Review of the City of Stockton Urban Stormwater Runoff Aquatic Life Toxicity Studies Conducted by the CVRWQCB, DeltaKeeper and the University of California, Davis, Aquatic Toxicology Laboratory between 1994 and 1999

R49-C

Prepared by

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April 2001

Beginning in 1994, the Central Valley Regional Water Quality Control Board (CVRWQCB) under Dr. Val Connor's leadership with support of a US EPA grant and with the assistance of the University of California, Davis, Aquatic Toxicology Laboratory (UCD-ATL), initiated a study of aquatic life toxicity in the City of Stockton's urban stormwater runoff to the city's sloughs. Samples of stormwater runoff were obtained from Mosher Slough, Five Mile Slough, Calaveras River, Walker Slough and the Smith Canal. Smith Canal and Five Mile Slough receive stormwater runoff only from the City of Stockton. Mosher Slough, Calaveras River and Walker Slough also at times receive stormwater runoff from agricultural areas and agricultural return (drain waters) upstream of the City of Stockton. All of these waterbodies are tidal freshwater within the City of Stockton with a one- to three-foot tide. The City of Stockton pumps dry weather flow from the City's storm sewer system and stormwater runoff into these waterbodies.

An extensive set of samples and detailed analyses were conducted in 1994. Additional sampling was done in 1995. Beginning in 1996 through 1999, the DeltaKeeper continued the sample collection and supported the toxicity testing and chemical analysis of the samples. A total of about 160 toxicity tests have been conducted on these samples over this time. Figure 1 shows the location of the sampling stations. In general, the samples of each waterbody were taken at the location where it crosses I-5.

All samples were analyzed for aquatic life toxicity by the University of California, Davis, Aquatic Toxicology Laboratory using the US EPA standard three species toxicity test (Lewis, *et al.*, 1994) with *Ceriodaphnia dubia* (freshwater zooplankton), *Pimephales promelas* (fathead minnow larvae) and *Selenastrum capricornutum* (freshwater alga) as the test organisms. Some of the samples were processed through a toxicity testing dilution series in order to estimate the total amount of toxicity present in the sample. Some of the original and dilutions were treated with piperonyl butoxide (PBO). PBO interacts with organophosphate pesticides such as diazinon and chlorpyrifos to eliminate and/or reduce their toxicity (Bailey, *et al.*, 1996).

Some of the samples were analyzed for the OP pesticides diazinon and chlorpyrifos using the enzyme linked immuno sorbent assay (ELISA) procedure. Details of the sampling and analytical procedures are provided by the UCD-ATL QAPP.

Figure 1

While not involved in the original studies, the authors, Drs. G. Fred Lee and Anne Jones-Lee, were asked to assist the DeltaKeeper in developing a report summarizing the data obtained in these studies. In addition to the CVRWQCB/DeltaKeeper/UCD ATL data, the City of Stockton holds an NPDES stormwater permit that requires monitoring of stormwater runoff. Stormwater monitoring data was available for 1997–1998 (Stockton 1998, San Joaquin County 1997). Additional aquatic life toxicity and/or OP pesticide data has been collected by Stockton that is not available. Summaries of that data indicate that the results are similar to the 1997-1998 data. This report presents an overview assessment of the information available from the 1994-1999 City of Stockton urban stormwater runoff aquatic life toxicity studies. Some of the data used in this report have previously been reported on by Connor (1994, 1995) and Fong, *et al.* (2000).

REGULATORY REQUIREMENTS

In accord with the US EPA Clean Water Act requirements, the CVRWQCB has adopted a Basin Plan objective of no toxicity in ambient waters. The CVRWQCB (1998) states,

> *"Toxicity*
> *All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Compliance with this objective will be determined by analyses of indicator organisms, species diversity, population density, growth anomalies, and biotoxicity tests of appropriate duration or other methods as specified by the Regional Water Board. The Regional Water Board will also consider all material and relevant information submitted by the discharger and other interested parties and numerical criteria and guidelines for toxic substances developed by the State Water Board, the California Office of Environmental Health Hazard Assessment, the California Department of Health Services, the U.S. Food and Drug Administration, the National Academy of Sciences, the U.S. Environmental Protection Agency, and other appropriate organizations to evaluate compliance with this objective. The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water quality factors shall not be less than that for the same water body in areas unaffected by the waste discharge, or, when necessary, for other control water that is consistent with the requirements for "experimental water" as described in Standard Methods for the Examination of Water and Wastewater, latest edition. As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour bioassay. In addition, effluent limits based upon acute biotoxicity tests of effluents will be prescribed where appropriate; additional numerical receiving water quality objectives for specific toxicants will be established as sufficient data become available; and source control of toxic substances will be encouraged."*

The toxicity reported herein is a violation of the CVRWQCB Basin Plan objective for protection of aquatic life from aquatic life toxicity. This toxicity has caused Five Mile Slough and Mosher Slough to be listed on the Clean Water Act 303(d) list of "impaired" waterbodies. This listing requires that a total maximum daily load (TMDL) be established to control the constituents responsible for the toxicity.

Water Quality Criteria/Standards as TMDL Goals. The current US EPA approach for establishing TMDL goals is to control the constituent that causes the 303(d) listing of the waterbody as being an "impaired" waterbody. Typically, the 303(d) listing arises out of an exceedance of a worst-case-based water quality standard. While the US EPA (1987) published a water quality criterion for chlorpyrifos, the Agency did not require that this criterion be adopted by the states as a standard since chlorpyrifos is not considered a "toxic" pollutant.

The US EPA has not developed a water quality criterion for diazinon. An Agency contractor has developed a proposed acute criterion; however, there are problems in developing the chronic criterion. The California Department of Fish and Game, however, using US EPA criteria development approaches, has developed recommended water quality criteria for diazinon and chlorpyrifos. Siepmann and Findlayson (2000) have recently completed an updated evaluation of the recommended water quality criteria for diazinon and chlorpyrifos. They recommend a freshwater diazinon acute criterion (CMC) of 80 ng/L and a chronic criterion (CCC) of 50 ng/L. No saltwater criteria were recommended for diazinon. They recommend a freshwater chlorpyrifos CMC of 20 ng/L and a CCC of 14 ng/L. The corresponding recommended chlorpyrifos saltwater CMC was 20 ng/L and CCC was 9 ng/L. They also indicate that the diazinon and chlorpyrifos toxicities are additive.

Implementation of these criteria as worst case water quality standards which are not to be exceeded by any amount more than once in three years would likely mean that neither diazinon nor chlorpyrifos could be used on residential properties where there is any possibility of runoff from the property that has either of these OP pesticides in the runoff waters.

Strauss (2000) has indicated that the Fish and Game criteria would be acceptable TMDL goals to the US EPA Region IX.

SUMMARY OF RESULTS

A summary of the data obtained in these studies is presented in Tables 1-8. The original data tables with some minor modifications from that developed by the UCD-ATL are included in the Appendix to this report. Also included in the Appendix is a brief discussion of the data pertinent to a particular sampling event.

The rainfall data reported in Table 9 was collected from the City of Stockton Metro as retrieved from www.ncdc.noaa.gov/onlineprod/gsod/temp/gsod_28393.txt. At times, precipitation can be highly localized, where the amount of precipitation collected at a particular gage may not be representative of the amount of precipitation that occurred at other locations within the City of Stockton. The rainfall record of data for Stockton indicates that there was no recording of rainfall data during weekends.

Tables 1-8 provide information on the toxicity test results and chemical analyses obtained in these studies for each of the dates for which samples were collected. The *Ceriodaphnia* data set "% Sample" column indicates whether there was any dilution of the sample or any additions such as PBO or EDTA. The "Toxic Response" column provides the percent kill information on the day indicated in parentheses. The "Comments" column provides a brief summary of the most outstanding feature of that particular data set. The "Diazinon" and "Chlorpyrifos" concentrations are based on the ELISA testing where the < value was the indicated detection limit of the test. The "Calculated TUa" column represents a value obtained by dividing the concentration of diazinon or chlorpyrifos by the LC_{50} value and summing the two quotients. For diazinon a *Ceriodaphnia* LC_{50} value of 450 ng/L was used. For chlorpyrifos, the LC_{50} value that was used was 80 ng/L.

For the fathead minnow larvae tests, the "% Mortality" is provided with a comment as to whether it was statistically significant. The *Selenastrum* tests were summarized in terms of whether there was a toxic response based on a decrease in the number of *Selenastrum* cells in the test samples compared to the control. The "Comment" section indicates whether the algae in the test samples grew to a greater degree than the reference, indicating a "stimulation" of growth by nutrients in the samples.

CONCLUSIONS

The overall conclusions from the City of Stockton urban stormwater runoff aquatic life toxicity studies of Mosher Slough, Five Mile Slough, Calaveras River, Walker Slough, and Smith Canal (waterbodies) are presented below.

- Stormwater runoff to the investigated waterbodies causes the waterbody to be toxic to *Ceriodaphnia*.
- Typically, one to two acute toxic units (TUa) were present in the waterbodies during a stormwater runoff event.
- The concentrations of diazinon and chlorpyrifos found in Stockton slough and other waterbodies investigated in this study following stormwater runoff events frequently exceeded the California Department of Fish and Game recommended criteria for these pesticides. This exceedance would cause these waterbodies to be in violation of a TMDL goal for the control of aquatic life toxicity caused by these pesticides that was numerically equal to the California Department of Fish and Game criterion.
- Samples taken the day after a stormwater runoff event were nontoxic and had low levels of OP pesticides.
- Stormwater runoff to these waterbodies did not cause toxicity to fathead minnow larvae or the alga *Selenastrum*. Typically, samples of the waterbodies during stormwater runoff stimulated the growth of the test alga.
- Based on toxicity investigation evaluations (TIEs), PBO and ELISA testing, diazinon is the chemical primarily responsible for the observed toxicity. Some samples had sufficient chlorpyrifos concentrations to contribute to the toxicity found.
- Based on limited TIE studies utilizing EDTA to complex the heavy metals, heavy metals do not appear to be a contributor to the aquatic life toxicity found.
- Samples of precipitation taken in Stockton in 1996 showed concentrations of diazinon and chlorpyrifos well below toxic levels for *Ceriodaphnia*.
- There is some indication of possible pyrethroid pesticide toxicity as indicated by PBO enhanced toxicity.
- Urban stormwater runoff monitoring conducted by the City of Stockton during 1995-1998 shows *Ceriodaphnia* toxicity
- Studies conducted by the DeltaKeeper and UCD-ATL during the fall and winter of 1998-1999 of the various Stockton Sloughs and rivers show that stormwater runoff was toxic to *Ceriodaphnia* due to OP pesticides.
- The Stockton stormwater runoff associated toxicity to zooplankton may be having an adverse impact on the dissolved oxygen concentrations in the Stockton sloughs, as well as in the San Joaquin River Deep Water Ship Channel, as a result of killing zooplankton in the sloughs, Ship Channel and San Joaquin River that normally graze phytoplankton. The lack of grazing due to toxicity to zooplankton could be responsible for phytoplankton blooms that lead to DO depletion in the sloughs and Deep Water Ship Channel below water quality objectives.
- The aquatic life toxicity found in City of Stockton stormwater runoff is similar to what has been found in urban stormwater runoff in the San Francisco Bay region, Sacramento area, Orange County, Los Angeles and San Diego (Lee and Taylor 1999, 2001).
- There is need for the CVRWQCB to consider adding the other Stockton sloughs and waterbodies investigated in this study to the 303(d) list of impaired waterbodies because of the aquatic life toxicity found.

RECOMMENDATIONS FOR FUTURE WORK

Presented below are recommendations for future studies and programs that need to be evaluated and, if appropriate, implemented.

- There is need to evaluate the contribution of agricultural stormwater runoff to the aquatic life toxicity present in the City of Stockton waterbodies that receive agricultural runoff/drainage from upstream sources.

- There is need to evaluate the potential for enhanced toxicity due to OP pesticides associated with low dissolved oxygen concentrations in the waterbodies and downstream.
- There is need to understand the dry weather flow toxicity to young fathead minnows (not larvae) that the DeltaKeeper is finding in caged fathead minnows placed in the waterbodies near City of Stockton stormwater sewer discharges.
- There is need to evaluate the water quality/ecological significance of periodic toxic pulses associated with stormwater runoff events within the City of Stockton on the sloughs' aquatic resources and the nearby Delta aquatic resources. The slough backwater areas could be important nursery grounds for Delta fish that are being adversely impacted by current OP pesticide-caused aquatic life toxicity.
- There is need to determine whether the toxicity of fall stormwater runoff events kills zooplankton in the San Joaquin River and/or Deep Water Ship Channel and thereby enables a greater algal bloom to occur than would occur if the zooplankton were able to graze the phytoplankton. If the zooplankton populations are depressed following a fall precipitation runoff event, then there is need to see if a phytoplankton bloom occurs which causes a greater DO depletion in the Deep Water Ship Channel than normally occurs during the fall.
- During the fall and winter of 1999, US EPA announced agreements which effectively phase out the use of the OP pesticides diazinon and chlorpyrifos in residential areas during 2001 for chlorpyrifos and by 2005 for diazinon. This situation means that the aquatic life toxicity due to the use of these pesticides in residential areas within Stockton will be significantly decreased, and possibly eliminated, within a few years. Since some uses of these pesticides will still be allowed, such as on golf courses and in agricultural pest control, it will be important to continue to monitor diazinon, chlorpyrifos and aquatic life toxicity in stormwater runoff within the City of Stockton and upstream of the City's sources that receive agricultural stormwater runoff and irrigation tailwater.
- Since the phase-out of residential use of diazinon and chlorpyrifos will result in the use of other pesticides that have the potential to be present in stormwater runoff, it will be important to determine what pesticides are being used on residential properties, the amounts used, how and where they are being applied and the concentrations present in stormwater runoff. Also, the aquatic life toxicity of stormwater runoff to Stockton sloughs should be monitored on a regular basis, using the US EPA standard three species tests to evaluate how the toxicity of the runoff changes as diazinon and chlorpyrifos are phased out of urban residential use and new pesticides are used in their place. It is possible that this substitution of pesticides could cause significantly greater adverse impacts to the aquatic life-related beneficial uses of Stockton sloughs and the nearby associated Delta waters than were caused by the OP pesticides diazinon and chlorpyrifos.
- There is need to evaluate the possible control of OP pesticide-and other/substitute pesticide-caused aquatic life toxicity in Stockton stormwater runoff. Consideration should be given to public education as a means of controlling both residential and agriculturally-derived pesticide-caused aquatic life toxicity.
- There is need to understand how the use of pesticides in residential areas for termite and ant control and lawn and garden pest control leads to stormwater runoff that is toxic to *Ceriodaphnia*.
- There is need to evaluate the effectiveness of education programs in reducing the amounts of pesticides and aquatic life toxicity in City of Stockton waterbodies. Also, consideration should be given to assessing the improvements in the aquatic life-related beneficial uses that could result from controlling the use of pesticides within the City of Stockton that causes aquatic life toxicity in the City's waterbodies and nearshore regions of the Delta.

ACKNOWLEDGMENTS

Dr. Val Connor of the Central Valley Regional Water Quality Control Board planned many of these studies. Her assistance in obtaining these data and in this project is appreciated. The assistance of Bryan Stafford and Karen Larsen of the CVRWQCB staff is appreciated.

All samples except those collected by the Stockton Stormwater monitoring program were processed by the University of California, Davis, Aquatic Toxicology Laboratory. The assistance of Linda Deanovic, Stephanie Fong and Karen Larsen of the UCD ATL is greatly appreciated. The DeltaKeeper (Bill Jennings) and its staff were responsible for sample collection during 1996–1999. The assistance of Bill Jennings in providing information for the development of this report is appreciated.

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Table 1. Summary of Aquatic Toxicity Test Data
Mosher Slough, Stockton, CA (1994-1999)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
2/6/94	100	100 (1)		900	--	2
2/6/94	100	100 (1)		--	--	
2/6/94	100+200µg/L PBO	20 (2)	PBO reduced toxicity	--	--	
2/7/94	100	100 (1)		630	--	1.2
2/7/94	100	100 (1)		--	--	
2/7/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
10/5/94	100	100 (2)		459	<80	1
10/5/94	100	100 (3)		--	--	
10/5/94	100	50 (2)		--	--	1 to 2
10/5/94	50	0 (4)		--	--	
10/5/94	100+200µg/L PBO	10 (4)	PBO reduced toxicity	--	--	
11/6/94	100	100 (2)		--	--	
11/6/94	100	100 (3)		499	<80	1
11/6/94	100+200µg/L PBO	0 (4)	PBO reduced toxicity	--	--	
5/3/95	100	100 (2)	At Don Ave.	417	120	2
5/3/95	100+200µg/L PBO	0 (4)	PBO reduced toxicity	--	--	
10/29/96	100	100 (7)	No information on kill rate	486	103	2
10/29/96	100+200µg/L PBO	100 (7)		--	--	
10/29/96	100	100 (1)	(H36)	--	--	
10/29/96	50	80 (4)		--	--	
10/29/96	50+100µg/L PBO	0 (4)	PBO reduced toxicity	--	--	
10/29/96	50+200µg/L PBO	13 (4)	PBO activated toxicity	--	--	
10/29/96	25	0 (4)		--	--	2 to 4
10/29/96	25+100µg/L PBO	0 (4)		--	--	
10/29/96	25+200µg/L PBO	77 (3)	PBO activated toxicity	--	--	
10/29/96	12.5	7 (4)		--	--	
10/29/96	100+15mg/L EDTA	93 (4)	Not metal toxicity	--	--	
10/29/96	100+30mg/L EDTA	100 (1)		--	--	
11/16/96*	100		At Kelley Drive	640 830	80 120	2 2.5
11/16/96*	100		At Thornton Road	760	70	2
11/10/97*			At Thornton Road	1,500	100	3
11/10/97*	100	6.0 TUa	At Kelley Drive	2,300	150	6

(continues)

Table 1. Summary of Aquatic Toxicity Test Data Mosher Slough, Stockton, CA (1994-1999) (continued)

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
11/10/97*	100+125µg/L PBO	1.6 TUa	At Thornton Road PBO reduced toxicity	--	--	
11/13/97	100	100 (3)		461	59	2
11/13/97	100+ 100 µg/L PBO	90 (3)		--	--	
1/14/98*			at Kelley Drive	830	<500	--
1/14/98*			at Thornton Road	360J	<500	--
2/19/98*			at Kelley Drive	430J	<500	--
2/19/98*			at Thornton Road	320J	<500	--
9/9/98	100	0 (7)		--	--	
10/24/98	100	100 (3)	At Mariner	310	--	
10/24/98	100+ 100 µg/L PBO	20 (7)		--	--	
12/7/98	100	60 (7)		--	--	
12/7/98	100	90 (7)		--	--	
12/7/98	100+ 100 µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
1/20/99	100	100 (1)		--	--	
1/20/99	100+100 µg/L PBO	100 (6)	PBO slowed kill rate	--	--	
1/20/99	100	100 (1)	At I-5	1,200	50	3
1/20/99	100	100 (1)	At Don Ave	--	--	
2/8/99	100	100 (1)	At I-5	820	40	
2/8/99	100+ 100 µg/L PBO	0 (4)	At I-5	--	--	
2/8/99	50	100 (2)	At I-5	--	--	
2/8/99	25	0 (4)	At I-5	--	--	
2/8/99	25+ 100 µg/L PBO	0 (4)	At I-5	--	--	
2/8/99	12.5	0 (4)	At I-5	--	--	
2/8/99	100	100 (1)	At Don Ave	860	30	
2/8/99	100+ 100 µg/L PBO	5 (3)	At Don Ave; PBO reduced toxicity	--	--	
2/8/99	50	100 (1)		--	--	
2/8/99	25	0 (4)		--	--	
2/8/99	25+ 100 µg/L PBO	0 (4)		--	--	
9/22/99	100	100 (3)				
9/22/99	100+100 µg/L PBO	20	PBO reduced toxicity			

* – City of Stockton data
J – Estimated < detection limit
-- – Not measured

(table continues)

Table 1. Summary of Aquatic Toxicity Test Data
Mosher Slough, Stockton, CA (1994-1999) (continued)

Fathead Minnow Larvae

Date	% Mortality	Comment
10/5/96	0	
10/29/96	5	Not statistically significant
11/13/97	22	Not statistically significant
9/9/98	0	
10/24/98	2.5	Not statistically significant
12/7/98	0	
2/8/99	5	at I-5; Not statistically significant
2/8/99	10	at Don Ave; Not statistically significant

Selenastrum capricornutum

Date	Toxic Response	Comment
10/5/94	No	Stimulation
11/6/94	No	
10/29/96	No	Stimulation
11/13/97	No	
9/9/98	No	Stimulation
10/24/98	No	Stimulation
12/7/98	No	
1/20/99	No	
2/8/99	Yes	At I-5
2/8/99	Yes	At Don Ave

Table 2. Summary of Aquatic Toxicity Test Data
Five Mile Slough, Stockton, CA (1994-1998)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
2/6/94	100	100 (2)		1,000	--	2
2/6/94	100	100 (1)		--	--	
2/6/94	100+200µg/L PBO	80 (4)	PBO reduced toxicity	--	--	
2/7/94	100	100 (1)		>1,000	--	> 2
2/7/94	100	100 (1)		1,200	--	2.5
2/7/94	100+200µg/L PBO	20 (4)	PBO reduced toxicity	--	--	
10/5/94	100	100 (2)		278	<80	0.5
10/5/94	100	100 (3)		--	--	
10/5/94	50	0 (4)	Between 1 and 2 TUa	--	--	
10/5/94	100+200µg/L PBO	60 (7)	PBO reduced toxicity	--	--	
11/6/94	100	0 (4)		80	<80	1
10/29/96	100	100 (7)	No information on rate of kill	304	84	1.5
10/29/96	100+100µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
11/13/97	100	100 (5)		359	52	2
11/13/97	100+100µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
10/24/98	100	0 (7)		--	--	
10/24/98	100+100µg/L PBO	10 (7)		--	--	
9/22/99	100	100 (7)				
9/22/99	100+100µg/L PBO	0				

-- – Not measured

Fathead Minnow Larvae

Date	% Mortality	Comment
10/5/94	7	Not statistically significant
10/29/96	42	Not statistically significant
11/13/97	75	Statistically significant
10/24/98	0	

Selenastrum capricornutum

Date	Toxic Response	Comment
10/5/94	No	Stimulation
11/6/94	No	
10/29/96	No	Stimulation
11/13/97	No	Stimulation
10/24/98	No	Stimulation

Table 3. Summary of Aquatic Toxicity Test Data
Calaveras River, Stockton, CA (1994-1998)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
2/6/94	100	100 (2)		380	--	0.8
2/6/94	100	100 (2)		--	--	
2/6/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
2/7/94	100	100 (2)		450	--	1
2/7/94	100	100 (2)		--	--	
2/7/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
10/5/94	100	100 (4)		299	<80	0.5
10/5/94	100	100 (4)		--	--	
10/5/94	100+100µg/L PBO	5 (6)	PBO reduced toxicity	--	--	
11/6/94	100	0 (4)		199	88	1.5
10/29/96	100	0 (7)	TUa could not be calculated	36	<50	
10/29/96	100+100µg/L PBO	0 (7)			--	
11/16/96*			At Sutter Street	640	<50	
11/16/96*			At West Lane	170	<50	
1/22/97*			At Sutter Street	130	70	
1/22/97*			At West Lane	210 200	100 90	
11/10/97*			At Sutter Street	480	<50	
11/10/97*	100	<1.0TUa	At West Lane	380	<50	
11/10/97*	100+125µg/L PBO		At West Lane	--	--	
1/14/98*			At Sutter Street	320J	<500	
1/14/98*			At West Lane	310J	<500	
2/19/98*			At Sutter Street	<500	<500	
2/19/98*			At West Lane	<500	<500	
10/24/98	100	10 (7)	At Pershing	--	--	
10/24/98	100+100µg/L PBO	0 (7)		--	--	

* - City of Stockton data
J – Estimated < detection limit
-- – Not measured

(continues)

Table 3. Summary of Aquatic Toxicity Test Data
Calaveras River, Stockton, CA (1994-1998) (continued)

Fathead Minnow Larvae

Date	% Mortality	Comment
10/5/94	0	
10/29/96	2	Not statistically significant
10/24/98	2	Not statistically significant

Selenastrum capricornutum

Date	Toxic Response	Comment
10/5/94	No	
11/6/94	No	Stimulation
10/29/96	No	Stimulation
10/24/98	No	Stimulation

Table 4. Summary of Aquatic Toxicity Test Data
Walker Slough, Stockton, CA (1994-1998)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-Pyrifos (ng/L)	Calculated TUa
10/5/94	100	100 (7)	No information on rate of kill	273	<80	0.5
11/6/94	100	0 (4)	TUa could not be calculated	<30	<80	
12/11/95	100	100 (2)	White light	--	--	
12/11/95	100	100 (2)	UV light	--	--	
12/11/95	80	100 (3)		--	--	
12/11/95	60	100 (4)		--	--	
12/11/95	40	64 (7)		--	--	
12/11/95	20	0 (7)		--	--	4 to 5
10/29/96	100	0 (7)		96	65	1
10/29/96	100+100µg/L PBO	0 (7)		--	--	
11/16/96*			At Western Pacific Industrial Park	470	<50	
1/22/97*			At Western Pacific Industrial Park	150	90	
11/10/97*	100	<1.0 TUa	At Western Pacific Industrial Park	<50	<50	
11/10/97*	100+125µg/L PBO	<1.0 TUa	At Western Pacific Industrial Park	--	--	
1/4/98*			At Western Pacific Industrial Park	<320J	<500	
2/19/98*			At Western Pacific Industrial Park	<500	<500	
9/9/98	100	0 (7)			--	
10/24/98	100	100 (2)		170	--	
10/24/98	100+100µg/L PBO	0 (7)		--	--	
12/7/98	100	0 (7)		--	--	

* – City of Stockton data
J – Estimated < detection limit
-- – Not measured

(continues)

Table 4. Summary of Aquatic Toxicity Test Data
Walker Slough, Stockton, CA (1994-1998) (continued)

Fathead Minnow Larvae

Date	% Mortality	Comment
10/5/94	0	Impaired growth
10/29/96	0	
9/9/98	5	Not statistically significant
10/24/98	10	Not statistically significant
12/7/98	0	

Selenastrum capricornutum

Date	Toxic Response	Comment
10/5/94	No	
11/6/94	No	Stimulation
10/29/96	No	Stimulation
9/9/98	No	Stimulation
10/24/98	No	Stimulation
12/7/98	No	
12/7/98	Yes	
12/7/98	No	
12/14/98	No	

Table 5. Summary of Aquatic Toxicity Test Data
Smith Canal, Stockton, CA (1994-1998)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-Pyrifos (ng/L)	Calculated TUa
11/6/94	100	100 (7)	No information on rate of kill	186	122	1.5
11/8/96	100	0 (7)	TUa could not be calculated	<30	<80	
11/6/94	100	100 (6)		--	--	
11/6/94	100+100µg/L PBO	87 (7)	PBO caused delayed mortality	--	--	
11/9/94	100	100 (7)		166	<80	0.25
11/9/94	100	??		--	--	
11/9/94	100+200µg/L PBO	0 (7)		--	--	
11/25/94	100	20 (7)		106	<80	0.25
12/4/94	100	0 (7)	TUa could not be calculated	<30	<80	
3/11/95	100	100 (7)		--	--	
3/11/95	100+200µg/L PBO	20 (3)	PBO reduced toxicity	--	--	
10/29/96	100	100 (7)		129	<30	0.25
10/29/96	100+100µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
10/24/98	100	0 (7)-?	At Pershing	--	--	
10/24/98	100+100µg/L PBO	0 (7)		--	--	

-- – Not measured

Fathead Minnow Larvae

Date	% Mortality	Comment
11/6/94	7	Not statically significant
1/25/94	7	Not statically significant
12/4/94	0	
10/29/96	2	Not statistically significant
10/24/98	0	

Selenastrum capricornutum

Date	Toxic Response	Comment
11/6/94	No	
11/8/94	No	Stimulation
11/19/94	No	Stimulation
11/25/94	No	Stimulation
12/4/94	No	Stimulation
10/24/98	No	Stimulation

Table 6 Summary of Aquatic Toxicity Test Data Mormon Slough, Stockton, CA (1994)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
2/6/94	100	100 (6)		320	--	0.8
2/6/94	100	100 (7)		--	--	
2/6/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
2/7/94	100	100 (1)		900	--	2
2/7/94	100	100 (1)		--	--	
2/7/94	100+200µg/L PBO	100 (2)	PBO reduced toxicity	--	--	

-- – Not measured

Table 7. Summary of Aquatic Toxicity Test Data Lake McLeod, Stockton, CA (1994)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
2/6/94	100	100 (6)		200	--	< 0.5
2/6/94	100	100 (6)		--	--	
2/6/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	
2/7/94	100	100 (2)		500	--	1
2/7/94	100	100 (2)		--	--	
2/7/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	

-- – Not measured

Table 8. Summary of Aquatic Toxicity Test Data Turning Basin, Stockton, CA (1994)

Ceriodaphnia

Date	% Sample	Toxicity Response %kill in (days)	Comments	Diazinon (ng/L)	Chlor-pyrifos (ng/L)	Calculated TUa
2/6/94	100	0 (7)		190	--	< 0.5
2/6/94	100	0 (7)		--	--	
2/6/94	100+200µg/L PBO	0 (7)		--	--	
2/7/94	100	100 (1)		600	--	1
2/7/94	100	100 (1)		--	--	
2/7/94	100+200µg/L PBO	0 (7)	PBO reduced toxicity	--	--	

-- – Not measured

Table 9
City of Stockton Precipitation Data for Sampling Events

Date	Precipitation
2/7/94	0.08
10/5/94	0.42
10/6/94	0.00
11/8/94	0.00
11/9/94	0.00
11/25/94	0.33
3/2/95	0.08
4/27/95	0.04
4/28/95	0.00
4/29/95	0.00
5/1/95	0.33
5/3/95	0.00
12/11/95	0.00
10/29/96	1.28
11/16/96	0.60
11/17/96	1.06
11/18/96	0.71
1/22/97	0.28
11/10/97	0.20
11/13/97	0.12
1/4/98	0.24
1/14/98	0.04
2/19/98	0.08
9/9/98	0.00
10/24/98	0.67
12/7/98	0.00
12/12/98	0.00
1/19/99	0.56
1/20/99	0.00
2/8/99	0.16
3/8/99	0.20
6/7/99	0.00
6/16/99	0.00
8/18/99	0.00
9/22/99	0.24

Source: Stockton Metro precipitation gage, as reported at www.ncdc.noaa.gov/onlineprod/gsod/temp/gsod_28393.txt

Appendix
Background Data for City of Stockton Slough Aquatic Toxicity Testing

Beginning in February 1994, the Central Valley Regional Water Quality Control Board (CVRWQCB), under the leadership of Dr. Val Connor, initiated studies on the aquatic life toxicity of Stockton urban stormwater runoff. Samples were taken of various Stockton sloughs, typically during runoff events. These samples were transported to the University of California, Davis, Aquatic Toxicology Laboratory, where toxicity testing was conducted using the test organisms *Ceriodaphnia dubia, Pimephales promelas* (fathead minnow larvae) and *Selenastrum capricornutum.* The CVRWQCB collected stormwater runoff during 1995. Beginning in 1996 the DeltaKeeper collected stormwater runoff samples through 1999. The results of the toxicity tests are presented in this Appendix. A brief summary of the key features of each of the toxicity test results is presented below. A list of acronyms and abbreviations used in the tables is presented at the end of this Appendix.

February 1994

On February 7, 1994, 0.08 inch of precipitation was recorded in Stockton. Table 94-1 presents the results of the toxicity testing and chemical analyses that were conducted on the Stockton area stormwater runoff samples collected on February 6 and 7, 1994. Seven-day toxicity tests were conducted on these samples, where 100 µg/L PBO were added to one of the tests and no PBO was added to the other. The Mosher Slough samples collected on February 6 and 7, 1994, contained 900 and 630 ng/L diazinon, respectively. As expected, these samples killed 100 percent of the *Ceriodaphnia* organisms within one day. The addition of 100 µg/L PBO eliminated the toxicity over the 7-day period for the February 7 sample, and reduced it to only 20 percent kill on the February 6 sample.

The Five Mile Slough samples collected on February 6 and 7 had 1,000 ng/L diazinon on February 6, and greater than 1,000 ng/L on February 7. Both samples were highly toxic to *Ceriodaphnia*, with 100 percent kill in 2 days on the February 6 sample and 100 percent kill in 1 day on the February 7 sample. The addition of 100 µg/L PBO reduced the rate of kill, so that 100 percent kill was not achieved until 5 days for both the February 6 and 7 samples.

The samples collected of the Calaveras River on February 6 and 7 had 380 ng/L diazinon on February 6 and 450 ng/L diazinon on February 7. Both samples killed all *Ceriodaphnia* in the test system within 2 days. The addition of 100 µg/L PBO eliminated the toxicity from the February 7 sample and reduced the toxicity to 20 percent kill on the February 6 sample.

The Mormon Slough sample collected on February 6 had 320 ng/L diazinon. This sample did not show 100 percent kill until the seventh day of testing. The February 7 sample from Mormon Slough had 900 ng/L diazinon, and, as expected, there was 100 percent kill of *Ceriodaphnia* within 1 day.

The Lake McLeod sample, located in downtown Stockton, had 200 ng/L diazinon, which killed 100 percent of the *Ceriodaphnia* in 6 days. The February 7 sample had 500 ng/L diazinon and killed all *Ceriodaphnia* within 2 days.

The Port of Stockton Turning Basin sample collected February 6 had 190 ng/L diazinon, and this sample was nontoxic to *Ceriodaphnia* over the 7-day test period. On February 7, the Turning Basin sample was found to contain 600 ng/L diazinon, and killed 100 percent of the *Ceriodaphnia* within 1 day. The addition of 100 µg/L PBO essentially eliminated this toxicity, where on days 4 through 7 there was only 20 percent kill of *Ceriodaphnia* in the test system.

The results of the February 6-7 sampling show that high concentrations of diazinon were present in stormwater runoff in City of Stockton sloughs and associated waters, including the Calaveras River. The diazinon concentrations found produced the toxicity expected, with rapid kill of *Ceriodaphnia* within 1 to 2 days when the concentrations were greater than about 450 ng/L (i.e., the LC_{50} value for diazinon's toxicity to *Ceriodaphnia*). The addition of 100 µg/L of PBO to the samples showed that, in general, the toxicity to *Ceriodaphnia* was essentially eliminated. It is of interest to find that the February 6-7, 1994, samples had among the highest concentrations of diazinon found in the 5-year study reported herein.

Table 94-1
Stockton Stormwater Runoff Toxicity to *Ceriodaphnia*
Collected on February 6 and 7, 1994

			Percent Organism Mortality Days of Incubation							
Treatment/ Location/Date	**PBO add**	**Diazinon ng/L**	**1**	**2**		**3**	**4**	**5**	**6**	**7**
				% kill	**pH**					
SSEPAMH			0	0		0	0	0	15	15
	+PBO		0	0		0	0	0	0	0
Dilute EI			0	0		0	0	0	0	0
	+PBO		0	0		0	0	0	0	0
Mosher Slough	2/6	900	100							
2/6	+PBO		0	20		20	20	80	80	80
Mosher Slough	2/7	630	100		7.8					
2/7	+PBO		0	0		0	0	0	0	0
5-Mile Slough	2/6	1000	80	100						
2/6	+PBO		0	0		20	20	100		
5-Mile Slough	2/7	>1000	100		7.9					
2/7	+PBO		0	0		0	80	100		
Calaveras River	2/6	380	0	100						
2/6	+PBO		0	0		20	20	20	20	20
Calaveras River	2/7	450	0	100	8.3					
2/7	+PBO		0	0		0	0	0	0	0
Mormon Slough	2/6	320	0	0		15	15	20	95	100
2/6	+PBO		0	0		0	0	0	0	0
Mormon Slough	2/7	900	100		8.3					
2/7	+PBO		60	100						
Lake McLeod	2/6	200	0	0		0	0	0	100	
2/6	+PBO		0	0		0	0	0	0	0
Lake McLeod	2/7	500	0	100	8.4					
2/7	+PBO		0	0		0	0	0	0	0
Turning Basin	2/6	190	0	0		0	0	0	0	0
2/6	+PBO		0	0		0	0	0	0	0
Turning Basin	2/7	600	100	0	8.4					
2/7	+PBO		0	0		0	20	20	20	20

PBO added at 100 µg/L

October 1994

On October 5, 1994, 0.42 inch of precipitation was recorded in Stockton. There was no precipitation recorded in Stockton on October 6, 1994. Samples of Five-Mile Slough, Calaveras River,

Mosher Slough and Walker Slough were collected on October 5 and 6, 1994. Table 94-2 presents the results of an 8-day toxicity test using *Ceriodaphnia* as the test organism. The results of these tests show that both Five-Mile Slough and Mosher Slough samples killed all *Ceriodaphnia* in two days, while the Calaveras River sample killed all *Ceriodaphnia* in the test system in four days, and Walker Slough, in seven days.

Table 94-2
Stockton Urban Run-off 10/5/94 and 10/6/94
8-day *Ceriodaphnia* Test[1,2]

Set up on 10/6/94

Treatment	Reproduction[3] (neonates/adult)		Mortality (%)	Final pH @ 24 hrs
	mean	standard error		
Dilute EI	38.6[P]	1.5	0.0[P]	8.5
SSEPAMH	28.7	2.3	0.0	8.4
Five Mile Slough	0.0	0.0	100 (2)	7.7
Calaveras River	1.2	0.6	100 (4)	7.9
Mosher Slough	0.0	0.0	100 (2)	7.9
Walker Slough	14.9	1.5	100 (7)	8.3

P. The dilute EI control met all US EPA criteria for test acceptability. 100% of the daphnids had a third brood.
1. Ten replicates with 15 ml of sample and one *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
3. Highlighted areas indicate a significant reduction in reproduction or increase in mortality relative to the dilute EI control water. The reproductive endpoint was analyzed using Dunnett's Test ($p<0.05$) and the mortality endpoint was analyzed using Fisher's Exact Test.

(#) Number in parenthesis denotes days to 100% mortality

Table 94-3 presents the results of a 4-day *Ceriodaphnia* dilution series for the Five-Mile Slough and Mosher Slough waters obtained on October 5, 1994. The Five-Mile Slough and Mosher Slough undiluted samples showed 40 to 50 percent kill within two days and 100 percent kill within three days. No toxicity, however, was observed on the 50 percent sample, 25 percent sample or 12.5 percent sample. These results indicate that there was between 1 to 2 TUa of acute *Ceriodaphnia* toxicity in the Five-Mile Slough and Mosher Slough samples obtained on October 5, 1994.

Table 94-3
Five Mile Slough and Mosher Slough 10/5/94
4-day *Ceriodaphnia* Dilution Series[1,2]

Set up on 10/17/94

Treatment (%Sample Water)	% Mortality for each day of the test[3]				Final pH @ 48hrs
	1	2	3	4	
Dilute EI				0[P]	8.4
Five Mile Slough (12.5%)				0	8.3
Five Mile Slough (25%)				0	8.2
Five Mile Slough (50%)				0	8.1
Five Mile Slough (100%)		40	100	100	8.0
Mosher Slough (12.5%)				0	8.3
Mosher Slough (25%)				0	8.2
Mosher Slough (50%)				0	8.1
Mosher Slough (100%)		50	100	100	8.1

P. The dilute EI control met all US EPA criteria for test acceptability.
1. Two replicates with 18 ml of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.

Table 94-4 presents the data of a 7-day *Ceriodaphnia* Phase I TIE testing, in which Five-Mile Slough and the Calaveras River samples were subjected to various modified testing procedures. One of these involved the addition of 200 µg/L of piperonyl butoxide (PBO). Table 94-4 shows that the addition of the PBO to the Five-Mile Slough unfiltered sample decreased the toxicity over seven days from 100 percent kill without PBO to 65 percent with PBO. The filtered Five-Mile Slough sample with 200 µg/L PBO also showed a reduced toxicity – in this case, of about 74 percent over seven days. These results are indicative of OP pesticides being potentially responsible for at least part of this toxicity. The filtered Calaveras River samples with 200 µg/L PBO added showed a significant reduction in toxicity compared to the samples without PBO. There was a small difference – probably not statistically significant – depending on whether or not the sample was filtered. Mosher Slough samples also showed a significant decrease in toxicity in the presence of 200 µg/L PBO.

Table 94-4
Stockton Urban Run-off 10/5/94 and 10/6/94
7-day *Ceriodaphnia* Phase I TIE[1,2]

Set up on 10/9/94

Treatment	% Mortality for each day of the test[3]							Conclusions	Final pH @ 48 hrs
	1	2	3	4	5	6	7		
Dilute EI unfiltered				5	5.3	5.5	5.5	Control met US EPA criteria for test acceptability.	8.6
Dilute EI filtered							0	No artifactual toxicity in control blanks.	-
Dilute EI unfiltered + 200 µg/L PBO				5	5	10	10		8.5
Dilute EI filtered + 200 µg/L PBO			5	5	10	10	15		8.6
Five Mile Slough unfiltered	20	100	100	100	100	100	100	Toxicity detected.	8.2
Five Mile Slough filtered		100	100	100	100	100	100		8.1
Five Mile Slough unfiltered + 200 µg/LPBO		5	10	20	50	50	65	The delay in mortality suggests that an OP pesticide may be responsible, in part, for toxicity. However, high mortality suggests a second toxicant may also exist.	7.9
Five Mile filtered + 200 µg/L PBO		5	5	15.8	42.1	73.7	73.7		8.0
Calaveras River unfiltered		5	95	100	100	100	100	Toxicity detected.	8.4
Calaveras River filtered			100	100	100	100	100		8.3
Calaveras River unfiltered + 200 µg/L PBO						5	15	Decrease in mortality relative to ambient water suggests that an OP pesticide is responsible for the toxicity.	8.2
Calaveras River filtered + 200 µg/L PBO			5	5	5	5	5		8.2
Mosher Slough unfiltered	5	100	100	100	100	100	100	Toxicity detected.	8.3
Mosher Slough filtered		100	100	100	100	100	100		8.4
Mosher Slough unfiltered + 200 µg/L PBO			5	10	10	10	10	Decrease in mortality relative to ambient water suggests that an OP pesticide is responsible for the toxicity.	8.2
Mosher Slough filtered + 200 µg/L PBO							0		8.2

1. Three replicates with 18 ml of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.

The Five-Mile Slough sample taken on October 5, 1994, was subjected to a 6-day *Ceriodaphnia* Phase II TIE, in which the sample was passed through a C8 column, and the toxicity of the eluate was determined. The results of this testing are shown in Table 94-5. The fractions obtained from various methanol (MeOH) eluates of the column show that the toxicity was eluded in certain fractions from 70 to 80 percent. This experiment shows that the toxicant elutes in fractions 70, 75, and 80% (percent methanol by volume). This suggests possible diazinon and/or chlorpyrifos as the toxicant(s). Diazinon elutes in fractions 70, 75, and 80% and chlorpyrifos elutes in fractions 75, 80, and 85%.

Table 94-5
Five Mile Slough 10/5/94
6-day *Ceriodaphnia* Phase II TIE[1,2]

Set up on 11/2/94

Treatment[4]	% Mortality for each day of the test[3]							Conclusions	Final pH @ 48 hrs
	1	2	3	4	5	6	7		
Dilute EI							0	Control met US EPA criteria for test acceptability.	7.5
Dilute EI + 1% MeOH							0	No artifactual toxicity in control blanks.	8.0
Dilute EI C8 Blank for 5-Mile Slough Column 1[4]							0		7.8
Dilute EI C8 Blank for 5-Mile Slough Column 2[4]							0		8.0
Dilute EI + 5-Mile 50% Fraction @ 4.67x							0	Toxicant(s) absent in this fraction.	8.0
Dilute EI + 5-Mile 70% Fraction @ 4.67x							40	Toxicant(s) present in these fractions.	8.1
Dilute EI + 5-Mile 75% Fraction @ 4.67x				30	100	100	100		8.1
Dilute EI + 5-Mile 80% Fraction @ 4.67x		20	60	60	90	100	100		8.1
Dilute EI + 5-Mile 85% Fraction @ 4.67x							0	Toxicant(s) absent in these fractions.	8.2
Dilute EI + 5-Mile 90% Fraction @ 4.67x					10	10	10		8.2
Dilute EI + 5-Mile 95% Fraction @ 4.67x							0		8.2
Dilute EI + 5-Mile 100% Fraction @ 4.67x							0		8.2

1. Two replicates with 18 ml of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. 600 ml and 800 ml of sample water were run through C8 SPE columns at a rate of 10 ml/min on 10/28/94 and 10/29/94, respectively. The two columns were extracted in series using 3.0 ml of MeOH to produce each fraction 467-times as concentrated as the ambient water.

Similar tests were conducted with Walker Slough samples. These data are presented in Table 94-6. This experiment implicates diazinon and chlorpyrifos as possible causes of toxicity (see explanation of Table 94-8 for fractions that diazinon and chlorpyrifos elute in). The Five Mile Slough part of the experiment was to determine if the column becomes overloaded with toxicant, becoming unable to capture any more after a certain amount of sample has been extracted. This experiment showed that at least for this Five-Mile Slough sample, the column did not become overloaded, as the latest extracted portion was still nontoxic.

Table 94-6

Five Mile Slough and Walker Slough 10/5/94 7-day *Ceriodaphnia* Phase II TIE[1,2]

Set up on 10/23/94

Treatment	No.[4]	% Mortality for each day of the test							Conclusions	Final pH @ 48 hrs
		1	2	3	4	5	6	7		
Dilute EI	4							0	Control met US EPA criteria for test acceptability.	8.1
Dilute EI + 1% MeOH	4					0 +			No artifactual toxicity in control blanks.	8.1
Dilute EI C8 Blank for 5-Mile Slough	4							0		8.1
Dilute EI C8 Blank for Walker Slough	4							0		8.1
5-Mile Slough settled	4	5	65	100	100	100	100	100	Toxicity detected.	7.9
1st 530 ml 5-Mile Slough PCCA[5]	4							0	Significant decrease in mortality relative to ambient water suggests that an organic is responsible for toxicity.	7.8
2nd 530 ml 5-Mile Slough PCCA	4						5	10		7.7
3rd 530 ml 5-Mile Slough PCAA	4							0		7.7
Walker Slough unfiltered	4			5	40	85	100	100	Toxicity detected.	7.0
Walker Slough filtered	4				5	20	95	95	Delay in mortality relative to unfiltered sample suggests that a toxicant may be sediment-bound.	7.4
Walker Slough filtered + 200µg/L PBO	4							0	Significant decrease in mortality relative to ambient water suggests that an OP is responsible for toxicity.	7.5
Walker Slough PCCA	4							0	Significant decrease in mortality relative to ambient water suggests that an organic is responsible for toxicity.	8.1
Dilute EI + Walker 50% fraction @5x	2					0+			Toxicant(s) absent in these fractions.	7.6
Dilute EI + Walker 70% fraction @5x	2					0+				7.7
Dilute EI + Walker 75% fraction @5x	2		40	100	100	100 +			Toxicant(s) present in these fractions. Accelerated mortality in the 75% fraction is consistent with diazinon toxicity.	7.8
Dilute EI + Walker 80% fraction @5x	2		10	30	50	100 +				7.9
Dilute EI + Walker 85% fraction @5x	2		10	10	20	50+				7.9
Dilute EI + Walker 90% fraction @5x	1	20	40	40	40	60+				8.0
Dilute EI + Walker 95% fraction @5x	2					0+			Toxicant(s) absent in these fractions.	8.0

Dilute EI + Walker 100% fraction @ 5x	2				20	20+				8.1

1. Each replicate had 18 ml of sample and five *Ceriodaphnia* each. Daphnids were fed the standard US EPA amt of food for only four hrs a d
2. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
3. 1800 ml of sample water were run through a C8 SPE column at a rate of 10 ml/min. The column was extracted using 3.0 ml MeOH to produce each fraction 600 times more concentrated than the ambient water.
4. Number of replicates per given treatment.
5. PCCA - Sample water Post C8 SPE Column Application

\+ These treatments were taken down at 5 days.

Calaveras River samples tested through Phase II TIEs are shown in Table 94-7. Again, similar results to the other Phase II TIEs were found. This experiment implicates diazinon as the primary toxicant in both the Calaveras and Mosher Slough samples (see above for fractions in which diazinon elutes); however, a significant amount of "bleeding" to other fractions occurred as evidenced by the mortality observed in several fractions besides those that diazinon elutes in. Diazinon may be the primary toxicant; however, this experiment does not rule out other possible toxicants.

Table 94-7
Calaveras River and Mosher Slough 10/5/94
4-day *Ceriodaphnia* Phase II TIE[1,2]

Set up on 10/18/94

Treatment	% Mortality for each day of the test[3]				Conclusions	Final pH@ 48hrs
	1	2	3	4		
Dilute EI				0	Control met US EPA criteria for test acceptability.	8.2
Dilute EI + 1% MeOH			10	10	No artifactual toxicity in control blank.	8.3
Dilute EI + Calaveras 50% fraction @ 5x				0	Toxicant(s) absent in this fraction.	8.1
Dilute EI + Calaveras 70% fraction @ 5x			50	50	Toxicant(s) present in these fractions. Accelerated mortality in the 75% fraction is consistent with diazinon toxicity	8.3
Dilute EI + Calaveras 75% fraction @ 5x	90	100	100	100		8.4
Dilute EI + Calaveras 80% fraction @ 5x		80	100	100		8.3
Dilute EI + Calaveras 85% fraction @ 5x			30	50		8.4
Dilute EI + Calaveras 90% fraction @ 5x				0	Toxicant(s) absent in these fractions.	8.4
Dilute EI + Calaveras 95% fraction @ 5x			10	10		8.4
Dilute EI + Calaveras 100% fraction @5x		20	30	40	Toxicant(s) absent in this fraction.	8.4
Dilute EI + Mosher 50% fraction @ 5x				0	Toxicant(s) absent in this fraction.	8.2
Dilute EI + Mosher 70% fraction @ 5x		80	100	100	Toxicant(s) present in these fractions. Accelerated mortality in the 75% fraction is consistent with diazinon toxicity	8.3
Dilute EI + Mosher 75% fraction @ 5x	100	100	100	100		-
Dilute EI + Mosher 80% fraction @ 5x	10	100	100	100		8.4
Dilute EI + Mosher 85% fraction @ 5x				0	Toxicant(s) absent in these fractions.	8.3
Dilute EI + Mosher 90% fraction @ 5x				0		8.4

Dilute EI + Mosher 95% fraction @ 5x			20	40	Toxicant(s) absent in this fraction.	8.4
Dilute EI + Mosher 100% fraction @ 5x		10	20	30	Toxicant(s) absent in this fraction.	8.4

1. Two replicates with 18 ml of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. 1800 ml of sample water were run through a C8 SPE column at a rate of 10 ml/min. The column was extracted using 3.0 ml of MeOH to produce each fraction 600 times more concentrated than the ambient water.

\- Dash indicates not measured.

Table 94-8 presents the Calaveras River and Mosher Slough test results for a Phase II TIE using *Ceriodaphnia*, in which various percent fractions were examined with and without PBO. It was found that the PBO did alter the toxicity pattern. This experiment is consistent with the previous one in that it shows evidence of a toxicant present other than an OP pesticide (diazinon).

Table 94-8
Calaveras River and Mosher Slough 10/5/94, 4-day *Ceriodaphnia* Phase II TIE[1,2]

Set up on 10/26/94

Treatment[4,5]	No.[6]	% Mortality for each day of the test[3]				Conclusions	Chlor-pyrifos (ng/L)	Diazinon (ng/L)	Final pH @ 48hrs
		1	2	3	4				
Dilute EI	4				5	Control met US EPA criteria for test acceptability.			8.0
Dilute EI + 1% MeOH	4				0	No artifactual toxicity in control blanks.			8.1
Dilute EI + 1% MeOH + 200µg/L PBO	4			5	5				8.1
Dilute EI + Calaveras 70% fraction @ 5x *	2		40	100	100	Toxicant(s) present in these fractions.	ND	241	8.0
Dilute EI + Calaveras 75% fraction @ 5x *	2		100	100	100		ND	391	8.1
Dilute EI + Calaveras 75% fraction @ 5x + 200µg/L PBO	2			20	100	The delay in mortality suggests an OP pesticide may, in part, be responsible for the toxicity. High mortality suggests a second toxicant may exist.			8.1
Dilute EI + Calaveras 80% fraction @ 5x *	2		30	70	100	Toxicant(s) present in this fraction.	ND	191	8.1
Dilute EI + Calaveras 80% fraction @ 5x + 200µg/L PBO	2			50	90	The delay in mortality suggests an OP pesticide may, in part, be responsible for the toxicity. High mortality suggests a second toxicant may exist.			8.1
Dilute EI + Calaveras 85% fraction @ 5x *	2		10	10	40	Toxicant(s) present in these fractions.	ND	ND	8.1
Dilute EI + Mosher 70% fraction @ 5x *	2		100	100	100			295	8.2
Dilute EI + Mosher 70% fraction @ 5x + 200µg/L PBO	2				0	Significant decrease in mortality suggests that an OP pesticide is responsible for toxicity.			8.0
Dilute EI + Mosher 75% fraction @ 5x *	2	100	100	100	100	Toxicant(s) present in this fraction.		538	8.3+
Dilute EI + Mosher 75% fraction @ 5x + 200µg/L PBO	2		100	100	100	The delay in mortality suggests an OP pesticide may, in part, be responsible for toxicity. High mortality suggests a second toxicant may exist.			8.0
Dilute EI + Mosher 80% fraction @ 5x *	2		60	100	100	Toxicant(s) present in this fraction.		317	8.1

Dilute EI + Mosher 80% fraction @ 5x + 200µg/L PBO	2			10	60	The delay in mortality suggests an OP pesticide may, in part, be responsible for the toxicity. High mortality suggests a second toxicant may exist.			8.1

1. Each replicate contained 18 ml of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. 1800 ml of sample water were run through a C8 SPE column at a rate of 10 ml/min. The column was extracted using 3 ml of MeOH to produce each fraction 600 times more concentrated than the ambient water.
5. All treatments were renewed only up to 48 hours due to shortage in eluates. The test was then allowed to continue to 96 hours without any water renewal.
6. Number of replicates per given treatment.

\+ Final pH measured at 24 hours.

ND Not detected. Detection limits for ELISA kits were 80 ng/L for chlorpyrifos and 40 ng/L for diazinon.

Table 94-9 shows that the stormwater runoff collected in the various sloughs and the river were not acutely toxic to fathead minnow larvae; however, the sample of Walker Slough water did show a statistically significant reduced rate of growth. The other samples obtained on October 5 did not exhibit any statistically significant inhibition of fathead minnow larval growth during the test period.

Table 94-10 presents the toxicity testing that was done with *Selenastrum*. None of the slough or river samples tested were toxic to *Selenastrum*.

Table 94-9
Stockton Urban Run-off 10/5/94 and 10/6/94
***Pimephales* Test[1,2]**

Set up on 10/5/94

Treatment	Growth (mg)[3]		Mortality (%)		Final pH @ 24 hrs
	mean	standard error	mean	standard error	
Dilute EI	0.43[P]	0.01	0.0[P]	0.00	8.1
Dilute EI aerated[4]	0.46	0.01	3.3	3.33	8.0
SSEPAMH	0.47	0.02	0.0	0.00	8.0
5-Mile Slough aerated[4]	0.38	0.01	6.7	6.67	7.5
Calaveras River	0.39	0.03	0.0	0.00	7.8
Mosher Slough	0.44	0.03	0.0	0.00	7.6
Walker Slough	0.36	0.00	0.0	0.00	7.9

P. The dilute EI control met US EPA criteria for test acceptability.

1. Three replicate beakers with 250 ml of sample and 10 minnows in each replicate.
2. Minnows were fed three times daily.
3. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the dilute EI control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<0.05$).
4. 5-Mile Slough exhibited a notable DO sag within half an hour after normal aeration. This treatment and a control were aerated throughout the test to prevent toxicity to the fish resulting from low DO.

Table 94-10
Stockton Urban Run-off 10/5/94 and 10/6/94
96-hour *Selenastrum* Test[1]

Set up on 10/6/94

Treatment	Cell Count (x 10^4) (2)		% CV	Final pH @ 96 hrs
	mean	standard error		
Glass Distilled	40[NP]	9.6	47.4	8.4
Dilute EI	79	14.1	35.9	8.6

SSEPAMH	87	4.9	11.3	8.2
5-mile Slough	104	22.1	42.5	8.2
Calaveras River	25	1.2	9.9	9.0
Mosher Slough	86	2.4	5.6	8.2
Walker Slough	26	0.4	3.2	9.5

NP. The glass distilled control did not meet all US EPA criteria for test acceptability. The coefficient of variation (CV) was 47.5% in this treatment.

1. Four replicate flasks with 100 ml of sample in each flask.
2. Highlighted areas show a significant reduction in growth compared to the glass distilled control. Cell counts were analyzed using Dunnett's Test ($p<0.05$).

Table 94-11 represents a modification of the standard *Selenastrum* testing, in which the Calaveras River and Walker Slough waters were passed through a C8 column. It is of interest to find that the waters passed through the column inhibited *Selenastrum* growth. A similar result was obtained with the Calaveras River sample, which had passed through a post-C8 SPE (PCCA) column.

Table 94-12 presents the results of the chemical characterization of the samples that were tested. The data show that the Five-Mile Slough, Calaveras River and Walker Slough samples contained from about 273 to 300 ng/L diazinon, while Mosher Slough had about 460 ng/L diazinon. The chlorpyrifos concentrations in these samples were below the detection limit of 80 ng/L. Using an LC_{50} for *Ceriodaphnia* of 450 ng/L over a 4-day period, it is concluded that an appreciable part of the toxicity found in the October 5 sample could have been due to diazinon, although part of this toxicity may have been due to other constituents that were not measured in the chemical analyses.

Table 94-11
Calaveras River and Walker Slough 10/5/94
96-hour *Selenastrum* Test[1]

Set up on 10/13/94

Treatment[3]	Cell Count (x 10^4) (2)		Conclusions	Final pH @ 96 hrs
	mean	standard error		
Glass Distilled	45[P]	1	Control met US EPA criteria for test acceptability.	9.0
Dilute EI	122	5		8.3
Calaveras River C8 Blank	15	2	Inhibition in growth relative to dilute EI suggests that application to C8 columns may be causing toxicity.	8.7
Walker Slough C8 Blank	20	3		8.4
Calaveras River	250	10	Sample lost toxicity due to storage time.	9.1
Calaveras River PCCA[4]	315	13	Slight improvement in growth relative to the ambient water may suggest that some toxicity was due to an organic.	9.2
Walker Slough	377	10	Sample lost toxicity due to storage time.	9.6
Walker Slough PCCA	371	6	No artifactual toxicity resulting from manipulation	9.7

P. The glass distilled control met all US EPA criteria for test acceptability. The coefficient of variation was 5.2% in this treatment.

1. Four replicate flasks with 100 ml of sample in each flask.
2. Highlighted cells indicate areas of significant interest. Cell counts were analyzed using Dunnett's Test ($p<0.05$).
3. 1200 ml of each water was run through a C8 SPE column at a rate of 10.2 ml/min.
4. PCCA - Sample water Post C8 SPE Column Application.

Table 94-12

Chemical Characteristics in Runoff and Test Set-Ups
Stockton Urban Run-off Sites 10/5/94 and 10/6/94

Set up on 10/5/94 and 10/6/94

Treatment	pH	DO (mg/L)	EC (µmhos/cm)	Total Hardness (mg/L as $CaCO_3$)	Calcium Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	NH_3 ($mgNH_3/L$)	Chlor-pyrifos (ng/L)	Diazinon (ng/L)
Glass Distilled	-	-	0	2	0	2	0	-	-
Dilute EI	8.2	8.3	215	96	32	102	-	-	-
Dilute EI aerated	-	-	-	-	-	-	-	-	-
SSEPAMH	8.2	8.3	240	78	44	76	-	-	-
5-mile Slough	7.4	7.0	185	80	40.8	30	1.2	ND	278
Calaveras River	8.0	7.5	260	80	50.8	71	0	ND	299
Mosher Slough	8.0	8.0	185	68	43.2	63	0.5	ND	459
Walker Slough	8.2	8.4	220	78	45.2	73	0	ND	273

ND – Not Detected. Detection limits for ELISA kits are 30 ng/L for diazinon and 80 ng/L for chlorpyrifos.

November 6 and 8, 1994 Samples

On November 6, 1994, and again on November 8, 1994, samples were taken of several of the Stockton sloughs during a stormwater runoff event. No record of precipitation was available for November 6. The rain gage showed 0.15 inch of precipitation on November 7 and no precipitation on November 8. Table 94-13 presents the results for the Smith Canal sample taken on November 6, which showed 100 percent toxicity over a seven-day period. The Smith Canal sample taken on November 8 showed no toxicity over this period.

A 4-day *Ceriodaphnia* test of the November 6 sample was conducted, which showed (Table 94-14) that there was no toxicity.

Table 94-13
Smith Canal 11/6/94 and 11/8/94
7-day *Ceriodaphnia* Test[1,2]

Set up on 11/9/94

Treatment	Reproduction[3] (neonates/adult)		Mortality (%)	Conclusions	Final pH @ 24 hrs
	mean	standard error			
Dilute EI	19.8	1.4	0	Control met all US EPA criteria for test acceptability.	8.4
SSEPAMH	7.1	1.3	10	Toxicity detected in laboratory water.	8.6
Smith Canal 11/6	0	0	100	Toxicity detected.	8.0
Smith Canal 11/8	40.5	1.5	0	Sample non-toxic.	8.2

1. Ten replicates with 15 ml of sample and one *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
3. Highlighted areas indicate a significant reduction in reproduction or increase in mortality relative to the Dilute EI control water. The reproductive endpoint was analyzed using Dunnett's Test ($p<0.05$) and the mortality endpoint was analyzed using Fisher's Exact Test.

Table 94-14
Stockton Urban Run-off 11/6/94

4-Day *Ceriodaphnia* Test[1,2]

Set up on 11/9/94

Treatment[4,5]	% Mortality for each day of the test[3]				Conclusions	Final pH @ 48hrs
	1	2	3	4		
Dilute E1				0	Control met US EPA criteria for test acceptability.	8.18
Mosher Slough	0	100	100	100	Toxicity detected.	8.02
5-Mile Slough				0	No toxicity detected.	8.00
Calaveras River				0		8.22
Walker Slough				0		8.39

P. The Dilute EI control met all US EPA criteria for test acceptability.
1. Each replicate contained 18 mls of sample and five Ceriodaphnia each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. Number of replicates per given treatment.

Table 94-15 presents the Mosher Slough and Smith Canal 7-day *Ceriodaphnia* Phase I TIE results, which show that Mosher Slough killed all *Ceriodaphnia* within 4 days; however, the addition of 200 g/L PBO eliminated this toxicity. Somewhat similar results were obtained for Smith Canal for the November 6 sample over the 7-day period. There was a smaller reduction in toxicity. The Smith Canal sample taken on November 9 killed 100 percent of the *Ceriodaphnia* within 5 days.

Table 94-16 presents the results of the *Selenastrum* toxicity test conducted on November 6 and November 8, 1994. Again, as with the October samples, there was no toxicity to *Selenastrum.*

Table 94-15
Mosher Slough 11/6/94 and Smith Canal 11/6/94, 11/9/94
7-day *Ceriodaphnia* Phase I TIE[1,2]

Set up on 11/12/94

Treatment	% Mortality for each day of the test							Conclusions	Final pH @ 48 hrs
	1	2	3	4	5	6	7		
Dilute EI							6.0	Control met US EPA criteria for test acceptability.	8.6
Dilute EI + 200µg/L PBO							0.0	No artifactual toxicity in control blank.	8.5
Mosher Slough		80	100	100+				Toxicity detected.	8.3
Mosher Slough + 200µg/L PBO				0+				Significant decrease in mortality relative to ambient water suggests that an OP pesticide is responsible for toxicity.	8.3
Smith Canal (11/6)				33.3	93.3	100	100	Toxicity detected.	8.1
Smith Canal (11/6) + 200µg/L PBO							86.7	The delay in mortality suggests that an OP pesticide may, in part, be responsible for toxicity. However, high mortality suggests a second toxicant may also exist.	8.0
Smith Canal (11/9)				60	100	100	100	Toxicity detected.	8.2

1. Three replicates with 18 ml of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
+ These treatments were taken down at 96 hours.

Table 94-16

Stockton Urban Run-off 11/6/94 and 11/8/94
96-hour *Selenastrum* Test[1]

Set up on 11/9/94

Treatment	Cell Count (x 10^4) (2)		Final pH @ 96 hrs
	Mean	standard error	
Glass Distilled	66.7[P]	1.7	9.0
Dilute EI	90.3	2.3	8.7
5-Mile Slough 11/6	75.8	7.8	9.0
Calaveras River 11/6	108	9.6	9.1
Mosher Slough 11/6	96.6	8.5	9.0
Smith Canal 11/6	79.6	0.5	8.9
Smith Canal 11/8	139	10.2	9.3
Walker Slough 11/6	102	8.9	9.2

P. The glass distilled control met all US EPA criteria for test acceptability. The coefficient of variation was 4.5% in this treatment.

1. Three replicate flasks with 100 ml of sample in each flask.
2. Highlighted cells indicate areas of significant interest. Cell counts were analyzed using Dunnett's Test ($p<0.05$).

The chemical characteristics of the November 6 and 8, 1994, samples are presented in Table 94-17. The concentrations of diazinon found in samples from Five-Mile Slough, Calaveras River, Smith Canal and Walker Slough would be less than that expected to be acutely toxic within 4 days; however, the Mosher Slough sample had 499 ng/L diazinon, which would be expected to be acutely toxic to *Ceriodaphnia* within 4 days. These results are in accord with the results presented in 94-15. It is possible that, at least for Smith Canal samples, which had about 186 ng/L diazinon, as expected, chlorpyrifos, in this case, is a significant contributor to the toxicity found. The LC_{50} for *Ceriodaphnia* for chlorpyrifos is 80 ng/L. Based on the concentrations of chlorpyrifos and diazinon found in the November 6 samples, there would be expected to be about 1 TUa of *Ceriodaphnia* toxicity. It is of interest to find the Smith Canal sample taken on November 8 had non-detectable chlorpyrifos and diazinon, and this is in accord with the lack of toxicity found in that sample. This demonstrates that the toxicity associated with a rainfall event is a short-term phenomenon and does not carry over to the following day after the runoff has occurred.

Table 94-17
Chemical Characteristics of Water
Stockton Urban Run-Off Sites 11/6/94 and 11/8/94

Set up on 11/9/94

Treatment	pH	DO (mg/L)	EC (µmhos/cm)	Total Hardness (mg/L as $CaCO_3$)	Calcium Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	Chlorpyrifos (ng/L)	Diazinon (ng/L)
Glass Distilled	8.8	-	0	-	-	-	-	-
Dilute EI	8.3	8.5	200	92	-	-	-	-
SSEPAMH	8.4	8.5	205	80	-	-	-	-
5-mile Slough 11/6	7.5	8.5	373	116	72	90	ND	80
Calaveras River 11/6	7.7	8.6	384	132	72	116	88	199
Mosher Slough 11/6	7.7	8.5	201	84	48	84	ND	499
Smith Canal 11/6	7.4	8.4	349	128	76	88	123	186
Smith Canal 11/6	8.0	7.1	360	128	76	88	123	186
Smith Canal 11/8	8.1	8.5	650	192	-	-	ND	ND
Walker Slough 11/6	7.6	8.6	498	172	96	148	ND	ND

ND Not detected. Detection limits for ELISA kits are 80 ng/L for chlorpyrifos and 30 ng/L for diazinon.

November 9 and 25, and December 4, 1994

Table 94-18 presents the results of 7-day *Ceriodaphnia* toxicity tests for Smith Canal obtained on November 9 and 25 and December 4. These results show that the November 9 sample killed 100 percent of the *Ceriodaphnia* within 7 days, and there was little toxicity on November 25 or December 4. The available rainfall data indicate that there was no precipitation on November 9, and 0.33 inch on November 25. No rainfall data are available for December 4.

Table 94-19 presents the results of the 7-day *Ceriodaphnia* Phase I TIE test for the Smith Canal samples obtained on November 9, 1994.

Table 94-20 presents the Smith Canal toxicity test results for the fathead minnow larvae. These results show that there was no toxicity to fathead minnow larvae over the 7-day test period.

Table 94-21 presents the toxicity test results for the Smith Canal samples obtained on November 9 and 25 and December 4, 1994, using *Selenastrum* as the test organism. The Smith Canal samples were not toxic to *Selenastrum*; in fact, it appears from the data that they stimulated *Selenastrum* growth.

Table 94-18
Smith Canal 11/9/94, 11/25/94 and 12/4/94
7-day *Ceriodaphnia* Test[1,2]

Set up on 12/7/94

Treatment	Reproduction[3] (neonates/adult)		Mortality (%)	Final pH @ 24 hrs
	x	s.e.		
Dilute EI	26.6[P]	1.3	0.0[P]	8.6
SSEPAMH	13.4	1.8	10.0	8.5
Smith Canal 11/9	17.8	3.3	100.0 (7)	8.3
Smith Canal 11/25	48.3	1.0	20.0	8.1
Smith Canal 12/4	59.0	1.9	0.0	8.2

P. The Dilute EI control met all US EPA criteria for test acceptability. 90.0% of the daphnids had a third brood.
1. Ten replicates with 15 mls of sample and one *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
(#) Number in parenthesis denotes days to 100% mortality.
Highlighted areas indicate a significant reduction in reproduction or increase in mortality relative to the Dilute EI control water. The reproductive endpoint was analyzed using Dunnett's Test ($p<.05$) and the mortality endpoint was analyzed using Fisher's Exact Test.

Table 94-19
Smith Canal 11/9/94 7-day *Ceriodaphnia* Phase I TIE[1,2]

Set up on 12/6/94

Treatment	% Mortality for each day of the test[3]							Conclusions	Final pH @ 48 hrs
	1	2	3	4	5	6	7		
Dilute EI							0	Control water met all US EPA criteria for test acceptability.	8.4
Dilute EI + PBO		20	53	53	53	53	53	Toxicity detected in method blank.	8.2

Smith Canal						7	7	No toxicity detected.	8.0
Smith Canal + PBO							0		7.9

1. Three replicates with 18 mls of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.

Highlighted cells indicate areas of significant interest. No statistical analyses were done.

Table 94-20
Smith Canal 11/9/94, 11/25/94 and 12/4/94
7-day *Pimephales* Test[1,2]

Set up on 12/7/94

Treatment	Mortality (%)[3]		Final pH @ 24 hrs
	X	s.e.	
Dilute EI	0.0[P]	0.0	8.2
SSEPAMH	0.0	0.0	7.7
Smith Canal 11/9	6.7	6.7	7.5
Smith Canal 11/25	6.7	6.7	7.7
Smith Canal 12/4	0.0	0.0	7.8

P. The Dilute EI control met all US EPA criteria for test acceptability.
1. Three replicate beakers with 250 ml of sample and 10 minnows in each replicate.
2. Minnows were fed three times daily.
3. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the Dilute EI control. The mortality endpoint was analyzed with Dunnett's Test ($p<.05$).

Table 94-21
Smith Canal 11/9/94, 11/25/94 and 12/4/94
96-Hour *Selenastrum* Test[1]

Set up on 12/7/94

Treatment	Cell Count[2] (x 10^4)		Final pH @ 96 hrs
	X	s.e.	
Glass Distilled	55.0[P]	4.6	7.7
Dilute EI	94.4	4.1	8.5
SSEPAMH	63.1	9.2	8.5
Smith Canal 11/9	251.6	6.6	9.5
Smith Canal 11/25	214.2	8.1	9.3
Smith Canal 12/4	246.1	15.8	9.5

P. The glass distilled control met all US EPA criteria for test acceptability. The coefficient of variation was 16.8% in this treatment.
1. Four replicate flasks with 100 ml of sample in each flask, except for the Smith Canal treatments which had three replicates.

Highlighted areas show a significant reduction in growth compared to the glass distilled control. Cell counts were analyzed using Dunnett's Test ($p<.05$).

Table 94-22 presents the chemical characteristic data for samples taken from Smith Canal on November 9 and 25 and December 4, 1994. The data presented in Table 94-22 show that there were readily detectable amounts of diazinon present in Smith Canal on November 9 and November 25; however, these concentrations were well below the LC_{50} for *Ceriodaphnia*. There were no detectable amounts of chlorpyrifos present in the samples using a detection limit of 80 ng/L. These results indicate that no toxicity would be expected to *Ceriodaphnia* from these samples.

Table 94-22
Water Chemical Characteristics for Smith Canal 11/9/94, 11/25/94 and 12/4/94

Set up on 12/7/94

Treatment	pH	DO (mg/L)	EC (µmhos/ cm)	Total Hardness (mg/L as $CaCO_3$)	Calcium Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	NH_3 (mg/L)	Chlorpyrifos (ng/L)	Diazinon (ng/L)
Glass Distilled	8.6	-	10	0	-	-	0.0	-	-
Dilute EI	8.1	8.6	200	92	-	-	-	-	-
SSEPAMH	7.8	8.7	220	84	-	-	-	-	-
Smith Canal 11/9	7.8	8.3	325	108	68	132	0.5	ND	166
Smith Canal 11/25	8.2	7.8	122	48	28	32	0.2	ND	106*
Smith Canal 12/4	7.8	8.4	450	128	88	88	0.5	ND	ND

* This sample was stored for almost 2 months before it was analyzed for diazinon.

ND Non Detect Detection limits for ELISA kits are 80 ng/L for chlorpyrifos and 30 ng/L for diazinon.

1994 Summary. In summary, the 1994 testing showed that stormwater runoff events were acutely toxic to *Ceriodaphnia* and were nontoxic to fathead minnow larvae and the alga *Selenastrum*. The level of toxicity was about 1 TUa. It was primarily due to diazinon, but, in some samples, chlorpyrifos was an important, if not the dominant, cause of toxicity.

1995 Studies

The CVRWQCB conducted sampling of several of the City of Stockton sloughs, as well as several creeks or stormwater drains in Sacramento on April 28, 1995, and May 1, 1995. Table 95-1 presents the results of the 7-day *Ceriodaphnia* test. The Mosher Slough sample taken on May 1, 1995, was nontoxic. On the other hand, Arcade Creek, Elder Creek and Sump 104, located in the City of Sacramento, were 100 percent toxic to *Ceriodaphnia* in 1 to 5 days. Precipitation data for the City of Stockton shows 0.33 inch for May 1. The lack of toxicity in Mosher Slough for the May 1 sample is unusual for this magnitude of rainfall.

The Mosher Slough sample taken on May 1, 1995, was subjected to a Phase III TIE. Table 95-2 presents the results of a 3-day *Ceriodaphnia* Phase III TIE. This test of the May 1 runoff event showed toxicity to *Ceriodaphnia*. It is not clear why there was no toxicity found in the 7-day *Ceriodaphnia* test. The Phase III TIE confirmed that the diazinon and chlorpyrifos measured in the sampled collected from Mosher Slough on 5/1/95 were the chemicals causing the observed toxicity. The C8 solid phase extracted water (indicated as PCCP in this table) was spiked with the same amount of diazinon and chlorpyrifos as was detected in the ambient sample. Then the spiked and ambient samples were set up in side-by-side dilution series to confirm that the organism response was the same in both samples.

Similarly, Table 95-3 presents a Mosher Slough May 1, 1995, sample additivity study. This experiment was conducted to show that diazinon and chlorpyrifos act additively when present in a sample together. In the dilution series of chlorpyrifos alone and diazinon alone the *Ceriodaphnia* mortality was less than 100 percent in 3 days (in the 100% dilution), however, when present together 100 percent *Ceriodaphnia* mortality occurs in 2 days.

Table 95-1
Urban Runoff 4/28/95 to 5/1/95
7-day *Ceriodaphnia* Test[1,2]

Set up on 5/2/95

Treatment	Reproduction[3] (neonates/adult)		Mortality (%)	Final pH @ 24 hrs
	x	s.e.		
Dilute EI	n=9 19.9[P]	2.0	0[P]	8.2
SSEPAMH	n=9 21.1	1.6	10	8.4
Arcade Creek 5/1/95	0.0	0.0	100 (1)	7.8
Elder Creek 4/29/95	4.0	0.8	100 (4)	8.0
Sump 104 4/28/95	6.7	1.1	100 (5)	8.4
Sump 111 4/28/95	10.7	2.2	20	7.8
Mosher Slough 5/1/95	27.3	0.6	0	8.0

P. The Dilute EI control met all US EPA criteria for test acceptability. 88.9% of the daphnids had a third brood.
1. Ten replicates with 15 mls of sample and one *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
3. Highlighted areas indicate a significant reduction in reproduction or increase in mortality relative to the Dilute EI control water. The reproductive endpoint was analyzed using Dunn's Test ($p<.05$) and the mortality endpoint was analyzed using Fisher's Exact Test.

(#) Number in parenthesis represents days to 100% mortality.

Table 95-2
Mosher Slough 5/1/95
3-Day *Ceriodaphnia* Phase III TIE[1,2]

Set up on 5/17/95

Treatment[4,5]	% Mortality for each day of the test[3]			Chlorpyrifos (ng/L)	Diazinon (ng/L)	Final pH @ 48hrs
	1	2	3			
Dilute EI			20			8.0
Dilute EI C8 Blank for Mosher Slough			13			8.2
Spiked PCCP @ 200%	100	100	100			7.9*
Mosher 5/1 @ 100%	20	100	100	ND (78)	420	7.6
Spiked PCCP @ 100%	33	100	100	89	416	7.6
Mosher 5/1 @ 75%		13	100			8.0
Spiked PCCP @ 75%		26	100			7.9
Mosher 5/1 @ 50%			13			8.1
Spiked PCCP @ 50%			0			7.8
Mosher 5/1 @ 25%			6.7			8.1
Spiked PCCP @ 25%			0			7.9
Unspiked PCCP			0	ND	ND	8.0
Unspiked PCCP + 200 µg/L PBO			0			8.2

1. Three replicates with 18 mls of sample and five *Ceriodaphnia* each.
2. Daphnids were not fed.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. 1800 ml of Sample water was run through a C8 SPE column at a rate of 10 ml/min.
5. PCCP Sample water **P**ost **C**8 SPE **C**olumn **P**assage

ND Non Detect Detection limits for ELISA kits are 80 ng/L for chlorpyrifos and 30 ng/L for diazinon.

+ Final pH taken at 24 hours.

Table 95-3

Mosher Slough 5/1/95 Additivity Study 3-Day *Ceriodaphnia* Test[1,2]

Set up on 6/17/95

Treatment[4,5]	% Mortality for each day of the test[3]			Chlorpyrifos (ng/L)	Diazinon (ng/L)	Final pH @ 48hrs
	1	2	3			
Dilute EI			0			7.6
Dilute EI C8 Blank for Mosher Slough			0			8.0
200% spiked Diazinon and Chlorpyrifos	100	100	100	119	896	7.6+
100% spiked Diazinon and Chlorpyrifos	60	100	100	41	493	7.1
75% spiked Diazinon and Chlorpyrifos		87	100			7.1
50% spiked Diazinon and Chlorpyrifos		6.7	100			7.8
25% spiked Diazinon and Chlorpyrifos			0			7.7
200% spiked Chlorpyrifos	40	100	100	148		7.5
100% spiked Chlorpyrifos			47	32		7.8
75% spiked Chlorpyrifos			0			7.7
50% spiked Chlorpyrifos			0			7.7
25% spiked Chlorpyrifos			0			7.7
200% spiked Diazinon	87	100	100		1,132	7.9+
100% spiked Diazinon		47	73		255	7.9
75% spiked Diazinon			27			7.7
50% spiked Diazinon			0			7.7
25% spiked Diazinon			0			7.8
Mosher Slough 5/1/95 PCCP*			0			8.0

1. Three replicates with 18 mls of sample and five *Ceriodaphnia* each.
2. Daphnids were not fed.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. 1800 ml of Sample water was run through a C8 SPE column at a rate of 10 ml/min.

+ Final pH taken at 24 hours.

* PCCP sample water Post C8 SPE Column Passage

ND Non Detect Detection limits for ELISA kits are 50 ng/L for chlorpyrifos and 30 ng/L for diazinon.

The Arcade Creek/Mosher Slough samples obtained on May 1, 1995, were subjected to a 4-day *Ceriodaphnia* toxicity test in which PBO was added to some of the tests. The data presented in Table 95-4 shows that the addition of PBO significantly reduced the toxicity measured over the 4-day period for both Arcade Creek and Mosher Slough. This is an indication of an organophosphate pesticide being responsible for the toxicity. The 50 percent dilution of the Arcade Creek sample still showed some toxicity, indicating that the level of toxicity present in the sample was about 2 TUa.

The chemical characteristic data for the April 27-May 1, 1995, City of Stockton and Sacramento samples are shown in Table 95-5. These data show that the chlorpyrifos and diazinon concentrations in the samples were sufficient to cause toxicity to *Ceriodaphnia* in all samples except the Sump 111 sample

taken on April 28. That sample was, as expected, nontoxic, based on the low concentrations of diazinon and chlorpyrifos (see Table 95-1).

Table 95-4
Arcade Creek, Mosher Slough 5/1/95
4-Day *Ceriodaphnia* PBO Test[1,2]

Set up on 5/3/95

Treatment[4]	% Mortality for each day of the test[3]				Conclusions	Final pH @ 48hrs
	1	2	3	4		
Dilute EI				0	Control met all US EPA criteria for test acceptability.	8.4
Dilute EI + 200 µg/L PBO		5	95	95	Increase in mortality relative to control water suggests that the addition of PBO may be negatively affecting the daphnids.	8.3
Arcade Creek 100%	100	100	100	100		7.7*
Arcade Creek 100% + 200 µg/L PBO	5	5	25	25	Toxicity detected up to the 50% dilution.	7.7
Arcade Creek 50%			75	90	Addition of PBO resulted in a significant decrease in mortality suggesting toxicity may be due to organophosphate pesticide(s).	8.1
Arcade Creek 50% + 200 µg/L PBO	5	5	10	10		8.0
Arcade Creek 25%				0		8.3
Arcade Creek 12.5%				0		8.4
Mosher Slough		100	100	100	Toxicity detected.	7.9
Mosher Slough + 200 µg/L PBO				0	Significant decrease in mortality relative to ambient water suggests that an organophosphate pesticide is responsible for the toxicity.	8.0

1. Four replicates with 18 mls of sample and five *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.

* Final pH taken at 24 hours.

Table 95-5

Urban Run-Off 4/27-5/1/95 Water Chemical Characteristics

Treatment	Initial pH	EC (µmhos / cm)	Total Hardness (mg/L as $CaCO_3$)	Ca Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	TSS (mg/L)	Chlorpyrifos (ng/L)	Diazinon (ng/L)
Glass Distilled	9.0	5	0	-	-	3.3	-	-
Dilute EI	8.2	210	88	-	-	-	-	-
SSEPAMH	8.2	235		-	-	-	-	-
Arcade Creek 5/1	8.2	50	22	14	18	355.4	ND[67]	334
Elder Creek 4/29	8.1	100	46	26	44	496.7	90	216
Strong Ranch 4/27			22	14	22	210.4	116	424
Sump 104 4/28	8.0	310	122	78	104	15.5	ND [75]	170
Sump 111 4/28	8.0	100	36	26	30	16.5	145	ND
Mosher Slough 5/1	7.9	95	32	-	-		120	417

ND Non Detect Detection limits for ELISA kits are 80 ng/L for chlorpyrifos and 30 ng/L for diazinon.
[#] numbers in brackets are calculated ELISA values for chlorpyrifos non detects

December 11, 1995

The sample of Duck Creek, obtained on December 11, 1995, was tested for *Ceriodaphnia* toxicity under conditions where some of the tests were exposed to UV light and others were exposed to white light. Table 95-6 presents the results of this study. There was no rainfall reported at the rain gage in Stockton for this date. Comparing the results for the 100 percent sample and various dilutions of the Duck Creek sample with white light or UV light shows that the UV light did not affect toxicity. The dilution series on this sample showed that there were about 5 TUa of *Ceriodaphnia* toxicity over a 7-day period. This is one of the more toxic samples obtained in the study of the creeks/sloughs in the Stockton area. Duck Creek receives drainage from upstream agricultural sources, which could have been the source responsible for part of this elevated toxicity.

Table 95-6

Duck Creek 12/11/95 7-Day *Ceriodaphnia* in & out of UV Light TIE[1,2]

Set up on 12/29/95

Treatment	% Mortality for each day of the test[3]							Final pH @ 24 hrs
	1	2	3	4	5	6	7	
Dilute EI							0	8.0
Dilute EI in UV light							0	8.0
100% Duck Cr in white light	13	100	100	100	100	100	100	8.0
100% Duck Cr in UV light	7	100	100	100	100	100	100	7.9
80% Duck Cr in white light		80	100	100	100	100	100	8.0
80% Duck Cr in UV light		73	100	100	100	100	100	8.0
60% Duck Cr in white light		7	27	100	100	100	100	8.1
60% Duck Cr in UV light				100	100	100	100	8.0
40% Duck Cr in white light		7	7	7	29	57	64	8.1
40% Duck Cr in UV light						20	33	8.1
20% Duck Cr in white light							0	8.0
20% Duck Cr in UV light							0	8.1

1. Three replicates with 18 mls of sample and five *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.

1996 Studies

Beginning in 1996, the DeltaKeeper assumed the responsibility for sampling of the Stockton Slough stormwater runoff.

A sample of the various Stockton sloughs' stormwater runoff was collected on October 29, 1996. Precipitation on this date in the Stockton area was 1.28 inches. *Ceriodaphnia* toxicity test results for this sample, which was the first runoff event of the season, are presented in Table 96-1. The data in this table show that Mosher Slough, even with the addition of 100 µg/L PBO, killed 100 percent of the *Ceriodaphnia* in 7 days. Five-Mile Slough also killed 100 percent of the test organisms in this period; however, the Five-Mile Slough sample with 100 µg/L PBO was nontoxic. The Calaveras River and Duck Creek samples were nontoxic on this sampling day, while the Smith Canal sample killed 100 percent of the *Ceriodaphnia* in 7 days. However, with the addition of 100 µg/L PBO, there was no toxicity.

Table 96-1

7-day *Ceriodaphnia* Test Conducted on Samples Collected 10/29/96[1,2]

Set up on 10/30/96

Treatment	Reproduction[3] (neonates/adult)		Mortality (%)	Initial pH	Final pH @ 24 hrs	EC (µmhos/cm)	Hardness (mg/L)	TSS (mg/L)
	x	s.e.						
SSEPAMH	19.4[P]	2.6	0[P]	8.3	8.3	275	92	
SSEPAMH + 100 µg/L PBO	17.2	3.2	0					

Mosher Slough	0	0	100	7.6	7.3	105	36	288.0
Mosher + 100 µg/L PBO	0	0	100					
Five Mile Slough	0	0	100	7.9	7.5	200	56	79.0
Five Mile + 100 µg/L PBO	22.7	1.2	0					
Calaveras River	33.0	0.8	0	8.2	8.3	280	88	23.1
Calaveras + 100 µg/L PBO	33.5	1.8	0					
Smith Canal	9.8	1.6	100	8.1	7.8	490	132	55.5
Smith + 100 µg/L PBO	13.3	0.7	0					
Duck Creek	32.2	1.4	0	8.0	7.8	200	56	82.7
Duck + 100 µg/L PBO	27.5	1.8	0					

P. The Dilute EI control met all US EPA criteria for test acceptability. 70% of the daphnids had a third brood.
1. Ten replicates with 15 mls of sample and one *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
3. Highlighted areas indicate a significant reduction in reproduction or increase in mortality relative to the Dilute EI control water. The reproductive endpoint was analyzed using Dunnett's Test ($p<.05$) and the mortality endpoint was analyzed using Fisher's Exact Test.

The Mosher Slough sample obtained on October 29, 1996, was subjected to a 96-hour Phase I TIE, using *Ceriodaphnia* as the test organism. The data presented in Table 96-2 show that there were about 2 TUa of 4-day *Ceriodaphnia* acute toxicity and that the presence of PBO reduced this toxicity. However, the addition of EDTA at either 15 or 30 mg/L did not affect the toxicity, indicating that the toxicity was not likely due to a heavy metal.

Table 96-3 presents the fathead minnow larvae test results for the October 29, 1996, samples. The samples of Mosher Slough, Five-Mile Slough, Calaveras River, Smith Canal and Duck Creek were all nontoxic to fathead minnow larvae.

Table 96-4 presents the results of the *Selenastrum* testing for the October 29, 1996, samples, which also showed no toxicity to this organism.

Table 96-5 presents the chemical characteristics of the 10/29/96 samples. From the data presented in Table 96-5, the Mosher Slough sample taken on October 29, 1996, had 486 ng/L diazinon and 103 ng/L chlorpyrifos. These concentrations would be expected to contain about 2 TUa of *Ceriodaphnia* acute toxicity. This is similar to what was found in the test, indicating that the toxicity could be accounted for based on diazinon and chlorpyrifos. The Five-Mile Slough sample would be expected to have some toxicity, which is estimated to be about 1.5 TUa, based on diazinon and chlorpyrifos concentrations. Calaveras River, Smith Canal and Duck Creek would not be expected to be toxic based on diazinon and chlorpyrifos concentrations. This was what was found in the toxicity testing for the Calaveras River and Duck Creek; however, the Smith Canal sample showed 100 percent kill of *Ceriodaphnia* in 7 days. It is possible, then, that there were other toxicants in the Smith Canal sample, which would cause the sample to be toxic, but not have sufficient diazinon and chlorpyrifos to account for the magnitude of the toxicity found.

Table 96-2

Mosher Slough 10/29/96 96-Hour *Ceriodaphnia* Phase I Test[1]

Set up on 11/9/96

Treatment[2]	ELISA values		# of Reps	% Mortality for each day of test				Conclusion[3]	Final pH @ 24h
	Diazinon	Chlorpyrifos		1	2	3	4		

Lab Control (SSEPAMH), Hardness 80			4				0	Controls met all US EPA criteria for test acceptability.	8.4
Lab Control, Hardness 36 (H36)			4				5		8.1
Lab Control + 100 µg/L PBO			4			5	20	Toxicity in the PBO manipulation	8.3
Lab Control + 200 µg/L PBO			4			53	84	suggests that 200 µg/L may be too high.	8.3
Lab Control H36 + 15 mg/L EDTA			4		5	5	5	No artifactual toxicity in these control blanks.	8.0
Lab Control H 36 + 30 mg/L EDTA			4	5	5	5	5		8.0
Mosher 10/29/96 100% (H36)			3	100	100	100	100	The dilution series suggests that toxicant(s) may be present at approximately two toxic units. Significant reduction in toxicity with the addition of PBO suggests toxicity may be due to metabolically activated organophosphorous pesticide(s).	7.6
Mosher 50%			3		33	53	80		7.6
Mosher 50% + 100 µg/L PBO			3				0		7.5
Mosher 50% + 200 µg/L PBO			3		7	13	13		7.3
Mosher 25%			3				0		7.6
Mosher 25% + 100 µg/L PBO			3				0		7.4
Mosher 25% + 200 µg/L PBO			3		7	27	27		7.5
Mosher 12.5%			3				7		7.6
Mosher + 15 mg/L EDTA			3	93	100	100	100	No reduction in toxicity with the addition of EDTA suggests toxicity is not due to metals.	7.5
Mosher + 30 mg/L EDTA			3	100	100	100	100		7.5

1. Each replicate vial with 15 ml of sample and 5 daphnids.
2. 4-hr feeding
3. Highlighted cells show areas of interest. No statistical analyses were conducted.

Table 96-3

Pimephales Toxicity Test Conducted on Samples Collected 10/29/96[1,2]

Set up on 10/31/96

Treatment[3]	Growth (mg)		Mortality (%)[4]		Initial pH	Final pH	EC
	x	Se	X	s.e.		@ 24 hrs	(µmhos/cm)
SSEPAMH	0.44[P]	0.02	0.0[P]	0	8.3	8.0	275
Mosher Slough	0.37	0.02	5.0	0.03	7.6	7.0	105
Five Mile Slough	0.46	0.02	42.5	0.19	7.9	7.3	200
Calaveras River	0.46	0.03	2.5	0.03	8.2	7.9	280
Smith Canal	0.48	0.03	2.5	0.03	8.1	7.5	490
Duck Creek	0.41	0.01	0	0	8.0	7.5	200

P. The Dilute EI control met the criteria for test acceptability.

1. Three replicate beakers with 250 ml of sample and 10 minnows in each replicate.
2. Minnows were three times daily.
4. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the Dilute EI control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).

Table 96-4
96-Hour *Selenastrum* Test Conducted on Samples Collected 10/29/96[1]

Set up on 10/30/96

Treatment	Cell Count[2] (x 10^4)		Initial pH	Final pH @ 96 hrs	EC (µmhos/cm)	Hardness (mg/L)	TSS (mg/L)
	x	s.e.					
Glass Distilled	202.7[P]	19.1	8.0	7.8	70	0	
Duck Creek	370.8	6.8	7.8	10.2	210	56	82.7
Smith Canal	355.2	19.3	8.1	9.5	455	132	55.5
Calaveras River	328.5	38.8	8.0	9.7	275	88	23.1
Five Mile Slough	392.3	9.4	7.9	10.0	225	56	79.0
Mosher Slough	364.2	6.3	8.0	9.9	155	36	288.0

P. The glass distilled control met all US EPA criteria for test acceptability. The coefficient of variation was 18.8% in this treatment.
1. Four replicate flasks with 100 ml of sample in each flask.
2. Highlighted areas show a significant reduction in growth compared to the glass distilled control. Cell counts were analyzed using Dunnett's Test ($p<.05$).

Table 96-5
10/29/96 Water Chemical Characteristics

Treatment	Diazinon[3] (ng/L)	Chlorpyrifos[3] (ng/L)	Diuron (ng/L)	EC (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	TSS (x±se mg/L)
Lab Control for *Ceriodaphnia*	-	-	-	275	92	-
Lab Control for *Pimephales*	-	-	-	275	92	-
Lab Control for *Selenastrum*	-	-	-	70	0	-.316±.017
Mosher Slough 10/29/96	486[1]	103[1]	ND[3]	155	36	288.0±11.5
Five Mile Slough 10/29/96	304[2]	84[1]	ND[3]	225	56	79.0±4.3
Calaveras River 10/29/96	36[2]	ND[1]	ND[3]	275	88	23.1±0.2
Smith Canal 10/29/96	129[2]	ND[1]	ND[3]	455	132	55.5±0.3
Duck Creek 10/29/96	96[2]	65[1]	ND[3]	210	56	82.7±3.6

The DeltaKeeper took several rainfall samples during October and November 1996. The data for diazinon and chlorpyrifos in these samples are presented in Table 96-6. The concentrations of chlorpyrifos found in the rainfall samples at the various locations were less than the detection limit of 50 ng/L. Diazinon concentrations in the rainfall samples at the various locations in October and November 1996 ranged from about 42 to 97 ng/L.

Table 96-6
DeltaKeeper Backyard Rainwater Sampling ELISA Values

Site or Collector ID	Diazinon[5] (ng/L)	Chlorpyrifos[5] (ng/L)
2352 Dry Creek Way 10/29/96 (Emilie Reyes, UCDATL)	42[1]	ND[3]
Weston Ranch in South Stockton 10/29/96 (Stephen Clark, UCDATL)	46[1]	ND[3]

John Newbold 10/29/96	ND[1]	ND[1]
1924 Meadow 11/16/96	97[4]	ND[4]
2230 Kensington 11/17/96	32[4]	ND[4]
Collector WB 11/17/96	ND[4]	ND[4]
2925 Princeton 11/18/96	91[4]	ND[4]

1 ELISA conducted on 11/2/96.
2 ELISA conducted on 10/30/96.
3 ELISA conducted on 11/3/96.
4 ELISA conducted on 11/20/96.
5 UCDATL LC_{50} values for *Ceriodaphnia dubia* are 400-500 ng/L for diazinon and 80-100 ng/L for chlorpyrifos. Values obtained using ELISA method.
ND Non Detect-detection limits for diazinon, chlorpyrifos and diuron ELISA are 30 ng/L, 50 ng/L and 30 ng/L, respectively.

1997 Studies

The DeltaKeeper collected stormwater runoff from Mosher Slough and Five-Mile Slough on November 13, 1997. Rainfall in the Stockton area measured for that date was 0.12 inch. Table 97-1 presents the results of the 7-day *Ceriodaphnia* test for these samples. Mosher Slough was found to be 100 percent toxic, even with PBO, in the 7 days. The Five-Mile Slough sample was 100 percent toxic within 5 days and nontoxic within 7 days, with PBO.

Table 97-1
Stockton Urban Runoff 11/13/97
7-day *Ceriodaphnia* Test[1,2]

Set up on 11/14/97

Treatment	Reproduction[3] (neonates/adult)		Mortality (%)	Final pH @ 24 hrs
	x	s.e.		
Laboratory Control	27.4[P]	0.1	0[P]	8.6
Laboratory Control + PBO	16.67	1.1	0	8.5
Mosher Slough	*	*	100 (3)	8.1
Mosher Slough + PBO	*	*	90	7.9
5-Mile Slough	*	*	100 (5)	7.7
5-Mile Slough + PBO	29.3	0.1	0	7.6

P. The laboratory control met all US EPA criteria for test acceptability. 100% of the daphnids had a third brood.
1. Ten replicates with 15 ml of sample and one *Ceriodaphnia* each.
2. Standard US EPA feeding procedures were used during this test.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
(#) Denotes days to 100% mortality.

Table 97-2 presents the fathead minnow larvae tests for the Mosher Slough and Five-Mile Slough samples collected on November 13, 1997. The Mosher Slough sample was nontoxic, while the Five-Mile Slough sample did show mortalities to the fathead minnow larvae over the 7-day test period.

Table 97-3 presents the results of the toxicity tests for the November 13, 1997, samples taken of Mosher Slough and Five-Mile Slough for *Selenastrum*. The samples were nontoxic to this alga during the test period.

Table 97-4 presents the chemical characteristic data for the November 13, 1997, sample. The data in Table 97-4 show that Mosher Slough contained 460 ng/L of diazinon, while Five-Mile Slough had about 360 ng/L of diazinon. Both samples contained between 50 and 60 ng/L of chlorpyrifos. These concentrations of diazinon and chlorpyrifos would be expected to be toxic to *Ceriodaphnia*. This is what

was found, as shown in Table 97-1. The toxicity to fathead minnow larvae shown for Five-Mile Slough is due to unknown causes.

Table 97-2
7-day *Pimephales* Test[1,2]

Set up on 11/14/97

Treatment	Growth (mg)		Mortality (%)[3]		Final pH @ 24 hrs
	x	Se	x	s.e.	
Laboratory Control	0.274[P]	0.009	0[P]	0	8.0
Mosher Slough	0.318	0.041	22.5	19.3	7.7
5-Mile Slough	0.1710	0.031	75.0	8.66	7.6

P. The laboratory control met all US EPA criteria for test acceptability.
1. Four replicate beakers with 250 ml of sample and 10 minnows in each replicate.
2. Minnows were fed three times daily.
3. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).

Table 97-3
96-Hour *Selenastrum* Test[1]

Set up on 11/14/97

Treatment	Cell Count[1] (x 10^4)		% CV	Final pH @ 96 hrs
	x	s.e.		
Laboratory Control	133.5	15.5	23.2[NP]	7.5
Mosher Slough	161.9	9.9	6.1	9.3
5-Mile Slough	207.0	2.9	1.4	9.7

NP. The glass distilled control did not meet all US EPA criteria for test acceptability. The coefficient of variation was 23.2% in this treatment.
1. Four replicate flasks with 100 ml of sample in each flask.
2. Highlighted areas show a significant reduction in growth compared to the glass distilled control. Cell counts were analyzed using Dunnett's Test ($p<.05$).

Table 97-4
Chemical characteristics for Stockton Urban Runoff samples collected 13 November 1997

Treatment	Diazinon[1] ELISA value (ng/L)	Chlorpyrifos[1] ELISA value (ng/L)	Lab pH	Lab EC[2] (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Ammonia (mg/L as NH_4)	Alkalinity (mg/L as $CaCO_3$)
Lab Control (EPAMH)			8.4	260	8.2	80		58
Lab Control (Glass Distilled)			7.9	91			0	
Lab Control (SSEPAMH)			8.4	209	8.3	84		66
Lab Control (GDEPAMH)			8.4	267	8.0			
Mosher Slough 11/13/97	461	59	7.9	99	8.3	42	0.5	46
5-Mile Slough 11/13/97	359	52	7.5	118	7.8	46	1.2	48

1. Detection limits for ELISA diazinon and chlorpyrifos are 30 ng/L and 50 ng/L, respectively. Diazinon and chlorpyrifos ELISA were conducted on 11/14/97.
2. All EC values reported in this column were taken at 25° C.

1998 Studies

DeltaKeeper collected a sample of Walker Slough and Mosher Slough stormwater runoff on September 9, 1998. According to the rainfall data available, there was no rainfall on that date in Stockton.

Table 98-1 presents the 7-day *Ceriodaphnia* toxicity test results for that sample, which show that neither Walker Slough nor Mosher Slough was toxic to *Ceriodaphnia*. Table 98-2 shows that similar results for the fathead minnow larvae were found for the sample collected on September 9, 1998, in which there was no toxicity found. This was also the result for the *Selenastrum* testing for that sample (see Table 98-3). There was appreciable stimulation of *Selenastrum* growth in the Walker Slough and Mosher Slough samples. The chemical characteristic data for the September 9, 1998, samples are presented in Table 98-4. No data are available for ELISA tests on these samples.

Table 98-1
Summary of 7-day *Ceriodaphnia* toxicity test conducted during September 1998.[2]

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	18.9[P]	1.1	0[P]	8.4
Walker Slough	18.2	1.9	0	8.3
Mosher Slough at Mariners	29.1	1.2	0	8.4

P. The laboratory control met all US EPA criteria for test acceptability. 90% of the daphnids had a third brood.
1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).
2. The samples were collected on 9 September 1998. This test was set up on 10 September 1998.

Table 98-2
Summary of 7-day *Pimephales* toxicity test conducted during September 1998.[2]

Treatment	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control	0.355[P]	0.020	5.0[P]	3.0	7.8
Walker Slough	0.429	0.035	5.0	5.0	7.7
Mosher Slough at Mariners	0.436	0.016	0.0	0.0	7.8

P. The laboratory control met the criteria for test acceptability.
1. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).

2. The samples were collected on 9 Septernber 1998. This test was set up on 10 September 1998.

Table 98-3
Summary of 96-hr *Selenastrum* toxicity test conducted during September 1998[2]

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	185.4[P]	16.7	18.0	8.5
Walker Slough	500.9	10.8	4.3	10.2
Mosher Slough at Mariners	429.9	12.5	5.8	10.2

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 18.0% in this treatment.
1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).
2. Samples were collected on 9 September 1998. This toxicity test was set up on 10 September 1998.

Table 98-4
Water Chemical Characteristic Data for Stockton Urban Runoff Samples Collected 9 September 1998

Treatment	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Lab Control (EPAMH)	8.0	287	8.3	88	86
Lab Control (SSEPAMH)	8.0	233	8.5	96	82
Lab Control (Glass Distilled)					
Walker Slough	7.7	137	8.4	60	62
Mosher Slough at Mariners	7.8	166	8.3	72	82

October 24, 1998

A sample of stormwater runoff was obtained by the DeltaKeeper for October 24, 1998 from several of the Stockton sloughs. The rainfall data for that date for the City of Stockton show that there was 0.67 inch of precipitation.

Table 98-5 presents the results of the 7-day *Ceriodaphnia* toxicity test. Both Mosher Slough and Walker Slough showed 100 percent mortality of the *Ceriodaphnia* in 3 and 2 days, respectively. This toxicity was essentially eliminated through the addition of 100 µg/L PBO. Five-Mile Slough, Calaveras River and Smith Canal samples taken on October 24, 1998, did not show toxicity to *Ceriodaphnia* over the 7-day test.

Tables 98-6 and 98-7 show the fathead minnow larvae and *Selenastrum* toxicity test data for the October 24, 1998, sample. No toxicity was observed to either of these organisms in Five-Mile Slough, Calaveras River, Smith Canal, Mosher Slough and Walker Slough.

The data in Table 98-8 show that Mosher Slough had 310 ng/L diazinon, while Walker Slough had 170 ng/L diazinon. There is no indication as to whether chlorpyrifos was measured on these samples. Since both samples showed high levels of acute toxicity to *Ceriodaphnia* over 7 days, it appears that there may be diazinon or other toxicants present to account for the toxicity measured.

Table 98-5
Summary of 7-day *Ceriodaphnia* toxicity test conducted during October 1998[2]

Treatment	Reproduction[1] (neonates/adult)	Mortality[1] (%)	Final pH at 24 hours

	x	se		
Laboratory Control	21.5[P]	1.1	0.0[P]	8.5
Laboratory Control + PBO	16.0	2.8	10	8.5
5-Mile Slough	34.9	1.3	0	8.0
5-Mile Slough + PBO	30.3	3.7	10	8.0
Calaveras River	28.2	2.0	10	7.9
Calaveras River + PBO	24.9	1.2	0	7.9
Smith Canal	25.3	2.4	0	7.7
Smith Canal + PBO	22.8	1.2	0	7.6
Mosher Slough	*	*	100 (3)	7.7
Mosher Slough + PBO	14.7	2.5	20	7.6
Walker Slough	*	*	100 (2)	7.4
Walker Slough + PBO	12.1	1.0	0	7.4

P. The laboratory control met all US EPA criteria for test acceptability. 90% of the daphnids had a third brood.
1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).
2. The samples were collected on 24 October 1998. This test was set up on 25 October 1998.

* Due to significant mortality observed in this sample, reproduction was not calculated.

(#) Number in parentheses represents days to 100% mortality.

Table 98-6
Summary of 7-day *Pimephales* toxicity test conducted during October 1998[2]

Treatment	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control	0.476[P]	0.016	0.0[P]	0.0	8.1
5 Mile Slough	0.473	0.029	0.0	0.0	7.6
Calaveras River	0.528	0.028	2.5	3.0	7.4
Smith Canal	0.424	0.010	0.0	0.0	7.2
Mosher Slough	0.486	0.017	2.5	3.0	7.3
Walker Slough	0.435	0.022	10.0	4.0	7.2

P. The laboratory control met the criteria for test acceptability.
1. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).
2. The samples were collected on 24 October 1998. This test was set up on 28 October 1998.

Table 98-7
Summary of 96-hr *Selenastrum* toxicity test conducted during October 1998[2]

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	187.3[P]	9.3	9.9	8.0
5-Mile Slough	364.1	24.6	13.5	9.8
Calaveras River	337.0	11.0	6.5	10.1
Smith Canal	268.2	2.6	1.9	9.4
Mosher Slough	376.9	10.0	5.3	9.8
Walker Slough	279.6	10.4	7.4	9.6

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 9.9% in this treatment.
1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).
2. The samples were collected on 24 October 1998. This test was set up on 25 October 1998.

Table 98-8

Summary of water chemical characteristic measurements on samples collected on 24 October 1998

Treatment	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Lab Control (EPAMH)				8.3	284	8.3	88	60
Lab Control (SSEPAMH)				8.3	221	8.2	88	66
Lab Control (Glass Distilled)				7.8	90	8.7		
5 Mile Slough				7.6	236	7.5	70	63
Calaveras River	*	*	89	7.6	103	7.9	42	40
Smith Canal	*	*	164	7.2	178	6.1	56	44
Mosher Slough	*	*	91	7.2	110	6.4	44	41
Walker Slough				7.3	140	7.1	48	28

* These values are not available due to a lack of available field equipment.

Treatment	Diazinon (ng/L)
Mosher Slough	310
Walker Slough	170

December 7, 1998

DeltaKeeper collected samples of Walker Slough and Mosher Slough on December 7, 1998. There was no rainfall on that day. Table 98-9 shows that, while Walker Slough was nontoxic to *Ceriodaphnia* during the 7-day period, Mosher Slough showed 60 percent mortality over that period. Blind duplicates on the Walker Slough samples showed similar results. Table 98-10 shows that the addition of 100 µg/L PBO eliminated the toxicity that was found to *Ceriodaphnia* over the 7-day test.

The December 7 sample was found to be nontoxic to fathead minnow larvae and to *Selenastrum*. These data are presented in Tables 98-11 and 98-12. While there was an apparent decrease in the cell count for the Walker Slough sample collected on December 7, 1998, this decrease was not statistically significant. A partial TIE was conducted on the Walker Slough sample collected on December 7, 1998, using *Selenastrum* as the test organism (Table 98-13). The cell count in this sample for Walker Slough was statistically significantly depressed. Passing the sample through a C8 column extracted water eliminated the toxicity.

Table 98-9

Summary of 7-day *Ceriodaphnia* toxicity test (chronic) conducted during December 1998[2]

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	21.8[P]	2.8	0[P]	8.3
Walker Slough	24.4	0.8	0	8.3
Mosher Slough at Mariners	*	*	60	8.2

Quality Assurance Samples

Blind Duplicate	Reproduction[1] (neonates/adult)		Mortality (%)	Final pH at 24 hours
	x	se		
Walker Slough	24.4	0.8	0	8.3
Walker Slough duplicate	25.0	1.3	0	8.2

P. The laboratory control met all US EPA criteria for test acceptability. 78% of the daphnids had a third brood.

1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive

endpoint was analyzed using Dunnett's test ($p<0.05$).
2. The samples were collected on 7 December 1998. This test was set up on 8 December 1998.
* Due to significant mortality observed in these samples, reproduction was not calculated.

Table 98-10
Summary of 7-day *Ceriodaphnia* toxicity test (TIE) conducted during December 1998[2]

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	24.8[P]	1.1	0[P]	8.4
Laboratory Control + PBO	17.9	0.9	0	8.4
Mosher Slough	*	*	90	8.3
Mosher Slough + PBO	29.6	0.5	0	8.3

P. The laboratory control met all EPA criteria for test acceptability. 89% of the daphnids had a third brood.
1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).
2. The samples were collected on 7 December 1998. This test was set up on 16 December 1998.
* Due to significant mortality observed in this sample, reproduction was not calculated.

Table 98-11
Summary of 7-day *Pimephales* toxicity test conducted during December 1998[2]

Treatment	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control	0.446[P]	0.063	2.5[P]	3.0	8.1
Walker Slough	0.383	0.014	0.0	0.0	8.1
Mosher Slough at Mariners	0.380	0.008	0.0	0.0	8.1

Quality Assurance Samples

Blind Duplicate	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Walker Slough	0.383	0.014	0.0	0.0	8.1
Walker Slough duplicate	0.416	0.020	12.5	8.0	8.0

P. The laboratory control met the criteria for test acceptability.
1. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).
2. The samples were collected on 7 December 1998. This test was set up on 8 December 1998.

Table 98-12
Summary of 96-hr *Selenastrum* toxicity test (chronic) conducted during December 1998[2]

Treatment	Cell Count ($x\ 10^4$)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	206.4[P]	11.2	10.8	7.5
Walker Slough	65.8	11.3	34.3	8.9
Mosher Slough at Mariners	123.6	3.0	4.8	9.5

Quality Assurance Samples

Blind Duplicates	Cell Count ($x\ 10^4$)[1]		% CV	Final pH at 96 hours
	x	se		
Walker Slough	65.8	11.3	34.3	8.9
Walker Slough duplicate	59.2	6.0	20.1	8.8

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 10.8% in this treatment.
1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).

2. Samples were collected on 7 December 1998. This test was set up on 8 December 1998.

Table 98-13
Summary of 96-hr *Selenastrum* toxicity test (TIE) conducted during December 1998[2]

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	200.5[P]	8.9	8.8	8.8
Laboratory Control C8 method blank	75.8	5.1	13.5	8.5
Walker Slough 12/7/98	69.2	4.1	11.8	8.9
Walker Slough 12/7/98 C8 solid phase extracted water	209.5	5.0	4.8	10.0
Re-sampled Walker Slough 12/14/98	188.9	6.3	6.6	10.0

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 8.8% in this treatment.
1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control or increase in growth (in the solid phase extracted water) compared to the ambient sample. Cell counts were analyzed using Dunnett's Test ($p<.05$).
2. The samples were collected on the dates indicated in the table. This test was set up on 16 December 1998.

Walker Slough was re-sampled on December 14, and was not found to be toxic. While there is no information on whether there was precipitation on December 14, it appears that the toxicity found on December 7 was transitory, associated with a runoff event, and it did not persist for a week until it was re-sampled.

The chemical characteristic data for the December 7 sample are presented in Table 98-14. No ELISA results were available, since the samples were nontoxic. This test is only run when toxicity is found.

Table 98-14
Summary of water chemical characteristics of samples collected on 7 December 1998

Treatment	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Lab Control (EPAMH)				8.2	291	8.4	84	36
Lab Control (SSEPAMH)				8.3	227	8.4	88	70
Lab Control (Glass Distilled)				8.4	90	8.4		
Walker Slough	7.9	7.1	105	8.2	161	8.4	56	21
Mosher Slough at Mariners	10.4	7.5		8.1	195	8.3	88	18

Quality Assurance Samples

Blind Duplicate	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Walker Slough				8.2	161	8.4	56	21
Walker Slough duplicate				8.2	158	8.4	58	13

1999 Studies

The DeltaKeeper collected samples from Mosher Slough on January 20, 1999. There was no rain on the day of collection. The data from the 7-day *Ceriodaphnia* toxicity test are presented in Table 99-1. Mosher Slough water caused 100 percent mortality within 1 day. The addition of 100 g/L PBO extended the time to 6 days for 100 percent mortality.

Table 99-2 presents the toxicity test results with *Selenastrum* for the January 20 sample. The Mosher Slough sample was not toxic to *Selenastrum.*

The data presented in Table 99-3 for the chemical characteristics show that there were 50 ng/L chlorpyrifos and 1,200 ng/L diazinon. This sample would be expected to be highly toxic. It is somewhat surprising that Mosher Slough had that level of toxicity in a non-runoff situation. While the day of sampling had no rainfall, the day before (1/19/99) had 0.56 inch of rain. Evidently, there was sufficient carryover from one day to the next in this case to cause Mosher Slough to be toxic the day after a rainfall event. This situation is somewhat different from what has been found in the past; however, the other samples did not have such high levels of diazinon as this sample.

Table 99-1
Summary of 7-day *Ceriodaphnia* toxicity test conducted during January 1999[2]

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	22.3[P]	0.3	0[P]	8.4
Laboratory Control + PBO	16.2	1.0	0	8.4
Mosher Slough	*	*	100 (1)	8.1
Mosher Slough + PBO	*	*	100 (6)	8.0

P. The laboratory control met all US EPA criteria for test acceptability. 100% of the daphnids had a third brood.
1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).
2. The samples were collected on 20 January 1999. This test was set up on 21 January 1999.

Table 99-2
Summary of 96-hr *Selenastrum* toxicity test conducted during January 1999[2]

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	221.3[P]	11.2	6.0	8.4
Laboratory Control C8 Blank	73.6	1.7	4.5	8.2
Mosher Slough	287.0	10.0	7.0	8.3

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 6.0% in this treatment.
1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).
2. Samples were collected on 19-20 January 1999. This test was set up on 21 January 1999.

Table 99-3
Summary of water chemical characteristics of samples collected during January 1999

Treatment	Field Temp (^oC)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)

Lab Control (SSEPAMH)				8.4	217	8.4	84	70
Lab Control (Glass Distilled)				7.7	95	8.3	0	4
Mosher Slough				8.2	102	8.3	24	36

Treatment	Chemical Concentration (ng/L)			
	Chlorpyrifos	Diazinon	Simazine	Diuron
Mosher Slough	50	1,200	440	2,500

February 8, 1999

DeltaKeeper took a sample of Mosher Slough on February 8, 1999. There was 0.16 inch of rain on that day in Stockton. Mosher Slough was sampled at both I-5 and Don Avenue. As shown in Table 99-4, both samples showed 100 percent mortality within 1 day to *Ceriodaphnia*. Duplicates of the I-5 sample showed the same results.

A 96-hour series of toxicity tests using *Ceriodaphnia*, with or without PBO, were conducted on the February 8, 1999, samples taken from Mosher Slough. The Mosher Slough sample taken at Don Avenue showed 100 percent mortality within 1 day. The addition of 100 g/L PBO essentially eliminated this toxicity over 4 days. Based on the data presented in Table 99-5, there were approximately 3 to 4 TUa of *Ceriodaphnia* toxicity in the February 8, 1999, sample of Mosher Slough water.

Table 99-6 presents the 7-day fathead minnow larvae test results for the February 8 sample. There was no toxicity to fathead minnow larvae in this runoff event.

Table 99-7 presents the results of the toxicity tests with *Selenastrum* for the February 8, 1999, samples taken from Mosher Slough. The Mosher Slough samples were toxic to *Selenastrum*. The cause of this toxicity was not determined.

Table 99-4
Summary of 7-day *Ceriodaphnia* toxicity test conducted during February 1999[2]

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	20.5[P]	0.6	0[P]	8.5
Mosher Slough at I-5	*	*	100 (1)	8.0
Mosher Slough at Don Avenue	*	*	100 (1)	8.1

Quality Assurance Samples

Blind Duplicate	Reproduction[1] (neonates/adult)		Mortality (%)	Final pH at 24 hours
	x	se		
Mosher Slough at I-5	*	*	100 (1)	8.0
Mosher Slough at I-5 duplicate	*	*	100 (1)	8.0

Trip Blank	Reproduction[1] (neonates/adult)		Mortality (%)	Final pH at 24 hours
	x	se		
Laboratory Control Trip Blank	21.1	1.2	0	8.5

P. The laboratory control met all US EPA criteria for test acceptability. 100% of the daphnids had a third brood.
1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the

laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).

2. The samples were collected on 8 February 1999. This test was set up on 9 February 1999.

Table 99-5
Summary of *Ceriodaphnia* 96-hour PBO TIE and dilution series conducted during February 1999[1,2,4]

Treatment	Mortality for each day of the test[3]				Conclusions	Final pH at 24 hrs
	1	2	3	4		
Laboratory Control				0	Control met all US EPA criteria for test acceptability.	8.3
Laboratory Control + PBO				0	No artifactual toxicity present in control blanks.	8.4
100% Mosher Slough at I-5	100	100	100	100	Toxicity detected.	8.0
100% Mosher Slough at I-5 + PBO				0	Toxicity alleviated by the addition of PBO suggests that toxicity was due to a metabolically activated OP pesticide.	7.9
50% Mosher Slough at I-5	50	100	100	100	Toxicity detected.	8.2
25% Mosher Slough at I-5				0	No toxicity detected.	8.3
25% Mosher Slough at I-5 + PBO				0		8.2
12.5% Mosher Slough at I-5				0		8.3
100% Mosher Slough at Don Ave.	100	100	100	100	Toxicity detected.	8.0
100% Mosher Slough at Don Ave. + PBO			5	5	Toxicity alleviated by the addition of PBO suggests that toxicity was due to a metabolically activated OP pesticide.	8.2
50% Mosher Slough at Don Ave.	100	100	100	100	Toxicity detected.	8.0
25% Mosher Slough at Don Ave.				0	No toxicity detected.	8.3
25% Mosher Slough at Don Ave. + PBO				0		8.4
12.5% Mosher Slough at Don Ave.		5	5	5		8.2

1. Four replicates with 18 mls of sample and 5 *Ceriodaphnia* each.
2. Daphnids were fed the standard US EPA amount of food for only four hours a day.
3. Highlighted cells indicate areas of significant interest. No statistical analyses were done.
4. The site was sampled on 8 February 1999. This test was set up on 12 February 1999.

Table 99-6
Summary of 7-day *Pimephales* toxicity test conducted during February 1999[2]

Treatment	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control	0.413[P]	0.022	0[P]	0.0	8.0
Mosher Slough at I-5	0.466	0.024	5.0	5.0	7.4
Mosher Slough at Don Avenue	0.482	0.024	10.0	4.0	7.5

Quality Assurance Samples

Blind Duplicate	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Mosher Slough at I-5	0.466	0.024	5.0	5.0	7.4
Mosher Slough at I-5 duplicate	0.438	0.033	5.0	3.0	7.5

Trip Blank	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control Trip Blank	0.423	0.019	7.5	5.0	8.1

P. The laboratory control met the criteria for test acceptability.

1. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).
2. The samples were collected on 8 February 1999. This test was set up on 9 February 1999.

Table 99-7
Summary of 96-hr *Selenastrum* toxicity test conducted during February 1999[2]

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	207.6[P]	8.6	8.3	8.4
Mosher Slough at I-5	13.0	0.7	11.3	8.2
Mosher Slough at Don Avenue	71.3	0.8	2.1	8.2

Quality Assurance Samples

Blind Duplicate	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Mosher Slough at I-5	13.0	0.7	11.3	8.2
Mosher Slough at I-5 duplicate	13.0	0.3	3.9	8.2

Trip blank	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control Trip Blank	102.6	7.9	15.5	8.4

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 8.3% in this treatment.
1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).
2. Samples were collected on 8 February 1999. This test was set up on 9 February 1999.

Table 99-8 presents the chemical characteristic data for the February 8, 1999, sample. This sample was found to contain from 30 to 40 ng/L chlorpyrifos and 860 ng/L diazinon. These concentrations of these two pesticides would be expected to be highly toxic to *Ceriodaphnia*. This is in accord with the toxicity test results.

Table 99-8
Summary of water chemical characteristics of samples collected during February 1999

Treatment	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Lab Control (EPAMH)				7.8	260	8.6	96	60
Lab Control (SSEPAMH)				8.2	234	8.6	88	66
Lab Control (Glass Distilled)				9.0	94	8.4		
Mosher Slough at I-5				7.8	91	8.6	36	30
Mosher Slough at Don Avenue				7.9	91	8.7	36	34

Quality Assurance Samples

Blind Duplicate	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Mosher Slough at I-5				7.8	91	8.6	36	30
Mosher Slough at I-5 duplicate				7.8	87	8.7	36	30

Trip Blank	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Laboratory Control Trip Blank				8.2	224	8.5	88	66

Treatment	Chemical Concentration (ng/L)			
	Chlorpyrifos	Diazinon	Prowl	Simazine
Mosher Slough at I-5	40	820	100	5,500
Mosher Slough at Don Avenue	30	860	60	5,300

March 1999

On March 8, 1999, a set of samples was collected from several of the City of Stockton sloughs, as well as other waterbodies in the Delta. The Stockton rainfall gage reported 0.20 inch of precipitation on that date. Tables 99-9 through 99-12 present the results of the toxicity testing and chemical characteristic measurements on this set of samples. Review of the data in these tables shows that Walker Slough and Mosher Slough were nontoxic to *Ceriodaphnia*, fathead minnow larvae and *Selenastrum*. The data obtained from other waterbodies in the region, such as the San Joaquin River at Vernalis, Mokelumne River at New Hope, French Camp Slough at El Dorado, Old River at Tracy, etc., also showed no toxicity to the test organisms. Table 99-13 presents a summary of the toxicity test results obtained for the March 8, 1999, sample.

Table 99-9
Summary of 7-day *Ceriodaphnia* toxicity test conducted on samples collected from the Sacramento-San Joaquin River Delta on 8 March 1999

Set up on 3/9/99

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	21.7[P]	0.6	0[P]	8.2
San Joaquin River at Vernalis	24.6	1.8	10	8.2
Mokelumne River at New Hope	10.6	1.2	0	7.9
Paradise Cut	36.1	1.3	0	8.3
French Camp Slough at El Dorado	26.9	0.6	0	8.3
Walker Slough	33.9	0.8	0	8.2
Mosher Slough at Mariners	33.1	1.0	30	8.5
Stockton Treatment Plant	24.5	1.1	0	8.2
White Slough	25.0	1.0	0	8.1
Old River at Tracy	29.8	0.7	0	8.2
Quality Assurance Samples				
Mosher Slough	33.1	1.0	30	8.5
Mosher Slough duplicate	32.7	1.2	0	8.5
Stockton Treatment Plant	24.5	1.1	0	8.2
Stockton Treatment Plant duplicate	26.9	1.3	0	8.2
Stockton Treatment Plant duplicate	27.9	0.8	0	8.1

P. The laboratory control met all US EPA criteria for test acceptability. 100% of the daphnids had a third brood.

1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).

Table 99-10

Summary of 7-day *Pimephales* toxicity test conducted on samples collected from the Sacramento-San Joaquin River Delta on 8 March 1999

Set up on 3/9/99

Treatment	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control	0.407[P]	0.009	0[P]	0.0	7.9
San Joaquin River at Vernalis	0.381	0.002	0.0	0.0	7.8
Mokelumne River at New Hope	0.292	0.079	25.0	3.0	7.5
Paradise Cut	0.426	0.023	5.0	5.0	7.9
French Camp Slough at El Dorado	0.379	0.042	25.0	18.0	7.9
Walker Slough	0.424	0.015	5.0	3.0	7.7
Mosher Slough at Mariners	0.414	0.005	0.0	0.0	8.1
Stockton Treatment Plant	0.402	0.021	0.0	0.0	7.8
White Slough	0.395	0.015	5.0	3.0	7.7
Old River at Tracy	0.396	0.011	0.0	0.0	7.8
Quality Assurance Samples					
Mosher Slough	0.414	0.005	0.0	0.0	8.1
Mosher Slough Duplicate	0.438	0.025	2.5	3.0	8.2
Stockton Treatment Plant	0.402	0.021	0.0	0.0	7.8
Stockton Treatment Plant duplicate	0.395	0.017	2.5	3.0	7.8
Stockton Treatment Plant duplicate	0.411	0.006	7.5	5.0	7.8

P. The laboratory control met all US EPA criteria for test acceptability.

1. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).

Table 99-11

Summary of 7-day *Selenastrum* toxicity test conducted on samples collected from the Sacramento-San Joaquin River Delta on 8 March 1999

Set up on 3/9/99

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	218.4[P]	3.2	2.9	8.6
San Joaquin River at Vernalis	232.3	19.2	16.5	9.8
Mokelumne River at New Hope	275.3	10.6	7.7	9.4
Paradise Cut	158.9	35.8	45.1	8.6
French Camp Slough at El Dorado	305.6	15.5	10.2	9.8
Walker Slough	295.6	18.9	12.8	9.9
Mosher Slough at Mariners	306.0	21.3	13.9	9.9
Stockton Treatment Plant	284.1	8.0	5.6	9.9
White Slough	308.9	20.1	13.0	9.8
Old River at Tracy	279.8	19.9	14.3	9.9
Quality Assurance Samples				
Mosher Slough	306.0	21.3	13.9	9.9
Mosher Slough duplicate	270.1	9.4	6.9	9.7
Stockton Treatment Plant	284.1	8.0	5.6	9.9
Stockton Treatment Plant duplicate	264.1	22.0	16.7	9.9
Stockton Treatment Plant duplicate	289.9	11.6	8.0	9.8

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 2.9% in this treatment.

1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).

Table 99-12

Summary of chemical characteristic measurements on samples collected from the Sacramento-San Joaquin River Delta on 8 March 1999

Treatment	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
ab Control (DIEPAMH)				8.1	223	8.6	80	62
ab Control (SSEPAMH)				8.2	222	8.2	86	68
ab Control (Glass Distilled)								
an Joaquin River at Vernalis	10.8	6.7	241	8.1	319	8.4	82	56
lokelumne River at New Hope	9.6	7.6	32	7.9	50	8.3	20	44
aradise Cut	11.6	7.4	965	8.2	865	8.4	272	102
rench Camp Slough at El Dorado	11.5	8.3	207	8.2	202	8.4	80	
/alker Slough	11.5	7.4	109	8.2	142	8.3	56	60
losher Slough at Mariners	12.3	7.5	426	8.4	375	8.3	140	60
tockton Treatment Plant	11.0	8.2	326	8.1	305	8.3	76	56
/hite Slough	11.2	7.4	152	8.0	136	8.4	50	44
ld River at Tracy	11.0	7.6	258	8.1	333	8.4	86	58
uality Assurance Samples								
losher Slough				8.4	375	8.3	140	60
losher Slough duplicate				8.5	382	8.3	142	
tockton Treatment Plant				8.1	305	8.3	76	56
tockton Treatment Plant uplicate				8.1	309	8.2	76	54
tockton Treatment Plant uplicate				8.1	309	8.2	80	

Table 99-13

Summary of toxicity test results for the third quarterly sampling from the Sacramento-San Joaquin Delta collected on 8 March 1999

Set up on 3/9/99

Treatment	*Ceriodaphnia*		*Pimephales*		*Selenastrum*
	Reproduction	Mortality	Growth	Mortality	Cell Count
	Neonate/adult	%	mg/indiv	%	$x10^4$
Laboratory Control	21.7	0	0.407	0.0	218.4
San Joaquin River at Vernalis	24.6	10	0.381	0.0	232.3
Mokelumne River at New Hope	10.6	0	0.292	25.0	275.3
Paradise Cut	36.1	0	0.426	5.0	158.9
French Camp Slough at El Dorado	26.9	0	0.379	25.0	305.6
Walker Slough	33.9	0	0.424	5.0	295.6
Mosher Slough at Mariners	33.1	30	0.414	0.0	306.0
Stockton Treatment Plant	24.5	0	0.402	0.0	284.1
White Slough	25.0	0	0.395	5.0	308.9
Old River at Tracy	29.8	0	0.396	0.0	279.8

1. Highlighted cells indicate a significant reduction in reproduction, growth or cell count or increase in mortality relative to the laboratory control water. The *Ceriodaphnia* mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint, fish growth and mortality, and cell counts were analyzed using Dunnett's Test ($p<.05$).

June 7, 1999

A set of dry weather flow samples was collected from Walker Slough, Mosher Slough, as well as several other waterbodies in the region of the South and Central Delta. The Stockton Slough samples showed no toxicity to *Ceriodaphnia* (Tables 99-14 and 99-15); however, there was toxicity of Mosher Slough water to fathead minnow larvae (Table 99-16), with about 20 percent mortality over the period of the seven-day test. There was no toxicity to *Selenastrum* for the June 7 sample (Table 99-17). Paradise

Cut, located within the South Delta near Tracy, did show toxicity to *Ceriodaphnia*. It was not toxic to fathead minnow larvae; however, Mokelumne River was toxic to fathead minnow larvae.

Table 99-18 presents a summary of the toxicity test results for samples collected on June 7, 1999.

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	18.5[P]	1.2	0[P]	8.4
San Joaquin River at Vernalis	23.7	2.8	10	8.3
Mokelumne River at New Hope	22.0	2.6	10	8.4
Paradise Cut	*	*	70	8.5
French Camp Slough at El Dorado	22.6	0.7	0	8.3
Walker Slough	22.4	1.1	0	8.4
Mosher Slough at Mariners	21.5	2.5	10	8.5
Stockton Treatment Plant	22.1	1.0	0	8.3
White Slough	27.0	0.6	10	8.4
Old River at Tracy	27.2	3.2	10	8.4
Quality Assurance Samples – Blind Duplicate				
San Joaquin River at Vernalis	23.7	2.8	10	8.3
San Joaquin River at Vernalis duplicate	27.7	1.0	0	8.4

P. The laboratory control met all US EPA criteria for test acceptability. 90% of the daphnids had a third brood.

1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).

* Due to significant mortality observed in this sample, reproduction was not calculated.

The sample of the San Joaquin River at Vernalis was nontoxic to *Ceriodaphnia*, fathead minnow larvae and *Selenastrum*. The sample of the Mokelumne River at New Hope was nontoxic to *Ceriodaphnia* and *Selenastrum*, but caused about 58 percent mortality to fathead minnow larvae. The Paradise Cut sample showed 70 percent mortality to *Ceriodaphnia* and was toxic to *Selenastrum*. It was nontoxic to fathead minnow larvae. The June 7 samples collected from French Camp Slough, Walker Slough, White Slough and Old River at Tracy were all nontoxic to the three test species. The Stockton Wastewater Treatment Plant and Mosher Slough samples were nontoxic to *Ceriodaphnia* and *Selenastrum*; however, they did show low levels of toxicity to fathead minnow larvae.

Table 99-19 presents information on the chemical characteristics of the samples collected on June 7 and 16, 1999. No data were provided on diazinon and chlorpyrifos concentrations in the samples.

Table 99-14
Summary of 7-day *Ceriodaphnia* toxicity test conducted on samples collected from the Sacramento-San Joaquin Delta on 7 June 1999

Set up on 6/8/00

Table 99-15
Summary of 7-day *Ceriodaphnia* PBO TIE conducted on samples collected from Paradise Cut and 5-Mile Slough on 7 and 16 June 1999

Set up on 6/8/99

Treatment	Reproduction[1] (neonates/adult)		Mortality[1] (%)	Final pH at 24 hours
	x	se		
Laboratory Control	21.7[P]	2.1	10[P]	8.4
Laboratory Control + PBO	22.0	1.1	0	8.4
Paradise Cut 6/7/99	*	*	50	8.5
Paradise Cut 6/7/99 + PBO	31.6	1.1	0	8.4
Paradise Cut 6/16/99	33.6	0.6	0	8.5
5-Mile Slough 6/16/99	18.8	1.2	0	8.6

P. The laboratory control met all US EPA criteria for test acceptability. 90% of the daphnids had a third brood.

1. Highlighted cells indicate a significant reduction in reproduction or increase in mortality relative to the laboratory control water. The mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint was analyzed using Dunnett's test ($p<0.05$).

* Due to significant mortality observed in this sample, reproduction was not calculated.

Table 99-16
Summary of 7-day *Pimephales* toxicity test conducted on samples collected from the Sacramento-San Joaquin Delta on 7 June 1999

Set up on 6/8/99

Treatment	Growth[1] (mg/indiv)		Mortality (%)[1]		Final pH at 24 hours
	x	se	x	se	
Laboratory Control	0.313[P]	0.011	1.25[P]	1.3	8.2
San Joaquin River at Vernalis	0.333	0.012	0.0	0.0	8.2
Mokelumne River at New Hope	0.395	0.040	57.5	18.9	8.0
Paradise Cut	0.374	0.020	2.5	2.5	8.3
French Camp Slough at El Dorado	0.369	0.012	7.5	4.8	8.0
Walker Slough	0.313	0.011	4.3	4.3	8.0
Mosher Slough at Mariners	0.349	0.021	20.0	13.5	8.2
Stockton Treatment Plant	0.399	0.025	17.5	7.5	8.2
White Slough	0.356	0.030	27.5	17.0	8.0
Old River at Tracy	0.360	0.014	0.0	0.0	8.3
Quality Assurance Samples – Blind Duplicate					
San Joaquin River at Vernalis	0.333	0.012	0.0	0.0	8.2
San Joaquin River at Vernalis duplicate	0.339	0.014	2.5	2.5	8.2

P. The laboratory control met the criteria for test acceptability.

1. Highlighted areas indicate a significant increase in mortality or decrease in growth when compared to the laboratory control. The growth and mortality endpoints were analyzed with Dunnett's Test ($p<.05$).

Table 99-17

Summary of 96-hr *Selenastrum* toxicity test conducted on samples collected from the Sacramento-San Joaquin Delta on 7 June 1999

Set up on 6/8/99

Treatment	Cell Count (x 10^4)[1]		% CV	Final pH at 96 hours
	x	se		
Laboratory Control	75.6[P]	3.8	10.0	7.8
San Joaquin River at Vernalis	139.5	17.3	24.8	8.5
Mokelumne River at New Hope	184.2	15.2	16.6	9.5
Paradise Cut	23.4	5.9	50.2	8.6
French Camp Slough at El Dorado	164.6	5.4	6.6	9.7
Walker Slough	218.2	10.0	9.2	10.0
Mosher Slough at Mariners	144.3	5.4	7.5	9.6
Stockton Treatment Plant	149.0	20.0	26.8	8.6
White Slough	196.9	10.9	10.7	9.7
Old River at Tracy	51.3	5.1	19.7	8.5
Quality Assurance Samples				
San Joaquin River at Vernalis	139.5	17.3	24.8	8.5
San Joaquin River at Vernalis duplicate	142.7	15.3	21.5	8.5

P. The laboratory control met all US EPA criteria for test acceptability. The coefficient of variation was 10% in this treatment.

1. Highlighted areas indicate a significant reduction in growth compared to the laboratory control. Cell counts were analyzed using Dunnett's Test ($p<.05$).

Table 99-18
Summary of toxicity test results for samples from the Sacramento - San Joaquin Delta collected on 7 June 1999

Set up on 6/8/99

Treatment	*Ceriodaphnia*		*Pimephales*		*Selenastrum*
	Reproduction	Mortality	Growth	Mortality	Cell Count
	neonate/adult	%	mg/indiv	%	x10^4
Laboratory Control	18.5[P]	0[P]	0.313[P]	1.25[P]	75.6[P]
San Joaquin River at Vernalis	23.7	10	0.333	0.0	139.5
Mokelumne River at New Hope	22.0	10	0.395	57.5	184.2
Paradise Cut	*	70	0.374	2.5	23.4
French Camp Slough at El Dorado	22.6	0	0.369	7.5	164.6
Walker Slough	22.4	0	0.313	4.3	218.2
Mosher Slough at Mariners	21.5	10	0.349	20.0	144.3
Stockton Treatment Plant	22.1	0	0.399	17.5	149.0
White Slough	27.0	10	0.356	27.5	196.9
Old River at Tracy	27.2	10	0.360	0.0	51.3

1. Highlighted cells indicate a significant reduction in reproduction, growth or cell count or increase in mortality relative to the laboratory control water. The *Ceriodaphnia* mortality endpoint was analyzed using Fisher's Exact Test. The reproductive endpoint, fish growth and mortality, and cell counts were analyzed using Dunnett's Test ($p<.05$).

Table 99-19
Summary of chemical characteristic measurements on samples collected from the Sacramento-San Joaquin Delta on 7 and 16 June 1999

Treatment	Field Temp (°C)	Field pH	Field EC (µmhos/cm)	Lab pH	Lab EC (µmhos/cm)	Lab DO (mg/L)	Total Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)
Lab Control (DIEPAMH)				8.2	318	7.6	84	60

Lab Control (SSEPAMH)				8.3	260	8.1	92	76
Lab Control (Glass Distilled)				8.1	106	8.1		
San Joaquin River at Vernalis	19.0	7.8	502	8.3	490	8.1	112	76
Mokelumne River at New Hope	16.4	8.1	78	8.0	100	8.0	44	24
Paradise Cut	NA	NA	NA	8.4	945	8.1	256	120
French Camp Slough at El Dorado	20.5	8.1	135	8.1	179	8.7	64	50
Walker Slough	22.7	8.0	283	8.1	174	8.1	32	60
Mosher Slough at Mariners	22.6	7.8	177	8.2	189	8.0	84	64
Stockton Treatment Plant	19.9	6.6	437	8.4	486	8.0	124	80
White Slough	20.5	7.4	137	8.8	160	7.8	56	46
Old River at Tracy	NA	NA	NA	8.1	614	8.0	168	90
Paradise Cut 6/16/99	19.8	7.2	1746	8.2	1000	7.9	292	122
Old River at Tracy 6/16/99	20.6	7.9	1054	8.3	644	7.9	152	87
5-Mile Slough 6/16/99				8.4	349	7.9	96	93

Quality Assurance Samples

San Joaquin River at Vernalis	19.0	7.8	502	8.3	490	8.1	112	76
San Joaquin River at Vernalis duplicate	19.0	7.8	502	8.3	471	8.0	108	74

September 22, 1999

On September 22, 1999, DeltaKeeper collected samples from Walker Slough, Mosher Slough, and 5 Mile Slough. Table 99-20 showed that the Mosher Slough and 5 Mile Slough samples killed 100 % of the *Ceriodaphnia* in six and seven days, respectively. The Walker Slough sample was non-toxic to *Ceriodaphnia*. Table 99-21 shows that the addition of 100 µg/L PBO reduced the toxicity for Mosher Slough to 20 % mortality over seven days. Table 99-22 shows that the addition of 100 µg/L of PBO caused the 5 Mile Slough sample to be non-toxic to *Ceriodaphnia*. However, the re-setup of the 5 Mile Slough sample collected on September 22, 1999, shown in Table 99-22 was non-toxic over the seven-day test period. As shown in Table 99-20, the 5 Mile Slough sample killed 100 % of the *Ceriodaphnia* in seven days. The Table 99-22 tests were set up on October 1, some nine days after the sample was originally collected on September 22. Evidently, during this period, some of the toxicity that was found for 5 Mile Slough for the tests that were set up the day following collection, was lost in the sample.

Table 99-23 presents the chemical analysis of the samples collected on September 22, 1999. The parameters analyzed are in accord with what would be expected. No analysis were conducted for the OP pesticides, diazinon and chlorpyrifos.

Insert Tables 99-20 through 99-23

ACRONYMS AND ABBREVIATIONS

CVRWQCB	Central Valley Regional Water Quality Control Board
DIEPAMH	US EPA deionized moderately hard control water
Dilute EI	UCD Institute of Ecology Well Water diluted to an EC of approx. 200 µmhos/cm
DO	dissolved oxygen
EC	electrical conductivity
EDTA	ethylene diamine tetraacetic acid
ELISA	enzyme linked immuno sorbent assay
EPAMH	US EPA moderately hard control water
GDEPAMH	glass distilled water amended with salts to EPA moderately hard standards
LC_{50}	lethal concentration that kills 50 percent
NPDES	national pollutant discharge elimination system
OP	organophosphate
PBO	piperonyl butoxide
PCCP	Post C8 SPE Column Passage
SSEPAMH	Sierra Spring US EPA moderately hard control water
TIE	toxicity investigation evaluation
TUa	acute toxic units
UCD ATL	University of California, Davis, Aquatic Toxicology Laboratory
US EPA	United States Environmental Protection Agency

Dissolved Oxygen Depletion in the Stockton Sloughs

Report prepared for DeltaKeeper by
G. Fred Lee & Associates

August 2000

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August 25, 2000

William Jennings
DeltaKeeper
3536 Rainier Avenue
Stockton, CA 95204

Dear Bill:

In accord with your request for my assistance in helping the DeltaKeeper interpret some of the water quality characteristic data that DeltaKeeper has been collecting on the Stockton sloughs, I wish to provide the following comments on the DO data that you have asked me to review.

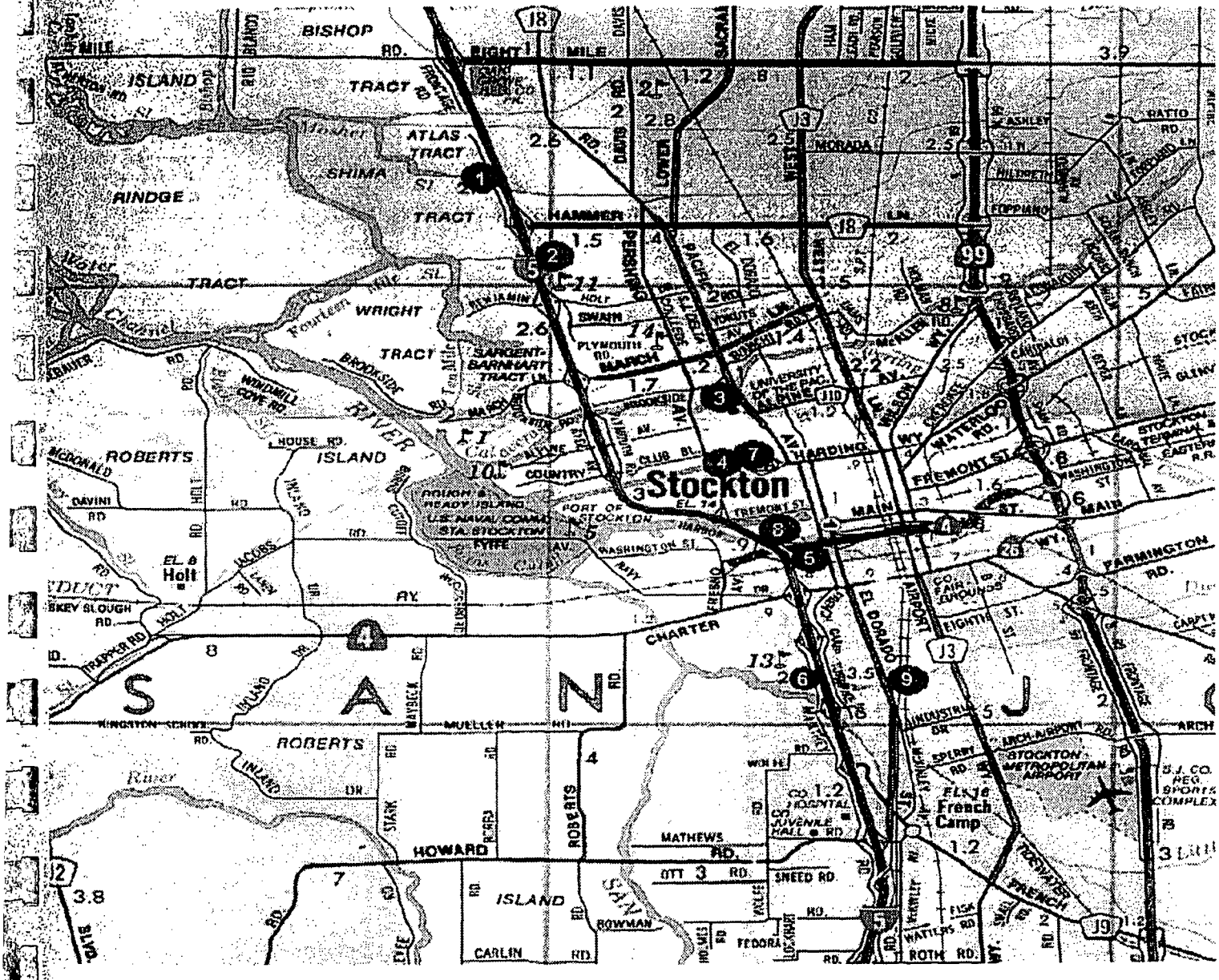
Dissolved Oxygen Depletion in the Stockton Sloughs

During the fall and winter of 1999-2000, the DeltaKeeper collected DO data on several City of Stockton sloughs. The sampling locations used are shown in Figure 1. The data are presented in Table 1.

Examination of the data in Table 1 shows that DO concentrations of less than 2 mg/L were found on several occasions in Mormon Slough, Five Mile Slough, Mosher Slough, and Smith Canal. Table 1 also presents the Stockton slough monitoring data collected by the DeltaKeeper for the fall of 1996. These data show that this low DO problem in the Stockton sloughs has been occurring in other years. A review of the data shows that often the DO concentration in the sloughs increases during a rainfall event. This is evidently related to dilution and mixing.

Lee and Jones-Lee (2000) summarized the studies of Chen and Tsai (2000), who conducted a limited study of dissolved oxygen depletion in Smith Canal (which is one of the Stockton sloughs) after stormwater runoff events. The purpose of this study was to evaluate the reasons for the dissolved oxygen depression in Smith Canal that occurs after stormwater runoff. Smith Canal is a dead-end slough connected to the San Joaquin River opposite Rough and Ready Island. It receives stormwater inflow from an urban area of Stockton. During or soon after a stormwater runoff event, the water quality in Smith Canal is sufficiently deteriorated so that fish kills have occurred. Smith Canal has a drainage area of 3,300 ac., with 50 percent residential, 18 percent commercial and 26 percent streets. The institution and industrial activities occupy about six percent. In the late 1990s the City of Stockton conducted a multi-year monitoring program to measure stormwater input and water quality response in Smith Canal.

Figure 1



DeltaKeeper Dissolved Oxygen Sampling Sites -November 1999

1 Mosher Slough - Mariner's Drive bridge at I-5
2 Five-Mile Slough - at Plymouth Road bridge
3 Calaveras River - at Woods Bridge, north of UOP campus
4 Smiths Canal - at Pershing Avenue bridge
5 Mormon Slough - at Lincoln Street bridge
6 Walker Slough - at Manthey Road bridge and I-5 (Van Buskirk Park)
7 Smiths Canal - at Yosemite Street
8 Mormon Slough - at Turning Basin
9 Walker Slough - upstream from confluence with Duck Creek

Table 1
Dissolved Oxygen Concentrations in Stockton Sloughs during November 1999 and January-February 2000

Mosher Slough

Date	Time	Depth (ft)	Temp (C)	DO mg/L	DO % Sat.[a]	Spec Cond[b]	Tide	Notes
11/8/99	850	3.4	14.5	8.5	86	66	low	" rain 11/7-11/8
11/9/99	845	2.9	14.7	4.0	39	78	low	
11/10/99	1020	1.5	14.7	2.3	23	108	low	
11/11/99	1015	1.2	14.8	1.4	14	120	low	blackish brown
11/12/99	920	1.3	15.2	1.6	16	138	incoming	
11/13/99	925	1.3	15.3	1.8	18	123	incoming	
11/14/99	950	1.3	15.3	1.9	19	125	incoming	
11/15/99	920	1.3	15.3	2.5	25	142	incoming	
11/16/99	915	1.2	14.8	2.4	23	150	incoming	
11/17/99	1013	1.5	15.3	3.3	33	95	incmg/mid	
11/18/99	925	1.5	13	1.3	12	93	incmg/low	
11/19/99	850	0.6	11.8	2.0	19	104	outg/vlow	
11/20/99	830	1.3	12.7	6.4	60	57	outg/low	
11/21/99	745	1.5	12.7	5.3	50	133	outg/low	
11/22/99	900	1.2	10.1	5.5	49	131	outg/low	
11/23/99	900	1.4	10.5	4.9	44	137	outg/mid	
11/24/99	910	1.1	11	4.6	41	146	outg/low	
1/14/00	922	1	9.4	8.6	75	225	incoming	day after rain
1/19/00	904	1	11.7	6.1	57	104	low/outgoing	rain
1/20/00	1016	1	12.1	4.8	45	121	low/outgoing	rain
1/21/00	959	1	11	3.9	35	140	low/outgoing	no rain
1/22/00	958	1	11.3	4	37	161	low/outgoing	no rain
1/23/00	1012	1.5	11.6	5.5	50	147	low/outgoing	rain
1/25/00	1544	1	13.1	9.3	88	154	low/outgoing	no rain - fast, muddy flow
1/26/00	1433	0.5	12	5.9	54	199	low/outgoing	no rain
1/27/00	1442	1.5	11.5	7.4	68	184	low/outgoing	no rain
1/28/00	1411	1.5	11.6	6.3	58	194	low/outgoi	rain

[a] Percent dissolved oxygen saturation
[b] Specific Conductivity in µmhos/cm at 20 C

							ng	
2/1/00	850	1	11.1	5.4	49	139	low/outgoing	day after rain
2/2/00	1735	1	12.5	4.1	38	177	low/outgoing	no rain
2/3/00	1040	1	10.5	8.6	77	173	low/outgoing	rain
2/4/00	914	1	11.8	6.4	59	158	low/outgoing	day after rain
2/7/00	904	1	11.7	3.8	35	185	low/outgoing	3 days after rain

Five Mile Slough

Date	Time	Depth (ft)	Temp (C)	DO (mg/l)	DO% Sat	Spec Cond	Tide	Notes
11/8/99	915	1.1	14.5	6.	59	328	low	" rain 11/7-8
11/9/99	900	0.3	13.6	0.8	8	251	low	
11/10/99	1040	0.8	14.8	1.9	19	356	low	
11/11/99	1030	0.5	15.2	3.1	31	309	low	blackish brown
11/12/99	930	1.1	14.6	2.6	26	326		
11/13/99	945	1.2	14.6	4.8	47	282	incoming	
11/14/99	1000	1.1	15.3	6	60	295	incoming	
11/15/99	935	1.1	15.8	6.5	66	317		
11/16/99	930	0.8	15.2	4.8	48	329		
11/17/99	1026	1	14.6	4	39	181	high/slack	
11/18/99	950	1	12.8	3	28	199	slack	
11/19/99	905	1	11	3.8	36	214	mid/outg	
11/20/99	850	0.9	12	2.9	29	126	low	
11/21/99	800	0.9	12.7	3.9	36	162	mid/incmg	
11/22/99	916	1.1	10	6.2	55	182	mid	
11/23/99	915	1.0	10.3	6.9	62	210	slack/high	
11/24/99	925	1.3	10.2	7.8	69	238	mid	
1/14/00	922	1	9.4	8.6	75	225	incoming	day after rain
1/19/00	918	1	11.8	2.4	22	150	low/outgoing	rain – oil sheen
1/20/00	1036	1	12.2	2.4	23	151	low/outgoing	rain – oil sheen
1/21/00	1012	1	10.8	2.4	21	144	low/outgoing	no rain
1/22/00	1012	1	11.7	2.8	26	178	low/outgoing	no rain
1/23/00	1026	1.5	11.5	8.7	80	67	High	rain
1/25/00	1414	1	14.6	6.7	66	109	low/outgoing	day after rain
1/26/00	1500	1	13	5.2	49	74	low/outgoing	no rain
1/27/00	1452	0.5	13	4.4	42	81	low/outgoing	no rain

1/28/00	1424	0.5	12	5.5	52	103	low/outgoing	rain
2/1/00	902	1	10	4.7	42	94	low/outgoing	day after rain
2/2/00	1719	0.5	13.6	4.2	40	96	low/outgoing	duckweed
2/3/00	935	1	10.5	8.6	77	173	low/outgoing	rain
2/4/00	930	1	11.5	6.1	57	86	low/outgoing	day after rain
2/7/00	915	0.5	11.4	4.6	42	107	low/outgoing	3 days after rain

Walker Slough

Date	Time	Depth (ft)	Temp (C)	DO mg/L	DO % Sat	Spec Cond	Tide	Notes
11/8/99	1115	1.3	15.4	6.4	64	287	Low	" rain 11/7-8
11/9/99	945	1.7	14.5	4.7	46	359	Low	
11/10/99	1200	1.1	15.5	5.7	58	330	Low	
11/11/99	1140	1.3	15.7	5.3	54	380	Low	
11/12/99	1115	1.2	15.2	5.1	50	429	Outg	
11/13/99	1115	1.3	15.2	7	70	457	Outg	
11/15/99	1050	1.2	15.6	6.4	54	448	Incmg	
11/16/99	1045	1.2	15.3	5.7	57	408	incmg/mid	heavy brown scum
11/17/99	1150	1.1	15.5	5.6	56	400	incmg/mid	oil circles
11/18/99	1105	1.1	14	5.9	57	351	incmg/low	
11/19/99	1225	1.1	12.5	5.6	53	390	incmg/low	rain
11/20/99	1110	0.7	13	5.6	53	185	low/slack	
11/21/99	1020	0.6	11.8	4.7	43	260	low/slack	
11/22/99	1045	0.7	9.1	7.0	61	277	incm/low	
11/23/99	1035	1.4	9.5	7.3	64	329	outg/vlow	
11/24/99	1055	1.2	9.9	7.3	64	376	outg/low	
1/14/00	1100	1	9.3	10	88	706	high/incoming	day after rain
1/19/00	1039	1	11.9	4.9	46	256	low/slack	rain
1/20/00	1153	1	12.1	5.2	49	241	low/incom	rain
1/21/00	1135	1	11.1	5.6	51	215	low/outgoing	no rain
1/22/00	1117	1	12.1	6	56	222	low/outgoing	no rain
1/23/00	1128	1	11.8	9.1	84	163	low/outgoing	rain
1/25/00	1544	1	13.1	9.3	88	154	low/outgoing	no rain
1/26/00	1610	1	13	9.4	89	88	low/outgoing	no rain
1/27/00	1610	1.5	12.6	9.3	88	108	low/outgoing	no rain
1/28/00	1637	1	11.3	8.2	75	140	low/outgoing	rain
2/1/00	1008	1	10.2	8	71	168	low/outgoing	day after rain
2/2/00	1559	1	12.5	9.5	89	205	slack/outgoing	no rain
2/3/00	1040	1	10.5	8.6	77	173	low/outgoing	rain
2/4/00	1053	1	11.3	8.4	77	152	low/outgoing	day after rain
2/7/00	1045	1	10.9	9.7	87	108	low/outgoing	3 days after rain

Mormon Slough

Date	Time	Depth (ft)	Temp (C)	DO mg/L	DO % Sat	Spec Cond	Tide	Notes

11/8/99	1050	1.2	15.7	8.3	83	84	low	" rain 11/7-8
11/10/99	1135	1	16	1.3	14	165	low	
11/11/99	1130	1.1	15.9	0.7	8	185	low	blackish brown
11/12/99	1100	1.4	15.6	0.5	4.8	264	outg	
11/13/99	1100	1.5	15.5	0.6	6	269	incmg	
11/15/99	1030	1.2	15.7	2.2	22	335	incmg	
11/16/99	1030	1.1	15.4	2.0	20	349	outg	
11/17/99	1135	1.4	15.4	1.0	10	293	incmg/mid	
11/18/99	1040	1.4	14.2	0.7	7	245	incmg/mid	
11/19/99	1205	1.5	13	1.5	14	270	incmg/mid	
11/20/99	1050	1.2	14.1	3.5	34	115	incmg/low	
11/21/99	1005	1.0	13.3	2.6	25	149	low/slack	
11/22/99	1021	0.6	11.6	3.4	31	162	outg/vlow	
11/23/99	1020	1.0	10.8	3.2	29	172	slack/vlow	
11/24/99	1045	1.2	11.1	3.6	33	196	slack/low	
1/14/00	1045	1	9.5	4	35	749	high/slack	day after rain
1/99/00	1022	1	12.2	4.3	40	117	low/outgoing	rain
1/20/00	1138	1	12	3.4	32	318	low/incoming	rain
1/21/00	1120	1	11.7	3.1	29	322	low/outgoing	no rain
1/22/00	1102	1	11.8	2.8	26	456	low/outgoing	no rain
1/23/00	1117	1	11.8	9.6	89	72	low/outgoing	rain
1/25/00	1527	1	13.7	5.9	57	182	low/outgoing	no rain–oily bubbles
1/26/00	1552	1.5	12.7	4.0	38	113	low/outgoing	no rain
1/27/00	1343	1.5	12.4	3.5	33	219	low/outgoing	no rain
1/28/00	1623	1	11.6	3.4	32	281	low/outgoing	rain
2/1/00	955	1	10.6	3.1	28	305	low/outgoing	day after rain
2/2/00	1624	1.5	12.9	4.8	45	385	slack/outgoing	no rain
2/3/00	1025	1	11.3	3.7	34	336	low/outgoing	rain
2/4/00	1037	1	12.1	4.0	37	192	low/outgoing	day after rain
2/7/00	1035	1	12.1	2.7	25	278	low/outgoing	3 days after rain

Smith Canal

Date	Time	Depth (ft)	Temp (C)	DO mg/L	DO % Sat	Spec Cond	Tide	Notes
11/8/99	1020	3.1	15.7	7.7	77	272	Low	" rain 11/7-8
11/9/99	930	0.9	15.6	0.4	4	334	low	
11/10/99	1115	1.3	15.9	1.5	15	327	low	
11/11/99	1105	1.3	15.8	1.7	17	356	low	blackish brown
11/12/99	1045	1.4	15.8	2.9	29	411	outgoing	
11/13/99	1045	1.3	15.4	3.4	35	359	incoming	
11/15/99	1015	1.4	15.3	3.5	35	388	incoming	
11/16/99	1015	1.4	15.3	2.9	29	393	incom/mid	
11/17/99	1104	1.2	15	2.3	23	390	incom/mid	

11/18/99	1025	1.2	14.3	1.6	16	375	incom/low	
11/19/99	1150	1.3	13.6	1.8	18	296	incmg/mid	
11/20/99	1020	1.1	13.5	1.6	16	268	incmg/low	
11/21/99	950	1.4	13.3	0.7	6	279	low/slack	
11/22/99	1001	1.3	11.9	1.1	10	292	outg/low	
11/23/99	955	1.5	10.8	1.4	13	327	outg/vlow	
11/24/99	1012	1.5	11.2	1.7	15	352	outg/low	
1/14/00	1026	1	9.1	3.9	34	718	high/slack	day after rain
1/19/00	1004	1	11.4	5.2	48	359	low/outgoing	rain
1/20/00	1122	1	11.6	4.0	37	405	low/incoming	rain
1/21/00	1058	1	11	3.6	33	419	low/outgoing	no rain
1/22/00	1048	1	11.4	3.3	30	449	low/outgoing	no rain
1/23/00	1101	2	11.8	5.7	52	331	low/outgoing	rain
1/25/00	1501	1	13.1	8.7	83	100	low/outgoing	no rain
1/26/00	1537	1	12.9	7.0	6	60	low/outgoing	no rain
1/27/00	1357	1	12.2	5.4	50	86	low/outgoing	no rain
1/28/00	1609	1	12.4	4.8	45	121	low/outgoing	rain
2/1/00	938	1	11.1	3.5	32	169	low/outgoing	day after rain
2/2/00	1640	1	12.4	3.8	35	215	slack/outgoing	no rain
2/3/00	1010	1	11.3	3.6	33	184	low/outgoing	rain
2/4/00	1015	1	11.7	4.4	41	171	low/outgoing	day after rain
2/7/00	1018	1	11.9	3.2	30	208	low/outgoing	3 days after rain

Calaveras River

Date	Time	Depth (ft)	Temp (C)	DO mg/L	DO % Sat	Spec Cond	Tide	Notes
11/8/99	1000	2.2	14.9	9.1	90	101	low	" rain 11/7-11/8
11/9/99	915	1.1	14.6	4.8	47	126	low	
11/10/99	1055	0.8	14.9	4.0	40	136	low	
11/11/99	1050	1.9	14.8	3.5	35	151	low	blackish brown
11/12/99	1030	2.1	15.0	2.9	29	153		
11/13/99	1030	2.1	14.8	3.2	32	133	outgoing	
11/14/99	1020	2.0	14.9	3.4	34	137	incoming	
11/15/99	1000	2.1	15.0	3.9	39	152	incoming	
11/16/99	1015	2.2	14.9	4.2	42	161	incoming	
11/17/99	1050	1.4	14.7	5.4	54	176	incom/mid	
11/18/99	1010	1.4	14.0	4.8	47	175	incmg/low	
11/19/99	920	2	13	5.1	48	175	incmg/vlow	
11/20/99	850	1.0	12.9	8.6	82	160	incmg/low	
11/21/99	830	0.6	12.7	7.2	68	169	incmg/low	
11/22/99	951	1.5	11.5	7.6	70	169	outg/low	
11/23/99	935	2.0	10.9	8.2	75	182	outg/vlow	
11/24/99	1000	2.1	10.6	8.4	76	187	outg/low	
1/14/00	1009	1	9.5	4.6	40	212	high/incoming	day after rain

1/19/00	942	1	11.8	8.8	81	170	low/outgoing	rain
1/20/00	1100	1	12.1	9.9	92	199	low/outgoing	rain
1/21/00	1044	1	11.4	9.9	91	177	low/outgoing	no rain
1/22/00	1032	1	11.3	10.2	93	198	low/outgoing	no rain
1/23/00	1047	1	12.1	10.2	95	152	low/outgoing	rain
1/25/00	1440	1	12.7	10.3	97	198	low/outgoing	no rain
1/26/00	1524	1	12.6	10.7	100	118	low/outgoing	no rain
1/27/00	1422	1	12.1	11.0	103	149	low/outgoing	no rain
1/28/00	1555	1	11.2	11.1	101	191	low/outgoing	rain
2/1/00	924	1	10.3	11.5	103	229	low/outgoing	day after rain
2/2/00	1655	1	11.5	11.6	106	189	slack/outgoing	no rain
2/3/00	1000	1	11.2	11.8	107	205	low/outgoing	rain
2/4/00	955	1	11.4	11.7	107	198	low/outgoing	day after rain
2/7/00	940	1	11.1	11.7	42	107	low/outgoing	3 days after rain

Monitoring of Stockton Sloughs, 1996

Mosher Slough

Date	Time	Depth (ft)	Temp (C)	DO (mg/l)	DO %	Spec Cond	Tide	Weather
10/15/96	1405	1.5	16.3	9.3	97	274	Out-Low	Clear
10/29/96	1250	1.3	13.6	9.9	96	215	Out-Low	Raining
10/29/96	1307	2.4	13.5	9.7	95	215	Out-Low	Raining
10/30/96	1345	1.8	13.4	9.4	90	253	Out-Low	Partly Cloudy
10/31/96	1447	2.4	13.1	5.5	54	224	Out-Low	Overcast
11/1/96	1010	3.6	13.1	4.1	39	233	In-High	Sunny
11/1/96	1643	2.3	13.1	6.5	62	180	Out-Low	Clear
11/1/96	1648	2.3	13.5	5.7	55	202	Out-Low	Clear
11/2/96	1400	2.8	13.1	5.8	56	242	Out-High	Overcast
11/3/96	1615	2.8	12.4	6.0	56	190		Partly Cloudy
11/8/96	1105	2.2	12.7	8.0	75	219	Low-In	Clear and Warm

Five Mile Slough

Date	Time	Depth (ft)	Temp (C)	DO (mg/l)	DO %	Spec Cond	Tide	Weather
10/15/96	1425	1.6	22.3	9.4	110	838	Out-Low	Clear
10/29/96	1335	1.4	13.9	9.5	84	365	Out-Low	Raining
10/30/96	1404	1.7	13.9	5.9	60	165	Out-Low	Partly Cloudy
10/31/96	1504	2.2	14.2	0.86	8.5	255	Out-Low	Overcast
11/1/96	1143	1.9	13.3	0.31	2.9	288	In-High	Sunny
11/1/96	1705	2.0	14.6	0.25	2.5	285	Low	Clear
11/2/96	1345	2.0	15.0	0.55	5.5	339	Out-High	Overcast
11/3/96	1630	2.1	15.5	4.2	42	391		Partly Cloudy
11/8/96	1120	1.7	13.7	10.6	102	452	Low-In	Clear and Warm

Smith Canal

Date	Time	Depth	Temp	DO	DO	Spec	Tide	Weather

		(ft)	(C)	(mg/l)	%	Cond		
10/15/96	1500	5.1	20.9	9.3	107	1393	In-Low	Clear
10/15/96	1500	2.0	21.6	11	126	1383	In-Low	Clear
10/29/96	1645	4.8	13.8	10	97	966	In	Raining
10/30/96	1432	3.4	14.1	6.7	69	384	Out-Low	Partly Cloudy
10/31/96	1535	3.5	13.6	0.6	5.6	387	Out-Low	Partly Cloudy
11/1/96	1237	4.9	13.1	0.3	3.3	533	Out-High	Sunny
11/1/96	1734	3.7	13.5	0.2	2.1	466	In-Low	Clear
11/2/96	1441	4.2	13.0	0.3	2.6	470	Out-High	Partly Cloudy
11/3/96	1655	4.3	12.8	0.2	2.4	473		Partly Cloudy
11/8/96	1138	5.8	12.2	2.7	26	602	Low-In	Clear and Warm

Calaveras River

Date	Time	Depth (ft)	Temp (C)	DO (mg/l)	DO %	Spec Cond	Tide	Weather
10/15/96	1444	3.7	21.1	6.7	79	959	Out-Low	Clear
10/29/96	1525	6.3	13.8	9.1	88	549	In-Low	Raining
10/30/96	1541	4.6	13.1	7.7	77	486	In-Low	Partly Cloudy
10/31/96	1707	3.3	13.8	2.4	23	487	In-Low	Partly Cloudy
11/1/96	1550	3.1	13.3	1.0	10	323	Out-Low	Clear
11/1/96	1557	6.4	13.0	1.0	9.5	303	Out-Low	Clear
11/1/96	1600	11.0	12.8	0.9	8.9	296	Out-Low	Clear
11/2/96	1552	3.3	13.3	1.2	12	333	Out-Low	Partly Cloudy
11/2/96	1559	6.4	13.3	1.2	12	333	Out-Low	Partly Cloudy
11/2/96	1605	11.3	13.3	1.2	11	332	Out-Low	Partly Cloudy
11/8/96	1020	5.0	12.6	5.3	50	429	Low-In	Clear and Warm
11/8/96	1028	9.2	12.4	4.9	46	427	Low-In	Clear and Warm

Duck Creek

Date	Time	Depth (ft)	Temp (C)	DO (mg/l)	DO %	Spec Cond	Tide	Weather
10/15/96	1515	1.7	20.4	12.3	140	462	In-Low	Clear
10/29/96	1715	2.9	13.1	8.8	84	385	In	Raining
10/30/96	1500	1.6	14.4	6.2	62	411	In-Low	Partly Cloudy
10/31/96	1555	2.0	14.4	4.1	40	380	Low	Partly Cloudy
11/1/96	1300	3.6	13.8	3.1	30	471	Out-High	Sunny
11/1/96	1800	2.7	14.2	4.6	45	416	In-Low	Clear
11/2/96	1507	3.4	14.3	5.6	50	451	Out-High	Partly Cloudy
11/3/96	1718	3.2	14.1	6.3	62	485		Partly Cloudy
11/8/96	1145	2.1	12.8	8.2	77	616	Low-In	Clear and Warm

In the Chen and Tsai (2000) studies, the dissolved oxygen in Smith Canal decreased to about 1 mg/L about two days after initiation of the stormwater runoff event. It was found that the sediments in Smith Canal had an oxygen demand of about 0.3 g/ft^2/day, which translates to about 3 g/m^2/day, which is in the high range of SOD for waterbodies.

Chen and Tsai (2000) applied the Stockton SJR DO Model to the DO depletion that occurs after runoff events. The Stockton SJR DO Model was modified to include sediment scour transport and deposition of scoured particles. Further, a routine was added to the model to account for the oxygen demand of the scoured sediments. Chen and Tsai (2000) were able to tune the model so that it tracked reasonably closely the DO depletion. They concluded that the primary cause of DO depletion at the dead-end part of Smith Canal was due to constituents present in the urban stormwater discharged to this point. They also concluded that the primary cause of dissolved oxygen depletion is the scour of the sediments and the oxygen demand associated with the sediments.

Chen and Tsai (2000) conducted a limited study of dissolved oxygen depletion in Smith Canal (which is one of the Stockton sloughs) after stormwater runoff events. The purpose of this study was to evaluate the reasons for the dissolved oxygen depression in Smith Canal that occurs after stormwater runoff. Smith Canal is a dead-end slough connected to the San Joaquin River opposite Rough and Ready Island. It receives stormwater inflow from an urban area of Stockton. During or soon after a stormwater runoff event, the water quality in Smith Canal is sufficiently deteriorated so that fish kills have occurred. Smith Canal has a drainage area of 3,300 ac., with 50 percent residential, 18 percent commercial and 26 percent streets. The institution and industrial activities occupy about six percent. In the late 1990s the City of Stockton conducted a multi-year monitoring program to measure stormwater input and water quality response in Smith Canal.

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Chen and Tsai (2000) found that the BOD_5 in stormwater runoff to Smith Canal ranged from 12 to 19 mg/L. They concluded that the BOD was not the cause of the DO depletion that occurs in Smith Canal, that the cause for this depression was due to scouring and resuspension of

sediments from the channel (Smith Canal) bottom, as well as scouring and resuspension of sediments present in the storm sewers that discharge to Smith Canal. It was found that the DO in Smith Canal recovered from the depression more than five days after the storm. They concluded that the impact of DO depletion was on aquatic life within Smith Canal and there was little impact on the San Joaquin River Deep Water Ship Channel into which Smith Canal discharges.

In July 1999 Camp, Dresser and McKee (CDM, 1999) issued a technical memorandum entitled, "Assessment of Water Quality Data from Smith Canal," which is appended to the Chen and Tsai (2000) report. This memorandum is a follow-up to the work of Chen and Tsai. In addition to examining the results of the Chen and Tsai studies, CDM also conducted a review of the past City of Stockton stormwater monitoring and Smith Canal water quality characteristic data. The CDM review primarily focused on the water quality characteristic monitoring of the Smith Canal that the City of Stockton has done over recent years. This monitoring included continuous recording of several parameters, including dissolved oxygen, water depth, pH, specific conductivity, and temperature.

CDM (1999) reported, based on a review of both winter and summer data on Smith Canal, that low DOs were also encountered during summer non-stormwater runoff event periods. Generally, poorer water quality was found during the wet season. CDM reported large diel variations in DO of about 2 to sometimes as large as 10 mg/L, indicating high levels of algal photosynthesis and microbial respiration.

Lehman (2000) collected data on Smith Canal and Calaveras River water quality characteristics during August and September 1999 as part of the SJR DO TMDL TAC fall 1999 studies. She reported DOs below the water quality objectives for Smith Canal; the Calaveras River just upstream of where it enters the DWSC also had DO concentrations during August and September below WQOs. Lehman also reported chlorophyll and phaeophytin concentrations for Smith Canal and Calaveras River. The concentrations ranged from about 5 µg/L to almost 40 µg/L, with the majority of the values in the 10 to 20 µg/L range.

The data that DeltaKeeper has provided (Table 1), as well as those of Chen and Tsai and CDM, on the dissolved oxygen concentrations in the City of Stockton sloughs show severe depletion of dissolved oxygen through the late fall and winter. While there is some question about the significance of small short-term DO depletions below 5 mg/L (which is the US EPA national water quality criterion for DO), where these excursions below this criterion occur for limited periods of time and to a limited extent of no more than a mg/L or so, there is no question about the significance of DO concentrations being strongly adverse to aquatic life when the concentrations are as low as the DeltaKeeper has found in the Stockton sloughs over the late fall and winter of 1999-2000. DO concentrations less than 3 mg/L are significantly adverse to aquatic life-related beneficial uses of these sloughs. Additional information on the adverse impacts of low DO to aquatic life is found in the US EPA dissolved oxygen criterion document (US EPA 1986, 1987).

Please feel free to distribute my comments to anyone you feel might be interested. Please contact me if you have questions about them or need further assistance.

Sincerely yours,

G. Fred Lee, PhD, DEE

GFL:ds

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CDM, "Assessment of Water Quality Data from Smith Canal," Report prepared by Camp Dresser & McKee Inc. for City of Stockton Stormwater Division, Sacramento, CA, July (1999).

Chen, C.W. and Tsai, W., "Rough Loading Calculation for Dissolved Oxygen Links in Lower San Joaquin River," Systech Engineering, Inc., San Ramon, CA, January (2000).

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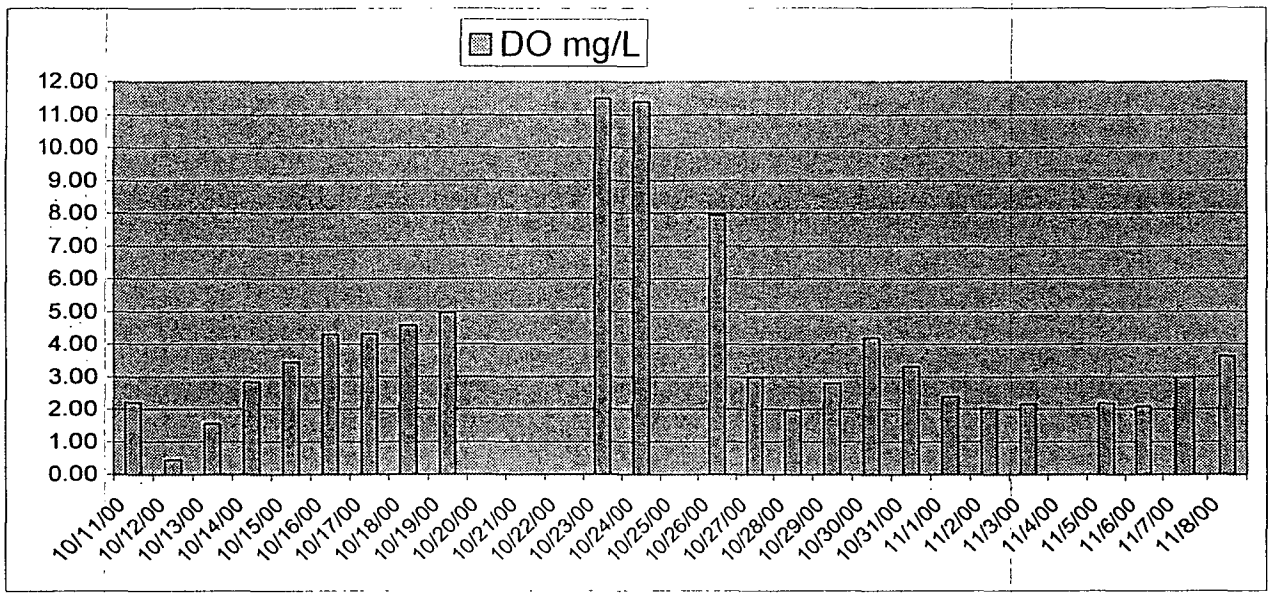
Lehman, P., "Results of the 1999 Field Study in the Stockton Deep Water Channel for August and September," (Draft Summary #1 – Preliminary Data), January (2000).

US EPA, "Ambient Water Quality Criteria for Dissolved Oxygen," US Environmental Protection Agency Office of Water Regulations and Standards, Criteria and Standards Division, Washington, DC, EPA 440/5-86-003, April (1986).

US EPA, Quality Criteria for Water 1986, US EPA 44/5-86-001, Office of Water Regulations and Standards, Washington, D.C., May (1987).

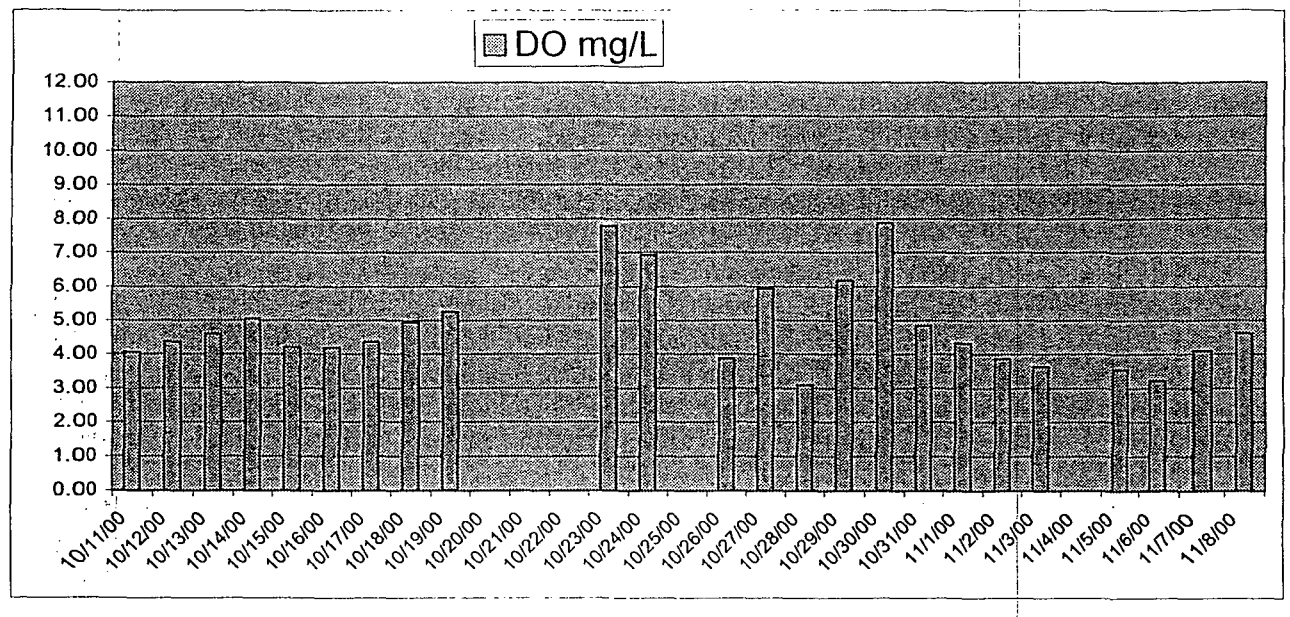
Smith Canal

Date	DO mg/L	Rain in Past 24 Hours
11-Oct-00	2.19	0.30
12-Oct-00	0.43	0.22
13-Oct-00	1.55	
14-Oct-00	2.84	
15-Oct-00	3.45	
16-Oct-00	4.29	
17-Oct-00	4.32	
18-Oct-00	4.58	
19-Oct-00	4.97	
23-Oct-00	11.49	
24-Oct-00	11.38	
26-Oct-00	7.94	0.48
27-Oct-00	3.00	0.57
28-Oct-00	1.97	0.08
29-Oct-00	2.79	0.71
30-Oct-00	4.20	0.21
31-Oct-00	3.30	
01-Nov-00	2.38	
02-Nov-00	2.01	
03-Nov-00	2.16	
05-Nov-00	2.17	
06-Nov-00	2.08	
07-Nov-00	2.97	
08-Nov-00	3.62	



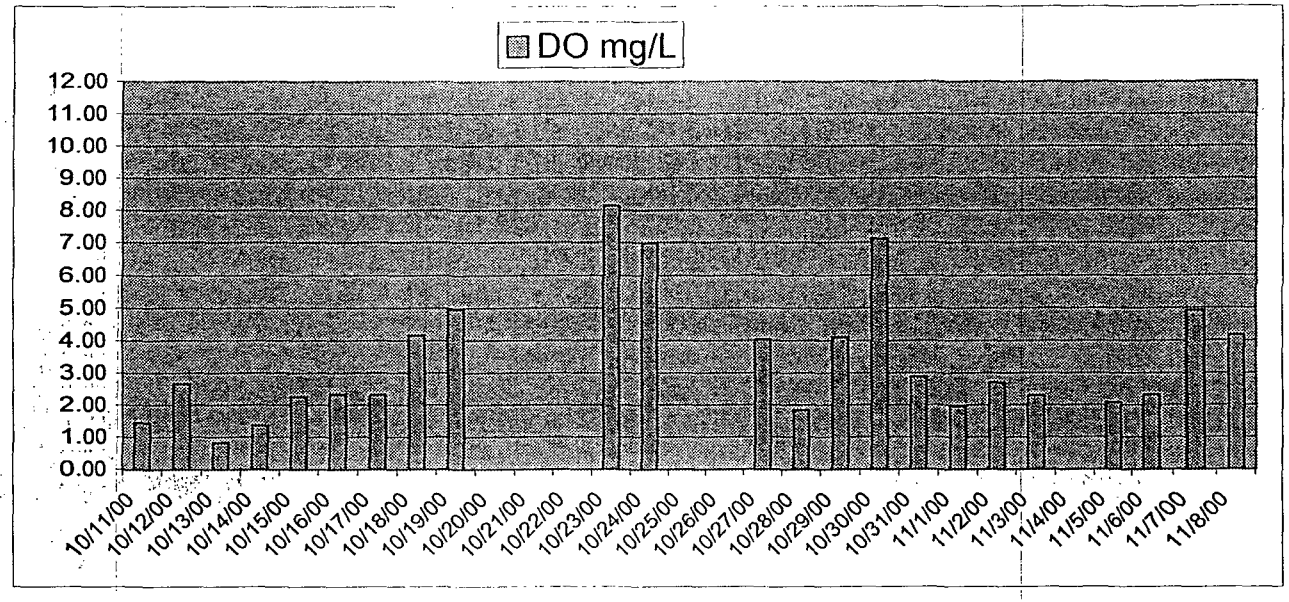
Mosher Slough

Date	DO mg/L	Rain in Past 24 Hours
17-Oct-00	4.36	0.30
11-Oct-00	4.06	0.22
12-Oct-00	4.37	
13-Oct-00	4.59	
14-Oct-00	5.06	
15-Oct-00	4.22	
16-Oct-00	4.20	
18-Oct-00	4.94	
19-Oct-00	5.25	
23-Oct-00	7.79	
24-Oct-00	6.92	
26-Oct-00	3.88	0.48
27-Oct-00	5.93	0.57
28-Oct-00	3.10	0.08
29-Oct-00	6.18	0.71
30-Oct-00	7.87	0.21
31-Oct-00	4.85	
01-Nov-00	4.33	
02-Nov-00	3.87	
03-Nov-00	3.65	
05-Nov-00	3.55	
06-Nov-00	3.22	
07-Nov-00	4.11	
08-Nov-00	4.61	



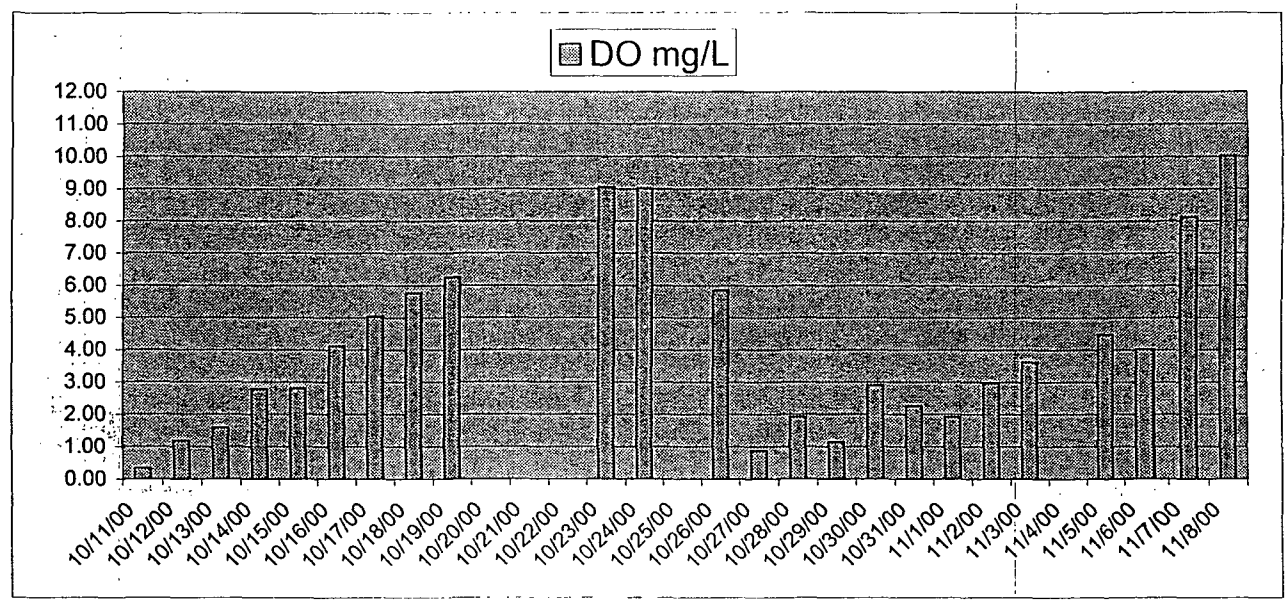
Mormon Slough

Date	DO mg/L	Rain in Past 24 Hours
11-Oct-00	1.44	0.30
12-Oct-00	2.66	0.22
13-Oct-00	0.82	
14-Oct-00	1.36	
15-Oct-00	2.26	
16-Oct-00	2.33	
17-Oct-00	2.32	
18-Oct-00	4.15	
19-Oct-00	4.95	
23-Oct-00	8.15	
24-Oct-00	6.99	
26-Oct-00		0.48
27-Oct-00	4.04	0.57
28-Oct-00	1.84	0.08
29-Oct-00	4.10	0.71
30-Oct-00	7.12	0.21
31-Oct-00	2.87	
01-Nov-00	1.96	
02-Nov-00	2.70	
03-Nov-00	2.29	
05-Nov-00	2.07	
06-Nov-00	2.32	
07-Nov-00	4.91	
08-Nov-00	4.15	



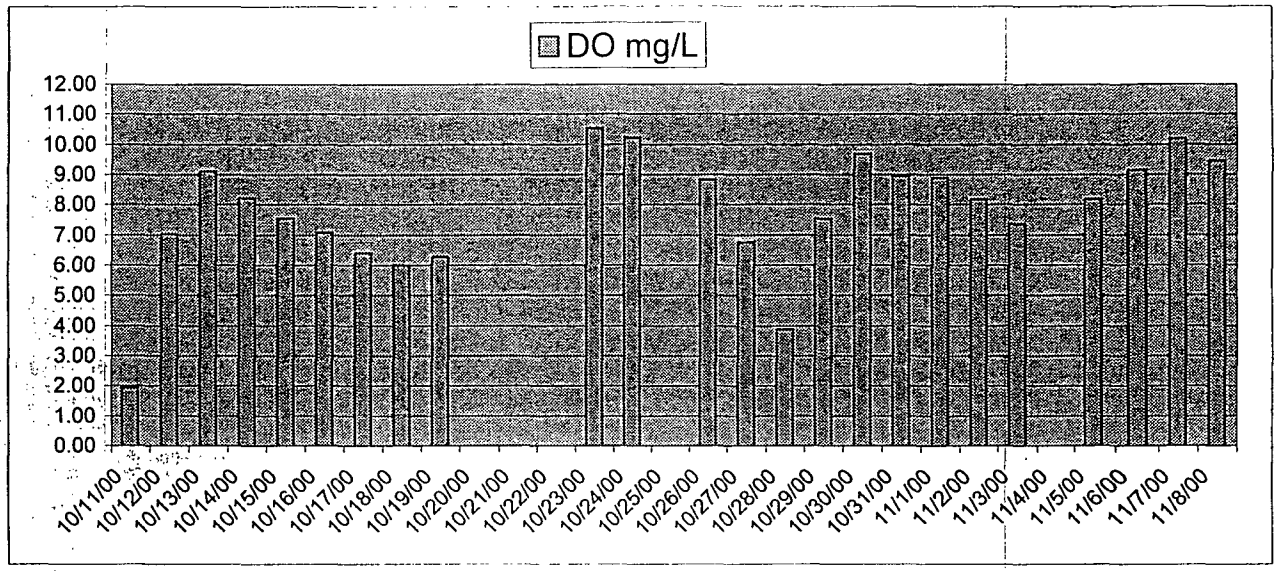
Five Mile Slough

Date	DO mg/L	Rain in Past 24 Hours
11-Oct-00	0.34	0.30
12-Oct-00	1.18	0.22
13-Oct-00	1.58	
14-Oct-00	2.78	
15-Oct-00	2.81	
16-Oct-00	4.12	
17-Oct-00	5.05	
18-Oct-00	5.77	
19-Oct-00	6.25	
23-Oct-00	9.05	
24-Oct-00	9.01	
26-Oct-00	5.85	0.48
27-Oct-00	0.89	0.57
28-Oct-00	1.93	0.08
29-Oct-00	1.15	0.71
30-Oct-00	2.90	0.21
31-Oct-00	2.26	
01-Nov-00	1.93	
02-Nov-00	2.99	
03-Nov-00	3.62	
05-Nov-00	4.48	
06-Nov-00	4.02	
07-Nov-00	8.12	
08-Nov-00	10.02	



Calaveras River

Date	DO mg/L	Rain in Past 24 Hours
11-Oct-00	1.95	0.30
12-Oct-00	7.03	0.22
13-Oct-00	9.11	
14-Oct-00	8.22	
15-Oct-00	7.55	
16-Oct-00	7.08	
17-Oct-00	6.41	
18-Oct-00	5.99	
19-Oct-00	6.27	
23-Oct-00	10.54	
24-Oct-00	10.22	
26-Oct-00	8.83	0.48
27-Oct-00	6.76	0.57
28-Oct-00	3.89	0.08
29-Oct-00	7.54	0.71
30-Oct-00	9.69	0.21
31-Oct-00	8.95	
01-Nov-00	8.90	
02-Nov-00	8.17	
03-Nov-00	7.35	
05-Nov-00	8.19	
06-Nov-00	9.15	
07-Nov-00	10.19	
08-Nov-00	9.45	



Walker Slough

Date	DO mg/L	Rain in Past 24 Hours
11-Oct-00	8.85	0.30
12-Oct-00	6.77	0.22
13-Oct-00	8.19	
14-Oct-00	7.77	
15-Oct-00	8.28	
16-Oct-00	8.41	
17-Oct-00	8.94	
18-Oct-00	8.59	
19-Oct-00	8.15	
23-Oct-00	9.77	
24-Oct-00	8.81	
26-Oct-00	10.05	0.48
27-Oct-00	5.88	0.57
28-Oct-00	4.68	0.08
29-Oct-00	6.45	0.71
30-Oct-00	7.29	0.21
31-Oct-00	7.28	
02-Nov-00	6.89	
03-Nov-00	7.15	
05-Nov-00	7.79	
01-Nov-00	7.87	
06-Nov-00	6.90	
07-Nov-00	8.64	
08-Nov-00	8.23