urban areas are the two largest urban areas in the Delta watershed. It is likely that other urban areas in the watershed also contribute mercury; however, these loads are already accounted for indirectly through their inclusion in the waters sampled to assess mercury loads. In addition, lower total mercury loads from urban runoff would be expected in urban areas that are smaller than Sacramento and Stockton.

2.2.3 Mercury Associated with Historical Mining

Mercury associated with historical mining occurs at and downstream from both inactive mercury mines in the Coast Range and inactive gold mines in the Sierra Nevada foothills. Mercury mining occurred at numerous locations in the Coast Range from the 1850s through the 1970s. Approximately 90 percent of the mercury (roughly 104 MKg) used in the United States between 1846 and 1980 was mined in the Coast Ranges of California (Churchill 2000). Much of the mining and extraction occurred prior to 1890 when mercury processing was crude and inefficient. While the ore was processed at the mine sites, an estimated 35 MKg of mercury was released to the environment. Mercury mining activities generated millions of cubic yards of mine wastes (including overburden, waste rock, and tailings) and sediment. These mine wastes and sediment contain mercury in the form of mercury sulfide (cinnabar or metacinnabar), elemental mercury and less abundant mercury chloride compounds. The mercury in the mine wastes is most often bound to soil particles. The mercury containing particles are subject to chemical weathering and mechanical erosion that can result in the transport of mercury to surface water.

Inactive mercury mines are present in the Cache Creek and Putah Creek watersheds. The mercury mines in the Putah Creek watershed are located upstream from Lake Berryessa. The mercury mines in the Cache Creek watershed are located downstream from any lakes or reservoirs. Erosion and transport of mercury containing particles may have resulted in accumulation of mercury within in-stream sediment of Cache Creek and its tributaries (Regional Board 2004). Pre-reservoir sediment along Putah Creek, and sediment along Cache Creek that contain elevated mercury can be remobilized during peak flow events and contribute to mercury loads entering the Delta.

Gold mining in the western foothills of the Sierra Nevada Mountains began in the 1840s and continues on a smaller scale today. Recovery of gold relied on the use of liquid elemental mercury through the 1960s. Mercury was used in hydraulic mines to recover the fine gold particles that would have otherwise been lost. Mercury was also used at stamp mills to recover fine gold, and mercury was used in the dredges that separated gold from gravel deposits along many streams draining the Sierra Nevada foothills. Estimates are that 3 to 4.5 MKg of mercury was lost to the foothill watersheds during historic gold mining activity (Churchill 1999). In addition, accumulations of elemental mercury have been documented in foothill streams. Thus, erosion of mine waste and/or sediment containing this mercury can result in its migration through the Delta watershed.

Hydraulic mining in the 1880s resulted in deposition of tens of feet of sediment and debris on the Sacramento Valley floor along the Yuba and Feather Rivers in particular, and increased sedimentation in the Bay. These sediment deposits are located downstream of reservoirs on the tributary rivers, and may contain elevated mercury that could be mobilized by erosion during flood events or by routine flows as streams meander within their floodplains.

While estimates of mercury loading for each of the abandoned mine related mercury sources are not available, the available data support a conclusion that abandoned mines and downstream sediment affected by mining contribute a significant mercury load to the Delta watershed. This conclusion is supported by comparison of bed sediment total mercury concentrations with the total mercury to TSS ratio (see Section 2.3 below) for different locations within the Sacramento River watershed. Figure 2-3 is a plot of bed sediment mercury concentrations compared against the total mercury to TSS ratio for several locations within the Delta watershed. The plot was constructed using bed sediment data from the USGS National Water Quality Assessment (NAWQA) for the Sacramento and San Joaquin Rivers, available at http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:1542281691220337 and accessed on February 25, 2008. The total mercury concentrations in the sediment are based on the less than 0.63-micrometer (silt and finer) fraction of sediment at each location sampled. Sediment from the tributaries known to be affected by mercury mining (Cache Creek) and gold mining (Yuba, Bear, Feather, and American Rivers) have the highest total mercury to TSS ratios.

2.2.4 Soils Naturally Enriched with Mercury

The ore deposits developed as mercury mines in the Coast Ranges resulted from natural geologic processes that concentrated mercury. These natural geologic processes have also enriched soil, rock and sediment with mercury that is released to the watershed through erosion and transport. Hydrothermal fluids discharge at springs and generate mercury enriched precipitates along Sulfur Creek (a tributary to Bear Creek and ultimately Cache Creek). These precipitates contain up to 250 milligrams per kilogram (mg/kg) mercury and are transported to the Cache Creek watershed during peak flow events. Naturally enriched rock and soil developed from weathering of the enriched rock can be eroded and transported into the Cache Creek and Putah watersheds. Churchill and Clinkenbeard (2002) estimated that up to 45 percent of the total mercury load from Cache Creek may be derived from such naturally enriched soil and rock.

2.3 MERCURY AND TOTAL SUSPENDED SOLIDS LOADS

Table 2-1 (reproduced from the Draft Staff Regional Board Report: *Sacramento—San Joaquin Delta Estuary Total Maximum Daily Load for Mercury*) lists the estimated total mercury loads associated with each of the Delta tributaries for WY2000-2003 and WY1984-2003 (Regional Board 2008). Total mercury loads were calculated for WY2000-2003, a relatively dry period; and WY1984-2003 to determine mass balances for a more typical hydrologic period. This 20-year period includes a mix of wet and dry years that is statistically similar to what has occurred in the Sacramento Basin since accurate water records began to be collected (about 100 years). Assessment of loading during a typical distribution of wet and dry WYs is necessary because sediment and mercury transport is a function of water velocity and volume.

The loads presented in Table 2-1 were estimated by evaluating the relationship between flow and total mercury concentration, and flow and TSS concentration (Regional Board 2008). For water bodies with a significant relationship as determined by linear regression, the total mercury and TSS loads were calculated based on the mathematical relationship determined by the regression. For water bodies that did not exhibit a significant relationship, the average mercury and TSS concentrations were multiplied by the annual flow volume for the water body to estimate the annual load.

The information about annual total mercury and TSS loads presented in Table 2-1 shows that the Sacramento River and its tributaries are the most significant source for mercury to the Delta. For this reason, a more detailed discussion of the Sacramento River watershed is provided below.

2.3.1 Sacramento Basin Tributaries

The Sacramento River watershed is the major source of water, mercury, and sediment to the Delta. The Sacramento Basin alone (Sacramento River at Freeport and the Yolo Bypass) contributed more than 80 percent of all mercury and TSS loads entering the Delta. Export of total mercury from the Sacramento Basin is strongly related to the amount of precipitation received during the WY. The lowest mercury export rate (94.8 kg/yr) occurred during the driest study period (Foe 2003), while the highest (801 kg/yr) was during a very wet period (Foe and Croyle 1998). Most annual loading rate estimates fall between 200 and 500 kilograms (kg) of mercury per year. The WY1984-2003 average annual mercury loading rate of 345 kg/yr is midway between these values.

Sediment transport is also strongly a function of WY type. The smallest export rate (568 Mkg/yr) occurred during the driest period studied (Foe 2002), while the highest rate (3,900 Mkg/yr) happened during a wet year (Foe and Croyle 1998). The WY1984-2003 average annual sediment export rate of 2,056 Mkg/yr is among the higher water years reported. The influence of the Yolo Bypass, similar to its influence on mercury transport, is strongly a function of flow. The Yolo Bypass only exports a small amount of sediment during dry periods, but TSS loads increase and equal or exceed those of the Sacramento River during wet periods.

Table 2-2 compares the estimated total mercury load with the mercury to TSS ratio for each tributary to the Sacramento Basin. The information in Table 2-2 shows that the largest mass of mercury is from the Sacramento River above Colusa. The Cache Creek Settling Basin and Feather River contribute the second and third largest mercury mass to the Sacramento Basin, respectively. However, consideration of the total mercury to TSS ratio for Sacramento River tributaries shows that Natomas East Main Drain, Putah Creek (tributary to the Yolo Bypass), Cache Creek Settling Basin, and the Feather River have the highest ratios while the upper Sacramento River above Colusa (0.10 mg/kg) has one of the lowest ratios.

An elevated total mercury to suspended solid ratio is considered to be significant because more mercury is associated with particulates as this ratio increases. Higher ratios are associated with mercury enriched source areas and load reduction can be more efficiently carried out by capturing solids than by attempting to treat aqueous mercury. In addition, the San Francisco Bay TMDL identifies a mercury in sediment objective of 0.2 mg/kg (the method used to estimate the total mercury to TSS ratio yields units of mg/kg). A total mercury to suspended solids ratio above 0.2 mg/kg indicates that suspended solids also exceed the TMDL sediment objective. The regression equation derived from Figure 2-3 suggests that sediment with a total mercury concentration above 0.16 mg/kg in the less than 63-micrometer fraction is related to total mercury to TSS ratios above 0.2 mg/kg. Alternatively, the regression equation suggests that sediment with a total mercury concentration of 0.2 mg/kg in the less than 0.63-micrometer fraction is associated with a total mercury to TSS ratio of approximately 0.24 mg/kg.

This information supports a conclusion that mercury sources located in the Putah Creek, Cache Creek, Feather River watershed (including the Yuba River and Bear River watersheds) continue to contribute significant mercury loads to the Delta. Cache Creek contributes approximately 28 percent of the total annual Sacramento Basin mercury load. The Feather River watershed contributes approximately 18 percent of the total annual Sacramento Basin mercury load. This information also shows that the upper Sacramento River transports a large mass of mercury that is dispersed within a large mass of sediment. The upper Sacramento River watershed contributes more than 35 percent of the total annual Sacramento Basin mercury load.

2.3.2 San Joaquin River

The San Joaquin River contributes approximately 7.6 percent of the total mercury load to the Delta. The total mercury to TSS ratio for the San Joaquin River is 0.13, well below the San Francisco Bay TMDL sediment objective. The estimated total mercury load of 30 kg/yr from the San Joaquin River appears to be dispersed within the suspended sediment and does not appear to reflect a significant effect from ongoing mercury sources.

2.3.3 Direct Delta Tributaries

Direct Delta tributaries are a set of rivers and creeks that discharge directly to the Delta and are not included in the Sacramento Basin or San Joaquin River watersheds. The direct Delta tributaries include the Calaveras River, Mokelumne River (and its major tributary the Cosumnes River), Ulatis Creek, French Camp Slough, Morrison Creek, Marsh Creek, and Bear and Mosher Creeks. The combined mercury load from these tributaries is approximately 3.5 percent of the total mercury load to the Delta. The estimated total mercury to TSS ratio for these Delta tributaries ranges from 0.11 mg/kg for Ulatis Creek to approximately 0.69 mg/kg at French Camp Slough. The relatively elevated total mercury to TSS ratio for these watersheds may indicate the presence of ongoing mercury sources (for example, the Mount Diablo Mercury Mine is located in the Marsh Creek watershed); however, the load contributed by each of these watersheds is very small compared to the load reduction necessary to meet the TMDL requirement.

3.0 IDENTIFICATION AND SCREENING OF POTENTIAL PROJECT AREAS FOR MERCURY LOAD REDUCTION

This section of the report identifies areas containing elevated levels of mercury within the Delta watershed, identifies potential mercury load reduction project areas within the potentially impacted areas, and screens project areas to be retained for selection and detailed evaluation of mercury load reduction projects in Section 6 of this report.

3.1 IDENTIFICATION OF POTENTIALLY IMPACTED AREAS

This section focuses on identification of potentially impacted areas within Delta tributaries and the Sacramento River Basin that could be contributing mercury to the Delta.

3.1.1 Delta Tributaries

Based on the total mercury loads presented in Table 3-1, the Sacramento Basin (Sacramento River and Yolo Bypass [Prospect Slough, located at the end of the Yolo Bypass] combined) contributes approximately 345 kg/yr (86 percent) of the total mercury load to the Delta, while direct tributaries to the Delta only contribute an additional 44 kg/yr (14 percent). Table 3-1 also summarizes the total mercury to TSS ratio for Delta tributaries. Ratios above 0.2 mg/kg are identified for the Sacramento River, Calaveras River, Mokelumne-Cosumnes Rivers, French Camp Slough, and Marsh Creek. However, the mercury load from the Calaveras River, Mokelumne-Cosumnes Rivers, French Camp Slough, and Marsh Creek is very small. Therefore, mercury load reduction projects in these tributaries would not contribute to significant progress in meeting the San Francisco Bay TMDL total mercury load goal for the Delta.

There may be other reasons to attempt to reduce the mercury loads (for example, methyl mercury load reduction) from these Delta tributaries. However, the focus of this report is on reduction of total mercury loading to the Delta to comply with the San Francisco Bay TMDL total mercury load reduction goals. Based on the total mercury loads and total mercury to TSS ratios summarized in Table 3-1, the Sacramento Basin should be the focus of efforts to reduce the load of total mercury to the Delta by 110 kg/yr.

3.1.2 Sacramento River Basin

Based on the total mercury and TSS loads to the Sacramento Basin presented in Table 3-2, the three largest total mercury load contributions to the Sacramento Basin are from the Sacramento River above Colusa (152 kg/yr), Cache Creek Settling Basin (119 kg/yr) and Feather River (76 kg/yr). In addition, the

Colusa Basin Drain, Sutter Bypass, American River and Putah Creek each contribute total mercury loads above 10 kg/yr. The Feather River, Cache Creek Settling Basin, Natomas East Main Drain, American River, and Putah Creek have total mercury to TSS ratios above the 0.2 mg/kg screening objective. The total mercury to TSS ratio for the Sacramento River above Colusa is 0.1 mg/kg.

The large total mercury load from the Sacramento River above Colusa is likely caused by the large volume of sediment transported by the river and is not thought to be the result of significant mercury sources. This interpretation is supported by the observation that the 0.10 mg/kg total mercury to TSS ratio for this reach of the river is very similar to the mercury concentrations measured for agricultural soils in the Sacramento Valley and documented in the Kearney Report (Bradford and others 1996), and average mercury concentrations for county soils reported in the National Geochemical Database (USGS 2004). Eight of the thirteen Central Valley agricultural soil samples from the Sacramento Basin watershed contained less than the 0.2 mg/kg total mercury detection limit reported for the Kearney Special Report (Bradford and others 1996). The average of the total mercury concentrations measured in agricultural soil samples from the Sacramento Basin was 0.26 mg/kg (including eight samples reported as 0.10 mg/kg because they were below the detection limit) (Bradford and others 1996). The National Geochemical Database (USGS 2004) provides mercury concentration data by county. The average mercury concentration reported in soil by county ranges from 0.038 mg/kg (Sutter County) to 0.68 mg/kg (Colusa County). Only two of the 10 counties queried as part of this study (Colusa at 0.68 mg/kg and Yolo at 0.33 mg/kg) yielded an average mercury concentration in soil above 0.10 mg/kg. Average mercury concentrations for other counties ranged from 0.038 mg/kg to 0.09 mg/kg. The county data sets queried from the National Geochemical Database for this study included Butte, Colusa, Glenn, Sacramento, Shasta, Solano, Sutter, Tehama, Yuba, and Yolo.

Based on the estimated total mercury loads and total mercury to TSS ratios above 0.2 mg/kg, the Feather/Yuba Rivers, Cache Creek, American River, Natomas East Main Drain, and Putah Creek watersheds (see Figures 3-1 and 3-2) should be considered as potentially impacted areas and evaluated for potential mercury load reduction projects. Cache Creek Settling Basin and Putah Creek discharge into the Yolo Bypass and contribute to mercury loading as measured at Prospect Slough. The Feather River enters the Sacramento River near Verona. Evaluation of the total mercury to TSS ratios in tributaries to the Feather River indicates that the Yuba River (0.30 mg/kg at Marysville) and Bear River (0.44 mg/kg at Wheatland) likely contribute to the total mercury and TSS loads in the Feather River. The Sacramento River, Sutter Bypass, and Feather River also discharge, in part, to the Yolo Bypass during flood events when the majority of the sediment in the system is mobile. Therefore, the Yolo Bypass should also be considered as a potentially impacted area that can operate as a source or sink for total mercury load to the Delta, depending on flow conditions.

The Sacramento River between Verona and Freeport should also be considered as a potentially impacted area contributing total mercury load to the Delta. This is because the total mercury to TSS ratio at Freeport is 0.21 mg/kg, a 200 percent increase over the estimated ratio for the Sacramento River above Colusa. This elevated ratio is interpreted as being due to mercury inputs from a combination of the Feather River, Natomas East Main Drain, and American River. In addition to these potential sources, the operation of the Sacramento Weir during peak flow events encourages settling of sediment containing elevated concentrations of mercury from these three watersheds, particularly the American River watershed. During flood events, water from the American River flows upstream to the Sacramento Weir, contributing to sediment deposits between the American River and Sacramento Weir (DWR 2003).

3.2 IDENTIFICATION AND SELECTION OF PROJECT AREAS TO BE RETAINED FOR DETAILED EVALUATION

This section focuses on identification and selection of project areas within the Sacramento River Basin where mercury load reduction projects could be implemented to facilitate attainment of the San Francisco Bay TMDL total mercury load reduction goals for the Delta. Selection and detailed evaluation of mercury load reduction projects in retained project areas are addressed in Section 6 of this report.

Table 3-3 identifies the potential mercury sources and project areas within the potentially impacted areas identified in Section 3.1 above. The sections below describe potential mercury sources, potential project areas, and the rationale for retaining project areas presented in Table 3-4 and shown on Figure 3-3 and Figure 3-4.

3.2.1 Feather River Watershed

The total mercury load contributed by the Feather River and it tributaries (76 kg/yr) exceeds one-half of the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The Feather River watershed means the reach of the Feather River downstream from Lake Oroville to the confluence with the Sacramento River near Verona. Potential mercury sources within this potentially impacted watershed include point sources such as abandoned gold mines above Lake Oroville, and non-point sources such as floodplain sediment affected by historic mining (Yuba Goldfields), within channel mining-affected sediment, and the Yuba and Bear Rivers, which are considered separately. The Feather River channel has been modified by the influx of sediment resulting from historic mining activity, for example, as much as 15 feet of sediment directly attributed to the results of mining activity may have accumulated in the Feather River channel at Marysville (USGS 1961). Total mercury loading from the Feather River (estimated at 71 kg/yr) exceeds the total loads contributed by the Yuba and Bear Rivers (estimated at 52 kg/yr). The Feather River at Gridley (above the confluence with the Yuba River) contributes approximately 6 kg/yr of total mercury. Thus, approximately 13 kg/yr of total mercury are not accounted for and may be attributed to in channel sediment and erosion of floodplain sediment containing mercury from historic gold mining activity.

Because contributions from abandoned gold mines above Lake Oroville are captured behind its dam and the reach of the river from the dam to Marysville contributes less than 6 kg/yr mercury load to the river, these areas will not be retained for evaluation of potential mercury load reduction projects. The reaches of the Feather River above and below its confluence with the Yuba and Bear Rivers (additive, ongoing sources) and between Nicolaus and Verona will be retained due to the large quantity of in channel sediment and sediment contained within the active floodplain.

3.2.2 Yuba River Watershed

The total mercury load contributed by the Feather River and it tributaries (76 kg/yr), including the Yuba River, exceeds one-half of the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The total mercury load from the Yuba River is estimated at 43 kg/yr. The Yuba River watershed means the reach of the Yuba River downstream from Englebright Lake to the confluence with the Feather River. Potential mercury sources within this potentially impacted watershed include point sources such as abandoned gold mines above Englebright Lake and Lake Wildwood (on Deer Creek a Yuba River tributary), non-point sources such as floodplain sediment (Yuba Goldfields) affected by historic mining, and within channel mining-affected sediment.

Because contributions from abandoned gold mines above Englebright Lake and Lake Wildwood are captured behind their dams, the upstream areas will not be retained for evaluation of potential mercury load reduction projects. Lake Wildwood will not be retained due to the low loading potential to the Yuba River. Englebright Lake will be retained as a project area due to the large quantity of sediment deposited from historic upstream hydraulic mining. The reach of the Yuba River between Englebright Lake and its confluence with the Feather River, including the Yuba Goldfields, will be retained as project areas, due to the large quantity of in channel sediment and hydraulic mine-related sediment contained within and adjacent to the active floodplain.

3.2.3 Bear River Watershed

The total mercury load contributed by the Feather River and it tributaries (76 kg/yr), including the Yuba River, exceeds one-half of the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The total mercury load from the Bear River is estimated at 9 kg/yr. The Bear River watershed means the reach of the Bear River downstream from Camp Far West Reservoir to the confluence with the Feather River. Potential mercury sources within this potentially impacted watershed include point sources such as abandoned gold mines above Camp Far West Reservoir, non-point sources such as floodplain sediment affected by historic mining, and within channel mining-affected sediment.

Because contributions from abandoned gold mines above Camp Far West Reservoir are captured behind the dam, the upstream areas will not be retained for evaluation of potential mercury load reduction projects. Camp Far West Reservoir will not be retained as a project area as only a low to moderate quantity of sediment has been deposited from historic upstream hydraulic mining. The reach of the Bear River between Camp Far West Reservoir and just above its confluence with the Feather River will not be retained due to scouring of sediment from the channel. However, the area of the Bear River just above its confluence with the Feather River will be retained as project area, due to the large active floodplain at the river mouth.

3.2.4 Cache Creek Watershed

The average annual total mercury load from Cache Creek (119 kg/yr) is above the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The Cache Creek watershed means the entire Cache Creek watershed including the Cache Creek Settling Basin at the bottom of the watershed. Potential mercury sources within this potentially impacted watershed include non-point sources such as floodplain and channel sediments that contain material originating from historic mining (Harley Gulch, Sulphur Creek, and Bear Creek), and erosion of naturally mercury enriched soils; and point sources such as inactive mercury mines and hydrothermal springs (primarily in the Sulphur Creek Mining District). Total mercury load for water discharging from the Cache Creek Settling Basin to the Yolo Bypass is estimated at 119 kg/yr. This load enters the Cache Creek Settling Basin approximately twice before sediment deposition. Available information shows that most of this total mercury load (approximately 350 kg/yr from 1996 to 2000,) originates from Harley Gulch and Bear Creek, tributaries to upper Cache Creek, as well as in channel and active floodplain sediment along lower Cache Creek from Capay to Yolo (Regional Board 2004).

Retained project areas include Harley Gulch, Sulphur Creek, and Bear Creek active channels and floodplains containing mine waste, Lower Cache Creek active channel and floodplains containing mine waste from Capay to Yolo, and the Cache Creek Settling Basin. Only those mercury mine sites within the Sulphur Creek Mining District that 1) are located on or immediately adjacent to an active channel or floodplain, and 2) could contribute a significant mercury load have been retained as a project area. A removal action was conducted at the Abbott and Turkey Run Mines in the summer of 2007 that moved tailings back from Harley Gulch, reduced over steep slopes, cover tailings within an earthen cap, routed storm water and spring discharge around covered mine waste, and removed mill structure and wastes from the site. Mercury mine sites retained as a project area include Elgin, West End, and Manzanita Mines located in the Sulphur Creek subwatershed.

3.2.5 Putah Creek Watershed

The average annual total mercury load for the Yolo Bypass (162 kg/yr) (including the Cache and Putah Creek loads) is above the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The total mercury load from Putah Creek is estimated at 13 kg/yr. The Putah Creek watershed means the reach from Lake Berryessa to the Yolo Bypass. Potential mercury sources in the potentially impacted watershed include non-point sources such as floodplain and channel sediments affected by historic mining, and erosion of naturally mercury enriched soils; and point sources such as inactive mercury mines and hydrothermal springs above Lake Berryessa.

Because contributions from historic mining and erosion of naturally mercury enriched soils above Lake Berryessa are captured behind the dam and the total mercury load for Putah Creek is relatively low, the upper reach of Putah Creek will not be retained for evaluation of potential mercury load reduction projects. However, the area of the Putah Creek just above its confluence with the Yolo Bypass will be retained as project area, due to in channel sediment deposition.

3.2.6 Yolo Bypass

The average annual total mercury load for the Yolo Bypass (including the Cache and Putah Creek loads) is above the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. As measured at Prospect Slough, approximately 162 kg/yr of total mercury is discharged from the Yolo Bypass to the Delta. The Yolo Bypass receives water during flood events from the Sacramento and Feather Rivers and Sutter Bypass at the Fremont Weir; the Sacramento Weir via the Sacramento Bypass; Cache Creek via the Cache Creek Settling Basin Weir; and Putah Creek. Each of these water bodies contribute total mercury on suspended sediment to the Yolo Bypass. In addition to these tributary mercury loads, the Yolo Bypass mercury balance indicates the presence of an unknown mercury source within the Yolo Bypass (approximately 24 kg/yr), likely related to entrainment of deposited sediment during flood events.

Retained project areas include the Yolo Bypass from Freemont Weir downstream to Cache Creek Settling Basin Weir, Yolo Bypass from Cache Creek Settling Basin Weir downstream to Lisbon Weir, and Yolo Bypass at the confluence with Putah Creek. The lower portion of the Yolo Bypass was not retained because the majority of the sediment deposition is expected to occur near the source water body inputs.

3.2.7 American River Watershed

The average annual total mercury load for the Sacramento River (183 kg/yr), including the American River tributary, is above the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The total mercury load from the American River is estimated at 14 kg/yr. The American River watershed means the reach from Lake Natomas to its confluence with the Sacramento River. Potential sources of total mercury in the American River watershed include non-point sources such as floodplain and channel sediments affected by historic mining, and point sources such as inactive gold mines above Lake Natomas and Folsom Lake.

Because contributions from inactive gold mines above Folsom Lake and Lake Natomas are captured behind their dams, the upstream areas will not be retained for evaluation of potential mercury load reduction projects. Folsom Lake and Lake Natomas will not be retained as project areas as only a low quantity of sediment has been deposited from upstream gold mining. The reach of the American River between Lake Natomas and just above its confluence with the Sacramento River will not be retained due to scouring of sediment from the channel. However, the area of the American River just above its confluence with the Sacramento River will be retained as a project area due to in channel sediment deposition.

3.2.8 Sacramento River between Verona and Freeport

The average annual total mercury load for the Sacramento River at Freeport, including American River tributaries, is above the 110 kg/yr load reduction required by the San Francisco Bay TMDL and Basin Plan. The Sacramento River at Freeport discharges approximately 183 kg/yr total mercury. The Sacramento River at Verona is near the confluence with the Feather River and the Sutter Bypass, both significant inputs for sediment bound mercury. A short distance downstream is the Sacramento Weir. When opened during flood events, flow through the weir causes the Sacramento River to flow upstream from the vicinity of the American River to the weir (DWR 2003). As a consequence of reduced stream energy, sediment enriched in mercury is deposited in the Sacramento River channel primarily downstream of Verona to the American River. The sources for these sediment deposits are American River, Feather River, and Sutter Bypass channel sediment and floodplain deposits mobilized during flood flows.

The retained project areas include the Sacramento River channel from just upstream of the Fremont Weir (near Verona) to Freeport, the confluence of the Sacramento River and American River, and the lower reach of the American River channel.

3.3 OTHER ONGOING PROJECTS THAT CONTRIBUTE TO MERCURY LOAD REDUCTION TO THE DELTA

Other ongoing projects within the Delta watershed currently contribute to mercury load reduction to the Delta and could be actively managed to increase the amount of load reduction.

3.3.1 Delta Dredging

Sediment is dredged from waterways in the Delta to maintain the design depth of ship channels and marinas. The Port of Sacramento and Port of Stockton maintain annual deep water channel dredging programs. Dredging occurs at other Delta locations when needed, when funds are available, or when special projects take place. Approximately 533,000 CY of sediment are removed annually with about 199,000 CY (36 kg) from the Sacramento Deep Water Ship Channel and about 270,000 CY (49 kg) from the Stockton Deep Water Channel (Regional Board 2008). It is assumed that there is 0.2 mg/kg of mercury in the sediment. Other minor dredging projects, mostly at marinas, remove an additional 64,000 CY (11.6 kg) per year. The amount of mercury exported from the Delta through dredging projects could be increased above current levels through partnering and collaboration with the ports and other project proponents.

3.3.2 Water Exports from the Delta

Water is currently exported from the Delta to the California Water Project and the federal CVP. Approximately 5 million acre feet of water are exported per year from the vicinity of Tracy, California. Approximately 20 kilograms of total mercury are exported with the water (Regional Board 2008). Should the location where water is exported from the Delta be moved to the north, such as the location shown in the document *Isolated Facility Incised Canal Bay-Delta System Estimate of Construction Costs* (Washington Group International 2006), the mass of mercury exported could increase to approximately 56 kg/yr (assuming a similar volume of water is diverted).

4.0 IDENTIFICATION AND INITIAL SCREENING OF POTENTIAL CONTROL ACTIONS FOR LOAD REDUCTION

Recognition of the different forms of mercury within the Delta watershed and the differing modes of mercury occurrence within each subwatershed implies that there is no one single control action that is likely to succeed in reducing the load of total mercury to the Delta and the Bay. In order to facilitate the selection of the appropriate load reduction alternative(s) for each project area, the following four steps were followed: 1) identification and description of general response actions (GRA), control actions, and process options; 2) initial screening of control actions and development of load reduction alternatives; 3) detailed analysis of load reduction alternatives; and 4) comparative analysis of load reduction alternatives. GRAs are divided into control actions and process options for land based and stream based project areas (see Sections 4.1 and 4.2, respectively). Land based control actions are applicable at the original sources of mercury and to project areas outside of the existing levee system. Stream based control actions are applicable to projects within active channels, active floodplains, and potentially mobile sediment within the confines of the existing levee system.

The first step in the selection process is identifying and describing GRAs that may satisfy the load reduction goals and then progressively refining the GRAs into control actions and process options (see Sections 4.1.1 and 4.2.1). These process options are then screened and the retained process options are combined into potential load reduction alternatives. The purpose of the initial screening is to eliminate process options that are not feasible and retain those process options that are potentially feasible for further consideration. GRAs, control actions, and process options potentially capable of meeting the objective of reducing the load of total mercury in the Delta and the Bay are identified in Tables 4-1a and 4-1b for land based and stream based GRAs, respectively. Screening comments on the land based and stream based control actions are summarized in Tables 4-2a and 4-2b, respectively.

The following sections describe the GRAs, control actions, and process options for land based and stream based project areas, respectively, within the Sacramento Basin. The detailed evaluation of retained load reduction alternatives is presented in Section 5.0. A comparative analysis of retained load reduction alternatives for retained project areas is presented in Section 6.0.

4.1 POTENTIAL CONTROL ACTIONS FOR LAND BASED PROJECT AREAS

Control actions for land based project areas focus on mining related sources such as mine sites and impacted floodplains in upper watersheds. The following subsections focus on potential land based control actions and (1) identify and describe potential control actions for land based project areas, (2) present the initial screening, and (3) identify the retained control actions.

4.1.1 Survey of Control Actions for Land Based Project Areas

Control actions identified for land based project areas include no action, institutional controls, selected engineering controls, excavation and treatment of solids, and in-place treatment of solids. These control actions are summarized in Table 4-1a and described below.

4.1.1.1 No Action

Under the no action option, no control actions would occur within the Sacramento Basin watersheds. The no action response is a stand-alone response that is used as a baseline against which other control actions are compared.

4.1.1.2 Institutional Controls

Institutional controls involve actions such as legal controls that minimize the potential for mercury migration from historic mine sites and areas impacted by historic mining activity. Potentially applicable institutional controls consist of land use and water use restrictions.

Land use restrictions, comprised of zoning, deed restrictions, or environment control easements would limit existing and potential future uses of the land that could result in unacceptable risks due to human exposure to mercury in soils associated with historic mining activities or loss of future control action integrity. Soil conservation, tillage, and crop cover best management practices (BMP) could be implemented to reduce mercury laden sediment runoff from mine sites and undeveloped land and farm land that received outwash from historic mining activities, thus reducing the mobility of potentially mercury-laden soils and sediment.

Water use restrictions would limit existing and potential future uses of surface water that could result in unacceptable risks due to human exposure to mercury in sediment and surface water impacted by historic mining activities or loss of future control action integrity. Surface water use restrictions may also be necessary to limit existing and potential future uses of surface water fed by naturally occurring hydrothermal springs containing elevated concentrations of mercury not associated with mining activity.

Institutional controls could be implemented as a stand-alone action, or in combination with other alternatives. A local government or a cognizant state or federal agency would likely enforce institutional controls. Therefore, these entities must be involved in developing and eventually implementing any institutional controls.

4.1.1.3 Engineering Controls

Engineering controls are used primarily to reduce the mobility of and exposure to chemicals. These goals are accomplished by creating a barrier that prevents direct exposure or transport of waste from the source to the surrounding media. Engineering controls do not reduce the volume or toxicity of mercury in the environment. Potentially applicable land based engineering control actions include surface controls, containment, and excavation and disposal, each of which are discussed in the following subsections.

4.1.1.3.1 Surface Controls

Surface control measures are used primarily to reduce mercury mobility and limit direct exposure. Surface controls may be appropriate in areas where direct human contact is not a primary concern (human receptors are not living or working directly on or near the site). Process options include revegetation to control erosion, grading to control runoff and erosion, consolidation of mine waste and/or settling basin sediments, run-on and runoff controls/diversions, and erosion/flood controls. These process options are usually integrated as a single load reduction alternative.

Revegetation to Control Erosion. Revegetation to control erosion involves adding soil amendments to the waste surface to provide nutrients, organic material, and neutralizing agents. Revegetation also improves the water storage capacity of the mine waste, active floodplains, and floodplains that received outwash from historic mining. Revegetation will provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion and reduces net infiltration through the impacted medium by increasing evapotranspiration. Revegetation can also reduce the potential for direct contact. In general, revegetation includes the following steps: (1) selecting appropriate plant species, (2) preparing seed bed, (3) seeding and planting, and (4) mulching and/or chemical fertilizing. Revegetation would likely take place during the fall of the year. A native seed mixture would be used for revegetation to address local elevated salt and metals concentrations in soil.

Grading to Control Runoff and Erosion. Disturbed mine features and mine waste, stream banks, and active floodplains of ephemeral streams would be graded to manage surface water infiltration, runoff, and erosion. Grading is the general term for techniques used to reshape the ground surface to reduce slopes, manage surface water infiltration and runoff, restore eroded areas, and to aid in erosion control. However, grading can disturb existing vegetation.

Grading is a routine construction practice. The equipment and methods used in grading are similar for all surfaces, but will vary slightly depending on the waste location and the surrounding terrain. Equipment may include bulldozers, scrapers, graders, and compactors. Periodic maintenance and regrading may be necessary to eliminate depressions formed as a result of settlement, subsidence, or erosion.

Consolidation of Mine Waste and/or Settling Basin Sediments. Consolidation involves combining similar mine waste types or sediment with similar mercury concentrations in a common location for revegetation, covering, or engineered containment. Excavation during consolidation is accomplished with standard earthmoving equipment, including scrapers, bulldozers, excavators, loaders, and dump trucks. Consolidation is especially applicable when multiple waste sources are present in reasonably close proximity and one or more of the sources require removal from particularly sensitive areas (floodplain, overly steep slope, slide area, erosive area, or heavy traffic area). Consolidation is beneficial in this scenario because treating a large combined waste source in one location, rather than several smaller waste sources, is more efficient. Additional precautionary measures, such as stream diversion or isolation may be necessary in sensitive areas. Containment and treatment of water encountered during excavation may also be necessary.

Run-on and Runoff Controls/Diversions. Run-on controls, including water control bars, berms, ditches, and piping would be constructed to divert upstream surface water flow around and away from potential mine waste. Run-on controls would limit the amount of water entering the waste and would also prevent flowing water in streams from contacting the mine waste. Run-on controls would be used to reduce the potential for erosion and transport of mine waste away from the area. Runoff controls, including drains, ditches, and piping would be constructed to convey impacted water away from waste and source areas, and any transported sediments to an infiltration basin. Runoff control construction would be used to reduce transport of eroded waste into nearby creeks.

Erosion/Flood Controls. Erosion control and protection includes using erosion-resistant materials, such as mulch, natural or synthetic fabric mats, gabions, velocity breaks, and riprap to reduce the erosion potential at the surface of the mine waste. Managing flood flows would be achieved using box culverts, rock falls, and dry dams to reduce the erosive force of water within and adjacent to mine waste. In channel energy dissipation measures may include rock armoring of banks, wing dams, and widening of channel upstream and through mine waste. The erosion-resistant materials are placed in areas susceptible to surface water erosion (concentrated flow or overland flow) or wind erosion. Proper erosion protection design requires knowledge of drainage area characteristics, average slopes, soil texture, vegetation types and abundance, and precipitation data.

4.1.1.3.2 Containment

A containment approach uses an earthen cover, check dam, settling basin, or levee to capture or isolate mine waste and reduce or eliminate its mobility and exposure to surface water and storm water runoff. Containment measures can be used to divert surface water away from the mine waste and to minimize entrainment. Factors to consider when selecting a containment approach include the type and volume of the mine waste, location, and space limitations.

Earthen Cover over Mine Waste. Inert waste, overburden, soil, or sediment would be applied over intact and/or consolidated mine waste containing elevated concentrations of mercury. The area would then be graded to control runoff and divert high velocity flows. A vegetative cover would be established to stabilize the surface.

Check Dams to Capture Solids from Mine Site. One or more check dams would be constructed downstream of mine site(s) to promote settling of solids from storm water runoff. Maintenance includes periodic removal of accumulated sediment and placement back at the mine site or off-site disposal in a Class III solid waste landfill or Class I repository, depending on the mercury concentration.

Settling Basins to Capture Solids from Mine Site. On- or off-stream settling basin (or basins) downstream of mine site(s) would be constructed to promote settling of solids from storm water runoff. Maintenance includes periodic removal of accumulated sediment and placement back at the mine site or off-site disposal in a Class III solid waste landfill or Class I repository, depending on mercury concentration.

Levees to Isolate Mine Waste from Creeks, Streams, and Rivers. Set back levees would be constructed to isolate mine waste on a floodplain or adjacent to a stream from the active stream channel. This action is applicable where the volume of mine waste is too large to excavate and consolidate on-site or dispose of at an off-site facility.

4.1.1.3.3 Excavation and Disposal

Excavation and disposal incorporate the removal of mine waste and disposing of it either on site or off site. Excavation can be completed using conventional earth-moving equipment and accepted hazardous materials-handling procedures. Precautionary measures, such as stream diversion or isolation, would be necessary for excavating materials near sensitive areas. Containment and treatment of water encountered during excavation may also be necessary.

Permanent, on-site disposal is used as a control measure and is similar to containment. The objectives of on-site disposal are the same as for containment, except that disposal includes excavation and consolidation of waste into a single, usually smaller area, and may involve installing physical barriers (geomembranes or geosynthetic clay liners [GCL]) beneath as well as above the waste. This added barrier may be needed to provide additional protection of groundwater from potential leachate contamination.

On-site disposal options may be applied to treated or untreated mine waste. As mine waste is excavated and moved during this process, treatment may become a cost-effective option.

Factors to consider in design include physical condition of the mine waste, topography, slope stability, leachability, site hydrogeology, precipitation, depth to groundwater, current groundwater quality, area groundwater use, and applicable groundwater standards. Stringent cover or cap performance standards may not always be appropriate, particularly in instances where the toxicity of the impacted medium is relatively low, where there is very low precipitation, or where the waste is not leached by infiltrating rainwater. Desired land use following cover or cap construction should also be considered in cover or cap design.

Off-site disposal involves placing excavated mine waste in an engineered waste repository at a permitted facility. Off-site disposal would involve placement in either an off-site location owned by the same party who owns the mine or at another appropriate permitted facility. Off-site disposal options may be applied to pretreated or untreated impacted materials. Materials considered hazardous and failing to meet the leachability criteria, if disposed of off-site, would require disposal in a permitted Class I repository. Conversely, less mobile and less toxic materials could be disposed of off-site in a Class III solid waste landfill in compliance with other applicable laws.

Placement of Non-Hazardous Solids or Processed Fines Under an Earthen Cover. Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would then be backfilled with inert material and/or graded to control runoff and divert high velocity flows. A vegetative cover would be established to stabilize the surface.

Non-hazardous excavated materials or processed fine materials would be consolidated in one location. Inert waste, overburden, soil, or sediment would then be applied over non-hazardous excavated materials or processed fine materials. The area would be graded to control runoff; high velocity flows diverted; and a vegetative cover established to stabilize the surface.

Placement of Hazardous Solids or Processed Fines in an On-site Engineered Repository (Group A or B). Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would be backfilled with inert material and/or graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface.

The excavated materials or processed fine materials would be consolidated in one location in an engineered Group A (hazardous leachable materials) or Group B (hazardous, non-leachable materials) mine waste repository. Excavated materials or processed fine materials are considered hazardous when total mercury concentrations are greater than 20 mg/kg or leachable when leachability mercury concentrations are greater than 0.2 mg/l (STLC). The repository would then be graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface.

Placement of Non-Hazardous Solids in an Off-site Class III Solid Waste Landfill. Non-hazardous mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury; would be excavated and backfilled with inert material. The area would then be graded to control runoff and high velocity flow diverted. A vegetative cover would be established to stabilize the surface. The non-hazardous materials (mercury content below 20 mg/kg) would be hauled off site and placed in an off-site Class III solid waste landfill.

Placement of Hazardous Solids or Processed Fines in an Off-site Class I Repository. Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would be backfilled with inert material and/or graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface. The hazardous materials (mercury content between 20 mg/kg and 260 mg/kg or leachable mercury greater than 0.2 milligram per liter [mg/L]) would be hauled to and placed in an off-site Class I repository for hazardous materials.

4.1.1.4 Excavation and Treatment of Solids

Excavation and treatment incorporate the removal of mine waste and subsequent treatment through a specific process that chemically, physically, or thermally results in a reduction of chemical toxicity and volume. Treatment processes have the primary objective of either: (1) concentrating metal constituents for additional treatment or recovery of valuable materials, or (2) reducing the toxicity of the hazardous constituents. Excavation can be completed using conventional earth-moving equipment and accepted hazardous materials-handling procedures. Precautionary measures, such as stream diversion or isolation, would be necessary for excavating materials near sensitive areas. Containment and treatment of water encountered during excavation may also be necessary. Potentially applicable land based excavation and treatment control actions include processing and physical/chemical treatment, which are discussed in the following subsections.

4.1.1.4.1 Physical Separation

Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would then be backfilled with inert material and/or graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface.

A batch sand and gravel plant setup for mercury recovery would be mobilized to the site to separate aggregate from fines containing mercury. The aggregate would be returned to the excavation or sold as a commodity. The fines would then be disposed of as a non-hazardous material (mercury content below 20 mg/kg) or as a hazardous material (mercury content above 20 mg/kg or leachable mercury greater than 0.2 mg/L).

4.1.1.4.2 Physical/Chemical Treatment

Physical treatment processes use physical characteristics to concentrate constituents into a relatively small volume for disposal or further treatment. Chemical treatment processes act through the addition of a chemical reagent that removes or fixates the chemicals. The net result of chemical treatment processes is a reduction of toxicity and mobility of chemicals in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the impacted media with water, acids, bases, or surfactant. Potentially applicable physical and chemical treatment process options include retorting, fixation/stabilization, and soil washing.

On-site Physical Separation of Aggregate from Fines and Off-Site Retorting of Processed Fines. Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would then be backfilled with inert material and/or graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface.

A batch sand and gravel plant setup for mercury recovery would be mobilized to the site to separate coarse material from fine materials containing mercury. The coarse fraction would be returned to the excavation or sold as an aggregate commodity.

Fine materials containing hazardous concentrations of mercury, above 260 mg/kg, that cannot be disposed of in a Class I repository would be transported to an off-site permitted retorting facility. The retort process volatilizes mercury from the processed fines by heating the material. Mercury vapor is then collected, recondensed, and sold as an economic commodity. The fine material is disposed of as an inert waste at an off-site Class III landfill.

On-site Physical Separation of Aggregate from Fines and Fixation/Stabilization of Processed Fines. Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would then be backfilled with inert material and/or graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface.

A batch sand and gravel plant setup for mercury recovery would be mobilized to the site to separate coarse material from fine materials containing mercury. The coarse fraction would be returned to the excavation or sold as an aggregate commodity. The remaining concentrated fine material containing hazardous concentrations of mercury would then be stabilized for disposal.

Fixation/stabilization can be used as a pretreatment process to limit the leachability of mercury prior to disposal of excavated hazardous fine materials on site or in an off-site waste repository. This helps address leachability concerns for disposal in a Class II solid waste landfill. Solidifying/stabilizing agents would be used in conjunction with mixing techniques to facilitate a physical or chemical change in the mobility of the mercury.

On-site Physical Separation of Aggregate from Fines and Soil Washing of Processed Fines. Mine waste, settled solids, or floodplain deposits containing elevated concentrations of mercury would be excavated. The excavation would then be backfilled with inert material and/or graded to control runoff and high velocity flows diverted. A vegetative cover would be established to stabilize the surface.

A batch sand and gravel plant setup for mercury recovery would be mobilized to the site to separate coarse material from fine materials containing mercury. The coarse fraction would be returned to the excavation or sold as an aggregate commodity. The remaining concentrated hazardous fine material would then be washed for disposal. Soil washing would be used to separate metals from processed fine materials via dissolution in a heap, vat, or agitated vessel followed by precipitation in a separate vessel. Washed fines would be consolidated on-site.

4.1.1.5 In-Place Treatment of Solids

In-place treatment reduces the need for excavation and transport of mine waste. A potentially applicable control action for land based in-place treatment of solids includes physical/chemical treatment. Physical treatment processes use physical characteristics to concentrate constituents into a relatively small volume for disposal or further treatment. Chemical treatment processes act through the addition of a chemical reagent that removes or fixates the chemicals. The net result of chemical treatment processes is a reduction of toxicity and mobility of chemicals in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the impacted media with water, acids, bases, or surfactant. Potentially applicable physical and chemical treatment process options include soil flushing and fixation/stabilization.

Soil Flushing. Soil flushing involves injection of an acid/base reagent or chelating agent into solid media to solubilize mercury. The solubilized mercury and reagents are then subsequently extracted using dewatering techniques. Soil flushing would potentially reduce mercury concentrations in near surface mine wastes available for erosion.

Fixation/Stabilization. Fixation and stabilization technologies are used to treat materials by physically encapsulating them in an inert matrix (stabilization) and chemically altering them to reduce the mobility and toxicity of their constituents (fixation). These technologies generally involve mixing materials with binding agents under prescribed conditions to form a stable matrix. Fixation and stabilization are established technologies for treating inorganic chemicals. The technologies incorporate a reagent or combination of reagents to facilitate a chemical and physical reduction of the mobility of chemicals in the solid media. Lime/fly ash-based treatment processes and pozzolan/cement-based treatment processes are potentially applicable fixation and stabilization technologies.

4.1.2 Initial Screening of Control Actions for Land Based Project Areas

The purpose of the initial screening is to eliminate control actions that are not feasible from further consideration and retain those actions that are potentially feasible for detailed evaluation. The following subsections discuss the effectiveness and implementability of each GRA, control action, and process option identified above. A summary of these screening results is presented in Table 4-2a.

4.1.2.1 No Action

No action is a stand-alone control action that is used as a baseline for comparison against other load reduction alternatives. It could be low to moderately effective, as natural flushing of sediments through and gradual attenuation of mercury from the system would occur, and would be easy to implement. However, there would be no short-term change to mercury concentrations in the Bay-Delta. No action was retained through the detailed evaluation of load reduction alternatives as it is a baseline for comparison.

4.1.2.2 Institutional Controls

Institutional controls could be low to moderately effective, depending on the degree of implementation. Although easily implementable, land and water use restrictions are expected to meet some resistance. The timeframe to achieve load reduction is a short to moderate term. Implementation of land use restrictions and soil conservation, soil tillage, and crop cover BMPs could reduce erosion and sediment loading at all scales. Land use restrictions would primarily address mercury in soils at mine sites and sediment stored in old floodplains. Institutional controls provide relatively low load reduction in the system overall; however, over time they reduce the buildup of mercury mass in the river system sediment. Institutional controls were retained through the detailed evaluation of load reduction alternatives. Water use restrictions would have little impact on mercury load reduction.

4.1.2.3 Engineering Controls

Land based engineering controls include surface controls, containment, and excavation and disposal.

4.1.2.3.1 Surface Controls

Surface controls were retained for further consideration as load reduction alternative or in combination with other alternatives. Potentially applicable surface control actions include revegetation to control erosion, grading to control runoff and erosion, consolidation of mine waste and/or settling basin sediments, run-on and runoff controls/diversions, and erosion/flood controls.

Revegetation to Control Erosion. Revegetation could be moderately effective but easy to implement. The timeframe to achieve load reduction is moderate to long term due to the time required to establish sufficient vegetative cover. It could reduce erosion and sediment loading at all scales from mine reclamation to floodplain stabilization. Revegetation primarily addresses mercury contained in actively eroding mine waste and sediment originated from mining and would provide relatively low to moderate load reduction depending on the project scale. It could also be used to stabilize diffuse mercury stored in active floodplains. Therefore, this process option was retained through the detailed evaluation of load reduction alternatives.

Grading to Control Runoff and Erosion. Grading could be low to moderately effective at reducing mercury loading to the down gradient watersheds. It is easily implementable at mine remediation sites, but becomes difficult at larger scales due to disturbance of intact vegetation. The timeframe to achieve load reduction is short term for small-scale projects and moderate to long term for large-scale projects due to the time needed to establish sufficient cover over newly disturbed soils. It could reduce erosion and sediment loading at all scales from mine reclamation to floodplain stabilization. Grading would primarily address mercury contained in actively eroding mine waste and sediment originated from mining; however, it could be used to stabilize diffuse mercury stored in active floodplains. It provides relatively low to moderate load reduction depending on the project scale. Therefore, this process option was retained through the detailed evaluation of load reduction alternatives.

Consolidation of Mine Waste and/or Settling Basin Sediments. Consolidation may have limited effectiveness, as soil and sediment are still subject to erosion, and would need to be combined with other control actions to improve its effectiveness; however, it is easily implemented. The timeframe to achieve load reduction is over the short term. Consolidation could address mercury contained in actively eroding mine waste and reduce the area available for erosion on a small scale, primarily at mine reclamation sites. It would provide relatively low load reduction to the system as a whole; although, it would provide a moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). This process option was retained through the detailed evaluation of load reduction alternatives.

Run-on and Runoff Controls/Diversions. Run-on and runoff controls could be moderately effective and easy to implement. The timeframe to achieve load reduction and to addresses mercury contained in actively eroding mine waste is over the short term. It could reduce erosion and sediment loading on a small scale, primarily at mine reclamation sites. Run-on and runoff controls provide relatively low load reduction to the system as a whole; however, they would provide a moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). Therefore, this process option was retained through the detailed evaluation of load reduction alternatives.

Erosion/Flood Controls. These controls could be moderately effective and easy to moderately implementable, depending on the degree of stream channel modification. The timeframe to achieve load reduction is over the short term and could address mercury contained in actively eroding mine waste and floodplain deposits. Erosion and sediment loading would be reduced on a small scale, primarily at mine reclamation sites. Erosion/flood controls would provide relatively low load reduction to the system as a whole; however, they would provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). Therefore, this process option was retained through the detailed evaluation of load reduction alternatives.

4.1.2.3.2 Containment

Containment is considered a standard construction practice. Equipment and construction methods associated with containment are readily available, and design methods and requirements are well understood. Containment is considered a feasible action for all waste and most source types at mines and will be retained for further consideration as a load reduction alternative or in combination with other alternatives. Potentially applicable containment process options include placement of earthen cover over mine waste and construction of check dams to capture solids from mine sites; settling basins to capture solids from mine sites; and levees to isolate mine waste from creeks, streams, and rivers.

Earthen Cover Over Mine Waste. An earthen cover could be moderately effective and easy to implement at mine sites. The timeframe to achieve load reduction is over the short term. Covers can eliminate mine waste available for erosion on a small scale, primarily at mine reclamation sites. An earthen cover would primarily address mercury contained in actively eroding mine waste. Relatively low load reduction would be provided to the system as a whole although projects at mine sites would provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). This process option was retained through the detailed evaluation of load reduction alternatives.

Check Dams to Capture Solids from Mine Site. Check dams could be moderately to highly effective, depending on the size of the basin behind the check dam, and are easy to moderately implementable, depending on the size of the structure. The timeframe to achieve load reduction is over the short term. Mercury from actively eroding mine waste would be captured before it disperses throughout the watershed and degrades the downstream water quality. Predominately medium- to coarse-grained sediment would be captured and sediment loading could be reduced on a small scale, primarily downstream of the mine reclamation sites. However, it would require frequent excavation and disposal of sediment. It provides relatively low load reduction to the system as a whole; however, it would provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). There is also a potential for generation of methyl mercury in sediments retained behind check dam. This process option was retained through the detailed evaluation of load reduction alternatives.

Settling Basins to Capture Solids from Mine Site. Settling basins could be moderately to highly effective, depending on the size of the settling basin, and easy to moderately implementable, depending on the available space and retention structure size. The timeframe to achieve load reduction is over the short term. This option captures more size fractions of sediment than a check dam and reduces sediment loading on a small scale, primarily downstream of mine reclamation sites. Eventually excavation and disposal of sediment would be required. It addresses mercury from actively eroding mine waste before it disperses throughout the watershed and can degrade downstream water quality. Relatively low load reduction would be provided to the system as a whole; however, it would provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). There is also a potential for generation of methyl mercury in sediments retained in settling basin. This process option was retained through the detailed evaluation of load reduction alternatives.

Levees to Isolate Mine Waste from Creeks, Streams, and Rivers. This option could be highly effective and easy to moderately implementable, depending on the degree of stream channel modification. The timeframe to achieve load reduction is over the short term. It would address actively eroding mine waste and eliminate mine waste available for erosion on a small scale, primarily at mine reclamation sites. However, if the floodplain is restricted, the potential erosive force of floodwaters should be considered. Relatively low load reduction would be provided to the system as a whole; however, projects at mine sites would provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). This process option was retained through the detailed evaluation of load reduction alternatives.

4.1.2.3.3 Excavation and Disposal

Factors to consider in design include physical condition of the impacted media, topography, slope stability, leachability, site hydrogeology, precipitation, depth to groundwater, current groundwater quality, area groundwater use, and applicable groundwater standards. Stringent cover or cap performance standards may not always be appropriate, particularly in instances where the toxicity of the impacted medium is relatively low, where there is very low precipitation, or where the waste is not leached by infiltrating rainwater. Desired land use following cover or cap construction should also be considered in cover or cap design. Materials considered hazardous and failing to meet the leachability criteria, if disposed of outside the project area, would require disposal in an off-site permitted Class I facility. Conversely, less mobile and less toxic materials could be disposed of in a Class III solid waste landfill in compliance with applicable laws. Excavation and disposal is considered a feasible action for all waste and most source types at mines and will be retained for further consideration as a load reduction alternative. Potentially applicable excavation and disposal process options include placement of non-hazardous solids or processed fines under an earthen cover, in an on-site engineered repository (Group A or B), in an off-site Class III solid waste landfill, and in an off-site Class I repository.

Placement of Non-Hazardous Solids or Processed Fines Under an Earthen Cover. An earthen cover could be highly effective and easy to implement at mine sites. The timeframe to achieve load reduction is over the short term. It addresses mercury contained in actively eroding mine waste and floodplain deposits containing mine related sediment and would eliminate mine waste available for erosion on a small scale, primarily at mine reclamation sites. It would not be cost effective to excavate, consolidate, and cover a large volume of non-hazardous solids from non-mine related areas. Relatively low load reduction would be provided to the system as a whole; however, projects at mine sites would provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). Therefore, this process option was retained for the detailed evaluation of load reduction alternatives.

Placement of Hazardous Solids or Processed Fines in an On-site Engineered Repository (Group A or B). Placement in an on-site engineered repository could be highly effective but not readily implementable at individual mine sites due to restrictive construction and siting requirements. It is also not cost effective unless a large volume of hazardous solids requires containment. The timeframe to achieve load reduction is over the short term. It could eliminate mine waste available for erosion at a small scale and would be most effective at mine reclamation sites. The repository addresses mercury contained in actively eroding mine waste and floodplain deposits containing mine wastes. Although projects at mine sites would provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins), it provides relatively low to moderate load reduction to the system while not being readily implementable or cost effective. Therefore, this process option was not retained for the detailed evaluation of load reduction alternatives.

Placement of Non-Hazardous Solids or Processed Fines in an Off-site Class III Solid Waste Landfill. Placement of non-hazardous solids or processed fines in an off-site Class III solid waste landfill could be highly effective and easy to implement at mine sites. The timeframe to achieve load reduction is over the short term. This option addresses mercury contained in actively eroding mine waste and floodplain deposits containing mine related sediment and could eliminate mine waste available for erosion at a small scale, primarily at mine reclamation sites; however, it is not as cost effective to excavate and transport a large volume of non-hazardous solids from non-mine related areas. It would provide relatively low load reduction to the system as a whole; however, projects at mine sites would provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). Therefore, this process option was retained for the detailed evaluation of load reduction alternatives.

Placement of Hazardous Solids or Processed Fines in an Off-site Class I Repository. This option could be highly effective and easy to implement at mine sites. The timeframe to achieve load reduction is over the short term. Mercury contained in actively eroding mine waste and floodplain deposits containing mine related sediment would be addressed and could be eliminated at a small scale, primarily at mine reclamation sites. Relatively low to moderate load reduction would be provided to the system as a whole by removing high concentrations of mercury; however, projects at mine sites would provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). Therefore, this process option was retained for the detailed evaluation of load reduction alternatives.

4.1.2.4 Excavation and Treatment of Solids

Excavation and treatment of solids is considered a feasible action for mine reclamation sites and mine related floodplain deposits and was retained for further consideration as a load reduction alternative. Potentially applicable excavation and treatment of solids control actions include processing and physical/chemical treatment, which are discussed further in the following subsections.

4.1.2.4.1 Physical Separation

Processing could be highly effective and easy to implement at mine sites; however, it would require bulk soil transport to a centralized facility from multiple mine sites or floodplain reclamation. The timeframe to achieve load reduction is short term at mine sites and medium term for floodplain deposits, due to longer processing time. Mercury contained in actively eroding mine waste and floodplain deposits containing mine related sediment would be addressed, and mine waste available for erosion could be eliminated on a small to medium scale, primarily at mine reclamation sites and in mine related floodplain deposits containing elevated concentrations of mercury. Disposal of fine materials as non-hazardous or hazardous material is required. It provides relatively low to moderate load reduction to the system as a whole; however, by removing high concentrations of mercury, it provides high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). This action was retained for the detailed analysis of load reduction alternatives.

4.1.2.4.2 Physical/Chemical Treatment

Potentially applicable physical/chemical process options include on-site physical separation of aggregate from fines and either off-site retorting of processed fines, fixation/stabilization of processed fines, or soil washing of processed fines.

On-site Physical Separation of Aggregate from Fines and Off-site Retorting of Processed Fines. This option could be highly effective and easy to implement at mine sites. The timeframe to achieve load reduction is short term at mine sites and medium term for floodplain deposits, due to the longer processing times. Mercury contained in actively eroding mine waste and mine related floodplain deposits would be addressed. This option eliminates mine waste available for erosion at a small to medium scale, primarily at mine reclamation sites and mine related floodplain deposits containing elevated concentrations of mercury. It would also require transport to a centralized facility from multiple mine or floodplain reclamation. It provides relatively low to moderate load reduction to the system as a whole by removing high concentrations of mercury and provides high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). This process option was retained for the detailed analysis of load reduction alternatives.

On-site Physical Separation of Aggregate from Fines and Fixation/Stabilization of Processed Fines. This option could be highly effective and easy to implement at mine sites. The timeframe to achieve load reduction is short term at mine sites and medium term for floodplain deposits due to longer processing time. It addresses mercury contained in actively eroding mine waste and floodplain deposits related to mining and could eliminate mine waste available for erosion on a small to medium scale, primarily at mine reclamation sites and mine related floodplain deposits containing elevated concentrations of mercury. It would require bulk soil transport to a centralized facility for multiple mine or floodplain site reclamations. Fixation/stabilization of fine materials should be considered where leachability of mercury from fines would otherwise preclude disposal in a Class III solid waste landfill versus a more restrictive Class I repository. It provides relatively low to moderate load reduction to the system as a whole by removing high concentrations of mercury but provides a high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). This process option was retained for the detailed analysis of load reduction alternatives.

On-site Physical Separation of Aggregate from Fines and Soil Washing of Processed Fines. Excavation and physical separation could be highly effective; however, soil washing of processed fines has limited effectiveness at removing low to moderate concentrations of mercury from soil. The excavation and physical separation process is easily implementable at mine sites but would require bulk soil transport to a centralized facility for multiple mine sites or floodplain reclamation. The timeframe to achieve load reduction is short term at mine sites and medium term for floodplain deposits, due to longer processing time. Soil washing eliminates mine waste available for erosion at a small to medium scale, primarily at mine reclamation sites and floodplain deposits containing elevated concentrations of mercury. The soil washing process would require construction of a large plant to remove mercury from fines and may still require off-site disposal of fines in a Class I repository if the process is not effective. This option addresses mercury contained in actively eroding mine waste and floodplain deposits related to mining. Although it may provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins), it provides relatively low to moderate load reduction to the system as a whole by removing high concentrations of mercury. Because soil washing has limited effectiveness at removing low to moderate concentrations of mercury from soil, this process option was not retained for the detailed analysis of load reduction alternatives.

4.1.2.5 In-Place Treatment of Solids

Potentially applicable physical and chemical treatment process options include soil flushing and fixation/stabilization, which are discussed further below. This control action will not be retained for the detailed analysis of load reduction alternatives.

Soil Flushing. In situ soil flushing may have moderate effectiveness where hydraulic conductivity is good; however, poorly structured mine waste typically contains a large amount of fines which would limit effectiveness at removing low to moderate concentrations of mercury from the soil. It requires groundwater extraction and treatment to recover mercury leached from mine waste; therefore, the in situ soil flushing process is difficult to implement due to the large number of injection and extraction points necessary to achieve hydraulic control and leachate capture. The timeframe to achieve load reduction is over the short term at mine sites; however, mine waste may still require excavation and off-site disposal in a Class I repository if the process is not effective. Soil flushing potentially reduces mercury concentration in near surface mine wastes available for erosion at a small scale, primarily at mine reclamation sites. This option would address mercury contained in mine waste. Although it could provide high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins), by removing high concentrations of mercury, this option provides relatively low to moderate load reduction to the system as a whole. This process is expected to have limited effectiveness at removing low to moderate concentrations of mercury from the soil; therefore, it was not retained for the detailed analysis of load reduction alternatives.

Fixation/Stabilization. In situ fixation/stabilization may have moderate effectiveness where hydraulic conductivity is good. This method would stabilize mercury in place by injecting stabilizing agents into the solid media to facilitate a physical or chemical change in mobility of the chemicals; however, poorly structured mine waste typically contains a large amount of fines which would limit effectiveness at introducing reagents. In situ fixation/stabilization process is difficult to implement due to the large number of injection points necessary to distribute reagents. The timeframe to achieve load reduction is over the short term at mine sites; however, mine waste may still require excavation and off-site disposal in a Class I repository if process is not effective. It potentially reduces mercury concentration in near surface mine waste available for erosion at a small scale, primarily at mine reclamation sites and requires a dense array of injection points to fix mercury in place. It provides relatively low to moderate load reduction to the system as a whole by removing high concentrations of mercury; provides high load reduction in specific sub-basins, and could reduce the scale of downstream projects (for example, settling basins). As this process option is expected to have limited effectiveness at introducing reagents, it was not retained for the detailed analysis of load reduction alternatives.

4.1.3 Retained Load Reduction Alternatives for Land Based Project Areas

Those control actions potentially capable of meeting TMDL goals for the land based project areas were combined into load reduction alternatives and are identified in Table 4-3a. Detailed evaluation of load reduction alternatives for land based project areas is presented in Section 5.1.

4.2 POTENTIAL CONTROL ACTIONS FOR STREAM BASED PROJECT AREAS

Control actions for stream based project areas focus on retention or removal of in channel and floodplain sediments associated with historical deposition of mercury from mining activities. The following subsections focus on potential stream based control actions and (1) identify and describe potential control actions for stream based project areas, (2) present the initial screening, and (3) identify the retained control actions.

4.2.1 Survey of Control Actions for Stream Based Project Areas

Control actions identified for stream based project areas include no action, institutional controls, selected engineering controls, and dredging and treatment of sediment. These control actions are summarized in Table 4-1b and described below.

4.2.1.1 No Action

Under the no action option, no control actions occur within the Sacramento Basin. Natural flushing of sediments and gradual attenuation of mercury from the lower watershed would occur. The no action response is a stand-alone response that is used as a baseline for comparison against other control action alternatives.

4.2.1.2 Institutional Controls

Institutional controls involve actions such as legal controls that minimize the potential for human exposure to contaminants. Institutional controls could be implemented as a stand-alone action or in combination with other alternatives. A local government or a cognizant state or federal agency would likely enforce institutional controls. Therefore, these entities must be involved in developing and eventually implementing any institutional controls. Potentially applicable stream based institutional controls include ensuring implementation of existing programs and improving operation and maintenance (O&M) activities, which are discussed in the following subsections.

4.2.1.2.1 Ensure Implementation of Existing Programs

Implement an effective mercury recovery program and support river dredging and recreational mining activities that encourage mercury recycling. Community mercury recovery programs would reduce mercury discharged to the sanitary sewer, storm drains, and landfills. Dredging to clear waterways and water conveyance structures of accumulated sediment and debris also removes free mercury from stream beds. Dredging programs would be coordinated with other agencies to ensure mercury laden sediments are removed from the system, placed, and maintained in a manner to reduce migration back into the system. Recreational mining practices include dredging of stream beds. Recreational dredging of elemental mercury from sediments downstream of mining districts and a buy back program for mercury could be promoted. Both commercial and recreational dredging of mercury impacted sediments may result in short term dispersion of fines containing mercury within the water column; however, the total mass of mercury removed by dredging activities outweighs the potential short term impacts.

4.2.1.2.2 Improve Operation and Maintenance Activities

O&M activities include inspection and maintenance of flood control levees, reservoir management, flood and irrigation management activities, and flood control system operation. Continued maintenance of smaller flood control levees reduces erosion, seepage, and breaches of levees, thereby limiting historic floodplain erosion and transport of mercury laden sediment.

Reservoirs could be operated as sedimentation basins by delaying the discharge of water until the majority of suspended solids have settled, thereby reducing the transport of mercury laden sediment. Existing reservoir storage and subsequent release would be coordinated with other agencies to minimize discharge of suspended sediments and channel scour, where feasible.

Flood control and irrigation management activities include conveyance and storage of water in bypasses and settling basins. Flood and irrigation management activities would be coordinated with other agencies to improve off-stream storage and allow setting of suspended solids during flood events.

4.2.1.3 Engineering Controls

Engineering controls are used primarily to reduce the mobility of and exposure to mercury. These goals are accomplished by creating a barrier that prevents direct exposure and transport of waste from the impacted source to the surrounding media. Engineering controls do not reduce the volume or toxicity of the mercury in the environment. Potentially applicable stream based engineering controls include surface controls, containment, and dredging and disposal.

4.2.1.3.1 Surface Controls

Surface control actions are used primarily to reduce mercury mobility and limit direct exposure. Surface control measures include improving the efficiency of existing sediment control structures; stabilization of stream banks, the surface of active floodplains, and settling basin surfaces; and stabilization of Delta marshlands and unprotected Delta islands.

Improve Efficiency of Existing Sediment Control Structures. Existing sediment control structures include settling basins, dams, and bypasses. Their efficiency would be improved by increasing the size (area and/or depth) of existing settling basins and/or installing additional flow control berms and weirs to increase the hydraulic residence time within existing settling basins, which would improve sediment retention during flood events. The height of existing debris and flood control structures would also be increased to improve sediment retention during flood events. Periodic removal of accumulated sediment from settling basins would be required to maintain the hydraulic retention time required for settling of fines. Sediment would also be processed for aggregate, and non-hazardous fines would be transported to and placed on farmland protected by levees or used as fill at a construction site.

Stabilization of Stream Banks, Floodplains, and Settling Basin Surfaces. Stream banks, the surface of active floodplains, and settling basin surfaces would be stabilized to reduce erosion of sediment containing elevated levels of mercury and mine waste. Channel geometry would be altered and/or wing dams and rip rap would be installed to reduce erosion and lateral migration of the stream into active and historic floodplain deposits that contain elevated levels of mercury and mine waste. To reduce erosion during flood flows, stream banks would be laid back and active floodplains, containing elevated levels of mercury and mine waste, would be graded. Soil amendments would also be added and seed, plant cover crops, brush, and/or trees would be planted to reduce the erosion of stream banks, active floodplains, and settling basin surfaces.

Stabilization of Delta Marshlands and Unprotected Delta Islands. Delta marshlands containing elevated levels of mercury would be stabilized through revegetation and increasing the rate of sediment deposition. Hydraulic control levees would be constructed around larger marshlands to increase hydraulic retention time and settling of fines. Dredged channel sediment would also be placed adjacent to the marshlands to increase shoreline protection.

Unprotected Delta islands (no levees) containing elevated levels of mercury would be stabilized through construction of reclamation levees. Dredged channel sediment would also be placed on reclaimed islands to stabilize the toe of levees and develop upland areas.

4.2.1.3.2 Containment

The following containment approaches leave mercury-impacted sediment in place and use an earthen cover or engineered cap or divert surface water away from the impacted medium to reduce or eliminate mobility of mercury. The physical covering or capping of wastes during containment reduces or eliminates chemical mobility and the potential risk that may be associated with exposure to the impacted media.

Cap/Cover Lake and Settling Basin Sediments. Inert sediment or sediment with low concentrations of mercury would be placed over sediment within existing reservoirs and settling basins that have elevated concentrations of mercury. In addition, high velocity flows would also be diverted from the covered sediment. This would reduce the entrainment of sediment with elevated concentrations of mercury during flood events.

Flow Diversion to New Bypass to Promote Solids Settling. Flood routing and associated solids settling capacities would be increased through the construction of additional flood control bypasses. Surface water flow would be diverted to bypasses using weirs or berms to improve sediment retention during flood events. Water velocity would be reduced, providing time for sediment to settle. This action would require construction of additional flood control levees on farmland and passive/active weirs at up and down stream ends. Flow control berms and weirs would also be installed within the flood control bypass to improve sediment retention.

Flow Diversion to New Settling Basin to Promote Solids Settling. Additional off-stream settling basins would be constructed to promote settling of solids during high flow and flood events, with special consideration given to areas where streams exit the foothills to help reduce stream energy and control downstream bank erosion. Hydraulic control levees and passive/active weirs would be constructed at the up and down stream ends, and surface water flow would be diverted using weirs or dams. Water would be temporarily stored until the sediment had settled, then reintroduced downstream. Periodic removal of accumulated sediment from the settling basins may be required over the long-term to maintain the hydraulic retention time for settling of fines. Sediment would be processed for aggregate and non-hazardous fines would be transported to and placed on farmland protected by levees or used as fill at a construction site.

Containment of Flood Flows within New Levees to Limit Entrainment of Historic Floodplain Sediment. In areas where the volume of impacted floodplain sediment is too large to excavate and dispose of off-site, levees would be constructed to isolate the mercury and mine waste in the floodplain sediment from the adjacent active stream channel. Flood flows would be contained within the levees, thereby limiting the entrainment of historic floodplain sediment.

Capture Sediment Using Low Dams and Weirs within Small Creeks and Streams. On smaller streams, flood control and debris dams would be installed to capture sediment and reduce stream energy contributing to the lateral migration of streams into active and historic floodplain deposits that contain elevated levels of mercury and mine waste. Periodic removal of the accumulated sediment from behind the dams would be required to maintain the hydraulic retention time required for energy dissipation and settling of fines. Sediment would be processed for aggregate and non-hazardous fines would be transported to and placed on farmland protected by levees or used as fill at a construction site.

Cleaning and Grouting Floor of Hydraulic Mine Drainage Tunnels. Sediment would be evacuated or mucked from ground sluices, drainage tunnels, and plunge pools of foothill hydraulic gold mines. After the sediment is removed, the floor of the ground sluice, drainage tunnel, or plunge pool would be sealed to ensure that residual mercury in the bedrock cracks is isolated. The sealed ground sluices would be backfilled and vegetation established to stabilize the surface.

Plugging of Hydraulic Mine Sluices and Drainage Tunnels. Inlets to hydraulic mine drainage tunnels would be plugged to stop erosion of tunnel sediments containing mercury. The mine pit floor would be contoured or a pipe installed to divert storm water to aboveground drainage pathways.

4.2.1.3.3 Dredging and Disposal

Dredging and disposal incorporate the removal of bottom sediment, with disposal of sediment either adjacent to a levee controlled stream, in an upland area, or at an off-site waste repository, depending on hazardous characteristics. Dredging can be completed using conventional equipment. Dredging of mercury impacted sediments may result in short term dispersion of fines containing mercury within the water column; however, the total mass of mercury removed by dredging activities outweighs the potential short term impacts.

Permanent, on-site disposal of dredge material is used as a source control measure and is similar to containment. The objective of on-site disposal is to consolidate waste into a single, usually smaller area.

Off-site disposal involves placing dredge material in an engineered waste repository at a permitted facility. Materials considered hazardous and failing to meet the leachability criteria, if disposed of outside the project area, would require disposal in an off-site permitted Class I facility. Conversely, less mobile and less toxic materials could be disposed of in an off-site Class III solid waste landfill in compliance with applicable laws.

Placement of Dredge Material on Farmland or Delta Islands with Control Levees. Sediment with elevated concentrations of mercury would be dredged from streams and/or excavated from active floodplain deposits. Non-hazardous sediment or processed fines would be transported to and placed on farmland protected by levees. Crop cover would be established or other control measures would be used to reduce erosion.

Placement of Dredge Material or Processed Fines as Fill for Construction. Sediment with elevated concentrations of mercury would be dredged from streams and/or excavated from active floodplain deposits. Non-hazardous sediment or processed fines would be transported to and used as construction fill. Pavement, building foundations, or other control measures would be used to reduce erosion.

Placement of Dredge Material or Processed Fines in an Off-site Class III Solid Waste Landfill. Sediment with elevated concentrations of mercury would be dredged from streams and/or excavated from active floodplain deposits. Non-hazardous sediment or processed fines with a mercury concentration below 20 mg/kg would be transported to and placed in an off-site Class III solid waste landfill.

Placement of Dredge Material or Processed Fines in an Off-site Class I Repository. Sediment with hazardous concentrations of mercury (from 20 to 260 mg/kg) would be dredged from streams and/or excavated from active floodplain deposits. Hazardous sediment or processed fines would be transported to and placed in a Class I repository.

4.2.1.4 Dredging and Treatment of Sediment

This alternative would incorporate the removal of sediment through dredging, or excavation of active floodplain deposits using conventional equipment, physical separation of aggregate from fines, and subsequent treatment that chemically, physically, or thermally results in a reduction of chemical toxicity and volume. Dredging and excavation can be completed using conventional equipment and accepted hazardous materials handling procedures. Containment and treatment of water encountered during dredging and excavation may also be necessary. Treatment processes have the primary objective of either: (1) concentrating the metal chemicals for additional treatment or recovery of valuable constituents, or (2) reducing the toxicity of the hazardous constituents, as described further below.

4.2.1.4.1 Physical Separation

Processing involves physical separation of the aggregate from fines and disposal of fine materials containing mercury under other desired control action. A batch sand and gravel plant set up for mercury recovery would be mobilized to the site to separate coarse material from fine materials containing mercury. The coarse fraction would be sold as an aggregate commodity.

4.2.1.4.2 Physical/Chemical Treatment

Dredged sediment or excavated active floodplain deposits would be processed as described above using a sand and gravel plant setup for mercury recovery. Fine materials would then be treated using physical/chemical treatment processes. Physical treatment processes use physical characteristics to concentrate constituents into a relatively small volume for disposal or further treatment. Chemical treatment processes act through the addition of a chemical reagent that removes or fixates the chemicals. The net result of chemical treatment processes is a reduction of toxicity and mobility of chemicals in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the impacted media with water, acids, bases, or surfactant.

Physical Separation of Aggregate from Fines and Off-site Retorting of Processed Fines. After physical separation of the fine materials from the coarse fraction, the fine materials would be disposed of as a non-hazardous material (mercury content below 20 mg/kg) or as a hazardous material (mercury content between 20 mg/kg and 260 mg/kg or leachable mercury greater than 0.2 mg/L) in an off-site Class I repository. Fine materials containing hazardous concentrations of mercury, above 260 mg/kg, which cannot be disposed of in a Class I repository would be transported to an off-site permitted retorting facility. The retort process volatilizes mercury from the processed fines by heating of material. Mercury vapor is then collected, recondensed, and sold as a commodity.

Physical Separation of Aggregate from Fines and Fixation/Stabilization of Processed Fines. After physical separation of the fine materials from the coarse fraction, the remaining concentrated fine material would then be fixed/stabilized for disposal. Fixation/stabilization can be used as a pretreatment process to limit the leachability of mercury prior to disposal of excavated non-hazardous fine materials on site or hazardous fine materials in an off-site waste repository. This helps address leachability concerns which would otherwise preclude off-site disposal in a Class III solid waste landfill. Solidifying/ stabilizing agents would be used in conjunction with mixing techniques to facilitate a physical or chemical change in the mobility of the mercury.

Physical Separation of Aggregate from Fines and Soil Washing of Processed Fines. After physical separation of the fine materials from the coarse fraction, the remaining concentrated fine material would then be washed for disposal. Soil washing would be used to separate metals from processed fine materials via dissolution in a heap, vat, or agitated vessel followed by precipitation in a separate vessel, thereby reducing the volume of material requiring off-site disposal in a Class III solid waste landfill or more restrictive Class I repository. The soil washing process would require construction of a large plant to remove mercury from fines and may still require disposal of fines in a Class I repository if the process is not effective.

4.2.2 Initial Screening of Control Actions for Stream Based Project Areas

The purpose of the initial screening is to eliminate process options that are not feasible from further consideration and retain those process options that are potentially feasible for detailed evaluation. The following subsections discuss the effectiveness and implementability of each GRA, control action, and process option identified above. A summary of these screening results is presented in Table 4-2b.

4.2.2.1 No Action

No action is a stand-alone control action that is used as a baseline for comparison against other load reduction alternatives. It would be of low to moderate effectiveness, as natural flushing of sediments through and gradual attenuation of mercury from the system would occur, and would be easy to implement. However, there would be no short-term change to mercury concentrations in the Bay-Delta. No action was retained through the detailed evaluation of load reduction alternatives as it is a baseline for comparison.

4.2.2.2 Institutional Controls

Stream based institutional controls include ensuring implementation of existing programs and improving O&M activities.

4.2.2.2.1 Ensure Implementation of Existing Programs

Depending on the degree of implementation, this control action would be of low to moderate effectiveness; however, it would be easy to implement. The timeframe to achieve load reduction is long term. Existing programs include community mercury recovery, river maintenance dredging, and recreational mining. Ensuring implementation of these existing programs could remove mercury from the system above the reservoirs, prevent its reintroduction, and reduce loading of mercury from urban areas. This control action primarily addresses mercury stored in stream sediments; however, controlling mercury releases from urban sources would also address active loading. Disturbance of mercury on fines during dredging may lead to a short term increase in mercury load; however, the total mass of mercury removed would outweigh any potential short term impacts. Although it would provide a relatively low load reduction in the overall system, over time it would reduce the buildup of the mercury mass in river sediment. Therefore, this action was retained through the detailed evaluation of load reduction alternatives.

4.2.2.2.2 Improve Operation and Maintenance Activities

Improving O&M activities could be moderately effective and easily implemented. The timeframe to achieve load reduction is short term, primarily by reducing mercury input from above reservoirs and reducing in channel load peaks during high flow events. This control action would reduce channel and floodplain erosion and in channel scour. It would also improve settling of suspended sediment within existing structures during high flow and flood events, when the majority of mercury is mobilized. Activities would be applicable at a local to regional scale and would primarily address fine sediment entering upstream reservoirs and active channel sediment within the lower system. Depending on the scale of flood events, it would provide relatively moderate to high load reduction from active sediment, and low to moderate reduction of the load entering the lower system from reservoirs. It may increase the wetting frequency/duration of off-stream land and provide an environment for mercury methylation. Because of the potential for high load reduction and easy implementability, this action was retained for the detailed evaluation of load reduction alternatives.

4.2.2.3 Engineering Controls

Stream based engineering controls include surface controls, containment, and dredging and disposal, which are discussed further below.

4.2.2.3.1 Surface Controls

The surface control action was retained for further consideration as a load reduction alternative or in combination with other alternatives. Potentially applicable surface control process options include the following: improving the efficiency of existing sediment control structures; stabilization of stream banks, the surface of active floodplains, and settling basin surfaces; and stabilization of Delta marshlands and unprotected Delta islands.

Improve Efficiency of Existing Sediment Control Structures. This option may provide a moderate increase in the effectiveness of existing sediment control structures and would be easy to moderately implementable, depending on the structure size and available space for expansion. The timeframe to achieve additional load reduction is over the short term, though the majority of load reduction will occur during high flow and flood events. Improving the efficiency of existing settling basins, flow control berms, and weirs would reduce flood flow velocity and increase the hydraulic residence time within settling basins and bypasses, and behind weirs and dams. It would capture all sediment size fractions, including fines with extended hydraulic residence time, and is applicable to all stream and river reaches and associated sediment control structures. There would be a relatively moderate load reduction for the system as a whole; however, it may increase the wetting frequency/duration of off-stream land and sediment behind the structures, providing an environment for mercury methylation. This process option was retained for the detailed evaluation of load reduction alternatives.

Stabilization of Stream Banks, Active Floodplain Surface, and Settling Basin Surface. Altering channel geometry and/or installing wing dams and rip rap, which reduce energy, could be moderately effective. Grading and revegetation would stabilize currently eroding stream banks, floodplains, and settling basin surfaces, could be moderately to highly effective. Energy reduction measures may be moderately difficult to implement, depending on the size of the stream and amount of channel alteration, while grading and revegetation measures are easily implementable. The timeframe to achieve load reduction is moderate term because it is necessary for vegetation to stabilize currently eroding stream banks, floodplains, and settling basin surfaces. Stabilization of stream banks, active floodplain surfaces, and settling basin surfaces reduces the energy contributing to the lateral migration of streams into and erosion of active and historic floodplains containing elevated levels of mercury from upstream mine sites. It would also reduce erosion of sediment from settling basin surfaces. Altering channel geometry and/or installing wing dams and rip rap is applicable primarily at small to medium size ephemeral to flashy streams. Grading and vegetative stabilization is applicable to all active floodplains and settling basins. This option provides relatively low to moderate load reduction to the system as a whole; however, it would provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). There is no net impact on the potential for mercury methylation anticipated. This process option was retained for the detailed evaluation of load reduction alternatives.

Stabilization of Delta Marshlands and Unprotected Delta Islands. This option could be highly effective at reducing erosion and capturing sediment during high tide and flood events. It would be moderately to difficult to implement, depending on the length of the levee system and hydraulic modifications. The timeframe to achieve load reduction is long term, as it would reduce the energy of water flowing through and over the marshlands and island and provide an environment for the deposition of sediment. Over time, the older sediment containing elevated levels of mercury would be covered and the margins of the marshlands and islands would be protected by reducing the lateral migration of the river. It would be applicable primarily to active lateral erosion areas on unprotected marshlands and islands in the Delta and should also be combined with stream bank stabilization measures. The potential erosive force of floodwaters must be considered if floodplains are restricted. Stabilization of Delta marshlands and unprotected Delta islands provides relatively low load reduction to the system as a whole and may increase the wetting frequency/duration of sediments captured in marshlands, providing an enhanced environment for mercury methylation. Therefore, this process option was not retained for the detailed evaluation of load reduction alternatives.

4.2.2.3.2 Containment

The containment control action was retained for further consideration as a load reduction alternative or in combination with other alternatives. Potentially applicable containment process options include leaving mercury-impacted sediment in place and using an earthen cover or engineered cap or diverting surface water from the impacted medium to reduce or eliminate the mobility of mercury.

Cap/Cover Lake and Settling Basin Sediments. This option could be moderately effective and moderately implementable for settling basins; however, it could be moderately to very difficult to implement for reservoirs. The timeframe to achieve load reduction is over the short term. Capping and covering limits erosion and/or entrainment of sediment containing elevated levels of mercury and reduces mercury available for methylation through isolation. As it only addresses mercury contained in the upper layer of mobile/erodible sediment, it provides relatively low load reduction to the system as a whole. It would provide moderate methyl mercury load reduction in sub-basins. However, the integrity of the cap/cover cannot be guaranteed due to erosive flood events in settling basins and potential exposure/down cutting during summer reservoir operations. Therefore, this process option was not retained for the detailed analysis of load reduction alternatives.

Flow Diversion to New Bypass to Promote Solids Settling. Diversion of flood waters to new bypasses to promote solids settling could be moderately effective, depending on the velocity reduction and length of the bypass, and moderately implementable, due to the need to construct long levees and the amount of farm land that would be placed under water during the winter. The timeframe to achieve load reduction is moderate term as the majority of the load is from sediment containing low mercury levels and the majority of load reduction will occur only during flood events. This option would allow capture of all sediment size fractions, including some fines when flow control weirs are added to slow down water velocity. It would be applicable to medium streams to large size rivers, primarily on the valley floor, where removal of heavy sediment loads during flood events is desired. Residual levels of mercury in deposited sediment would also need to be stabilized through crop cover. Although it may increase the wetting frequency/duration of off-stream land, providing an environment for mercury methylation, this option would provide relatively moderate load reduction to the system as a whole. Therefore, this process option was retained for the detailed analysis of load reduction alternatives.

Flow Diversion to New Settling Basin to Promote Solids Settling. This process option could be moderately to highly effective, depending on the size of the settling basin, and easy to moderately implementable, depending on available space and levee and weir structure sizing. The timeframe to achieved load reduction is short term; however, the majority of load reduction will occur during high flow and flood events. It captures all sediment size fractions, including fines with extended hydraulic residence time, and is applicable to small to medium size streams, primarily downstream of mining districts where relatively high mercury loading occurs during high flow and flood events. Excavation and disposal of sediment would be eventually required to maintain hydraulic residence time. It addresses mercury from mining districts before it disperses into main stem rivers; however, it may increase the wetting frequency/duration of off-stream land, providing an environment for mercury methylation. This option provides relatively moderate load reduction to the system as a whole; therefore, it was retained for the detailed analysis of load reduction alternatives.

Containment of Flood Flows within Levees to Limit Entrainment of Historic Floodplain Sediment. This process option could be highly effective at reducing erosion and easy to moderately implementable, depending on the degree of stream channel modification. The timeframe to achieve load reduction is short term. It would reduce exposure of active and historic floodplains containing elevated levels of mercury from upstream mine sites but is applicable primarily to active lateral erosion areas within and along small to medium size streams. The potential erosive force of floodwaters must be considered if the floodplain is restricted. This process option addresses mercury contained in actively eroding floodplain deposits containing mine waste. It provides relatively low to moderate load reduction to the system as a whole; however, it would provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). No net impact on potential for mercury methylation is anticipated. This process option was retained for the detailed analysis of load reduction alternatives.

Capture Sediment using Low Dams and Weirs within Small Creeks and Streams. This process option could be moderately to highly effective, depending on the size of the structure and sediment retention basin behind the structure, and would have moderate to difficult implementablity, depending on the size of the structure. The timeframe to achieve load reduction is short term for retained sediment and moderate term for necessary stabilization of currently eroding stream banks. The energy contributing to lateral migration of streams into and erosion of active and historic floodplains containing elevated levels of mercury from upstream mine sites is reduced. It is applicable primarily to small to medium size, ephemeral to flashy streams. Predominately medium- to coarse-grained mobile sediment would be captured behind the structure during high energy events and fine grained sediment would be captured at low to moderate flows. This action should be combined with stream bank stabilization measures and would require relatively frequent removal and disposal of accumulated sediment. It provides relatively low to moderate load reduction to the system as a whole; however, it would provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). It may increase the wetting frequency/duration of sediments contained behind the structure in ephemeral creeks, providing an enhanced environment for mercury methylation. This process option was retained for the detailed analysis of load reduction alternatives.

Cleaning and Grouting Floor of Hydraulic Mine Drainage Tunnels. This process option could be highly effective and easy to implement. The timeframe to achieve load reduction is short term. It removes sediment containing mercury from historic hydraulic mine drainage tunnels and reduces dissolution of mercury from tunnel host rock through isolation. However, it is applicable primarily at small-scale mine reclamation sites. Mercury contained in sediment is processed to reduce volume and retorted or placed in an off-site Class III landfill or Class I repository depending on waste characteristics. Mercury contained in actively eroding and intact tunnel sediment would be addressed. It may reduce the potential for mercury methylation through mass reduction and isolation of residual mercury in host rock. Although projects at mine sites could provide a moderate load reduction in specific sub-basins, it provides relatively little discernable load reduction to the system as a whole. In addition, load reduction to the lower river system would be limited as hydraulic mine sites are above foothill reservoirs. Therefore, this process option was not retained for the detailed analysis of load reduction alternatives.

Plugging of Hydraulic Mine Sluices and Drainage Tunnels. This process option could be highly effective and easily implementable, although the mass of mercury would remain within the drainage tunnel. Entry and movement of water through historic hydraulic mine drainage tunnels would be eliminated, and erosion and/or dissolution of mercury from tunnel sediment would be greatly reduced. However, it is applicable primarily at small-scale mine reclamation sites. The timeframe to achieve load reduction is short term. It addresses mercury contained in actively eroding and intact tunnel sediment, and may reduce the wetting frequency/duration of sediments within and downstream of drainage tunnels, reducing the potential for mercury methylation. Although projects at mine sites could obtain a moderate load reduction in specific sub-basins, there would be relatively little discernable load reduction provided to the system as a whole and limited load reduction to the lower river system as hydraulic mine sites are above foothill reservoirs. This process option was not retained for the detailed analysis of load reduction alternatives.

4.2.2.3.3 Dredging and Disposal

The dredging and disposal control action was retained for further consideration as a load reduction alternative. Potentially applicable process options incorporate the removal of sediment through dredging or excavation of floodplain deposits using conventional equipment, potential physical separation of aggregate from fines, and subsequent disposal of bulk sediment or fine materials. Dredging of mercury impacted sediments may result in short term dispersion of fines containing mercury within the water column; however, the total mass of mercury removed by dredging activities outweighs the potential short term impacts.

Placement of Dredge Materials on Farmland or Delta Islands with Control Levees. Placement of dredge materials on farmland or Delta islands with control levees could be highly effective and easy to implement, as whole sediment would be placed directly on Delta islands without processing. The timeframe to achieve load reduction is short to medium term depending on the scale of the dredging project. This option would address mercury contained in active stream and floodplain sediments and it could be removed from stream channels and active floodplains at small to large scales. If dredging or processing of fines occurred outside of the Delta, it would require trucking or barging of sediment to the Delta islands. In addition, placement of sediment on a levee controlled island would require controls to prevent reintroduction of sediment to the Delta. Depending on the mercury content and volume of sediment removed, this option would provide a relatively moderate to high load reduction within the system, and no net impact on potential mercury methylation is anticipated, other than through mercury mass reduction. Therefore, this process option was retained for the detailed analysis of load reduction alternatives.

Placement of Dredge Material or Processed Fines as Fill for Construction. Placement of dredge materials or processed fines as fill construction could be highly effective and easy to moderately implementable, as trucking of whole sediment or processed fines to a construction site is required. The timeframe to achieve load reduction is short to medium term depending on the scale of the dredging project. Mercury contained in active stream and floodplain sediments would be addressed at small to large scales and would require the use of erosion controls for construction fill not placed under pavement or foundations, so the reintroduction of sediment to the Delta is controlled. Although trucking costs may become prohibitive with large-scale projects, this option provides relatively moderate to high load reduction within the system, depending on the mercury content and volume of sediment removed. Therefore, this process option was retained for the detailed analysis of load reduction alternatives.

Placement of Dredge Material or Processed Fines in a Class III Solid Waste Landfill. Placement of dredge materials or processed fines in a Class III solid waste landfill could be highly effective and easy to moderately implementable, as trucking of whole sediment or processed fines would be required. The timeframe to achieve load reduction is short to medium term depending on the scale of the dredging project. Mercury contained in active stream and floodplain sediments could be addressed at small to large scales, which would provide relatively moderate to high load reduction within the system, depending on the mercury content and volume of sediment removed. However, trucking costs can become prohibitive with large-scale projects, and it is not cost-effective to dispose of a large volume of non-hazardous sediment or processed fines in a Class III solid waste landfill. As the concentration of mercury in stream sediment has not been documented at a high enough concentration to warrant disposal in a Class III solid waste landfill, this process option was not retained for the detailed analysis of load reduction alternatives.

Placement of Dredge Material or Processed Fines in an Off-site Class I Repository. Placement of dredge materials or processed fines in an off-site Class I repository could be highly effective and easy to moderately implementable, as trucking of whole sediment or processed fines would be required. The timeframe to achieve load reduction is short to medium term depending on the scale of the dredging project. Mercury contained in active sediment in stream channels and active floodplains could be addressed at small to large scales, which would provide relatively moderate to high load reduction within the system, depending on the mercury content and volume of sediment removed. However, trucking costs can become prohibitive with large-scale projects, and it is not cost-effective to dispose of a large volume of non-hazardous sediment or processed fines in a Class I repository. In addition, sufficient space may not be available within the repository for sediment disposal. As the concentration of mercury in stream sediment has not been documented at a high enough concentration to warrant disposal in a Class I repository, this process option was not retained for the detailed analysis of load reduction alternatives.

4.2.2.4 Dredging and Treatment of Sediment

Dredging and treatment incorporate the removal of sediment through dredging or excavation of active floodplain deposits, physical separation of aggregate from fines, and subsequent treatment through a specific treatment process that chemically, physically, or thermally results in a reduction of chemical toxicity and volume. Potentially applicable stream based dredging and treatment control actions include physical separation and physical/chemical treatment.

4.2.2.4.1 Physical Separation

This control action could be highly effective and be easy to moderately implementable, depending on whether aggregate processing is completed on the dredge or at a centralized facility. The timeframe to achieve load reduction is short to medium term depending on the scale of the project. Mercury contained in stream and active floodplain sediment would be addressed by removing the sediment at small to large scales. Placement of fine materials in a levee controlled area or managed environment is required. It provides relatively moderate to high load reduction within the system, depending on mercury content and volume of sediment removed; therefore, this action was retained for the detailed analysis of load reduction alternatives.

4.2.2.4.2 Physical/Chemical Treatment

Physical/chemical treatment control actions were not retained for further consideration as load reduction alternatives. Potentially applicable process options include physical separation of aggregate from fines and off-site retorting of processed fines, fixation/stabilization of processed fines, or soil washing of processed fines.

Physical Separation of Aggregate from Fines and Off-site Retorting of Processed Fines. This process option could be highly effective and be easy to moderately implementable, depending on whether aggregate processing is completed on the dredge or at a centralized facility. The timeframe to achieve load reduction is short to medium term depending on the scale of the project. Sediment containing mercury would be removed from stream channels and active floodplains at small to large scales. Depending on the mercury content and volume of sediment removed, it provides relatively moderate to high load reduction within the system. However, the concentration of mercury in stream sediment has not been documented at a high enough concentration to warrant retorting; therefore, this process option was not retained for the detailed analysis of load reduction alternatives.

Physical Separation of Aggregate from Fines and Fixation/Stabilization of Processed Fines. This process option could be highly effective and easy to moderately implementable, depending on whether aggregate processing is completed on the dredge or at a centralized facility. The timeframe to achieve load reduction is short to medium term depending on the scale of the project. Sediment containing mercury would be removed from stream channels and active floodplains at small to large scales, providing relatively moderate to high load reduction within system, depending on the mercury content and volume of sediment removed. As the concentration of mercury in stream sediment has not been documented at a high enough concentration for classification as a hazardous material or as a threat to water quality, fixation/stabilization is not necessary, and this process option was not retained for the detailed analysis of load reduction alternatives.

Physical Separation of Aggregate from Fines and Soil Washing of Processed Fines. This process option could be highly effective and easy to moderately implementable, depending on whether aggregate processing is completed on the dredge or at a centralized facility. The timeframe to achieve load reduction is short to medium term depending on the scale of the project. Sediment containing mercury would be removed from stream channels and active floodplains at small to large scales, providing relatively moderate to high load reduction within the system, depending on the mercury content and volume of sediment removed. As the concentration of mercury in stream sediment has not been documented at a high enough concentration for classification as a hazardous material or as a threat to water quality, washing of fine materials is not necessary, and this process option was not retained for the detailed analysis of load reduction alternatives.

4.2.3 Retained Load Reduction Alternatives for Stream Based Project Areas

Those control actions potentially capable of meeting TMDL goals for the stream based project areas have been combined into load reduction alternatives and are identified in Table 4-3b. Detailed evaluation of load reduction alternatives for stream based project areas is presented in Section 5.2. As mercury in lower watersheds is considered far too widespread for control measures such as stabilization, capping, and covering to be effective or economically feasible, the retained load reduction alternatives include control actions that may effectively reduce mercury-impacted sediment transport into the Delta.

5.0 ENGINEERING EVALUATION FOR RETAINED LOAD REDUCTION ALTERNATIVES

Selection of the appropriate load reduction alternative(s) depends on the following: 1) type of project area, 2) scalability, 3) effectiveness, 4) implementability, and 5) the range of costs. For both land based and stream based load reduction alternatives, the retained alternatives identified in Section 4.0 were evaluated.

5.1 LAND BASED LOAD REDUCTION ALTERNATIVES

Eleven land based load reduction alternatives were identified for areas outside of the levees or active floodplains and at the original sources of mercury. These retained load reduction alternatives may be applicable to upstream hydraulic and hard rock mines, upstream mercury mines, active channels, active floodplains, eroding stream banks, and historic floodplains. A summary of the engineering evaluation for land based load reduction alternatives is presented in Table 5-1a.

5.1.1 Alternative 1 - No Action

Under the no action alternative, no control action would occur associated with this project. Consequently, potential human health, ecological, and water quality impacts associated with mercury in sediment and surface water are assumed to remain unchanged. The no action alternative is used as a baseline against which other removal action alternatives are compared. The no action alternative was retained through the detailed analysis of alternatives.

5.1.1.1 Typical Project Area Types

The no action alternative applies to all potential project areas and locations.

5.1.1.2 Scalability

The no action alternative does not require evaluation of scalability for different size project areas.

5.1.1.3 Effectiveness

The no action alternative was considered to have low effectiveness for reducing mercury loading to the Delta. This alternative would not minimize or prevent the migration of sediment containing mercury. Mercury loading and migration to the Delta would be unchanged.

Under the no action alternative, no controls or long-term measures would be implemented to control mercury; consequently, this alternative provides no long-term effectiveness. The no action alternative would not be effective at reducing mercury loading to the Delta. The no action alternative would not provide any reduction in toxicity, mobility, or volume of mercury entering the Delta. In the short term, the no action alternative would pose no additional threats to the community or the environment.

5.1.1.4 Implementability

The no action alternative would be readily implementable and administratively feasible. No permits would be required to implement this alternative. No services or materials would be needed for the implementation of the no action alternative.

5.1.1.5 Costs

There are no costs associated with the no action alternative; therefore, this alternative was considered low cost.

5.1.2 Alternative 2 - Institute Land Use Restrictions and Ensure Implementation of Existing BMPs to Limit Practices that may Disturb Soils with Elevated Levels of Mercury

Under this alternative, zoning, deed restrictions, or easements could be instituted to help limit disturbance of soils containing elevated levels of mercury and also limit mobility of mercury laden soils. Soil conservation, tillage, crop cover management BMPs could also be used to reduce mercury laden sediment runoff from areas that received outwash from historic hydraulic mining.

5.1.2.1 Typical Project Area Types

This alternative would be applicable to historic mine sites and to those areas known to have mercury containing soil from historic hydraulic mining outwash that could potentially erode and be transported off site.

5.1.2.2 Scalability

This control action is applicable from individual mine sites up to floodplains adjacent to major rivers.

5.1.2.3 Effectiveness

Effectiveness would depend on the individual BMPs or land use restrictions to be implemented. The mercury reduction to the system as a whole is expected to be relatively low. However, individual sites may contribute moderate amounts of mercury to specific sub-basins. Implementation of BMPs could also reduce the scale of potential downstream projects such as settling basins.

5.1.2.4 Implementability

This control action is both technically and administratively feasible. The time frame for implementation would generally depend on the individual BMPs to be used, scale of land use restrictions proposed, and extent of input from stakeholders. Additional long-term monitoring and/or site management may be required to ensure that sites remain in compliance with land use restrictions and BMPs.

5.1.2.5 Costs

This alternative was considered low cost as it consists of implementation of existing BMPs and land use practices; however, long-term monitoring and verification of management practices may increase costs unless self reporting is implemented.

5.1.3 Alternative 3 - Grade, Revegetate, and Install Run-on and Runoff Controls/Diversions for Intact Mine Waste or Soils with Elevated Levels of Mercury

Under this alternative, disturbed mine features and mine waste, stream banks, and active floodplains (areas without levees) will be graded and revegetated to manage surface water infiltration, run-on, runoff, and erosion. Grading is the general term for techniques used to reshape the ground surface to reduce slopes, manage surface water infiltration and runoff, restore eroded areas, and to aid in erosion control. These techniques may include installation of berms, ditches, drains, and water control bars. Techniques used in grading are routine construction practices. The equipment and methods used in grading are similar for all surfaces, but will vary slightly depending on the waste location and the surrounding terrain. Equipment may include bulldozers, scrapers, graders, and compactors. Periodic maintenance and regrading may be necessary to eliminate depressions formed as a result of settlement, subsidence, or erosion and to aid revegetation.

Revegetation to control erosion involves adding soil amendments to the waste surface to provide nutrients, organic material, and neutralizing agents and improve the water storage capacity of the mine waste, active floodplains (no levees), and floodplains that received outwash from historic hydraulic mining. Revegetation will provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion and reduces net infiltration through the impacted medium by increasing evapotranspiration processes.

5.1.3.1 Typical Project Area Types

This alternative would generally be considered for hydraulic, hard rock, and mercury mines, active and historic floodplains and eroding stream banks and channels of ephemeral streams where erosion could transport mercury laden sediment downstream. Slopes too steep to be efficiently revegetated may require alternate treatment methods such as rock armoring or geotextile covering. As with all potential projects present and future land use needs to be considered in order to cost effectively prevent sediment migration.

5.1.3.2 Scalability

Grading, revegetation, and run-on/runoff controls reduce erosion and sediment loading at all scales from potentially impacted sites. However, large-scale grading could become less effective due to the disturbance of intact vegetation. This alternative could also be used in conjunction with other more effective alternatives to prevent erosion and scouring and to improve permanence of the alternative.

5.1.3.3 Effectiveness

Grading would be low to moderately effective at reducing mercury loading to the down gradient watersheds. Grading would reduce run-on and runoff of surface water and the rate that erosion carries mine waste containing mercury to downstream surface waters, especially for active and historic floodplains. The permanence of grading alone for reducing waste migration to surface water and the threat of human health and ecological exposure is highly dependent on maintenance activities and should be performed in conjunction with revegetation efforts. The objective of this alternative is to reduce mobility and loading; the volume and toxicity of the contaminants would not be physically reduced.

Revegetation would improve the effectiveness and permanence of grading measures that are implemented. Revegetation alone would be less effective. The timeframe to achieve load reduction is moderate to long term due to the time required to establish sufficient vegetative cover. Revegetation primarily addresses mercury contained in actively eroding mine waste and sediment originated from mining; however, it could also be used to stabilize diffuse mercury stored in active floodplains. Revegetation would provide relatively low load reduction depending on project scale.

This alternative provides relatively very low load reduction to the system as a whole; however, it could provide low to moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). The low effectiveness is primarily because the volume and toxicity of mercury in the environment would remain unchanged. However, mercury loading associated with sediment transport would be decreased downstream of the site due to a reduction in sediment mobility. Entrainment of impacted sediment, dissolution and migration of mercury, and mercury methylation would also be reduced.

5.1.3.4 Implementability

Grading is easily implementable at mine remediation sites, but becomes difficult at larger scales due to disturbance of intact vegetation. The timeframe to achieved load reduction is short term for small-scale projects, and moderate to long term for large-scale projects due to time for establishment of sufficient vegetative cover over newly disturbed soils.

This control action is technically and administratively feasible. Depending on the scale and available resources, all necessary actions could be implemented within one field season. However, follow up maintenance would likely be required for revegetation. Long-term monitoring and maintenance would be required.

Grading and slope stabilization require conventional construction practices; materials and construction methods are readily available. Design methods, construction practices, and engineering requirements for installation of berms, ditches, drains, box culverts, velocity breaks, water control bars, and sedimentation basins are well documented and understood. Equipment, materials, and labor would be available through the local market. Contacts with appropriate agencies regarding historical, cultural, and archeological remains would be required.

In addition, standards for grading, contouring; and erosion controls; and revegetation contained in the California Surface Mining and Reclamation Act (SMARA) would also be met. Appropriate air quality management district (AQMD) requirements for nuisance dust suppression and control apply for earth moving associated with this alternative -- these requirements would be met by applying water to roads that receive heavy vehicular traffic and to excavation/grading areas, if necessary. Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the grading. Appropriate levels of dermal and respiratory protection will be evaluated and implemented as necessary during disturbance of mine waste containing mercury.

The construction phase for this alternative could be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. On-site workers would be adequately protected by using appropriate personal protective equipment and by following safe work practices. Short-term air quality impacts to the surrounding environment may also occur. Control of fugitive dust emissions would be provided by applying water to surfaces receiving heavy vehicular traffic, as needed. Short-term risks of physical injury during construction activities would also exist, as well as community risk off site from increased truck traffic required to transport construction material to the site.

5.1.3.5 Costs

This alternative was considered low to moderate cost as it incorporates on-site controls.

5.1.4 Alternative 4 - Consolidate Non-Hazardous Mine Waste and/or Basin Sediment, Revegetate, and Install Run-on and Runoff Controls

Consolidation involves combining similar mine waste types or sediments with similar mercury concentrations in a common location for revegetation and run-on/runoff controls. Excavation during consolidation is accomplished with standard earthmoving equipment, including scrapers, bulldozers, excavators, loaders, and trucks. Additional precautionary measures, such as stream diversion or isolation, may be necessary in sensitive areas.

Excavation and consolidation of wastes combined with surface controls is used primarily to reduce the mobility of chemicals by reducing the area of exposure and moving the impacted waste to a location less susceptible to erosion. Surface control measures include grading, revegetation, run-on and runoff controls would further protect the waste from erosive forces.

Surface control measures would be used to divert surface water away from the consolidation area and to minimize infiltration of surface water and precipitation into the underlying impacted waste. Revegetation would increase evapotranspiration, which would further reduce infiltration. Precautionary measures, such as stream diversion or isolation, may be necessary for excavating materials contained on a floodplain. Containment and treatment of water encountered during excavation may also be necessary. In addition, the Regional Board Designated Level Methodology (DLM) should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. To ensure long-term reduction of mercury loading to local streams, consolidated waste containing mercury should be placed above floodplains and protected from future erosion to the extent practicable.

5.1.4.1 Typical Project Area Types

Consolidation is most applicable when multiple waste sources are present in reasonably close proximity, especially when one or more of the sources require removal from sensitive areas (floodplain, over steep slope, slide area, erosive area, or heavy traffic area). Consolidation is beneficial because treating a large combined waste source in one location is more efficient than treating several smaller waste sources dispersed throughout an area.

5.1.4.2 Scalability

Consolidation reduces the area available for erosion at a small scale, primarily at individual mine reclamation sites. Medium-scale consolidation (within a mining district) could be an option if there is an ideal location for consolidation centrally located to a number of mine sites or areas of contamination. However, large-scale consolidation will increase transportation costs of mine waste and may incur administrative barriers due to waste generator liability.

5.1.4.3 Effectiveness

This alternative adds an additional level of protection to the environment compared to grading, run-on, runoff controls and revegetation alone. The effectiveness of consolidation alone would still be limited as soil and sediment are subject to erosion. Revegetation and both run-on and runoff controls would stabilize the surface cover by providing additional erosion protection. This alternative provides relatively low load reduction to the system as a whole; however, it would provide a low to moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins).

Under this alternative, revegetation, and run-on and runoff controls would have to be inspected to ensure that the vegetation becomes established and the controls continue to perform as designed. Consequently, the long-term effectiveness and permanence depends on proper maintenance, including long-term monitoring and routine inspections. Selecting the appropriate plant species for revegetation would enhance the long-term effectiveness of containing the waste in place.

The objective of this alternative is to reduce chemical mobility and mercury loading; the volume and toxicity of the chemicals would not be physically reduced. Consolidating and containing the waste would reduce the number of sources, minimize surface water runoff, and minimize precipitation infiltration and leachate generation.

Overall, this alternative provides relatively low load reduction to the system as a whole; however, it could provide moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). Entrainment of impacted sediment, dissolution and migration of mercury, and mercury methylation would be reduced. Mercury loading associated with sediment transport would be decreased downstream of the site due to the reduction in sediment mobility.

5.1.4.4 Implementability

This alternative is readily implementable for mine waste and sediment containing mine waste and is both technically and administratively feasible. Excavation, backfilling, grading, and revegetation require conventional construction practices and materials are readily available. Design methods, construction practices, and engineering requirements for excavation and backfilling are well documented and understood. Equipment, materials, and labor would be available through local markets. Long-term monitoring and maintenance would be required.

The mining wastes addressed by this alternative were derived from the beneficiation and extraction of ores and are assumed to be exempt from federal government regulation through Resource Conservation and Recovery Act (RCRA) as hazardous material. Waste consolidation, containment, and construction of surface controls would meet the standards for diversion of flow from disturbed areas and revegetation requirements contained in the Surface Mining Control and Reclamation Act (SMCRA). In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality.

In addition, standards contained in the SMARA for backfilling, regrading, slope stability and recontouring, drainage, waterways, erosion control and revegetation would be met. Storm water generated during consolidation and construction activities would be managed in accordance with the CWA. Air pollution control district (APCD) nuisance dust suppression and control requirements are applicable for construction and earth-moving activities associated with this alternative for the control of fugitive dust emissions; these requirements would be met through water application to roads receiving heavy vehicular traffic and to construction or excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase.

Storm water, surface water, and/or groundwater intercepted during excavation activities may contain suspended sediment and residual levels of mercury and would therefore require collection, settling, and potential pretreatment prior to discharge to land or surface water. Likewise, process water generated during aggregate processing and storm water intercepted at or around the aggregate processing plant may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and implementation of water pretreatment methods are well understood and readily implementable.

The construction phase of this alternative could be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. There would be some potential of short-term risks of exposure to impacted material for the site worker during excavation, hauling, consolidation, and construction of run-on and runoff controls. Therefore, on-site workers must be adequately protected by using appropriate personal protective equipment and by following proper operating and safety procedures. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volumes of waste requiring hauling and consolidation. Control of fugitive dust emissions would be provided by applying water to surfaces receiving heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during construction activities would also exist on site, as well as off site from increased truck traffic required to transport construction material.

5.1.4.5 Costs

This alternative was considered low to moderate cost as it incorporates on-site controls.

5.1.5 Alternative 5 - Place an Earthen Cover over Intact or Consolidated Mine Waste and/or Basin Sediment, Revegetate, and Install Run-on and Runoff Controls

An inert waste, overburden, soil, or sediment would be applied over intact mine waste containing elevated concentrations of mercury. Containment of the waste would involve grading, construction of an earthen cover, and implementation of surface control measures. The cover would then be graded to control runoff and to divert high velocity flows. A vegetative cover would also be established to stabilize erodible surfaces. However, future removal of the impacted materials, if deemed necessary, would be more costly after a cover has been installed.

Containment of wastes combined with surface controls is used primarily to reduce the mobility of and exposure to chemicals. Wastes would be consolidated as part of this alternative to address highly mobile waste or waste in sensitive areas, such as near stream banks or drainages. The physical covering of wastes during containment reduces erosion of the actual waste and the potential health risk that may be associated with exposure (direct contact, airborne releases of particulates, or eroding to downstream surface waters) to the impacted media. Surface controls would be used to reduce chemical mobility and limit direct exposure to chemicals in those areas where containment is not employed. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality.

The containment steps would generally include the following: (1) consolidating and regrading the materials, (2) placement and compaction of a minimum of 6 inches of fill on top of the waste, (3) placement of an additional 12 inches of fill material on top of the compacted fill, and (4) grading and revegetating the disturbed areas and the cover. Surface control measures would be used to divert surface water away from the cover and to minimize infiltration (and subsequent formation of leachate) of surface water and precipitation into the underlying impacted waste. To ensure long-term reduction of mercury loading to local streams, the solidified/stabilized fines containing mercury should be placed above floodplains and protected from future erosion.

5.1.5.1 Typical Project Area Types

This alternative would generally be considered for upstream mercury, hydraulic and hard rock mine sites and for sediment containing mine waste in adjacent ephemeral creeks. This alternative would be applicable where mine waste and material containing non-hazardous concentrations of mercury are currently subject to erosion and contributing to the mercury loading.

5.1.5.2 Scalability

This alternative would generally be conducted on a small scale (single mine) to medium scale (multiple mines within a mining district). Consolidating mine waste at a central location from a number of mine sites could be advantageous if there is a single central area that is not subject to substantial erosive forces and is available for cost effective consolidation. Using a centralized consolidation area would generally only be advantageous if individual mine sites do not have appropriate areas for consolidation and covering.

5.1.5.3 Effectiveness

This alternative adds an additional level of protection to the environment compared to consolidation, grading, run-on, runoff controls and revegetation as described in the previous alternatives. The effectiveness of consolidation or surface controls alone would be limited as mine waste is still open to the environment and subject to erosion. An earthen cover provides a barrier to better isolate the material; surface controls and revegetation can then be used to make the earthen cover more permanent. Consolidation of waste would reduce the number of sources from which mine waste could be transported off the site.

Under this alternative, the earthen cover, revegetation, run-on, and runoff controls would have to be inspected to ensure that the cover remains intact, that vegetation becomes established and the controls continue to perform as designed. Consequently, long-term monitoring and maintenance would be required. The long-term effectiveness and permanence depends on proper maintenance, including long-term monitoring and routine inspections. Selecting the appropriate plant species for revegetation would enhance the long-term effectiveness of containing the waste in place.

The objective of this alternative is to reduce chemical mobility (for example, mercury loading); the volume or toxicity of the chemicals would not be physically reduced. Consolidating and covering the waste would reduce the number of sources, minimize chemical mobility from surface water runoff, minimize precipitation infiltration and leachate generation to a greater degree than consolidation alone.

Overall, this alternative provides relatively low load reduction to the system as a whole; however, it could provide moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins). The volume and toxicity of mercury in the environment would remain unchanged. Mercury loading associated with sediment transport would be decreased due to a reduction in sediment mobility and greater containment of the impacted sediment. Entrainment of impacted sediment, dissolution and migration of mercury, and mercury methylation would also be reduced.

5.1.5.4 Implementability

This alternative is readily implementable for mine waste and sediment containing mine waste and is both technically and administratively feasible. Excavation, backfilling, grading, and revegetation require conventional construction practices and materials are readily available. Design methods, construction practices, and engineering requirements for excavation and backfilling are well documented and understood. It is assumed that clean fill material for the earthen cover is available from a local source. Installation of an earthen cover would require the services of a contractor experienced in the proper installation of specialized caps. Equipment, materials, and labor would be available through most local markets. Long-term monitoring and maintenance would also be required.

The mining wastes addressed by this alternative were derived from the beneficiation and extraction of ores and are assumed to be exempt from federal government regulation through RCRA as hazardous material. Waste consolidation, containment, covering and construction of surface controls would meet the standards for diversion of flow from disturbed areas and revegetation requirements contained in the SMCRA. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality.

In addition, standards in the SMARA for backfilling, regrading, slope stability, and recontouring, drainage, erosion control, and revegetation would also be met. Storm water generated during consolidation and construction activities would be managed in accordance with the CWA. APCD nuisance dust suppression and control requirements are applicable for construction and earth-moving activities associated with this alternative for the control of fugitive dust emissions --these requirements would be met through water application to roads receiving heavy vehicular traffic and to construction or excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase.

Under this alternative, the cover would have to be inspected to ensure that the vegetation becomes established and continues to perform as designed. Consequently, long-term monitoring and maintenance would be required, especially of the revegetated slopes of the mine sites since the disturbed surfaces are susceptible to erosion. The waste cover would be the component most vulnerable to any damage or degradation that might occur. The cover would be susceptible to settlement, surface water ponding, erosion, and disruption of cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. The actual design life of the cover is not certain; however, since the cover would be periodically inspected, the required maintenance could be determined and implemented. The long-term effectiveness of containing the waste in place would be enhanced by determining the proper cover design and appropriate grading layout, and by selecting the appropriate plant species for revegetation. In addition, institutional controls may be required to prevent land uses incompatible with the mitigation alternative. Specifically, land uses that would compromise the waste cover should be precluded.

Storm water, surface water, and/or groundwater intercepted during excavation activities may contain suspended sediment and residual levels of mercury and would therefore require collection, settling, and potential pretreatment prior to discharge to land or surface water. Likewise process water generated during aggregate processing and storm water intercepted at or around the aggregate processing plant may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and implementation of water pretreatment methods are well understood and readily implementable.

The construction phase of this alternative could be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. There would be some potential short-term risks of exposure to impacted material for the site worker during excavation, hauling, consolidation, and construction of run-on and runoff controls. Therefore, on-site workers must be adequately protected by using appropriate personal protective equipment and by following proper operating and safety procedures. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volumes of waste requiring hauling and consolidation. Control of fugitive dust emissions would be provided by applying water to surfaces receiving heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during construction activities would also exist on site and off site due to the increased truck traffic required to transport construction material.

5.1.5.5 Costs

This alternative was considered moderate in cost as it incorporates an earthen cover, an on-site containment structure.

5.1.6 Alternative 6 - Excavation, Process Aggregate as a Commodity, and On- or Off-Site Disposal of Non-Hazardous Fines

Under this alternative, a portable aggregate plant would be mobilized to the site to separate particles of high specific gravity (including mercury) from excavated mine waste, process waste, and mine related sediment containing total mercury at a concentration of less than 20 mg/kg. Grizzlies, vibrating screens, trommels, concentration tables, and sluices would be used to segregate oversize, coarse, medium, and fine materials at the aggregate plant. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury that would be captured during processing, and to estimate the volume of saleable aggregate compared to the amount of fines that would be generated. Results of the treatability study would also help guide the selection of an appropriate method of disposal for the fines.

The excavation(s) would then be backfilled as necessary with inert material, including the fraction of aggregate that is not a saleable commodity and any necessary make-up clean fill material. The backfilled area would then be graded to control runoff, divert high velocity flows, establish vegetative cover and stabilize the surface. Aggregate material with economic value would be transported off site for use in construction in the local area. Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. Unrestricted on- or off-site site disposal of fines would require a total mercury concentration of less than 20 mg/kg and a leachable mercury concentration of less than 0.2 mg/L (soluble threshold limit concentration [STLC]). If either the total mercury concentration or leachable fraction exceed these criteria, an alternate disposal method would be necessary for the processed fines. In addition, the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. To ensure long-term reduction of mercury loading to local streams, fines containing mercury should be placed above floodplains and protected from future erosion.

5.1.6.1 Typical Project Area Types

This alternative would generally be considered for upstream mercury, hydraulic and hard rock mine sites, and sediment containing mine waste in adjacent ephemeral creeks. This alternative would be applicable where mine waste and material containing non-hazardous concentrations of mercury are currently subject to erosion and contribute to the mercury loading. While the mercury concentration in mine waste or material containing mine waste may not be high enough to warrant removal based on hazardous characteristic, threat to human health, or ecological receptors alone, it may still contribute to mercury loading in a Delta tributary. Therefore, excavation and processing of such mine wastes may be justified.

5.1.6.2 Scalability

This alternative would generally be conducted on a small (single mine) to medium scale (multiple mines within a mining district). Conducting physical separation of aggregate from fines at a location that is convenient for a number of excavation sites (throughout a mining district for instance) would reduce processing plant mobilization costs. However, it would require bulk material transport to a centralized facility and substantial coordination between excavation contractors and the processing facility. Disposing of fines in a common location may also be advantageous if there is a single central area that is not subject to substantial erosive forces and is available for cost effective consolidation. Using a centralized processing facility or disposal area would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.1.6.3 Effectiveness

This alternative addresses mercury contained in actively eroding mine waste and adjacent ephemeral creeks containing mine related waste. Implementation of each step of this alternative would reduce, to varying degrees, the volume, mobility, load, and potential human health, ecological, and water quality threats posed by mercury contained in mine waste.

The first step of this alternative involves excavation and transport of erodible mine waste to an on-site aggregate processing plant and backfilling of the open excavation as needed with inert material (the processed non-saleable aggregate could be used as a portion of the inert material). Excavation of the mine waste would greatly reduce the volume and mobility of mine waste available for erosion and subsequent mercury load as the mine waste is removed from the site. In addition, excavation of mine waste would also reduce the potential threat to human health, ecological receptors, and water quality (if applicable) through material removal from the site.

The second step of this alternative involves the processing of the bulk mine waste to separate saleable aggregate from fines containing residual mercury. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury that would be captured during processing, and to estimate the volume of saleable aggregate compared to the amount of fines that would be generated. Results of the treatability study would also help guide the selection of an appropriate method of disposal for the concentrated fines. Separation of fines from the bulk material would greatly reduce the volume of material though concentration of fines; however, the physical separation process alone would not reduce the mobility, load, or potential threat posed by residual mercury to human health, ecological receptors, and water quality. Instead, the processed fines would require disposal in an area isolated from streams and creeks and protected from erosion through grading and revegetation.

The final step of this alternative involves the disposal of concentrated fines generated during the processing of bulk mine waste. Unrestricted on- or off-site site disposal of fines would require a total mercury concentration of less than 20 mg/kg and a leachable mercury concentration of less than 0.2 mg/L. If either the total mercury concentration or leachable fraction exceed these criteria, an alternate disposal method would be necessary for the processed fines. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. To ensure long-term reduction of mercury loading to local streams, fines containing mercury should be placed above floodplains and protected from future erosion. Permanence would be achieved by isolating fines using run-on/runoff controls and revegetation practices. Exclusion of the on-site disposal area for concentrated fines from floodplains and revegetation of the disposal area would greatly reduce the mobility of fines and potential loading to creeks. In addition, the potential threat to human health, ecological receptors, and water quality would be minimized due to the large reduction in waste volume and exposure area. Off-site disposal of fines would maximize the reduction of volume, mobility, and loading; however, BMPs would be required to control erosion at the off-site disposal area. In addition, the potential threat to human health, ecological receptors, and water quality (if applicable) would be eliminated as material is not returned to site.

Overall, this alternative greatly reduces the volume of material available for erosion and the mobility of processed fines placed on site, provides a large reduction in mercury load, and provides a moderate reduction in potential human health, ecological, and water quality threats. Load reduction effectiveness would be rated very high; however, the overall mercury load reduction to the watershed would depend on the mercury concentration of the bulk material at the site and the timing and duration of sediment delivery to the watershed. In general, potential mercury load reduction from mine sites with low to moderate mercury concentrations (background to 20 mg/kg) and small, short flow duration creeks is considered to be low to moderate for subwatersheds and very low for the Delta system as a whole. However, a low to moderate load reduction in specific subwatersheds could reduce the scale of downstream projects (for example, settling basins).

5.1.6.4 Implementability

This alternative is readily implementable for mine waste, process waste, and sediment containing mine waste and is both technically and administratively feasible. Excavation, backfilling, grading, and revegetation require conventional construction practices and materials are readily available. Design methods, construction practices, and engineering requirements for excavation and backfilling are well documented and understood. Physical separation of aggregate from fines containing mercury would require a standard aggregate processing plant. Equipment, materials, and labor would be available through most local markets.

Storm water, surface water, and/or groundwater intercepted during excavation activities may contain suspended sediment and residual levels of mercury; therefore, collection, settling, and potential pretreatment may be required prior to discharge to land or surface water. Likewise, process water generated during aggregate processing and storm water intercepted at or around the aggregate processing plant may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and implementation of water pretreatment methods are well understood and readily implementable.

In addition, standards in the SMARA for backfilling, grading and contouring, drainage and erosion controls, and revegetation would also be met. AQMD requirements for nuisance dust suppression and control apply for earth moving and aggregate process plant operation would be met by applying water to roads that receive heavy vehicular traffic, to bar screens, and to excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the excavation, backfilling, and process plant operations. Appropriate levels of dermal and respiratory protection would be evaluated and implemented as necessary during removal of mine waste containing mercury and during bulk material processing.

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volumes of waste requiring hauling and aggregate processing. Control of fugitive dust emissions would be provided by applying water to roads and surfaces receiving heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during excavation, backfilling, equipment and material transport, and aggregate processing activities would also exist on site.

5.1.6.5 Costs

This alternative was considered moderate to high cost due to equipment and transportation costs associated with excavation, aggregate processing, and off-site disposal.

5.1.7 Alternative 7 - Excavation, Process Aggregate as a Commodity, and On-Site Fixation/Stabilization of Hazardous Fines

Under this alternative, a portable aggregate plant would be mobilized to the site to separate particles of high specific gravity (including mercury) from excavated mine waste, process waste, and mine related sediment containing total mercury at a concentration of greater than 20 mg/kg or leachable mercury greater than 0.2 mg/L. Grizzlies, vibrating screens, trommels, concentration tables, and sluices would be used to segregate oversize, coarse, medium, and fine materials at the aggregate plant. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury and fines that would be captured during processing, and to estimate the volume of saleable aggregate compared to the amount of fines that would be generated. Results of the treatability study would also help guide the selection for an appropriate method of disposal for the mercury and fines.

The excavation(s) would then be backfilled as necessary with inert material, including the fraction of aggregate that is not a saleable commodity and any necessary make up clean fill material. The backfilled area would then be graded to control runoff and divert high velocity flows. A vegetative cover would be established to stabilize the surface. Aggregate material with economic value would be transported off site for use in construction in the local area. Fines that are separated from the bulk mine waste would be solidified/stabilized and tested to determine the appropriate disposal methods. Solidification/stabilization of fines and on-site disposal would require a leachable mercury concentration of less than 0.2 mg/L. Total mercury concentration is not regulated because the mercury is not available for transport and the impacted sediments were derived from the beneficiation and extraction of ores and therefore are assumed to be exempt from federal and California regulations as a hazardous waste. However, if the leachable fraction exceeds the criteria, an alternate disposal method would be necessary for the processed fines. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. To ensure long-term reduction of mercury loading to local streams, the solidified/stabilized fines containing mercury should be placed above floodplains and protected from future erosion.

5.1.7.1 Typical Project Area Types

This alternative would generally be considered for upstream mercury, hydraulic and hard rock mine sites, and sediment containing mine waste in adjacent ephemeral creeks. This alternative would be applicable where mine waste and material containing hazardous concentrations of mercury are currently subject to erosion and contribute to the mercury loading.

5.1.7.2 Scalability

This alternative would generally be conducted on a small scale (single mine) to medium scale (multiple mines within a mining district). Physically separating aggregate from fines at a location that is central to a number of excavation sites (throughout a mining district for instance) would reduce processing plant mobilization costs. However, it would require bulk material transport to a centralized facility and substantial coordination between excavation contractors and the processing facility. Using a centralized processing facility would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.1.7.3 Effectiveness

This alternative addresses mercury contained in actively eroding mine waste and adjacent ephemeral creeks containing mine related waste. Implementation of each step of this alternative would reduce, to varying degrees, the volume, mobility, load, and potential human health, ecological, and water quality threats posed by mercury contained in mine waste.

The first step of this alternative involves excavation and transport of erodible mine waste to an on-site aggregate processing plant and backfilling of the open excavation as needed with inert material (the processed non-saleable aggregate could be used as a portion of the inert material). Excavation of the mine waste would greatly reduce the volume and mobility of mine waste available for erosion and subsequent mercury load as the mine waste is removed from the site. In addition, excavation of mine waste would also reduce the potential threat to human health, ecological receptors, and water quality (if applicable) through material removal from the site.

The second step of this alternative involves the processing of the bulk mine waste to separate saleable aggregate from fines containing mercury and other heavy metals. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury and heavy metals that would be captured during processing and to estimate the volume of saleable aggregate compared to the amount of fines that would be generated. Results of the treatability study would also help guide the selection of an appropriate method of disposal for the concentrated fines. Separation of fines from the bulk material would greatly reduce the volume of material through concentration of fines; however, the physical separation process alone would not reduce the mobility, load, or potential threat posed by residual mercury to human health, ecological receptors, and water quality. Instead, the processed fines would require solidification/stabilization in an area isolated from streams and creeks and protected from erosion through grading and revegetation.

The final step of this alternative involves the disposal of the solidified/stabilized concentrated fines. On-site disposal of fines would require a leachable mercury concentration of less than 0.2 mg/L. If the leachable fraction exceeds this criterion, an alternate disposal method would be necessary for the processed and solidified/stabilized fines. In addition, the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. Permanence would be achieved by solidifying/stabilizing the fines into an inert form. Location of the on-site disposal area for the solidified/stabilized fines away from floodplains and revegetation of the disposal area would reduce the possibility of solidified/stabilized fines being transported downstream during a high water event. In addition, the potential threat to human health, ecological receptors, and water quality (if applicable) would be minimized due to the large reduction in waste volume and exposure area and stabilization into an inert form.

Overall, this alternative greatly reduces the volume of material available for erosion and the mobility of stabilized/solidified fines should be nearly non-existent. It provides a large reduction in mercury load and a moderate to large reduction in potential human health, ecological, and water quality threats. Load reduction effectiveness would be rated very high, though the overall mercury load reduction to the watershed would depend on mercury concentration of the bulk material at the site and the timing and duration of sediment delivery to the watershed. In general, mercury load reduction from mine sites with moderate to high mercury concentrations (greater than 20 mg/kg) and small, short flow duration creeks is considered to be moderate for subwatersheds and very low to low for the Delta system as a whole. However, a moderate load reduction in specific subwatersheds could reduce the scale of downstream projects (for example, settling basins).

5.1.7.4 Implementability

This alternative is readily implementable for mine waste, process waste, and sediment containing mine waste and is both technically and administratively feasible. Solidification/stabilization, excavation, backfilling, grading, and revegetation require conventional construction practices and materials are readily available. Design methods, construction practices, and engineering requirements for excavation and backfilling are well documented and understood. Physical separation of heavy minerals from excavated sediment would require a specialized aggregate processing plant and a contractor experienced with mercury recovery and management. Equipment, materials, and labor would be available through most local markets.

Storm water, surface water, and/or groundwater intercepted during excavation activities may contain suspended sediment and residual levels of mercury; therefore, collection, settling, and potential pretreatment would be required prior to discharge to land or surface water. Likewise process water generated during aggregate processing and storm water intercepted at the aggregate processing plant may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and implementation of water pretreatment methods are well understood and readily implementable.

In addition, standards in the SMARA for backfilling, grading and contouring, drainage and erosion controls, and revegetation would also be met. Appropriate AQMD requirements for nuisance dust suppression and control apply for earth moving and aggregate process plant operation associated with this alternative; these requirements would be met by applying water to roads that receive heavy vehicular traffic, to bar screens, and to excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the excavation, backfilling, and process plant operations. Appropriate levels of dermal and respiratory protection will be evaluated and implemented as necessary during removal of mine waste containing mercury and during bulk material processing.

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volumes of waste requiring hauling and aggregate processing. Control of fugitive dust emissions would be provided by applying water to roads and surfaces receiving heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during excavation, backfilling, equipment and material transport and aggregate processing activities would also exist on site.

5.1.7.5 Costs

This alternative was considered moderate to high cost due to equipment and treatment costs associated with excavation, aggregate processing, and on-site fixation/stabilization of hazardous fines.

5.1.8 Alternative 8 - Excavation, Process Aggregate as a Commodity, and Placement of Hazardous Fines in an Off-Site Class I Repository

Under this alternative, a portable aggregate plant would be mobilized to the site to separate particles of high specific gravity (including mercury) from excavated mine waste, process waste, and mine related sediment containing total mercury at a concentration of greater than 20 mg/kg or leachable mercury greater than 0.2 mg/L. Grizzlies, vibrating screens, trommels, concentration tables, and sluices would be used to segregate oversize, coarse, medium, and fine materials at the aggregate plant. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury and fines that would be captured during processing and to estimate the volume of saleable aggregate compared to the amount of fines and heavy metals that would be generated. Results of the treatability study would also help guide the selection for an appropriate method of disposal for the mercury and fines.

The excavation(s) would then be backfilled as necessary with inert material, including the fraction of aggregate that is not a saleable commodity and any necessary make up clean fill material. The backfilled area would then be graded to control runoff; divert high velocity flows; establish vegetative cover and to stabilize the surface. Aggregate material with economic value would be transported off-site for use in construction in the local area. Fines that are separated from the bulk mine waste would be tested to confirm the total mercury content and transported off-site to a Class I repository. Off-site disposal at a Class I repository would require a total mercury concentration of less than 260 mg/kg. If the total mercury concentration is greater than 260 mg/kg, an alternate disposal method would be required.

5.1.8.1 Typical Project Area Types

This alternative would generally be considered for upstream mercury, hydraulic and hard rock mine sites and sediment containing mine waste in adjacent ephemeral creeks. This alternative would be applicable where mine waste and material containing hazardous concentrations of mercury are currently subject to erosion and contribute to mercury loading.

5.1.8.2 Scalability

This alternative would generally be conducted on a small scale (single mine) to medium scale (multiple mines within a mining district). Physically separating aggregate from fines at a location that is central to a number of excavation sites (throughout a mining district for instance) would reduce processing plant mobilization costs. However, it would require bulk material transport to a centralized facility and substantial coordination between excavation contractors and the processing facility. Using a centralized processing facility would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.1.8.3 Effectiveness

This alternative addresses mercury contained in actively eroding mine waste and adjacent ephemeral creeks containing mine related waste. Implementation of each step of this alternative would reduce, to varying degrees, the volume, mobility, load, and potential human health, ecological, and water quality threats posed by mercury contained in mine waste.

The first step of this alternative involves excavation and transport of erodible mine waste to an on-site aggregate processing plant and backfilling of the open excavation as needed with inert material (the processed non-saleable aggregate could be used as a portion of the inert material). Excavation of the mine waste would greatly reduce the volume and mobility of mine waste available for erosion and subsequent mercury load as the mine waste is removed from the site. In addition, excavation of mine waste would also reduce the potential threat to human health, ecological receptors, and water quality (if applicable) through material removal from the site.

The second step of this alternative involves the processing of the bulk mine waste to separate saleable aggregate from impacted fines and other heavy metals. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury and heavy metals that would be captured during processing and to estimate the volume of saleable aggregate compared to the amount of fines that would be generated. Results of the treatability study would also help guide the selection of an appropriate method of disposal for the concentrated fines. Separation of fines from the bulk material would greatly reduce the volume of material through concentration of fines; however, the physical separation process alone would not reduce the mobility, load, or potential threat posed by residual mercury to human health, ecological receptors, and water quality. Instead, the processed fines would require off-site disposal to remove them from watershed.

The final step of this alternative involves the disposal of the concentrated fines. Off-site disposal of fines at a Class I repository would require a total mercury concentration of less than 260 mg/kg. If the total mercury concentration exceeds this criterion, an alternate disposal method would be necessary for the processed fines. Permanence would be achieved by removing the fines containing mercury from the system. In addition, the potential threat to human health, ecological receptors, and water quality (if applicable) would be nearly removed due to the large reduction in waste volume and exposure area. Off-site disposal of fines at a Class I repository would maximize the reduction of volume, mobility, and loading. In addition, the potential threat to human health, ecological receptors, and water quality (if applicable) would be eliminated as material is not returned to site.

Overall, this alternative removes the impacted volume of material available for erosion, and mobility of fines should be nearly non-existent. It provides a large reduction in mercury load and a large reduction in potential human health, ecological, and water quality threats. Load reduction effectiveness would be rated high, though the overall mercury load reduction to the watershed would depend on mercury concentration of the bulk material at the site and the timing and duration of sediment delivery to the watershed. In general, mercury load reduction from mine sites with moderate to high mercury concentrations (greater than 20 mg/kg) and small, short flow duration creeks is considered to be moderate for subwatersheds and very low to low for the Delta system as a whole. However, a moderate load reduction in specific subwatersheds could reduce the scale of downstream projects (for example, settling basins).

5.1.8.4 Implementability

This alternative is readily implementable for mine waste, process waste, and sediment containing mine waste and is both technically and administratively feasible. Excavation, backfilling, grading, and revegetation require conventional construction practices and materials are readily available. Design methods, construction practices, and engineering requirements for excavation and backfilling are well documented and understood. Physical separation of heavy minerals from excavated sediment would require a specialized aggregate processing plant and a contractor experienced with mercury recovery and management. Removal of hazardous material would require a certified hazardous waste hauling contractor and a permitted Class I Repository. Equipment, materials, and labor would be available through most local markets. A Class I repository may require more substantial transportation distance.

Storm water, surface water, and/or groundwater intercepted during excavation activities may contain suspended sediment and residual levels of mercury; therefore collection, settling, and potential pretreatment would be required prior to discharge to land or surface water. Likewise process water generated during aggregate processing and storm water intercepted at the aggregate processing plant may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and implementation of water pretreatment methods are well understood and readily implementable.

In addition, standards in the SMARA for backfilling, grading and contouring, drainage and erosion controls, and revegetation would also be met. Appropriate AQMD requirements for nuisance dust suppression and control apply for earth moving and aggregate process plant operation associated with this alternative; these requirements would be met by applying water to roads that receive heavy vehicular traffic, to bar screens, and to excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the excavation, backfilling, and process plant operations. Appropriate levels of dermal and respiratory protection will be evaluated and implemented as necessary during removal of mine waste containing mercury and during bulk material processing.

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volumes of waste requiring hauling and aggregate processing. Control of fugitive dust emissions would be provided by applying water to roads and surfaces receiving heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during excavation, backfilling, and aggregate processing activities would also exist on site, as well as off-site from increased truck traffic required to mobilize and demobilize construction equipment and transport bulk material and processed fines.

5.1.8.5 Costs

This alternative was considered high cost due to equipment, transportation, and disposal costs associated with excavation, aggregate processing, and placement of hazardous fines in an off-site Class I repository.

5.1.9 Alternative 9 -Excavation, Process Aggregate as a Commodity, and Off-Site Retorting of Hazardous Fines

Under this alternative, a portable aggregate plant would be mobilized to the site to separate particles of high specific gravity (including mercury) from excavated mine waste, process waste and mine related sediment containing hazardous total mercury at a concentration of greater than 20 mg/kg. Grizzlies, vibrating screens, trommels, concentration tables, and sluices would be used to segregate oversize, coarse, medium, and fine materials at the aggregate plant. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury and fines that would be captured during processing and to estimate the volume of saleable aggregate compared to the amount of fines and heavy metals that would be generated. Results of the treatability study would also help guide the selection for an appropriate method of disposal for the mercury and fines.

The excavation(s) would then be backfilled as necessary with inert material, including the fraction of aggregate that is not a saleable commodity and any necessary make up clean fill material. The backfilled area would then be graded to control runoff; divert high velocity flows; establish vegetative cover and to stabilize the surface. Aggregate material with economic value would be transported off site for use in construction in the local area. Fines that are separated from the bulk mine waste would be tested to confirm the total mercury content and transported off site to a retorting facility. Retorting of fines is only necessary if the total mercury concentration is greater than 260 mg/kg. If the total mercury concentration is less than 260 mg/kg, a less costly disposal method would be recommended.

5.1.9.1 Typical Project Area Types

This alternative would generally be considered for highly impacted upstream mercury, hydraulic and hard rock mine sites and sediment containing highly impacted mine waste in adjacent ephemeral creeks. This alternative would be applicable where mine waste and material containing hazardous concentrations of mercury are currently subject to erosion and contribute to mercury loading.

5.1.9.2 Scalability

This alternative would generally be conducted on a small (single mine) to medium scale (multiple mines within a mining district). Physically separating aggregate from fines at a location that is central to a number of excavation sites (throughout a mining district for instance) would reduce processing plant mobilization costs if multiple sites. However, it would require bulk material transport to a centralized facility and substantial coordination between excavation contractors and the processing facility. Using a centralized processing facility would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.1.9.3 Effectiveness

This alternative addresses mercury contained in actively eroding mine waste and adjacent ephemeral creeks containing mine related waste. Implementation of each step of this alternative would reduce, to varying degrees, the volume, mobility, load, and potential human health, ecological, and water quality threats posed by mercury contained in mine waste.

The first step of this alternative involves excavation and transport of erodible mine waste to an on-site aggregate processing plant and backfilling of the open excavation as needed with inert material (the processed non-saleable aggregate could be used as a portion of the inert material). Excavation of the mine waste would greatly reduce the volume and mobility of mine waste available for erosion and subsequent mercury load as the mine waste is removed from the site. In addition, excavation of mine waste would also reduce the potential threat to human health, ecological receptors, and water quality (if applicable) through material removal from the site.

The second step of this alternative involves the processing of the bulk mine waste to separate saleable aggregate from impacted fines, mercury, and other heavy metals. A treatability study would be necessary to ensure that physical separation is feasible, determine the amount of mercury and heavy metals that would be captured during processing and to estimate the volume of saleable aggregate compared to the amount of fines that would be generated. Results of the treatability study would also help guide the selection of an appropriate method of disposal for the concentrated fines. Separation of fines from the bulk material would greatly reduce the volume of material through concentration of fines; however, the physical separation process alone would not reduce the mobility, load, or potential threat posed by residual mercury to human health, ecological receptors, and water quality. Instead, the processed fines would require off-site disposal/retorting to remove them from watershed.

The final step of this alternative involves the disposal of the concentrated fines. Retorting of fines would be required for total mercury concentration of greater than 260 mg/kg. If the total mercury concentrations do not exceed this criterion, an alternate disposal method for the fines would be more cost effective. Permanence would be achieved by removing the fines containing mercury from the system. In addition, the potential threat to human health, ecological receptors, and water quality (if applicable) would be nearly removed due to the large reduction in waste volume and exposure area. Off-site retorting of fines would maximize the reduction of volume, mobility, and loading. In addition, the potential threat to human health, ecological receptors, and water quality (if applicable) would be eliminated as material is not returned to site.

Overall, this alternative removes the impacted volume of material available for erosion, and mobility of fines should be nearly non-existent. It provides a large reduction in mercury load and a large reduction in potential human health, ecological, and water quality threats. Load reduction effectiveness would be rated high, though the overall mercury load reduction to the watershed would depend on the mercury concentration of the bulk material at the site and the timing and duration of sediment delivery to the watershed. In general, mercury load reduction from mine sites with high mercury concentrations (greater than 20 mg/kg) and small, short flow duration creeks is considered to be moderate to high for subwatersheds and very low to low for the Delta system as a whole. However, a moderate to high load reduction in specific subwatersheds could reduce the scale of downstream projects (for example, settling basins).

5.1.9.4 Implementability

This alternative is readily implementable for mine waste, and sediment containing mine waste and is both technically and administratively feasible. Excavation, backfilling, grading, and revegetation require conventional construction practices and materials are readily available. Design methods, construction practices, and engineering requirements for excavation and backfilling are well documented and understood. Physical separation of heavy minerals from excavated sediment would require a specialized aggregate processing plant and a contractor experienced with mercury recovery and management. Removal of hazardous material would require a certified hazardous waste hauling contractor and a permitted retort facility. Equipment, materials, and labor would be available through most local markets. Hauling hazardous material to retorting facilities may require substantial transportation.

Storm water, surface water, and/or groundwater intercepted during excavation activities may contain suspended sediment and residual levels of mercury; therefore, collection, settling, and potential pretreatment would be required prior to discharge to land or surface water. Likewise process water generated during aggregate processing and storm water intercepted at the aggregate processing plant may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and implementation of water pretreatment methods are well understood and readily implementable.

In addition, standards in the SMARA for backfilling, grading and contouring, drainage and erosion controls, and revegetation would also be met. Appropriate AQMD requirements for nuisance dust suppression and control apply for earth moving and aggregate process plant operation associated with this alternative; these requirements would be met by applying water to roads that receive heavy vehicular traffic, to bar screens, and to excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the excavation, backfilling, and process plant operations. Appropriate levels of dermal and respiratory protection will be evaluated and implemented as necessary during removal of mine waste containing mercury and during bulk material processing.

The construction phase of this alternative would likely be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volumes of waste requiring hauling and aggregate processing. Control of fugitive dust emissions would be provided by applying water to roads and surfaces receiving heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during excavation, backfilling, and aggregate processing activities would also exist on site, as well as off-site from increased truck traffic required to mobilize and demobilize construction equipment and transport bulk material and processed fines.

5.1.9.5 Costs

This alternative was considered high cost due to equipment, transportation, and treatment/disposal costs associated with excavation, aggregate processing, and off-site retorting of hazardous fines.

5.1.10 Alternative 10 - Construct Check Dams and Settling Basins to Capture Solids Eroding from Mine Site

This alternative would consist of constructing one or more check dams or settling basins downstream of various mine site features to promote settling of solids from storm water runoff. The check dams and settling basins in this alternative would generally be constructed in tributaries, site drainages, and ephemeral streams. Larger scale settling basins are discussed in Section 5.2. The check dams and settling basins would capture mercury laden sediment from actively eroding mine waste before it disperses throughout the watershed and can degrade downstream water quality. It would require long-term maintenance to inspect for and periodically remove accumulated sediment. The sediment could then be placed back at the mine site, in an off-site Class III solid waste landfill, or an off-site Class I repository, depending on mercury concentration and leachability.

Construction of check dams and settling basins has the added benefit that it would slow the flow of storm water during high water events and thereby reduce erosion downstream. The reduced energy of storm water flow would allow medium to large sediment particles and particulate-bound mercury, which is mobilized from upstream waste piles at mine sites, to be deposited behind the check dams instead of discharging from the site. Settling basins would allow relatively smaller sized particulate matter to settle out but would require greater space and involve higher capital costs. Human and ecological risk associated with sediment and particulate-bound mercury would be decreased downstream of the site due to a reduction in overall sediment mobility and the volume of impacted water discharged from the mine sites. However, the volume and toxicity of mercury in the environment would remain unchanged.

5.1.10.1 Typical Project Area Types

Check dams would be designed to capture mercury from actively eroding mine waste before it disperses throughout the watershed and degrades downstream water quality. Check dams would primarily be placed in drainages either on or downstream of mine reclamation sites or downstream of specific mine features containing mercury.

Settling basins would also be designed to capture mercury from actively eroding mine waste before it disperses throughout the watershed and degrades downstream water quality. Settling basins are generally larger than check dams and would be placed at the base of major drainages downstream of mine reclamation sites.

5.1.10.2 Scalability

Check dams capture predominately medium- to coarse-grained sediment and would be implemented on a small scale generally to reduce runoff from specific mine features. Settling basins capture a greater range of size fractions of sediment and reduce sediment loading. Settling basins may be effectively used at nearly any scale. Larger scale settling basins are described in Section 5.2 whereas this alternative discusses settling basins at the small to medium scale. These settling basins would be constructed in tributaries and ephemeral streams or drainages for multiple mine site features or potentially multiple mine sites that share a common drainage.

5.1.10.3 Effectiveness

Check dams are low to moderately effective, depending on the size of the check dam and the velocity of the flow. Larger check dams or slower flow will allow smaller particle sizes to be captured. The reduction in mobility would be achieved by detaining storm water to allow the majority of the mobile sediment from surface runoff to settle and be contained on site. Check dams generally capture medium to large particulate matter and provide relatively low load reduction to the system as a whole; however, they could provide a moderate to high load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, settling basins).

Settling basins constructed in drainages and ephemeral streams captures more size fractions of sediment than check dams but generally require greater areas to be constructed and are more costly. They are of low to moderate effectiveness, depending on the size of the settling basin. Settling basins will provide relatively low load reduction to the system as a whole; however, they would provide moderate load reduction in specific sub-basins and could reduce the scale of downstream projects (for example, in-stream settling basins). However, there is a possibility of generation of methyl mercury in sediments retained in the settling basins or behind check dams.

Check dams and settling basins are considered feasible alternatives for managing surface water runoff from erosion in the mine pit or within drainages and ephemeral streams. The permanence of these alternatives for reducing sediment and particulate-bound mercury migration to downstream surface water depends on maintenance activities, including dam maintenance and regular removal of accumulated sediment. This alternative would likely decrease the mercury loading and mobility but would not reduce the volume or toxicity of mercury in the system.

5.1.10.4 Implementability

This alternative is easily to moderately implementable, depending on the size of the check dams or settling basins and the surrounding terrain. Excavation, grading, dam and basin construction and revegetation require conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements for construction of check dams and settling basins are well documented and understood. Construction of these features would require a contractor experienced in construction of small dams and basins. Removal of accumulated sediment could require a certified hazardous waste hauling contractor. Equipment, materials, and labor would be available through most local markets.

Storm water, surface water, and/or groundwater intercepted during construction activities may contain suspended sediment and residual levels of mercury; collection, settling, and potential pretreatment would be required prior to discharge to land or surface water. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and water pretreatment systems are well understood and readily implementable.

The construction phase for this alternative could be accomplished within one field season; therefore, impacts associated with construction would likely be short-term and minimal. Construction of check dams would meet the standards for diversion of flow from disturbed areas and revegetation requirements contained in SMCRA and SMARA. In addition, standards for drainage, diversion structures, waterways, and erosion control contained in SMARA would also be met. Storm water generated during construction activities, though not anticipated, will be managed in accordance with the CWA. Nuisance dust suppression and control requirements may be applicable for the control of fugitive dust emissions during construction and earth-moving activities. These requirements would be met through water application to roads receiving heavy vehicular traffic and to construction or excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Appropriate levels of dermal and respiratory protection will be evaluated and implemented as necessary. Short-term risks of physical injury would exist for site workers during construction. Increased truck traffic required to transport construction material to the site would have a short-term impact on local air quality and traffic safety.

5.1.10.5 Costs

This alternative was considered moderate in cost due to construction of containment structures such as check dams and settling basins.

5.1.11 Alternative 11 - Install In-Channel Erosion and Flood Controls; Construct Setback Levees to Isolate Mine Waste from Streams

Erosion and flood controls would be used to manage flood flows using box culverts, rock falls, and dry dams to reduce the erosive force of water within and adjacent to mine waste. In-channel energy dissipation measures may include rock armoring of banks, wing dams, and widening of channels upstream and through areas where mine waste is available for erosion.

Box culverts would be used to route flow though mine waste areas to avoid creating runnels or undermining existing flood or erosion controls. Rock falls would be placed in new or existing flood paths to slow high velocity storm water. The rock falls would be underlain with a geo-synthetic layer to help keep existing soils in place. Dry dams would be placed within major drainage pathways to regulate storm water flow and prevent downstream scouring of mercury-impacted mine waste. Wing dams would be used to deflect storm water flow along stretches of streams and drainages where stream banks could potentially be undermined or scoured. Drainage channels would be widened or rerouted as necessary to create a meandering path for storm water flow that would slow storm water velocity. Levees would be used to isolate mine waste from creeks, streams, and rivers to prevent future transport of mine waste. This alternative would generally be used to reduce impacted sediment mobility when it may not be cost effective to cover or excavate and treat it.

5.1.11.1 Typical Project Area Types

Erosion and flood-controls measures would primarily be performed at or upstream of sites where mercury laden sediment may be subject to high velocity storm flow but concentrations are not high enough to warrant excavation. Mine waste isolating levees would be constructed in areas where mine waste is located directly adjacent to an existing drainage channel. A levee would be built to reduce or eliminate undermining and transport of mine waste due to the potential for streams to overflow the normal stream channel.

5.1.11.2 Scalability

Erosion and flood controls would be performed on a smaller scale at specific mine features subject to higher velocity flood waters. Conducting multiple projects together within close proximity of each other could reduce overall costs. However, the scale of this alternative would be small (individual mine sites or mine features) or possibly medium (mine districts or floodplains). Conducting multiple projects together within close proximity of each other would reduce overall costs.

5.1.11.3 Effectiveness

Erosion and flood controls in areas that have erodible mine waste would be moderately effective at reducing mercury mobility and loading from mine waste. Isolating mine waste using levees or box culverts can also be a cost effective alternative compared to excavation, covering, or disposal. The timeframe to achieve the load reduction is over the short term. This alternative could address mercury contained in both actively eroding and potentially erodible mine waste and floodplain deposits.

The effectiveness of erosion and flood controls alone is limited as soil and sediment may still be transported to surface water at a reduced rate. Isolating mine waste from flows can be highly effective at reducing mercury and sediment load but could increase downstream flow velocities. Therefore, downstream flow would need to be modeled and changes in flow patterns would need to be accounted for and mitigated as necessary. Under this alternative, the flood controls would have to be inspected regularly to ensure that they do not become inundated with sediment, which would decrease their effectiveness. Consequently, long-term monitoring and maintenance would be required.

Overall, the objective of this alternative is to isolate impacted material and reduce scouring and erosion of stream banks and drainages. Load reduction effectiveness would be rated low to moderate; however, the overall mercury load reduction to the watershed would depend on the mercury concentration of the bulk material at the site and the timing and duration of sediment delivery to the watershed. In general, mercury load reduction from mine sites with low mercury concentrations (less than 20 mg/kg) and small, short flow duration creeks is considered to be low for subwatersheds and very low for the Delta system as a whole. However, a more invasive alternative would often be recommended for sites where mercury content is higher.

This alternative provides a low reduction in potential human health, ecological, and water quality threats because it would be implemented at low mercury content sites. However, reducing sediment load at these sites could also reduce the scale and frequency of maintenance for downstream settling basins.

5.1.11.4 Implementability

This alternative is easily to moderately implementable. Excavation, grading, flood control construction and revegetation require conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements for construction of box culverts, levees, wing dams, rock falls and dry dams are well documented and understood. Construction of these features would require a contractor experienced with flood control measures. Maintenance activities, including removal of accumulated sediment, could require a certified hazardous waste hauling contractor. Equipment, materials, and labor would be available through most local markets.

Storm water, surface water, and/or groundwater intercepted during construction activities may contain suspended sediment and residual levels of mercury; therefore, collection, settling, and potential pretreatment would be required prior to discharge to land or surface water. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and water pretreatment systems are well understood and readily implementable.

The construction phase for this alternative could be accomplished within one field season; therefore, impacts associated with construction would likely be short-term and minimal. Construction of levees would meet the standards for diversion of flow and realignment of streams contained in SMCRA and SMARA. In addition, standards for drainage, diversion structures, waterways, and erosion control contained in SMARA would also be met. Storm water generated during construction activities, though not anticipated, would be managed in accordance with the CWA. Nuisance dust suppression and control requirements for the control of fugitive dust emissions may be applicable for construction and earth-moving activities. These requirements would be met through water application to roads receiving heavy vehicular traffic and to construction or excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Short-term risks of physical injury would exist for site workers during construction. Appropriate levels of dermal and respiratory protection would be evaluated and implemented as necessary. Increased truck traffic required to transport construction material to the site would have a short-term impact on local air quality and traffic safety.

5.1.11.5 Costs

This alternative was considered low to high cost depending on the type of project. Higher costs were associated with applications that involve construction of containment structures, in channel erosion and flood controls, and setback levees.

5.2 STREAM BASED LOAD REDUCTION ALTERNATIVES

Eight stream based load reduction alternatives were identified for areas inside of the levees or on the active floodplains. These retained load reduction alternatives may be applicable to active channels, active floodplains, eroding stream banks, historic floodplains, flood control bypasses/basins, Delta islands and marshlands, reservoirs and hydraulic and hard rock mines. A summary of the engineering evaluation for stream based load reduction alternatives is presented in Table 5-1b.

5.2.1 Alternative 1 - No Action

Under this alternative, no actions would occur within the Sacramento and San Joaquin River watersheds. Only natural flushing of sediments and gradual attenuation of mercury from the watersheds would occur. It is a baseline for comparison against other load reduction alternatives.

5.2.1.1 Typical Project Area Types

This alternative was generally considered for all project areas.

5.2.1.2 Scalability

This alternative was considered for all size projects, small to large scale.

5.2.1.3 Effectiveness

This alternative could be low to moderately effective, as natural flushing of sediments through and gradual attenuation of mercury from the system would occur. Over time, no action would reduce the volume, mobility, load, and potential human health, ecological, and water quality threats posed by mercury contained in sediment and the watersheds.

5.2.1.4 Implementability

This alternative is readily implementable and administratively feasible, as no actions would be required. No permits would be required or services or materials for implementation of the no action alternative.

5.2.1.5 Costs

There are no costs associated with the no action alternative; therefore, this alternative was considered low cost.

5.2.2 Alternative 2 - Ensure Implementation of Existing Programs; Coordinate Flood Control Operations, Water Transfers, and Irrigation Management; and Improve Levee and Sediment Control Structure Maintenance Activities

Under this alternative, existing programs, which include community mercury recovery, river dredging, and recreational mining, would be enforced. Existing maintenance dredging activities that clear waterways and water conveyance structures from unnecessary silt and debris and recreational mine dredging of stream beds would be used to remove mercury laden sediment from stream beds. Dredging programs would be coordinated with other agencies to ensure mercury laden sediments are removed from the system, placed, and maintained in a manner to reduce migration back into the system. Recreational dredging of elemental mercury from sediments downstream of mining districts and a buy back program for mercury would be promoted.

O&M activities, which include flood control operations, water transfers, and irrigation management, would be improved through coordination with other agencies to improve off-stream storage and allow settling of suspended solids during the winter. During peak flow periods, water would be diverted to bypasses, settling basins, reservoirs, and farmlands, which would reduce river flow, volume, and channel scour and in turn reduce the suspension of mercury laden sediment. The bypasses, settling basins, reservoirs, and farmlands would then be operated to improve settling of suspended solids. By delaying the discharge of water until suspended solids have settled, the transport of mercury laden sediment would be reduced.

Maintenance of levees and sediment control structures would be improved to limit transport of mercury laden sediment to the watershed. Maintenance of levees would reduce erosion, seepage, and breaches of levees, thereby limiting bank and floodplain erosion, release of suspended solids, and transport of mercury laden sediment. Existing sediment control structures include settling basins, dams, and bypasses. Periodic removal of accumulated sediment would improve the hydraulic retention time required for settling of fines.

5.2.2.1 Typical Project Area Types

This alternative would generally be considered for active channels, active floodplains, eroding stream banks, flood control bypasses/basins, Delta islands and marshlands, and reservoirs. It would be applicable to areas where: 1) mercury is stored in stream and floodplain sediments upstream of reservoirs and settling basins, 2) erosion and channel scour are occurring and contributing to mercury loading, and 3) settling of suspended mercury laden sediment within existing structures could be improved. While mercury concentrations in sediment may not be high enough to warrant removal based on hazardous characteristics or threat to human health or ecological receptors, it may still be contributing to the mercury loading to a tributary to the Delta; therefore, reducing the suspension of mercury laden sediment and its transport to the watershed may still be justified.

5.2.2.2 Scalability

This alternative would generally be conducted where existing programs and maintenance activities are occurring, either as a large scale or regional project, rather than at the local level. As it would require dredging programs to be coordinated with other agencies to ensure mercury laden sediments are managed to reduce migration back into the system, it may be advantageous if a centralized disposal area that is not subject to substantial erosive forces is used.

5.2.2.3 Effectiveness

Depending on the degree of implementation, this alternative could be moderately effective. It addresses mercury contained in stream sediment and suspended solids contributing to mercury loading within the system. Implementation of each step of this alternative would reduce to varying degrees the volume, mobility, load, and water quality threat posed by mercury.

The first step of this alternative involves enforcing existing programs. Ensuring implementation of these existing programs would remove mercury from the system above the reservoirs and settling basins and prevent its introduction or reintroduction. Dredging of mercury laden sediment and removal from the system would reduce the buildup of the mercury mass in the river system and subsequently reduce the volume, load, and water quality threat posed by mercury. Depending on the scale of dredging, this step would be of low to moderate effectiveness.

The second step of this alternative involves improving O&M activities, which include flood control operations, water transfers, and irrigation management. Coordination with other agencies would improve off-stream storage and allow settling of suspended solids during the winter. Improved settling of suspended solids would reduce the volume and load of mercury within the system and subsequently the water quality threat posed by mercury. Depending on the scale of flood events, it would provide relatively moderate to high load reduction from active sediment and low to moderate reduction of the load entering the lower system from reservoirs. It may increase the wetting frequency/duration of off-stream land and provide an environment for mercury methylation. However, it would also provide greater flood protection to surrounding areas.

The final step of this alternative involves improving maintenance of levees and sediment control structures to limit transport of mercury laden sediment to the watershed. Maintenance of levees would reduce erosion, seepage, and breaches of levees, thereby limiting bank and floodplain erosion, release of suspended solids, and transport of mercury laden sediment. This would subsequently reduce the mobility, load, and water quality threat posed by mercury and would be moderately effective. In addition, it would also provide greater flood protection to surrounding areas.

Overall, this alternative provides a moderate reduction in the volume of material available for erosion and the mobility of mercury laden sediment, a moderate reduction in mercury load and a moderate reduction in the water quality threat. Load reduction effectiveness would be rated moderate, though the overall mercury load reduction to the watershed would depend on mercury concentrations in the dredged sediment and the duration of off-stream storage to allow settling of suspended solids during the winter.

5.2.2.4 Implementability

This alternative is readily and easily implementable for mercury contained in stream sediment and suspended solids and is both technically and administratively feasible. Under this alternative, existing programs would be enforced or coordinated with other agencies. Dredging of mercury laden sediment; coordination with other agencies to improve off-stream storage and allow settling of suspended solids during the winter; and improving maintenance of levees and sediment control structures require conventional construction, engineering, and design practices and materials that are readily available. Design methods, construction practices, and engineering requirements are well documented and understood.

5.2.2.5 Costs

This alternative was considered low cost as it consists of implementation of existing programs or practices and incorporates on-site controls.

5.2.3 Alternative 3 - Modify Existing Sediment Control Structures to Improve Capture Efficiency

Under this alternative, the efficiency of existing sediment control structures, which include settling basins, dams, and bypasses, would be improved by increasing the size (area and/or depth) and/or installing additional flow control berms and weirs to increase the hydraulic residence time. This would improve sediment retention during flood events. The height of existing debris and flood control structures would also be increased to improve sediment retention during flood events.

Periodic removal of accumulated sediment would be required to maintain the hydraulic retention time required for settling of fines. Sediment would be processed for aggregate, and non-hazardous fines would be transported to and placed on farmland protected by levees or used as fill at a construction site. Aggregate material with economic value would be transported off-site for use in construction in the local area. Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. Unrestricted on- or off-site site disposal of fines would require a total mercury concentration of less than 20 mg/kg and a leachable mercury concentration of less than 0.2 mg/L. If either the total mercury concentration or leachable fraction exceed these criteria, an alternate disposal method would be necessary for the processed fines. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. To ensure long-term reduction of mercury loading to local streams, fines containing mercury should be placed above floodplains and protected from future erosion.

5.2.3.1 Typical Project Area Types

This alternative would generally be considered for active channels, active floodplains, flood control bypasses/basins, Delta islands and marshlands, and hydraulic and hard rock mines. It would be applicable to areas where settling of suspended mercury laden sediment could be improved either within existing structures or by installing additional flow control berms and weirs to increase the hydraulic residence time and settling of suspended mercury laden sediment. While mercury concentrations in sediment may not be high enough to warrant removal based on hazardous characteristics or threat to human health or ecological receptors, it may still be contributing to mercury loading to a tributary to the Delta; therefore, reducing the suspension of mercury laden sediment and its transport to the watershed may still be justified.

5.2.3.2 Scalability

This alternative would generally be conducted on all size projects, small (50-acres settling basin, lower Cache Creek bypass) to large scale (Cache Creek Settling Basin [3,500-acres], Yolo Bypass), as it is applicable to all stream and river reaches, all sediment control structures, and where mine waste and material are currently subject to erosion and contribute to the mercury loading.

Management of the additional sediment that is captured is a key element of this alternative. Physically separating aggregate from fines at a central location would reduce processing plant mobilization costs if multiple sites could be efficiently managed at once. However, it would require bulk sediment transport from multiple site reclamation areas to a centralized facility and substantial coordination between excavation contractors and the processing facility. Disposing of fines in a common location may also be advantageous if there is a single central area that is not subject to substantial erosive forces and is available for cost effective consolidation. Using a centralized processing facility or disposal area would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.2.3.3 Effectiveness

Depending on the degree of implementation, this alternative could be moderately effective. It addresses mercury in suspended solids contributing to mercury loading within the system. Overall, this alternative would moderately reduce the mobility of mercury laden sediment, provide a moderate reduction in mercury load, and provide a moderate reduction in water quality threat. Load reduction effectiveness would be rated moderate, though the overall mercury load reduction to the watershed would depend on the duration of off-stream storage to allow settling of suspended solids during the winter and the management of periodically excavated fines to ensure protection from future erosion. It may increase the wetting frequency/duration of off-stream land and sediment behind the structures, providing an environment for mercury methylation.

5.2.3.4 Implementability

This alternative is readily implementable for mercury contained in suspended solids and is both technically and administratively feasible. Depending on the structure size and available space for expansion, it would be easy to moderately implementable. Expansion of sediment control structures, installation of flow control berms and weirs, and excavation of accumulated sediment require conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements are well documented and understood.

Physical separation of aggregate from fines containing mercury would require a standard aggregate processing plant. Equipment, materials, and labor would be available through most local markets. Process water generated during aggregate processing may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and water pretreatment systems are well understood and readily implementable.

5.2.3.5 Costs

This alternative was considered moderate in cost as it consists of modifying existing sediment control structures.

5.2.4 Alternative 4 - Stabilize Stream Banks, Floodplains, and Settling Basin Surfaces

Under this alternative, stream banks, the surface of active floodplains, settling basin surfaces, and Delta marshlands and islands would be stabilized to reduce erosion of sediment and mine waste containing elevated levels of mercury. Stream banks would be stabilized by altering channel geometry and being laid back, which would reduce hydraulic energy. Wing dams and rip rap would be installed to reduce erosion and lateral migration of the stream into active and historic floodplain deposits that contain elevated levels of mercury.

Active floodplains and settling basin surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients necessary to aid germination and support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration should be given to native seed mixtures.

Delta marshlands and islands containing elevated levels of mercury would be stabilized through revegetation and installation of hydraulic control/reclamation levees. Hydraulic control levees would be constructed around larger marshlands to increase hydraulic retention time and settling of fines, and reclamation levees would be installed around unprotected Delta islands. Dredged channel sediment would be placed adjacent to the marshlands and/or on reclaimed islands to increase shoreline protection, stabilize the toe of levees, and develop upland areas.

5.2.4.1 Typical Project Area Types

This alternative would generally be considered for active channels, active floodplains, eroding stream banks, historic floodplains, flood control bypasses/basins, Delta islands and marshlands, and hydraulic and hard rock mines. It would be applicable to areas where erosion and channel scour are occurring and contributing to mercury loading. While mercury concentrations in sediment may not be high enough to warrant removal based on hazardous characteristics or threat to human health or ecological receptors, it may still be contributing to mercury loading in a tributary to the Delta and reducing its transport to the watershed may still be justified.

5.2.4.2 Scalability

Stream banks would generally be stabilized on small scale (Putah and Bear Creeks) to medium scale projects (Cache Creek) because this practice is applicable to ephemeral to flashy streams where mine waste and sediment containing mercury is currently subject to erosion. Stabilization of floodplains and settling basin surfaces, through grading and vegetation, and Delta marshlands and islands, through vegetation and installation of hydraulic control/reclamation levees, would also be applicable to all scale projects.

5.2.4.3 Effectiveness

Depending on the degree of implementation, this alternative could be moderately effective. It addresses mercury in mine waste and sediment contained in actively eroding areas. Overall, this alternative would moderately reduce the mobility of mercury laden sediment and mine waste, provide a moderate reduction in mercury load, and provide a moderate reduction in water quality threat. Load reduction effectiveness would be more specific to sub-basins; however, it would be rated moderate for the system as a whole for larger scale projects. Placement of dredged channel sediment adjacent to the marshlands and/or on reclaimed islands would also be advantageous by decreasing material transportation costs.

5.2.4.4 Implementability

This alternative is readily implementable for mercury contained in sediment and mine waste and is both technically and administratively feasible. Depending on the action and scale, overall this alternative is moderately implementable, with stabilization of stream banks being moderately difficult to implement and stabilization of active floodplains, settling basin surfaces, Delta marshlands and islands, and mine sites being easier to implement. Channel alteration, installation of wing dams and rip rap, grading, revegetation, installation of hydraulic control/reclamation levees, and placement of dredged sediment require conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements are well documented and understood; however, larger scale channel alterations would be more difficult to design and implement. Placement of dredged sediment would require coordination with other agencies.

5.2.4.5 Costs

This alternative was considered moderate in cost due to equipment and transportation costs associated with stabilizing stream banks, floodplains, and settling basin surfaces.

5.2.5 Alternative 5 - Construct Flood Control Bypasses and/or Settling Basins to Promote Solids Settling

Under this alternative, flood routing and associated solids settling capacities would be increased through the construction of additional sediment control structures (flood control bypasses and settling basins). Surface water flow would be diverted using passive/active weirs, berms, or hydraulic control levees, which would be constructed at up and down stream ends. During peak flow periods, water would be diverted to reduce river flow, volume, and channel scour and in turn reduce the suspension of mercury laden sediment. The bypasses and settling basins would then be operated to improve settling of suspended solids. By delaying the discharge of water until suspended solids have settled, the transport of mercury laden sediment would be reduced. This alternative would also allow capture of all sediment size fractions, including some fines.

Periodic removal of accumulated sediment from settling basins would be required to maintain the hydraulic retention time required for settling of fines. Sediment would be processed for aggregate, and non-hazardous fines would be transported to and placed on farmland protected by levees or used as fill at a construction site. Aggregate material with economic value would be transported off-site for use in construction in the local area. Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. Unrestricted on- or off-site site disposal of fines would require a total mercury concentration of less than 20 mg/kg and a leachable mercury concentration of less than 0.2 mg/L. If either the total mercury concentration or leachable fraction exceed these criteria, an alternate disposal method would be necessary for the processed fines. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality. To ensure long-term reduction of mercury loading to local streams, fines containing mercury should be placed above floodplains and protected from future erosion.

5.2.5.1 Typical Project Areas

This alternative would generally be considered for active channels, active floodplains, flood control bypasses/basins, and hydraulic and hard rock mines. It would be applicable to areas where velocity reduction, extended hydraulic residence time, and removal of heavy sediment loads during flood events are desired. Special consideration would be given to areas where streams exit the foothills to help control downstream bank erosion. While mercury concentrations in sediment may not be high enough to warrant removal based on hazardous characteristics or threat to human health or ecological receptors, it may still be contributing to mercury loading in a tributary to the Delta and reducing the suspension of mercury laden sediment may still be justified.

5.2.5.2 Scalability

This alternative would generally be conducted on small creeks (Putah and Bear) to large rivers (Sacramento, Feather, Yuba), primarily on the valley floor where removal of heavy sediment loads during flood events is desired. It could also be conducted downstream of mining districts, where relatively high mercury loading occurs during high flow and flood events.

Physically separating aggregate from fines at a central location would reduce processing plant mobilization costs if multiple sites could be efficiently managed at once. However, it would require bulk sediment transport from multiple site reclamation areas to a centralized facility and substantial coordination between excavation contractors and the processing facility. Disposing of fines in a common location may also be advantageous if there is a single central area that is not subject to substantial erosive forces and is available for cost effective consolidation. Using a centralized processing facility or disposal area would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.2.5.3 Effectiveness

Depending on the degree of implementation, this alternative could be highly effective. It addresses mercury in suspended solids contributing to mercury loading within the system. Overall, this alternative could significantly reduce the mobility of mercury laden sediment, mercury loading, and provide a reduction in water quality threat. The majority of load reduction will occur during high flow and flood events. Load reduction effectiveness would depend on the duration of off-stream storage to allow settling of suspended solids during the winter and management of excavated fines to ensure protection from future erosion. It may increase the wetting frequency/duration of off-stream land and sediment behind the structures, providing an environment for mercury methylation.

5.2.5.4 Implementability

This alternative is readily implementable for mercury contained in suspended solids and is both technically and administratively feasible. Due to potential space restrictions, the need to construct long levees, and the amount of farm land that would be placed under water during the winter, it would be moderately implementable. Construction of sediment control structures; installation of flow control weirs, berms, and levees; and excavation of accumulated sediment require conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements are well documented and understood.

Physical separation of aggregate from fines containing mercury would require a standard aggregate processing plant. Equipment, materials, and labor would be available through most local markets. Process water generated during aggregate processing may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs would be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and water pretreatment systems are well understood and readily implementable.

5.2.5.5 Costs

This alternative was considered high cost due to equipment and transportation costs associated with construction of containment/settling structures, such as flood control bypasses and/or settling basins.

5.2.6 Alternative 6 - Construct Levees to Isolate Mercury and Mine Waste Contained in Floodplain Sediment from Adjacent Active Stream Channel

This alternative would be implemented in areas where the volume of impacted floodplain sediment is too large to excavate and dispose off site. Levees would be constructed to isolate the mercury and mine waste in the active and historic floodplain sediment from the adjacent eroding stream bank. Flood flows would be contained within the levees, mine waste would be isolated and its mobility would be reduced or eliminated, thereby minimizing the transport of mercury laden sediment. Maintenance of levees would be necessary to reduce erosion, seepage, and breaches. It would also require consideration of the potential erosive forces of floodwaters downstream of the constructed levees and coordination with downstream flood protection measures.

5.2.6.1 Typical Project Area Types

This alternative would generally be considered for active floodplains, eroding stream banks, and historic floodplains. It would be applicable to floodplains containing elevated levels of mercury from upstream mine sites, with special consideration given to active lateral erosion areas. While the mercury concentrations may not be high enough to warrant removal based on hazardous characteristic or threat to human health or ecological receptors, it may still be contributing to mercury loading in a tributary to the Delta and reducing the suspension of mercury laden sediment may still be justified.

5.2.6.2 Scalability

To isolate mercury laden sediment and mine waste in active and historic floodplain sediment, levees would generally be constructed on small scale (Putah and Bear Creeks) to medium scale projects (Cache Creek), where mercury and mine waste is currently subject to erosion and contributing to mercury loading. This alternative could reduce the scale of downstream projects (for example, settling basins).

5.2.6.3 Effectiveness

This alternative could be highly effective at reducing erosion over the short term, as it addresses mercury and mine waste in actively eroding areas. It provides moderate reduction in the mercury load and a moderate reduction in water quality threat. Load reduction effectiveness would be more specific to sub-basins; however, it would be rated moderate for the system as a whole for larger scale projects. If the floodplain is restricted and the erosive forces of floodwaters downstream are not accounted for, it could impact the overall effectiveness of this alternative. No net impact on potential for mercury methylation is anticipated.

5.2.6.4 Implementability

This alternative is readily implementable for mercury laden sediment and mine waste and is both technically and administratively feasible. It would be easy to moderately implementable, depending on the degree of levee construction. Construction of levees requires conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements are well documented and understood.

5.2.6.5 Costs

This alternative was considered high cost due to construction of containment structures such as levees to isolate mercury and mine waste. Costs may become prohibitive with large-scale projects.

5.2.7 Alternative 7 - Capture Sediment Using Low Dams and Weirs within Small Creeks and Streams

This alternative would be implemented on smaller creeks and streams to reduce the energy contributing to the lateral migration of streams into active and historic floodplains that contain elevated levels of mercury and mine waste. It could also be implemented near mine sites to limit transport of mercury laden sediment to the watershed. Low dams and weirs would be constructed within the creeks and rivers, thereby maintaining the hydraulic retention time required for energy dissipation and settling of fines, reducing erosion of stream banks, and isolating mercury and mine waste from the watershed. Predominately medium- to coarse-grained mobile sediment would be captured behind the structure during high energy events and fine grained sediment would be captured at low to moderate flows. Relatively frequent removal and disposal of the accumulated sediment from behind the dams and weirs would be required to maintain the hydraulic retention time. Sediment would be processed for aggregate and non-hazardous fines would be transported to and placed on farmland protected by levees or used as fill at a construction site.

5.2.7.1 Typical Project Area Types

This alternative would generally be considered for active channels, active floodplains, eroding stream banks, historic floodplains, and hydraulic and hard rock mines. It would be applicable to smaller creeks and streams located near floodplains and mine sites containing elevated levels of mercury and mine waste. While mercury concentrations may not be high enough to warrant removal based on hazardous characteristic or threat to human health or ecological receptors, it may still be contributing to mercury loading in a tributary to the Delta and reducing the suspension of mercury laden sediment may still be justified.

5.2.7.2 Scalability

Sediment would generally be captured using low dams and weirs on small scale (Putah and Bear Creeks) to medium scale projects (Cache Creek), as it is applicable to ephemeral to flashy streams where mine waste and sediment containing mercury is currently subject to erosion.

Physically separating aggregate from fines at a central location would reduce processing plant mobilization costs if multiple sites could be efficiently managed at once. However, it would require bulk sediment transport from multiple site reclamation areas to a centralized facility and substantial coordination between excavation contractors and processing facility. Disposing of fines in a common location may also be advantageous if there is a single central area that is not subject to substantial erosive forces and is available for cost effective consolidation. Using a centralized processing facility or disposal area would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.2.7.3 Effectiveness

This alternative could be moderately effective, depending on the size of the structure and sediment retention basin behind the structure. It provides moderate reduction in the mercury load and a moderate reduction in water quality threat, with load reduction effectiveness being more specific to sub-basins. The scale of downstream projects (for example, settling basins) could be reduced by implementing this alternative. It may increase the wetting frequency/duration of sediments contained behind the structure, providing an enhanced environment for mercury methylation.

5.2.7.4 Implementability

This alternative is readily implementable for mercury laden sediment and mine waste and is both technically and administratively feasible. It would be moderately difficult to difficult to implement, depending on the size of the structure and location. Construction of low dams and weirs requires conventional construction practices and materials that are readily available. Design methods, construction practices, and engineering requirements are well documented and understood. However, an environmental impact review may affect implementation.

5.2.7.5 Costs

This alternative was considered moderate in cost due to construction of containment structures such as low dams and weirs.

5.2.8 Alternative 8 - Dredge, Process Aggregate as a Commodity, and Dispose of Fines (Farmland, Delta Islands, Construction Sites)

Under this alternative, mercury laden sediment would be dredged from streams and/or excavated from floodplains using conventional equipment and disposed of on-site either on farmland, Delta islands, or construction sites. Containment and treatment of water encountered during excavation may also be necessary.

Accumulated sediment would be physically processed for aggregate, and aggregate material with economic value would be transported off-site for use in construction. Depending on the scale of the project, a batch sand and gravel plant set up for mercury recovery would either be mobilized to the site or sediment would be transported to a centralized facility to separate coarse material from fine materials containing mercury.

Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. Non-hazardous fines would be transported by truck or barge and placed on farmland or Delta islands protected by levees or used as fill at construction sites. Permanent, on-site disposal would consolidate waste into a single, smaller area. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be placed above floodplains and protected from future erosion using crop cover, levees, or other control measures.

Unrestricted on-site disposal of fines would require a total mercury concentration of less than 20 mg/kg and a leachable mercury concentration of less than 0.2 mg/L. If either the total mercury concentration or leachable fraction exceeds these criteria, an alternate disposal method would be necessary for the processed fines. In addition the Regional Board DLM should be used to assess potential site-specific impacts of residual mercury on groundwater and surface water quality.

5.2.8.1 Typical Project Area Types

This alternative would generally be considered for active channels, active floodplains, flood control bypasses/basins, and reservoirs. It would be applicable to any area containing elevated levels of mercury in sediment and mine waste and contributing to relatively high mercury loadings. While mercury concentrations may not be high enough to warrant removal based on hazardous characteristic or threat to human health or ecological receptors, it is still contributing to mercury loading to the Delta and reducing the presence of mercury laden sediment within the watershed may still be justified.

5.2.8.2 Scalability

Mercury laden sediment would generally be removed at small scale (Putah and Bear Creeks) to large scale (Sacramento, Feather, Yuba Rivers) projects, as it is applicable to any area containing elevated levels of mercury and contributing to relatively high mercury loading.

Physically separating aggregate from fines at a central location would reduce processing plant mobilization costs if multiple sites could be efficiently managed at once. However, it would require bulk sediment transport to a centralized facility from multiple sites and substantial coordination between excavation contractors and the processing facility. Disposing of fines in a common location may also be advantageous if there is a single central area that is not subject to substantial erosive forces and is available for cost effective consolidation. Using a centralized processing facility or disposal area would only be advantageous if the mobilization and coordination cost savings exceed the increase in material transportation costs.

5.2.8.3 Effectiveness

Depending on the degree of implementation, this alternative could be highly effective. It addresses mercury contained in stream sediment and mine waste actively and contributing to mercury loading within the system year round. Depending on the mercury content and volume of sediment removed, it provides a high reduction in the mercury load and water quality threat. Implementation of this alternative would reduce the mobility, load, and water quality threat posed by mercury. No net impact on potential mercury methylation is anticipated.

5.2.8.4 Implementability

This alternative is readily implementable for sediment and mine waste containing elevated levels of mercury and is both technically and administratively feasible. It would be easy to moderately difficult to implement, depending on the scale of the project, location of sediment processing, and final disposal location. If processing of fines occurred outside of the Delta, it would require trucking or barging of sediment. Design methods, construction practices, and engineering requirements are well documented and understood. However, environmental impact review may affect implementation.

Physical separation of aggregate from fines containing mercury would require a standard aggregate processing plant. Equipment, materials, and labor would be available through most local markets. Process water generated during aggregate processing may require pretreatment prior to discharge to land or surface water. To minimize the volume of process water discharged from the aggregate processing plant, water would be recycled to the extent practicable. Storm water BMPs will be used to minimize entrainment of sediment to the extent practicable. Design and construction of BMPs and water pretreatment systems are well understood and readily implementable.

5.2.8.5 Costs

This alternative was considered high cost due to equipment, transportation, and disposal costs associated with dredging, processing aggregate as a commodity, and disposing of fines. Costs may become prohibitive with large-scale projects.

6.0 COMPARATIVE EVALUATION OF LOAD REDUCTION ALTERNATIVES FOR RETAINED PROJECT AREAS

Selection of the appropriate load reduction alternative(s) for a project area depends on the following: 1) project type (active channel, floodplain, reservoir, mine), 2) scalability, 3) effectiveness, 4) implementability, 5) range of costs, and 6) estimated load reduction. The retained load reduction alternatives discussed in Section 5.0 are comparatively evaluated below for each of the specific project areas selected in Section 3.0 and summarized in Table 3-4. The comparative evaluations are separated into land based and stream based project areas (Sections 6.1 and 6.2, respectively).

6.1 LAND BASED PROJECT AREAS

Eleven land based load reduction alternatives were identified for possible implementation at the following four project areas:

1. Mercury Mines in Sulphur Creek Watershed
2. Floodplain Containing Mine Waste on Sulphur Creek
3. Floodplain Containing Mine Waste on Bear Creek
4. Floodplain Containing Mine Waste on Harley Gulch

These project areas are shown on Figures 6-1 through 6-5. The comparative evaluation of load reduction alternatives applicable to each of these project areas are discussed below and summarized in Table 6-1a. Load reduction efficiencies and comparative costs for each project area are provided in Tables 6-2a through 6-2d. Cost estimate summary tables are provided in Appendix A.

6.1.1 Project Area 1 - Mercury Mines in Sulphur Creek Watershed

Project Area 1 consists of three mercury mines (the West End, Manzanita, and Elgin Mines) located within the Sulphur Creek watershed, which is upstream of Cache Creek (see Figures 6-1 and 3-2). These inactive mine were sporadically mined for mercury and/or gold between the 1860s and 1970s. For this project area, total mercury concentrations in mine waste are assumed to hazardous. The West End and Manzanita Mines have the potential to contribute the mercury load to Sulphur Creek as waste from both mines is located within the Sulphur Creek floodplain. Located within the upper watershed, the Elgin Mine, also has the potential to contribute a substantial mercury load to Sulphur Creek. The remaining mines within the watershed do not contribute enough of a load to warrant an action.

The primary sources of mercury at the West End Mine are waste rock that covers the slope from the adits to the channel of Sulphur Creek, where it forms the east bank of Sulphur Creek. Approximately 150 feet of Sulphur Creek have been encroached upon by the waste rock, and during winter high flows this area is eroded. The volume of waste rock is estimated to be about 3,600 CY over an area of 1.2 acres. Churchill and Clinkenbeard (2002) estimated that up to 1,400 kg of mercury remains in waste rock piles at the West End Mine. The estimated mercury load from West End Mine is up to 1.1 kg/yr, is located on the floodplain and in channel, and is subject to pulse type release events.

The primary sources of mercury at Manzanita Mine are waste rock on the slope below the mine and above the Sulphur Creek floodplain, waste rock and tailings on the floodplain of Sulphur Creek, and tailings exposed on the north stream bank of Sulphur Creek. Approximately 1,400 feet of Sulphur Creek have been encroached upon by the tailings. Both the waste rock and tailings on the floodplain are subject to erosion during winter high flows. The volume of waste rock and tailings on and within the floodplain is estimated to be about 23,000 CY, assuming an average depth of 3 feet over approximately 4.5 to 5 acres. No estimate of the mercury content in the waste rock and tailings is available. The estimated mercury load from Manzanita Mine is up to 6.5 kg/yr, is located above and on the floodplain and in channel, and is subject to pulse type release events. The mercury load estimate does not include the tailings within the Sulphur Creek floodplain.

The primary sources of mercury at Elgin Mine are waste rock, hydrothermal springs, and tailings. Waste rock in the upper portion of the mine site, the volume of which is estimated to be between 1,000 and 4,100 CY over approximately 2 acres, is subject to erosion by storm water. Churchill and Clinkenbeard (2002) estimated that up to 1,400 kg of mercury remains in the two Elgin Mine waste piles. In addition, discharge from a hydrothermal spring is pooled directly on the waste rock and flows through the waste rock toward the west fork of Sulphur Creek. Interaction between hydrothermal fluids and waste rock has been demonstrated to mobilize mercury. The remnants of a retort and a small volume of tailings (less than 100 CY) are present on the Sulphur Creek floodplain below the mine site where winter flooding could lead to erosion and transport of mercury containing material. The estimated mercury load from Elgin Mine is up to 9.3 kg/yr, is located in an upland area, and is considered a potential load versus constant or pulse type of load release.

6.1.1.1 Alternative 3 - Grade, Revegetate, and Install Run-on and Runoff Controls

Implementation of this alternative includes grading, revegetating, and installing run-on and runoff controls. This alternative was recently implemented, in part, at the Abbott and Turkey Run mines in the Harley Gulch watershed. It would not be applicable at the West End Mine where waste rock is within Sulphur Creek and needs to be removed.

For the Manzanita Mine, the control action would include grading, installation of run-on and runoff controls and sediment detention basins, and revegetation. It is assumed that approximately 0.25 acre of waste rock at the toe of the slope below the mine would be graded to control storm water run-on to the area and four-180 foot long trenches (3 foot by 3 foot) would be excavated to divert water to two constructed sediment detention basins. Two of the trenches (one running from the upper cut to the lower cut and one running from the lower cut to the base of the slope) would be excavated on the east side of the waste rock area to divert water into a constructed sediment detention basin located in the flat area on the side of the mine. Two additional trenches would be excavated on the west side of the waste rock area to divert water into another constructed sediment detention basin located in the flat area on the side of the mine. Each trench would be lined with 18 to 24 inches of riprap. The sediment detention basins on the east and west sides are assumed to be 100 feet by 100 feet by 4 feet deep and 200 feet by 100 feet by 4 feet deep, respectively. A 36-inch pipe would also be installed to convey water from the west sediment detention basin to the creek. Approximately 0.5 acre of disturbed area would be fertilized and hydroseeded. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

For the Elgin Mine, the control action would include grading, installation of run-on and runoff controls, and revegetation. Approximately 1.75 acres of overcast waste rock would be graded and benched to control erosion, and a ditch (approximately 200 feet in length) would be installed around the uphill side of the overcast waste rock to route all storm water runoff around the area. Approximately 1.75 acres of the graded area would be fertilized and hydroseeded. In addition, approximately 0.125 acre of the former retort tailings pile would be graded, fertilized, and hydroseeded. A ditch (approximately 500 feet in length) would also be installed above the tailings to prevent storm water run-on to the revegetated area. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size of run-on and runoff controls, revegetation areas, and the retention time for solids settling in the sediment detention basins. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. O&M activities include ensuring revegetation takes hold (short term) and sediment detention basins are cleaned out to maintain capacity (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.1.2 Alternative 4 - Consolidate Non-Hazardous Mine Waste, Revegetate, and Install Run-on and Runoff Controls

Implementation of this alternative includes consolidating non-hazardous mine waste from the West End and Elgin Mines, revegetating, and installing run-on and runoff controls. This alternative was recently implemented, in part, at the Abbott and Turkey Run mines in the Harley Gulch watershed. This alternative would not be applicable at the Manzanita Mine as there is no place to consolidate mine waste above the floodplain.

For the West End Mine, approximately 3,600 CY of waste rock would be excavated from approximately 150 feet of the Sulphur Creek bank and bed and placed northwest of the mine above the floodplain in an area of approximately 0.75 acres. The consolidated waste rock area would be fertilized, revegetated with reserved vegetation, and approximately 200 feet of drainage channel excavated around the upslope edge to prevent run-on of storm water. The excavated creek bank would be laid back in two terraces to stabilize it and replanted with reserved vegetation. It is estimated that approximately 0.5 acre of exposed areas would not be replanted and instead would be fertilized and hydroseeded. Storm water run-on to the restored area would be controlled with hay bales on the steep slope above.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Removal of mine waste from the north bank of Sulphur Creek will involve temporary removal of riparian habitat. The riparian habitat will be replaced after terracing the slope and final grading has been completed in order to mitigate the loss of habitat.

For the Elgin Mine, approximately 4,000 CY of waste rock on the down slope side of the open cuts would be pulled back up into approximately 1.75 acres of the upper mine site area, and an additional 76 CY of tailings from the retort site would also be placed in this area. The consolidated waste rock area would be graded, benched, fertilized, and hydroseeded. A ditch (approximately 200 feet in length) would be installed around the uphill side of the consolidated waste rock to route all storm water runoff around the area. The former retort area excavation, estimated at approximately 0.125 acre, would also be graded, fertilized, and hydroseeded; and a ditch approximately 200 feet in length would be installed above the excavation area to prevent storm water run-on to the revegetated area. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and location of the consolidated mine waste, run-on and runoff surface control measures, and revegetation area. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of a control action at the West End mine may require inclusion of mitigation measures during project design to ensure attainment of a CEQA (California Environmental Quality Act) negative declaration. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.1.3 Alternative 5 – Place Earthen Cover over Intact and/or Consolidated Mine Waste, Revegetate, and Install Run-on and Runoff Controls

Implementation of this alternative consists of placing an earthen cover over intact and/or consolidated mine waste containing elevated concentrations of mercury, revegetation to stabilize eroding surfaces, and installation of run-on and runoff surface control measures. This alternative was recently implemented, in part, at the Abbott and Turkey Run mines in the Harley Gulch watershed. This alternative would not be applicable at the Manzanita Mine as there is no place to consolidate mine waste above the floodplain.

For the West End Mine, 3,600 CY of waste rock would be excavated from approximately 150 feet of the Sulphur Creek bank and bed and placed northwest of the mine above the floodplain. The stream bank would be excavated in two terraces to stabilize it and replanted with reserved vegetation. It is estimated that approximately 0.5 acre of exposed stream bank would not be replanted and instead would be fertilized and hydroseeded. Storm water run-on would be controlled within the excavated area with hay bales placed on the steep slope above. An earthen cover consisting of approximately 1 foot of imported fill material would be placed over an approximate area of 0.75 acre of consolidated waste rock. The cover would be graded, fertilized, and revegetated using reserve vegetation. In addition, approximately 200 feet of drainage channel would be excavated around the upslope edge of the consolidated waste rock/earthen cover to prevent run-on of storm water.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Removal of mine waste from the north bank of Sulphur Creek will involve temporary removal of riparian habitat. The riparian habitat will be replaced after terracing the slope and final grading has been completed in order to mitigate the loss of habitat.

For the Elgin Mine, approximately 4,000 CY of waste rock would be pulled from the down slope side of open cuts back up onto the cuts. An additional 76 CY of tailings excavated from the retort site would also be placed with the consolidated waste rock. An earthen cover consisting of approximately 1 foot of imported fill material would be placed over the approximate area of 0.75 acre. The cover would be graded, fertilized, and revegetated. In addition, approximately 200 feet of drainage channel would be excavated around the uphill side of the consolidated waste rock/earthen cover to route all storm water runoff around the area. The approximately 1.75-acre waste rock excavation area and 0.125-acre former retort area would be graded and benched, fertilized, and hydroseeded to control erosion. Storm water run-on would be controlled within the revegetated waste rock excavation area by installing a 500-foot long ditch above. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and location of the consolidated mine waste, associated earthen cover, run-on and runoff surface control measures, and revegetation area. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of a control action at the West End mine may require inclusion of mitigation measures during project design to ensure attainment of a CEQA negative declaration. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.1.4 Alternative 7 – Excavate Mine Waste, Process Aggregate as a Commodity, Fix/Stabilize Hazardous Fines On Site

Implementation of this alternative consists of excavating mine waste, processing aggregate as a commodity, and either fixing or stabilizing the hazardous fines on site. This alternative was implemented, in part, at the Boston Hydraulic Mine in 2005 to treat mine waste excavated from ground sluices, a drainage tunnel, and plunge pool. It is not applicable at the Manzanita Mine as the only location available to place the solidified material would be the floodplain.

For the West End Mine, 3,600 CY of waste rock would be excavated from approximately 150 feet of the Sulphur Creek bank and bed. The excavated stream bank would be stabilized by laying it back with two terraces and either replanting it with reserved vegetation or fertilizing and hydroseeding it. Storm water run-on to the excavated/revegetated area would be controlled with hay bales placed above the steep slope. The excavated waste rock would be hauled to a centralized aggregate processing plant within 1 mile of the site, and the mercury laden fines would be separated from the aggregate, which would be sold as a commodity. It is assumed that up to 900 CY of mercury laden fines would be considered hazardous and fixed/stabilized by combining the fines and a stabilizing agent in a mobile pug mill. The solidified fines would be placed at a location northwest of the mine above the floodplain. Approximately 1 foot of imported fill material would be placed over the solidified fines assumed to occupy 0.25 acre, and the area would be fertilized and revegetated. Approximately 200 feet of drainage channel would also be excavated around the upslope edge of the solidified fines to prevent run-on of storm water.

For the Elgin Mine, approximately 4,000 CY of waste rock would be excavated from the down slope side of open cuts, along with an additional 76 CY of tailings from the retort site. The excavated slope, assumed to be 1.75 acres, and former retort area, assumed to be 0.125 acre, would be stabilized by grading and benching, fertilizing, hydroseeding, and preventing storm water run-on by installing a 500-foot ditch above the excavation area. The excavated waste rock and retort tailings would be hauled to a centralized aggregate processing plant within 2 miles of mine, and the mercury laden fines would be separated from the aggregate, which would be sold as a commodity. It is assumed that up to 1,000 CY of mercury laden fines would be considered hazardous and fixed/stabilized by combining the fines and a stabilizing agent in a mobile pug mill. The solidified fines would be returned to the mine cuts. Approximately 1 foot of imported fill material would be placed over the solidified fines assumed to occupy 0.25 acre, and the area would be fertilized and revegetated. Approximately 200 feet of drainage channel would also be excavated around the uphill side of the solidified fines to route storm water runoff around the area.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Removal of mine waste from the north bank of Sulphur Creek at West End Mine will involve temporary removal of riparian habitat. The riparian habitat will be replaced after terracing the slope and final grading has been completed in order to mitigate the loss of habitat.

- Noise – Processing (sorting and screening) of bulk mine waste to separate saleable aggregate from fines potentially containing mercury would generate elevated noise levels in the vicinity of both project sites for a period of two weeks. In addition, mixing of solidifying and stabilizing agents would generate elevated noise levels in the vicinity of the project site for a period of one week. Homes and business are not located in close proximity to the project site.

- Transportation – Saleable aggregate will be hauled from both project sites, along unpaved roads to storage areas along the Highway 20 corridor. Therefore, traffic disruption and controls may extend over a period of two weeks over the unpaved roads and a moderate length of Highway 20.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of the waste requiring excavation, the disposal locations for the solidified fines, and revegetation area. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of a control action at the West End mine may require inclusion of mitigation measures during project design to ensure attainment of a CEQA negative declaration. The duration of noise and transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR (environmental impact statement/environmental impact report) preparation. O&M (operation and maintenance) activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.1.5 Alternative 8 – Excavate Mine Waste, Process Aggregate as a Commodity, Dispose of Hazardous Fines at Off-Site Class I Repository

Implementation of this alternative consists of excavating mine waste, processing aggregate as a commodity, and disposing of the hazardous fines at an off-site Class I repository. It is applicable at all three mines. Disposal of fines in an off-site Class I repository is required when total mercury concentration is greater than 20 mg/kg or the leachable mercury concentration is greater than 0.2 mg/l (STLC). This alternative was recently implemented, in part, for mill waste at the Abbott and Turkey Run mines in the Harley Gulch watershed and at the Deertrail Mine, Los Padres National Forest, in 2004.

For the West End Mine, approximately 3,600 CY of waste rock would be excavated from approximately 150 feet of the Sulphur Creek bank and bed. The excavated stream bank would be stabilized by laying it back with two terraces, either replanting it with reserved vegetation or fertilizing and hydroseeding it, and controlling storm water run-on to the excavated/revegetated area with hay bales placed above the steep slope. The excavated waste rock would be hauled to a centralized aggregate processing plant within 1 mile of the mine, and the mercury laden fines would be separated from the aggregate, which would be sold as a commodity. It is assumed that up to 900 CY of mercury laden fines would be considered hazardous and hauled to an off-site Class I waste repository.

For the Manzanita Mine, 150 CY waste rock located on the floodplain at the toe of the slope below the mine would be excavated. The excavated waste rock would be hauled to a centralized aggregate processing plant within 1 mile of the mine, and the mercury laden fines would be separated from the aggregate, which would be sold as a commodity. Approximately 40 CY of process fines would be considered hazardous and hauled to an off-site Class I waste repository. Four-180 foot trenches (3 foot by 3 foot) would be excavated on the east and west sides of the waste rock area to divert water to two constructed sediment detention basins. Each trench would be lined with 18 to 24 inches of riprap. The sediment detention basins are assumed to be 100 feet by 100 feet by 4 feet deep and 200 feet by 100 feet by 4 feet deep, respectively. A 36-inch pipe would also be installed to convey water from the sediment detention basins to the creek. Approximately 0.5 acres of disturbed area would be fertilized and hydroseeded.

For the Elgin Mine**,** approximately 4,000 CY of waste rock would be excavated from the down slope side of open cuts and 76 CY of tailings from the retort site. The excavated slope, assumed to be 1.75 acres, and former retort area, assumed to be 0.125 acre, would be stabilized by grading and benching, fertilizing, hydroseeding, and preventing storm water run-on by installing a 500-foot ditch above the excavation area. The excavated waste rock and retort tailings would be hauled to a centralized aggregate processing plant within 2 miles of the mine, and the mercury laden fines would be separated from the aggregate, which would be sold as a commodity. It is assumed that up to 1,000 CY of mercury laden fines would be considered hazardous and hauled to an off-site Class I waste repository.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Removal of mine waste from the north bank of Sulphur Creek at West End Mine will involve temporary removal of riparian habitat. The riparian habitat will be replaced after terracing the slope and final grading has been completed in order to mitigate the loss of habitat.
- Noise – Processing (sorting and screening) of bulk mine waste to separate saleable aggregate from fines potentially containing mercury would generate elevated noise levels in the vicinity of

at all three project sites for a period of two weeks. Homes and business are not located in close proximity to the project site.

- Transportation – Saleable aggregate will be hauled from all three project sites, along unpaved roads to storage areas along the Highway 20 corridor. In addition, hazardous fines would be hauled off-site to a Class I repository located in southern California. Therefore, traffic disruption and controls may extend over a period of two weeks over the unpaved roads and the stretch of Highway 20 between Clear Lake and Interstate 5. The short term impact of increased traffic on Interstate 5 would be of little consequence.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of the waste requiring excavation and that the concentrations of mercury in the excavated waste requires disposal in an off-site Class I waste repository. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of a control action at the West End mine may require inclusion of mitigation measures during project design to ensure attainment of a CEQA negative declaration. The duration of noise and transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term) and sediment detention basins are cleaned out to maintain capacity (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.1.6 Alternative 10 – Construct Check Dams and Settling Basins in Ephemeral Drainages to Capture Eroding Mine Waste

Implementation of this alternative consists of constructing check dams and settling basins in ephemeral drainages to capture eroding mine waste. It is not applicable at West End Mine as no ephemeral drainages are present.

At the Manzanita Mine, two sediment detention basins would be installed in drainage ditches to capture runoff from the upper cuts located on the east and west sides of the mine. The sediment detention basin on the east side would be 100 feet by 100 feet by 4 feet deep, and the sediment detention basin on the west side would be 200 feet by 100 feet by 4 feet deep. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

At the Elgin Mine, five riprap velocity breaks would be installed at accessible locations along the ephemeral drainage starting at Elgin Spring in the upper portion of the mine site and extending down the canyon to the former retort location. Each velocity break would be constructed with 10 to 20 CY of 18 to 24 inch riprap. A 75-foot wide by 5-foot high earthen check dam would also be constructed with a 30-foot-wide broad crested concrete weir within the ephemeral drainage at the base of the meadow 0.5 mile upstream from the west fork of Sulphur Creek.

- Biological Resources – Installation of an earthen check dam within the ephemeral drainage at the base of the meadow may cause runoff to backup into the meadow and disrupt or cause a change in the type and size of habitat. In addition, preliminary studies should be undertaken to determine if wetlands are present in the meadow. No fishery is present in the ephemeral drainage or downstream Sulphur Creek.
- Hydrology – Installation of an earthen check dam within the ephemeral drainage at the base of the meadow will involve disturbing the natural course of ephemeral channel and hydrologic conditions within the upstream meadow.
- Transportation – Earth fill, rock, and concrete used to construct the check dam will be imported from off-site. The quantity of material brought into the site will be minimal; however, traffic disruption and controls on unpaved roads within the Sulphur Creek drainage may extend over a period of one month.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of the sediment detention basins, velocity breaks, and check dam, determining the retention time for solids settling, and determining if wetlands are present in the meadow below the Elgin mine. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of a control action at the Elgin mine may require preparation of an EIS/EIR due to construction of an earthen dam within a drainage and periodic inundation of a meadow. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to evaluate the need to prepare an EIS/EIR. The duration of noise and transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term) and sediment detention basins are cleaned out to maintain capacity (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.1.7 Comparative Analysis of Alternatives for Project Area 1

The effectiveness of Alternative 3, 4, 5, and 10 was considered limited to high (see Table 6-1a). For Alternatives 7 and 8, there would be a moderate to high reduction in the total and mobile mercury load, respectively, because mercury containing waste would be excavated and either fixed/stabilized on site or placed in an off-site Class I repository. Consequently, the volume, mobility, load, and water quality threat posed by mercury would be reduced. For Alternatives 4, 5, and 10, waste would either be consolidated and managed with run-on and runoff controls and/or an earthen cap, or captured by check dams and settling basins in ephemeral drainages. Consequently, there would be only a moderate reduction in the total and mobile mercury load. Alternative 3 would just consist of grading, revegetating, and installation of run-on and runoff controls/diversions for intact mine waste, which are highly dependent on maintenance activities; therefore, its effectiveness would be limited to moderate.

Alternatives 3, 4, 5, 7, 8, and 10 were considered readily implementable to more difficult to implement and technically feasible (see Table 6-1a). Alternative 3 would be readily to slightly difficult to implement, as conventional construction practices, materials, and engineering requirements are readily available, but long term O&M would be required.. Alternatives 4 and 5 would also be readily to slightly difficult to implement, as they both incorporate waste consolidation and on-site disposal, which may have potential site-specific impacts from residual mercury and mitigation measures may be required to address potential environmental impacts. Alternative 8 would be moderately difficult to difficult to implement because a Class I repository would require a more substantial transportation distance and engineering requirements, mitigation measures may be required to address potential environmental impacts, and long term O&M would be required. Alternative 10 would be moderately difficult to difficult to implement because of the potential need for preparation of an EIS/EIR, and long term O&M would be required. Alternative 7 would be difficult to implement as it requires fixation/stabilization of hazardous fines and placement of solidified fines on site and may require mitigation measures to address potential environmental impacts. None of the alternatives required significant preconstruction studies, or property acquisitions or easements, though stakeholder coordination would be required before proceeding with any of the alternatives.

Costs associated with the alternatives ranged from low to high (Tables 6-1a and 6-2a). Alternatives 3 and 4 were considered low to moderate in cost, as they incorporate on-site controls. Costs for Alternatives 5 and 10 were considered moderate and high, respectively, because they incorporate on-site containment structures such as an earthen cover or settling basin. Additional administrative costs for Alternative 10 include potential EIS/EIR preparation. Costs for Alternatives 7 and 8 were considered moderate to high and high, respectively, due to equipment and transportation costs associated with excavation, aggregate processing, and off-site disposal. Alternatives 3, 8, and 10 also require long term O&M, which extends on-going costs over time.

Alternative 8 was identified as the best alternative for Project Area 1 based on expected mercury concentrations in the mine waste and tailings and projected load reduction (see Table 6-2a); however, this conclusion is subject to additional data collection. Alternative 8 was also more administratively feasible than most of the other alternatives. The cost efficiency (cost divided by load reduction) was rated low to moderate, depending on the mercury concentrations in the waste and volume placed in an off-site Class I repository.

6.1.2 Project Area 2 - Floodplain Containing Mine Waste on Sulphur Creek

Project Area 2 consists of the Sulphur Creek floodplain, which contains mine waste that is assumed to be hazardous (see Figure 6-1). Sulphur Creek receives runoff from multiple mercury mines (Wide Awake, Manzanita, Central, Clyde, Elgin, West End, Cherry Hill, and Empire) and multiple springs. In addition, mine waste has been observed in eroded stream banks along Sulphur Creek between the Cherry Hill and Central mines. The floodplain below the mines also contains waste, which is being actively eroded. Up to 72,800 tons per yr of sediment is estimated to erode from the Sulphur Creek watershed; however, the quantity of sediment that actually reaches Sulphur Creek is not known. After receiving runoff from the mines, springs, and actively eroding floodplain, Sulphur Creek passes through a narrow canyon, before discharging to Bear Creek.

The estimated dissolved mercury load in surface water discharging from Sulphur Creek to Bear Creek is up to 0.3 kg/yr and is constant, while the total mine-related mercury load in sediment that discharges from Sulphur Creek to Bear Creek is up to 18.6 kg/yr, is located primarily in upland areas (mines) and is considered a potential load versus constant or pulse type of load release. The mercury load from erosion of the floodplain has not been estimated, but would be considered a pulsing type of release, primarily during runoff events. Mercury in Bear Creek sediments increases from 0.30 mg/kg above the confluence with Sulphur Creek to 12.9 mg/kg below the confluence and is a constant load.

6.1.2.1 Alternative 2 – Institute Land Use Restrictions and Implement BMPs to Limit Disturbance of Floodplain Containing Mine Waste

Alternative 2 consists of instituting land use restrictions and implementing BMPs to limit the disturbance of the Sulphur Creek floodplain containing mine waste. This project area consists of floodplain deposits containing mine waste from mercury mines within the Sulphur Creek Mining District that could potentially erode and be transported downstream; therefore, BMP measures such as soil conservation and crop cover would be enforced to limit the mobility of mercury laden soils. Institution of land use restrictions should also be considered to limit ongoing or future activities that would disturb intact mine waste. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, BMPs would have to be reviewed and effectiveness monitoring requirements established. Property acquisition, property easements, or building relocation is not required. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and community to discuss BMPs and evaluate potential impact of changes in land use on land owner/managers. No O&M activities are required as BMPs would continue to be implemented under existing programs. Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.1.2.2 Alternative 3 – Grade Floodplain Sediments Containing Mine Waste Away From Active Channel and Revegetate

Implementation of this alternative includes contouring the surface of the floodplain, installation of velocity breaks, and revegetation to restrict mine waste from the active channel. The surface of an estimated 28 acres of floodplain would be contoured to control sheet erosion. Hydroseed would be placed on the graded area and covered with mulch to protect the surface. Straw wattles would also be placed perpendicular to the contoured surface to slow runoff into the drainage channels that bisect the floodplain. It is assumed that 16 straw wattles would be placed every 50 feet and will be required for every acre of contoured floodplain.

Three velocity breaks would also be installed in each of six ephemeral drainage channels above the floodplain and one every 100 feet along each ephemeral drainage channel (20 total) on the floodplain. They would consist of jute matting and hydroseed banks. It is assumed that a total of 1,960 feet of ephemeral drainage channel is present on the floodplain.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Recontouring of the floodplain will involve temporary removal of upland and riparian habitat on the floodplain along the south bank of Sulphur Creek. The upland and riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size of the floodplain surface requiring contouring and revegetation, and location and number of velocity breaks. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require inclusion of mitigation measures during project design to ensure attainment of a CEQA negative declaration. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to ensure mitigation measures preclude the need to prepare an EIS/EIR. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.2.3 Alternative 10 – Construct Check Dam in Active Channel to Capture Eroding Sediment Containing Mine Waste

Implementation of this alternative includes construction of a low, earthen dam on Bear Creek downstream of the confluence with Sulphur Creek to capture eroding sediment containing mine waste. It would be located 0.25 mile downstream of the confluence with Sulphur Creek, along Bear Creek Road. The dam would be approximately 250 feet long by 20 feet high with a 150-foot concrete broad crested weir.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Installation of an earthen check dam within Bear Creek may alter the visual character of the Bear Creek canyon for visitors traveling to and from the Wilbur Hot Springs Resort. The earthen check dam can be sited to minimize visibility from the road and operated to minimize pool elevation.

- Biological Resources – Installation of an earthen check dam within Bear Creek just downstream of the confluence with Sulphur Creek will cause runoff to backup behind the check dam and disrupt or cause a change in the type and size of habitat along Bear Creek and its floodplain. In addition, a fishery is present in Bear Creek. The earthen check dam can be operated to minimize pool elevation and a fish ladder installed to minimize disruption of the fishery.

- Geology – Faults are present within or adjacent to the Bear Creek canyon; therefore, preliminary studies are recommended to determine if the site and soils are suitable for an earthen check dam.

- Hydrology – Installation of an earthen check dam within Bear Creek just downstream of the confluence with Sulphur Creek will involve disturbing the natural course of creek and hydrologic conditions upstream of the check dam. Scour may occur downstream of the proposed earthen dam; therefore, a preliminary scour analysis is recommended.

- Transportation – Earth fill, rock, and concrete used to construct the check dam will be imported from off-site. The quantity of material brought into the site will be significant and traffic disruption and controls on Highway 20 and unpaved roads within the Bear Creek canyon may extend over a period of two to three months.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include determining the retention time for solids settling, verifying the size of the dam and associated outlet weir, determining if geological conditions are suitable for construction of an earthen dam, and determining the potential impact of the earthen dam on downstream hydraulics. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to construction of an earthen dam within the drainage. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include cleaned out of accumulated sediments at the dam site to maintain capacity (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.2.4 Alternative 11 – Install In-Channel Erosion and Flood Controls to Reduce Erosion of Floodplain Sediment Containing Mine Waste

Implementation of this alternative includes installation of channel erosion and flood controls to reduce the erosion of floodplain sediment containing mine waste between the West End and Central Mines and adjacent to the Manzanita Mine. Channel erosion and flood controls include grading, placement of gabions, installing geogrids, planting vegetation, and creating a new meander pattern within Sulphur Creek.

Approximately 1 mile of the channel bank along Sulphur Creek between the West End and Central Mines would be graded back to a maximum 1:1 slope. Gabions would be installed along 0.25 mile of the channel to reduce side cutting and geogrids would be installed along the remainder of the channel bank (0.75 mile) to hold vegetation and support planted vegetation and hydroseeded channel banks. It is assumed that an average of 8 feet of bank requires restoration above the creek bed, and 19 riprap wing deflectors (average 10 feet long) would be placed in the channel to control stream velocity and scour.

The Sulphur Creek floodplain adjacent to the Manzanita Mine would be excavated. Approximately 2,800 CY of material from the floodplain and an additional 250 CY of sediment excavated from Sulphur Creek at the confluence with Bear Creek would be redistributed to create a new meander pattern within Sulphur Creek. Approximately 0.25 mile of the stream channel and bank along the new meander pattern would be graded to a maximum 1:1 slope, and gabions would be placed along 350 feet of the stream bank to reduce side cutting. Geogrids would also be installed along the remainder of the new channel bank (1,000 feet) to hold new seed and vegetation. It is assumed that an average of 8 feet of bank requires restoration above the creek bed, and seven riprap wing deflectors (average 10 feet long) would be placed in the channel to control stream velocity and scour.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Modification of the Sulphur Creek channel and stream banks may alter the visual character of Sulphur Creek for visitors at Wilbur Hot Springs Resort. However, the project will improve the visual impact of the riparian corridor along the stream.
- Biological Resources – Alteration of the Sulphur Creek channel and grading of stream banks will involve temporary removal of riparian habitat along Sulphur Creek. The riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat.
- Hydrology – Modification of the path of the Sulphur Creek channel will involve disturbing the natural course of creek and associated hydraulic conditions. In addition, installation of riprap wing deflectors will alter hydraulic conditions during high flow. Preliminary hydraulic and scour studies should be conducted before developing construction designs. Erosion of the recontoured stream banks and modified channel will be controlled through the use of riprap, gabions, and revegetation of riparian corridor.
- Transportation – Riprap used to construct wing deflectors will be imported from off-site. The quantity of material brought into the site will be minor and traffic disruption and controls on Highway 20 and unpaved roads within the Bear Creek canyon will not be required.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of channel erosion and flood controls, and conducting hydraulic and scour analysis. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to extensive modification of the stream channel, hydraulics, and riparian vegetation. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term) and energy dissipators along stream banks (low frequency, medium term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.2.5 Comparative Analysis of Alternatives for Project Area 2

The effectiveness of Alternative 2, 3, 10, and 11 would be limited to moderate (see Table 6-1a). For Alternatives 3 and 10, there would be a moderate reduction in the total and mobile mercury load because the effectiveness of grading, revegetating, and installation of run-on and runoff controls/diversions and the check dam depend on maintenance activities. For Alternative 11, there would be a moderate reduction in the total and mobile mercury load because channel erosion and flood controls would have to be inspected regularly to ensure that the stream banks are holding and the wing dams do not become inundated with sediment, which would decrease their effectiveness. For Alternative 2, there would be a limited reduction in total and mobile mercury load as the land use restrictions and BMPs only limit upland erosion. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternative 10, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 3, 10, and 11 were considered readily implementable to moderately difficult to implement and technically feasible (see Table 6-1a). Alternatives 2 and 3 would be readily implementable and moderately implementable, respectively, as they require only conventional construction practices, materials, and engineering. However, Alternative 3 would require mitigation measures to address potential environmental impacts. Alternatives 10 and 11 would be moderately difficult to difficult to implement, due to more complex engineering requirements, the potential need for preparation of an EIS/EIR, preconstruction studies, and long term O&M requirements. None of the alternatives required property acquisitions or easements, though stakeholder coordination would be required before proceeding with any of the alternatives.

Costs associated with the alternatives ranged from low to high (see Tables 6-1a and 6-2b). Alternatives 2 and 3 were considered low to moderate in cost, respectively, as they incorporate on-site controls. Alternatives 10 and 11 would have moderate to high and high cost, respectively, as they incorporate construction of a check dam and various floodplain erosion and flood controls. Additional administrative costs for Alternatives 10 and 11 include preconstruction studies and potential EIS/EIR preparation. Alternatives 10 and 11 also require long term O&M, which extends on-going costs over time.

Alternative 3 was identified as the best alternative for Project Area 2 due to the high mercury concentrations in the mine waste and floodplain sediment and projected load reduction (see Table 6-2b); however, this is subject to additional data collection. Alternative 3 was also more administratively feasible than Alternatives 10 and 11. The cost efficiency (cost divided by load reduction) was rated excellent, depending on the mercury concentrations in and stabilization of the floodplain sediments.

6.1.3 Project Area 3 - Floodplain Containing Mine Waste on Bear Creek

Project Area 3 consists of the Bear Creek floodplain containing mine waste (see Figure 6-1), which is assumed to have hazardous concentrations of mercury. Bear Creek receives runoff from ephemeral creeks draining the Rathburn, Rathburn-Petray, Petray North, and Petray South mercury mines. It also receives runoff directly from multiple springs, multiple mercury mines (Wide Awake, Manzanita, Central, Clyde, Elgin, West End, Cherry Hill, Empire) and the floodplain below these mines via Sulphur Creek. After receiving runoff from these sources, Bear Creek passes through a narrow canyon before discharging to a wide floodplain at the intersection of Highways 16 and 20. It is assumed that the Bear Creek floodplain contains elevated concentrations of mercury from the mines. The estimated mobile mercury load is up to 13.5 kg/yr and is considered a combination of a pulsing load (erosion of floodplain during runoff events) and a constant load (in channel sediments).

6.1.3.1 Alternative 2 – Institute Land Use Restrictions and Implement BMPs to Limit Disturbance of Floodplain Containing Mine Waste

Alternative 2 consists of instituting land use restrictions and implementing BMPs to limit the disturbance of the Bear Creek floodplain containing mine waste. This project area consists of floodplain deposits containing mine waste from Sulphur Creek Mining District mercury mines that could potentially erode and be transported downstream; therefore, BMP measures such as soil conservation and crop cover would be enforced to limit the mobility of mercury laden soils. Institution of land use restrictions should also be considered to limit ongoing or future activities that would disturb intact mine waste. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, BMPs would have to be reviewed and effectiveness monitoring requirements established. Property acquisition, property easements, or building relocation is not required. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and community to discuss BMPs and evaluate potential impact of changes in land use on land owner/managers. No O&M activities are required as BMPs would continue to be implemented under existing programs. Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.1.3.2 Alternative 3 – Grade Floodplain Sediments Containing Mine Waste Away From Active Channel and Revegetate

Implementation of this alternative includes grading sediments containing mine waste away from the active channel and revegetation. The Bear Creek floodplain likely contains elevated concentrations of mercury and is approximately 36 acres. Approximately 7,000 feet of the Bear Creek channel passes through this potentially impacted floodplain; therefore, approximately 80 feet on each side of the channel would be graded and revegetated to reduce the amount of sediment available for erosion.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Recontouring of the floodplain will involve temporary removal of riparian habitat along both banks of Bear Creek. The riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size of the floodplain surface requiring contouring and revegetation. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require inclusion of mitigation measures during project design to ensure attainment of a CEQA negative declaration. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to ensure mitigation measures preclude the need to prepare an EIS/EIR. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.3.3 Alternative 10 – Construct a Low Dam on the Active Floodplain to Capture Mobile Sediment Containing Mine Waste

Implementation of this alternative includes construction of a low, earthen dam at the outlet of Bear Creek meadow to capture mobile sediment containing mine waste. It would be located 0.5 mile south of the intersection of Highways 16 and 20. The dam would be approximately 700 feet long by 15 feet high with a 200-foot concrete broad crested weir.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Installation of an earthen check dam within Bear Creek may alter the visual character of the Bear Creek meadow near the intersection of Highways 16 and 20 for visitors traveling to and from the Clear Lake and Wilbur Hot Springs Resort. The earthen check dam can be sited to minimize visibility from the road and operated to minimize pool elevation.
- Biological Resources – Installation of an earthen check dam within Bear Creek just downstream of the Bear Creek meadow will cause runoff to backup behind the check dam and disrupt or cause a change in the type and size of habitat along Bear Creek and the meadow. Preliminary studies should be undertaken to determine if wetlands are present in the meadow. In addition, a fishery is present in Bear Creek. The earthen check dam can be operated to minimize pool elevation and a fish ladder installed to minimize disruption of the fishery.
- Geology – Faults are present within or adjacent to the Bear Creek canyon; therefore, preliminary studies are recommended to determine if the site and soils are suitable for an earthen check dam.
- Hydrology – Installation of an earthen check dam within Bear Creek just downstream of the Bear Creek meadow will involve disturbing the natural course of creek and hydrologic conditions upstream of the check dam. Scour may occur downstream of the proposed earthen dam; therefore, a preliminary scour analysis is recommended.
- Transportation – Earth fill, rock, and concrete used to construct the check dam will be imported from off-site. The quantity of material brought into the site will be significant and traffic disruption and controls on Highways 16 and 20 may extend over a period of three to four months.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include determining the retention time for solids settling, verifying the size of the dam and associated outlet weir, determining if geological conditions are suitable for construction of an earthen dam, determining if wetlands are present in the meadow, and determining the potential impact of the earthen dam on downstream hydraulics. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to construction of an earthen dam within a drainage and periodic inundation of a meadow. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include cleaned out of accumulated sediments at the dam site to maintain capacity (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.3.4 Comparative Analysis of Alternatives for Project Area 3

The effectiveness of Alternative 2, 3, and 10 would be limited to moderate (see Table 6-1a). For Alternatives 3 and 10, there would be a moderate to limited and moderate reduction, respectively, in the total and mobile mercury load because the effectiveness of grading and revegetating, and the check dam depend on maintenance activities. For Alternative 2, there would be a limited reduction in total and mobile mercury load as the land use restrictions and BMPs only limit upland erosion. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternative 10, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 3, and 10 were considered readily implementable to difficult to implement and technically feasible (see Table 6-1a). Alternatives 2 and 3 would be readily implementable and moderately implementable, respectively, as they require only conventional construction practices, materials, and engineering. However, Alternative 3 would require mitigation measures to address potential environmental impacts. Alternative 10 would be moderate to moderately difficult to implement, due to more complex engineering requirements, the potential need for preparation of an EIS/EIR, preconstruction studies, and long term O&M requirements. None of the alternatives required property acquisitions or easements, though stakeholder coordination would be required before proceeding with any of the alternatives.

Costs associated with the alternatives ranged from low to high (see Tables 6-1a and 6-2c). Alternatives 2 and 3 were considered low to moderate in cost, respectively, as they incorporate on-site controls. Alternative 10 would have a high cost as it incorporates construction of an earthen check dam. Additional administrative costs for Alternative 10 include preconstruction studies and potential EIS/EIR preparation. Alternative 10 also requires long term O&M, which extends on-going costs over time.

Alternative 3 was identified as the best alternative for Project Area 3 due to the high mercury concentrations in floodplain sediment and projected load reduction (see Table 6-2c); however, this is subject to additional data collection. Alternative 3 was also more administratively feasible than

Alternative 10. The cost efficiency (cost divided by load reduction) was rated excellent, depending on the mercury concentrations in and stabilization of the floodplain sediments.

6.1.4 Project Area 4 - Floodplain Containing Mine Waste on Harley Gulch

Project Area 4 consists of the floodplain containing mine waste on Harley Gulch (see Figure 6-1), where the mine waste is assumed to have hazardous concentrations of mercury. The project area consists of the West Fork of Harley Gulch and associated floodplain as well as the meadow at the confluence of the East and West Forks of Harley Gulch before the stream drops into the canyon. The West Fork of Harley Gulch receives runoff from Abbott and Turkey Run mines and Turkey Run Spring. Mine waste has been observed in eroded stream banks along Harley Gulch. After receiving runoff from the mines, springs, and actively eroding floodplain, Harley Gulch passes through a steep canyon before discharging to Cache Creek. The estimated mercury load from the floodplain is up to 7 kg/yr and is considered a pulsing load (erosion of floodplain and in channel sediments during runoff events).

6.1.4.1 Alternative 2 – Institute Land Use Restrictions and Implement BMPs to Limit Disturbance of Floodplain Containing Mine Waste

Alternative 2 consists of instituting land use restrictions and implementing BMPs to limit the disturbance of the Harley Gulch floodplain containing mine waste. This project area consists of floodplain deposits containing mine waste from Abbott and Turkey Run mines that could potentially erode and be transported downstream; therefore, BMP measures such as soil conservation and crop cover would be enforced to limit the mobility of mercury laden soils. Institution of land use restrictions should also be considered to limit ongoing or future activities that would disturb intact mine waste. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, BMPs would have to be reviewed and effectiveness monitoring requirements established. Property acquisition, property easements, or building relocation is not required. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and community to discuss BMPs and evaluate potential impact of changes in land use on land owner/managers. No O&M activities are required as BMPs would continue to be implemented under existing programs. Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.1.4.2 Alternative 3 – Grade Floodplain Sediments Containing Mine Waste Away From Harley Gulch Active Channel and Revegetate

Implementation of Alternative 3 includes grading of sediment containing mine waste away from the Harley Gulch active channel and revegetation. It is assumed that 30 feet of floodplain on average would be graded to an average depth of 5 feet on each side of the Harley Gulch channel. Because the total length of the channel through the floodplain is approximately 3,600 feet, it is assumed that about 5 acres of floodplain will be graded away from active channel and revegetated. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Recontouring of the floodplain will involve temporary removal of riparian habitat along both banks of Harley Gulch. The riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size of the floodplain surface requiring contouring and revegetation. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require inclusion of mitigation measures during project design to ensure attainment of a CEQA negative declaration. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, and technical experts to ensure mitigation measures preclude the need to prepare an EIS/EIR. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.4.3 Alternative 4 – Consolidate Floodplain Sediment Containing Mine Waste Above Floodplain, Revegetate, and Install Run-on and Runoff Controls

Implementation of Alternative 4 consists of consolidation of floodplain sediment containing mine waste, revegetation, and installation of run-on and runoff controls. It is assumed that approximately 7.5 acres of the floodplain will be excavated to an average depth of 5 feet and consolidated at the Abbott and Turkey Run Mines. The mines are located adjacent to ephemeral Harley Gulch and are the original sources of the material. It assumes that the consolidated material will cover an area of 4 acres to a depth of approximately 10 feet and will be graded and revegetated to reduce erosion. Run-on of water will be controlled using ditches. The floodplain will be recontoured following excavation and the ephemeral Harley Gulch channel realigned where disturbed. Velocity breaks will be installed in the stream channel to reduce velocity during high flow events. The entire area will be revegetated and riparian vegetation established along the stream channel.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Excavation of mine waste from and recontouring of the floodplain will involve temporary removal of riparian habitat along both banks of Harley Gulch. The riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat. In addition, preliminary studies should be undertaken to determine if wetlands are present on the floodplain.
- Hydrology **-** Excavation of mine waste from the floodplain will involve disturbing the natural course of ephemeral Harley Gulch. Any alteration of the channel during excavation will be removed as a part of floodplain recontouring. Erosion of the recontoured floodplain and channel will be controlled through the use of riprap velocity breaks and revegetation of riparian corridor.
- Transportation – Excavation of mine waste and hauling to the Abbott Mine requires use of Highway 20. The stretch of road to be used is very short; however, traffic disruption and controls may extend over a period of one to two months.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of the waste requiring excavation, size and location of the consolidation area, run-on and runoff surface control measures, the size of the area to be revegetated, and determining if wetland are present in the meadow. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to extensive excavation of the meadow and drainage channel, recontouring of the floodplain, and realigning the channel. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, does not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.4.4 Alternative 5 – Place Earthen Cover over Consolidated Floodplain Sediment Containing Mine Waste, Revegetate, and Install Run-on and Runoff Controls

Alternative 5 consists of placing an earthen cover over consolidated floodplain sediment containing mine waste, revegetation, and installation of run-on and runoff controls. It is assumed that approximately 7.5 acres of the floodplain will be excavated to an average depth of 5 feet and consolidated at the Abbott and Turkey Run Mines. The mines are located adjacent to ephemeral Harley Gulch and are the original sources of the material. It is assumed that the consolidated material will cover an area of 4 acres to a depth of approximately 10 feet, and the material will be graded, covered, and revegetated to reduce erosion. Run-on of water will be controlled using ditches. The floodplain will be recontoured following excavation and the ephemeral Harley Gulch channel realigned where disturbed. Velocity breaks will be installed in the stream channel to reduce velocity during high flow events. The entire area will be revegetated and riparian vegetation established along the stream channel.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Excavation of mine waste from and recontouring of the floodplain will involve temporary removal of riparian habitat along both banks of Harley Gulch. The riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat. In addition, preliminary studies should be undertaken to determine if wetlands are present on the floodplain.
- Hydrology - Excavation of mine waste from the floodplain will involve disturbing the natural course of ephemeral Harley Gulch. Any alteration of the channel during excavation will be removed as a part of floodplain recontouring. Erosion of the recontoured floodplain and channel will be controlled through the use of riprap velocity breaks and revegetation of riparian corridor.
- Transportation – Excavation of mine waste and hauling to the Abbott Mine requires use of Highway 20. The stretch of road to be used is very short; however, traffic disruption and controls may extend over a period of one to two months.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of the waste requiring excavation, size and location of the consolidation area, run-on and runoff surface control measures, the size of the area to be revegetated, and determining if wetland are present in the meadow. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to extensive excavation of the meadow and drainage channel, recontouring of the floodplain, and realigning the channel. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, does not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.4.5 Alternative 6 – Excavate Floodplain Sediment Containing Mine Waste, Process Aggregate as a Commodity, Dispose of Non-Hazardous Fines Off Site

Alternative 6 consists of excavation of the floodplain sediment containing mine waste, processing the aggregate as a commodity, and disposing of the non-hazardous fines off site. It is assumed that approximately 7.5 acres of the floodplain would be excavated to an average depth of 5 feet, and the material would be processed by a mobile physical separation plant to remove the saleable aggregate. The fines would be consolidated at the Abbott and Turkey Run Mines, adjacent to ephemeral Harley Gulch, which were the original sources of the material. The area would be graded and revegetated to reduce erosion, and run-on of water would be controlled using ditches. The floodplain will be recontoured following excavation and the ephemeral Harley Gulch channel realigned where disturbed. Velocity breaks will be installed in the stream channel to reduce velocity during high flow events. The entire area will be revegetated and riparian vegetation established along the stream channel.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Excavation of mine waste from and recontouring of the floodplain will involve temporary removal of riparian habitat along both banks of Harley Gulch. The riparian habitat will be replaced after grading has been completed in order to mitigate the loss of habitat. In addition, preliminary studies should be undertaken to determine if wetlands are present on the floodplain.

- Hydrology - Excavation of mine waste from the floodplain will involve disturbing the natural course of ephemeral Harley Gulch. Any alteration of the channel during excavation will be removed as a part of floodplain recontouring. Erosion of the recontoured floodplain and channel will be controlled through the use of riprap velocity breaks and revegetation of riparian corridor.

- Noise – Processing (sorting and screening) of bulk mine waste to separate saleable aggregate from fines potentially containing mercury would generate elevated noise levels in the vicinity of the project for a period of one to two months. Homes and business are not located in close proximity to the project site.
- Transportation – Excavation of mine waste and hauling to the Abbott Mine requires use of Highway 20. The stretch of road to be used is very short; however, traffic disruption and controls may extend over a period of one month. In addition, saleable aggregate will be hauled from the project site to storage areas along the Highway 20 corridor. Therefore, traffic disruption and controls may extend over a period of two months over a moderate length of Highway 20.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of the waste requiring excavation, fines disposal location, the size of the area to be revegetated, and determining if wetland are present in the meadow. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to extensive excavation of the meadow and drainage channel, recontouring of the floodplain, and realigning the channel. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. The duration of noise and transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.4.6 Alternative 10 – Construct Check Dam in Harley Gulch to Capture Eroding Mine Waste

Implementation of Alternative 10 consists of constructing an earthen check dam at the outlet to Harley Gulch meadow, just before it drops into the canyon to capture eroding mine waste. The dam would be approximately 200 feet long by 15 feet high, with a 50-foot concrete broad crested weir.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Installation of an earthen check dam within ephemeral Harley Gulch may alter the visual character of the Harley Gulch meadow south of Highway 20 for visitors traveling to and from the Clear Lake. The earthen check dam can be sited to minimize visibility from the road and operated to minimize pool elevation.

- Biological Resources – Installation of an earthen check dam within Harley Gulch just downstream of the meadow will cause runoff to backup behind the check dam and disrupt or cause a change in the type and size of habitat along Harley Gulch and the meadow. Preliminary studies should be undertaken to determine if wetlands are present in the meadow. A fishery is not present in ephemeral Harley Gulch.
- Geology – Faults are present within or adjacent to the Harley Gulch canyon; therefore, preliminary studies are recommended to determine if the site and soils are suitable for an earthen check dam.
- Hydrology – Installation of an earthen check dam within Harley Gulch just downstream of the meadow will involve disturbing the natural course of creek and hydrologic conditions upstream of the check dam. Scour may occur downstream of the proposed earthen dam; therefore, a preliminary scour analysis is recommended.
- Transportation – Earth fill, rock, and concrete used to construct the check dam will be imported from off-site. The quantity of material brought into the site will be significant and traffic disruption and controls on Highway 20 may extend over a period of two to three months.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include determining the retention time for solids settling, verifying the size of the dam and associated outlet weir, determining if geological conditions are suitable for construction of an earthen dam, determining if wetlands are present in the meadow, and determining the potential impact of the earthen dam on downstream hydraulics. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to construction of an earthen dam within a drainage and periodic inundation of a meadow. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, do not warrant an EIS/EIR preparation. O&M activities include cleaned out of accumulated sediments at the dam site to maintain capacity (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.4.7 Alternative 11 – Install In-Channel Erosion and Flood Controls to Isolate Mine Waste from Active Stream Channel

Implementation of Alternative 11 consists of installation of in-channel erosion and flood controls to isolate mine waste from the active stream channel. The entire West Fork of Harley Gulch and the confluence area would be placed in a concrete channel to isolate the mine waste from the active channel. The concrete channel would be 10 feet wide by 5 feet deep and approximately 3,600 feet in length.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Removal of the Harley Gulch channel and replacement with a concrete channel may alter the visual character of Harley Gulch for visitors traveling to and from Clear Lake along Highway 20. The visual impact could be reduced with a vegetative screen or by using a concrete box culvert along the proposed channel alteration corridor.
- Biological Resources – Replacing the Harley Gulch channel with a concrete channel would result in a permanent loss of riparian habitat along the channel and adjacent floodplain (loss of subsurface water). Preliminary studies should be undertaken to determine if wetlands are present in the meadow. A fishery is not present in ephemeral Harley Gulch.
- Hydrology – Replacing the Harley Gulch channel with a concrete channel will involve removing the natural course of creek and altering hydraulic conditions. Preliminary hydraulic and scour studies should be conducted for the concrete channel before developing construction designs.
- Transportation – Concrete used to construct the channel will be imported from off-site. The quantity of material brought into the site will be significant and traffic disruption and controls on Highway 20 will be required for a two to three month period.

Prior to implementation, preconstruction studies would be conducted and effectiveness monitoring requirements established. Preconstruction studies would include verifying the size and locations of channel erosion and flood controls, determining if wetlands are present in the meadow, and conducting hydraulic and scour analysis. Property acquisition, property easements, or building relocation is not required, though land owner/manager permission is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to extensive modification of the stream channel and hydraulics, permanent removal of riparian vegetation, and permanent impact on scenic vista. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. The duration of transportation disruption is short term and in a rural area and while potentially significant, does not warrant an EIS/EIR preparation. O&M activities include ensuring revegetation takes hold (short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.1.4.8 Comparative Analysis of Alternatives for Project Area 4

The effectiveness of Alternatives 2 through 6, 10, and 11 was considered limited to high (see Table 6-1a). Alternatives 4, and 5, and 6 were considered moderately high to highly effective, respectively, due to excavation and consolidation of waste materials or fines, which would reduce the volume, mobility, load, and water quality threat posed by mercury. Alternatives 10 and 11, which capture sediment or control creek exposure to floodplain sediment, were considered to have moderate and moderate to high effectiveness, respectively. Alternative 3 was considered to have limited effectiveness because mercury containing waste would be managed with floodplain grading and revegetation alone. For Alternative 2, there would be a limited reduction in total and mobile mercury load as the land use restrictions and BMPs only limit upland erosion. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternative 10, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2 through 6, 10, and 11 were considered readily to moderately implementable and technically feasible (see Table 6-1a). Alternatives 2 and 3 would be readily implementable, as conventional construction practices, materials, and engineering requirements are readily available. However, Alternative 3 would require mitigation measures to address potential environmental impacts. Alternatives 4, 5, and 6 would be moderately difficult to implement due to the potential need for preparation of an EIS/EIR. Alternatives 10 and 11 would be moderately difficult to implement, due to more complex engineering requirements, the potential need for preparation of an EIS/EIR, and preconstruction studies. Alternative 10 also requires long term O&M, which extends on-going costs over time. None of the alternatives required property acquisitions or easements, though stakeholder coordination would be required before proceeding with any of the alternatives.

Costs associated with the alternatives ranged from low to high (see Tables 6-1a and 6-2d). Alternatives 2 and 3 were considered low in cost as they incorporate on-site controls. Alternatives 4, 5, and 6 would have a high cost due to waste excavation, consolidation, and covering. Alternatives 10 and 11 would also have a moderate to high cost due preconstruction studies and construction of an earthen check dam and concrete lined drainage channel, respectively. Additional administrative costs for Alternatives 4, 5, 6, 10, and 11 include potential EIS/EIR preparation. Alternative 10 also requires long term O&M, which extends on-going costs over time.

Alternative 10 was identified as the best alternative for Project Area 4 due to the high mercury concentrations in floodplain sediment and projected load reduction (see Table 6-2d); however, this is subject to additional data collection. Alternative 10 was equally administratively feasible as Alternatives 4, 5, 6 and 11; although it does require long term O&M. The cost efficiency (cost divided by load reduction) was rated excellent, depending on the mercury concentrations in the floodplain sediments.

6.2 STREAM BASED PROJECT AREAS

Eight stream based load reduction alternatives were identified for possible implementation at the following 11 project areas:

1. South Fork Yuba River at Englebright Reservoir
2. Active Channel and Floodplain of Yuba River within the Yuba Goldfields
3. Active Channel and Floodplain of Feather River near confluence with Yuba River
4. Active Channel and Floodplain of Feather River near confluence with Bear River
5. Active Channel and Floodplain of Feather River from Nicolaus to Verona
6. Active Channel and Floodplain of Sacramento River Upstream of Feather River
7. Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo
8. Cache Creek Settling Basin
9. Yolo Bypass from Fremont Weir to Putah Creek
10. Lower Putah Creek Upstream of Yolo Bypass
11. Active Channel and Floodplain of Sacramento River from Verona to Freeport

These project areas are shown on Figures 6-1 through 6-5. The load reduction alternatives applicable to each of these project areas are compared in the following subsections, and this comparison is summarized in Table 6-1b. Load reduction efficiencies and comparative costs for each project area are provided in Tables 6-3a through 6-3k. Cost estimate summary tables are provided in Appendix A.

6.2.1 Project Area 1 - South Fork of the Yuba River at Englebright Reservoir

Project Area 1 consists of the South Fork of the Yuba River at Englebright (Lake) Reservoir. It is located northeast of Yuba City and the Yuba Goldfields, within the steep Yuba River canyon of the Sierra Nevada foothills, and is a major tributary of the Feather River (see Figure 6-3).

Englebright Reservoir is a narrow, 9-mile-long reservoir completed in 1941 for the primary purpose of trapping sediment derived from mining operations in the Yuba watershed. No other reservoirs are located between Englebright Reservoir and the hydraulic mine source areas. Today, Englebright Reservoir is used primarily for recreation and hydropower. It has a surface area of 815 acres and a shoreline of 24 miles. The reservoir provides 45,000 acre feet (or 56,000,000 cubic meters [m^3]) of stored water-right capacity, which is released each year through dam operations to benefit fish downstream. Associated hydroelectric generation provides annual energy needs for 50,000 homes. Water is also diverted for regional domestic and agricultural uses. The volume of stored water has been substantially reduced (approximately 26 percent) due to filling with a large volume of sediment. The estimated mobile mercury load from Englebright Reservoir is up to 11 kg/yr and is considered both a constant load (base flow) and pulsing load (releases during runoff events).

6.2.1.1 Alternative 2 - Reservoir Storage and Release Management

Implementation of this alternative includes managing the storage and release of water to reduce the total and mobile mercury load downstream, rather than just operating the reservoir for water storage, ecological benefit, and hydroelectric generation. The storage and release of water from the reservoir would be managed to allow optimum settling of suspended solids during the winter; a reduction in river flow, volume, and channel scour downstream of the reservoir; and, in turn, a reduction in the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Englebright Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system.

- Hydrology and Water Quality **-** Controlling the timing and volumetric rate of water release from Englebright Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.

- Utilities and Service Systems **-** Controlling the timing and volumetric rate of water release from Englebright Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters at the reservoir outfall.

6.2.1.2 Alternative 8 - Reservoir Dredging, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging of mercury laden sediment from the reservoir using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that dredging will remove approximately 8 million CY of sediment to an average depth of 20 below current reservoir bottom and would take approximately 8 to 10 years to complete. Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, or other control measures. The partially completed dredging of McNary and Lower Snake River reservoirs are projects of a similar scale that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury

load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the reservoir.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the reservoir on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the reservoir on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of reservoir sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the reservoir could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the reservoir over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present within or upstream of the reservoir. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present within any proposed fill site.
- Hydrology and Water Quality – Dredging of sediment from reservoir deposits may cause a temporary violation of water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling).

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within or upstream of the reservoir; and documenting habitat, species, and wetlands present within any proposed sediment disposal site. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters at the reservoir outfall.

6.2.1.3 Comparative Analysis of Alternatives for Project Area 1

The effectiveness for Alternatives 2 and 8 was considered limited to moderate and moderate, respectively (see Table 6-1b). For Alternative 2, improved settling of suspended solids would reduce the volume and load of mercury within the system downstream but is dependent on the mercury concentrations in the suspended solids and the duration of reservoir storage to allow settling of suspended solids. Alternative 8 would reduce the volume, mobility, load, and water quality threat posed by mercury contained in sediment within the reservoir through sediment removal from the system.

Alternatives 2 and 8 were considered moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternative 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternative 8 may require property acquisitions or easements for sediment disposal sites. Alternatives 2 and 8 would both require O&M activities, though only reservoir operations would be required over the long term.

Costs associated with the alternatives ranged from low to very high (see Tables 6-1b and 6-3a). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 8 would have a high cost due to extensive dredging, trucking, and off-site disposal of sediment. Additional administrative costs for Alternatives 2 and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternative 8 may require property acquisition or fees for off-site sediment disposal.

Alternative 2 was identified as the best alternative for Project Area 1 due to relatively cost efficient load reduction (see Table 6-3a); however, this is subject to additional data collection. Alternative 2 was more administratively feasible than Alternative 8; although it does require long term O&M. The cost efficiency (cost divided by load reduction) was rated excellent, depending on the mercury concentrations in the suspended sediments and solids settling rate.

6.2.2 Project Area 2 - Active Channel and Floodplain of the Yuba River within the Yuba Goldfields

Project Area 2 consists of the active channel and floodplain of the Yuba River within the Yuba Goldfields, which is a tributary of the Sacramento River. This area is located northeast of Yuba City, downstream of the Englebright Reservoir, and near Daguerre Point Dam (see Figure 6-3).

The Yuba Goldfields are a 10,000-acre valley on both sides of the Yuba River in Yuba County. They were created during the California Gold Rush when the first miners panned for gold in the stream beds in the valley, which was followed by hydraulic mining a decade later. After extracting the gold, the gravel was dumped back into the streams and river, which resulted in a flood of sediment, called slickens. Approximately 685 million cubic feet (1.94 m^3) of mining debris was deposited in the Yuba River, which raised the riverbed by up to 100 feet [30 m] in some cases and at times caused flooding. The river has since been dredged and the gravel piled along the river banks, creating piles of rock tailings and over 200 ponds. The slickens have undergone continual remining for gold and mercury recovery as well as aggregate mining. In addition, the active channel has been moved for remining, the levees are currently being trained in place to maintain the channel location, and a low debris dam is in place. Water from the Yuba River migrates into and through the goldfields, forming the interconnected ponds, which rise and fall according to the stage of the Yuba River and act as settling ponds. The Yuba Goldfields also consist of wetlands and ponds filled with bass and trout that are frequented by migrating waterfowl. There has also been a movement to establish a nature reserve on a portion of the goldfields. The estimated mobile mercury load from the Yuba River within the goldfields is up to 32 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

6.2.2.1 Alternative 2 - Coordinate Reservoir Release Management and Improve Control Structure Management

Implementation of this alternative includes coordinating the release of water from Englebright Reservoir and improving Daguerre Point Dam O&M activities. Flood control operations would be coordinated to manage the storage and release of water from Englebright Reservoir to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed. O&M activities for Daguerre Point Dam would be conducted to ensure the removal of sediment from behind the dam to minimize mercury laden sediment mobilization.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Englebright Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system. Periodic removal of in channel sediments behind Daguerre Point Dam may temporarily alter fisheries habitat after dredging, but is necessary to prevent sediment from choking the channel over the long term.

- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Englebright Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event, to determine the rate of reservoir storage capacity loss due to sediment infill, and to determine the frequency of maintenance dredging upstream of Daguerre Point Dam.

- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Englebright Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Yuba River, Daguerre Point Dam sediment removal efficiency, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); removal of accumulated sediment behind Daguerre Point dam (low frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters at the reservoir outfall and lower Yuba River.

6.2.2.2 Alternative 4 - Stabilize Stream Banks and Floodplain Surfaces

Implementation of this alternative includes stabilizing the Yuba River stream banks and floodplain surfaces to reduce erosion and mobilization of sediment containing elevated levels of mercury into the Yuba River. It is assumed that approximately 8 miles of stream bank adjacent to the goldfields, with a 15-foot height, and 960 acres of active channel and floodplain would be stabilized. Stream banks would be stabilized by altering channel geometry and being laid back, which would reduce hydraulic energy, and/or the installation of wing dams and riprap to reduce erosion and lateral migration of the stream into the floodplain. Riparian vegetation would be established to stabilize stream banks.

Floodplain surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients necessary to support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration would be given to native seed mixtures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Excavation and grading of stream banks and floodplain surfaces could alter the visual character of the Yuba River corridor, primarily due to short term removal of riparian vegetation, reworking of channel geometry, and construction of wing dams along the channel. The riparian vegetation will be replanted and become reestablish over the short term. Placement of wing dams within the channel should consider scenic vistas from highways, major roads, and wildlife areas.
- Biological Resources – Excavation and grading of stream banks along the south edge of the Yuba River will remove riparian habitat during the construction process; however, riparian vegetation will be replanted upon completion of construction. Future riparian habitat will be improved as the stream bank and active floodplain will be expanded along the river, providing a larger riparian corridor. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain. Construction of the proposed wing dams for energy dissipation within the existing channel may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. In addition, an estimate of fines loading and potential scour in the river should be developed.
- Hydrology and Water Quality – Construction of wing dams and placement of riprap on stream banks in high energy zones would reduce erosion and entrainment of mining impacted sediments; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Alteration of channel geometry by laying back stream banks would also reduce stream energy, but may contribute to a short term increase in local sediment load until the channel is stabilized. Water quality may be improved over the long term through reduced side cutting into floodplain sediments and associated decrease of suspended solids and mercury concentrations in river. Preliminary studies

should be conducted to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel.

- Noise – Excavation, screening, and grading of stream bank and floodplain sediments would generate elevated noise levels and vibrations in the vicinity of the river for a period of 1 to 2 years. Trucking noise from material runs between the project area and local aggregate processing plants for crushing and sizing would also generate elevated noise levels. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the project corridor passes close to existing towns.
- Transportation – Bulk materials will be hauled to and from the project corridor for aggregate crushing and sizing and return of final grading materials. Trucks will be routed along unpaved and paved roads along the Hammonton-Smartville Road corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 0.5 to 1 year. A separate haul road between the project corridor and existing aggregate processing plants may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the river; and to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel. Property acquisition and building relocation is not required, though property easements may be required to access the entire project area. Implementation of the control action may require preparation of an EIS/EIR due to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of stream banks (moderate frequency, medium term), revegetation of the floodplain (low frequency, short term), and fisheries monitoring during stream bank grading activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.2.3 Alternative 5 - Construct Flood Control Bypasses to Promote Solids Settling

Under this alternative flood routing and associated solids settling capacities would be increased through construction of an additional sediment control structure (flood control bypass) to promote solids settling.

To reduce stream energy at high flows and promote solids settling in a low energy environment, it is assumed that the flood control bypass would be approximately 6.5 miles in length by 0.5 mile wide. Examples of other flood control bypasses that promote solids removal include the Yolo and Sutter Bypasses within the Sacramento Basin.

Surface water flow would be diverted using passive/active weirs, berms, or hydraulic control levees. During peak flow periods, water would be diverted to the bypass to reduce river flow, volume, and channel scour and in turn reduce the suspension of mercury laden sediment in the watershed. The bypass would then be operated to improve settling of suspended solids. By delaying the discharge of water until suspended solids have settled, the transport of mercury laden sediment would be reduced. This alternative would also allow capture of all sediment size fractions, including some fines. There may be a concern regarding entrainment of residual mercury in the goldfield tailings.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of a flood control bypass would require levees to route flood water around the river. Placement of earthen levees within the Yuba Goldfields (dredge tailings) could alter the visual character of the region, likely for the better. Placement of the levees should consider scenic vistas from highways, major roads, and wildlife areas. Returning the Yuba Goldfields to a natural habitat or riparian habitat could improve the visual character of the area.
- Biological Resources – Periodic inundation of the Yuba Goldfields within the bypass may alter existing habitat (dredge tailings and ponds). Future land use practices within the bypass will determine the degree to which the Yuba Goldfields reverts back to upland and riparian habitat. Construction of levees to contain bypass flood flows will effectively alter wildlife migration patterns, diverting north-south migration. However, the bypass will provide a permanent east-west corridor for wildlife movement. A reduction in flood flows within the river may allow stabilization of the stream channel and growth of riparian vegetation along the channel and floodplain. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river, on the floodplain, and within the proposed bypass corridor. Diversion of peak flood flows to the bypass may reduce flushing of fine sediment from the river over the long term. Fine sediment may build up in the river, degrading spawning gravels over time. Therefore, use of an active weir to control bypass of flood flows from the river would be desirable, allowing periodic flushing of fines from the river. Preliminary studies should be conducted to document

fisheries habitat, species present, and spawning/rearing areas present along the river. In addition, an estimate of fines loading in the river and frequency of fines flushing should be developed.

- Hydrology and Water Quality – Redirecting flood flows from the river to a bypass will alter the existing drainage pattern for the region. A new drainage channel and floodplain will be created within the proposed bypass and will only receive water during periodic peak flow events. The flood control capacity of the existing system will be effectively doubled when overflow to the bypass occurs. Introduction of water to the bypass may lead to areas of scour and deposition, until a stable channel is established. In addition, removal of water volume and energy from the river may alter channel geometry downstream of the point of diversion. Reducing the volume and energy of flow within the river may reduce erosion, allowing the channel and floodplain to stabilize over the long term. Water quality will be improved through reduction of suspended solids and mercury concentrations in river and bypass discharge. Preliminary studies should be conducted to determine the potential affect of peak flow bypass on channel geometry, flood routing, and scour in both the existing river and proposed bypass.
- Noise – Importing, placement, and compaction of materials during levee construction would generate elevated noise levels and vibrations in the vicinity of the bypass corridor for a period of 2 to 3 years. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the bypass corridor passes close to existing towns.
- Transportation – Bulk materials (soils, gravels, and rock) will be hauled to the proposed bypass corridor for levee construction. Trucks will be routed along unpaved and paved roads along the Hammonton-Smartville Road corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 2 to 3 years. A separate haul road between the proposed bypass corridor and existing aggregate processing plants may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river, on the active floodplain, and within the proposed bypass corridor; to document fisheries habitat, species present, and spawning/rearing areas present along the river; to estimate fines loading in the river and required frequency of fines flushing; and to determine the potential affect of peak flow bypass on channel geometry, flood routing, and scour in both the river and proposed bypass. Property acquisition and easements may be required to access and construct the bypass corridor. Implementation of the control action may require preparation of an EIS/EIR due to levee construction, rerouting of flood water, alteration of riparian and upland habitat, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of the bypass corridor (low frequency, short term), levee and weir maintenance (low frequency, long term), and fines balancing and fisheries monitoring (low frequency, medium term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters up and down stream of the project area.

6.2.2.4 Alternative 6 - Construct Setback Levees to Isolate Yuba Goldfield Sediment from Adjacent Yuba River

As the volume of impacted floodplain sediment is too large to excavate and dispose of off site, this alternative would be implemented to isolate mercury and mine waste contained within the floodplain from the adjacent active stream channel and to reduce entrainment of mercury in goldfield tailings. It is assumed that 8 miles of setback levee (15 feet high) would be constructed adjacent to the goldfields. Setback levees would be constructed adjacent to the active stream channel, and flood flows would be contained within the levees, reducing or eliminating the transport of mercury laden sediment and mine waste from the floodplain. Maintenance of levees would be necessary to reduce erosion. It would also require consideration of the potential erosive forces of floodwaters downstream of the constructed levees and coordination of downstream flood protection measures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of an earthen levee along the north edge of the Yuba Goldfields (dredge tailings) could alter the visual character of the region, though it would be difficult to distinguish it from dredge tailings. Placement of the levee should consider scenic vistas from highways, major roads, and wildlife areas.
- Biological Resources – Construction of an earthen levee along the south edge of the Yuba River will remove riparian habitat during the construction process; however, riparian vegetation will be replanted upon completion of construction. Future riparian habitat will be improved as the levee will be set back from the river, providing a wider riparian corridor. The proposed levee may partially isolate the Yuba River from the flood plain, potentially altering existing floodplain habitat (dredge tailings and ponds), where existing tailings piles do not already abut the river. Overall, the proposed levee is not any taller than existing tailings piles, so large scale flood events

would still migrate into the Yuba Goldfields. The proposed levee may also alter wildlife migration patterns diverting north-south migration to an east-west corridor, though the levee is not a greater a barrier as the Yuba River itself. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the floodplain. Construction of the proposed levee back from the existing channel may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. In addition, an estimate of fines loading and potential scour in the river should be developed.

- Hydrology and Water Quality – Partial isolation of the river from the floodplain at moderate flood flows would reduce erosion and entrainment of mining impacted sediments; however, there is the potential for increased channel scour and new areas of fines deposition due to alteration of channel geometry and hydraulics. Water quality may be improved over the long term through reduced side cutting into floodplain sediments and associated decrease of suspended solids and mercury concentrations in river. There may also be a slight increase in flood risk on agricultural lands at moderate flood flow due to containment of the river within the proposed levee; however, existing regional flood control levees would still contain flood waters. Preliminary studies should be conducted to determine the potential affect of the proposed levee on channel geometry, flood routing, and scour/deposition in the river channel.
- Noise – Importing, placement, and compaction of materials during levee construction would generate elevated noise levels and vibrations in the vicinity of the river for a period of about 2 years. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the bypass corridor passes close to existing towns.
- Transportation – Bulk materials (soils, gravels, and rock) will be hauled to the north edge of the Yuba Goldfields for levee construction. Trucks will be routed along unpaved and paved roads along the Hammonton-Smartville Road corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of about 2 years. A separate haul road between the north edge of the Yuba Goldfields and existing aggregate processing plants may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the river; and to determine the potential affect of the proposed levee on channel geometry, flood routing, and scour/deposition in the river channel. Property easements may be required to access and construct the setback levee. Implementation of the control action may require preparation of an EIS/EIR due to levee construction, modification of channel geometry and hydraulics, alteration of riparian and upland habitat, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of stream banks (moderate frequency, medium term), levee maintenance (low frequency, long term), and fisheries monitoring during levee construction (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters up and down stream of the project area.

6.2.2.5 Alternative 8 - Dredging of Yuba River, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging of mercury laden sediment from the Yuba River and active floodplain using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that approximately 960 acres would be dredged to a depth of 10 feet (15.5 MCY). Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, or other control measures. The partially completed dredging of the Sacramento Shipping Channel is a project of a larger scale within the Sacramento Basin that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the river.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the river on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the river on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of in channel sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. Dredging of sediment from the river may alter riparian habitat. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and within any proposed fill site.
- Hydrology and Water Quality – Dredging of sediment from in channel river deposits may cause a temporary violation of in channel water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling). Dredging of sediment from an active channel may alter channel geometry and the erosive force of water downstream of the dredge area. Preliminary studies should be conducted to determine the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the river; documenting habitat, species, and wetlands present along the river and within any proposed sediment disposal site; determining the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the dredge area, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.2.6 Comparative Analysis of Alternatives for Project Area 2

The effectiveness for Alternatives 2, 4 and 8, and 5 and 6 were considered limited to moderate, moderate, and moderate to high, respectively (see Table 6-1b). For Alternative 2, managing the storage and release of water from Englebright Reservoir and removal of sediment from behind Daguerre Point Dam would reduce erosion and minimize mercury laden sediment mobilization but is dependent on the mercury concentrations in the suspended solids and the duration of reservoir storage to allow settling of suspended solids. Subsequently, there would be a limited to moderate reduction in the total and mobile mercury load. Through stabilization and dredging, Alternatives 4 and 8 would reduce the mobility, load, and water quality threat posed by mercury contained in sediment within the stream banks and floodplain that are actively contributing to mercury loading within the system downstream. Alternative 8 would also reduce the volume through dredging. Subsequently, there would be a moderate reduction in the total and mobile mercury load but it is dependent on the mercury content and volume of sediment stabilized or removed. Under Alternatives 5 and 6, a flood control bypass and setback levees would be constructed to reduce or eliminate the entrainment and transport of mercury laden sediment to the watershed. The majority of load reduction will occur during high flow and flood events, and load reduction effectiveness would depend on the duration of off-stream storage in the bypass and the scale of the setback levees. If the floodplain is restricted by setback levees and the erosive forces of floodwaters downstream are not accounted for, it could impact the overall effectiveness of this alternative. Subsequently, there would be a moderate to high reduction in the total and mobile mercury load for Alternatives 5 and 6. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternative 5, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 4, and 8 were considered moderately difficult to implement and Alternatives 5 and 6 difficult to implement, while all alternative are technically feasible (see Table 6-1b). All alternatives would require major preliminary studies and preparation of an EIS/EIR. Alternatives 4, 5, 6, and 8 may require property acquisitions or easements for site access, levee and bypass construction, and sediment disposal sites. All alternatives would require long term O&M activities, with only Alternative 8 requiring short term maintenance activities. No additional dredging for sediment removal is anticipated under Alternative 8, assuming stabilization of the Yuba Goldfields would also be conducted.

Costs associated with the alternatives ranged from moderate to very high (see Tables 6-1b and 6-3b). Alternative 2 was considered the least costly as it takes advantage of ongoing reservoir operations, though long-term maintenance dredging behind Daguerre Point Dam would be required. Alternative 4 would have a high cost associated primarily with grading and revegetation of stream banks and the active floodplain. Alternatives 5, 6, and 8 would have very high costs due to levee construction, bypass construction, and dredging, respectively. Additional administrative costs for all alternatives include preliminary studies and preparation of an EIS/EIR. Alternatives 2, 4, 5, and 6 also require long term O&M, which extends on-going costs over time. Alternative 4, 5, 6, and 8 may require property acquisition or easement fees for site access, construction, and sediment disposal.

Alternative 4 was identified as the best alternative for Project Area 2 due to relatively cost efficient load reduction (see Table 6-3b); however, this is subject to additional data collection. Alternative 4 was more administratively feasible than Alternatives 5 and 6; primarily due to simpler planning requirements and less extensive construction requirements. The cost efficiency (cost divided by load reduction) was rated as fair to good, depending on the mercury concentrations in and stabilization of stream bank and active floodplain sediments. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.2.3 Project Area 3 - Active Channel and Floodplain of the Feather River near the Confluence with the Yuba River

Project Area 3 consists of the active channel and floodplain of the Feather River near the confluence with the Yuba River. This area is located within the Yuba City metropolitan area, downstream of Englebright Reservoir and the Yuba Goldfields and Lake Oroville (see Figures 6-3 and 1-1). The Feather River channel project area is assumed to be 4 miles long, with an average width of 400 feet and average sediment depth of 10 feet. The Yuba River channel is assumed to be 0.75 mile long, with an average width of 150 feet and average sediment depth of 8 feet. The Yuba River floodplain is assumed to be 0.5 miles long, with an average width of 500 feet and average sediment depth of 15 feet. The estimated mobile mercury load in the Feather River between the Yuba and Bear Rivers is up to 13 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

The Feather River has a rich history of gold mining, is 170 miles long, and a principal tributary of the Sacramento River (Wikipedia 2008). The river consists of three separate forks, which unite as arms of Lake Oroville (a reservoir in the foothills 5 miles northeast of the city of Oroville. It generally flows south past Oroville and Yuba City, where it joins the Sacramento River. The levee system that protects adjacent land from river flooding does not completely cut off the stream from its floodplain. In other locations, levees may be absent altogether. The Feather River also receives water from the Yuba River, a major tributary located to the east. The confluence with the Yuba River is downstream of Englebright Reservoir, which was constructed for the primary purpose of trapping sediment derived from mining operations in the Yuba River watershed.

Lake Oroville is a large man-made reservoir located in the foothills of the Sierra Nevada, east of the city of Oroville. The lake has a capacity of 3,537,580 acre feet and is created by the Oroville Dam on the Feather River. The lake supplies water for transport to the Bay Area and southern portions of the state, and the dam houses an underground hydro-electric plant. It is also a state recreation area used for boating and is a popular fishing destination.

6.2.3.1 Alternative 2 - Coordinate Reservoir Release Management and Flood Control Operations

Implementation of this alternative includes coordinating the release of water from Lake Oroville and Englebright Reservoir. Flood control operations would be coordinated to manage the storage and release of water from the reservoir and lake to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Oroville and Englebright Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system.
- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Oroville and Englebright Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.
- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Oroville and Englebright Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Feather and Yuba Rivers, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.3.2 Alternative 4 - Stabilize Stream Banks and Floodplain Surfaces

Implementation of this alternative includes stabilizing the south side of the Yuba River stream bank and floodplain surfaces to reduce erosion and mobilization of sediment containing elevated levels of mercury into the Yuba River. It is assumed that approximately 0.75 miles of the channel and the floodplain, which averages 500 feet wide by 15 feet deep, would be stabilized. The stream bank would be stabilized by altering channel geometry and being laid back, which would reduce hydraulic energy, and/or the installation of wing dams and riprap to reduce erosion and lateral migration of the stream into the floodplain. Riparian vegetation would be established to stabilize stream banks.

Floodplain surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients and support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration would be given to native seed mixtures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Excavation and grading of stream banks and floodplain surfaces could alter the visual character of the Yuba River corridor, primarily due to short term removal of riparian vegetation, reworking of channel geometry, and construction of wing dams along the channel. The riparian vegetation will be replanted and become reestablish over the short term. Placement of wing dams within the channel should consider scenic vistas from highways, major roads, and wildlife areas.

- Biological Resources – Excavation and grading of stream banks along the south edge of the Yuba River will remove riparian habitat during the construction process; however, riparian vegetation will be replanted upon completion of construction. Future riparian habitat will be improved as the stream bank and active floodplain will be expanded along the river, providing a larger riparian corridor. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain. Construction of the proposed wing dams for energy dissipation within the existing channel may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. In addition, an estimate of fines loading and potential scour in the river should be developed.
- Hydrology and Water Quality – Construction of wing dams and placement of riprap on stream banks in high energy zones would reduce erosion and entrainment of mining impacted sediments; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Alteration of channel geometry by laying back stream banks would also reduce stream energy, but may contribute to a short term increase in local sediment load until the channel is stabilized. Water quality may be improved over the long term through reduced side cutting into floodplain sediments and associated decrease of suspended solids and mercury concentrations in river. Preliminary studies should be conducted to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel.
- Noise – Excavation, screening, and grading of stream bank and floodplain sediments would generate elevated noise levels and vibrations in the vicinity of the river for a period of 1 year. Trucking noise from material runs between the project area and local aggregate processing plants for crushing and sizing would also generate elevated noise levels. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the project corridor passes close to existing towns.
- Transportation – Bulk materials will be hauled to and from the project corridor for aggregate crushing and sizing and return of final grading materials. Trucks will be routed along unpaved and paved roads along the Hammonton-Smartville Road corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 0.5 year.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the river; and to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel. Property acquisition and building relocation is not required, though property easements may be required to access the entire project area. Implementation of the control action may require preparation of an EIS/EIR due to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of stream banks (moderate frequency, medium term), revegetation of the floodplain (low frequency, short term), and fisheries monitoring during stream bank grading activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.3.3 Alternative 8 - Dredging of Feather and Yuba Rivers near Point of Confluence, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging mercury laden sediment from the Feather and Yuba Rivers and the Yuba River floodplain using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that the following would be dredged: (1) 4 miles of the Feather River channel at average width of 400 feet and average sediment depth of 10 feet (3.1 MCY), (2) 0.75 mile of the Yuba River channel at an average width of 150 and average sediment depth of 8 feet (176,000 CY), and (3) 0.5 mile of the Yuba River floodplain at an average width of 500 feet and average depth of 15 feet deep (733,333 CY). Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, or other control measures. The partially completed dredging of the Sacramento Shipping Channel is a project of a larger scale within the Sacramento Basin that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury

load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the river.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the river on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the river on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of in channel sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. Dredging of sediment from the river may alter riparian habitat. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and within any proposed fill site.
- Hydrology and Water Quality – Dredging of sediment from in channel river deposits may cause a temporary violation of in channel water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling). Dredging of sediment from an active channel may alter channel geometry

and the erosive force of water downstream of the dredge area. Preliminary studies should be conducted to determine the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the river; documenting habitat, species, and wetlands present along the river and within any proposed sediment disposal site; determining the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the dredge area, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.3.4 Comparative Analysis of Alternatives for Project Area 3

The effectiveness for Alternatives 2, 4, and 8 were considered limited to high (see Table 6-1b). Under Alternative 2, managing the storage and release of water from reservoirs to reduce the flow and volume of the Feather and Yuba Rivers, respectively; their sediment carrying capacity; and channel and floodplain erosion and in-channel scour would reduce erosion and minimize mercury laden sediment mobilization but is dependent on the mercury concentrations in the suspended solids and the rate at which water is released. Subsequently, there would be a limited reduction in the total and mobile mercury load. Through stabilization, Alternative 4 would reduce the mobility, load, and water quality threat posed by mercury contained in sediment within the stream banks and floodplains that are actively contributing to mercury loading within the system downstream. Subsequently, there would be a moderate reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment stabilized. For Alternative 8, dredging would reduce the volume, mobility, load, and water quality threat posed by mercury contained sediment that is actively contributing to mercury loading within the system. Subsequently, there would be a high reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment removed. No net impact on potential mercury methylation is anticipated.

Alternatives 2, 4, and 8 were considered moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternatives 4 and 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternative 8 may require property acquisitions or easements for sediment disposal sites. Alternatives 2, 4, and 8 would require O&M activities, though only reservoir operations would be required over the long term. No additional dredging for sediment removal is anticipated under Alternative 8, assuming stabilization or dredging of the Yuba River would also be conducted.

Costs associated with the alternatives ranged from low to moderate (see Tables 6-1b and 6-3c). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 4 would have a moderate cost associated primarily with grading and revegetation of the floodplain. Alternative 8 would have a moderate to high cost due to extensive dredging, trucking or pumping of sediment, and off-stream disposal of sediment. Additional administrative costs for Alternatives 2, 4, and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternative 8 may require property acquisition or fees for off-site sediment disposal.

Alternative 4 was identified as the best alternative for Project Area 3 due to relatively cost efficient load reduction (see Table 6-3c); however, this is subject to additional data collection. Alternative 4 was more administratively feasible than Alternative 8; primarily due to no requirement to acquire or lease property to implement the control action. The cost efficiency (cost divided by load reduction) was rated as excellent, depending on the mercury concentrations in and stabilization of floodplain sediments. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.2.4 Project Area 4 - Active Channel and Floodplain of the Feather River near the Confluence with the Bear River

Project Area 4 consists of the active channel and floodplain of the Feather River near the confluence with the Bear River. This area is located south of Yuba City near the town of Nicolaus (see Figure 6-4). The project area is assumed to be approximately 2.5 miles of Feather River channel with at average width of 700 feet and average sediment depth of 10 feet and 1.5 miles of Feather River floodplain with at average width of 0.25 feet and average sediment depth of 12 feet. It also includes approximately 0.5 mile of Bear River channel with an average width of 120 feet and an average sediment depth of 6 feet, and Bear River floodplain with an average width of 0.25 mile and a depth of 12 feet. The estimated mobile mercury load from the Feather River at the Bear River is up to 9 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

The Feather River generally flows south past Oroville and Yuba City, where it joins the Sacramento River. The levee system that protects adjacent land from Feather River flooding does not completely cut off the stream from its floodplain. In other locations, levees may be absent altogether. Prior to joining the Sacramento River, the Feather River receives water from the Yuba River, a major tributary located to the east, which contains Englebright Reservoir and the Bear River a major tributary located to the east, which contains Camp Far West Reservoir (see Figure 1-1).

6.2.4.1 Alternative 2 - Coordinate Reservoir Release Management and Flood Control Operations

Implementation of this alternative includes coordinating the release of water from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir. Flood control operations would be coordinated to manage the storage and release of water from the lake and reservoirs to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system.
- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer

(less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.

- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Feather, Yuba, and Bear Rivers, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.4.2 Alternative 4 - Stabilize Stream Banks and Floodplain Surfaces

Implementation of this alternative includes stabilizing the active channel and floodplain of the Feather River near the confluence with the Bear River to reduce erosion and mobilization of sediment containing elevated levels of mercury into the Feather River. It is assumed that approximately 1.5 miles of the channel and the floodplain, which averages 0.25 mile wide by 15 feet deep, would be stabilized. A portion of the Feather River floodplain is already vegetated. Stabilization of the edge of the floodplain for the Bear River is not recommended as it is also already vegetated.

The stream bank of the Feather River would be stabilized by altering channel geometry and being laid back, which would reduce hydraulic energy, and/or the installation of wing dams and riprap to reduce erosion and lateral migration of the stream into the floodplain. Riparian vegetation would be established to stabilize stream banks.

Floodplain surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients and support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration would be given to native seed mixtures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Excavation and grading of stream banks and floodplain surfaces could alter the visual character of the Feather River corridor, primarily due to short term removal of riparian vegetation, reworking of channel geometry, and construction of wing dams along the channel. The riparian vegetation will be replanted and become reestablish over the short term. Placement of wing dams within the channel should consider scenic vistas from highways, major roads, and wildlife areas.
- Biological Resources – Excavation and grading of stream banks along the Feather River will remove riparian habitat during the construction process; however, riparian vegetation will be replanted upon completion of construction. Future riparian habitat will be improved as the stream banks and active floodplain will be expanded along the river, providing a larger riparian corridor. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain. Construction of the proposed wing dams for energy dissipation within the existing channel may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas

present along the river. In addition, an estimate of fines loading and potential scour in the river should be developed.

- Hydrology and Water Quality – Construction of wing dams and placement of riprap on stream banks in high energy zones would reduce erosion and entrainment of mining impacted sediments; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Alteration of channel geometry by laying back stream banks would also reduce stream energy, but may contribute to a short term increase in local sediment load until the channel is stabilized. Water quality may be improved over the long term through reduced side cutting into floodplain sediments and associated decrease of suspended solids and mercury concentrations in river. Preliminary studies should be conducted to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel.
- Noise – Excavation, screening, and grading of stream bank and floodplain sediments would generate elevated noise levels and vibrations in the vicinity of the river for a period of 1 year. Trucking noise from material runs between the project area and regional aggregate processing plants for crushing and sizing would also generate elevated noise levels. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the project corridor passes close to existing towns.
- Transportation – Bulk materials will be hauled to and from the project corridor for aggregate crushing and sizing and return of final grading materials. Trucks will be routed along Highway 70 and Hammonton-Smartville Road on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 0.5 year.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the river; and to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel. Property acquisition and building relocation is not required, though property easements may be required to access the entire project area. Implementation of the control action may require preparation of an EIS/EIR due to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of stream banks (moderate frequency, medium term), revegetation of the floodplain (low frequency, short term), and fisheries monitoring during stream bank grading activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.4.3 Alternative 7 - Capture Sediment Using Low Dam on Lower Bear River

Under this alternative, a low dam would be constructed on the Lower Bear River to maintain the hydraulic retention time required for energy dissipation and settling of fines and reduce the energy contributing to the lateral migration of the active channel and floodplain at its confluence with the Feather River that contains elevated levels of mercury and mine waste. It is assumed that the Bear River channel has an average width of 120 feet and the low earthen dam will include a concrete broad-crested weir with a maximum height of 8 feet.

By allowing suspended solids to settle, the transport of mercury laden sediment would be reduced. This alternative would also allow capture of all sediment size fractions, including some fines. Predominately medium- to coarse-grained mobile sediment would be captured by the dam during high energy events and fine grained sediment at low to moderate flows. Periodic removal of accumulated sediment would be required to maintain the hydraulic retention time required for settling of fines. Accumulated sediment would be physically processed for aggregate, and aggregate material with economic value would be transported off site for use in construction. Sediment would be processed at a central aggregate processing plant to separate coarse material from fine materials containing mercury.

Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, or other control measures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Installation of an earthen dam within Bear River just above its confluence with the Feather River may alter the visual character of the Bear River between of Highways 70 and 99.

The earthen dam can be sited to minimize visibility from the Highways and operated to minimize pool elevation.

- Agricultural Resources – Operation of the earthen dam could result in periodic inundation of orchards planted on the Bear River floodplain. The floodplain is bounded by regional levees which would increase the depth of inundation during even moderate flood flows. Consideration should be given to minimizing the time that the orchards are inundated to minimize root damage.
- Biological Resources – Installation of an earthen dam within Bear River just above its confluence with the Feather River will cause runoff to backup behind the dam and may cause a change in the type and size of riparian and upland habitat along Bear River and its floodplain. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain. A fishery is present in the Bear River. Construction of an earthen dam may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels (if any). A fish ladder could also be installed to minimize disruption of the migration patterns of the fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. In addition, an estimate of fines loading and potential scour in the river should be developed.
- Hydrology and Water Quality – Construction of an earthen dam within the Bear River just above its confluence with the Feather River would reduce erosion and entrainment of mining impacted sediments from the Bear River floodplain; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Water quality may be improved over the long term through reduced side cutting into floodplain sediments, settling of solids within the active channel, and associated decrease of suspended solids and mercury concentrations in river. Preliminary studies should be conducted to determine the potential affect of the proposed earthen dam construction on channel geometry and scour/deposition in the river channel. A detailed analysis of flood routing under various dam operation scenarios should also be developed to evaluate the potential for increased flood risk.
- Noise – Excavation, grading, and compaction of materials at the proposed dam site would generate elevated noise levels and vibrations in the vicinity of the river for a period of six months to a year.   Trucking noise from material runs between regional aggregate processing plants and the project site would also generate elevated noise levels. Homes and business are not located in close proximity to the project site.

- Transportation – Earth fill, rock, and concrete used to construct the earthen dam will be imported from regional aggregate processing plants. The quantity of material brought into the site will be significant and traffic disruption and controls on local paved and unpaved roads may extend over a period of six months to a year.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the river and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the river; and to determine the potential affect of the proposed earthen dam construction on channel geometry, flood routing, and scour/deposition in the river channel. Property acquisition and easements may be required to access the project site and construct the earthen dam. Implementation of the control action may require preparation of an EIS/EIR due to earthen dam construction, to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include earthen dam and weir maintenance (low frequency, long term), accumulated sediment removal and disposal (low frequency, long term), and fisheries monitoring during earthen dam (fish ladder/bypass) operations (low frequency, medium term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.4.4 Alternative 8 - Dredging of Feather and Bear Rivers near Point of Confluence, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging mercury laden sediment from the Feather River channel and the Feather and Bear River floodplains using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that the following would be dredged: (1) 2.5 miles of the Feather River channel at a average width of 700 feet and average sediment depth of 10 feet (3.42 MCY), (2) 1.5 mile of the Feather River Floodplain at an average width of 0.25 miles and average sediment depth of 15 feet (5.81 MCY), and (3) 2 miles of the Yuba River floodplain at an average width of 0.25 miles and average depth of 12 feet deep (6.2 MCY). Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be pumped over levees to a disposal area. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, and/or other control measures. The partially completed dredging of the Sacramento Shipping Channel is a project of a larger scale within the

Sacramento Basin that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the river.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the river on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the river on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of in channel sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. Dredging of sediment from the river may alter riparian habitat. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term.   Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and within any proposed fill site.

- Hydrology and Water Quality – Dredging of sediment from in channel river deposits may cause a temporary violation of in channel water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling). Dredging of sediment from an active channel may alter channel geometry and the erosive force of water downstream of the dredge area. Preliminary studies should be conducted to determine the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the river; documenting habitat, species, and wetlands present along the river and within any proposed sediment disposal site; determining the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the dredge area, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.4.5 Comparative Analysis of Alternatives for Project Area 4

The effectiveness for Alternatives 2, 4, 7, and 8 were considered limited to high (see Table 6-1b). Under Alternative 2, managing the storage and release of water from reservoirs would reduce erosion and minimize mercury laden sediment mobilization but is dependent on the mercury concentrations in the suspended solids and the rate at which water is released. Subsequently, there would be a limited reduction in the total and mobile mercury load. Through stabilization, Alternative 4 would reduce the mobility, load, and water quality threat posed by mercury contained in sediment within the stream banks and floodplains that are actively contributing to mercury loading within the system downstream. Subsequently, there would be a moderate reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment stabilized. For Alternative 7, installation of a low dam to reduce stream energy and promote settling of fines would reduce the mobility, load, and water quality threat posed by mercury in mobile sediment but is dependent on the mercury concentrations in the contained suspended solids and sediment. Subsequently, there would be a moderate reduction in the total and mobile mercury load. For Alternative 8, dredging would reduce the volume, mobility, load, and water quality threat posed by mercury contained sediment that is actively contributing to mercury loading within the system. Subsequently, there would be a high reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment removed. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternative 7, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 4, 7,and 8 were considered moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternatives 4, 7, and 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternatives 7 and 8 may require property acquisitions or easements for earthen dam construction and sediment disposal sites. Alternatives 2, 4, 7, and 8 would require O&M activities, though only reservoir operations would be required over the long term. No additional dredging for sediment removal is anticipated under Alternative 8, assuming stabilization or dredging of the Feather and Yuba Rivers would also be conducted.

Costs associated with the alternatives ranged from low to moderate (see Tables 6-1b and 6-3d). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 4 would have a moderate cost associated primarily with grading and revegetation of stream banks and floodplain. Alternative 7 would have a moderate cost associated with earthen dam construction. Alternative 8 would have a high cost due to extensive dredging, trucking or pumping of sediment, and off-stream disposal of sediment. Additional administrative costs for Alternatives 2, 4, 7, and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternatives 7 and 8 may require property acquisition or fees for earthen dam construction and off-site sediment disposal.

Alternative 4 was identified as the best alternative for Project Area 4 due to relatively cost efficient load reduction (see Table 6-3d); however, this is subject to additional data collection. Alternative 4 was more administratively feasible than Alternative 7; primarily due to no requirement to acquire or lease property to implement the control action and no impact on flood routing. The cost efficiency (cost divided by load reduction) was rated as good, depending on the mercury concentrations in and stabilization of floodplain sediments. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.2.5 Project Area 5 - Active Channel and Floodplain of the Feather River from Nicolaus to Verona

Project Area 5 consists of the active channel and floodplain of the Feather River from Nicolaus to Verona. This area is located south of Nicolaus and north of Verona (see Figure 6-4). The project area is assumed to be approximately 10.2 miles of Feather River channel with at average width of 475 feet and average sediment depth of 10 feet and 3 miles of Feather River floodplain (Nicolaus area) with at average width of 0.5 miles and average sediment depth of 15 feet. The estimated mobile mercury load from the Feather River from Nicolaus to Verona is up to 13 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

The Feather River generally flows south past Oroville and Yuba City, where it joins the Sacramento River. The levee system that protects adjacent land from Feather River flooding does not completely cut off the stream from its floodplain. In other locations, levees may be absent altogether. Prior to joining the Sacramento River, the Feather River receives water from the Yuba River, a major tributary located to the east that contains Englebright Reservoir, and the Bear River that contains Camp Far West Reservoir (see Figures 1-1 and 6-4).

6.2.5.1 Alternative 2 - Coordinate Reservoir Release Management and Flood Control Operations

Implementation of this alternative includes coordinating the release of water from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir. Flood control operations would be coordinated to manage the storage and release of water from the lake and reservoirs to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system.

- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.
- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Feather, Yuba, and Bear Rivers, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.5.2 Alternative 4 - Stabilize Floodplain Surfaces on the Feather River Near Nicolaus

Implementation of this alternative includes stabilizing the active floodplain surfaces of the Feather River near Nicolaus to reduce erosion and mobilization of sediment containing elevated levels of mercury into the Feather River. It is assumed that approximately 3 miles of the channel and the floodplain, which averages 0.5 mile wide by 15 feet deep, would be stabilized.

Floodplain surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients and support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration would be given to native seed mixtures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Excavation and grading of floodplain surfaces could alter the visual character of the Feather River corridor, primarily due to short term removal of riparian vegetation and reworking of channel geometry along the channel. The riparian vegetation will be replanted and become reestablish over the short term.
- Biological Resources – Excavation and grading of the active floodplain will remove riparian habitat during the construction process; however, riparian vegetation will be replanted upon completion of construction. Preliminary studies should be conducted to document habitat and species present on the active floodplain.
- Hydrology and Water Quality – Alteration of channel geometry by grading of the active floodplain would also reduce stream energy, but may contribute to a short term increase in local sediment load until the floodplain vegetation is stabilized. Water quality may be improved over the long term through reduced side cutting into and surface erosion of floodplain sediments and associated decrease of suspended solids and mercury concentrations in river. Preliminary studies

should be conducted to determine the potential affect of the proposed active floodplain grading on channel geometry and flood routing in the river channel.

- Noise – Excavation, screening, and grading of floodplain sediments would generate elevated noise levels and vibrations in the vicinity of the river for a period of 1 year. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the project corridor passes close to existing towns.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present on the active floodplain; and to determine the potential affect of the proposed active floodplain grading on channel geometry, flood routing, and scour/deposition in the river channel. Property acquisition and building relocation is not required, though property easements may be required to access the entire project area. Implementation of the control action may require preparation of an EIS/EIR due to alteration of riparian and upland habitat, and modification of channel geometry and hydraulics. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of the floodplain (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.5.3 Alternative 8 - Dredging of Feather River from Nicolaus to Verona, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging mercury laden sediment from the Feather River channel and floodplain using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that the following would be dredged: (1) 10.2 miles of the Feather River channel at an average width of 475 feet and average sediment depth of 10 feet (9.5 MCY) and (2) 3 miles of the Feather River floodplain (Nicolaus area) at an average width of 0.5 miles and average sediment depth of 15 feet (23.2 MCY). Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be pumped over levees to a disposal area. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, and/or other control measures. The partially completed dredging of the Sacramento Shipping Channel is a project of a larger scale within the Sacramento Basin that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the river.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the river on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the river on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of in channel sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. Dredging of sediment from the river may alter riparian habitat. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and within any proposed fill site.
- Hydrology and Water Quality – Dredging of sediment from in channel river deposits may cause a temporary violation of in channel water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations

of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling). Dredging of sediment from an active channel may alter channel geometry and the erosive force of water downstream of the dredge area. Preliminary studies should be conducted to determine the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the river; documenting habitat, species, and wetlands present along the river and within any proposed sediment disposal site; determining the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the dredge area, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.5.4 Comparative Analysis of Alternatives for Project Area 5

The effectiveness for Alternatives 2, 4, and 8 were considered limited to high (see Table 6-1b). Under Alternative 2, managing the storage and release of water from reservoirs would reduce erosion and minimize mercury laden sediment mobilization over time but is dependent on the mercury concentrations in the suspended solids and eroding active channel. This project area is further downstream from the reservoirs than other project areas; therefore, there would be a limited reduction in the total and mobile mercury load. For Alternative 4, stabilizing the active floodplain would minimize mercury laden sediment mobilization but is dependent on the mercury concentrations in the suspended solids and floodplain. Subsequently, there would be a moderate reduction in the total and mobile mercury load. For Alternative 8, dredging would reduce the volume, mobility, load, and water quality threat posed by mercury contained sediment that is actively contributing to mercury loading within the system. Subsequently, there would be a high reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment removed. No net impact on potential mercury methylation is anticipated.

Alternatives 2, 4, and 8 were considered moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternatives 4 and 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternative 8 may require property acquisitions or easements for sediment disposal sites. Alternatives 2, 4, and 8 would require O&M activities, though only reservoir operations would be required over the long term. No additional dredging for sediment removal is anticipated under Alternative 8, assuming stabilization or dredging of the Yuba River would also be conducted.

Costs associated with the alternatives ranged from low to moderate (see Tables 6-1b and 6-3e). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 4 would have a moderate cost associated primarily with grading and revegetation of the floodplain. Alternative 8 would have a moderate cost due to extensive dredging, trucking or pumping of sediment, and off-stream disposal of sediment. Additional administrative costs for Alternatives 2, 4, and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternative 8 may require property acquisition or fees for off-site sediment disposal.

Alternative 4 was identified as the best alternative for Project Area 5 due to relatively cost efficient load reduction (see Table 6-3e); however, this is subject to additional data collection. Alternative 4 was more administratively feasible than Alternative 8; primarily due to no requirement to acquire or lease property to implement the control action. The cost efficiency (cost divided by load reduction) was rated as good, depending on the mercury concentrations in and stabilization of floodplain sediments. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.2.6 Project Area 6 - Active Channel and Floodplain of the Sacramento River Upstream of Feather River

Project Area 6 consists of the active channel and floodplain of the Sacramento River upstream of the confluence with the Feather River. This area is located to the west of the Feather River near Verona, south of the Sutter Bypass and north of the Yolo Bypass (see Figures 6-5 and 6-4). The project area is assumed to be approximately 5.5 miles of Sacramento River channel with at average width of 300 feet and average sediment depth of 10 feet. The estimated mobile mercury load from the Sacramento River upstream of the Feather River is up to 138 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

The Sacramento River is the longest river in California at 447 miles (Wikipedia 2008). It starts near Mount Shasta and extends through the northern Central Valley before joining the San Joaquin River in the Delta, which ultimately empties into the Bay (see Figure 1-1). The principal tributaries of the Sacramento River consist of the Pit, Feather, McCloud, and American Rivers, with the Feather and American Rivers carrying the larger volumes of water.

6.2.6.1 Alternative 2 - Coordinate Reservoir Release Management and Flood Control Operations

Implementation of this alternative includes coordinating the release of water from all upstream reservoirs (Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir), including the Sutter and Yuba bypasses. The Sutter Bypass is located north of the project area, and the Yuba Bypass is located in the Yuba Goldfields, along the south side of the Yuba River (see Figures 6-4 and 6-3, respectively). Flood control operations would be coordinated to manage the storage and release of water from the reservoirs and bypasses to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system. Modifying the timing of flood control diversions at passive and active weirs (Colusa and Freemont) to increase sediment removal could potentially impact the volume and duration of peak flows necessary for fisheries migration, though flood protection is the overriding concern.

- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Modifying the timing of flood control diversions to maximize the volume of water diverted and sediment captured could also increase flood risk at peak flows due to loss of bypass flow capacity. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.
- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries. Modifying the timing of flood control diversions at passive and active weirs (Colusa and Freemont) could potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Sacramento and Feather Rivers, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations; flood control diversions (moderate frequency, long term); stream gaging (high frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.6.2 Alternative 8 - Dredging of Sacramento River Upstream of Verona, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging mercury laden sediment from the Sacramento River upstream of Verona using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that dredging will consist of 5.5 miles of the Sacramento River channel at an average width of 300 feet and average sediment depth of 10 feet (3.3 MCY). Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be pumped over levees to a disposal area. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, and/or other control measures. The partially completed dredging of the Sacramento Shipping Channel is a project of a larger scale within the Sacramento Basin that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the river.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the river on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the river on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of in channel sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel

structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. Dredging of sediment from the river may alter riparian habitat. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term.   Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and within any proposed fill site.

- Hydrology and Water Quality – Dredging of sediment from in channel river deposits may cause a temporary violation of in channel water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling). Dredging of sediment from an active channel may alter channel geometry and the erosive force of water downstream of the dredge area. Preliminary studies should be conducted to determine the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the river; documenting habitat, species, and wetlands present along the river and within any proposed sediment disposal site; determining the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the dredge area, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.6.3 Comparative Analysis of Alternatives for Project Area 6

The effectiveness for Alternatives 2 and 8 were considered limited and high, respectively (see Table 6-1b). Under Alternative 2, managing the storage and release of water from reservoirs and bypasses would reduce erosion and minimize mercury laden sediment mobilization over time but is dependent on the mercury concentrations in the suspended solids and eroding active channel. This project area is further downstream from the reservoirs than other project areas; therefore, there would be a limited reduction in the total and mobile mercury load. For Alternative 8, dredging would reduce the volume, mobility, load, and water quality threat posed by mercury contained sediment that is actively contributing to mercury loading within the system. Subsequently, there would be a high reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment removed. No net impact on potential mercury methylation is anticipated.

Alternatives 2 and 8 were considered moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternative 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternative 8 may require property acquisitions or easements for sediment disposal sites. Alternatives 2 and 8 would both require O&M activities, though only reservoir operations would be required over the long term. No additional dredging for sediment removal is anticipated under Alternative 8.

Costs associated with the alternatives ranged from low to moderate (see Tables 6-1b and 6-3f). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 8 would have a moderate cost due to extensive dredging, trucking or pumping of sediment, and off-stream disposal of sediment. Additional administrative costs for Alternatives 2 and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternative 8 may require property acquisition or fees for off-site sediment disposal.

Alternative 2 was identified as the best alternative for Project Area 6 due to relatively cost efficient load reduction (see Table 6-3f); however, this is subject to additional data collection. Alternative 2 was more administratively feasible than Alternative 8; although it does require long term O&M. The cost efficiency (cost divided by load reduction) was rated excellent, depending on the mercury concentrations in the suspended sediments and solids settling rate. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.2.7 Project Area 7 - Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo

Project Area 7 consists of the active channel and floodplain on Lower Cache Creek between the towns of Capay and Yolo, located west of Interstate-5 (I-5) and bisected by I-505 (see Figure 6-2). The project area consists of portions of the Lower Cache Creek active channel and floodplain west of I-505 to Capay and east of I-505 to Yolo. The portion of the project area from Capay to I-505 is assumed to consist of 6 miles of active channel at an average width of 50 feet and average sediment depth of 8 feet and 6 miles of active floodplain with an average width of 1,000 feet and depth of 15 feet. This reach of the creek has the biggest active floodplain that is clearly eroding and side cutting. The portion of the project area east of I-505 to Yolo is assumed to consist of 6 miles of active channel at an average width of 60 feet and average sediment depth of 6 feet and 6 miles of active floodplain with an average width of 450 feet and depth of 12 feet. This reach of the creek has about half of the active floodplain and less side cutting. The estimated mobile mercury load from the Lower Cache Creek is up to 224 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

Cache Creek is a large stream that originates at Clear Lake and is a smaller tributary of the Sacramento River. Clear Lake, Indian Valley Reservoir, and dams on upstream tributaries are managed to supply irrigation water to farmers in the lower parts of the Cache Creek basin. The Capay Diversion Dam serves as a diversion point for releasing water from the creek into two main channels, the Winters Canal to the south and West Adams Canal to the north, which irrigate more than 50,000 acres downstream. The dam is located above the town of Capay and is a concrete structure, 474 feet long and 15 feet high that was built in 1914. In 1994, an inflatable dam was added to the top of the old concrete and can be raised or lowered in 30 minutes; it raises the dam 5 feet and increases its ability to divert water. Three inactive mercury mining districts are also located in the upper Cache Creek Basin and are contributing to mercury loads within Lower Cache Creek. The lower portion of Cache Creek between the towns of Capay and Yolo has also been extensively mined for aggregate. In wet winters, creek bank erosion is common, and flooding occurs.

Cache Creek hosts one of the largest populations of wintering bald eagles in California, surrounding valleys and hills provide habitat for one of the largest tule elk herds in the state, black bear often search here for food, and the area is rich in Native American culture and is recognized on the National Register of Historic Places. Lower Cache Creek is also used for recreational purposes such as camping and rafting. In addition, The Cache Creek Nature Preserve and several other demonstration sites have been established for restoration of riparian vegetation, including Elderberry shrubs.

6.2.7.1 Alternative 4 - Stabilize Stream Banks and Floodplain Surfaces

Implementation of this alternative includes stabilizing the active channel and floodplain surfaces of the Lower Cache Creek to the west of I-505 to Capay and east of I-505 to Yolo to reduce erosion and mobilization of sediment containing elevated levels of mercury into Cache Creek. It is assumed that 6 miles of the Lower Cache Creek floodplain from Capay to I-505, which averages 1,000 feet wide by 15 feet deep would be stabilized. This reach of the creek has the biggest active floodplain that is clearly eroding and side cutting. It is also assumed that 6 miles of the Lower Cache Creek floodplain from I-505 to west of Yolo, which averages 450 feet wide by 12 feet deep would be stabilized. This reach of the creek has about half the active floodplain and less side cutting. Stream bank stabilization is not considered as the creek is too flashy and immediately migrates out onto floodplain. Rather, energy dissipation levees (right angle to flow) would be constructed to slow the water down and return the creek to a defined channel. It is expected that erosion would not be controlled for 5 to 10 years. Riparian vegetation would be established as an O&M activity after the creek has settled into a new channel.

Floodplain surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients and support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration would be given to native seed mixtures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Excavation and grading of stream banks and floodplain surfaces could alter the visual character of the Cache Creek corridor, primarily due to short term removal of riparian vegetation (if any), reworking of channel geometry, and construction of wing dams along the channel. The riparian vegetation will be replanted and become reestablish over the medium term.

Placement of wing dams within the channel should consider scenic vistas from highways, major roads, and wildlife areas.

- Biological Resources – Excavation and grading of stream banks along the Cache Creek will remove riparian habitat (if any) during the construction process; however, riparian vegetation will be replanted upon completion of construction. Future riparian habitat will be improved as the stream bank and active floodplain will be expanded along the creek, providing a larger riparian corridor. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain. Construction of the proposed wing dams for energy dissipation within the existing channel may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. In addition, an estimate of fines loading and potential scour in the creek should be developed.

- Hydrology and Water Quality – Construction of wing dams and placement of riprap on stream banks in high energy zones would reduce erosion and entrainment of mining impacted sediments; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Alteration of channel geometry by laying back stream banks would also reduce stream energy, but may contribute to a short term increase in local sediment load until the channel is stabilized. Water quality may be improved over the long term through reduced side cutting into floodplain sediments and associated decrease of suspended solids and mercury concentrations in creek. Preliminary studies should be conducted to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the creek channel.

- Noise – Excavation, screening, and grading of stream bank and floodplain sediments would generate elevated noise levels and vibrations in the vicinity of the creek for a period of 3 years. Trucking noise from material runs between the project area and local aggregate processing plants for crushing and sizing would also generate elevated noise levels. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the project corridor passes close to existing towns.

- Transportation – Bulk materials will be hauled to and from the project corridor for aggregate crushing and sizing and return of final grading materials. Trucks will be routed along unpaved and paved roads along the Highway 16 corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 3 years. A separate haul road between the project corridor and existing aggregate processing plants may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the creek; and to determine the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the creek channel. Property acquisition is not required, though property easements may be required to access the entire project area. Implementation of the control action may require preparation of an EIS/EIR due to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of stream banks (high frequency, long term), revegetation of the floodplain (moderate frequency, medium term), and fisheries monitoring during stream bank and floodplain grading activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.7.2 Alternative 5 - Construct Flood Control Bypasses to Promote Solids Settling

Under this alternative flood routing and associated solids settling capacities would be increased through the construction of an additional sediment control structure (flood control bypass) to promote solids settling. To reduce stream energy at high flows and promote solids settling in a low energy environment, it is assumed that a 12-mile bypass would be constructed from Capay to just west of Yolo. The bypass would be approximately 0.25 mile wide and constrained by 15-foot high levees. Examples of other flood control bypasses that promote solids removal include the Yolo and Sutter Bypasses within the Sacramento Basin.

Surface water flow would be diverted using a passive/active weir and hydraulic control levees. During peak flow periods, water would be diverted to the bypass to reduce river flow, volume, and channel scour and in turn reduce the suspension of mercury laden sediment in the watershed. The bypass would then be operated to improve settling of suspended solids. By delaying the discharge of water until suspended solids have settled, the transport of mercury laden sediment would be reduced. This alternative would also allow capture of all sediment size fractions, including some fines.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of a flood control bypass would require levees to route flood water around the creek. Placement of earthen levees on rural farmland could alter the visual character of the farmland. Placement of the levees should consider scenic vistas from highways, major roads, wildlife areas, and homes. Returning farmland to natural habitat or riparian habitat could improve the visual character of the area.
- Agricultural Resources – Construction of a flood control bypass on rural farmland could remove land from production, depending on the type of habitat desired within the bypass floodplain. At a minimum, homes and other agriculture related buildings would be displaced due to threat of flooding. Continued farming of the bypass floodplain would be desirable as tillage and revegetation would occur on a regular basis, minimizing entrainment of deposited sediment.
- Biological Resources – Periodic inundation of farmland within the bypass may alter existing habitat, including the creation of wetlands. Future land use practices within the bypass will determine the degree to which the farmland reverts back to upland and riparian habitat. Construction of levees to contain bypass flood flows will effectively alter wildlife migration patterns, diverting north-south migration. However, the bypass will provide a permanent east-west corridor for wildlife movement. A reduction in flood flows within the creek may allow stabilization of the stream channel and growth of riparian vegetation along the channel and floodplain. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek, on the floodplain, and within the proposed bypass corridor. Diversion of peak flood flows to the bypass may reduce flushing of fine sediment from the creek over the long term. Fine sediment may build up in the creek, degrading spawning gravels over time. Therefore, use of an active weir to control bypass of flood flows from the creek would be desirable, allowing periodic flushing of fines from the creek. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. In addition, an estimate of fines loading in the creek and frequency of fines flushing should be developed.
- Hydrology and Water Quality – Redirecting flood flows from the creek to a bypass will alter the existing drainage pattern for the region. A new drainage channel and floodplain will be created within the proposed bypass and will only receive water during periodic peak flow events. The

flood control capacity of the existing system will be effectively doubled when overflow to the bypass occurs. Introduction of water to the bypass may lead to areas of scour and deposition, until a stable channel is established. In addition, removal of water volume and energy from the creek may alter channel geometry downstream of the point of diversion. Reducing the volume and energy of flow within the creek may reduce erosion, allowing the channel and floodplain to stabilize over the long term. Water quality will be improved through reduction of suspended solids and mercury concentrations in creek and bypass discharge. Preliminary studies should be conducted to determine the potential affect of peak flow bypass on channel geometry, flood routing, and scour in both the existing creek and proposed bypass.

- Noise – Importing, placement, and compaction of materials during levee construction would generate elevated noise levels and vibrations in the vicinity of the bypass corridor for a period of 3 to 5 years. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the bypass corridor passes close to existing towns.

- Population and Housing – Construction of the proposed bypass would require displacement of rural homes within the proposed bypass, potentially requiring new construction elsewhere within the area. The proposed bypass would also visually divide rural communities due the presence of levees. Placement of the proposed bypass to minimize disturbance of existing rural communities and construction of bridges across the bypass should be considered during the planning process.

- Transportation – Bulk materials (soils, gravels, and rock) will be hauled to the proposed bypass corridor for levee construction. Trucks will be routed along unpaved and paved roads along the Highway 16 corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 3 to 5 years. A separate haul road between the proposed bypass corridor and existing aggregate processing plants may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek, on the active floodplain, and within the proposed bypass corridor; to document fisheries habitat, species present, and spawning/rearing areas present along the creek; to estimate fines loading in the creek and required frequency of fines flushing; and to determine the potential affect of peak flow bypass on channel geometry, flood routing, and scour in both the creek and proposed bypass. Property acquisition, easements, and relocation of rural homes and farms may be required to access and construct the bypass corridor. Implementation of the control action may require preparation of an EIS/EIR due to levee construction, relocations of rural homes and farms, rerouting of flood water, alteration of riparian and upland habitat, potential disturbance of fisheries habitat and spawning/rearing areas, and traffic disruption during construction. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of the bypass corridor (low frequency, short term), levee and weir maintenance (low frequency, long term), and fines balancing and fisheries monitoring (low frequency, medium term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters up and down stream of the project area.

6.2.7.3 Alternative 6 - Construct Setback Levees to Isolate Floodplain Sediment from Adjacent Cache Creek

As the volume of impacted floodplain sediment is too large to excavate and dispose of off site, this alternative would be implemented to train the channel to flow to the more restricted floodplain and reduce entrainment of deposited sediment on the larger floodplain. It is assumed that 12 miles of setback levees would be constructed along the Lower Cache Creek channel, with an average height of 10 feet. Flood flows would be contained within the levees, reducing the transport of mercury laden sediment and mine waste from the floodplain. Maintenance of levees would be necessary to reduce erosion. It would also require consideration of the potential erosive forces of floodwaters downstream of the constructed levees and coordination of downstream flood protection measures. Riparian vegetation would be established as an O&M activity after the creek has settled into a new channel.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of earthen setback levees along the active channel of Cache Creek could alter the visual character of the riparian corridor, though the levees would sit within the confines of the existing levee system. Placement of the levee should consider scenic vistas from highways, major roads, and wildlife areas.
- Biological Resources – Construction of earthen levees along Cache Creek will remove riparian habitat during the construction process; however, riparian vegetation will be replanted upon completion of construction. Future riparian habitat will be improved as the levees will be set back from the creek, providing wider riparian corridors. The proposed levees will partially isolate Cache Creek from its flood plain during moderate flood flows, allowing the existing floodplain to stabilize and vegetation to take hold. The proposed levees would still allow large

scale flood events to migrate onto the existing floodplain. The proposed levees may also alter wildlife migration patterns diverting north-south migration to an east-west corridor. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the floodplain. Construction of the proposed levees back from the existing channel may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. In addition, an estimate of fines loading and potential scour in the creek should be developed.

- Hydrology and Water Quality – Partial isolation of the creek from its floodplain at moderate flood flows would reduce erosion and entrainment of mining impacted sediments; however, there is the potential for increased channel scour and new areas of fines deposition due to alteration of channel geometry and hydraulics. Water quality may be improved over the long term through reduced side cutting into floodplain sediments and associated decrease of suspended solids and mercury concentrations in the creek. There may also be a slight increase in flood risk on agricultural lands at moderate flood flow due to containment of the creek within the proposed levees; however, existing regional flood control levees would still contain flood waters. Preliminary studies should be conducted to determine the potential affect of the proposed levees on channel geometry, flood routing, and scour/deposition in the creek channel.
- Noise – Importing, placement, and compaction of materials during levee construction would generate elevated noise levels and vibrations in the vicinity of the creek for a period of about 3 to 5 years. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the creek passes close to existing towns.
- Transportation – Bulk materials (soils, gravels, and rock) will be hauled to the proposed levee construction corridor. Trucks will be routed along unpaved and paved roads along the Highway 16 corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 3 to 5 years. A separate haul road between the proposed levee construction corridor and existing aggregate processing plants may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the creek; and to determine the potential affect of the proposed levee on channel geometry, flood routing, and scour/deposition in the river channel. Property easements may be required to access and construct the setback levees. Implementation of the control action may require preparation of an EIS/EIR due to levee construction, modification of channel geometry and hydraulics, alteration of riparian and upland habitat, potential disturbance of fisheries habitat and spawning/rearing areas, and disruption of traffic during construction. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of stream banks (high frequency, long term), revegetation of the floodplain (low frequency, short term), levee maintenance (low frequency, long term), and fisheries monitoring during levee construction (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters up and down stream of the project area.

6.2.7.4 Alternative 7 - Capture Sediment Using Low Dam on Lower Cache Creek

Under this alternative, three earthen dams with concrete broad-crested weirs would be installed across Lower Cache Creek between Capay and I-505 to capture sediment as the creek leaves the canyon and moves into the flatter valley reach. It is assumed that the earthen dam with concrete weir would be approximately 1,000 feet long by 10 feet high.

By allowing suspended solids to settle, the transport of mercury laden sediment would be reduced. This alternative would also allow capture of all sediment size fractions, including some fines. Predominately medium- to coarse-grained mobile sediment would be captured by the dam during high energy events and fine grained sediment at low to moderate flows. Periodic removal of accumulated sediment would be required to maintain the hydraulic retention time required for settling of fines. Accumulated sediment would be physically processed for aggregate, and aggregate material with economic value would be transported off site for use in construction. Sediment would be processed at existing aggregate processing plants along lower Cache Creek to separate coarse material from fine materials containing mercury.

Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, or other control measures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Installation of earthen dams within Cache Creek may alter the visual character of the Cache Creek between Capay and I-505. The earthen dams can be sited to minimize visibility from Highway 16 and I-505 and operated to minimize pool elevations.
- Biological Resources – Installation of earthen dams within Cache Creek will cause runoff to backup behind the dam and may cause a change in the type and size of riparian and upland habitat (if any) along Cache Creek and its active floodplain. The proposed earthen dams should stabilize the creek and its floodplain over the long term, allowing riparian vegetation to take hold. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain. A fishery is present in Cache Creek. Construction of earthen dams may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels. Fish ladders could also be installed to minimize disruption of the migration patterns of the fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. In addition, an estimate of fines loading and potential scour in the creek should be developed.
- Hydrology and Water Quality – Construction of earthen dams within Cache Creek would reduce erosion and entrainment of mining impacted sediments from the Cache Creek floodplain; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Water quality may be improved over the long term through reduced side cutting into active floodplain sediments, settling of solids within the active channel, and associated decrease of suspended solids and mercury concentrations in creek. Preliminary studies should be conducted to determine the potential affect of earthen dam construction on channel geometry and scour/deposition in the creek channel. A detailed analysis of flood routing under various dam operation scenarios should also be developed to evaluate the potential for increased flood risk.
- Noise – Excavation, grading, and compaction of materials at the proposed dam sites would generate elevated noise levels and vibrations in the vicinity of the creek for a period of 3 years. Trucking noise from material runs between local aggregate processing plants and the project sites would also generate elevated noise levels. Homes and business are generally not located in close proximity to the project corridor; however, vibration studies may be necessary where the creek passes close to existing towns.

- Transportation – Earth fill, rock, and concrete used to construct the earthen dams will be imported from local aggregate processing plants. The quantity of material brought into the project sites will be significant and traffic disruption and controls on Highway 16 and unpaved roads may extend over a period of 3 years.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the creek; and to determine the potential affect of the proposed earthen dam construction on channel geometry, flood routing, and scour/deposition in the creek channel. Property acquisition and easements may be required to access the project sites and construct the earthen dams. Implementation of the control action may require preparation of an EIS/EIR due to earthen dam construction, to traffic disruption during construction, to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, and potential disturbance of fisheries habitat and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include earthen dam and weir maintenance (low frequency, long term), accumulated sediment removal and disposal (low frequency, long term), and fisheries monitoring during earthen dam (fish ladder/bypass) operations (low frequency, medium term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.7.5 Alternative 8 - Excavation of Cache Creek Floodplain, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes excavating mercury laden sediment from the Lower Cache Creek floodplain using conventional equipment, processing the sediment off-site for aggregate, and disposal of the fines. It is assumed that the excavation area will consist of 6 miles of active floodplain between Capay and I-505 at an average width of 1,000 feet and average sediment depth of 15 feet (17.6 MCY). For the floodplain between I-505 and Yolo, it is assumed that the excavation area will consist of 6 miles of active floodplain at an average width of 450 feet and average sediment depth of 12 feet (6.3 MCY). Implementation of this alternative is expected to take about 2 years. Accumulated sediment would be trucked to a central aggregate plant and processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, and/or other control measures.

Floodplain surfaces would be stabilized by grading, adding soil amendments, and planting cover crops, brush, and/or trees. Adding soil amendments would provide the nutrients and support vegetation growth, which would provide an erosion-resistant cover that protects the ground surface from surface water and wind erosion. Successful vegetation growth would also require selecting the appropriate plant species for the area (accounting for slope, aspect, elevation) and climate (temperature and moisture). Consideration would be given to native seed mixtures. Riparian vegetation would be established as an O&M activity after the creek has settled into a new channel.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the creek on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes. Excavation of sediment from the creek and floodplain could also alter the visual character of the channel and riparian corridor. Reestablishing riparian vegetation should minimize aesthetic impacts over the medium to long term.
- Agricultural Resources - Placement of sediment dredged from the creek on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources – Excavation of channel sediment may alter fisheries habitat by removal of spawning gravels and other in channel structures. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Excavation of channel sediment may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The excavation process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. Excavation of sediment from the creek and floodplain may alter riparian and upland habitat. Placement of fill may impact habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Habitat could be reestablished along the creek, floodplain, and proposed fill site as part of the surface stabilization process. Dredging and filling may impact wetlands requiring Section 404

consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek, on the floodplain, and within any proposed fill site.

- Hydrology and Water Quality – Excavation of sediment from the creek and floodplain may cause a violation of water quality standards over the short to medium term for suspended solids and mercury due to the lack vegetative cover on the excavated surface. Erosion of the newly vegetated surface may occur in response to high water flows along the creek. Excavation of sediment from the active channel may alter channel geometry and the erosive force of water downstream of the project area, potentially contributing to an unstable channel, increased erosion, and an increased sediment load. Preliminary studies should be conducted to determine the potential affect of sediment excavation on channel geometry, flood routing, and scour of downstream stream banks and structures.
- Noise – Processing (sorting and screening) of bulk sediment to separate saleable aggregate from fines potentially containing mercury would generate elevated noise levels in the vicinity of existing aggregate processing areas for a period of 2 years. Homes and business are not located in close proximity to the aggregate processing areas.
- Transportation – Bulk sediment will be hauled from the project site, along unpaved and paved roads to aggregate processing areas along the Highway 16 corridor on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of 2 years. A separate haul road between the project site and the aggregate processing areas may be desired. Processed fines will be hauled from the aggregate processing area on an infrequent basis, along unpaved and paved roads to fill sites within the region.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the creek; documenting habitat, species, and wetlands present along the creek, on the active floodplain, and within any proposed sediment disposal site; and determining the potential affect of excavation on channel geometry, flood routing, and scour of downstream stream banks and structures. Property acquisition and easements may be required along the active floodplain and for the sediment disposal sites. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the excavated area, and potential alteration of riparian and upland habitat in the excavated areas and at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of the excavated floodplain and riparian corridor (high frequency, moderate term), revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during excavation activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.7.6 Comparative Analysis of Alternatives for Project Area 7

The effectiveness of Alternatives 4 through 8 was considered moderate to high (see Table 6-1b). Through stabilization and dredging, Alternatives 4 and 8 would reduce the mobility, load, and water quality threat posed by mercury contained in sediment within the stream banks and floodplain that are actively contributing to mercury loading within the system downstream. Alternative 8 would also reduce the volume through dredging. Subsequently, there would be a moderate to high reduction in the total and mobile mercury load but it is dependent on the mercury content and volume of sediment stabilized or removed. Under Alternatives 5 and 6, a flood control bypass and setback levees would be constructed to reduce or eliminate the entrainment and transport of mercury laden sediment to the watershed. The majority of load reduction will occur during high flow and flood events, and load reduction effectiveness would depend on the duration of off-stream storage in the bypass and the scale of the setback levees. If the floodplain is restricted by setback levees and the erosive forces of floodwaters downstream are not accounted for, it could impact the overall effectiveness of this alternative. Subsequently, there would be a moderate to high reduction in the total and mobile mercury load for Alternatives 5 and 6. For Alternative 7, installation of low dams to reduce stream energy and promote settling of fines would reduce the mobility, load, and water quality threat posed by mercury in mobile sediment but is dependent on the mercury concentrations in the contained suspended solids and sediment. Subsequently, there would be a moderate to high reduction in the total and mobile mercury load. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternatives 5 and 7, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 4, and 8 were considered moderately difficult to implement and Alternatives 5 and 6 difficult to implement, while all alternative are technically feasible (see Table 6-1b). All alternatives would require major preliminary studies and preparation of an EIS/EIR. Alternatives 4, 5, 6, 7, and 8 may require property acquisitions or easements for site access, levee and bypass construction, earthen dam construction, and sediment disposal sites. All alternatives would require long term O&M activities, with only Alternative 8 requiring short term maintenance activities. No additional dredging for sediment removal is anticipated under Alternative 8, assuming stabilization of the Yuba Goldfields would also be conducted.

Costs associated with the alternatives ranged from moderate to very high (see Tables 6-1b and 6-3g). Alternative 4 was considered the least costly with a moderate cost associated primarily with grading and revegetation of stream banks and the active floodplain. Alternatives 5, 6, 7, and 8 would have very high costs due to levee construction, bypass construction, earthen dam construction, and dredging, respectively. Additional administrative costs for all alternatives include preliminary studies and preparation of an EIS/EIR. Alternatives 4, 5, 6, and 7 also require long term O&M, which extend on-going costs over time. Alternative 5, 6, 7, and 8 may require property acquisition or easement fees for site access, construction, and sediment disposal. Alternative 5 would also require relocation costs for rural homes and farms.

Alternative 4 was identified as the best alternative for Project Area 7 due to relatively cost efficient load reduction (see Table 6-3g); however, this is subject to additional data collection. Alternative 4 was more administratively feasible than Alternatives 5, 6, and 7; primarily due to simpler planning requirements and less extensive construction requirements. The cost efficiency (cost divided by load reduction) was rated as fair to good, depending on the mercury concentrations in and stabilization of stream bank and active floodplain sediments. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.2.8 Project Area 8 - Cache Creek Settling Basin

Project Area 8 consists of the Cache Creek Settling Basin. It is located at the base of Cache Creek between Woodland and the Yolo Bypass, where it discharges (see Figure 6-5). The project area is approximately 1,500 to 3,500 acres.

Cache Creek Settling Basin was originally constructed in 1937 to preserve the floodway capacity of the Yolo Bypass by entrapping the heavy sediment load. It was modified in 1991 to a 50-year storage capacity, with an average of 340 acre feet of sediment accumulation per year, and an average trapping efficiency of 55 percent (Assembly Informational Hearing). The basin is bound by levees on all sides and covers approximately 3,600 acres (DWR 2003). Along the east levee of the basin, a roller compacted concrete weir, which is 1,740 feet long, controls the discharge of water to the Yolo bypass. The estimated mobile mercury load from the Cache Creek Settling Basin is up to 118 kg/yr and is considered a pulsing load (erosion of upstream channel sediments and floodplain during flood events).

6.2.8.1 Alternative 3 - Modify Existing Settling Basin to Improve Capture Efficiency

Under this alternative flood routing and associated solids settling capacities would be increased through the expansion of the existing Cache Creek Settling Basin. To reduce stream energy at high flows and promote solids settling in a low energy environment, it is assumed that the existing basin would be expanded by 1,500 acres by constructing a 3.5-mile long levee that is 15 feet high on farmland to the northeast. The existing levee along northeastern edge would be maintained to provide two settling cells, one for coarse material (northern) and fine material (southern). In addition, a 1,800-foot long concrete weir would be installed within the existing northeastern levee to control flow between the two cells. By further delaying the discharge of water until suspended solids have settled, the transport of mercury laden sediment would be reduced.

Periodic removal of accumulated sediment from the settling basin would continue to be required to maintain the hydraulic retention time required for settling of fines. Accumulated sediment would be physically processed for aggregate at a central processing facility to separate coarse material from fine materials containing mercury. Aggregate material with economic value would be transported off site for use in construction.

Fines that are separated from the bulk mine waste would be tested to determine the appropriate disposal methods. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, or other control measures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of earthen levees, in conjunction with existing flood control levees to expand the existing Cache Creek Settling Basin would alter the visual character of the surrounding agricultural land. Visual impact will be limited to local residents within agricultural district.
- Agricultural Resources – Construction of earthen levees and expansion of the settling basin on rural farmland could remove land from production for a portion of the year. At a minimum, homes and other agriculture related buildings would be displaced due to threat of flooding. Continued farming within the settling basin would be desirable as tillage and revegetation would occur on a regular basis, minimizing entrainment of deposited sediment.

- Biological Resources – Construction of earthen levees to expand the existing settling basin will cause runoff to inundate farmland and may result in an increase in the amount of riparian habitat. The proposed levees may also alter wildlife migration patterns limiting northward movement to a narrow corridor between the proposed levee and the Sacramento River. Preliminary studies should be conducted to document habitat, species, and any wetlands present within the settling basin expansion area. Construction of earthen levees will increase sediment deposition within the settling basin and may alter scour downstream of the settling basin, which could alter fisheries habitat and structure within the Yolo Bypass toe drains and sloughs. Preliminary studies should be conducted to document fisheries habitat and species present downstream of the settling basin. In addition, an estimate of fines loading within the settling basin and potential scour in the Yolo Bypass downstream of the settling basin outfall should be developed.

- Hydrology and Water Quality – Construction of earthen levees to expand the existing settling basin would capture entrained sediments eroded from the Cache Creek floodplain; however, there is the potential for increased scour downstream due to alteration of system hydraulics. Water quality downstream of the settling basin may be improved through settling of solids within the settling basin and associated decrease of suspended solids and mercury concentrations. Preliminary studies should be conducted to determine the potential affect of the proposed levee construction on downstream scour in the Yolo Bypass.

- Population and Housing – Construction of the proposed levees and creation and operation of the expanded settling basin would require displacement of rural homes within the proposed settling basin expansion area, potentially requiring new construction elsewhere within the area. Placement of the proposed levees to minimize disturbance of existing rural communities should be considered during the planning process.

- Noise – Importing, placement, and compaction of materials during levee construction would generate elevated noise levels and vibrations in the vicinity of the creek for a period of one to two years. Trucking noise from material runs between regional aggregate processing plants and the project sites would also generate elevated noise levels. Homes and business are not located in close proximity to the project site.

- Transportation – Earth fill, rock, and concrete used to construct the proposed earthen levees will be imported from regional aggregate processing plants. Trucks will be routed along Highway 16 and unpaved roads on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of one to two years.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present within the settling basin expansion area; to document fisheries habitat and species present downstream of the settling basin; to estimate fines loading within the existing and expanded settling basin; and to determine the potential affect of the proposed settling basin expansion on scour/deposition downstream of the settling basin. Property acquisition and easements may be required to access the project area and construct levees necessary to expand the settling basin. Relocation of rural homes/farms may also be required. Implementation of the control action may require preparation of an EIS/EIR due to levee construction, to relocation of rural homes/farms, to traffic disruption during construction, to potential alteration of riparian and upland habitat, and potential disturbance of fisheries habitat and species downstream of the settling basin. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include levee and weir maintenance (low frequency, long term), accumulated sediment removal and disposal (low frequency, long term), and fisheries monitoring following construction (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the settling basin.

6.2.8.2 Alternative 4 - Stabilize Settling Basin Surface

Implementation of this alternative includes stabilizing the settling basin surface to reduce erosion of sediment containing elevated levels of mercury and mobilization into the watershed. Current tillage practices and crop cover on existing farm land within the settling basin would be maintained and expanded to include an additional 1,400 acres.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, the size and volume of the settling basin would need to be verified and effectiveness monitoring requirements established. Property acquisition, easements, and building relocation are not required. Stakeholder meetings should be conducted with regulatory agencies and land owner/manager to discuss implementation. O&M activities include seasonal replanting of cover crop to minimize erosion (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the settling basin.

6.2.8.3 Alternative 8 - Excavation of Sediment from Settling Basin, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes excavating mercury laden sediment from the Cache Creek Settling Basin using conventional equipment, processing the sediment off-site for aggregate, and disposal of the fines. Excavation would increase the capacity of the settling basin and reduce entrainment of deposited fines. It is assumed that the lowest 25 percent of the 3,500 acre basin would be excavated to a depth of 5 feet resulting in removal of 7 million CY of sediment. Implementation of this alternative is expected to take about 5 to 7 years. Accumulated sediment would be trucked to a central aggregate plant and processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be transported by truck and placed on farmland protected by levees or used as fill at construction sites. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, and/or other control measures.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the settling basin on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the settling basin on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources – Excavation of sediment from the settling basin may alter habitat and wetlands within the settling basin. Placement of fill may impact habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Habitat could be reestablished in both the settling basin and proposed fill site as part of the surface stabilization process. Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present within the settling basin and any proposed fill site.

- Hydrology and Water Quality – Excavation of sediment from the settling basin may cause a temporary violation of water quality standards at the overflow weir for suspended solids and mercury due to the lack vegetative cover on the excavated surface of the settling basin. Erosion of the unvegetated surface may occur in response to overflow from Cache Creek. It is likely that the hydraulic residence time of the settling basin will allow for sufficient time for settling to occur, minimizing the frequency of exceedence of water quality standards.
- Noise – Processing (sorting and screening) of bulk sediment to separate saleable aggregate from fines potentially containing mercury would generate elevated noise levels in the vicinity of the project site for a period of 5 to 7 years. Homes and business are not located in close proximity to the project site.
- Transportation – Saleable aggregate will be hauled from the project site, along unpaved and paved roads to storage areas west of Yolo along the Highway 16 corridor on an as needed basis. Processed fines will be hauled from the project site, along unpaved and paved roads to a disposal site nearby the project area. Local traffic disruption will occur at a regular frequency, extending over a period of 5 to 7 years. A separate haul road between the project site and the disposal area may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; and documenting habitat, species, and wetlands present within the settling basin and at proposed sediment disposal sites. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on potential alteration of riparian and upland habitat within the settling basin and at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of the settling basin and sediment disposal site (moderate frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the settling basin.

6.2.8.4 Comparative Analysis of Alternatives for Project Area 8

The effectiveness of Alternatives 4, 3, and 8 were considered moderate and moderate to high, respectively (see Table 6-1b). Alternative 3 would improve the current effectiveness of the existing sediment control structure by increasing the size of the settling basin and reducing the volume of suspended solids contributing to mercury loading within the system. Subsequently, there would be a moderate to high reduction in the total and mobile mercury load. For Alternative 8, excavation would reduce the volume, mobility, load, and water quality threat posed by removal of sediment from the system; however, it is dependent on the mercury content and volume of sediment removed. Subsequently, there would be a moderate to high reduction in the total and mobile mercury load. Alternative 4 would stabilize the basin and improve its trapping effectiveness subsequently, which would provide a moderate reduction in the mobility, load, and water quality threat posed by mercury. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternative 3, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 3, 4, and 8 were considered readily implementable to moderately difficult to implement and technically feasible (see Table 6-1b). Alternatives 3 and 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternatives 3 and 8 may require property acquisitions or easements for levee construction and sediment disposal sites. Relocation of rural homes/farms may also be required under Alternative 3. Alternatives 3 and 4 would require long term O&M activities.

Costs associated with the alternatives ranged from low to high (see Tables 6-1b and 6-3h). Alternative 4 would not require any additional cost to implement as it relies on maintaining current tillage practices and crop cover within the settling basin. Alternatives 3 and 8 would have moderate to high costs associated with levee construction and excavation, respectively. Additional administrative costs for Alternatives 3 and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 3 also requires long term O&M, which extends on-going costs over time. Alternatives 3 and 8 may require property acquisition or fees for levee and off-site sediment disposal. Alternative 3 may also require relocation costs for rural homes and farms.

Alternative 3 was identified as the best alternative for Project Area 8 due to relatively cost efficient load reduction (see Table 6-3h); however, this is subject to additional data collection. Alternative 4 was more administratively feasible than Alternatives 3 and 8; primarily due to no construction and no requirement to acquire property or relocate homes and farms to implement the control action. The cost efficiency (cost divided by load reduction) was rated as very good, depending on the mercury concentrations in mobile creek and floodplain sediments to be settled.

6.2.9 Project Area 9 - Yolo Bypass from Fremont Weir to Putah Creek

Project Area 9 is located within the upper Yolo Bypass and extends from the Fremont Weir to Putah Creek (see Figure 6-5). The project area is approximately 20 miles long by 1.75 miles wide.

The Yolo Bypass is a 59,000-acre area connected to the Sacramento River and Cache Creek by weirs, with the passive Fremont Weir being the main input. The bypass separates the cities of West Sacramento from Davis and is crossed by the Yolo Causeway, a highway bridge on I-80. It protects Sacramento and other Central Valley communities from flooding by routing flood water from the Sacramento River, Sutter Bypass, Feather River, and Cache Creek Settling Basin around the city of Sacramento, where it ends a few miles north of Rio Vista. During wet years, the bypass can be completely full of water. The estimated mobile mercury load from the Yolo Bypass is up to 154 kg/yr and is considered a pulsing load (carrying of suspended sediment and erosion of floodplain during flood events).

Downstream, the Sacramento Weir, located just north of the city of West Sacramento, can also be opened to divert additional waters to protect Sacramento and West Sacramento, if needed. The Yolo Bypass contains the Vic Fazio Yolo Wildlife Area, a public/private restoration project that forms a valuable wetland during many months. In the summer, the bypass is used for agriculture purposes.

6.2.9.1 Alternative 2 - Coordinate Reservoir Release Management and Improve Flood Control Bypass Management

Implementation of this alternative includes coordinating the release of water from upstream reservoirs (Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir), the Sutter and Yuba Bypasses, and the Cache Creek Settling Basin and weir to maximize the volume of sediment retained in the Yolo Bypass. Flood control operations would be coordinated to manage the storage and release of water to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system. Modifying the timing of flood control diversions at passive and active weirs (Colusa, Freemont, Cache, and Sacramento) to increase sediment removal could potentially impact the volume and duration of peak flows necessary for fisheries migration, though flood protection is the overriding concern. Increasing the rate of sediment deposition within the Yolo Bypass would increase the amount of mercury stored in the bypass. Research studies should be conducted to evaluate the potential change in methyl mercury load discharging from the Yolo Bypass in response to altering sediment deposition patterns.

- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Modifying the timing of flood control diversions to maximize the volume of water diverted and sediment captured could also increase flood risk at peak flows due to loss of bypass flow capacity. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.
- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright Reservoir, and Camp Far West Reservoir during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries. Modifying the timing of flood control diversions at passive and active weirs (Colusa, Freemont, and Sacramento) could potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Sacramento and Feather Rivers, Putah Creek, Cache Creek Settling Basin, and Yolo

Bypass, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); flood control diversions (moderate frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.9.2 Alternative 3 - Install Sediment Control Structures in Yolo Bypass to Improve Sediment Capture Efficiency

Under this alternative, the hydraulic retention time and associated solids settling capacities would be increased in the upper Yolo Bypass through the installation of four concrete weirs. It is assumed that the weirs would be approximately 1.75 miles long by 6 feet high. By further delaying the discharge of water until suspended solids have settled, the transport of mercury laden sediment would be reduced.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of concrete weirs within the Yolo Bypass to capture sediment during flood flows would alter the visual character of the floodplain and surrounding agricultural land and wildlife areas. Selection of a weir construction sites within the Yolo Bypass should consider scenic vistas from highways, major roads, and wildlife areas.
- Agricultural Resources – Construction of concrete weirs within the Yolo Bypass could increase the frequency and duration of farmland inundation, potentially removing land from production. Continued farming within the Yolo Bypass would be desirable as tillage and revegetation would occur on a regular basis, minimizing entrainment of deposited sediment.
- Biological Resources – Construction of concrete weirs within the Yolo Bypass to enhance sediment removal during flood flows may cause a change in the type and extent of riparian and upland habitat within the bypass. The proposed concrete weirs may also alter wildlife migration

patterns within the Yolo Bypass. Preliminary studies should be conducted to document habitat, species, and wetlands present within the Yolo Bypass. A fishery may be present in the toe drains and sloughs that drain the Yolo Bypass that are feed by discharge from Putah and Cache Creeks. Construction of concrete weirs will increase sediment deposition within the Yolo Bypass and could alter fisheries habitat within the toe drains and sloughs. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present within toe drains and sloughs.

- Hydrology and Water Quality – Construction of concrete weirs within the Yolo Bypass would enhance sediment removal during flood flows; however, there is the potential for increased scour of sediment downstream of each weir due to alteration of system hydraulics. Water quality in the stream that drain the Yolo Bypass may be improved through extended settling of solids behind each concrete weir and associated decrease of suspended solids and mercury concentrations. The proposed concrete weirs would still allow large scale flood events to pass through the existing system. A detailed analysis of channel hydraulics and flood routing at various weir design heights and locations should also be developed to evaluate the potential for increased scour and flood risk.
- Noise – Excavation and construction of the proposed concrete weirs would generate elevated noise levels and vibrations in the vicinity of each construction site for a period of one to two years. Trucking noise from material runs between regional aggregate and concrete batch plants and the project sites would also generate elevated noise levels. Homes and business are not located in close proximity to the project site; however, increased noise and vibration levels may disrupt wildlife using the Yolo Bypass.
- Transportation – Materials used to construct the proposed concrete weirs will be imported from regional aggregate and concrete batch plants. Trucks will be routed along numerous highways and paved and unpaved local roads on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of one to two years. Construction traffic may also disturb wildlife using the Yolo Bypass.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present within the Yolo Bypass; to document fisheries habitat, species present, and spawning/rearing areas present within toe drains and sloughs; and to determine the potential affect of the various weir design heights and locations on bypass hydraulics and flood routing. Property easements may be required to access the project area and construct weirs within the Yolo Bypass. Implementation of the control action may require preparation of an EIS/EIR due to weir construction, alteration of flood routing operations, to disruption of wildlife and local traffic during construction, to potential alteration of riparian and upland habitat, and potential disturbance of fisheries habitat spawning/rearing areas present within toe drains and sloughs. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include weir maintenance (low frequency, long term), and fisheries monitoring following construction (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.2.9.3 Alternative 4 - Stabilize Yolo Bypass Surface

Implementation of this alternative includes stabilizing the surface of the Yolo Bypass to reduce erosion of sediment containing elevated levels of mercury and mobilization into the watershed. Current tillage practices and crop cover on existing farm land within the bypass would be maintained and expanded to include an additional 1,400 acres just south of the Freemont Weir.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, the size and volume of the settling basin would need to be verified and effectiveness monitoring requirements established. Property acquisition, easements, and building relocation are not required. Stakeholder meetings should be conducted with regulatory agencies and land owner/manager to discuss implementation. O&M activities include seasonal replanting of cover crop to minimize erosion (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.2.9.4 Comparative Analysis of Alternatives for Project Area 9

The effectiveness of Alternatives 4, 2, and 3 was considered limited, limited to moderate, and moderate, respectively (see Table 6-1b). Under Alternative 2, managing the storage and release of water from reservoirs and bypasses would reduce erosion and minimize mercury laden sediment mobilization over time but is dependent on the mercury concentrations in the suspended solids and erosional surface of the Yolo Bypass. This project area is further downstream from the reservoirs than other project areas; therefore, there would be a limited to moderate reduction in the total and mobile mercury load. Alternative 3 would reduce the mobility, load, and water quality threat posed by mercury laden sediment by improving the current effectiveness of the Yolo Bypass by increasing the hydraulic retention time and associated solids settling capacities. Subsequently, there would be a moderate reduction in the total and mobile mercury load. Alternative 4 would stabilize the bypass surface and improve its trapping effectiveness subsequently, which would provide limited reduction in the mobility, load, and water quality threat posed by mercury. There may be an increase in the wetting frequency/duration of Yolo Bypass sediment under Alternative 3, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 3, and 4 were considered readily implementable to moderately difficult to implement and technically feasible (see Table 6-1b). Alternatives 2 and 3 would be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternative 3 may require property acquisitions or easements for weir construction. Alternatives 2, 3, and 4 would require long term O&M activities, though only reservoir operations would be required over the long term.

Costs associated with the alternatives ranged from low to high (see Tables 6-1b and 6-3i). Alternative 2 was considered moderate in cost as it takes advantage of ongoing reservoir operations. Additional administrative costs for Alternative 2 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternative 4 would not require any additional cost to implement as it relies on maintaining current tillage practices and crop cover within the Yolo Bypass. Alternative 3 would have moderate to high costs associated with weir construction. Additional administrative costs for Alternative 3 include preliminary studies and preparation of an EIS/EIR. Alternative 3 also requires long term O&M, which extends on-going costs over time. Alternative 3 may require property acquisition or fees for weir construction.

Alternative 3 was identified as the best alternative for Project Area 9 due to the large projected load reduction (see Table 6-3i); however, this is subject to additional data collection. Alternative 3 was more technically and administratively feasible than Alternative 2; primarily due to simpler planning requirements and less reliance on flood control operations. The cost efficiency (cost divided by load reduction) was rated as good, depending on the mercury concentrations in flood sediments to be settled.

6.2.10 Project Area 10 - Lower Putah Creek Upstream of Yolo Bypass

Project Area 10 consists of the Lower Putah Creek upstream of the Yolo Bypass (see Figures 6-5 and 3-1). It becomes the boundary between Yolo and Solano Counties and passes south of Davis.

Putah Creek is a 70-mile long major stream and is a tributary of the Yolo Bypass (Wikipedia 2008). It has been altered from mining, dredging, and construction of levees and dams to accommodate agriculture and flood controls. Lower Putah Creek originates from Lake Berryessa, which is formed by Monticello

Dam, a concrete arch dam. Lake Berryessa is one of the largest reservoirs in the state with a capacity of 1,602,000 acre feet. It provides water for irrigation and is also a municipal and industrial water supply, providing about 32,000 acre feet annually. A hydroelectric plant generates electricity for the Solano Irrigation District, which owns and operates the dam. The estimated mobile mercury load from Lower Putah Creek is up to 9 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments and floodplain during flood events).

6.2.10.1 Alternative 2 - Coordinate Reservoir Release Management

Implementation of this alternative includes coordinating the release of water from Lake Berryessa. Flood control operations would be coordinated to manage the storage and release of water to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Berryessa during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system.

- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Berryessa during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.

- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Berryessa during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of lower Putah Creek, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the creek. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.10.2 Alternative 3 - Modify Existing Sediment Control Structures in Lower Putah Creek at Yolo Bypass to Improve Sediment Capture Efficiency

Under this alternative, the hydraulic retention time and associated solids settling capacities would be increased in the Lower Putah Creek through the installation of 3 miles of levees (12 feet high), which would close off the existing levees and create a settling basin. A 2,000-foot-long concrete broad crested weir would be installed within a new levee to control releases from Putah Creek into the Yolo Bypass. Removal of accumulated sediment from the settling basin would be required after many years of operation to maintain the hydraulic retention time required for settling of fines.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Construction of earthen levees, in conjunction with existing flood control levees to create a settling basin, within Putah Creek floodplain west of its confluence with the Yolo Bypass would alter the visual character of the lower Putah Creek floodplain and surrounding agricultural land. Visual impact will be limited to local residents within agricultural district.

- Agricultural Resources – Construction of a settling basin on rural farmland could remove land from production, depending on the type of habitat desired within the floodplain. At a minimum, homes and other agriculture related buildings would be displaced due to threat of flooding. Continued farming within the settling basin would be desirable as tillage and revegetation would occur on a regular basis, minimizing entrainment of deposited sediment.

- Biological Resources – Construction of earthen levees within the Putah Creek floodplain to create a settling basin will cause runoff to backup and may cause a change in the type and size of riparian and upland habitat along Putah Creek and its active floodplain. The proposed levees may also alter wildlife migration patterns cutting off access between the Putah Creek riparian corridor and the Yolo Bypass. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain. A fishery may be present in Putah Creek. Construction of earthen levees will increase sediment deposition within the settling basin and may alter scour above and below the settling basin, which could alter fisheries habitat, structure, and spawning gravels (if any). A fish ladder could also be installed to minimize disruption of the migration patterns of the fishery, as necessary. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. In addition, an estimate of fines loading within the settling basin and potential scour in the creek downstream of the settling basin outfall should be developed.

- Hydrology and Water Quality – Construction of earthen levees within the Putah Creek floodplain to create a settling basin would capture entrained sediments eroded from the Putah Creek floodplain and discharge from Lake Berryessa; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of system hydraulics. Water quality downstream of the settling basin may be improved through settling of solids within the settling basin and associated decrease of suspended solids and mercury concentrations in creek. Preliminary studies should be conducted to determine the potential affect of the proposed levee construction on downstream channel geometry and scour/deposition in the creek channel. The proposed levees would still allow large scale flood events to pass through the existing flood control levees and over the settling basin weir to the Yolo Bypass. A detailed analysis of flood routing under various settling basin operation scenarios should also be developed to evaluate the potential for increased flood risk.

- Population and Housing – Construction of the proposed levees and creation and operation of a settling basin would require displacement of rural homes within the proposed settling basin, potentially requiring new construction elsewhere within the area. Placement of the proposed levees to minimize disturbance of existing rural communities should be considered during the planning process.
- Noise – Importing, placement, and compaction of materials during levee construction would generate elevated noise levels and vibrations in the vicinity of the creek for a period of two to three years. Trucking noise from material runs between regional aggregate processing plants and the project sites would also generate elevated noise levels. Homes and business are not located in close proximity to the project site.
- Transportation – Earth fill, rock, and concrete used to construct the proposed earthen levees will be imported from regional aggregate processing plants. Trucks will be routed along I-80, Mace Blvd., and unpaved roads on a regular basis. Local traffic disruption will occur at a regular frequency, extending over a period of two to three years. A separate haul road between the proposed levee construction site and I-80 may be desired.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the creek; to estimate potential fines loading within the proposed settling basin; to determine the potential affect of the proposed levee construction and settling basin operations on scour/deposition downstream of the settling basin; and to evaluate flood routing under various settling basin operation scenarios. Property acquisition and easements may be required to access the project area and construct levees necessary to construct the settling basin. Relocation of rural homes/farms may also be required. Implementation of the control action may require preparation of an EIS/EIR due to levee construction, to relocation of rural homes/farms, to alteration of flood routing operations, to traffic disruption during construction, to potential alteration of riparian and upland habitat, potential alteration of fishery migration within the creek, and potential disturbance of fisheries habitat, species, and spawning/rearing areas downstream of the settling basin. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include levee and weir maintenance (low frequency, long term), accumulated sediment removal and disposal (low frequency, long term), and fisheries monitoring following construction (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the settling basin.

6.2.10.3 Alternative 4 - Stabilize Lower Putah Creek Floodplain Surface

Implementation of this alternative includes stabilizing the surface of the Lower Putah Creek floodplain to reduce erosion of sediment containing elevated levels of mercury and mobilization into the watershed. Current tillage practices and crop cover on existing farm land within the floodplain would be maintained. Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements will not impact environmental factors identified in RWQCB Environmental Checklist.

Prior to implementation, the size and volume of the settling basin would need to be verified and effectiveness monitoring requirements established. Property acquisition, easements, and building relocation are not required. Stakeholder meetings should be conducted with regulatory agencies and land owner/manager to discuss implementation. O&M activities include seasonal replanting of cover crop to minimize erosion (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in flood waters downstream of the project area.

6.2.10.4 Alternative 7 - Capture Sediment Using Low Dam on Lower Putah Creek

Under this alternative, two earthen dams with concrete broad-crested weirs would be installed between existing levees along lower Putah Creek to increase the hydraulic retention time and improve solids capture. It is assumed that each earthen dam would be approximately 0.5 mile long by 6 feet high.

By allowing suspended solids to settle, the transport of mercury laden sediment would be reduced. This alternative would also allow capture of all sediment size fractions, including some fines. Predominately medium- to coarse-grained mobile sediment would be captured by the weir during high energy events and fine grained sediment at low to moderate flows. Removal of accumulated sediment from the settling basin would be required after many years of operation to maintain the hydraulic retention time required for settling of fines.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics – Installation of earthen dams within Putah Creek west of its confluence with the Yolo Bypass may alter the visual character of the lower Putah Creek floodplain and surrounding agricultural land. Visual impact will be limited to local residents within agricultural district.
- Agricultural Resources – Operation of the earthen dams could result in periodic inundation of row crops planted on the Putah Creek floodplain. The floodplain is bounded by flood control levees

which would increase the depth of inundation during even moderate flood flows. Consideration should be given to minimizing the time that the land is inundated to minimize crop loss (if any).

- Biological Resources – Installation of earthen dams within Putah Creek west of its confluence with the Yolo Bypass will cause runoff to backup behind the dams and may cause a change in the type and size of riparian and upland habitat along Putah Creek and its active floodplain. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain. A fishery may be present in Putah Creek. Construction of earthen dams may alter sediment deposition and scour within the channel, which could alter fisheries habitat, structure, and spawning gravels (if any). A fish ladder could also be installed to minimize disruption of the migration patterns of the fishery, as necessary. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the creek. In addition, an estimate of fines loading and potential scour in the creek should be developed.

- Hydrology and Water Quality – Construction of earthen dams within the Putah west of its confluence with the Yolo Bypass would capture entrained sediments eroded from the Putah Creek floodplain and discharge from Lake Berryessa; however, there is the potential for increased channel scour and new areas of fines deposition downstream due to alteration of channel geometry and hydraulics. Water quality may be improved through settling of solids within the active channel and associated decrease of suspended solids and mercury concentrations in creek. Preliminary studies should be conducted to determine the potential affect of the proposed earthen dam construction on channel geometry and scour/deposition in the creek channel. A detailed analysis of flood routing under various dam operation scenarios should also be developed to evaluate the potential for increased flood risk.

- Noise – Excavation, grading, and compaction of materials at the proposed dam sites would generate elevated noise levels and vibrations in the vicinity of the creek for a period of two to three years. Trucking noise from material runs between regional aggregate processing plants and the project sites would also generate elevated noise levels. Homes and business are not located in close proximity to the project site.

- Transportation – Earth fill, rock, and concrete used to construct the earthen dams will be imported from regional aggregate processing plants. The quantity of material brought into the site will be significant and traffic disruption and controls on local paved and unpaved roads may extend over a period of two to three years.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and on the active floodplain; to document fisheries habitat, species present, and spawning/rearing areas present along the creek; and to determine the potential affect of the proposed earthen dam construction on channel geometry and scour/deposition in the creek channel, and to evaluate flood routing under various earthen dam operation scenarios. Property acquisition and easements may be required to access the project site and construct the earthen dams. Implementation of the control action may require preparation of an EIS/EIR due to earthen dam construction, to alteration of flood routing operations, to traffic disruption during construction, to alteration of riparian and upland habitat, modification of channel geometry and hydraulics, potential alteration of fishery migration within the creek, and potential disturbance of fisheries habitat, species, and spawning/rearing areas. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include earthen dam and weir maintenance (low frequency, long term), accumulated sediment removal and disposal (low frequency, long term), and fisheries monitoring during earthen dam (fish ladder/bypass) operations (low frequency, medium term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.10.5 Comparative Analysis of Alternatives for Project Area 10

The effectiveness of Alternatives 2 and 4, and Alternatives 3 and 7 were considered limited and moderate, respectively (see Table 6-1b). Under Alternative 2, managing the storage and release of water from the reservoir would reduce erosion and minimize mercury laden sediment mobilization but is dependent on the mercury concentrations in the suspended solids and the rate at which water is released. Subsequently, there would be a limited to moderate reduction in the total and mobile mercury load. Alternative 3 would reduce the mobility, load, and water quality threat posed by mercury laden sediment by increasing the hydraulic retention time and associated solids settling capacities. Subsequently, there would be a moderate reduction in the total and mobile mercury load. Alternative 4 would reduce mobility, load, and water quality threat posed by mercury laden sediment through maintaining crop cover on the floodplain surface. The reduction in the total and mobile mercury load for this alternative is expected to be limited. For Alternative 7, installation of low dams to reduce stream energy and promote settling of fines would reduce the mobility, load, and water quality threat posed by mercury in mobile sediment but is dependent on the mercury concentrations in the contained suspended solids and sediment. Subsequently, there would be a moderate reduction in the total and mobile mercury load. There may be an increase in the wetting frequency/duration of floodplain sediment under Alternatives 3 and 7, providing an environment for mercury methylation, while no net impact on potential mercury methylation is anticipated for the other alternatives.

Alternatives 2, 3, 4, and 7 were considered readily implementable to moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternatives 3 and 7 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternatives 3 and 7 may require property acquisitions or easements for levee and earthen dam construction. Relocation of rural homes/farms may also be required under Alternative 3. Alternatives 2, 3, and 7 would require long term O&M activities.

Costs associated with the alternatives ranged from low to moderate (see Tables 6-1b and 6-3j). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 4 would not require any additional cost to implement as it relies on maintaining existing farming practices. Alternatives 3 and 7 would both have moderate costs associated with levee and earthen dam construction, respectively. Additional administrative costs for Alternatives 2, 3, and 7 include preliminary studies and preparation of an EIS/EIR. Alternatives 2, 3, and 7 also require long term O&M, which extends on-going costs over time. Alternatives 3 and 7 may require property acquisition or fees for levee and earthen dam construction. Alternative 3 may also require relocation costs for rural homes and farms.

Alternative 2 was identified as the best alternative for Project Area 10 due to relatively cost efficient load reduction (see Table 6-3d); however, this is subject to additional data collection. Alternative 2 was more administratively feasible than Alternatives 3 and 7; primarily due to no construction and no requirement to acquire property or relocate homes and farms to implement the control action. The cost efficiency (cost divided by load reduction) was rated as excellent, depending on the mercury concentrations in creek and floodplain sediments. Alternatives 3 and 7 would only be cost effective if short term reduction of mercury loads is desired.

6.2.11 Project Area 11 - Active Channel and Floodplain of the Sacramento River from Verona to Freeport

Project Area 11 consists of the active channel and floodplain of the Sacramento River from Verona to Freeport (see Figure 6-5). The project area is assumed to be approximately 35 miles of river channel.

The American River runs from the Sierra Nevada Mountains through Sacramento, where it flows into the Sacramento River within the project area. It is extensively dammed and diverted for hydroelectricity production. Reservoirs include Folsom Lake and Lake Natoma. Folsom Lake is formed by Folsom Dam, which was constructed in 1955 to provide flood control, hydroelectricity, and drinking and water irrigation. Folsom Lake is also a state recreation area used for boating and fishing. Lake Natoma is located between Nimbus Dam, also a hydroelectricity dam, and Folsom Dam and is currently over the historic Negro Bar area in Folsom, which was originally a gold mining camp. It is used as a recreational area for kayaking and swimming.

Overflow structures on this portion of the Sacramento River include the Freemont and Sacramento weirs, which are lowered sections of the levees that allow flood flows in excess of the downstream channel capacity to escape. The Freemont Weir is located within the northern portion of the project area, and the Sacramento Weir is located within the southern portion of the project area. Both divert flood flows to the Yolo Bypass. Completed in 1924, the Freemont Weir is 2 miles long and is the first overflow structure on the river's west side. Its primary purpose is to release overflow waters from the Sacramento River, Sutter Bypass, and the Feather River. The project design capacity of the weir is 343,000 cubic feet per second (cfs). The estimated mobile mercury load from the Sacramento River below the Freemont Weir is up to 88 kg/yr and is considered both a constant load (sediment entrainment at base flow) and pulsing load (erosion of channel sediments during flood events).

The Sacramento Weir was completed in 1916, is 1,920 feet long, consists of 48 gates, and is the only weir in the system that can be opened or closed. It is also located along the west levee of the Sacramento River, and its primary purpose is to protect the city of Sacramento from excessive flood stages in the river channel downstream of the American River. The project design capacity of the weir is 112,000 cfs. The opening and closing goals consist of minimizing sediment deposition and limiting flooding of agricultural lands in the Yolo Bypass to only until after they have been inundated by floodwaters over the Fremont Weir.

6.2.11.1 Alternative 2 - Coordinate Reservoir Release Management and Flood Control Operations

Implementation of this alternative includes coordinating the release of water from upstream reservoirs (Lake Shasta, Lake Oroville, Englebright Reservoir, Lake Natomas/Folsom Reservoir, and Camp Far West Reservoir), the Sutter and Yuba Bypasses, and Sacramento Weir. Flood control operations would be coordinated to manage the storage and release of water to reduce river flow and volume and its sediment carrying capacity; channel and floodplain erosion and in-channel scour; and, in turn, the suspension of mercury laden sediment in the watershed.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Biological Resources – Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright and Camp Far West Reservoirs, and Folsom and Natomas Lakes during winter and spring runoff could 1) potentially alter fisheries habitat through less scouring of fine sediment from gravels during the winter and 2) potentially reduce the volume and duration of peak flows necessary for fisheries migration. Preliminary studies should be conducted to determine the quality of spawning gravels, amount of fines scour that occurs during peak flows, and the minimum flows necessary to flush juveniles out of the river system. Modifying the timing of flood control diversions at passive and active weirs (Colusa, Freemont, and Sacramento) to increase sediment removal could potentially impact the volume and duration of peak flows necessary for fisheries migration, though flood protection is the overriding concern.
- Hydrology and Water Quality - Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright and Camp Far West Reservoirs, and Folsom and Natomas Lakes during winter and spring runoff could 1) potentially increase long term downstream flood risk by holding water longer (less capacity), and 2) potentially lead to the loss of water storage capacity through increased reservoir sedimentation. Modifying the timing of flood control diversions to maximize the volume of water diverted and sediment captured could also increase flood risk at peak flows due to loss of bypass flow capacity. Preliminary studies should be conducted to determine minimum available storage capacity necessary to protect against downstream flooding in response to a high runoff event and to determine the rate of storage capacity loss due to sediment infill.
- Utilities and Service Systems - Controlling the timing and volumetric rate of water release from Lake Shasta, Lake Oroville, Englebright and Camp Far West Reservoirs, and Folsom and Natomas Lakes during winter and spring runoff could 1) potentially lead to a loss of hydropower generated, and 2) potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts. A preliminary study should be conducted to determine the amount of hydropower that could be potentially lost. In addition, downstream water users should be contacted to determine the flexibility available for timing of water deliveries. Modifying the timing of flood control diversions at passive and active weirs (Colusa, Freemont, and Sacramento) could potentially alter the timing and volume of water delivery to downstream water purveyors and irrigation districts.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining the retention time for solids settling, minimum storage capacity necessary to protect against downstream flooding, rate of storage capacity loss due to sediment infill, amount of hydropower that could be potentially lost, the release volume limit to minimize downstream sediment mobilization and stream bank erosion, sediment carrying capacity of the Sacramento River, the quality of spawning gravels, amount of fines scour that occurs during peak flows, and minimum flows necessary to flush juveniles out of the river system. Property acquisition, property easements, or building relocation is not required, though multi-agency cooperation is required to implement the control action. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration; alteration of water storage operation, capacities, and delivery; and alteration of the generation of hydropower to customers. Stakeholder meetings should be conducted with regulatory agencies, reservoir operators, water purveyors, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include reservoir and hydropower system operations, stream gaging (high frequency, long term); flood control diversions (moderate frequency, long term); and evaluation of sediment deposition and scour, and fisheries monitoring (low frequency, long term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.11.2 Alternative 8 - Dredging of Sacramento River from Verona to Freeport, Process Aggregate as a Commodity, and Dispose of Fines

Implementation of this alternative includes dredging mercury laden sediment from the Sacramento channel using conventional equipment, processing the sediment on-site for aggregate, and disposal of the fines. It is assumed that 35 miles of channel with an average width of 550 feet and average sediment depth of 10 feet would be dredged (37.6 MCY). Implementation of this alternative is expected to take 4 to 5 years. Accumulated sediment would be processed to separate saleable aggregate from fines containing residual mercury. For this project area, fines are assumed to be non-hazardous and would be pumped over levees to a disposal area. To ensure long-term reduction of mercury loading to local streams, fines containing mercury would be protected from future erosion using crop cover, levees, and/or other control measures. The partially completed dredging of the Sacramento Shipping Channel is a project of similar scale (38 mile project length) that should be examined as part of the pre-planning activities if this load reduction alternative is implemented.

As dredging and processing often dislodges chemicals in the sediment and releases them into the water column, the storage and release of water during dredging should also be managed to reduce the mercury

load downstream. Management of runoff may also be necessary. Typically excess water in the dredged materials is spilled off as the heavier solids settle to the bottom, and water is returned to the river.

Based on available information, implementation of this load reduction alternative in compliance with Federal, State, and local requirements, may impact the following environmental factors identified in RWQCB Environmental Checklist:

- Aesthetics - Placement of sediment dredged from the river on to land could alter the visual character of the dredge disposal site. Selection of a dredge disposal site should consider scenic vistas from highways, major roads, wildlife areas, and homes.
- Agricultural Resources - Placement of sediment dredged from the river on agricultural land may temporarily remove land from production; however, the disposal site could be designed to improve surface and subsurface to the benefit of agricultural production after filling is completed.
- Biological Resources - Dredging of in channel sediment may disrupt fisheries through direct uptake of fish and may alter fisheries habitat by removal of spawning gravels and other in channel structures. Engineering controls such as screening, hydraulic disturbance, and physical separation of return water (food) and dredge location could help minimize uptake of fish. Return of gravels in hydraulically favorable locations within the project area could be used to improve spawning habitat. Dredging may also impact the movement and migration of fisheries through the project site over the multi-year duration of the project. The dredging process could be slowed or stopped during spawning and return migration runs to minimize impacts on migratory fishery. Preliminary studies should be conducted to document fisheries habitat, species present, and spawning/rearing areas present along the river. Dredging of sediment from the river may alter riparian habitat. Placement of fill may impact the habitat of both riparian and upland species, depending on the location of the proposed fill site. Selection and design of the fill site should be guided by the need to increase habitat over the long term. Dredging and filling may impact wetlands requiring Section 404 consultation and permitting. Preliminary studies should be conducted to document habitat, species, and wetlands present along the creek and within any proposed fill site.
- Hydrology and Water Quality – Dredging of sediment from in channel river deposits may cause a temporary violation of in channel water quality standards for suspended solids and mercury where fines are not adequately removed from return water. Discharge of elevated concentrations of suspended solids and mercury in return water could be addressed through engineering controls (filtration or settling). Dredging of sediment from an active channel may alter channel geometry

and the erosive force of water downstream of the dredge area. Preliminary studies should be conducted to determine the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures.

Prior to implementation, preliminary studies would be conducted and effectiveness monitoring requirements established. Preliminary studies would include determining depth and volume of sediment, mercury profile in sediment column, aggregate/fines ratio; documenting fisheries habitat, species present, and spawning/rearing areas present within the river; documenting habitat, species, and wetlands present along the river and within any proposed sediment disposal site; determining the amount of fines in channel sediment that may require separation from return water, the potential affect of dredging on flood routing, and the potential affect of dredging on scour of downstream stream banks and structures. Property acquisition, property easements, or building relocation is not required, though acquisition of property may be required for the sediment disposal site. Implementation of the control action may require preparation of an EIS/EIR due to potential impacts on fisheries habitat, spawning, and migration, potential alteration of channel geometry and the erosive force of water downstream of the dredge area, and potential alteration of riparian and upland habitat at sediment disposal sites. Stakeholder meetings should be conducted with regulatory agencies, land owner/manager, technical experts, and community to evaluate the need to prepare an EIS/EIR. O&M activities include revegetation of sediment disposal site (moderate frequency, short term), and fisheries monitoring during dredging activities (low frequency, short term). Effectiveness monitoring requirements would need to be established for TSS and mercury in seasonal and flood waters downstream of the project area.

6.2.11.3 Comparative Analysis of Alternatives for Project Area 11

The effectiveness for Alternatives 2 and 8 were considered limited and high, respectively (see Table 6-1b). Under Alternative 2, managing the storage and release of water from reservoirs, bypasses, and the Sacramento Weir would reduce erosion and minimize mercury laden sediment mobilization over time but is dependent on the mercury concentrations in the suspended solids and eroding active channel. This project area is further downstream from the reservoirs than other project areas; therefore, there would be a limited reduction in the total and mobile mercury load. For Alternative 8, dredging would reduce the volume, mobility, load, and water quality threat posed by mercury contained sediment that is actively contributing to mercury loading within the system. Subsequently, there would be a high reduction in the total and mobile mercury load, but it is dependent on the mercury content and volume of sediment removed. No net impact on potential mercury methylation is anticipated.

Alternatives 2 and 8 were considered moderately difficult to implement and technically feasible (see Table 6-1b). Alternative 2 would be moderately difficult to implement, requiring limited preliminary studies and preparation of an EIS/EIR. Alternative 8 would also be moderately difficult to implement, requiring major preliminary studies and preparation of an EIS/EIR. Alternative 8 may require property acquisitions or easements for sediment disposal sites. Alternatives 2 and 8 would both require O&M activities, though only reservoir operations would be required over the long term. No additional dredging for sediment removal is anticipated under Alternative 8, assuming dredging of the Feather River and stabilization or dredging of the Yuba River would also be conducted.

Costs associated with the alternatives ranged from low to very high (see Tables 6-1b and 6-3k). Alternative 2 was considered low in cost as it takes advantage of ongoing reservoir operations. Alternative 8 would have a very high cost due to extensive dredging, trucking or pumping of sediment, and off-stream disposal of sediment. Additional administrative costs for Alternatives 2 and 8 include preliminary studies and preparation of an EIS/EIR. Alternative 2 also requires long term O&M, which extends on-going costs over time. Alternative 8 may require property acquisition or fees for off-site sediment disposal.

Alternative 2 was identified as the best alternative for Project Area 11 due to relatively cost efficient load reduction (see Table 6-3k); however, this is subject to additional data collection. Alternative 2 was more administratively feasible than Alternative 8; although it does require long term O&M. The cost efficiency (cost divided by load reduction) was rated excellent, depending on the mercury concentrations in the suspended sediments and solids settling rate. Alternative 8 would only be cost effective if short term reduction of mercury loads is desired.

6.3 RANKING OF RETAINED PROJECT AREAS FOR FUTURE IMPLEMENTATION

As the Bay mercury TMDL allocated an annual mercury load of 330 kg/yr to the Delta (SWRCB 2007, Attachment 2), a 110 kg/yr reduction of the total mercury load from the Delta is required. Therefore, the goal of this regional mercury load reduction evaluation was to identify potential mercury load reduction alternatives, and candidate project areas that could be undertaken to reduce the loading of total mercury to the Delta and ultimately the Bay.

Eleven land based load reduction alternatives were identified (see Table 6-1a) and were evaluated for the following four project areas:

1. Mercury Mines in Sulphur Creek Watershed
2. Floodplain Containing Mine Waste on Sulphur Creek

3. Floodplain Containing Mine Waste on Bear Creek
4. Floodplain Containing Mine Waste on Harley Gulch

Eight stream based load reduction alternatives were identified (see Table 6-1b) and were evaluated for the following 11 project areas:

1. South Fork Yuba River at Englebright Reservoir
2. Active Channel and Floodplain of Yuba River within the Yuba Goldfields
3. Active Channel and Floodplain of Feather River near confluence with Yuba River
4. Active Channel and Floodplain of Feather River near confluence with Bear River
5. Active Channel and Floodplain of Feather River from Nicolaus to Verona
6. Active Channel and Floodplain of Sacramento River Upstream of Feather River
7. Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo
8. Cache Creek Settling Basin
9. Yolo Bypass from Fremont Weir to Putah Creek
10. Lower Putah Creek Upstream of Yolo Bypass
11. Active Channel and Floodplain of Sacramento River from Verona to Freeport

The load reduction alternatives applicable to each of these project areas were comparatively evaluated for 1) effectiveness, 2) implementability, and 3) cost. For each project area, the best alternative was selected based on its projected load reduction and comparative cost (cost efficiency) as summarized in Tables 6-2a through 6-2d for land based project areas and Tables 6-3a through 6-3k for stream based project areas. Based on this comparative analysis the following load reduction alternatives were selected for land based project areas:

- Mercury Mines in Sulphur Creek Watershed – Alternative 8
- Floodplain Containing Mine Waste on Sulphur Creek – Alternative 3
- Floodplain Containing Mine Waste on Bear Creek – Alternative 3
- Floodplain Containing Mine Waste on Harley Gulch – Alternative 10

Based on this comparative analysis the following load reduction alternatives were selected for stream based project areas:

- South Fork Yuba River at Englebright Reservoir – Alternative 2
- Active Channel and Floodplain of Yuba River within the Yuba Goldfields – Alternatives 2 and 4
- Active Channel and Floodplain of Feather River near confluence with Yuba River - Alternative 4
- Active Channel and Floodplain of Feather River near confluence with Bear River – Alternative 4
- Active Channel and Floodplain of Feather River from Nicolaus to Verona - Alternative 4

- Active Channel and Floodplain of Sacramento River Upstream of Feather River - Alternative 2
- Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo – Alternative 4
- Cache Creek Settling Basin - Alternative 3
- Yolo Bypass from Fremont Weir to Putah Creek - Alternative 3
- Lower Putah Creek Upstream of Yolo Bypass - Alternative 2
- Active Channel and Floodplain of Sacramento River from Verona to Freeport - Alternative 2

The best load reduction alternatives were ranked based on their projected load reduction and cost efficiencies, and the following projects are recommended for future implementation as summarized in Tables 6-4a and 6-4b for land based and stream based projects, respectively:

- **Active Channel and Floodplain of Yuba River within the Yuba Goldfields:** Alternatives 2 and 4 - Coordinate Reservoir Release And Improve Control Structure Management (4.8 kg/yr load reduction at $6.85 million) and Stabilize Stream Banks and Floodplain Surfaces (16 kg/yr load reduction at $62.8 million)

- **Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo:** Alternative 4 - Stabilize Stream Banks and Floodplain Surfaces (78 kg/yr load reduction at $42.9 million)

- **Cache Creek Settling Basin:** Alternative 3 - Modify Existing Settling Basin to Improve Capture Efficiency (59 kg/yr load reduction at $44.7 million)

6.4 NEXT STEPS

The next steps required to implement the recommend alternatives in the three project areas involve meeting with stakeholders to discuss 1) scope of preliminary studies, 2) required environmental documentation, and 3) property acquisition or property easements potentially required to gain access to and begin construction activities at each project area. These steps are described below for each project area.

<u>Project Area 2: Active Channel and Floodplain of Yuba River within the Yuba Goldfields</u>

Stakeholder meetings should be conducted with regulatory agencies, land owners/managers, reservoir operators, water purveyors, technical experts, and communities. Multi-agency cooperation will be required to modify reservoir operations and alter the riparian corridor along the Yuba River. Property easements may also be required to access the project corridor along the Yuba River.

Stakeholders should discuss potential preparation of an EIS/EIR to evaluate potential impacts to fisheries habitat, spawning/rearing areas, and migration; alteration of water storage operation, capacities, and delivery; alteration of the generation of hydropower to customers; alteration of riparian and upland habitat; and modification of channel geometry and hydraulics.

In order to prepare environmental documentation and develop project plans, the following preliminary studies may be required:

- Determining the reservoir retention time for solids settling, minimum reservoir storage capacity necessary to protect against downstream flooding, and rate of reservoir storage capacity loss due to sediment infill
- Determining the amount of hydropower that could be potentially lost by altering reservoir operations, and the release volume limit to minimize downstream sediment mobilization and stream bank erosion
- Determining the sediment carrying capacity of the Yuba River, Daguerre Point Dam sediment removal efficiency, amount of fines scour that occurs during peak flows, the quality of spawning gravels, and minimum flows necessary to flush juveniles out of the river system.
- Documenting habitat, species, and wetlands present along the Yuba River and on the active floodplain
- Documenting fisheries habitat, species present, and spawning/rearing areas present along the Yuba River
- Determining the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the river channel.

Project Area 7: Active Channel and Floodplain on Lower Cache Creek from Capay to Yolo

Stakeholder meetings should be conducted with regulatory agencies, land owners/managers, water purveyors, technical experts, and communities. Multi-agency cooperation will be required to alter the riparian corridor and floodplain along the Lower Cache Creek. Property easements may also be required to access the project corridor along Lower Cache Creek.

Stakeholders should discuss potential preparation of an EIS/EIR to evaluate potential impacts to fisheries habitat, spawning/rearing areas, and migration; alteration of riparian and upland habitat; and modification of channel geometry and hydraulics.

In order to prepare environmental documentation and develop project plans, the following preliminary studies may be required:

- Documenting habitat, species, and wetlands present along Lower Cache Creek and on the active floodplain
- Documenting fisheries habitat, species present, and spawning/rearing areas present along Lower Cache Creek

- Determining the potential affect of the proposed stream bank grading and wing dam construction on channel geometry, flood routing, and scour/deposition in the creek channel.

Project Area 8: Cache Creek Settling Basin

Stakeholder meetings should be conducted with regulatory agencies, land owners/managers, technical experts, and communities. Multi-agency cooperation will be required to alter the riparian corridor and floodplain along the Lower Cache Creek. Property acquisition and relocation of rural homes and farms within the proposed settling basin expansion area may be required. In addition, easements may also be required to access the project area at and adjacent to the existing settling basin.

Stakeholders should discuss potential preparation of an EIS/EIR to evaluate potential visual impact of proposed levee construction, potential relocation of rural homes and farms, potential traffic disruption during construction, alteration of riparian and upland habitat, and potential impacts to fisheries habitat and species downstream of the settling basin.

In order to prepare environmental documentation and develop project plans, the following preliminary studies may be required:

- Documenting habitat, species, and wetlands present within the proposed settling basin expansion area
- Documenting fisheries habitat and species present downstream of the settling basin
- Determining the potential affect of the proposed settling basin expansion on scour/deposition downstream of the settling basin
- Estimating fines loading within the existing and expanded settling basin

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