REGIONAL WATER QUALITY CONTROL BOARD, CENTRAL VALLEY REGION

Amendment
To
The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins

To
Determine Certain Beneficial Uses Are Not Applicable in and Establish Water Quality Objectives for Sulphur Creek

Final Staff Report

March 2007

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

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This publication is a report by staff of the California Regional Water Quality Control Board, Central Valley Region. This report contains the evaluation of alternatives and technical support for the adoption of an amendment to the Water Quality Control Plan for the Sacramento and San Joaquin River Basin (Resolution No. R5-2007-0021). Mention of specific products does not represent endorsement of those products by the Regional Board.

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CENTRAL VALLEY REGION

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To Determine Certain Beneficial Uses Are Not Applicable in and Establish Water Quality Objectives for Sulphur Creek

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EXECUTIVE SUMMARY

This staff report proposes an amendment to the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan) to make a determination that certain beneficial uses are not applicable and establish site-specific water quality objectives for mercury in Sulphur Creek (Colusa County, CA), a tributary to Bear Creek in the Cache Creek watershed. Natural sources of mercury and salts make Sulphur Creek unsuitable for drinking and for habitat for aquatic life that is consumable by humans. The proposed amendment would recognize that the beneficial uses of municipal and domestic supply (MUN) and the human consumption of aquatic organisms do not exist and are not attainable in Sulphur Creek. The Basin Plan currently does not specifically designate beneficial uses for Sulphur Creek.

Sulphur Creek does not support the MUN beneficial use or the human consumption of aquatic organisms. Naturally occurring concentrations of total suspended solids, mercury, and electrical conductivity exceed drinking water criteria and make Sulphur Creek unsuitable habitat for fish and consumable aquatic invertebrates. Total suspended solids and electrical conductivity also exceed the criteria in Resolution 88-63 for excepting the MUN beneficial use designation for surface and ground waters. These uses are not existing and cannot feasibly be attained in the future.

Because these uses do not exist and are not attainable, none of the promulgated water quality criteria for mercury apply, so staff proposes a site-specific water quality objective for mercury in Sulphur Creek based on natural background conditions. The site-specific objective will protect the beneficial uses of Sulphur Creek that existed prior to anthropogenic disturbance in the watershed. The implementation actions required to meet the proposed objective are described in the Sulphur Creek mercury total maximum daily load (TMDL) and the Cache Creek Watershed Basin Plan amendment adopted by the Central Valley Water Board in October 2005. This amendment, along with the Sulphur Creek mercury TMDL, fulfills the US EPA requirements for a TMDL.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CTR	California Toxics Rule
CWA	Clean Water Act
CWC	California Water Code
DFG	CA Department of Fish and Game
DWR	CA Department of Water Resources
EC	Electrical Conductivity
MUN	Municipal and Domestic Supply Beneficial Use
OAL	Office of Administrative Law
PRC	Public Resource Code
SSO	Site Specific Objective
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
UCD	University of California, Davis
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1 INTRODUCTION

The purpose of this staff report is to provide the rationale and supporting documentation for proposed amendments to the "Water Quality Control Plan for the Sacramento and San Joaquin River Basins, Fourth Edition (2006)." This section describes the regulatory context for basin planning.

1.1 REGULATORY AUTHORITY AND MANDATES FOR BASIN PLAN AMENDMENTS

The State Water Resources Control Board (State Water Board) and the nine Regional Water Quality Control Boards (Regional Water Boards) are the state agencies with primary responsibility for coordination and control of water quality. (California Water Code (CWC) §13000). Each Regional Water Board is required to adopt a water quality control plan, or basin plan, which provides the basis for regulatory actions to protect water quality. (CWC §13240 et seq.). Basin plans designate beneficial uses of water, water quality objectives to protect the uses, and a program of implementation to achieve the objectives. (CWC §13050(j)). Basin plans, once adopted, must be periodically reviewed and may be revised. (CWC §13240).

Under the federal Clean Water Act (CWA), 33 USC §1251 et seq., the states are required to adopt water quality standards for surface waters. (CWA §303(c)). Water quality standards consist of 1) designated uses; 2) water quality criteria necessary to protect designated uses; and 3) antidegradation policy. (CWA 303(c)(2)(A) and (d)(4)(B); 40 CFR 131.6). In California, water quality standards are found in the basin plans, statewide water quality control plans adopted by the State Water Board, and the federal California Toxics Rule. Under the CWA, the states must review water quality standards at least every three years.

Regional Water Boards adopt and amend basin plans through a structured process involving peer review, public participation, and environmental review. Regional Water Boards must comply with the California Environmental Quality Act (CEQA)(Public Resources Code (PRC) §21000 et seq.) when amending their basin plans. The Secretary of Resources has certified the basin planning process as exempt from the CEQA requirement to prepare an environmental impact report or other appropriate environmental document. (PRC 21080.5; Cal. Code Regs., tit. 14, §15251(g)). Instead, State Water Board regulations on its exempt regulatory programs require the Regional Water Boards to prepare a written report and an accompanying CEQA Environmental Checklist and Determination with respect to Significant Environmental Impacts (CEQA Checklist). (Cal. Code Regs., tit. 23, §3775 et seq.).

Basin plan amendments are not effective until they are approved by the State Water Board and the regulatory provisions are approved by the State Office of Administrative Law (OAL). The United States Environmental Protection Agency (USEPA) also must review and approve amendments that add or modify water quality standards for waters of the United States.

1.2 BASIN PLAN FOR THE SACRAMENTO AND SAN JOAQUIN RIVER BASINS

The Regional Water Quality Control Board, Central Valley Region (Central Valley Water Board) first adopted the Water Quality Control Plan for the Sacramento River and San Joaquin

River Basins in 1975. The current edition (Fourth Edition, 2006) incorporates all amendments since 1975.

1.3 DESIGNATED BENEFICIAL USES

In general, federal water quality standards regulations require that "existing" beneficial uses of water and uses specified in the Clean Water Act Section 101(a)(2) that are attainable be designated for protection. "Existing" uses are defined as uses that were attained on or after 28 November 1975. (40 CFR. §131.3(e)). An existing use is established if the use has been actually attained or the water quality necessary to support the use has been achieved at any time since November 28, 1975, even if the use itself is not currently established, unless physical factors prevent attainment of the use (USEPA, 1994).

Designated uses include both existing uses and potential uses. (40 CFR §131.3(f)). In Table II-1 of the Basin Plan, beneficial uses for listed water bodies within the Sacramento and San Joaquin River basins are identified as either Existing or Potential.

For tributary streams that are not listed in Table II-1, the Basin Plan states that "[t]he beneficial uses of any specifically identified water body generally apply to its tributary streams." (Basin Plan at II-2.00). The Basin Plan states, however, that in some cases, the beneficial use may not be applicable to the entire water body and that the uses for unidentified waters will be evaluated on a case-by-case basis. (Id.) The Basin Plan also provides that water bodies that are not listed in Table II-1 are assigned municipal and domestic supply (MUN) as a beneficial use in accordance with State Board Resolution No. 88-63, commonly referred to as the "Sources of Drinking Water Policy" unless certain exceptions are met.

1.4 WATER QUALITY OBJECTIVES

CWC §13050 defines water quality objectives as "…the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." Factors that the Central Valley Water Board must consider when adopting water quality objectives are:

(a) Past, present, and probable future beneficial uses of water.

(b) Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.

(c) Water Quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area.

(d) Economic considerations.

(e) The need for developing housing within the region.

(f) The need to develop and use recycled water. (CWC §13241)

1.5 PROPOSED AMENDMENT

Central Valley Water Board staff proposes to amend the Basin Plan to make a determination that the municipal and domestic supply (MUN) beneficial use and the human consumption of aquatic organisms do not exist and are not attainable in the lower two miles of Sulphur Creek

from Schoolhouse Canyon to the mouth. These beneficial uses are not existing in this reach of Sulphur Creek and this report concludes that they cannot feasibly be attained in the future. Sulphur Creek has never supported these uses due to naturally occurring conditions that prevent them from being attained.

Because these uses do not exist and are not attainable, none of the promulgated water quality criteria for mercury apply to protect the aquatic life beneficial uses that do exist in Sulphur Creek. Consequently, staff proposes to establish a site-specific water quality objective for mercury to return the creek to natural condition. Natural condition is defined as the state of the watershed prior to anthropogenic disturbance (e.g., mining). The proposed objective is:

"For Sulphur Creek (Colusa County), waters shall be maintained free of mercury from anthropogenic sources such that beneficial uses are not adversely affected. During low flow conditions, defined as flows less than 3 cfs, the instantaneous maximum total mercury concentration shall not exceed 1,800 ng/L. During high flow conditions, defined as flows greater than 3 cfs, the instantaneous maximum ratio of mercury to total suspended solids shall not exceed 35 mg/kg. Both objectives apply at the mouth of Sulphur Creek."

See Appendix A for the proposed changes to the Basin Plan language.

2 EXISTING CONDITIONS

Sulphur Creek drains a 6,543-acre watershed within the Cache Creek watershed, in the Coast Range of California (Figure 1). The creek is an intermittent stream with continuous flows between the fall and spring months (October through June). Stretches of the stream are wet throughout the year due to inputs from springs. Watershed land use is predominantly rangeland in undeveloped chaparral and California scrub oak (Foe and Croyle, 1998).

Water quality in the lower portion of Sulphur Creek is a function of inputs from the geothermal springs and erosion of naturally mercury-enriched soil. This section summarizes the history of the watershed and water quality data collected before and after 1975.

Water quality in Sulphur Creek likely has not changed since prior to 1975. Since 1975, there have been no changes in discharge to the creek, natural or anthropogenic, no major landslides, wildfires, or catastrophic erosion events have occurred, and operations at all mines had ceased by 1975[1].

The highest concentrations of mercury and dissolved solids are found in water from the springs that enter the creek. The spring and stream data in Table 1 were collected in the dry season, when springs provide most of the water in the creek.

Geothermal inputs are a natural feature of the creek that existed prior to mining and development activities. At the Wilbur Hot Springs Resort, water from several thermal springs is piped into the resort pool and baths and flows back to the creek. These springs are located on the bank of Sulphur Creek and flowed directly to Sulphur Creek prior to construction of the resort. Descriptions of other major springs (Jones Hot Springs, Blanck Hot Springs, and hot

[1] Mining ended at the lower Sulphur Creek mines (Central, Empire, Manzanita, Cherry Hill, West End, and Wide Awake) in 1942 and 1943 and at Elgin Mine in 1916 (Churchill and Clinkenbeard, 2004). Operations at the Rathburn-Petray mine group ceased in 1972 (Tetra Tech EM, Inc., 2004). Drainage from the southern end of the Rathburn-Petray group may reach the East Fork Sulphur Creek.

springs at Elgin Mine) provided years ago by the U.S. Geological Survey (Waring, 1915) are consistent with observations by Central Valley Water Board staff for this report.

Mining is not believed to have altered discharges of mercury or salts from springs in the lower Sulphur Creek watershed. Three points support this assertion. First, the springs are not adjacent to the mine sites or involved in the mine workings. This is in contrast to a thermal spring in the adjacent Harley Gulch watershed, which now flows from a collapsed adit on the Turkey Run mine site[2].

Second, springs were used at the same sites at or prior to mining. Native Americans used waters of the Elgin, Jones and Wilbur springs for healing before mining. Mineral spring resorts operated by immigrants of European descent opened at the sites of the present Elgin and Wilbur thermal springs prior to 1863, which is the earliest documentation of gold or mercury mining in the watershed (Davis, 2005). During the heydays of hot spring resorts in the Coast Range, at least four springs supported commercial operations (Wilbur, Jones, Blanck, and Elgin; Waring, 1915).

Third, water quality from the springs has not changed. In 1973, Barnes and colleagues published results of chemical analyses of Wilbur Hot Springs water showing high bicarbonate, chloride, sulfate, and boron concentrations (Barnes *et al.*, 1973). Samples collected after 1975 show similar results, suggesting little or no change in water quality from the springs (Thompson *et al.,* 1981; Goff *et al.*, 2001; Table 1). High sulfide concentrations, as detected by smell of the springs, are mentioned in anecdotes from the opening of the hotel at Wilbur Hot Springs in 1864 (Anderson, 1892) and persist today.

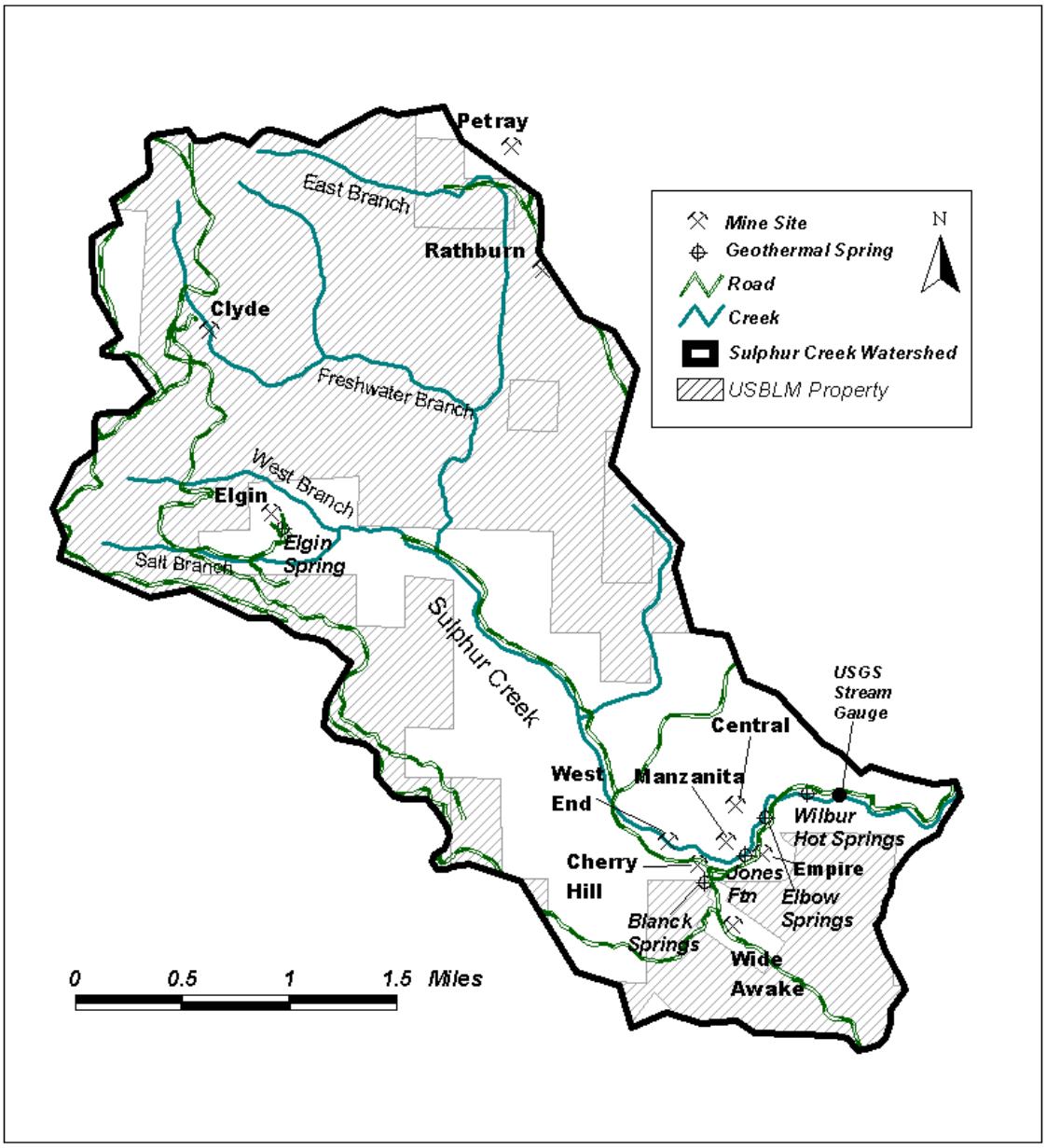
Table 1. Major constituents in water from Wilbur Springs.

Year	*Concentrations in mg/L*						*Reference*
	HCO_3-	*Cl*	*SO_4*	*Mg*	*B*	*Na*	
1910	na	9763	149	53	na	8370	Waring, 1915.(a)
1973	7130	9700	390	38	310	8500	Barnes et al, 1973
1976	7040	9810	390	44	280	9200	Thomson, et al, 1981
1991	7375	10710	420	55	285	8580	Goff et al., 2001
1992	6030	11100	157	51	295	10100	Goff et al., 2001
1994	6440	10910	73	50	283	8810	Goff et al., 2001
2001	na	na		45	250	12000	Suchanek et al., 2004

(a) Collected by W.H. Sloan (1910) and reported by Waring. Data for Main Spring that was piped to the bathhouse.

[2] Thermal springs at the Elgin Mine site do intersect mine workings (Churchill and Clinkenbeard, 2004). Elgin is in the upper Sulphur Creek watershed, approximately four miles upstream of Wilbur Hot Springs. As the stream bed is dry in summer between Elgin and the lower Sulphur Creek springs, Elgin spring is assumed not to contribute to high mercury and salt concentrations in Sulphur Creek downstream of Wilbur Hot Springs in the summer.

Figure 1. Map of the Sulphur Creek watershed.



3 USE ATTAINABILITY ANALYSIS FOR THE MUN AND HUMAN CONSUMPTION OF AQUATIC ORGANISMS BENEFICIAL USES

3.1 PURPOSE AND REGULATORY NEED FOR THE PROPOSED BASIN PLAN AMENDMENT

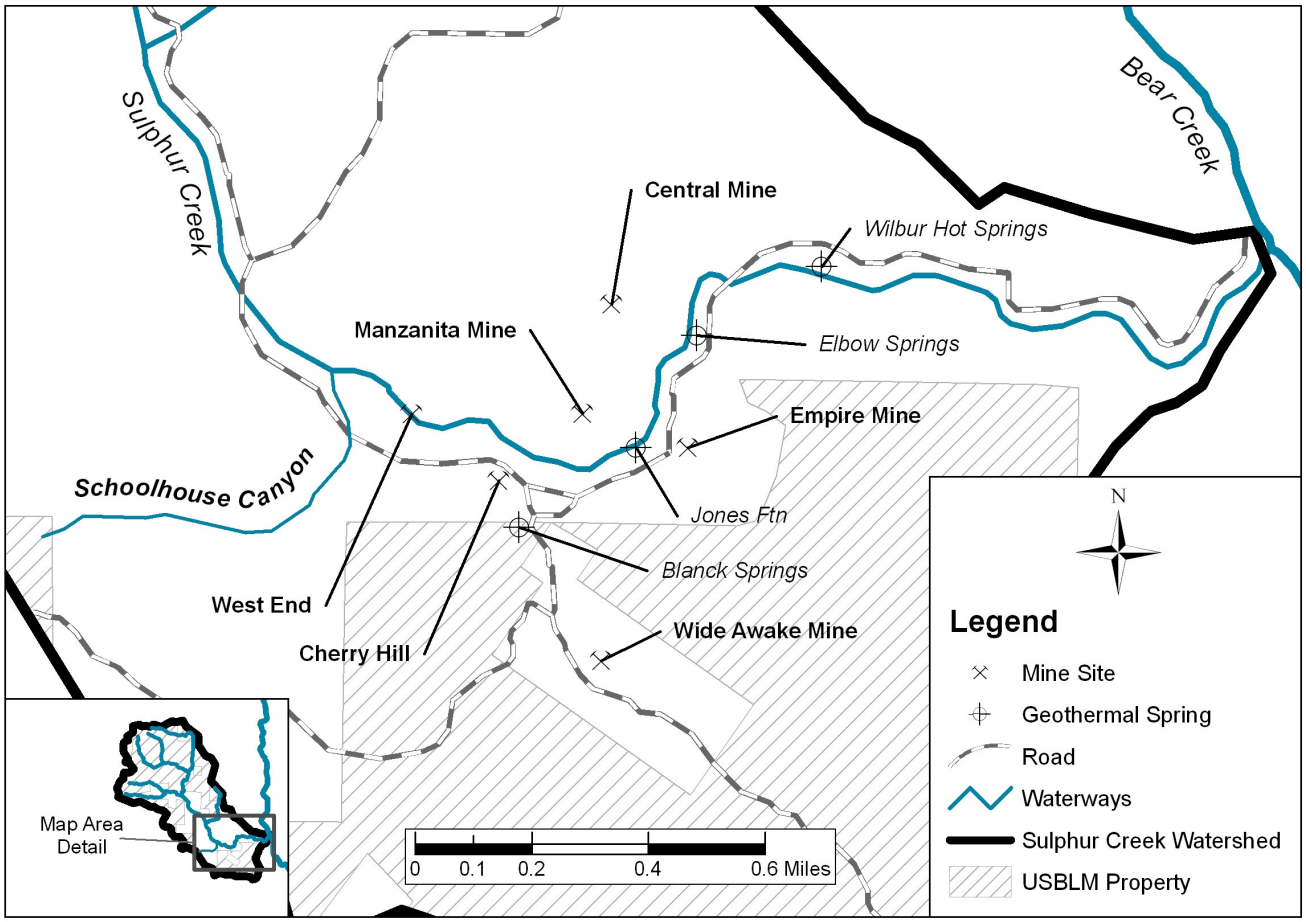
The purpose of the proposed amendment is to recognize that the MUN beneficial use and the human consumption of aquatic organisms do not exist and cannot be attained in the lower two miles of Sulphur Creek from Schoolhouse Canyon to the mouth (see Figure 2). Data only are

available for the lower reach of the creek. The available data support removal of the uses. This proposed action would allow the Central Valley Water Board to regulate discharges to and assess water quality impairments of Sulphur Creek based on use designations supported by the available data.

This proposed Basin Plan amendment does not address the appropriateness of beneficial uses of Sulphur Creek and its tributaries upstream from Schoolhouse Canyon. The uses of Sulphur Creek and its tributaries upstream from Schoolhouse Canyon will remain the same as before this amendment to the Basin Plan.

All references to Sulphur Creek throughout the remainder of the report refer to the lower two miles from Schoolhouse Canyon to the mouth unless otherwise noted.

Figure 2. Map of lower 2 miles of Sulphur Creek from Schoolhouse Canyon to the mouth.



3.2 REGULATIONS THAT APPLY TO BENEFICIAL USE ATTAINABILITY

3.2.1 Federal Regulations and Guidance

USEPA's water quality standards regulations allow a State to determine that a use is not existing or subcategorize a use if the State demonstrates that attaining the use is not feasible for one of the following reasons:

(1) Naturally occurring pollutant concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or

(3) Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like unrelated to water quality preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact. (40 CFR 131.10(g)).

In addition, the regulations establish special protections for CWA §101(a)(2) uses. CWA §101(a)(2) states that it is a national goal that wherever attainable, water quality should be sufficient "for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water." These uses are also referred to as "fishable/swimmable" uses. In order to de-designate, subcategorize, or not designate these uses, the state must support its demonstration of infeasibility with a use attainability analysis (40 CFR 131.10(j)). A use attainability analysis, or UAA, is a structured scientific assessment of the factors affecting attainment of the use, which may include physical, chemical, biological, and economic factors (40CFR 131.3(g)).

3.2.2 State Water Board Sources of Drinking Water Policy (Resolution 88-63)

State Water Board Resolution No. 88-63, commonly known as the Sources of Drinking Water Policy, establishes state policy that all waters are considered suitable or potentially suitable to support the MUN beneficial use, with certain exceptions. This policy was typically implemented in basin plans, excluding the Santa Ana Water Board's Basin Plan, with language assigning MUN to waters not identified in the basin plan's beneficial use tables (Table II-1).

The Basin Plan implements State Water Board Resolution 88-63 ("Sources of Drinking Water Policy") by assigning MUN to all water bodies not listed in Table II-1. Exceptions to the MUN

designation are allowed for surface and ground waters: 1) with total dissolved solids exceeding 3,000 mg/L (5,000 µS/cm EC), 2) with contamination that cannot reasonably be treated for domestic use, 3) where there is insufficient water supply, 4) in systems designed for wastewater collection or conveying or holding agricultural drainage, or 5) regulated as a geothermal energy producing source. Resolution 88-63 addresses only *designation* of water as drinking water sources; it does not establish objectives for constituents that threaten source waters designated MUN.

3.3 SCIENTIFIC JUSTIFICATION

3.3.1 MUN Beneficial Use

Central Valley Water Board staff is not aware of any direct municipal and domestic supply use of water from Sulphur Creek since 1975 (see section 1.3). Staff has spoken with the management of the Wilbur Hot Springs Resort, which is the only permanently occupied residence in the watershed. The resort obtains drinking water from shallow groundwater wells on a ridge above Sulphur Creek. Therapeutic bathing in the hot spring water, which also occurs at the resort, is considered contact recreation rather than a domestic use. Staff has also spoken with the owner of the Elgin property in the upper Sulphur Creek watershed, Mr. Jose Lucientes. Mr. Lucientes periodically resides on the Elgin property and utilizes bottled water for drinking rather than creek water. Staff walking the creek while collecting mercury samples did not find any intakes that would suggest use of water from the creek. There are no industrial uses of Sulphur Creek water.

Sulphur Creek flows to Bear Creek, which flows to Cache Creek. Cache Creek is designated for municipal and domestic supply. However, water from Sulphur Creek is well diluted in Cache Creek. Sulphur Creek provides less than one percent of the flow volume in Cache Creek (CVRWQCB, 2007).

3.3.1.1 TDS

Water in Sulphur Creek exceeds federal and state drinking water standards for total dissolved solids (TDS) and electrical conductivity (EC). Exceedances are greatest in the dry season, when springs comprise most of the water flow in Sulphur Creek.

The maximum contaminant level (secondary[3]) for TDS in drinking water is 500 mg/L. As noted in section 3.2.2, the criteria in Resolution 88-63 for excepting the MUN beneficial use is waters where the TDS exceeds 3,000 mg/L (5,000 µS/cm, EC). TDS concentrations measured at spring outflows were 24,943-33,024 mg/L (Goff *et al.*, 2001).

The USEPA and California public health goal (secondary) for conductivity is 900 µS/cm. The criteria in Resolution 88-63 for excepting the MUN beneficial use is waters where the EC exceeds 5,000 µS/cm (3,000 mg/L total dissolved solids). Electrical conductivity in Sulphur Creek was 11,360-36,700 µS/cm in the dry season (Goff *et al.*, 2001) and 299-1,974 µS/cm following winter storms (CVRWQCB, 2007; Suchanek *et al.*, 2004). Conductivities of spring outflows range from 31,900-44,930 µS/cm (Goff *et al.*, 2001; Suchanek *et al.*, 2004). See Appendix B for data.

[3] A secondary maximum contaminant level limits undesirable taste and odor characteristics of drinking water.

3.3.1.2 Mercury

The Sulphur Creek TMDL report provides data that demonstrate the California Toxics Rule (CTR) mercury criterion of 50 ng/L of total recoverable mercury is exceeded on a regular basis[4]. At the USGS gauge near the mouth of Sulphur Creek, the mean mercury concentration is over 2,700 ng/L with a range of 245 -16,411 ng/L total recoverable mercury (Appendix C; Foe and Croyle, 1998; Domagalski *et al*., 2004; Suchanek *et al*., 2004; data collected in 2003-2004 by CVRWQCB for the Sulphur Creek TMDL). Upstream of the majority of the mercury mines, the mean mercury concentration was 1,389 ng/L during winter flows (range 330-3,422 ng/L, 7 samples collected upstream of West End mine; Suchanek *et al*., 2004 and CVRWQCB data). There is no surface flow in Sulphur Creek upstream of West End mine in the summer.

Thermal springs in the watershed have mercury concentrations that range from 10,000 to 33,600 ng/L (Goff *et al*., 2001; Rytuba, 2000; Suchanek *et al*, 2004; CVRWQCB data). In winter, discharges from the springs are diluted by runoff from rain events. In periods of no precipitation, mercury concentrations in creek water are less than at the spring inputs for two reasons: 1) dilution by surface or subsurface flows, and 2) precipitation of mercury after leaving the spring outlets. These mercury concentrations in the creek are at levels that cannot reasonably be treated for domestic use.

3.3.2 Human Consumption of Aquatic Organisms Beneficial Uses

Humans do not fish in Sulphur Creek because fish are lacking. In April 2004, staff from the California Department of Fish and Game (DFG) and the Central Valley Water Board electroshocked Sulphur Creek from Jones Fountain of Life to the confluence with Bear Creek and found no fish (DFG, 2004). The Wilbur Hot Springs resort proprietors have not observed angling in the watershed. In addition, University of California, Davis (UCD) researchers have found no evidence of edible aquatic invertebrates, such as clams or crayfish, present in Sulphur Creek (Slotton *et al*., 1997; Slotton, 2006). As such, human consumption of aquatic organisms from the lower two miles of Sulphur Creek is not an existing or attainable use.

3.4 FEASIBILITY ANALYSIS

Natural sources of mercury and TDS cause Sulphur Creek water to be unsuitable for drinking. Sulphur Creek would have to be treated to remove mercury and TDS to fully attain the MUN beneficial use. As discussed in Section 6, fully attaining the MUN beneficial use is not feasible due to the cost of treating Sulphur Creek to meet drinking water standards.

The human consumption of aquatic organisms is not attainable due to the lack of fish and edible invertebrates in the lower two miles of Sulphur Creek. This reach of the creek is unsuitable habitat for fish because of naturally high TDS and sulfate concentrations from thermal springs. As with the MUN beneficial use, it is not feasible to treat Sulphur Creek water to make it suitable habitat for fish.

[4] Water quality data are typically compared with the criterion using a 30-day averaging interval with an allowable exceedance frequency of once every three years. Although Sulphur Creek data were not collected repeatedly during 30-day intervals, the water chemistry is sufficiently consistent to assume that the CTR criterion for mercury is exceeded.

4 ESTABLISHING SITE SPECIFIC WATER QUALITY OBJECTIVES FOR MERCURY IN SULPHUR CREEK

4.1 PURPOSE AND REGULATORY NEED FOR THE PROPOSED BASIN PLAN AMENDMENT

Because the MUN beneficial use and the human consumption of aquatic organisms do not apply to the lower two miles of Sulphur Creek, none of the promulgated water quality criteria for mercury apply to protect the aquatic life uses that do exist in Sulphur Creek and on which to support the TMDL. The purpose of the proposed Basin Plan amendment is to establish a water quality objective for mercury based on natural conditions that will protect beneficial uses of Sulphur Creek that existed before anthropogenic disturbance in the watershed. The proposed objective also will protect all beneficial uses in Bear and Cache Creeks.

Staff recognizes that there are constituents, besides mercury, listed in the CTR that, when MUN and the human consumption of aquatic organisms are removed, also will no longer apply to lower Sulphur Creek. Staff reviewed the list and determined that these other constituents are either man-made or are generated by natural processes, neither of which occur in this portion of Sulphur Creek. As such, these constituents do not adversely affect water quality or the attainment of beneficial uses of Sulphur Creek and there is no evidence to suggest they are present at a level to warrant concern in lower Sulphur Creek. (40 CFR 131.11(a)(2))

4.2 REGULATIONS THAT APPLY TO ESTABLISHING WATER QUALITY OBJECTIVES

4.2.1 Federal Regulations and Guidance

Federal regulations require States to adopt narrative or numeric water quality criteria (synonymous with water quality objectives) to protect designated beneficial uses. 40 CFR 131.11(a)(1). States are required to adopt numeric criteria for constituents considered priority toxic pollutants (e.g., mercury). CWA §303(c)(2)(B). Federal regulations permit States to establish water quality standards based on natural background conditions. 40 CFR 131.10.

4.2.2 State Regulations and Guidance

When adopting new water quality objectives, the Central Valley Water Board is required to consider past, present, and probable future beneficial uses; environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto; water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area; economic considerations; the need for developing housing within the region; and the need to recycle and use recycled water. CWC §13241.

4.2.3 Controllable Factors Policy

The Basin Plan Controllable Factors Policy (Page III-1) states that:

> *Controllable water quality factors are not allowed to cause further degradation of water quality in instances where other factors have already resulted in water quality objectives being exceeded. Controllable water quality factors are those actions, conditions, or cir-*

cumstances resulting from human activities that may influence the quality of the waters of the State, that are subject to the authority of the State Water Board or Regional Water Board, and that may be reasonably controlled.

Essentially, the Controllable Factors Policy requires the Regional Water Board to regulate water quality factors degrading water quality that are controllable. The proposed Basin Plan amendment is consistent with this policy because the water quality objectives for mercury are calculated to represent natural background (i.e., uncontrollable) conditions.

4.3 SCIENTIFIC JUSTIFICATION

4.3.1 Method of Calculating Objectives

The goal of the site-specific objective is to recognize that the natural conditions, estimated using data from natural (springs and naturally mercury enriched soils) and anthropogenic sources (mines), would sufficiently protect the existing and attainable beneficial uses of Sulphur Creek. The proposed objective is:

"For Sulphur Creek (Colusa County), waters shall be maintained free of mercury from anthropogenic sources such that beneficial uses are not adversely affected. During low flow conditions, defined as flows less than 3 cfs, the instantaneous maximum total mercury concentration shall not exceed 1,800 ng/L. During high flow conditions, defined as flows greater than 3 cfs, the instantaneous maximum ratio of total mercury to total suspended solids shall not exceed 35 mg/kg. Both objectives apply at the mouth of Sulphur Creek."

During summer, low-flow conditions, the only sources of mercury to Sulphur Creek are natural. The 1,800 ng/L objective represents the maximum measured total mercury concentration measured by Central Valley Water Board staff during low-flow conditions (Appendix C).

During high flow conditions, mercury sources to Sulphur Creek are associated with sediment runoff from the surrounding watershed. These sources include both naturally mercury-enriched soils and mine sites. As such, the proposed objective represents the runoff-associated mercury as measured by the ratio between mercury and total suspended solids. Available data show a statistically significant correlation between total mercury and total suspended solids (Hg/TSS). The maximum measured Hg/TSS ratio is 116 mg/kg during high flow conditions defined as greater than 3 cfs (Appendix C). The mine sites contribute 75% of the mercury load to Sulphur Creek (CVRWQCB, 2007). Central Valley Water Board staff estimates that remediation of the mine sites would reduce mercury loads from the mines to the creek by approximately 95% (this is not 100% because these sites likely were naturally mercury-enriched above regional background prior to mining). To account for this, the maximum Hg/TSS ratio was reduced by 71% (95% of the estimated contribution of mercury load from mine sites) to 35 mg/kg to estimate natural conditions prior to mining.

4.3.2 Data Used to Calculate Objectives

Data used to calculate the objectives described above are summarized in Appendix C. When flow data were not available, season was used as a surrogate to determine whether the data were collected during low or high flow conditions. The cutoff for low versus high flow conditions of 3 cfs was selected using daily stream flow data measured by the USGS flow

gauge at Wilbur Springs. Flows during the dry season from 1999 through 2003 never exceed 3 cfs and storm runoff flows far exceed 3 cfs (USGS, 2004). Mercury data span both wet and dry water year types and a range of stream flows. The data also produce statistically significant correlations between TSS and flow, total mercury and flow, and total mercury and TSS. The proposed objective is the best estimate to achieve natural, pre-mining disturbance conditions that can be calculated using available data.

4.3.3 Aquatic Life Protected by the Objectives

Aquatic life in Sulphur Creek presumably has adapted to the high mineral content and temperatures caused by inputs from the geothermal springs. As discussed in Section 2, the geothermal inputs and naturally mercury-enriched soils existed prior to anthropogenic activities. UCD researchers believe that the creek assemblage is dictated largely by the sulfate concentrations in the creek rather than mercury (Slotton *et al*., 1997; Schwarzbach *et al*., 2001; Slotton, 2006). The US Fish and Wildlife Service (Schwartzbach *et al*., 2001) collected caddis fly, dragon fly, and damsel fly larvae and researchers at UC Davis (Slotton *et al.,* 1997) collected mayfly, alderfly, and water bugs in Sulphur Creek. Because sources of sulfate are natural and have not changed due to anthropogenic activities (see Section 2) it is reasonable to assume that the creek assemblage has not changed either. The water quality objective described in section 4.3.1 will protect aquatic life that has adapted to the natural conditions in Sulphur Creek.

4.4 California Water Code Considerations

The proposed objective is discussed below relative to the factors that must be considered as required by CWC §13241.

Past, present, and future beneficial uses: The proposed objective fully protects all existing and attainable beneficial uses.

Environmental characteristics of the hydrographic unit and quality of available water: As indicated in Section 2, Sulphur Creek water exceeds the drinking water criteria for the constituents mercury, TDS, and EC. The State Water Board Sources of Drinking Water Policy sets limits that allow an exception for designation as a municipal or domestic supply. Levels of TDS and EC in Sulphur Creek are greater than these limits. High EC and TDS levels derive from naturally occurring springs that discharge to the creek. In low-flow periods, the springs also contribute mercury in excess of the CTR criterion.

Water quality conditions that could reasonably be achieved: Water quality that could reasonably be achieved is natural conditions (i.e., concentrations of TDS and mercury from naturally occurring sources) or background concentrations as indicated by the proposed objective. Mine sites are the only anthropogenic sources of mercury to the watershed. The TMDL for mercury in Sulphur Creek identifies the reduction in total mercury loads needed to eliminate inputs related to mining and other anthropogenic activities and restore the watershed to its estimated pre-mining conditions.

Need for developing housing: Wilbur Hot Springs resort is the only permanently occupied residence in the watershed. The resort obtains it drinking water from groundwater sources. Staff are not aware of plans to develop housing in the watershed; however, should additional

housing be developed it is unlikely that Sulphur Creek water could feasibly be treated to attain the MUN use (see section 6). Thus, the proposed water quality objective is not expected to prevent the development of additional housing.

Need to develop and use recycled water: Currently, the only discharge to Sulphur Creek is the water that is piped from the thermal springs into the baths at Wilbur Hot Springs and back into the Creek. The proposed objective is not expected to prevent development and use of recycled water.

4.5 IMPLEMENTATION

Staff recognizes that Sulphur Creek currently does not meet the proposed objective for high flow conditions. When a water body does not meet the Basin Plan water quality objectives, the Regional Water Board is required to develop an implementation plan and time schedule to achieve the objectives. (CWC §13242) This requirement already has been met through a separate action taken by the Regional Water Board, which is summarized below.

At the October 2005 meeting, the Central Valley Water Board adopted the Basin Plan Amendment for the Control of Mercury in the Cache Creek Watershed (CVRWQCB, 2005). The Basin Plan Amendment established numeric water quality objectives for methyl mercury in fish tissue in Bear and Cache Creeks and an implementation plan to achieve the objectives. The implementation plan allocated methyl mercury loads (with a margin of safety) to watersheds tributary to Cache Creek, including Sulphur Creek (allocation is 10% of existing annual methylmercury loads, estimated to average 0.8 g methylmercury/yr; Basin Plan table IV-8). It is assumed that reducing total mercury will result in reduction of methylmercury. The Cache Creek Watershed implementation plan, therefore, requires a 95% total mercury load reduction for all mercury mine sites including those in the Sulphur Creek watershed.

Implementation actions described in the Cache Creek Watershed Basin Plan amendment and the Sulphur Creek TMDL report are expected to achieve the loads allocated to Sulphur Creek and the proposed site-specific water quality objectives. The Basin Plan amendment proposed in this staff report along with the Sulphur Creek TMDL report and the Cache Creek Watershed Basin Plan amendment report fulfills USEPA requirements for a TMDL.

5 ENVIRONMENTAL ANALYSIS

The proposed amendment would make a determination that the MUN beneficial use and the human consumption of aquatic organisms are not applicable to the lower two miles of Sulphur Creek from Schoolhouse Canyon to the mouth. These uses do not exist and cannot feasibly be attained due to naturally occurring pollutant concentrations. In addition, the proposed amendment would set site-specific water quality objectives for mercury in Sulphur Creek. The proposed objective is based on natural conditions. Adoption of the proposed amendment will not have any effect on the existing physical environment because the amendment will not change Sulphur Creek's uses or otherwise change the environment. These conclusions are reflected in the CEQA Checklist prepared for this project. The amendment simply recognizes that the two uses do not currently exist and cannot feasibly be attained in the future. The amendment will enable the Central Valley Water Board to regulate waste discharges to Sulphur Creek and to make impairment assessments based on appropriate beneficial uses.

5.1 ALTERNATIVES TO THE PROPOSED BASIN PLAN AMENDMENT

Because adoption of the proposed amendment does not have the potential to adversely impact the existing physical environment, it is not necessary to consider alternatives to the proposed action. Nevertheless, staff has considered a "no action" alternative and an alternative to determine that MUN and human consumption of aquatic organisms beneficial uses do not apply to Sulphur Creek without establishing site-specific water quality objectives for mercury.

5.1.1 No Action

The "no action" alternative would preserve the status quo. It would require the Central Valley Water Board to regulate waste discharges to Sulphur Creek and make impairment assessments based on uses that do not exist and cannot feasibly be attained in the future. This result is undesirable because it would require the expenditure of resources to protect non-existent uses.

5.1.2 Determine Certain Beneficial Uses Do Not Apply Without Establishing Water Quality Objectives

If the Central Valley Water Board makes a determination that the MUN beneficial use and the human consumption of aquatic organisms do not apply, then none of the existing water quality objectives for mercury apply. If a new water quality objective were not promulgated, then the aquatic life beneficial uses that do exist in Sulphur Creek would not be protected.

6 ECONOMIC CONSIDERATIONS

As described above, Sulphur Creek water exceeds drinking water criteria for mercury, EC, and TDS. The high concentrations occur naturally because the area had natural mercury-enriched soils that cause the thermal springs to discharge high levels of mercury. Pollution control activities for these sources are not economically feasible. It is highly unlikely that the landowners have the ability or resources to control the discharge.

Table 2 summarizes control options and estimated costs for treating Sulphur Creek and springs entering the creek. Treatment would be needed within the creek as well as for the spring tributaries because some springs discharge directly to the creek bed. Tetra Tech EM, Inc. (2004) prepared the engineering analysis and cost estimates for the California Bay Delta Authority as part of a multi-investigator study of sources and treatment of mercury in the Cache Creek watershed. The goal of recommended treatments was to control metals, particularly mercury and sulfur[5].

Table 2. Estimated costs for treating Sulphur Creek water and springs to remove mercury.

Location	*Estimated Total Cost (a)*
Sulphur Creek water below Wilbur Springs	$10,960,900
Blanck Spring	$918,200

[5] The most effective treatment option proposed was to route the stream or spring through on-site basin for precipitation of metals and sulfur compounds. Iron filings in the basin cause the precipitation. Precipitates would need to be removed annually to prevent them from being washed downstream in storm flows. Iron would need to be replaced periodically (Tetra Tech EM, Inc., 2004).

Elgin Springs	$2,629,250

a). Tetra Tech EM, Inc. (2004). Includes capital cost and maintenance and monitoring for 30 years, in present worth dollars.

It is possible that additional or alternative treatment would be required to sufficiently remove all ions to meet the TDS criterion. Presumably, desalination using reverse osmosis would be needed to remove the remaining ions. The California Department of Water Resources (DWR) 2005 update to the California Water Plan estimates costs for desalination treatment from $250 to $2,000 per acre-foot depending on the type of plant (i.e., groundwater, wastewater, or seawater) in addition to capitol costs associated with constructing the plant.

7 ANTIDEGRADATION ANALYSIS

Both USEPA (40 CFR 131.12) and the State of California (State Board Resolution 68-16) have adopted antidegradation policies as part of their approach to regulating water quality. The Central Valley Water Board must ensure that its actions do not violate the federal or State antidegradation policies. This section of the Staff Report analyzes whether approval of the proposed amendments would be consistent with the federal and State antidegradation policies.

7.1 FEDERAL ANTIDEGRADATION POLICY

The federal antidegradation policy, 40 CFR 131.12(a), states in part:

(1) Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

(2) …Where the quality of waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located…

(3) Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

7.2 STATE ANTIDEGRADATION POLICY

Antidegradation provisions of State Water Board Resolution No. 68-16 ("Statement of Policy With Respect to Maintaining High Quality Waters in California") state, in part:

(1) Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.

(2) Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.

7.3 Antidegradation Analysis of the Proposed Amendments

The proposed amendment is not expected to result in a lowering of water quality in Sulphur Creek. The amendment would recognize that certain beneficial uses do not exist and cannot feasibly be attained and sets new water quality objectives for mercury that are expected to result in attainment of natural background conditions. This action is not expected to result in an increase of discharges to the creek.

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Appendix A. Proposed changes to the Basin Plan language

Modify the first two paragraphs on page II-2.00 of the Basin Plan, under the heading **SURFACE WATERS**, as follows:

SURFACE WATERS

Existing and potential beneficial uses which currently apply to surface waters of the basins are presented in Figure II-1 and Table II-1. The beneficial uses of any specifically identified water body generally apply to its tributary streams, *except as provided below:*

- MUN, COLD, MIGR and SPWN do not apply to Old Alamo Creek (Solano County) from its headwaters to the confluence with New Alamo Creek
- *MUN and the human consumption of aquatic organisms do not apply to Sulphur Creek (Colusa County) from Schoolhouse Canyon to the confluence with Bear Creek*

In some cases a beneficial use may not be applicable to the entire body of water. In these cases the Regional Water Board's judgment will be applied.

It should be noted that it is impractical to list every surface water body in the Region. For unidentified water bodies, the beneficial uses will be evaluated on a case-by-case basis.

Water Bodies within the basins that do not have beneficial uses designated in Table II-1 are assigned MUN designations in accordance with the provisions of State Water Board Resolution No. 88-63 which is, by reference, a part of this Basin Plan, *except as provided below:*

- Old Alamo Creek (Solano County) from its headwaters to the confluence with New Alamo Creek
- *Sulphur Creek (Colusa County) from Schoolhouse Canyon to the confluence with Bear Creek*

These MUN designations in no way affect the presence or absence of other beneficial use designations in these water bodies.

Add a subsection on page III-5.00 of the Basin Plan, under the heading **WATER QUALITY OBJECTIVES FOR INLAND SURFACE WATERS**, as follows:

Mercury

For Sulphur Creek (Colusa County), waters shall be maintained free of mercury from anthropogenic sources such that beneficial uses are not adversely affected. During low flow conditions, defined as flows less than 3 cfs, the instantaneous maximum total mercury concentration shall not exceed 1,800 ng/L. During high flow conditions, defined as flows greater than 3 cfs, the instantaneous maximum ratio of mercury to total suspended solids shall not exceed 35 mg/kg. Both objectives apply at the mouth of Sulphur Creek.

CHAPTER V: SURVEILLANCE AND MONITORING

Revise the subheading under the Mercury and Methyl Mercury section as follows:

Cache Creek, Bear Creek, ~~and~~ Harley Gulch, *and Sulphur Creek.*

Appendix B. Conductivity and total dissolved solids in Sulphur Creek and Springs (CVRWQCB, 2007).

Site Name	*Date/year*	*TDS (mg/L)*	*Conductivity (µS/cm)*	*Reference*
Wilbur Spring	1973		33000	Barnes et al, 73
Wilbur Spring	1976			Thomson et al., 1981
Wilbur Spring (White's site)	09/30/93	28290	37800	Goff et al, 2001
Wilbur Spring (White's site)	05/21/94	27070	36500	Goff et al, 2001
Wilbur Spring (White's site)	12/20/95	24943	34000	Goff et al, 2001
Wilbur Spring (main)	03/09/91	28160	39300	Goff et al, 2001
Wilbur Spring (main)	06/02/92	29520	31900	Goff et al, 2001
Wilbur Spring (main)	05/21/94	28880	36800	Goff et al, 2001
Wilbur Spring	02/22/01		45096	Suchanek et al., 2004
Wilbur Spring @ Gauge	02/02/04		575	CVRWQCB, 2007
Blanck Spring	12/05/93	24003	31800	Goff et al, 2001
Blanck Spring	05/22/94	24546	32200	Goff et al, 2001
Blanck Spring	12/20/95	19919	28400	Goff et al, 2001
Blanck Spring	02/22/01		7179	Suchanek et al., 2004
Blanck Springs Trib	12/14/03		10400	CVRWQCB, 2003
Blanck Springs Trib	02/25/04		642	CVRWQCB, 2007
Elbow Spring	09/30/93	33024	44100	Goff et al, 2001
Elbow Spring	12/05/93	33145	43900	Goff et al, 2001
Elbow Spring	05/23/94	34780	44700	Goff et al, 2001
Elbow Spring	12/19/95	32480	43300	Goff et al, 2001
Jones Hot Spring	03/09/91	30620	41000	Goff et al, 2001
Jones Hot Spring	06/02/92	30730	33200	Goff et al, 2001
Jones Hot Spring	05/23/94	29280	39000	Goff et al, 2001
Jones Hot Spring	04/01/95	27900	38000	Goff et al, 2001
Jones Hot Spring	10/12/95	28130	37900	Goff et al, 2001
Jones Hot Spring	02/22/01		44930	Suchanek et al., 2004
Jones Hot Spring	02/02/04		51000	CVRWQCB, 2007
Elgin Hot Spring (main outlet)	12/06/93	29250	39100	Goff et al, 2001
Elgin Hot Spring (main outlet)	05/24/94	29420	39000	Goff et al, 2001
Elgin Hot Spring (bathtub)	05/24/94	29310	39400	Goff et al, 2001
Wilbur Spring 1991			39300	Goff et al, 1993
Sulphur Creek @ gauge	02/22/01		1410	Suchanek et al., 2004
Sulphur Creek @ gauge	01/02/02		394	CVRWQCB, 2002
Sulphur Creek @ gauge	03/15/03		922	CVRWQCB, 2003
Sulphur Creek @ gauge	12/14/03		1974	CVRWQCB, 2003
Sulphur Creek @ gauge	12/29/03		810	CVRWQCB, 2003
Sulphur Creek @ gauge	02/02/04		575	CVRWQCB, 2007
Sulphur Creek @ gauge	02/25/04		339	CVRWQCB, 2007

Site Name	Date/year	TDS (mg/L)	Conductivity (µS/cm)	Reference
Sulphur Creek @ gauge	03/24/04		3625	CVRWQCB, 2007
Sulphur Creek @ gauge	04/28/04		6350	CVRWQCB, 2007
Sulphur Creek @ gauge	06/07/04		13180	CVRWQCB, 2007
Sulphur Creek @ gauge	08/03/04		17900	CVRWQCB, 2007
Sulphur Creek @ gauge	09/22/04		25190	CVRWQCB, 2007
Sulphur Creek @ gauge	10/26/04		26980	CVRWQCB, 2007
Sulphur Creek @ gauge	02/02/05		4940	CVRWQCB, 2007
Sulphur Creek @ gauge	05/21/94		18240	Goff et al, 2001
Sulphur Creek @ gauge	05/21/94		18790	Goff et al, 2001
Sulphur Creek @ gauge	05/22/94		20100	Goff et al, 2001
Sulphur Creek @ gauge	05/22/94		24800	Goff et al, 2001
Sulphur Creek @ gauge	05/22/94		23100	Goff et al, 2001
Sulphur Creek @ gauge	05/22/94		11360	Goff et al, 2001
Sulphur Creek d/s Wilbur Hot Springs	02/22/01		1377	Suchanek et al., 2004
Sulphur Creek u/s Wilbur Hot Springs	02/22/01		933	Suchanek et al., 2004
Sulphur Creek u/s Wilbur Hot Springs	12/14/03		1892	CVRWQCB, 2003
Sulphur Creek u/s Wilbur Hot Springs	2/2/04		547	CVRWQCB, 2007
Sulphur Creek u/s Wilbur Hot Springs	02/25/04		291	CVRWQCB, 2007
Sulphur Creek @ Elbow Spring	8/1994		36700	Goff et al, 2001
Sulphur Creek u/s Jones Fountain of Life Hot Spring	5/1994		11860	Goff et al, 2001
Sulphur Creek u/s Jones Fountain of Life Hot Spring	5/1994		13950	Goff et al, 2001
Sulphur Creek u/s Jones Fountain of Life Hot Spring	5/1994		16840	Goff et al, 2001
Sulphur Creek u/s Jones Fountain of Life Hot Spring	5/1994		35100	Goff et al, 2001
Sulphur Creek u/s Jones Fountain of Life Hot Spring	02/22/01		864	Suchanek et al., 2004
Sulphur Creek d/s Wide Awake Mine	02/22/01		1388	Suchanek et al., 2004
Sulphur Creek d/s Wide Awake Mine	01/02/02		358	CVRWQCB, 2002
Sulphur Creek d/s Wide Awake Mine	12/14/03		1432	CVRWQCB, 2003
Sulphur Creek d/s Wide Awake Mine	2/2/04		860	CVRWQCB, 2007
Sulphur Creek d/s Wide Awake Mine	02/25/04		256	CVRWQCB, 2007
Sulphur Creek trib d/s Wide Awake Mine	01/02/02		271	CVRWQCB, 2002
Sulphur Creek trib d/s Wide Awake Mine	12/14/03		2050	CVRWQCB, 2003
Sulphur Creek trib d/s Wide Awake Mine	2/2/04		150	CVRWQCB, 2007
Sulphur Creek trib d/s Wide Awake Mine	02/25/04		263	CVRWQCB, 2007
Sulphur Creek d/s Blanck Springs	01/02/02		526	CVRWQCB, 2002
Sulphur Creek d/s Blanck Springs	12/14/03		10400	CVRWQCB, 2003
Sulphur Creek d/s Blanck Springs	02/25/04		642	CVRWQCB, 2007
Sulphur Creek u/s Blanck Springs	02/22/01		796	Suchanek et al., 2004

Site Name	*Date/year*	*TDS (mg/L)*	*Conductivity (µS/cm)*	*Reference*
Sulphur Creek d/s West End Mine	01/02/02		295	CVRWQCB, 2002
Sulphur Creek d/s West End Mine	12/14/03		1270	CVRWQCB, 2003
Sulphur Creek d/s West End Mine	2/2/04		1991	CVRWQCB, 2007
Sulphur Creek d/s West End Mine	02/25/04		264	CVRWQCB, 2007
Sulphur Creek u/s West End Mine	02/22/01		675	Suchanek et al., 2004
Sulphur Creek u/s West End Mine	01/02/02		291	CVRWQCB, 2002
Sulphur Creek u/s West End Mine	12/14/03		1066	CVRWQCB, 2003
Sulphur Creek u/s West End Mine	2/2/04		1854	CVRWQCB, 2007
Sulphur Creek u/s West End Mine	02/25/04		266	CVRWQCB, 2007
Sulphur Creek u/s West End Mine & Sulphur Valley	02/25/04		233	CVRWQCB, 2007
Sulphur Creek trib near Empire Mine	12/14/03		715	CVRWQCB, 2003
Sulphur Creek trib near Empire Mine	2/2/04		230	CVRWQCB, 2007
Sulphur Creek trib near Empire Mine	2/25/04		191.7	CVRWQCB, 2007
Sulphur Creek u/s Clyde Mine	2/2/04		131	CVRWQCB, 2007
Clyde Mine runoff	2/25/04		106	CVRWQCB, 2007
Sulphur Creek d/s Clyde Mine	2/2/04		1370	CVRWQCB, 2007
Clyde d/s	2/25/04		120	CVRWQCB, 2007
Sulphur Creek West Fork d/s Elign Mine	2/2/04		997	CVRWQCB, 2007
Sulphur Creek West Fork d/s Elign Mine	2/25/04		691	CVRWQCB, 2007
Sulphur Creek West Fork u/s Elign Mine	2/2/04		699	CVRWQCB, 2007
Sulphur Creek West Fork u/s Elign Mine	2/25/04		594	CVRWQCB, 2007

Appendix C. Total mercury, TSS, and Hg/TSS concentrations in water samples collected at the USGS stream gauge on Sulphur Creek (CVRWQCB, 2007).

Date	*THg (ng/L)*	*TSS (mg/L)*	*Hg/TSS (mg/kg)*	*Flow (cfs)*
05/22/94	1000			
01/26/97	5316.4	320	16.6	
06/11/97	245			
02/02/98	8401.7	510	16.5	
02/16/98	1964.7	140	14.0	
01/31/00	1560.0	49.50	31.5	22.0
02/14/00	974.0	114.70	8.5	72.0
02/27/00	542			38.1
03/02/00	376.0	22.00	17.1	15.0
03/15/00	528			7.1
04/17/00	430.0	14.10	30.5	9.3
06/14/00	676.0	10.14	66.7	0.5
08/10/00	690.0	59.43	11.6	0.2
10/11/00	676.0	13.93	48.5	0.5
11/07/00	1320.0	4.23	312.1	0.41
01/11/01	3070.0	55.47	55.3	6.3
02/13/01	906.0	7.79	116.3	5.0
02/20/01	685			20.8
02/22/01	1340	56	23.9	19.0
05/03/01	557.0	10.08	55.3	0.9
07/12/01	1180.0	88.63	13.3	0.2
08/23/01	1051.0	65.08	16.1	0.2
11/20/01	1768	4.6	384.3	0.48
01/02/02	4118.7	396	10.4	156
03/15/03	1137	162.4	7.0	110.9
12/14/03	852	12	71.0	26.1
12/29/03	2097	151.7	13.82	90
02/02/04	12649	589.5	21.5	117.0
02/03/04	425	11.25	37.8	20
02/16/04	16411	1262	13.0	155
02/17/04	8574	497.5	17.2	191
02/25/04	3764	617.9	6.1	220.0
03/24/04	511	6	85.2	5.5
04/28/04	303	18.67	16.2	2.2