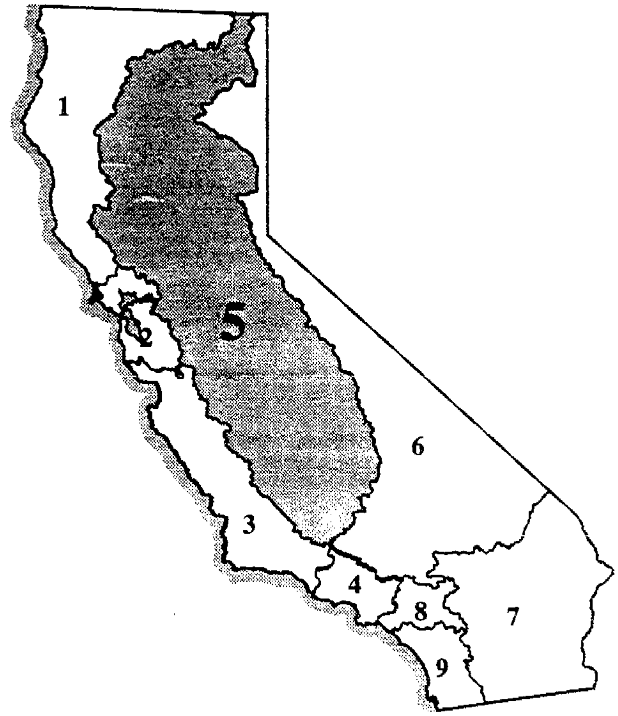
Bay Protection and Toxic Cleanup Program



Proposed Regional Toxic Hot Spot Cleanup Plan

December 1997

CENTRAL VALLEY REGION

REGIONAL WATER QUALITY CONTROL BOARD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

COV0067

REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

PROPOSED REGIONAL TOXIC HOT SPOT CLEANUP PLAN

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Part I

I. INTRODUCTION

In 1989 the California State legislature established the Bay Protection and Toxic Cleanup Program (BPTCP). The BPTCP has four major goals: (1) to provide protection of present and future beneficial uses of the bays and estuarine waters of California; (2) identify and characterize toxic hot spots; (3) plan for toxic hot spot cleanup or other remedial or mitigation actions; (4) develop prevention and control strategies for toxic pollutants that will prevent creation of new toxic hot spots or the perpetuation of existing ones within the bays and estuaries of the State.

This Regional Toxic Hot Spot Cleanup Plan is intended to provide direction for the remediation or prevention of toxic hot spots in the Central Valley Region (pursuant to Water Code Sections 13390 et seq.). Pursuant to Sections 13140 and 13143 of the Water Code, this Cleanup Plan is necessary to protect the quality of waters and sediments of the State from discharges of waste, in-place sediment pollution and contamination, and any other factor that can impact beneficial uses of enclosed bays, estuaries and coastal waters. This plan shall be reviewed periodically to ensure that the plan is adequate to complete the mandates of the Bay Protection and Toxic Cleanup Program (Water Code Section 13390 et seq.).

This Plan includes a specific definition of a Toxic Hot Spot, site ranking criteria, and the monitoring approach used to identify the Water Code-mandated requirements for Regional Toxic Hot Spot Cleanup Plans.

Region Description The Central Valley Region covers the entire area included in the Sacramento and San Joaquin River drainage basins. The two basins cover about one fourth of the total area of the State and include over 30% of the State's irrigable land. The Sacramento and San Joaquin Rivers furnish roughly 50% of the States water supply. Surface water from the two drainages meet and form the Delta which ultimately drains to San Francisco Bay.

The Delta, the area of primary focus for the BPTCP, is a maze of river channels and diked islands covering roughly 1,150 square miles, including 78 square miles of water area. Two major water projects located in the South Delta, the Federal Central Valley Project and the State Water Project, deliver water from the Delta to Southern California, the San Joaquin Valley, Tulare Lake Basin, the San Francisco Bay area, as well as within the Delta boundaries. The legal boundary of the Delta is described in Section 12220 of the Water Code.

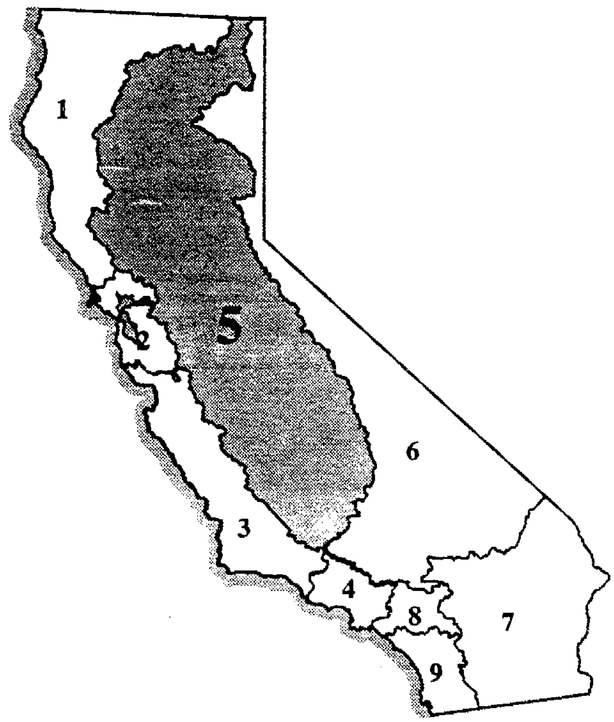
Legislative Authority

California Water Code, Division 7, Chapter 5.6 established a comprehensive program to protect the existing and future beneficial uses of California's enclosed bays and estuaries. SB 475 (1989), SB 1845 (1990), AB 41 (1989), and SB 1084 (1993) added and modified Chapter 5.6 [Bay Protection and Toxic Cleanup (Water Code Sections 13390-13396.5)] to Division 7 of the Water Code.

The BPTCP has provided a new focus on RWQCBs efforts to control pollution of the State's bays and estuaries by establishing a program to identify toxic hot spots and plan for their cleanup.

Water Code Section 13394 requires that each RWQCB complete a toxic hot spot cleanup plan. Each cleanup plan must include: (1) a priority listing of all known toxic hot spots covered by the plan; (2) a description of each toxic hot spot including a characterization of the pollutants present at the site; (3) an assessment of the most likely source or sources of pollutants; (4) an estimate of the total costs to implement the cleanup plan; (5) an estimate of the costs that can be recovered from parties responsible for the discharge of pollutants that have accumulated in sediments; (6) a preliminary assessment of the actions required to remedy or restore a toxic hot spot; and (7) a two-year expenditure schedule identifying State funds needed to implement the plan.

Bay Protection and Toxic Cleanup Program



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Limitations

This proposed regional toxic hot spot cleanup plan contains information on sites that are believed to be the worst sites in the Region. Much of the data collected as part of the BPTCP have not been reported and some analyses have yet to be completed. Consequently, this regional toxic hot spot cleanup plan is subject to revision as new information on toxic hot spot identification becomes available. In future versions of the Plan there is an expectation that (1) other sites may be identified as candidate toxic hot spots; (2) potential toxic hot spots will be addressed in future versions of the cleanup plan; (3) cleanup levels for sites may be added to the cleanup plan; and (4) site rankings may change as new information becomes available.

II. TOXIC HOT SPOT DEFINITION

Codified Definition of A Toxic Hot Spot

Section 13391.5 of the Water Code defines toxic hot spots as:

"...[L]ocations in enclosed bays, estuaries, or adjacent waters in the 'contiguous zone' or the 'ocean' as defined in Section 502 of the Clean Water Act (33. U.S.C. Section 1362), the pollution or contamination of which affects the interests of the State, and where hazardous substances have accumulated in the water or sediment to levels which (1) may pose a substantial present or potential hazard to aquatic life, wildlife, fisheries, or human health, or (2) may adversely affect the beneficial uses of the bay, estuary, or ocean waters as defined in the water quality control plans, or (3) exceeds adopted water quality or sediment quality objectives."

Specific Definition of A Toxic Hot Spot

Although the Water Code provides some direction in defining a toxic hot spot, the definition presented in Section 13391.5 is broad and somewhat ambiguous regarding the specific attributes of a toxic hot spot. The following specific definition provides a mechanism for identifying and distinguishing between "candidate" and "known" toxic hot spots. A Candidate Toxic Hot Spot is considered to have enough information to designate a site as a Known Toxic Hot Spot except that the candidate hot spot has not been approved by the RWQCB and the SWRCB. Once a candidate toxic hot spot has been adopted into the consolidated statewide toxic hot spot cleanup plan then the site shall be considered a known toxic hot spot and all the requirements of the Water Code shall apply to that site.

Candidate Toxic Hot Spot:

A site meeting any one or more of the following conditions is considered to be a "candidate" toxic hot spot.

1. The site exceeds water or sediment quality objectives for toxic pollutants that are contained in appropriate water quality control plans or exceeds water quality criteria promulgated by the U.S. Environmental Protection Agency (U.S. EPA).

   This finding requires chemical measurement of water or sediment, or measurement of toxicity using tests and objectives stipulated in water quality control plans. Determination of a toxic hot spot using this finding should rely on recurrent measures over time (at least two separate sampling dates). Suitable time intervals between measurements must be determined.

2. To determine whether toxicity exists, recurrent measurements (at least two separate sampling dates) should demonstrate an effect. Appropriate reference and control measures must be included in the toxicity testing. The methods acceptable to and used by the BPTCP may include some toxicity test protocols not referenced in water quality control plans (e.g., the Bay Protection and Toxic Cleanup Program Quality Assurance Project Plan). Toxic pollutants should be present in the media at concentrations sufficient to cause or contribute to toxic responses in order to satisfy this condition.

3. The tissue toxic pollutant levels of organisms collected from the site exceed levels established by the United States Food and Drug Administration (FDA) for the protection of human health, or the National Academy of Sciences (NAS) for the protection of human health or wildlife. When a health advisory against the consumption

of edible resident non-migratory organisms has been issued by Office of Environmental Health Hazard Assessment (OEHHA) or Department of Health Services (DHS), on a site or water body, the site or water body is automatically classified a "candidate" toxic hot spot if the chemical contaminant is associated with sediment or water at the site or water body.

Acceptable tissue concentrations are measured either as muscle tissue (preferred) or whole body residues. Residues in liver tissue alone are not considered a suitable measure for known toxic hot spot designation. Animals can either be deployed (if a resident species) or collected from resident populations. Recurrent measurements in tissue are required. Residue levels established for one species for the protection of human health can be applied to any other consumable species.

<u>Shellfish:</u> Except for existing information, each sampling episode should include a minimum of three replicates. The value of interest is the average value of the three replicates. Each replicate should be comprised of at least 15 individuals. For existing State Mussel Watch information related to organic pollutants, a single composite sample (20-100 individuals), may be used instead of the replicate measures. When recurrent measurements exceed one of the levels referred to above, the site is considered a candidate toxic hot spot.

<u>Fin-fish:</u> A minimum of three replicates is necessary. The number of individuals needed will depend on the size and availability of the animals collected; although a minimum of five animals per replicate is recommended. The value of interest is the average of the three replicates. Animals of similar age and reproductive stage should be used.

4. Impairment measured in the environment is associated with toxic pollutants found in resident individuals.

Impairment means reduction in growth, reduction in reproductive capacity, abnormal development, histopathological abnormalities. Each of these measures must be made in comparison to a reference condition where the endpoint is measured in the same species and tissue is collected from an unpolluted reference site. Each of the tests shall be acceptable to the SWRCB or the RWQCBs.

Growth Measures: Reductions in growth can be addressed using suitable bioassay acceptable to the State or Regional Boards or through measurements of field populations.

Reproductive Measures: Reproductive measures must clearly indicate reductions in viability of eggs or offspring, or reductions in fecundity. Suitable measures include: pollutant concentrations in tissue, sediment, or water which have been demonstrated in laboratory tests to cause reproductive impairment, or significant differences in viability or development of eggs between reference and test sites.

Abnormal Development: Abnormal development can be determined using measures of physical or behavioral disorders or aberrations. Evidence that the disorder can be caused by toxic pollutants, in whole or in part, must be available.

Histopathology: Abnormalities representing distinct adverse effects, such as carcinomas or tissue necrosis, must be evident. Evidence that toxic pollutants are capable of causing or contributing to the disease condition must also be available.

5. Significant degradation in biological populations and/or communities associated with the presence of elevated levels of toxic pollutants.

   This condition requires that the diminished numbers of species or individuals of a single species (when compared to a reference site) are associated with concentrations of toxic pollutants. The analysis should rely on measurements from multiple stations. Care should be taken to ensure that at least one site is not degraded so that a suitable comparison can be made.

In summary, sites are designated as "candidate" hot spots after generating information which satisfies any one of the five conditions constituting the definition.

Known Toxic Hot Spot:

A site meeting any one or more of the conditions necessary for the designation of a "candidate" toxic hot spot that has gone through a full SWRCB and RWQCB hearing process, is considered to be a "known" toxic hot spot. A site will be considered a "candidate" toxic hot spot until approved as a known toxic hot spot in a Regional Toxic Hot Spot Cleanup Plan by the RWQCB and approved by the SWRCB.

III. MONITORING APPROACH

As part of the legislative mandates, the BPTCP has implemented regional monitoring programs to identify toxic hot spots (Water Code Section 13392.5). The BPTCP has pioneered the use of effects-based measurements of impacts in California's enclosed bays and estuaries. In general the Program has used a two-step process to identify toxic hot spots. The first step was to screen sites using toxicity tests. In the second step, the highest priority sites with observed toxicity were retested to confirm the effects. This section presents descriptions of the BPTCP monitoring objectives and sampling strategy.

Monitoring Program Objectives

The four objectives of BPTCP regional monitoring are:

1. Identify locations in enclosed bays, estuaries, or the ocean that are potential or candidate toxic hot spots. Potential toxic hot spots are defined as suspect sites with existing information indicating possible impairment but without sufficient information to be classified further as a candidate toxic hot spot.

2. Determine the extent of biological impacts in portions of enclosed bays and estuaries not previously sampled (areas of unknown condition);

3. Confirm the extent of biological impacts in enclosed bays and estuaries that have been previously sampled; and

4. Assess the relationship between toxic pollutants and biological effects.

Sampling Strategy

Screening Sediment Sites and Confirming Toxic Hot Spots

In order to identify toxic hot spots a two step process was used. Both steps are designed around an approach with three measures (sediment quality triad analysis) plus an optional bioaccumulation component. The triad analysis consists of toxicity testing, benthic community analysis, and chemical analysis for metals and organic chemicals.

The first step is a screening phase that consists of measurements using toxicity tests or benthic community analysis or chemical tests or bioaccumulation data to provide sufficient information to list a site as a potential toxic hot spot or a site of concern. Sediment grain size, total organic carbon (TOC), NH_3 and H_2S concentration are measured to differentiate pollutant effects found in screening tests from natural factors.

A positive result or an effect in any of the triad tests would trigger the confirmation step (depending on available funding). The confirmation phase consists of performing all components of the sediment quality triad: toxicity, benthic community analysis, and chemical analysis, on the previously sampled site of concern. Assessment of benthic community structure may have not be completed if there was difficulty in measuring or interpreting the information for a water body.

Region-specific Modifications of the Monitoring Approach

The Central Valley Regional Board elected to spend most of its BPTCP resources on a surface water monitoring program in the Sacramento-San Joaquin Delta Estuary. The rationale was that extensive toxicity monitoring recently completed in the Central Valley had demonstrated that about half of all water samples collected and tested with the U.S. EPA three species bioassay procedure (U.S. EPA 1994) were toxic to one of the three test organisms (Foe and Connor,1991a,b; Connor et al.,1993). On several occasions in these studies toxic pulses of water were traced into the Estuary (Foe and Connor, 1991a,b). However, no estuarine monitoring program was in place and it was unclear what the concentration and duration of these toxic excursions might be once in the tidal prism. Likewise, some urban and agricultural practices which had previously been documented to cause toxicity in the Central Valley were also known to occur in the Delta. It was not known whether they might also cause toxicity in the Estuary.

In 1993 and 1994 the Regional Board collected water monthly for one year from 24 locations in the Estuary using BPTCP funding. The sampling strategy consisted of monitoring all three of the major freshwater inputs to the Estuary, the Sacramento, San Joaquin, and Mokelumne Rivers, and sites along the pathway of this water movement across the Estuary toward either the pumps in the South Delta or toward San Francisco Bay. In addition, water samples were obtained from selected large island agricultural drains and backsloughs. All samples were screened for toxicity using the U.S. EPA three species bioassay procedure. Follow-up studies were conducted when toxicity was detected to identify, if possible, the chemical(s) and source(s). In general the follow up studies consisted of a combination of intensive sampling, chemical analysis, and toxicity identification evaluations (TIEs). From these studies the application of diazinon on Central Valley orchards was identified as causing a candidate estuarine toxic hot spot (Kuivila and Foe,1995; Foe, in prep). Similarily, diazinon, chlorpyrifos, carbaryl, carbofuran and diuron were identified at toxic concentrations in backwater sloughs from agricultural and urban runoff (Deanovic *et al.* 1996; in prep; Connor,1994;1995a,b; 1996). Board staff believe that sufficient data have been collected to implicate diazinon and chlorpyrifos as causing candidate water column toxic hot spots in urban stormwater dominated waterways. Similarly, staff believe there is enough data to implicate chlorpyrifos as the cause of a candidate hot spots in several agriculturally dominated waterways. Cleanup plans are presented in part three for eliminating the water column toxicity of diazinon and chlorpyrifos.

Special Studies performed in the Region Two special studies were performed.

<u>Mercury</u> There is a human health advisory in the Delta recommending that pregnant women and children not consume striped bass because of elevated mercury tissue concentrations. BPTCP work in the Bay area have reconfirmed the advisory for bass and extended it to also include several species of shark (San Francisco Regional Board, 1995). It was assumed, prior to the BPTCP, that the major source of mercury in striped bass was from *in situ* sediment flux. Delta sediment was contaminated with mercury from extensive historical mercury mining in the Coast Range and placer gold mining operations in the Sierra Nevada Mountains.

In FY 1994-95 the Regional Board undertook a special study in the Sacramento River to better characterize concentrations and loads of all heavy metals transported into the Estuary. The concentrations of all metals, except mercury, were found to be below both U.S. EPA recommended dissolved criteria and proposed California Toxic Rule numbers (Stephenson *et al*., in prep). However, during winter high flow periods total recoverable mercury concentrations exceeded recommended U.S. EPA criteria (Foe *et al*, 1997; Foe in prep). Elevated concentrations in the Yolo Bypass suggested a local input which was subsequently traced to the Cache Creek basin. Follow-up monitoring in the Creek demonstrated that it exported a large load of mercury each winter to the Estuary. The source of mercury in the watershed is still being evaluated. The discovery of elevated mercury concentrations entering the Estuary in winter high flows, in combination with the striped bass human health advisory, has resulted in staff recommending that the Sacramento San Joaquin Delta Estuary be designated a candidate toxic hotspot because of elevated mercury concentrations. A mercury cleanup plan is presented in part three.

<u>Sediment</u> Little information is available on the potential toxicity of delta sediment to benthic organisms. However, at some locations delta sediments are known to exceed U.S. EPA sediment quality values for a variety of organochlorine compounds and/or NOAA effect range median concentrations for selected heavy metals (Montoya, 1991) suggesting the possibility of biological effects.

A reconnaisance sediment toxicity program was undertaken in 1997. Eighteen of the potentially most contaminated sediment sites were visited and sediment collected for *Hyallela* and *Chironomus* bioassays and bulk chemistry analysis. No toxicity was detected (Stephenson *et al*, in prep).

IV. CRITERIA FOR RANKING TOXIC HOT SPOTS

A value for each criterion described below should be developed provided appropriate information exists or estimates can be make. Any criterion for which no information exists should be assigned a value of "no action". The RWQCB should create a matrix of the scores of the ranking criteria. If the majority of ranking criteria are "high" then the site should be listed in the "high" priority list of Toxic Hot Spots. The following ranking criteria was used:

Human Health Impacts

Human Health Advisory issued for consumption of non-migratory aquatic life from the site (assign a "High"); Tissue residues in aquatic organisms exceed FDA/DHS action level and U.S. EPA screening levels ("Moderate").

Aquatic Life Impacts

For aquatic life, site ranking was based on an analysis of the preponderance of information available (i.e., weight-of-evidence). The measures considered were: the sediment quality triad (sediment chemistry, toxicity, and benthic community analysis), water toxicity, toxicity identification evaluations (TIEs), and/or bioaccumulation.

Stations with hits in any two of the measures if associated with high chemistry were assign a "High" priority. A hit in one of the measures associated with high chemistry was assigned a "moderate". Stations with high sediment or water chemistry only were assigned a "low".

Water Quality Objectives[1]:

Any chemistry data used for ranking under this section was no more than 10 years old, and was analyzed with appropriate analytical methods and quality assurance.

Water quality objective or water quality criterion: Exceeded regularly (assign a "High" priority), occasionally exceeded (a "Moderate"), infrequently exceeded (a "Low").

Areal Extent of Toxic Hot Spot

Select one of the following values: More than 10 acres, 1 to 10 acres, less than 1 acre.

Pollutant Source

Select one of the following values: Source(s) of pollution identified (assign a "High" priority), Source(s) partially known ("Moderate"), Source is unknown ("Low").

Natural Remediation Potential

Select one of the following values: Site is unlikely to improve without intervention ("High"), site may or may not improve without intervention ("Moderate"), site is likely to improve without intervention ("Low").

V. FUTURE NEEDS

Four areas for future study are identified below.

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[1]. Water quality objectives to be used are found in Regional Water Quality Control Board Basin Plans or the California Ocean Plan (depending on which plan applies to the water body being addressed). Where a Basin Plan contains a more stringent value than the statewide plan, the regional water quality objective will be used.

1. Sediment More sediment bioassay and pore water chemical analysis needs to be conducted in the Delta and Estuary. This information would serve as baseline data for evaluating future BPTCP hot spots, *in situ* dredge operations, beneficial reuse of dredge spoils on delta island levees and creation of CALFED shallow water habitat.

   Fish Tissue studies Several organochlorine compounds and mercury have been identified in multiple fish species inhabiting the Delta at concentrations in excess of FDA and the new U.S. EPA fish tissue screening values (Montoya, 1991). A fish tissue study needs to be undertaken in the delta in conjunction with the California Office of Enviromental Health Hazard Assessment to ascertain whether additional fish advisories are warranted to protect human health. A similar study was recently completed in the Bay area using BPTCP funding (San Francisco Regional Water Quality Control Board, 1995).

   The CALFED water quality program has identified mercury and several of these organochlorine compounds as contaminants of concern and are proposing actions to reduce their loading to the Estuary. Collection of fish tissue data would serve as baseline information to assess the future success of the CALFED program.

   Water column fish toxicity tests The Sacramento River is about 80% of the freshwater flow into the Estuary. About half of all water samples collected since 1991 at Freeport on the lower Sacramento River at the entrance to the Delta have tested toxic in 7 day U.S. EPA (1994) fathead minnow bioassays (summarized in Fox and Archibald,1997). The typical toxicological pattern is a 30-50% mortality rate within 7 days. The chemical cause of toxicity is not known. Follow-up bioassay and TIE studies are needed to determine the chemical(s) causing toxicity, the source(s), and their toxicological significance to threatened and endangered fish species using the lower River and Delta.

Algal TIEs About 2000 metric tons of herbicide are used annually in the Central Valley and Delta and some compounds are regularly detected in chemical analysis of estuarine surface water (Edmunds *et al.*, 1996). The impact of herbicides on Delta primary production rates are not known. Furthermore, no algal TIE procedures have been developed to ascertain this.

On occasion water samples collected as part of the BPTCP which exhibited low algal primary production in the three species algal bioassay were eluted through a C8 resin column and retested. Often primary production rates in eluted samples were statistically enhanced, sometimes by as much as an order of magnitude, over unmanipulated ones (Deanovic *et al.*,1996;in press). This suggests that a toxic non-polar organic compound was being removed from the solution. Chemical analysis was performed on splits of these water samples and diuron was observed in several urban runoff samples at toxic concentrations (Connor, 1995b). However, no chemical was usually identified. Algal TIE procedures need to be perfected for local diatom species (Delta algal community dominants) and estuarine surface water monitored to assess whether phytotoxins are present at concentrations impacting estuarine production.

Sites of Concern (Sites that do not qualify as Candidate Toxic Hot Spots)

Waterbody Name	Segment Name	Site Identification	Reason for Listing	Pollutants present at the site	Report reference
Delta-Estuary	Various	Paradise Cut, Old River, Mcleod Lake	Aquatic life impairment	Diuron	1
Delta-Estuary	Various	Paradise Cut, Bishop Cut	Aquatic life impairment	Carbofuran	1,2

References

1. Deanovic, L. H. Bailey, T.W. Shed and D. Hinton. 1996. Sacramento-San Joaquin Delta Bioassay Report. 1993-94. First annual report to the Central Valley Regional Water Quality Control Board. U.C. Davis Aquatic Toxicology Laboratory. U.C. Davis, Davis, CA.

2. Foe, C. and R. Sheipline. 1993. Pesticides in surface water from applications on orchards and alfalfa during the winter and spring of 1991-92. Staff report. Central Valley Regional Water Quality Control Board, Sacramento, CA.

Part II

Candidate Toxic Hot Spot List

Waterbody Name	Segment Name	Site Identification	Reason for Listing	Pollutants present at the site	Report reference
Delta Estuary	All	Delta	Aquatic Life	Diazinon	see cleanup plan
Delta Estuary	Various	Morrison Ck, Mosher, 5-Mile, Mormon Sls, & Calaveras R.	Aquatic Life	Diazinon & Chlorpyrifos	see cleanup plan
Delta Estuary	Various	Ulatis Ck, Paradise Cut, French Camp & Duck Sls	Aquatic Life	Chlorpyrifos	see cleanup plan
Delta Estuary	All	Delta	Human Health	Mercury	see cleanup plan
Delta Estuary	South Delta	San Joaquin River @ City of Stockton	Water Quality Objective	Low Dissolved Oxygen	see cleanup plan
Delta Estuary	Various	Smith Canal, Mosher & 5-Mile Sloughs and Calaveras R.	Water Quality Objective	Low Dissolved Oxygen	see cleanup plan
Delta Estuary	All	Delta	Human Health	Chlordane, Dieldrin, Total DDT,PCBs, Endosulfan & Toxaphene	Montoya, 1991
Delta Estuary	All	Delta	Aquatic Life	Chlordane, Dieldrin, Lindane, Heptachlor, Total PCBs, PAHs, DDT	Montoya, 1991

Waterbody Name	Site Identification	Human Health Impacts	Aquatic Life Impacts	Water Quality Objectives	Areal Extent	Pollutant Source	Remediation Potential
Delta Estuary	Delta		High		>10 acres	Partially Identified	High
Delta Estuary	Morrison Ck, Mosher, 5-Mile, Mormon Sls & Calaveras R.		High		>10 acres	Partially Identified	High
Delta Estuary	Ulatis Ck, Paradise Cut, French Camp & Duck Sls		High		>10 acres	Partially Identified	High
Delta Estuary	Delta	High			>10 acres	Partially Identified	High
Delta Estuary	San Joaquin River @ City of Stockton			High	>10 acres	Partially Identified	High
Delta Estuary	Smith Canal, Mosher & 5-Mile Sloughs and Calaveras R.			High	>10 acres	Partially Identified	High
Delta Estuary	Delta	Moderate			>10 acres	Partially Identified	moderate
Delta Estuary	Delta		Moderate		>10 acres	Partially Identified	moderate

Part III

High Priority Candidate Toxic Hot Spot Characterization

Diazinon Orchard Dormant Spray Cleanup Plan

BACKGROUND

Diazinon in orchard dormant spray runoff has been identified in Part II of the clean-up plan as constituting a candidate BPTCP hot spot in the Sacramento-San Joaquin Delta Estuary. Diazinon from orchards has also been noted in the Central Valley Regions 303(d) list as a water quality impairment in the main stem Sacramento and San Joaquin Rivers and in the Estuary. This plan primarily addresses the clean-up requirements of the BPTCP but was also written to be consistent with the proposed actions and schedule of the 303(d) listing.

About a million pounds of insecticide active ingredient are applied each January and February in the Central Valley on about half a million acres of stonefruit and almond orchards to control boring insects (Foe and Sheipline, 1993). The organophosphate insecticide diazinon accounts for about half the application. Numerous bioassay and chemical studies have measured diazinon in surface water samples in the Central Valley during winter months at toxic concentration to sensitive invertebrates (Foe and Connor,1991; Foe and Sheipline, 1993; Ross 1992;1993; Foe, 1995; Domagalski, 1995; Kratzer, 1997). The typical pattern is that the highest concentrations and longest exposures are in small water courses adjacent to high densities of orchards. However, after large storms in 1990 and 1992 diazion was measured in the San Joaquin River at the entrance to the Delta at toxic concentrations to the cladoceran invertebrate *Ceriodaphia dubia* in U.S. EPA three species bioassays (Foe and Connor,1991;Foe and Sheipline, 1993). Following up on these findings, the U.S. Geological Survey and Regional Board traced pulses of diazinon from both the Sacramento and San Joaquin Rivers across the Estuary in 1993 (Kuivila and Foe, 1995). Toxic concentrations to *Ceriodaphnia* were observed as far west in the Estuary as Chipps Island, some 60 miles downstream of the City of Sacramento and the entrance to the Delta.

Concern has been expressed that other contaminants might also be present in winter storm runoff from the Central Valley and contribute to invertebrate bioassay mortality. Therefore, in 1996 toxicity identification evaluations (TIEs) were conducted on three samples testing toxic in *Ceriodaphnia* bioassays from the San Joaquin River at Vernalis (Larson *et al.*, 1996). The results confirm that diazinon was the primary contaminant although other unidentified chemicals may also have contributed a minor amount of toxicity. The study was repeated in 1997 with the exception that samples were taken further upstream in the Sacramento and San Joaquin watersheds in the hope of collecting water with greater concentrations of unknown toxicants thereby facilitating their identification. TIEs were conducted on samples from Orestimba Creek in the San Joaquin Basin on 23 and 25 January and from the Sutter Bypass on 23, 25, and 26 January. Again, diazinon was confirmed as the primary toxicant (Larson *et al.*, 1997). No evidence was obtained suggesting a second contaminant.

No biological surveys have been undertaken to determine the ecological significance of toxic pulses of diazinon. However, Novartis, the Registrant for diazinon, has completed a diazinon probabalistic risk assessment for the Central Valley (Novartis Crop Protection, 1997). Little data were available for the Delta. The risk assessment, like chemical and bioassay studies, suggest that the greatest impacts are likely to occur in water courses adjacent to orchards. Lower concentrations are predicted in mainstem Rivers. The report predicts that the Sacramento and San Joaquin Rivers will experience acutely toxic conditions to the 10% of most sensitive species 0.4 and 11.6% of the time in February, the period of most intensive diazinon off site movement[2]. Novartis concludes that the risk of diazinon alone in the Sacramento-San Joaquin River basin is limited to the most sensitive invertebrates, primarily cladocerans. Furthermore, the report notes that cladocerans reproduce rapidly and their populations are therefore predicted to recover rapidly. Also, the report predicts that indirect effects on fish through

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[2]Unfortunately, many agricultural pesticides are applied in the Central Valley and measured in the Rivers. When the risk assessment is repeated with multiple chemicals (appendix C), the mainstem San Joaquin River is predicted to experience acutely toxic conditions about 30% of the year to the 10% of most sensitive species. Obviously, diazinon is only one of a suite of chemicals in the River and it is ecologically unrealistic to evaluate the impact of each chemical alone. However, regulatory efforts appear constrained to address each contaminant in isolation.

reductions in their invertebrate prey are unlikely as the preferred food species are unaffected by the diazinon concentrations observed in the rivers. The study recommends though, that the population dynamics of susceptible invertebrate species in the basin be evaluated along with the feeding habits and nutritional requirements of common fish species.

In conclusion, the only major use of diazinon in the Central Valley in January and February is on stonefruit and almond orchards. In 1990, 1992, 1993, and 1996 diazinon was observed entering the Estuary from either the Sacramento or San Joaquin Rivers at toxic concentration in *Ceriodaphnia* bioassays. In 1993 the chemical was followed at toxic concentrations across the Estuary. On each occasions diazinon was confirmed as being present in toxic water samples by GC/MS analysis. Finally, in 1996 and 1997 TIEs implicated diazinon as the primary contaminant responsible for the toxicity.

Bay Protection Toxic Cleanup Program guidance recommend that a site or situation be considered a candidate toxic hot spot if toxicity in bioassays can be demonstrated to reoccur repeatedly and the bioassay results are collaborated by chemical analysis and TIEs implicating a particular chemical. Board staff believe that the entire Sacramento San Joaquin Delta Estuary fit the recommended BPTCP criteria for listing as a candidate toxic hot spot because of diazinon.

A. Areal Extent

Studies demonstrate that the potential areal extent of diazinon water column contamination from orchard runoff is variable by year but may include in some years the entire Sacramento San Joaquin Delta Estuary. The Delta Estuary is a maze of river channels and diked islands covering some 78 square miles of water area and 1,000 linear miles of waterway.

B. Sources

The only major use of diazinon in agricultural areas in the Central Valley in winter is as a dormant orchard spray. Virtually every study investigating off site movement into the Rivers and Estuary have concluded that the primary source of the chemical is from agriculture (Foe and Connor, 1991; Foe and Sheipline,1993; Ross, 1992;1993; Domagalski, 1995;Kratzer,1997).

Farmers must obtain a permit to apply diazinon as a dormant spray and their names and addresses are available through the County Agricultural Commissioner's Office. However, not known at this time is the relative contribution of each application to total offsite movement. More information is needed on the primary factors influencing off site movement and the relative contribution of different portions of the Central Valley watershed. Such information is essential not only for assessing responsibility but also for successful development and implementation of agricultural Best Management Practices (BMPs).

C. Summary of Actions

The Department of Pesticide Regulation (DPR) and the State Water Resources Control Board (SWRCB) both have statutory responsibilities for protecting water quality from adverse effects of pesticides. In 1997, DPR and the SWRCB signed a management agency agreement (MAA), clarifying these responsibilities. In a companion document, the Pesticide Management Plan for Water Quality (Pesticide Management Plan), a process was outlined for protecting beneficial uses of surface water from the potential adverse effects of pesticides. The process relies on a four-stage approach: Stage 1 relies on education and outreach efforts to communicative pollution prevention strategies. Stage 2 efforts involve self-regulating or cooperative efforts to identify and implement the most appropriate site-specific reduced-risk practices. In stage 3, mandatory compliance is achieved through restricted use pesticide permit requirements, implementation of regulations, or other DPR regulatory authority. In stage 4, compliance is achieved through the SWRCB and RWQCB water quality control plans or other appropriate regulatory measures consistent with applicable authorities. Stages 1 through 4 are listed in a sequence that should generally apply. However, these stages need not be implemented in sequential order, but rather as necessary to assure protection of beneficial uses.

Currently, DPR is coordinating a stage 2 effort to address effects of dormant sprays on surface water. DPR's stated goal is to eliminate toxicity associated with dormant spray insecticides (i.e., chlorpyrifos, diazinon, and methidathion) in the Sacramento and San Joaquin River Basins and Delta. As long as progress continues toward compliance with appropriate water quality objectives, stage 3 activities will be unnecessary.

The U.S. EPA requires Regional Boards maintain 303(d) lists of impaired water bodies. The Sacramento and San Joaquin Rivers and Delta are on the Regional Boards 303(d) list because of elevated concentrations of diazinon. The list requires the Regional Board to adopt a schedule for setting Total Maximum Daily Load (TMDLs). In January of 1998 staff will request that the Central Valley Board approve a TMDL schedule for diazinon for the Sacramento and San Joaquin Rivers and the Delta. Components of a TMDL include problem description, numeric targets, monitoring and source analysis, implementation plan, load allocations, performance measures and feedback, margin of safety and seasonal variation and public participation. It should be noted that if monitoring demonstrates that the waterways are in compliance with the numeric target then no further action is required.

Several activities are underway in the Basin to develop agricultural BMPs to control orchard dormant spray runoff. These are summarized below by the Agency conducting the study.

Department of Pesticide Regulation In addition to the activities already discussed, DPR is investigating orchard floor management as a means to reduce discharges of dormant sprays into surface waterways (Ross *et al.*, 1997). At an experimental plot at UCD, DPR staff measured discharges of chlorpyrifos, diazinon, and methidathion from a peach orchard with three orchard floor treatments. Investigations are continuing in a commercial orchard. At California State University at Fresno, DPR is investigating the effects of microbial augmentation and postapplication tillage on runoff of dormant sprays. Results will be highlighted in DPR's own outreach activities and will be made available to other groups interested in the identification and promotion of reduced-risk management practices.

DPR is also monitoring water quality at four sites--two each within the Sacramento and San Joaquin river watersheds. During the dormant spray use season, approximately January through mid-March, water samples will be collected five times each week from each site. Chemical analyses are performed on each sample; one chronic and two acute toxicity tests, using *Ceriodaphnia dubia*, are performed each week.

Novartis The Registrant of diazinon distributed over ten thousand brochures last winter through U.C. Extension, County Agricultural Commissioner's Offices, and Pesticide distributors. The brochure described the water quality problems associated with dormant spray insecticides and recommended a voluntary set of BMPs to help protect surface waters. Novartis intends to repeat the education and outreach program this winter.

DowElanco and Novartis The Registrants of chlorpyrifos and diazinon have undertaken a multiyear study in Orestimba Creek in the San Joaquin Basin with the primary objective of identifying specific agricultural use patterns and practices which contribute the bulk of the off-site chemical movement into surface water. The study involves an evaluation of pesticide movement in both winter storms and in summer irrigation return flows. Objectives in subsequent years are to use the data to develop and field test BMPs to reduce off site chemical movement. The first year of work is complete and a report may be released soon.

Biologically Integrated Prune Systems (BIPS) The BIPS program is a community-based project that supports implementation of reduced-risk pest management strategies in prune orchards. The reduction or elimination of organophosphate dormant sprays is a goal. The project has a strong outreach component that includes demonstration sites and "hand-on" training for growers and pest control advisors (PCAs). BIPS is a recipient of one of DPR's pest management grants.

Biologically Integrated Orchard Systems (BIOS) The BIOS program pioneered community-based efforts to implement economically viable, nonconventional, pest management practices. It emphasizes management of almond orchards in Merced and Stanislaus counties in ways that minimize or eliminate the use of dormant spray insecticides. BIOS was a recipient of a DPR pest management grant and a federal Clean Water Act (CWA) section 319(h) nonpoint source implementation grant.

Biorational Cling Peach Orchard Systems (BCPOS) This project has the same goals as the BIPS program, except that it focuses on primary pests in cling peach orchards. The University of California Cooperative Extension is acting as project leader, with Sacramento and San Joaquin valley coordinators. BCPOS is another recipient of a DPR pest management grant.

Colusa County Resource Conservation District The Colusa County Resource Conservation District (RCD) is leading a runoff management project within the watershed of Hahn Creek. Project participants are trying to identify management practices that reduce runoff from almond orchards within the watershed, thereby reducing pesticide loads in the creek. Outreach and demonstration sites are part of this project. This project was the recipient of a CWA section 319(h) grant.

Glenn County Department of Agriculture The Glenn County Department of Agriculture is organizing local growers and PCAs to address the use of dormant spray insecticides in the county. The local RCD is also involved; they are applying for grants to facilitate the implementation of reduced-risk pest management practices.

Natural Resources Conservation Service-Colusa Office The Colusa County office of the Natural Resources Conservation Service (NRCS) was recently awarded over $100,000 from the Environmental Quality Incentives Program (EQIP), one of the conservation programs administered by the U.S. Department of Agriculture. EQIP offers contracts that provide incentive payments and cost sharing for conservation practices needed at each site. Most of these funds should be available to help implement reduced-risk pest management practices in almond orchards in the area.

Natural Resources Conservation ServiceBStanislaus Office The Stanislaus County office of NRCS was recently awarded $700,000 from EQIP. Half of the funds are allocated to address livestock production practices, but most of the remaining funds should be available to address dormant sprays and the implementation of reduced-risk pest management practices. Local work groups, comprised of RCDs, NRCS, the Farm Services Agency, county agricultural commissioners, Farm Bureau, and others will determine how EQIP funds will be distributed. Applicants for EQIP funds will be evaluated on their ability to provide the most environmental benefits.

Nature Conservancy The Nature Conservancy is enrolling more prune growers in the BIPS project as it proceeds with its Phelan Island restoration project in the Sacramento Valley. This project is supported by a CWA section 319(h) grant.

U.C. Statewide Integrated Pest Management Project In late 1997 the U.C. Statewide Integrated Pest Management Project was awarded a two year grant by the State Water Resource Control Board to: (1) identify alternate orchard management practices to prevent or reduce off site movement of dormant sprays, (2) provide outreach and education on these new practices to the agricultural community, and (3) design and initiate a monitoring program to assess the success of the new practices. A Steering Committee composed of representatives from Commodity groups, State Agencies including Regional Board staff, and U.C. Academics was formed to serve as a peer review body for the study.

D. Assessment of Actions Required

Proposed actions should be consistent with the MAA and Pesticide Management Plan, the requirements of the RWQCB under the 303(d) listing, and the BPTCP cleanup plans. The general actions that are required to resolve this water quality problem include (1) establishment of interim and long-term targets (quantitative response limits and water quality objectives, respectively), (2) development of management practices that can be implemented to meet the targets, (3) development of cost estimates to implement the practices, (4) completion of studies to determine potential ecological impacts, and (5) establishment of mechanisms for assuring implementation of management practices. For each element a time schedule, identification of responsible parties, and identification of resources to support the action are needed. Specific details are provided below.

Costs associated with widespread implementation of appropriate management practices (aside from grants awarded local implementation for demonstration purposes) will be borne by growers adopting alternatives to dormant sprays. In the event the stage 3 activities are necessary, costs for implementing regulatory requirements will be borne by growers affected by such regulation. Costs associated with using pest management strategies that do no include dormant sprays will be borne by practitioners of such strategies.

Water Quality Criteria The California Department of Fish and Game has developed an interim diazinon hazard assessment criteria to protect freshwater aquatic life (Menconi and Cox, 1994) using the standard U.S. EPA criteria development process (U.S. EPA, 1985). A final Hazard Assessment criteria was not recommended as several data gaps were identified in the toxicological literature. Studies should be undertaken to fill these gaps. Once completed the Department of Fish and Game should be requested to use the information and calculate a final diazinon Hazard Assessment criteria.

BMP Development Development of agricultural Best Management Practices (BMPs) to keep orchard dormant spray insecticides on farm and out of surface water is just beginning. The work of the Department of Pesticide Regulation, U.C. Integrated Pest Management, the Registrants, and others have been described above. The work of each group is too preliminary at present to ascertain whether any of these might be successfully implemented to fully correct the problem. Therefore, each group should be encouraged to continue their work and a forum sought to peer review the results. Once the preferred BMP options are identified, funding should be sought for their field evaluation. At a minimum, the field testing should ascertain the amount of pesticide reduction achieved under varying Central Valley orchard conditions, whether the reduction would eliminate all instream toxicity, and the cost per acre to the farmer to implement the practice.

Monitoring. DPR has committed to assist the Regional Board to monitor surface water in the Sacramento and San Joaquin river watersheds to help determine compliance with applicable water quality objectives and establish the data base needed to develop a TMDL, should it be needed. Specifically, DPR is monitoring water quality at four sites: Sacramento Slough, the Sacramento River at Bryte, Orestimba Creek, and the San Joaquin River at Vernalis. During the dormant spray use season, approximately January through mid-March, water samples will be collected five times each week from each site. Chemical analyses are performed on each sample; one chronic and two acute toxicity tests, using *Ceriodaphnia dubia*, are also performed each week.

Ecological Significance No instream monitoring to assess the impact of diazinon pulses on local aquatic communities has occurred. The Novartis diazinon ecological risk assessment indicates that impacts to sensitive invertebrates will occur, but that population recovery should be rapid. No indirect food chain effects upon larval and juvenile fish are predicted as these animals were assumed to be capable of switching to an alternate food source.

Detailed ecological studies are needed to ascertain whether invertebrate populations levels decrease and how long it takes for recovery to occur. These studies should target those areas of the watershed where monitoring has indicated that the most severe impacts might occur. The studies should also consider the additive ecological effect of multiple pesticide exposures. Studies are also needed to verify that higher trophic levels are not impacted by decreased invertebrate production. This work should emphasize potential impacts to threatened and endangered fish species.

Mechanisms for assuring compliance Currently DPR is coordinating voluntary efforts to reduce the toxicity associated with diazinon and will continue with this voluntary, self-regulating approach as long as there is progress towards compliance. The trigger for regulatory action will come if toxicity persists in unacceptable levels in the 2001-2002 use season; if that occurs, DPR will impose regulatory controls to lower dormant spray residues to acceptable levels. The Regional Board will review the program in a public forum and take action if appropriate. As DPR moves into a regulatory mode, the State will need to accelerate the process of developing a TMDL to assure that it can be in place should the voluntary efforts and/or DPR regulatory process is unsuccessful. The components of a TMDL include many of the actions discussed earlier and are what would be necessary for a successful voluntary effort or DPR's regulatory actions. Other requirements for a TMDL include load allocations with a margin of safety and seasonal variation and strong public participation. A model will need to be developed to define sources, allocate loads, and identify responsible parties for meeting the load allocations. An implementation plan will need to be developed with a time schedule for meeting the water quality standard. This could be a lengthy process and should be given the appropriate time for completion.

Public participation is a big component of the 303(d) listing and of the BPTCP. The Regional Board, DPR and stakeholders need to work together to develop and implement programs to reduce pesticide residues in the Rivers and Delta. Appropriate forums for public participation need to be established. Annual program reviews will be completed to assess progress of voluntary efforts, and/or DPR regulatory efforts to review the status of the five principal components of the cleanup plan and to determine whether changes are needed.

E. Estimate of the Potential Cost to Implement

Tentative costs to implement the program are contained in Table 1. Firmer cost estimates will be contained in the final cleanup plan after consultation with the Department of Pesticide Regulation, the Registrant, and agricultural stakeholder groups.

Table 1. Provisional estimate of costs to implement the diazinon toxic hotspot clean up plan.

Task	Rationale	Cost
BMP	field trials to assess economics	200-300K
		and attainability
Monitoring	Regional Board baseline monitoring	75-100k/yr
		DPR monitoring activities
	150-175k/yr	
Ecological significance	Invertebrate Studies	400-700K
	Fish Studies	200-300K
Water Quality Objectives	fill data gaps	100-150k

F. <u>An estimate of recoverable costs from potential dischargers</u>

An estimate of recoverable costs will be provided in the final clean up plan after consultation with DPR.

G. <u>A two year expenditure schedule identifying funds to implement the plans that are not recoverable from potential dischargers</u>

No funds are presently available to carry out the proposed BPTCP cleanup plan.

Urban Stormwater Pesticide Cleanup Plan

Background

Diazinon and chlorpyrifos in urban stormwater runoff have been identified in Part II of the cleanup plan as causing a candidate BPTCP hot spot in several Delta backsloughs.

Three hundred and forty thousand pounds of diazinon and 775 thousand pounds of chlorpyrifos active ingredients were used in landscape and structural pest control in California in 1994 for control of ants, fleas and spiders (Scanlin and Cooper, 1997; Department of Pesticide Regulation, 1996). The figure likely underestimates by about half the total use as it does not include homeowner purchases. In February and again in October 1994 *Ceriodaphnia* bioassay mortality was reported in Morrison Creek in the City of Sacramento and in Mosher Slough, 5 Mile Slough, Calaveras River, and Mormon Slough in the City of Stockton (Connor, 1994;1995). All these waterbodies are within the legal boundary of the Delta. A modified phase I TIE was conducted on samples from each site which implicated a metabolically activated pesticide(s) (such as diazinon and chlorpyrifos). Chemical analyses demonstrated that diazinon and occasionally chlorpyrifos was present at toxic concentrations. A phase III TIE was conducted on water collected from Mosher Slough on 1 May 1995 which confirmed that the primary cause of acute toxicity was a combination of diazinon and chlorpyrifos.

Background concentrations of diazinon in urban storm runoff in the Central Valley increase after application on orchards in January and February suggesting that urban use might not be the sole source of the chemical at this time (Connor, 1996). Volatization following application is known to be a major diazinon dissipation pathway from orchards (Glotfelty *et al.*, 1990) and a number of dormant spray insecticides have previously been reported in rain and fog in the Central Valley (Glotfelty *et al.*, 1987). Therefore, composite rainfall samples were collected in South Stockton in 1995 which demonstrated that diazinon concentrations in rain varied from below detection to about 4,000 ng/l (ten times the acute *Ceriodaphnia* concentration). The rainfall study was continued through March and April of 1995 to coincide with application of chlorprifos on alfalfa for weevil control. Chlorpyrifos concentrations in composite rainfall samples increased, ranging from below detection to 650 ng/l (again 10 times the acute *Ceriodaphnia* concentration). However, unlike with diazinon, no study was conducted to ascertain whether chlorpyrifos concentrations in street runoff increased suggesting that agricultural inputs might be a significant urban source.

Similar invertebrate bioassay results coupled with TIES and chemical analysis from the San Francisco Bay Area suggest that diazinon and chlorpyrifos may be a regional urban runoff problem (Katznelson and Mumley, 1997) This finding prompted the formation of an Urban Pesticide Committee (UPC). The UPC is an *ad hoc* committee formed to address the issue of toxicity in urban runoff and wastewater treatment plant effluent due to organophosphate insecticides, in particular diazinon and chlorpyrifos. The UPC is composed of staff from the U.S. EPA, the San Francisco Bay and Central Valley Regional Water Quality Control Boards, the Department of Pesticide Regulation, Novartis and Dow Elanco, municipal storm water programs, the Bay Area Stormwater Management Agencies Association, County Agricultural commissions, Wastewater treatment plants, the University of California, and Consultants. The members of the UPC are committed to working in partnership with the various stakeholders to develop effective measures to reduce the concentrations of organophosphate insecticides in urban runoff and wastewater treatment plant effluent.

In conclusion, a combination of bioassay, chemical, and TIE work demonstrate that diazinon and chlorpyrifos are present in urban stormwater runoff discharged to urban creeks and back sloughs around the Cities of Sacramento and Stockton at concentrations toxic to sensitive invertebrates. The source of the diazinon appears to be primairly from urban sources although agricultural orchard use may also be important. Chlorpyrifos appears to be predominately of urban origin but the impacts from agricultural use need to be evaluated. Similar results from urban sites in the Bay area indicate that pesticide storm runoff is a widespread problem.

The repeated toxicity of stormwater runoff in bioassays coupled with chemical analyses and TIEs implicating both diazinon and chlorpyrifos have led Board staff to conclude that urban stormwater dominated creeks fit the BPTCP criteria for listing as a candidate toxic hot spot because of their diazinon and chlorpyrifos contamination.

A. Areal Extent

The potential threat posed by diazinon and chlorpyrifos in urban storm runoff is localized to Morrison Creek in the City of Sacramento and Mosher Slough, 5 Mile Slough, Smith Canal, Duck Slough, the Calaveras River, and Mormon Slough in the City of Stockton. Together the areal extent of impairment may be up to 5 linear miles of back sloughs within the legal boundary of the Delta.

B. Sources

Detailed information on urban sources are not available for the Central Valley. However, source information has been obtained for the Bay Area and the conclusions are thought to also apply in the Valley with the caveat that the Bay area does not receive significant amounts of diazinon in rainfall as appears to occur in the Central Valley (personal communication, Val Connor). Confirmatory studies are needed to verify that the Bay Area conclusions also apply in the Valley.

The primary source of diazinon and chlorpyrifos in Bay Area creeks is from urban storm water runoff. Sampling in urbanized areas in Alameda County indicated that residential areas were a significant source but runoff from commercial areas may also be important (Scanlin and Feng, 1997). It is not known what portion of the diazinon and chlorpyrifos found in creeks is attributable to use in accordance with label directions versus improper disposal or over application.

However, a preliminary study of runoff from residential properties suggest that concentrations in creeks may be attributable to proper use (Scanlin and Feng, 1997).

C. Summary of Actions

The discovery of diazinon in urban storm runoff in both the Central Valley and San Francisco Bay Region at toxic concentrations to *Ceriodaphnia* led to the formation of the Urban Pesticide Committee (UPC). The objective of the UPC is to provide a forum for information exchange, coordination and collaboration on the development and implementation of a urban pesticide control strategy. An additional advantage of the Committee is that it facilitates a more efficient use of limited resources. The initial characterization of the pesticide problem through extensive bioassay, chemical and TIE work occurred in the Central Valley with confirmation in the Bay Area while the follow-up studies identifying sources and loads has primarily occurred in the Bay Area.

The UPC has prepared three reports describing various aspects of the urban pesticide problem in the Bay Area and a fourth volume describing a strategy for reducing diazion levels in urban runoff. The first report provides a compilation and review of water quality and aquatic toxicity data in urban creeks and storm water discharges in the San Francisco Bay Area focusing on diazinon (Katznelson and Mumley, 1997). The review also includes a discussion of the potential adverse impact of diazinon on aquatic ecosystems receiving urban runoff. The second report characterizes the temporal and spatial patterns of occurence of diazinon in the Castro Valley Creek watershed (Scanlin and Feng, 1997). Runoff at an integrator point for the entire watershed was sampled during multiple storms to record both seasonal and within-event variations in diazinon concentration. The purpose of the third report was to compile information on the outdoor use of diazinon in urban areas in Alameda County including estimates of quantity applied, target pests, and seasonal and long term trends (Scanlin and Cooper, 1997). This information will be used in the development of a strategy to reduce the levels of diazinon in Bay Area creeks. Finally, the UPC has produced a strategy for reducing diazinon levels in Bay Area creeks (Scanlin and Gosselin, 1997). Since pesticides are regulated on the state and national level, much of the strategy focuses on coordinating with enforcement agencies. The strategy presents a framework of roles and responsibilities that can be taken by various agencies to achieve the overall goal. The strategy focuses on diazion as it is the most common insecticide detected at toxic levels. In the Central Valley both diazinon and chlorpyrifos are regularly observed and must be simultaneously addressed in any cleanup plan.

As was explained in the diazinon orchard dormant spray clean up plan, DPR and the SWRCB both have statutory responsibilities for protecting water quality from adverse effects of pesticides. In 1997 DPR and the SWRCB signed a management agency agreement (MAA), clarifying these responsibilities. In a companion document, the Pesticide Management Plan for Water Quality (Pesticide Management Plan), a process was outlined for protecting beneficial uses of surface water from the potential adverse effects of pesticides. The process relies on a four-stage approach: Stage 1 relies on education and outreach efforts to communicative pollution prevention strategies. Stage 2 efforts involve self-regulating or cooperative efforts to identify and implement the most appropriate site-specific reduced-risk practices. In stage 3, mandatory compliance is achieved through restricted use pesticide permit requirements, implementation of regulations, or other DPR regulatory authority. In stage 4, compliance is achieved through the SWRCB and RWQCB water quality control plans or other appropriate regulatory measures consistent with applicable authorities. Stages 1 through 4 are listed in a sequence that should generally apply. However, these stages need not be implemented in sequential order, but rather as necessary to assure protection of beneficial uses. At present pesticides in urban storm water are managed through stage 1 of the MAA.

D. Assessment of Actions Required

Proposed actions should be consistent with the MAA and Pesticide Management Plan, the requirements of the Regional Board under section 303 (d) listing, and the BPTCP. The general actions that are required to resolve this water quality problem include (1) establishment of goals, (2) establishment of a monitoring program, (3) completion of studies to evaluate ecological significance, (4) evaluation of urban runoff information to determine what management practices need to be implemented to correct problems, and (5) development of a program to implement the practices. For each element we need to establish a time schedule, identify responsible parties and identify resources to support the actions.

Five actions should be undertaken. Each is briefly summarized below.

Non insecticidal BMPs The pesticide industry is unlikely to evaluate pesticide control options which involve using less or no insecticides. The UC Statewide IPM program or other appropriate groups should be requested to provide proposals for biological control of household pests. DPR and the Regional Board should solicit funding to evaluate these.

Monitoring A detailed multi year monitoring program must be established in representative waterways in both the Cities of Sacramento and Stockton. Purpose of the monitoring is to determine diazinon and chlorpyrifos variability both within and between storms. This information is needed to establish baseline conditions for assessing future success. The Department of Pesticide Regulation and Regional Board should solicit funding to conduct the monitoring.

Ecological Significance No instream monitoring to assess the impact of diazinon and chlorpyrifos concentrations on local aquatic communities has been conducted. Detailed ecological studies are needed to ascertain whether invertebrate and fish communities are degraded in contaminated waterways. The Regional Board should solicit funding to assess ecological significance.

Water Quality Criteria The California Department of Fish and Game has developed interim diazinon and chlorpyrifos criteria to protect freshwater aquatic life (Menconi and Cox, 1994;Menconi and Paul, 1994). Final Hazard Assessment criteria were not recommended as several data gaps were identified in the toxicological literature. Studies should be undertaken to fill these gaps. In addition, diazinon and chlorpyrifos are known to have additive toxicity when occuring together (Bailey *et al.*, 1997). Therefore, both proposed criteria should take into account additivity for instances when present together. The Department of Pesticide Regulation should solicit funding to complete the studies.

Evaluation and Implementation DPR and the RWQCB will jointly conduct a workshop in which data relating to impairment of beneficial uses are associated with the presence of pesticides in urban runoff. Information presented at the workshop will be summarized and presented to the RWQCB. The RWQCB will then consider the information and determine whether the presence of pesticides in urban runoff violate appropriate water quality objectives. If the information is inadequate to make such a determination, the RWQCB will request that DPR place the pesticides in question into reevaluation; DPR will require data to be submitted to satisfy data needs. Data necessary to adequately characterize occurrence of pesticides and their hazard to the aquatic environment, including data from toxicity studies necessary to develop water quality criteria, can be requested. If and when the RWQCB finds that water quality objectives are violated by the presence of specific pesticides in urban runoff, they will make recommendations to DPR on appropriate action. These actions will be implemented according to a time schedule approved by the Regional Board.

The existing Urban Pesticide Advisory Group should be used to assist in each of the steps. Annual progress reports will be prepared to facilitate input.

E. <u>Estimates of the Potential Cost to Implement</u>

Tentative costs to implement the program are contained in Table 1. Firmer cost estimates will be contained in the final cleanup plan after consultation with the Department of Pesticide Regulation and the UPC.

F. <u>An Estimate of Recoverable Costs from Potential Dischargers</u>

An estimate of recoverable costs will be provided in the final clean up plan after consultation with DPR.

G. <u>A two year expenditure schedule identifying funds to implement the plans that are not recoverable from potential dischargers</u>

No funds are presently available to carry out the proposed BPTCP cleanup plan.

Table 2. Provisional estimate of costs to implement the diazinon and chlorpyrifos urban stormwater toxic hot spot cleanup plan.

Task	Rationale	Cost
BMPs	Develop non insecticidal BMPs	200-300K
Monitoring	Establish baseline conditions	50-100K/yr
Ecological Significance	Biological studies	150-250K
Water Quality Objectives	Fill Data gaps	150-250K

Irrigation Return Flow Pesticide Cleanup Plan

Background

Chlorpyrifos in irrigation tailwater has been identified in Part II of the clean-up plan as responsible for creating a candidate BPTCP hot spot in various agriculturally dominated backsloughs within the Delta. Chlorpyrifos has also been noted in the Central Valley 303(d) list as a water quality impairment in the San Joaquin River and Sacramento San Joaquin Delta Estuary. This plan primarily addresses the clean up requirements of the BPTCP but has also been written to be consistent with the schedule for the 303(d) list.

One and a half million pounds of chlorpyrifos active ingredient were used in the Central Valley on agriculture in 1990 (Sheipline,1993). Major uses in March are on alfalfa and sugarbeets for weevil and worm control and between April and September on walnuts and almonds for codling moth and twig borer control. Two minor uses are on apples and corn. A bioassay study was conducted in agriculturally dominated waterways in the San Joaquin Basin in 1991 and 92. Chlorpyrifos was detected on 190 occasions between March and June of both years, 43 times at toxic concentrations to *Ceriodaphnia* (Foe, 1995). Many of the crops grown in the San Joaquin Basin are also cultivated on Delta Tracts and Islands. Not known was whether these same agricultural practices might also contribute to instream toxicity in the Delta. BPTCP resources were used between 1993 and 1995 to conduct a bioassay monitoring program in the Delta. Chlorpyrifos toxicity was detected on nine occasions in surface water from four agriculturally dominated backsloughs (French Camp Slough, Duck Slough, Paradise Cut, and Ulatis Creek; Deanovic *et al.*, 1996; Larson *et al.*, 1994). In each instance the *Ceriodaphnia* bioassay results were accompanied by modified phase I and II TIEs and chemical analysis which implicated chlorpyrifos. On four additional occasions phase III TIEs were conducted (Ulatis Creek 21 March 1995, Paradise Cut 15 March 1995, Duck Slough 21 March 1995, and French Camp Slough 23 March 1995). These confirmed that chlorpyrifos was the primary chemical agent responsible for the toxicity. Analysis of the spatial patterns of toxicity suggest that the impairment was confined to backsloughs and was diluted away upon tidal dispersal into main channels. The precise agricultural crops from which the chemicals originated are not known because chlorpyrifos is a commonly applied agricultural insecticide during the irrigation season. However, the widespread nature of chlorpyrifos toxicity in March of 1995 coincided with applications on alfalfa and subsequent large rainstorms. Follow up studies are needed to conclusively identify all responsible agriculture practices.

In conclusion, a combination of bioassay, chemical and TIE work demonstrate that chlorpyrifos was present periodically in at least four agriculturally dominated backsloughs at concentrations toxic to sensitive invertebrates. The source of the chlorpyrifos appears to be from agricultural use. These results have led Board staff to conclude that French Camp Slough, Duck Slough, Paradise Cut, and Ulatis Creek fit the BPTCP criteria for listing as candidate water column toxic hot spots because of elevated concentrations of chlorpyrifos.

A. Areal Extent

The potential aquatic threat posed by chlorpyrifos in agricultural return flow is confined to the four previously named Creeks and Sloughs. The areal extent of the impairment may be up to 15 linear miles of waterway within the legal boundary of the Delta.

B. Sources

The only major use of chlorpyfos in these four drainage basins is on agriculture. Detailed follow up studies are needed to determine the crop and precise agricultural practice which led to the off site movement.

C. Summary of Actions

As described previously, DPR and SWRCB both have statutory responsibilities for protecting water quality from adverse effects of pesticides. In 1997, DPR and the SWRCB signed a management agency agreement (MAA), clarifying these responsibilities. In a companion document, the Pesticide Management Plan for Water Quality (Pesticide Management Plan), a process was outlined for protecting beneficial uses of surface water from the potential adverse effects of pesticides. The process relies on a four-stage approach: Stage 1 relies on education and outreach efforts to communicative pollution prevention strategies. Stage 2 efforts involve self-regulating or cooperative efforts to identify and implement the most appropriate site-specific reduced-risk practices. In stage 3, mandatory compliance is achieved through restricted use pesticide permit requirements, implementation of regulations, or other DPR regulatory authority. In stage 4, compliance is achieved through the SWRCB and RWQCB water quality control plans or other appropriate regulatory measures consistent with applicable authorities. Stages 1 through 4 are listed in a sequence that should generally apply. However, these stages need not be implemented in sequential order, but rather as necessary to assure protection of beneficial uses.

Two activities are underway in the Central Valley to develop BMPs to reduce pesticide movement into surface water. Each are summarized below.

U.C. Statewide Integrated Pest Management Project. In December 1997 the U.C. Statewide Integrated Pest Management Project was awarded a three year one million dollar grant by the CALFED Bay Delta program. Objectives of the grant are to (1) Identify alternate urban and rural BMP practices to prevent and reduce off site movement of diazinon and chlorpyrifos into surface water. Study is to consider both summer and winter uses of the two insecticides. (2) Provide outreach and education on these new practices to the urban and agricultural community, and (3) design and initiate a monitoring program to assess the success of the new practices. Stanislaus County will be the focus of the study effort.

DowElanco The Registrant of chlorpyrifos has undertaken a multi year study in the San Joaquin Basin at Orestimba Creek to identify the specific agricultural use patterns and practices which contribute the majority of the off-site movement of their product into surface water. The study involves an evaluation of pesticide movement in both winter storms and in summer irrigation return flows. Objectives in subsequent years are to use the data to develop and field test BMPs to reduce off site chemical movement. The first year of work is complete. A report may be released soon.

Much similarity exits between agricultural practices in the San Joaquin Basin and the Delta. The results of the DowElanco work may be important in helping to identify the agricultural practices responsible for causing instream toxicity in the Estuary and also for developing successful BMPs to solve the problem. All promising solutions need to be field tested in Delta farmland.

D. Assessment of Actions Required

Proposed actions should be consistent with the MAA and Pesticide Management Plan, the requirements of the Regional Board under section 303 (d) listing, and the BPTCP. The general actions that are required to resolve this water quality problem include (1) establishment of goals, (2) establishment of a monitoring program, (3) completion of studies to evaluate ecological significance, (4) evaluation of urban runoff information to determine what management practices need to be implemented to correct problems, and (5) development of a program to implement the practices. For each element we need to establish a time schedule, identify responsible parties and resources to support the actions.

Four actions should be undertaken. Each is briefly described below

Monitoring A detailed multiyear monitoring program must be established in representative waterways in the Central Valley and Delta. Purpose of the monitoring is to determine the variability of pesticide concentrations including chlorpyrifos at all times of the year. This information is needed to establish baseline conditions for assessing future success. DPR and the Regional Board should solicit funding to conduct the monitoring.

Ecological Significance As noted in the diazinon orchard cleanup plan, no ecological monitoring has been conducted to determine the additive impact of all pesticides including chlorpyrifos on local aquatic communities. Detailed ecological studies are needed to ascertain whether invertebrate and fish communities are degraded in contaminated waterways. This work should be combined with studies conducted during the dormant spray season to insure that the combined response of all pesticide exposures are evaluated.. The Regional Board should solicit funding to assess ecological significance.

Water Quality Criteria As noted previously, the California Department of Fish and Game has developed an interim chlorpyrifos criteria to protect freshwater aquatic life (Menconi and Paul, 1994). A final Hazard Assessment criteria is not available as several data gaps were identified in the toxicological literature. Studies should be undertaken to fill these gaps and the Department of Fish and Game requested to evaluate the studies and publish a final Hazard Assessment Criteria. In addition, diazinon and chlorpyrifos, two commonly observed insecticides are known to have additive toxicity when occuring together (Bailey *et al.*, 1997). The proposed criteria should consider additivity if present together. The Department of Pesticide Regulation should solicit funding to complete criteria development.

Evaluation and Implementation DPR and the RWQCB will jointly conduct a workshop in which data relating to impairment of beneficial uses are associated with the presence of pesticides irrigation runoff. Information presented at the workshop will be summarized and presented to the RWQCB. The RWQCB will then consider the information and determine whether the presence of pesticides in urban runoff violate appropriate water quality objectives. If the information is inadequate to make such a determination, the RWQCB will request that DPR place the pesticides in question into reevaluation; DPR will require data to be submitted to satisfy data needs. Data necessary to adequately characterize occurrence of pesticides and their hazard to the aquatic environment, including data from toxicity studies necessary to develop water quality criteria, can be requested. If and when the RWQCB finds that water quality objectives are violated by the presence of specific pesticides in irrigation runoff, they will make recommendations to DPR on appropriate action. The Regional Board will review the program in a public forum and take action if appropriate. Annual progress reports will be prepared to facilitate input.

E. Estimates of the Potential Cost to Implement

Tentative costs to implement the program are contained in Table 3. Firmer cost estimates will be provided in the final cleanup plan after consultation with the Department of Pesticide Regulation.

Table 3. Provisional estimate of the cost to implement the Irrigation Return Water Pesticide Cleanup plan.

Task	Rationale	Cost
Monitoring	Establish baseline conditions	300-400k/yr
Ecological significance	Invertebrate Studies Fish Studies	400-700K 200-300K
Water Quality Objectives	fill data gaps	100-150k

F. An Estimate of Recoverable Costs from Potential Dischargers.

An estimate of recoverable costs will be provided in the final clean up plan after consultation with DPR

G. A two year expenditure schedule identifying funds to implement the plans that are not recoverable from potential dischargers.

No funds are presently available to carry out the proposed BPTCP cleanup plan.

Mercury Clean up Plan

Background

Mercury has been identified in part II of the cleanup plan as responsible for creating a candidate BPTCP hot spot in the Sacramento-San Joaquin Delta Estuary. Mercury has also been identified in the Central Valley 303(d) list as responsible for impairing water quality in 15 waterbodies in the Valley including the Delta-Estuary[3]. The San Francisco Bay Water Quality Control Board is preparing a similar candidate BPTCP hot spot clean up plan for mercury in San Francisco Bay. The widespread distribution of mercury contamination emphasizes the regional nature of the problem and the need for regional solutions. This interim clean up plan was written by staff from the Central Valley Region but the final plan should be prepared in cooperation with staff from the San Francisco Region and be endorsed by both Boards.

Mercury is a potent human neurotoxin with developing fetuses and small children being most at risk. The principal route of human exposure is through consumption of mercury contaminated fish. In 1973 a human health advisory was issued for the Sacramento San Joaquin Delta Estuary advising pregnant women and children not to consume striped bass. In 1994 an interim health advisory was issued by the Office of Environmental Health Hazard Assessment (OEHHA) for San Francisco Bay recommending no consumption of large striped bass and shark because of elevated mercury and PCB concentrations.

Factors which promote excess mercury in fish tissue are not well understood. To a large extent this is because until very recently there were no methodology to measure mercury at environmental concentrations (part per trillion) in surface water. However, it is generally agreed that mercury biomagnifies in the aquatic food chain with fish in California often having a

[3]303(d) mercury impaired water bodies include the Sacramento-San Joaquin Delta-Estuary, lower Sacramento River, Cache Creek, Sulfur Creek, Clear Lake, Lake Berryessa, lower American River, lower Feather River, Harley Gulch, Sacramento Slough, Davis Creek Reservoir, Marsh Creek and Reservoir, San Carlos Creek, James, Creek and Panoche Creek.

million times more mercury, on a weight basis, than ambient water. Methyl mercury is the primary form accumulating in the aquatic food chain. Over ninety percent of the mercury in fish tissue is usually the neurologically important methyl mercury. Conversion of inorganic to organic mercury appears to be controlled primarily by microorganisms, mostly sulphur reducing bacteria in sediment. Important factors in other systems which appear to control the conversion rate of inorganic to organic mercury include temperature, percent organic matter, redox potential, salinity, pH and mercury concentration (Gilmour, 1994). Neither the primary locations of methyl mercury production nor the principal factors controlling methylation are yet known for the Sacramento-San Joaquin Delta Estuary.

In California mercury was historically mined in the Coast Range both north and south of San Francisco Bay and transported across the Valley for use in placer gold mining in the Sierra Nevada Mountains. Both operations caused widespread mercury sediment contamination in water courses in the Coast Range, Sierra Nevada Mountains, Valley floor, and Sacramento San Joaquin Delta Estuary.

The limited mercury work undertaken so far in the Central Valley has concentrated on estimating mercury loads to the Estuary and on determining *in situ* mercury bioavailability in valley waterways. A loading study conducted by Larry Walker and Associates (1997) estimated that 640 kg of mercury were exported by the Sacramento watershed to the Estuary between October 1994 and September 1995. Most of the material was contributed during winter high flow periods. Surprisingly, the Feather and American River watersheds, sites of intensive historical placer gold mining activity, only accounted for about 25 percent of the total load. The majority of mercury appeared to originate from the Sacramento watershed above the confluence of the Feather River. The Sacramento Regional Wastewater Treatment Plant, the largest NPDES discharger in the Region, accounted for less than 2 percent of the total load.

In a companion study mercury concentration in aquatic invertebrates and fish in the historic gold mining region of the Sierra Nevada Mountains was evaluated (Slotton *et al.*, 1997a). Concentrations of mercury in aquatic indicator organisms increased in a predictable fashion with increasing trophic feeding level. A clear signature of mine derived mercury was found associated with the most intensively worked river stretches. Mercury concentrations were lower in non hydrologically mined reaches of the Feather and American Rivers.

Foothill reservoirs were found to operate as traps for both bioavailable and sediment associated inorganic mercury (Slotton et al., 1997a; Larry Walker and Associates, 1997). Significantly lower levels of mercury were found in aquatic organisms below reservoirs as compared to concentrations both in and above them. Similarly, bulk loads of mercury entering foothill reservoirs were greater than the amount exported. This suggests that foothill reservoirs in placer gold mining districts may act as interceptors of mercury, trapping and preventing downstream transport to the Estuary. This may explain the lower than expected loads measured by Larry Walker and Associates (1997) in the Feather and American Rivers.

Larry Walker and Associates (1997) caution, based upon limited fish tissue data, that consumption of fish from Sierra foothill reservoirs may pose a human health problem. Comprehensive fish tissue and fish consumption studies are recommended to evaluate the potential risk to the California angling public. This study should be conducted in cooperation with the California Department of Heath Services, OEHHA, and the Department of Fish and Game.

Between 1993 and 1995 the Central Valley Regional Board also conducted a bulk mercury loading study to the Estuary from the Sacramento watershed. The study differed from that of Larry Walker and Associates (1997) in that the Regional Board study also included an assessment of loads from the Yolo Bypass during high flows. During high flows the Bypass receives overflow from the Sacramento River and significant input from several coastal watersheds.

The Regional Board estimated that the Sacramento Watershed exported 800 kg of mercury to the Estuary between May 1994 and April 1995 (Foe *et al.*, 1997; Foe in prep). Staff found, like Larry Walker and Associates, that most of the mercury was transported into the Estuary during high flow periods. High mercury concentrations in the Yolo Bypass suggested possible local inputs. Follow up studies demonstrated that Cache Creek was exporting about 1,000 kg of mercury during the year. Half of the mercury appeared to be trapped by the Cache Creek Settling Basin at the confluence with the Bypass while the remainder was exported to the Estuary. The source(s) of the mercury in Cache Creek are not yet known although the Basin is well known for its abandoned mercury mines and geothermal spring with elevated metal concentrations.

In the spring of 1996 benthic invertebrate samples were collected in the upper Cache Creek basin to determine local bioavailability and attempt, if possible, to locate mercury hot spots (Slotton *et al.*, 1997b). All elevated invertebrate tissue samples were associated with known mercury mines or geothermal hot springs. The highly localized nature of these sites was demonstrated by the lower biotic tissue concentrations in adjacent streams without historic mercury mining activity. Invertebrates collected in the upper mainstem of Cache Creek had tissue concentrations comparable to similar indicator organisms obtained from Sierra Nevada gold mining areas. However, tissue concentrations in the mainstem Creek decreased downstream suggesting that much of the large bulk loads of mercury observed by the Regional Board might not be very biologically available while in the lower reaches of the Creek.

Estuarine bioavailability of Cache Creek mercury is not known. However, the Creek serves as the major water source for the recently created Yolo WildLife Refuge. In addition, the CALFED Bay Delta Program is proposing to purchase large areas downstream in the Yolo Bypass for conversion to shallow water wildlife habitat. These areas are being built upon fill, at least in part, derived from erosion of the Cache Creek watershed. They will also be watered by Cache Creek. Follow up studies are needed to ascertain whether wildlife areas will act as methylating environments and exacerbate mercury bioaccumulation in the estuarine aquatic food chain.

A. Areal Extent

There is a human health advisory in effect in the Delta and in San Francisco Bay because of elevated mercury levels in striped bass and other long lived fish. The entire area of the Delta is therefore considered a hot spot. The Delta is a maze of river channels and diked islands covering roughly 78 square miles of open water and about 1,000 linear miles of channel.

B. Sources

Four major bulk sources of estuarine mercury have been identified. They are exports from the placer gold mining regions of the Sierra Nevada Mountains, mercury mining in the Coast Range, resuspension of estuarine sediment, and effluent from municipal and industrial discharges to surface water. Not known, but critically important, is the relative methylation potential of mercury from each source once in the estuary. The four sources are briefly reviewed below.

Sierra Nevada Mountains It has been estimated that over 3 million kg of mercury were lost in the Sierra Nevada Mountains during the gold rush (Montoya, 1987). All this mercury was initially in an elemental form (quicksilver) and most of it is probably still highly oxidized. Foothill reservoirs appear to trap most of the bioavailable and total mercury entering them. Therefore, only the mercury presently located in water courses below the foothill reservoirs appear available for transport into the estuary.

Coast Range Some of the largest historic mercury mines in the world were located in the Coast Range both north and south of San Francisco Bay. Most of the mercury in the Coast Range is as mercuric sulfide (cinnabar) and is probably emanating from abandoned mine portals and deposits around retorts and slag piles, geothermal springs and seeps, and erosion of mercury rich landforms. The Coast Range is drier than the Sierra Nevada Mountains and therefore has fewer reservoirs and permanently flowing waterways. Off site movement of mercury from the Coast Range appears to occur mostly in the winter after large rainstorms. Cache Creek has been identified as a major source of mercury to the Estuary. However, other Coastal Range inputs to both the Sacramento and San Joaquin Rivers are expected.

Sediment The largest source of mercury is already present in the Estuary buried in sediment. Mercury from sediment is potentially available through natural fluxing, bioturbation, scour and erosion from wave action, dewatering and beneficial reuse of dredge spoils on levees, and creation of intertidal shallow water habitats by breaking levees and reflooding Delta agricultural land. Potential bioavailability of mercury from each action depends on, among other things, the chemical form of the metal in sediment and environmental conditions in the Estuary at the time of release to the foodchain.

Municipal and Industrial Discharges Undoubtedly, the smallest source of mercury to the Estuary is from permitted municipal and industrial discharges to surface water. Load estimates are only available for the Sacramento Regional Wastewater Treatment Plant, the largest discharger in the Central Valley. The facility was estimated to have discharged 9.9 kg mercury during water year 1995 (Larry Walker and Associates, 1997). This represents less than 2 percent of the total annual load from the Sacramento Basin.

C. Summary of Actions

Three actions have been taken in the Central Valley to begin addressing the human health problems posed by mercury. Each is summarized below.

Loading studies Bulk mercury loading studies conducted by the Central Valley Board (Foe *et al.*, 1997) and Larry Walker and Associates (1997) on the Sacramento River have determined that new loads of metal enter the estuary each year during high flows. Coast Range inputs appear more important than Sierra Nevada ones as the inputs from the latter are intercepted and trapped by foothill reservoirs. Cache Creek was identified as an important Coast Range mercury source. Other sources on the Sacramento River upstream of the confluence of the Feather River may also be important but remain unidentified.

Bioavailability Studies by Slotton *et al.* have determined that fish tissue concentrations can be predicted from changes in mercury concentration in invertebrate trophic levels. This relationship has been used to standardize mercury food chain bioaccumulation in the Central Valley and identify local hot spots where fish may or may not be present but elevated concentrations of bioavailable mercury are accumulating in the food chain. The studies have identified apparent hot spots in the Sierra Nevada mountains and Coast Range. All are associated with past intensive gold and mercury mining. The process has also suggested that some sites with large bulk mercury loads, such as the Cache Creek drainage, might not be as vulnerable to methyl mercury production as their loads would suggest. Similar food chain studies need to be completed for all mercury rich areas in the Central Valley.

CALFED The CALFED Water Quality Common Program has identified mercury as a contaminant of concern. The program is developing actions to attempt to reduce mercury tissue concentrations in edible fish from the Central Valley and Delta to concentrations below health advisory levels. A draft of the Water Quality Common Program is presently being circulated among the public for comment.

The CALFED Category III Ecosystem Restoration Program has proposed to purchase large tracts of farmland in the Estuary, break levees, and convert the fields to shallow water intertidal habitat. Newly flooded wetlands are known to have elevated rates of methyl mercury production and concern has been expressed that CALFED restoration activities might increase methyl mercury concentrations in estuarine fish. The CALFED Category III program announced in December 1997 that they would fund a grant entitled "The effects of wetland restoration on the production of methyl mercury in the San Francisco Bay Delta System". Purpose of the three year project is to quantify changes in methyl mercury production caused by restoration practices and evaluate the bioavailability and impact of the mercury on the Bay Delta Ecosystem. The ultimate intent of the Authors is to provide recommendations to managers for potentially modifying restoration approaches to minimize methyl mercury production.

D. Assessment of Actions Required

The goal of the mercury clean up plan is to reduce fish mercury tissue concentrations to levels that eliminate the need for advisories in the Central Valley and Delta-Estuary. This reduction will require implementation of a process which includes the following: (1) Formation of a taskforce to develop a regional mercury strategy, (2) Conduct source identification and assessment studies in the Central Valley and San Francisco Bay area, (3) Conduct directed research to better understand mercury cycling in the Central Valley and Estuary, (4) Conduct pilot mercury control projects and evaluate their effectiveness, and finally (5) Develop a plan to implement a mercury control strategy. Each step is described briefly below.

(1) Taskforce A regional mercury control strategy task force should be formed. The Task Force should be composed of scientists, watershed stakeholder groups, and resource managers from both the Central Valley and San Francisco Bay area. Purpose of the group is to assist in defining research needs, refine assessment and source identification studies, review proposed control stategies, assist in the development of a regional mercury control strategies, and act as a clearing house for mercury information. The Task

Force should make recommendations to the CALFED and other entities for possible funding.

(2) Source Identification and Assessment Task involves two elements both of which are already underway in the Central Valley and San Francisco Bay area. First, continue mercury loading and bioavailability studies and, second, conduct fish tissue burden studies to evaluate the public risk of elevated mercury concentrations. Both are reviewed briefly below.

(a) Source identification Mercury mass load studies should continue in the Central Valley with an emphasis on watersheds where no data are available. These should include the San Joaquin, Mokelumne, and Consumnes Rivers. Detailed follow up studies should be undertaken in watersheds where initial studies demonstrate the major sources of mercury come from. Follow up studies should include an assessment of inter annual variability and the precise locations of the mercury sources. The studies should also include assessments of the load contributions from major NPDES and stormwater discharges. The mass load work should be accompanied by biological surveys to identify locations with enhanced food chain mercury bioavailability.

(b) Public health Mercury fish tissue studies should be undertaken in the Delta. Studies should be designed and carried out in coordination with the Office of Environmental Health Hazard Assessment, Department of Health Services, and Fish and Game. Primary purpose is to establish the public risk posed by consumption of fish with elevated mercury levels. Angler fish consumption studies need to be conducted in the Delta to identify high risk groups and aid in development of fish advisories. Watershed groups should be encouraged to conduct public outreach and education programs, especially aimed at high risk groups in order to minimize their risk. A secondary objective of the fish tissue work is to establish baseline conditions to evaluate the future success of control efforts.

(3) Research Directed research should be undertaken to better understand mercury cycling in the Central Valley and Estuary. Research emphasis should be on evaluating the relative bioavailability of the different sources of mercuric material moving into the Estuary in comparison with concentrations already present and available in sediment porewater. At a minimum these should include an evaluation of inputs from the Coast Range, Sierra Nevada Mountains and municipal, industrial, and stormwater discharges. The studies should also include an evaluation of the importance of the remobilization of mercury from sediment by natural fluxing and release during dredging, disposal of dredge material on island levees, and creation of shallow water habitat. The ultimate purpose of the directed research is to provide resource managers with recommendations on how to minimize mercury bioaccumulation in the Central Valley, Delta and San Francisco Bay.

(4) Pilot Control Stategies Once estuarine mercury cycling is better understood and the primary sources of bioavailable mercury known, then pilot control studies should be undertaken to ascertain the most practical, cost effective method of minimizing mercury bioaccumulation. These may include runoff and waste material isolation studies, natural revegetation, waste rock removal, and infiltration evaluations. Ultimately, it is likely that some of the principal sources of bioavailable mercury will be determined to be from sites where the owners have insufficient resources to carry out the clean up. The State of California should pursue, in the interim, Federal "good samaritan" legislation to minimize State liability and insure that mercury control efforts can eventually be undertaken wherever they are most cost effective.

(5) Implementation Plan Develop a plan to reduce mercury tissue residues in Bay-Delta fish to levels that allow elimination of

consumer advisories. The plan should include (1) load reduction goals from the principal sources that contribute to elevated mercury levels in fish and (2) other management measures to reduce fish uptake. The plan will include a time schedule and recommendations on how to fund implementation. This may include a discussion of developing "Pollution Trading" opportunities whereby Central Valley and Bay Area Dischargers are allowed to fund more cost effective nonpoint source cleanup projects in the Central Valley *in lieu* of less effective abatement actions at their own facilities.

E. An estimate of the total cost to implement the clean up plan

A preliminary estimate of the cost to implement the plan is provide below for activities occurring in the Central Valley. A more detailed estimate covering all costs will be provided in the final plan after consultation with staff from the San Francisco Regional Board, OEHHA, Department of Fish and Game and Stakeholder groups.

Table 3. Preliminary estimate of cost to implement the mercury control strategy.

Task	Cost
1. Develop Regional Strategy	$200,000-300,000
2. Source Identification and Assessment	$2-3 Million
3. Directed Research	$3-4 Million
4. Pilot Control Strategies	$2-3 Million
5. Implementation	Undetermined >$10 Million

F. An estimate of recoverable costs from potential dischargers

Minimal cost recovery potential, if any.

G. A two year expenditure schedule identifying funds to implement the plans that are not recoverable from potential dischargers.

No fund sources have been identified at this time.

San Joaquin River Dissolved Oxygen Clean up Plan

Background

Low dissolved oxygen concentrations in the San Joaquin River in the vicinity of the City of Stockton has been identified in Part II of the clean up plan as constituting a candidate BPTCP hot spot. Oxygen suppression in the San Joaquin River has also been noted in the Central Valley Region's 303(d) list as a water quality impairment. This plan primarily addresses the clean up requirements of the BPTCP but is also consistent with the proposed actions and schedule of the 303(d) listing.

The San Joaquin River in the vicinity of the Stockton Waste Water Treatment Plant (WWTP) annually experiences violations of the 5.0 and 6.0 mg/l dissolved oxygen standard[4]. Violations are variable in time but usually occur over a ten mile River reach between June and November. Concentrations in the mainstem River have been measured as low as 2.5 mg/l.

In 1978 the Board adopted more stringent biochemical oxygen demand (BOD) and total suspended solid (TSS) effluent limits for the Stockton WWTP with the intent of reducing or eliminating the low dissolved oxygen conditions in the San Joaquin River. The plant has constructed the necessary additional treatment facilities and has complied with the more stringent effluent limitations. Despite the Cities best efforts, the low dissolved oxygen conditions persist.

The City completed a river model (Schanz and Chen, 1993) assessing the impact of the Stockton WWTP on receiving water quality. Water quality parameters considered included TSS, BOD, ammonia, nitrate and dissolved oxygen. The model suggested that: (1) low dissolved oxygen conditions occur in the fall and spring due to a high mass loading of BOD and ammonia, (2) the current WWTP contributions are up to 40% of the oxygen

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[4]The 5.0 mg/l standard applies between 1 December and 30 August while the 6.0 mg/l one is for the period of 1 September through 30 November.

demand of the River during critical low dissolved oxygen periods, (3) addition of activated sludge/nitrification units to provide a carbonaceous biochemical oxygen demand (CBOD) of 5 mg/l and ammonia of 0.5 mg/l would increase dissolved oxygen levels in the River from 2.5 to 3.0 mg/l during critical periods, (4) the San Joaquin River would not meet the receiving water dissolved oxygen standards even if the entire discharge from the WWTP were eliminated from the River.

Taking these facts into consideration, the Board adopted a stricter permit in 1994 requiring the Stockton WWTP to further reduce CBOD and ammonia concentrations. Stockton appealed the permit to the State Board on a variety of grounds including that hydraulic conditions had changed in the River since the Board had considered the permit. The State Board remanded the permit back to the Regional Board for consideration of Delta flow conditions. Staff intend to bring the permit back to the Board for reconsideration in the summer of 1998.

In the interim the Stockton WWTP has completed a new dissolved oxygen model for the River (Chen and Tsai, 1997). The model suggests that the principal factors controlling in stream oxygen concentration are temperature, flow, algal production, sediment oxygen demand and discharge from the WWTP. Obviously, only one of these factors is within the ability of the WWTP to control.

Dissolved oxygen problems are most acute at high temperature in the San Joaquin in late summer and early fall. Temperature is important because the oxygen carrying capacity of water decreases with increasing temperature while biotic respiration rates increase. Water temperature is controlled by air temperature and reservoir releases.

Flow of the San Joaquin River at Stockton is regulated by upstream reservoir releases and pumping at the state and federal pumping facilities at Tracy. Net flows at the City of Stockton are often zero or negative in late summer. The low dissolved oxygen levels in the River occur after prolonged periods of no net flow.

Algal blooms occasionally develop in the faster moving shallow upper River and are carried down past the City to the deeper slower moving deep water ship channel. Respiration exceeds photosynthesis here resulting in net oxygen deficits. Upstream algal blooms are controlled by BOD and nitrogen inputs from other NPDES dischargers, the dairy industry and agricultural runoff.

Finally, the new model identified discharge from the Stockton WWTP as contributing to the dissolved oxygen problem. The model indicates that improvements in effluent quality would increase dissolved oxygen levels in the River during critical periods. However, the model confirmed that exceedance of the dissolved oxygen water quality objective would persist if the entire discharge of the WWTP were removed from the River.

Adult San Joaquin fall run chinook salmon migrate up river between September and December to spawn in the Merced, Tuolumne, and Stanislaus Rivers (Mills and Fisher, 1994). The Basin Plan dissolved oxygen water quality objective was increased from 5.0 to 6.0 mg/l between 1 September and 30 November to aid in upstream migration. The San Joaquin population has experienced severe declines and is considered a 'species of concern' by the U.S. Fish and Wild Life Service. Low dissolved oxygen may act as a barrier preventing upstream movement. Also, low dissolved oxygen can kill or stress other species present in this portion of the Delta.

In conclusion, the San Joaquin River in the vicinity of the Stockton WWTP annually experiences dissolved oxygen concentrations below the Basin Plan water quality objective in late summer and fall. A model has been developed which identifies river flow and temperature, upstream algal blooms, sediment oxygen demand, and discharge from the WWTP as controlling variables. Only the latter variable is within the ability of the plant to influence. Fall run chinook salmon migrate upstream during this critical time period.

A. Areal extent

The areal extent of the water quality exceedance is variable but may in some years be as much as 10 miles of mainstem River. The temporal extent is also variable but can be for as long as 4 months. The lowest dissolved oxygen measurements average 2.5 mg/l.

B. Sources

A computer model developed for the Stockton WWTP identified ammonia and BOD as the primary cause of the low dissolved oxygen concentration. The sources are discharges from the Stockton WWTP and surrounding point and non point source discharges. River flow and water temperature were identified as two other variables strongly influencing oxygen concentrations.

C. Summary of Actions

Low dissolved oxygen levels around the Stockton WWTP in late summer are a well known problem. In 1978 the Regional Board adopted more stringent effluent limits which the WWTP met but these did not correct the in stream problem. A model developed for the WWTP suggested that further decreases in effluent BOD and ammonia would improve in stream dissolved oxygen concentrations during critical periods but would not completely correct the problem. In 1994 the Regional Board further tightened BOD and ammonia permit limits to protect water quality. The permit was appealed to State Board because River hydrology had changed since the permit was adopted. State Board remanded the permit back to the Regional Board to reevaluate the modelling based upon new Delta flow conditions. The revised permit is due to be heard during the summer of 1998. In the interim, the WWTP installed a gauge at their discharge point to measure River flow and also refined their computer model of River oxygen demand. The model concluded that the primary factors controlling dissolved oxygen concentration in the critical late summer and fall period were River flow and temperature, upstream algal blooms, sediment oxygen demand and discharge from the WWTP. The model also made a preliminary evaluation of the impact of placing aerators in the River during critical periods. The results appeared promising. Finally, simulations were run coupling the dissolved oxygen and the San Joaquin River daily input-output model. The results suggest that it may be possible to predict exceedances of the Basin Plan dissolved oxygen standard about two weeks in advance.

The U.S. EPA requires Regional Boards to maintain 303(d) lists of impaired water bodies. The San Joaquin River in the vicinity of the Stockton WWTP is on the Central Valley 303(d) list because of low dissolved oxygen concentration. The list requires the Regional Board to adopt a schedule for setting Total Maximum Daily Loads (TMDLs). In January 1998 staff will request that the Board approve a schedule for developing a TMDL for dissolved oxygen in the San Joaquin River. Components of a TMDL include problem description, numeric targets, monitoring and source analysis, implementation plans, load allocation, performance measures and feedback, margins of safety and seasonal variation and public participation.

D. Assessment of Actions required

The goal of the clean up plan is to ensure that the San Joaquin River achieves full compliance with the Basin Plan dissolved oxygen water quality objective. The initial emphasis should be on improving water quality during chinook salmon migration. Both interim and long term actions are recommended. Each are summarized below.

Interim The Regional Board will continue its efforts to reevaluate the NPDES Permit for the WWTP to reduce the impact of the WWTP discharge on River dissolved oxygen. Implementation of improved discharge standards will require several years. In addition, a program should be initiated to identify other short term solutions to the low dissolved oxygen problem in the San Joaquin River. The program should include a study to evaluate the cost and feasibility of using aeration in the mainstem River to increase dissolved oxygen concentrations. If aeration appears feasible, then the CALFED category III program might be approached, as they have identified fall run San Joaquin salmon as a priority species, to ascertain whether they would be interested in purchasing the aeration equipment. In addition, a study should be undertaken to ascertain how much water would be required in different water year types to guarantee a small net positive outflow at the City of Stockton during late summer and fall and whether this flow augmentation will significantly improve River dissolved oxygen conditions. The U.S. Bureau of Reclamation should be approached to ascertain whether they would consider pumping water south for immediate discharge to augment San Joaquin River outflow. The San Joaquin River daily input-output model could be used to identify the critical time periods needing augmentation. Again, CALFED might be approached to ascertain whether they would fund the project on an interim basis. All interim actions should only be considered for the time interval it takes to develop and implement a long term plan. At a maximum the interim actions should not extend past the due date for the TMDL schedule.

<u>Long term</u> Any long term solution to the dissolved oxygen problem must include a decrease in nitrogen and BOD loads to the River. An Oxygen Demand Reduction (ODR) subcommittee should be formed as part of the East Delta Watershed Program. At a minimum, the ODR subcommittee would be composed of the Stockton WWTP, upstream NPDES dischargers, the dairy industry, irrigated agriculture and downstream entities, including the Port of Stockton and City and County Storm water Programs. Purpose of the group would be to catalogue all BOD and nitrogen loads to the River, recommend load allocations to responsible parties and comply with all other components of the TMDL. Finally, the Regional Board in conjunction with the ODR subcommittee should develop a strategy for implementing the

preferred options. The final implementation schedule must be consistent with the time requirements of the 303(d) list.

E. <u>An estimate of the total cost to implement the clean up plan</u>.

No estimate is available at this time. A cost estimate will be included with the final plan.

F. <u>An estimate of recoverable costs from potential dischargers</u>

Not known

G. <u>Two year expenditure schedule identifying funds to implement the plan that are not recoverable from potential dischargers.</u>

Staff funding will be needed to participate in the East Delta Watershed Program.

Urban Dissolved Oxygen Clean up Plan

Background

Smith Canal, Mosher Slough, 5-Mile Slough and the Calaveras River are urban waterways located in the South Delta around the City of Stockton. Urban stormwater discharge to these waterbodies is regulated by Regional Board Order 95-035. The designated beneficial uses of the water include the preservation and enhancement of fish, wildlife, and other aquatic organisms. A dissolved oxygen water quality objective of 5.0 mg/l or greater applies in all four waterbodies throughout the year.

In 1994 Board staff noted that ambient dissolved oxygen levels were less than 1 mg/l in all four waterways after the first major storm of the year (first flush phenomena;Connor, in prep). A threadfin shad fish kill was observed to be happening in Smith Canal. Water samples from the Canal were taken to the U.C. Davis Aquatic Toxicology Laboratory and tested in seven day Fathead minnow bioassays (U.S. EPA, 1994). An elevated dissolved oxygen demand was repeatedly observed in the samples. However, fish tissue growth and survival, upon gentle aeration to maintain a high dissolved oxygen concentration, were not different than those of the control. Wild theadfin shad were collected next and exposed in clean laboratory water to the temperature and dissolved oxygen regimes measured during the first flush. Fish disequilibrium and death occurred only in the low dissolved oxygen treatment. The results of both sets of experiments suggest that the proximate cause of field mortality was asphyxiation. The chemical cause of the elevated oxygen demand was not evaluated. In 1995 staff again observed low dissolved oxygen (< 2.0 mg/l) associated with fish kills after the first flush in Smith Canal and in 5-Mile Slough. In 1996 after the first storm of the year, DeltaKeeper noted low dissolved oxygen levels and fish kills in Smith Canal and 5-Mile Slough and low dissolved oxygen, but no fish kills, in the Calaveras River (personal communication, Bill Jennings). In 1997 DeltaKeeper again reported low dissolved oxygen levels in all four waterways. They did not look for fish kills. Little suppression in dissolved oxygen has ever been noted in any storm runoff event after the first flush.

In conclusion, an annual pattern of low dissolved oxygen after the first storm of the year has been noted in urban waterways around the City of Stockton. The oxygen deficit is frequently associated with fish kills.

A. Areal extent.

The areal extent of aquatic life impacts in Smith Canal, the Calaveras River, Mosher Slough, and 5-Mile Slough from low dissolved oxygen do not exceed 8 linear miles. All waterways are located within the legal boundary of the Delta.

B. Assessment of the most likely sources of Pollutants

Urban stormwater runoff from the City of Stockton and San Joaquin County appear responsible for the movement of material with excess oxygen demand into surface water. The chemical(s) causing the dissolved oxygen deficit have not yet been identified.

C. Summary of Actions

Regional Board staff requested and the City of Stockton agreed to conduct a water quality study in Smith Canal in 1997 (Stockton ltr of 29 September 1997). Purpose of the study was to verify that low dissolved oxygen levels were associated with storm runoff, determine the temporal and spatial extent of the impairment and ascertain the chemicals responsible. A final report is expected in the summer of 1998.

D. Assessment of Actions required

The recommended follow up depends on the results of the study presently underway in Smith Canal. If the study is unsuccessful in ascertaining the chemicals responsible for the high oxygen demand then it should be repeated with the purpose of identifying the causes. Alternatively, if the study is successful then three follow up actions are recommended. First, repeat the Smith Canal study at 5-Mile and Mosher Sloughs and the Calaveras River to confirm that the same chemicals are responsible for the oxygen deficit in all waterways. Second, conduct a study at Smith Canal to evaluate control options to reduce the input of material with high oxygen demand. Finally, a plan should be submitted to the Regional Board describing how the preferred control option will be implemented throughout the stormwater district.

E. Estimate of the cost to implement the clean up plan

Costs to implement the clean up plan are not known but will be provided in the final plan after consultation with the Stormwater Agency.

F. An estimate of recoverable costs from potential dischargers

The City of Stockton and San Joaquin County stormwater program should fully fund the clean up plan and its implementation.

G. A two year expenditure schedule identifying funds to implement the plans that are not recoverable from potential dischargers

Not applicable

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