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Department of Pesticide Regulation

James W. Wells, Director
1020 N Street • Sacramento, California 95814-5624 • www.cdpr.ca.gov

Peter M. Rooney
Secretary for Environmental Protection

Pete Wilson
Governor

MEMORANDUM

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TO: Don Weaver, Senior Environmental Research Scientist Supervisor
Environmental Monitoring and Pest Management
Department of Pesticide Regulation
1020 N Street, Room 161
Sacramento, California 95814-5624

FROM: Craig Nordmark,
Environmental Research Scientist
(916) 324-4138

DATE: July 31, 1998

SUBJECT: PRELIMINARY RESULTS OF ACUTE AND CHRONIC TOXICITY TESTING OF SURFACE WATER MONITORED IN THE SACRAMENTO RIVER WATERSHED, WINTER 1997-98

SCOPE OF THIS MEMORANDUM

The purpose of this memorandum is to provide results of water sampling conducted on the Sacramento River by the Department of Pesticide Regulation (DPR). Data included here are from the period December 1, 1997 to March 6, 1998 and encompass results from both chemical analyses conducted by the California Department of Food and Agriculture (CDFA) Center for Analytical Chemistry and bioassays conducted by the California Department of Fish and Game (DFG). An in-depth interpretation of the data is not included here but will be provided in the final report.

BACKGROUND

The Sacramento River is the largest river in California both in volume of water and in drainage area (Friebel et al., 1995) (Figure 1). From Mount Shasta in the north to the Sacramento-San Joaquin Delta in the south, the river flows for 327 miles and drains approximately 27,000 square miles including agricultural, urban and undeveloped land areas (Domagalski and Brown, 1994). The primary source of water entering the system is surface runoff from the Sierra Nevada Mountains to the east and Cascade Range to the north (CSLC, 1993). Runoff from rain events occurring in the Sacramento Valley and Coastal Range Mountains provide short term increases in river flow. Seasonal rains occur from October to March with little significant rain from June to September. River flow during the summer is composed of dam releases of snow-melt water for agricultural, urban, recreational and wildlife purposes.

In the Sacramento Valley, the organophosphorus insecticides diazinon and methidathion are the primary dormant season insecticides used on stone fruit and nut crops (DPR 1993; DPR 1994; DPR 1995). This dormant spray application period coincides with the bulk of the seasonal rainfall, providing the potential for these pesticides to wash off target areas and migrate with surface runoff to the Sacramento River. Runoff from orchard areas west of the Sacramento River chiefly flows into the Colusa Basin Drain which enters the Sacramento River at Knights Landing (Figure 2). Runoff from dormant spray areas east of the Sacramento River principally flows into Butte Creek, which has been engineered to drain into the Sutter Bypass via the Butte Slough. Runoff from the west side of the Feather River also drains into the Sutter Bypass. During periods of normal flow, the Sutter Bypass enters the Sacramento River via the Sacramento Slough at Karnak. During periods of high flow, the Sutter Bypass channel fills completely with runoff from this area plus water diverted from the Sacramento River. This flow merges with the Feather River eight miles prior to entering the Sacramento River, forming a two mile wide channel which inundates the Sacramento Slough. During floods, a large portion of the flows of the Sacramento River and the Sutter Bypass/Feather River will be diverted into the Yolo Bypass. Runoff from areas east of the Feather River drains into the Feather River above Nicolaus.

Previous studies of the Sacramento River by the U.S. Geological Survey (USGS) and DPR have shown that most diazinon detections were observed during the dormant spray season (MacCoy et al., 1995; Ganapathy, 1997). The USGS study also detected low levels of methidathion during this season. In a California Regional Water Quality Control Board (CVRWQCB) study (Foe and Sheipline, 1993), acute toxicity to *Ceriodaphnia dubia* in conjunction with high diazinon and methidathion concentrations was found at Gilsizer Slough, which drains some of the area west of the Feather River and flows into the Sutter Bypass (Figure 2).

During the winter of 1996-97, DPR conducted toxicity monitoring at sites along the Sacramento River and Sutter Bypass (Nordmark et al., 1998). Extensive flooding occurred in January which greatly affected river discharges and modified the sampling schedule. No chronic toxicity or reproductive impairment was found at the Sacramento River at the Bryte site and no acute toxicity was found at the Sutter Bypass site. A single diazinon pulse lasting up to eight days was detected in the Sacramento River in late-January and diazinon was also detected in the Sutter Bypass at this time. Methidathion was detected in a single sample from the Sacramento River and from the Sutter Bypass. These detections appeared to be related to rain events. Diazinon was detected in a second pulse lasting up to two weeks in late-February in the Sutter Bypass, but did not appear to be related to any storm event. Diazinon was detected in 16% of the samples taken from the Sacramento River at Bryte and in 44% of the samples from the Sutter Bypass, with levels as high as 0.09 µg/L. This study was conducted during a dormant season marked by heavy rains, high river flows and significant flooding during January and virtually no rain after January 29.

The objective of this study was to continue the monitoring of the occurrence of aquatic toxicity, both acute and chronic, in portions of the Sacramento River watershed. Additionally, monitoring was conducted for organophosphate and carbamate insecticides that have historically been applied during the winter months and which have the potential to enter the Sacramento River with surface runoff (Table 1). Acute toxicity to *C. dubia* was tested in a relatively small tributary which does not contain major inputs from municipal or industrial sources. The potential for chronic toxicity was investigated in a section of the Sacramento River downstream from dormant spray insecticide inputs into the watershed, yet above input from the American River. Samples were also analyzed for the presence of certain soil applied herbicides which may also enter the river with surface runoff. A companion study was conducted to monitor pesticide levels and toxicity in the San Joaquin River watershed (Ganapathy, 1998) and these results will be presented in a separate memorandum. Long-term monitoring of acute and chronic toxicity in these watersheds will help scientists at DPR evaluate the effectiveness of programs designed to decrease the runoff of dormant spray insecticides.

MATERIALS AND METHODS

Study Site Description

Sutter Bypass

A small bridge across the western channel of the Sutter Bypass at the Karnak Pumping Station, just prior to the Sacramento Slough, was selected as the acute toxicity monitoring site. This site receives runoff water from most of the agricultural areas between the Sacramento and Feather Rivers. Previous studies have indicated the potential for high concentrations of pesticides in this area (Wofford and Lee, 1995). An alternate site for acute toxicity monitoring was required in case the Karnak site became flooded as it had the previous year. The alternate site chosen was on the western edge of the Sutter Bypass at Kirkville Road, approximately nine miles upstream from Karnak. Both sites had been used a year earlier for our original toxicity study. The alternate site was used for all samples collected after January 12, 1998.

Sacramento River

The chronic toxicity monitoring site was located on the right bank of the Sacramento River at the Alamar Marina Dock, nine miles below the confluence of the Feather River. This site receives discharge from all major agricultural tributaries but is above the confluence of the largely non-agricultural American River and the discharge of urban runoff from the cities of Sacramento and West Sacramento (Figure 2). The site was moved eight miles upstream from the site used in the previous year of the study due to sampling difficulties at Bryte.

Sample Collection

Background sampling was conducted during the week of December 1, 1997, prior to the onset of the dormant spray season. Dormant season sampling began on January 7, 1998 and continued through March 6, 1998 when no more dormant spray applications were reported.

Chemical analyses were performed on each water sample collected for both acute and chronic tests. Selected organophosphate and carbamate insecticides and soil applied herbicides were analyzed in three separate analyses with diazinon being analyzed in a fourth analysis (Table 1). Insecticides included in our analyses were chosen based on pesticide use reports indicating historical use during the dormant spray season in the Central Valley, previous detections in the watershed, the availability of analytical methods in the organophosphate or carbamate screens and to standardize analyses between the Sacramento and San Joaquin River studies. Herbicides included in our analyses were chosen based on historical use during the year in the Central Valley and the availability of analytical methods in a single screen.

Acute toxicity tests were performed twice per week, with samples collected on Monday and Wednesday. One chronic toxicity test was conducted weekly using water samples collected on Monday, Wednesday, and Friday. Water collected on Monday was used to begin the chronic toxicity tests. Water collected on Wednesday and Friday was used to renew chronic test water (see below).

Water samples were collected at the Alamar and Karnak sites, from as close to center channel as possible, using a depth-integrated sampler (D-77) with a 3-liter Teflon® bottle and nozzle. This method was unsuitable for use in the Sutter Bypass at Kirkville Road site. At this site, samples were collected by wading into the stream and utilizing a 1-liter bottle on the end of a 4-meter pole to collect subsurface grab samples.

Nine 1-liter splits were required for each sampling event. Approximately 12 liters of water were collected and composited in a stainless steel 10-gallon (38-liter) milk can. The composited sample was placed on wet ice for transportation back to the West Sacramento warehouse for splitting. All samples were split on the day of collection into 1-liter amber glass bottles, with Teflon® lined caps, using a (USGS designed) Geotech® 10-port splitter. One pair of 1-liter samples were submitted for toxicity testing. Four 1-liter samples were submitted for chemical analyses: one each for the organophosphate, carbamate, diazinon and herbicide analyses. Two 1-liter backups were stored at West Sacramento and 1-liter was used for acidification purposes.

Samples designated for organophosphate and carbamate chemical analysis were preserved by acidification to a pH of between 3.0 to 3.5 with 3N hydrochloric acid. Most organophosphate and carbamate pesticides are sufficiently preserved at this pH (Ross et al., 1996). Diazinon, however, rapidly degrades under acidic conditions and therefore was analyzed from a separate, unacidified, sample. Herbicide samples are stable enough without acidification and were thus not acidified. Samples were stored in a 4° C refrigerator until transported to the appropriate laboratory (on wet ice) for analysis. All primary samples were delivered to the testing laboratory within 24 hours of collection.

Environmental Measurements

Water quality parameters measured *in situ* included temperature, pH, electrical conductivity (EC), and dissolved oxygen (DO). Additionally, ammonia, alkalinity and hardness were measured by the DFG Aquatic Toxicity Laboratory upon delivery of the toxicity samples. Water pH was measured using either a Sentron® (model 1001) or Orion® Quickcheck (model 106) pH meter. EC was measured using a Orion® conductivity-salinity meter (model 142). Water temperature and DO were measured using a YSI dissolved oxygen meter (model 57 or 58).

Precipitation and discharge information were also gathered for the study area. Precipitation data was averaged from two sites: a Department of Forestry station located near Chico and the National Weather Service station located at the Sacramento Post Office (stations CHI and SPO, respectively) to approximate rainfall in the Sacramento Valley. Discharge from the Butte-Slough-near-Meridian gage and either estimated or actual flow (available starting January 28) were used to provide flow estimates for the Sutter Bypass sites. The data from the Verona USGS gaging station was used for Sacramento River discharge readings. The Verona site captures all major input to the Sacramento River above the sampling site. All precipitation and discharge data were taken from provisional, DWR, National Weather Service and Department of Forestry information and is subject to revision. Further refinements of flow data at each site will be investigated for the final report as more information becomes available. This information will be used to follow annual changes in chemical concentrations with respect to fluctuations in flow and will also be useful for modeling efforts, should they be undertaken.

Chemical Analysis and Toxicity Testing

Chemical Analyses

Pesticide analyses of water samples were performed by the CDFA Center for Analytical Chemistry. The organophosphate insecticides were analyzed using gas chromatography (GC) and a flame photometric detector (FPD). The carbamate insecticides and the herbicides were analyzed using high performance liquid chromatography (HPLC), post column-derivatization and a fluorescence detector. The herbicides were analyzed by HPLC with a UV detector, and GC with a nitrogen phosphorus detector (NPD). The pesticides and reporting limits are listed in Table 1. Details of chemical analytical methods will be provided in the final report.

Quality control (QC) for the chemistry portion of this study was in accordance with Standard Operating Procedure QAQC001.00 (DPR, 1996) and consisted of a continuing QC program, plus the submission of five rinse blanks of the splitting equipment and 32 blind spikes submitted for the Sacramento and San Joaquin studies. Continuing QC results for each of the analysis screens are presented in Tables 3 through 7. Study 166 and 167 refer to the Sacramento and San Joaquin River studies, respectively. There were no detections of any pesticides in any of the five rinse blank samples. The 32 blind spikes, submitted along with the field samples from the two studies for analysis as organophosphate, carbamate, diazinon or herbicide samples, contained 58 chemical analytes. More detailed quality control data, including method development, the establishment of control limits and spike recoveries, will be included in the final report.

Toxicity Tests

Acute toxicity testing was conducted by the DFG Aquatic Toxicity Laboratory following current U.S. Environmental Protection Agency (U.S.EPA) procedures using the cladoceran *Ceriodaphnia dubia* (U.S.EPA, 1993). Acute toxicity was determined using a 96-hour, static-renewal bioassay in undiluted sample water. Chronic toxicity was determined using a static-renewal 7-day bioassay of undiluted sample water with *C. dubia* and followed current U.S.EPA guidelines (U.S.EPA, 1994). Test organisms used in chronic testing were placed in sample water on day one of testing, with test water replenished on days three and five. Most acute and chronic tests commenced and renewal water was used within 36 hours of sample collection. However, three chronic tests failed due to control sample mortality and these tests were restarted outside the 36-hour window. One acute test was initiated 169 hours after sample collection (Table 2). Data were reported as percent survival for both acute and chronic tests and the average number of offspring per adult for the chronic tests. More complete information on chemical analytical and bioassay methods will be provided in the final report.

RESULTS

The following results include data collected during an unusually wet season which included almost daily measurable rains from the end of December through the end of February. River discharge remained high with the floodwater bypass in operation for almost the entire period. Any interpretation of the results by the reader should take into account that conditions during the monitoring period were not necessarily characteristic of a typical winter spray season.

Environmental Measurements

Sutter Bypass

Figure 3 presents the data for pH, DO, temperature, EC, alkalinity and hardness for the Sutter Bypass sites. Ammonia levels initially varied from 57 to 91 µg/L until January 12 then they fell below the detection limit of 50 µg/L for all remaining samples. pH values ranged from 7.2 to 8.4. Water temperature ranged from 8.6 to 11.8° C, DO ranged from 10.8 to 11.7 mg/L and EC ranged from 107 to 759 µS/cm.

Sacramento River

Figure 4 presents the data for pH, DO, temperature, EC, alkalinity and hardness for the Sacramento River at Alamar Marina site. Except for the December 1 sample, ammonia levels remained below the detection limit of 50 µg/L for all samples. pH values ranged from 6.8 to 8.0. Water temperature ranged from 8.1 to 11.3° C, DO ranged from 9.5 to 11.4 mg/L and EC ranged from 74 to 200 µS/cm.

Figure 5 presents precipitation averaged for two stations in the Sacramento Valley and discharge for the Sacramento River and the Sutter Bypass. All flow data presented in Figure 5 are based on preliminary data and are approximate as all inputs and diversions were not gaged and many gages are not accurately calibrated for such extreme flows (personal communication: Steven Graham, DWR Surface Water Unit). The estimated discharge in the Sutter Bypass peaked at 137,000 cfs which is nearly twice the discharge through the Sacramento River at Verona. This is possible due to the diversion of a large portion of the Sacramento River, Sutter Bypass and Feather River flows into the Yolo Bypass. Discharge for all inputs and outflows are not available. Data for discharge through Tisdale Weir was estimated based on historical data and flows at Wilkens Slough until January 28 at which time a gaging station on the weir became operational. Flows through the weir were added to the Sutter Bypass flows from January 15 through the end of the study. Inputs from sources such as Wadsworth Canal and Gilsizer Slough are unknown factors which would likely increase the discharges presented here.

Chemical Concentrations and Toxicity Data

Sutter Bypass

Diazinon was detected in six of the 20 samples collected in the Sutter Bypass (Table 2). Diazinon was first detected in the Sutter Bypass at Karnak on January 5 and 7 at 0.063 and 0.088 µg/L, respectively. Diazinon was again detected in the Sutter Bypass at Kirkville Road on January 14, and 28 and February 4 and 9 at levels ranging from 0.043 to 0.096 µg/L. Three herbicides were also detected in the Sutter Bypass. Diuron was detected in both samples in December and in the January 12 and 14 samples. Simazine was detected in both samples in December and bromacil was detected on January 12. Levels of these herbicides ranged from 0.053 to 0.16 µg/L. The highest combined level was on December 3 when diuron and simazine totaled 0.22 µg/L in water collected during background sampling in December. The percent survival of the *C. dubia* test animals ranged from 80% to 100% in the acute toxicity samples while the corresponding controls ranged from 90% to 100% survival. Possible relationships between the occurrence of pesticides and aquatic toxicity will be investigated in the final report.

Sacramento River

Diazinon was detected in 12 of 30 samples (40%) collected from the Sacramento River at Alamar Marina. These detections occurred in every sample from January 30 through February 27 except for the sample collected on February 4. Diazinon concentrations ranged from 0.058 to 0.17 µg/L (Table 2). Diuron was detected in 16 (53%) of the samples. Residues were detected in the background water at levels near the detection limit. Diuron residues were detected when sampling resumed on January 5 and continued to be found through the January 19 sample. Diuron was again detected in six consecutive samples beginning on January 30. The highest concentration detected was 0.24 µg/L. Simazine was detected only in the three background samples with the highest level being 0.078 µg/L. No other pesticides were detected.

No chronic toxicity test had less than 70% survival and no control less than 80% survival. All chronic toxicity samples had between 16 and 31 offspring and controls had between 14 and 30 offspring average per adult female at the end of the test. Several of the tests had to be restarted due to poor survival in the control sample (Table 2). Statistical analysis of reproduction data will be included in the final report.

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Table 1. California Department of Food and Agriculture, Center for Analytical Chemistry organophosphate and carbamate insecticide and triazine herbicide screens for the Sacramento River toxicity monitoring study.

Organophosphate Pesticides in Surface Water by GC Method: GC/FPD		**N-Methyl Carbamate in Surface Water by HPLC Method: HPLC/Post Column-fluorescence**		**Herbicides in Surface Water by HPLC Method: HPLC/UV detector and GC/NPD**	
Compound	**Reporting Limit (µg/L)**	**Compound**	**Reporting Limit (µg/L)**	**Compound**	**Reporting Limit (µg/L)**
Chlorpyrifos	0.04	Carbaryl	0.05	Atrazine	0.05
Diazinon[1]	0.04	Carbofuran	0.05	Bromacil	0.05
Dimethoate (Cygon)	0.05			Diuron	0.05
Fonofos	0.05			Cyanazine	0.2
Malathion	0.05			Hexazinone	0.2
Methidathion	0.05			Metribuzin	0.2
Methyl parathion	0.05			Prometon	0.05
Phosmet	0.05			Prometryn	0.05
				Simazine	0.05

[1] Diazinon was analyzed from a separate, unpreserved, split sample. Other OP and CB chemical samples were preserved with 3N HCl to a pH of 3-3.5 to retard analyte degradation. See text.

Table 2. Results of Sacramento River Watershed Toxicity Study, Winter 1997-98. Only results for *diazinon, diuron and simazine are shown.* Bromacil was detected in the January 12 Sutter Bypass sample. No other pesticides in the organophosphate, carbamate or herbicide screens were detected.

Table 2

SACRAMENTO RIVER AT ALAMAR						SUTTER BYPASS				
Sampling Date	Diazinon (µg/L)	Diuron (µg/L)	Simazine (µg/L)	Chronic Toxicity Percent Survival[1]	Chronic Toxicity Offspring /animal[1]	Site	Diazinon (µg/L)	Diuron (µg/L)	Simazine (µg/L)	Acute Toxicity Percent Survival[1]
12/1/97	nd[2]	0.059	0.078	-		Karnak	nd	0.072	0.11	100/90
12/3/97	nd	0.055	0.059	-		Karnak	nd	0.12	0.10	100/100
12/5/97	nd	0.055	0.060	100/90	18/15					
1/5/98	nd	0.24	nd	-		Karnak	0.063	nd	nd	85/100
1/7/98	nd	0.10	nd	-		Karnak	0.088	nd	nd	95/95
1/9/98	nd	0.050	nd	70/80	26/15					
1/12/98	nd	0.17	nd	-		Karnak	nd	0.053[5]	nd[5]	100/100
1/14/98	nd	0.12	nd	-		Kirkvl Rd	0.089	0.16	nd	90/100
1/16/98	nd	0.12	nd	100/100	16/15					
1/19/98	nd	0.05	nd	-		Kirkvl Rd	nd	nd	nd	90/95
1/21/98	nd	nd	nd	-		Kirkvl Rd	nd	nd	nd	100/100
1/23/98	nd	nd	nd	80/80	24/15					
1/26/98	nd	nd	nd	-		Kirkvl Rd	nd	nd	nd	90/95
1/28/98	nd	nd	nd	-		Kirkvl Rd	0.096	nd	nd	100/100
1/30/98	0.132	0.11	nd	80/80[3]	20/15[3]					
2/2/98	0.076	0.064	nd	-		Kirkvl Rd	nd	nd	nd	95/100
2/4/98	nd	0.17	nd	-		Kirkvl Rd	0.073	nd	nd	95/90
2/6/98	0.088	0.074	nd	90/100	29/15[4]					
2/9/98	0.066	0.056	nd	-		Kirkvl Rd	0.043	nd	nd	95/90
2/11/98	0.058	0.050	nd	-		Kirkvl Rd	nd	nd	nd	100/95
2/13/98	0.067	nd	nd	90/100[3]	31/30[3]					
2/16/98	0.090	nd	nd	-		Kirkvl Rd	nd	nd	nd	100/95
2/18/98	0.171	nd	nd	-		Kirkvl Rd	nd	nd	nd	95/95
2/20/98	0.059	nd	nd	90/100[3]	16/25[3]					
2/23/98	0.091	nd	nd	-		Kirkvl Rd	nd	nd	nd	80/90
2/25/98	0.073	nd	nd	-		Kirkvl Rd	nd[6]	nd[6]	nd[6]	100/100[6]
2/27/98	0.074	nd	nd	100/90	17/17					
3/2/98	nd	nd	nd	-		Kirkvl Rd	nd	nd	nd	100/100
3/4/98	nd	nd	nd	-		Kirkvl Rd	nd	nd	nd	100/100
3/6/98	nd	nd	nd	100/100	31/30					

Notes:

[1] Two numbers are reported for all Toxicity tests. The first number is the result from the sample, the second is the result from the corresponding control. Chronic toxicity water was replaced twice each week using new sample water. The numbers reported for percent survival refers to the survival at the end of the test. The number reported for offspring is the number of offspring produced divided by the number of adult animals used in the test.

Table 2 Notes Continued

[2] nd = none detected at the reporting limit for that chemical.

[3] These tests had to be restarted due to high mortality in the control. Retest data are presented here even though this exceeds the criteria for starting the test within 36 hours. All original sample tests had 90% survival at the time of initial test termination.

[4] In the February 2 through 6 chronic toxicity test, two animals in the control were inadvertently killed during handling while renewing water. The test was continued with eight animals in the control, all of which survived. The number of offspring per adult is based on eight adult animals instead of ten.

[5] Bromacil was also detected in the January 12, 1998, Sutter Bypass sample at 0.07 µg/L. This was the only detection of bromacil during this study.

[6] The acute test from the January 12, 1998 sample was set up 169 hours after sample collection.

Table 3. Continuing Quality Control-Carbamate Screen

Extraction Date	Sample Numbers	Percent Recovery	
		Carbofuran	Carbaryl
12/4/98	166-2,7,12,17. 167-2,7,12,17.	102.0	95.8
12/10/98	166-22. 167-22.	*88.4	86.4
1/8/98	166-27,32,37,42. 167-27 32.	98.6	94.0
1/13/98	166-47,52,63,68,86. 167-37,42,47.	99.4	97.2
1/16/98	166-55,60. 167-52,57.	95.5	94.5
1/21/98	166-75,80,85. 167-62/67,72.	95.5	94.5
1/27/98	166-92,97,102,107. 167-91,96,101,106,209.	86.2	89.4
1/29/98	166-110,115,120,125. 167-11,116,121,126.	98.4	99.4
2/3/98	166-130,135,140. 167-131,136,141,146.	94.4	99.6
2/5/98	166-145,150. 167-75,80.	92.0	96.1
2/10/98	166-155,160,163,168. 167-150,155,160,216.	96.4	96.2
2/17/98	166-173, 178, 183, 197, 202. 167-165, 170, 175, 180, 185.	86.4	87.4
2/19/98	166-188, 193. 167-190, 195, 200.	90.0	95.8
2/24/98	166-208,205,213,218,249 167-249,220,225	104.2	109.6
3/3/98	166-223,228,233,236 167-230,235,240	*115.7	114.4
3/5/98	166-241,255,260,265 167-245,250,255,260	*111.1	104.4
3/9/98	166-270,275 167-267	96.0	91.2
Average Recovery		91.7	96.8
Standard Deviation		8.0	7.3
CV		8.7	7.5
Upper Control Limit		113.0	124.0
Upper Warning Limit		108.0	116.0
Lower Warning Limit		89.0	83.0
Lower Control Limit		84.0	75.0

*Highlighted cells are percent recoveries exceeding control limits

Study 166 refers to Sacramento River Samples and Study 167 refers to San Joaquin River Samples.

The Sample Numbers are the field samples to which a particular extraction set applies.

Table 4. Continuing Quality Control-Diazinon Analysis

Extraction Date	Sample Numbers	Percent Recovery
		Diazinon
12/2/97	166-3, 8. 167-3,8.	89.0
12/4/97	166-13,18. 167-13,18	88.0
12/8/97	166-23. 167-23.	104.0
1/5/98	166-28, 33. 167-28.	96.0
1/7/98	166-38,43. 167-33.	95.0
1/12/98	166-48,53. 167-38.	103.0
1/14/98	166-64,69,56,61. 167-43,53,58,85.	103.0
1/20/98	166-76,81,88. 167-63,68,87.	102.8
1/22/98	166-93,98. 167-92,97,102.	91.0
1/26/98	166-105,108. 167-107,210.	93.0
1/27/98	166-111,116. 167-112,117.	101.5
1/29/98	166-121, 126. 167-122,127.	97.0
2/5/98	166-146, 151. 167-76, 81.	*80.5
2/3/98	166-136,141. 167-142,147.	97.0
2/9/98	166-156,161. 167-151,215.	83.0
2/11/98	166-164,169. 167-156,161.	91.0
2/13/98	166-174,179. 167-166,171.	101.0
2/18/98	166-184, 198,203, 246. 167-176,181,186.	80.0
2/20/98	166-189,194. 167-134,191,196,201	104.0
2/23/98	166-143,209,248. 167-206.	96.0
2/25/98	166-214,219. 167-221,226.	80.0
2/26/98	166-224,229,234,252. 167-231,236.	100.0
3/2/98	166-237. 167-241.	98.2
3/5/98	166-261,266. 167-256,261.	96.0
3/10/98	166-271,276. 167-268.	98.0
Average Recovery		94.7
Standard Deviation		7.3
CV		7.7
Upper Control Limit		109.0
Upper Warning Limit		104.0
Lower Warning Limit		86.0
Lower Control Limit		81.0

Table 5. Continuing Quality Control- Organophosphate Screen

Extraction Date	Sample Numbers	Percent Recovery							
		Chlorpyrifos	Diazinon	Dimethoate	Fonofos	Methyl Parathion	Malathion	ethidathion	Phosmet
12/2/98	166-1, 6. 167-6.	101.0	92.0	115.0	94.0	105.0	103.0	108.0	115.0
12/4/98	166-11,16. 167-4, 11, 16.	92.0	85.0	101.0	90.0	93.0	100.0	104.0	113.0
12/8/98	166-21. 167-11, 21.	102.0	103.0	112.0	105.0	107.0	106.0	110.0	116.0
1/5/98	166-26, 31. 167-26.	97.0	87.5	108.0	80.9	104.0	105.0	107.0	114.0
1/7/98	166-36, 41. 167-31, 73.	84.0	96.0	109.0	86.0	103.0	99.0	111.0	111.0
1/12/98	166-46, 51.	90.0	92.0	113.0	86.0	104.0	95.0	114.0	98.8
1/14/98	166-62, 67, 54, 59, 87. 167-41, 46, 51, 56.	103.0	101.8	97.2	97.8	105.6	104.8	109.4	100.6
1/20/98	166-74, 84, 79. 167-61, 66, 71, 86.	94.0	94.0	100.0	92.0	108.0	104.0	95.0	94.8
1/22/98	166-91, 96. 167-90, 95, 100.	91.3	92.3	102.9	94.1	102.3	99.2	86.8	94.2
1/26/98	166-101, 106. 167-105, 208.	90.0	96.0	112.0	84.0	111.0	107.0	93.0	101.2
1/27/98	166-109, 114. 167-110, 115.	101.5	93.0	101.5	94.3	111.0	105.5	116.5	115.0
1/29/98	166-119, 124. 167-120, 125, 211.	91.0	88.0	114.0	92.0	109.0	103.0	86.0	116.2
2/2/98	166-129. 167-130, 135, 212.	94.0	90.0	107.0	89.0	108.0	107.0	91.0	92.6
2/3/98	166-134, 139. 167-140,145	92.0	92.0	113.0	89.0	107.0	103.0	91.0	92.6
2/5/98	166-144,149. 167-74, 79.	92.5	85.0	102.0	96.8	99.5	97.0	101.5	92.0
2/9/98	166-154,159. 167-84,214.	89.0	89.0	84.0	86.0	109.0	98.0	97.0	106.8
2/11/98	166-162, 167. 167-159.	79.0	77.0	85.0	87.0	87.0	83.0	83.0	92.4
2/13/98	166-172, 177. 167-164, 169, 217.	98.6	95.0	101.6	89.0	101.0	97.6	105.0	113.6
2/17/98	166-182,244,196,201. 167-174,157,179,184.	92.0	98.0	96.0	92.0	106.0	98.0	99.0	104.6
2/20/98	166-187, 192. 167-189,194,199.	87.0	91.0	100.0	85.0	95.0	92.0	92.0	102.8
2/23/98	166-207, 247. 167-204.	98.5	89.0	96.5	91.9	101.5	99.0	100.0	91.0
2/25/98	166-212, 217. 167-219, 224, 265.	85.0	94.0	96.0	89.0	99.0	97.0	98.0	97.4
2/26/98	166-222,227,232, 250. 167-229,234.	90.0	98.0	84.0	99.0	98.0	104.0	90.4	84.0
3/4/98	166-240,254. 167-244, 249.	103.4	99.6	100.2	94.8	101.4	101.6	103.0	98.2
3/2/98	166-235. 167-239.	84.0	92.0	71.0	94.0	88.0	97.0	89.8	79.0
3/6/98	166-259,264. 167-254,259.	96.0	99.0	94.0	99.0	96.0	101.0	102.2	91.0
3/10/98	166-269,274. 167-266	87.2	86.0	85.2	96.0	91.2	91.2	96.8	91.4
Average Recovery		92.4	92.1	100.0	91.5	101.9	99.9	99.1	100.8
Standard Deviation		6.13	5.68	11.22	5.51	6.83	5.55	9.16	10.83
CV		6.63	6.17	11.20	6.02	6.70	5.55	9.24	10.74
Upper Control Limit		116.0	122.0	116.0	102.0	116.0	114.0	124.0	118.0
Upper Warning Limit		110.0	113.0	110.0	100.0	110.0	109.0	116.0	113.0
Lower Warning Limit		83.0	78.0	86.0	94.0	85.0	87.0	83.0	95.0
Lower Control Limit		76.0	69.0	80.0	92.0	79.0	81.0	75.0	90.0

*Highlighted cells are percent recoveries exceeding control limits

Study 166 refers to Sacramento River Samples and Study 167 refers to San Joaquin River Samples.

The Sample Numbers are the field samples to which a particular extraction set applies.

Table 6. Continuing Quality Control- Triazine/Diuron/Bromacil Screen

Extraction Date	Sample Numbers	Percent Recovery								
		Hexazinone	Cyanazine	Metribuzin	Atrazine	Simazine	Diuron	Prometon	Bromacil	Prometryn
12/4/97	166-400, 401, 402, 403. 167-400, 401, 402, 403.	111.2	102.8	86.4	102.4	112.0	90.0	96.0	89.6	96.4
12/11/97	166-404, 5, 10, 15, 20. 167-404, 5, 10, 15, 20, 25.	114.8	116.8	98.4	101.2	105.2	99.6	104.0	98.4	107.2
1/9/98	166-405, 406, 407, 408, 496. 167-405, 407.	98.4	100.0	89.2	104.4	110.0	97.6	105.0	98.4	94.0
1/14/98	166-409, 411, 484. 167-407, 408, 409, 435.	98.4	110.8	85.2	96.0	102.4	88.0	97.2	97.2	99.6
1/20/98	166-485,486,487,497. 167-410,411,412.	100.8	102.0	100.0	89.2	88.0	88.8	86.0	95.2	84.0
1/28/98	166-488,489,490,491. 167-413,414,415,416,417.	109.6	116.9	115.6	86.5	90.3	108.0	92.8	113.3	101.2
1/29/98	166-492, 493,494, 495, 498. 167-418,419,420.	106.9	111.1	97.9	104.8	103.4	98.6	99.2	112.0	100.8
2/2/98	166-412, 413, 414, 499. 167-421, 422, 423, 424.	100.2	109.8	97.2	95.4	98.0	92.8	91.2	103.6	87.4
2/3/98	166-415, 416. 167-425, 426.	98.8	110.0	95.6	89.0	94.8	90.6	88.2	106.8	89.2
2/9/98	166-417, 418, 419, 420, 424. 167-427, 428, 429.	99.6	95.6	105.2	95.0	86.4	83.4	88.2	90.8	86.4
2/11/98	166-421, 422. 167-430, 431, 461.	97.5	101.5	99.0	106.8	104.0	92.7	79.9	101.4	82.0
2/13/98	166-423, 425. 167-432, 433.	94.8	118.4	105.6	105.4	101.6	99.8	104.4	103.4	105.0
2/18/98	166-426, 427, 428. 167-436, 437, 438.	89.2	110.0	99.8	92.4	102.0	83.8	104.4	103.2	105.0
2/20/98	166-429, 430. 167-439, 440, 441.	95.2	111.2	100.8	107.6	84.4	97.2	84.8	108.4	84.8
2/23/98	166-431, 449, 450. 167-442.	106.4	117.2	80.4	86.8	101.0	90.0	89.2	100.8	91.2
2/26/98	166-432,433,435,437. 167-443,444,445,446.	109.0	101.6	100.0	84.0	98.0	99.2	104.4	102.8	96.8
3/3/98	166-436,438,439. 167-447,448,449.	101.0	115.2	102.8	95.6	94	95.6	92.0	101.6	91.2
3/5/98	166-440,441. 167-450,451.	102.0	113.4	111.2	84.4	90.8	85.2	82.4	93.6	91.6
3/9/98	166-442,443. 167-452.	101.0	98.8	108.2	88.3	96.6	89.1	89.6	92.1	100.4
Average Recovery		101.8	108.6	98.8	97.4	98.0	93.2	93.6	100.7	94.5
Standard Deviation		6.36	7.12	8.76	8.07	7.72	6.45	8.13	6.70	7.76
CV		6.25	6.56	8.87	8.29	7.88	6.92	8.69	6.65	8.21
Upper Control Limit		115.1	114.0	100.9	114.1	117.8	108.3	103.6	108.9	108.1
Upper Warning Limit		107.5	107.3	96.8	106.8	110.0	99.9	96.7	103.3	100.8
Lower Warning Limit		92.1	94.0	88.6	92.2	94.2	83.1	82.8	92.1	86.4
Lower Control Limit		84.5	87.4	84.5	85.0	86.4	74.6	75.9	86.5	79.1

*Highlighted cells are percent recoveries exceeding control limits

Study 166 refers to Sacramento River Samples and Study 167 refers to San Joaquin River Samples.
The Sample Numbers are the field samples to which a particular extraction set applies.

Table 7. Blind Spike Recoveries for the Sacramento River (166) and San Joaquin River (167) Studies.

Extraction	Study	Sample	Screen	Chemical	Spike Level	Recovery	Percent
1/9/98	166	496	Triazine	Diuron	0.2	0.205	102.5
				Metribuzin	0.5	0.512	102.4
1/7/98	167	73	Organophosphate	Fonofos	0.2	0.197	98.5
				Malathion	0.5	0.536	107.2
				Phosmet	0.1	0.101	101
1/14/98	167	435	Triazine	Atrazine	0.5	0.417	83.4
				Simazine	0.2	0.165	82.5
1/13/98	166	86	Carbamate	Carbaryl	0.1	0.101	101
				Carbofuran	0.2	0.198	99
1/14/98	167	85	Diazinon	Diazinon	0.5	0.493	98.6
1/14/98	166	87	Organophosphate	Chlorpyrifos	0.2	0.184	92
				Methidathion	0.1	0.098	98
1/20/98	166	497	Triazine	Hexazinone	0.5	0.454	90.8
				Cyanazine	0.5	0.537	107.4
1/20/98	167	86	Organophosphate	Chlorpyrifos	0.2	0.183	91.5
				Methidathion	0.2	0.23	115
				Dimethoate	0.1	0.109	109
1/29/98	166	498	Triazine	Hexazinone	0.5	0.483	96.6
				Simazine	0.1	0.113	113
1/27/98	167	209	Carbamate	Carbaryl	0.2	0.173	86.5
				Carbofuran	0.1	0.0983	98.3
1/26/98	167	208	Organophosphate	Methyl Parathion	0.2	0.19	95
				Chlorpyrifos	0.1	0.093	93
1/26/98	167	210	Diazinon	Diazinon	0.2	0.1	50 *
1/29/98	167	211	Organophosphate	Fonofos	0.2	0.157	78.5
				Chlorpyrifos	0.2	0.16	80
2/2/98	166	499	Triazine	Bromacil	0.2	0.207	103.5
				Prometryn	0.5	0.465	93
2/2/98	167	213	Diazinon	Diazinon	0.1	0.079	79
2/2/98	167	212	Organophosphate	Dimethoate	0.2	0.203	101.5
				Methidathion	0.1	0.103	103
2/9/98	167	215	Diazinon	Diazinon	0.3	0.287	95.7
2/9/98	167	214	Organophosphate	Fonofos	0.1	0.094	94
				Phosmet	0.2	0.346	173 **
2/9/98	166	424	Triazine	Atrazine	0.2	0.187	93.5
				Diuron	0.5	0.433	86.6
2/10/98	167	216	Carbamate	Carbaryl	0.3	0.306	102
				Carbofuran	0.2	0.208	104
2/11/98	167	461	Triazine	Metribuzin	0.5	0.517	103.4
2/13/98	167	217	Organophosphate	Dimethoate	0.1	0.099	99
				Methidathion	0.2	0.197	98.5
2/17/98	166	244	Organophosphate	Chlorpyrifos	0.1	0.103	103
				Malathion	0.2	0.21	105
2/13/98	166	246	Diazinon	Diazinon	0.1	0.106	106
2/23/98	166	449	Triazine	Hexazinone	0.5	0.617	123.4
				Prometryn	0.3	0.267	89
2/23/98	166	450	Triazine	Bromacil	0.2	0.211	105.5
				Prometon	0.5	0.442	88.4
2/23/98	166	248	Diazinon	Diazinon	0.1	0.084	84
2/23/98	166	247	Organophosphate	Fonofos	0.2	0.176	88
				Phosmet	0.1	0.114	114
2/25/98	167	265	Organophosphate	Dimethoate	0.2	0.179	89.5
				Methidathion	0.1	0.094	94
2/24/98	166	249	Carbamate	Carbaryl	0.1	0.1	100
				Carbofuran	0.2	0.2	100
2/26/98	166	252	Diazinon	Diazinon	0.2	0.180	90
2/26/98	166	250	Organophosphate	Chlorpyrifos	0.2	0.114	57
				Methyl Parathion	0.2	0.176	88

* sample may have been spiked at half the reported spike level

**a backup of this blind spike was run, resulting in a 90% recovery

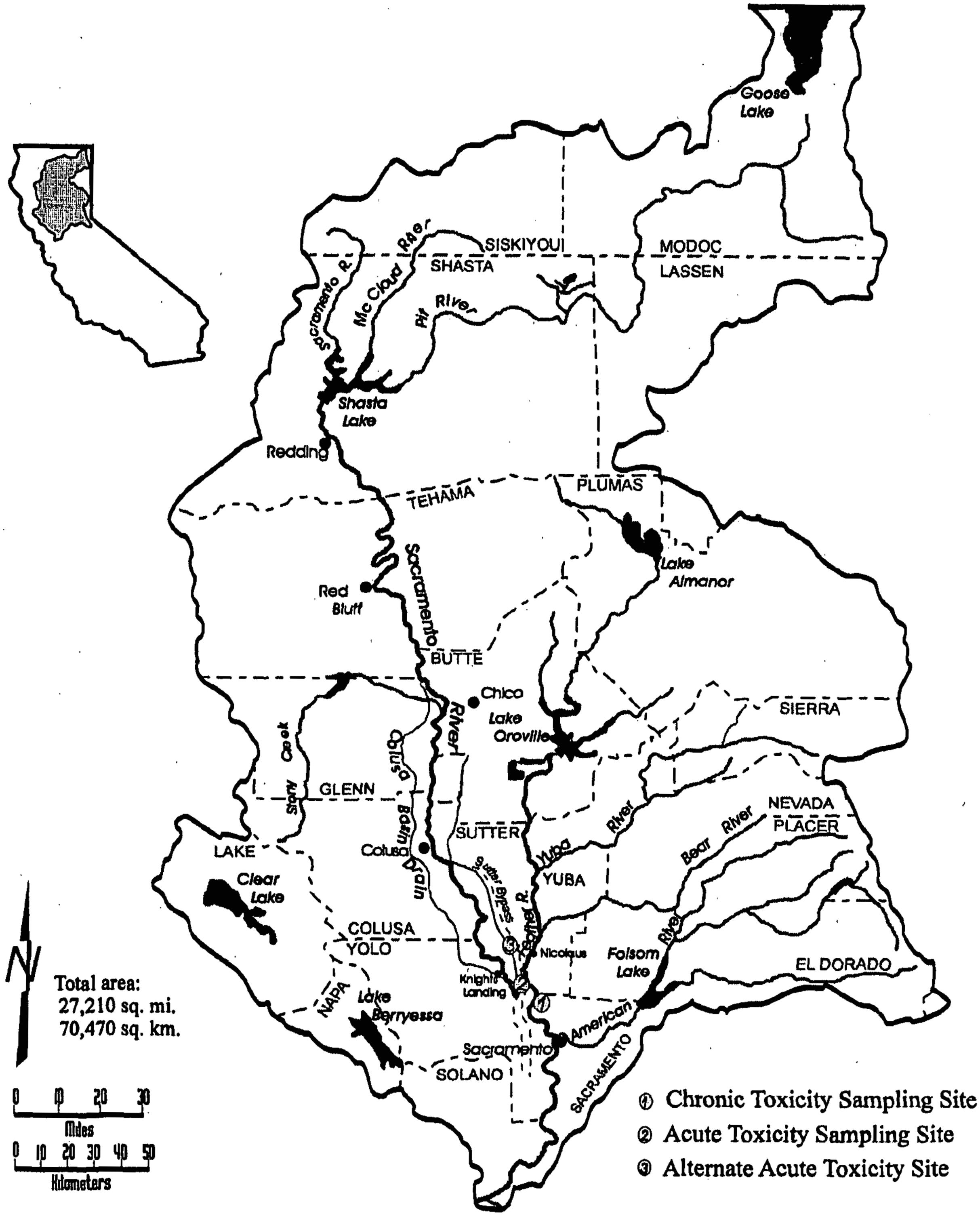

Figure 1. Map of the Sacramento River Hydrologic Basin.

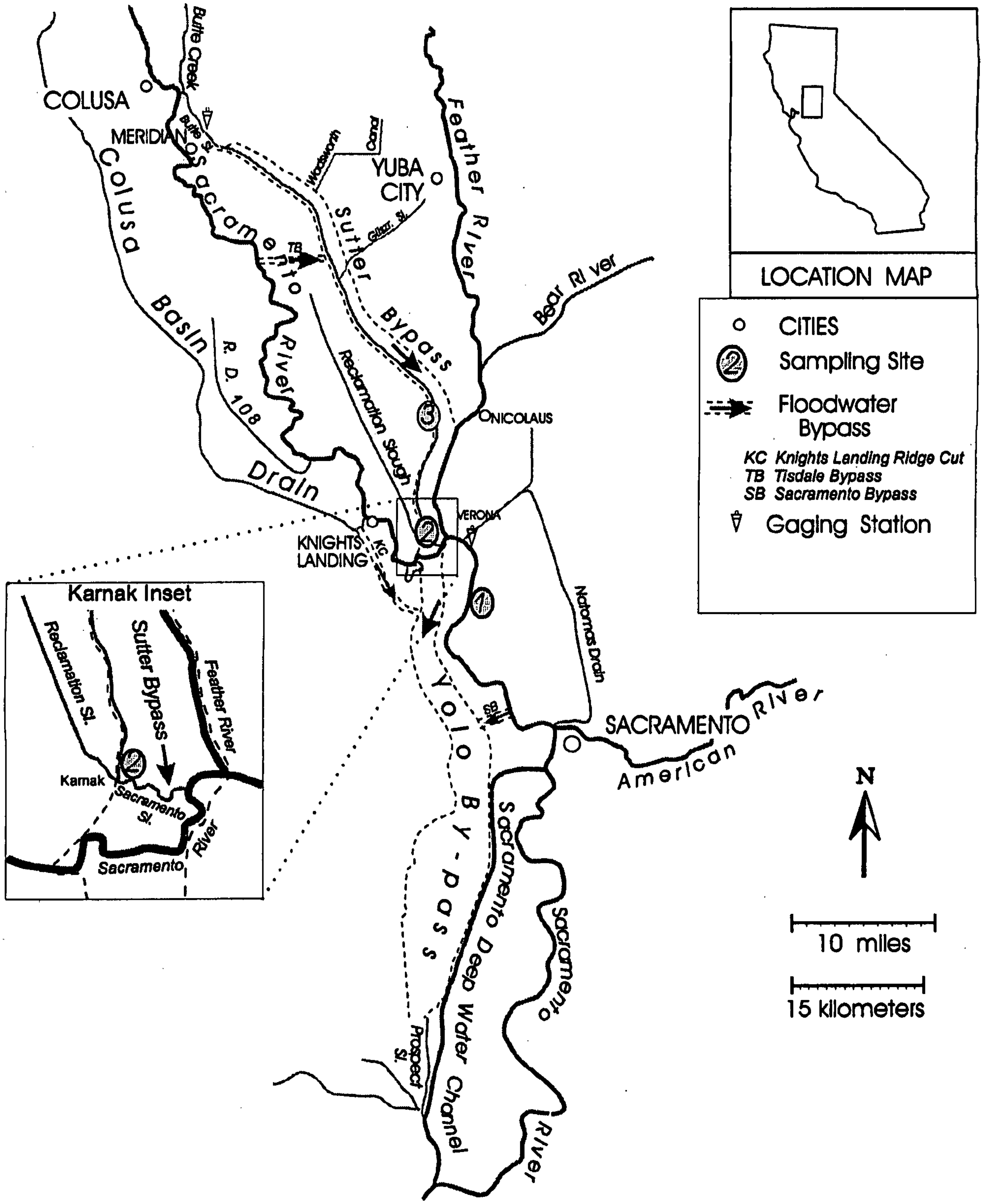

Figure 2: Sampling sites in the Sacramento River watershed.
Site 1 = Alamar Marina, Sacramento River Chronic Toxicity Site.
Site 2 = Sutter Bypass at Karnak Pumping Station, Acute Toxicity Site.
Site 3 = Sutter Bypass at Kirkville Road, Alternate Acute Toxicity Site.

ENVIRONMENTAL DATA FOR THE SUTTER BYPASS SITES, WINTER 1997-98

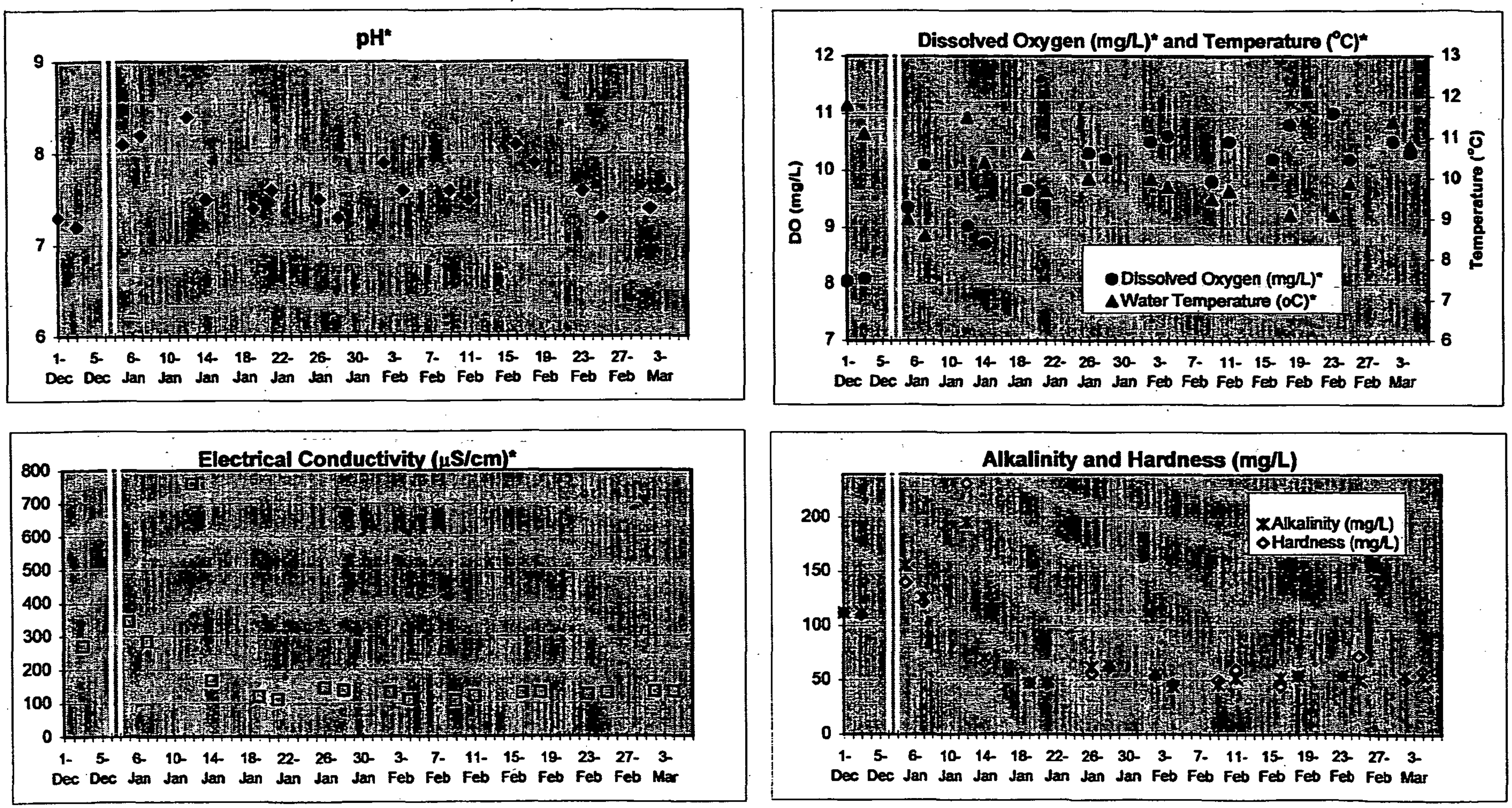

Figure 3. Environmental measurements for the Sutter Bypass taken either at the Karnak or the Kirkville Road sites. Data was collected at Karnak from December 1-5, 1997 and January 5-12, 1998. Data was taken at Kirkville Road from January 14 to March 4, 1998. Double bar denotes a break in sampling between background and dormant season samples. * Denotes measurements made on site.

ENVIRONMENTAL DATA FOR THE SACRAMENTO RIVER, WINTER 1997-98

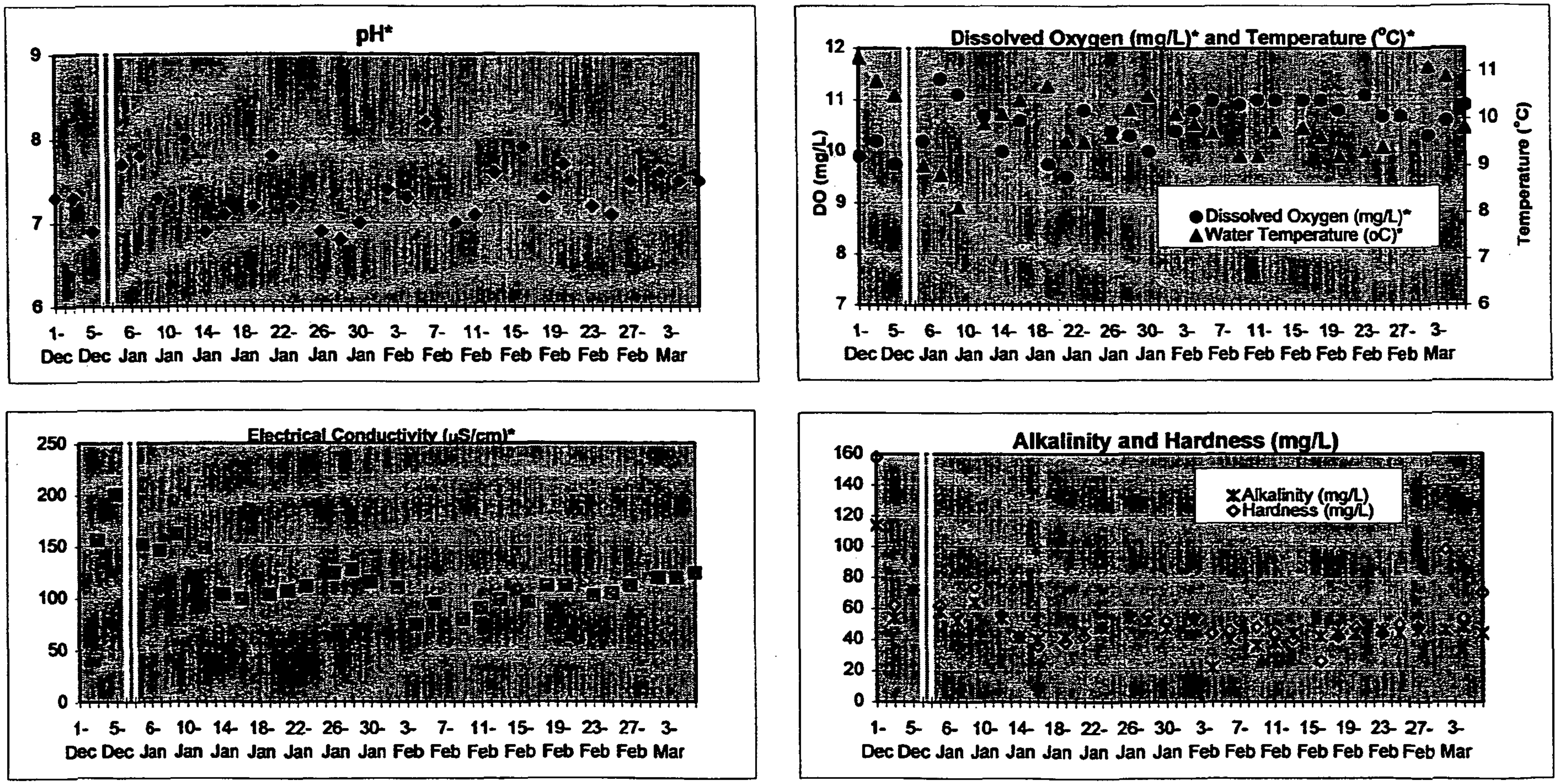

Figure 4. Environmental measurements for the Sacramento River at the Alamar Marina. Data collected from December 1-5, 1997 and January 5-March 6, 1998. Measurements were collected three times per week during the stated period. *Denotes measurements made on site. Double bar denotes a break in sampling between the background and dormant season samples.

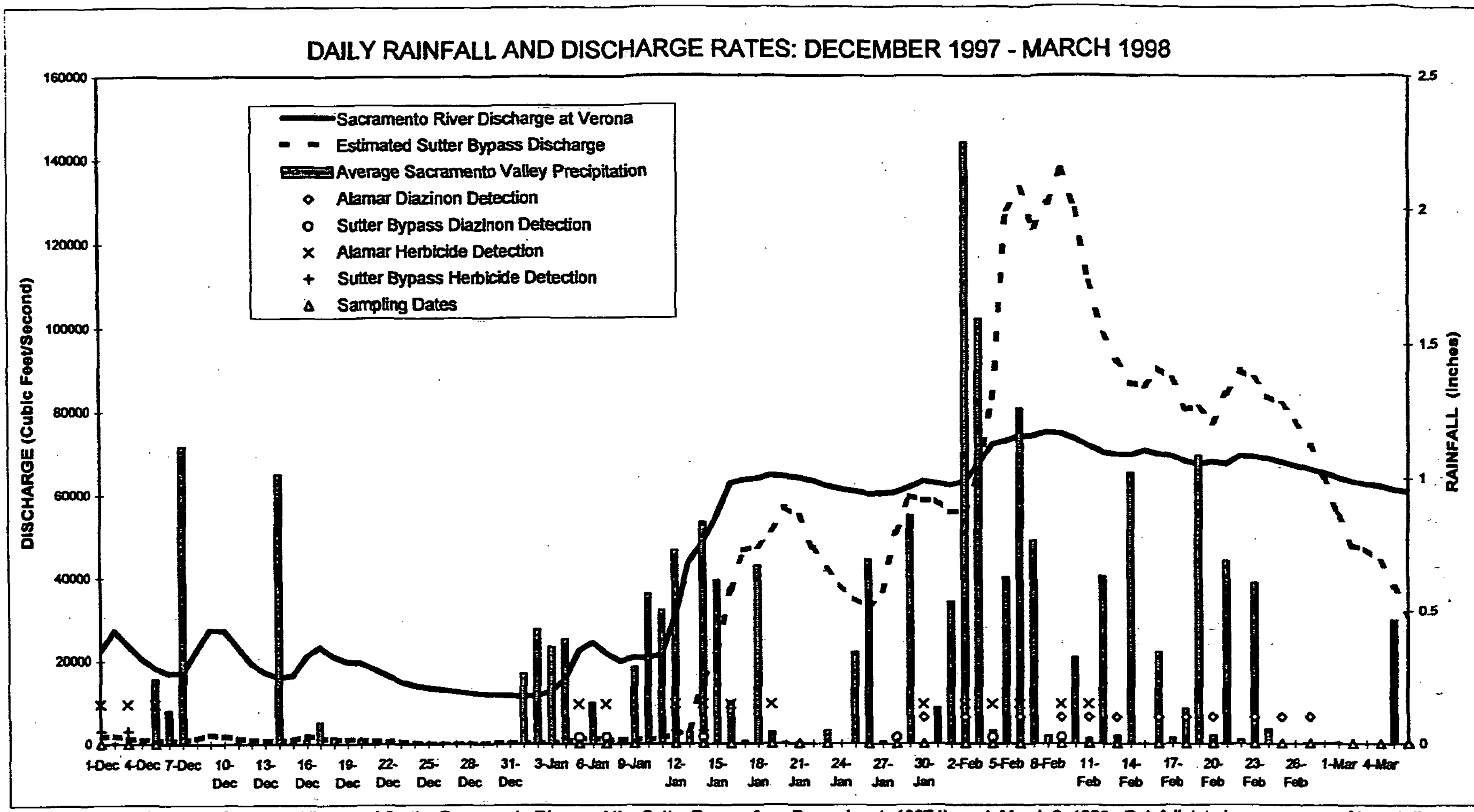

Figure 5. Daily rainfall and flow rates (discharge) for the Sacramento River and the Sutter Bypass from December 1, 1997 through March 6, 1998. Rainfall data is an average of two stations in the Sacramento River Basin: *Sacramento Post Office and Chico weather stations. Sacramento River discharge was measured at Verona. Sutter Bypass discharge was estimated by* adding measurements from the Butte Slough near Meridian gage and approximated flows for Tisdale Bypass based on discharge measurements at the Wilkins Slough DWR station or actual Tisdale Bypass discharge readings after January 28. Rainfall and discharge data is provisional and is subject to revision.

Document Review and Approval
Environmental Hazards Assessment Program
Department of Pesticide Regulation
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Author(s): Craig Nordmark

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APPROVED: ____________________ Date: 7/21/98
Don Weaver
Senior Environ. Res. Scientist
(Supervisor)

APPROVED: ____________________ Date: 7/21/98
John Troiano
Senior Environ. Res. Scientist
(Specialist)

APPROVED: ____________________ Date: 7/21/98
Kean S. Goh
Ag. Program Supervisor IV

APPROVED: ____________________ Date: 7-23-98
Doug Okumura
Branch Chief

APPROVED: ____________________ Date: 7/29/98
Ron Oshima
Assistant Director