



# Department of Pesticide Regulation



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## MEMORANDUM

Arnold Schwarzenegger  
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TO: John S. Sanders, Ph.D., Chief  
Environmental Monitoring Branch

FROM: Frank Spurlock, Ph.D. [Original signed by Frank Spurlock]  
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DATE: January 28, 2004

SUBJECT: ANALYSIS OF RECENT CHLORPYRIFOS USE AND SURFACE WATER  
MONITORING DATA

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### Background

The Department of Pesticide Regulation (DPR) recently completed an analysis of diazinon and chlorpyrifos surface water monitoring data in DPR's surface water database (SURF) (Spurlock, 2002). DPR subsequently placed diazinon-containing dormant spray pesticides into re-evaluation because of ongoing dormant season exceedances of Department of Fish and Game (DFG) diazinon water quality criteria (WQC) (DPR, 2003a).

The analysis also concluded that (a) there was only one chlorpyrifos detection reported in SURF since 1997, (b) that single detection occurred during DPR's winter dormant season monitoring, (c) the peak use periods for chlorpyrifos were the spring and summer months, and (d) that there were no recent chlorpyrifos monitoring data in SURF for the peak-use spring or summer months (Spurlock, 2002). Consequently, the SURF data available at that time were inadequate to determine whether chlorpyrifos was present in California surface water at levels that might exceed WQC. The availability of recent monitoring data during the use season was critical from a regulatory standpoint because use of chlorpyrifos had been steadily decreasing. Therefore, the available older historical data were not representative of current water quality conditions.

To address DPR's lack of recent chlorpyrifos monitoring data, the Department's Surface Water Protection Program conducted monitoring studies in 2002 and 2003 (Bacey, 2001; Bacey, 2002; Starner, 2002; Kelley, 2003), and also requested the Central Valley Regional Water Quality Control Board (CVRWQCB) to provide all recent chlorpyrifos monitoring data on March 27, 2003 (Spurlock, 2003). Data from all of the DPR monitoring studies were available by October, 2003, and all CVRWQCB data were subsequently received by November 26, 2003 (Grober, 2003; McClure, 2003). This memo provides a brief summary and analysis of these data, with particular emphasis on the exceedances of DFG chlorpyrifos WQC in recent years.



## Data Overview

### Monitoring data

The aggregate data from all sources consisted of 1,914 samples collected from 73 sites in four regions: Sacramento River basin, San Joaquin River basin, Salinas River basin, and Sacramento/San Joaquin Delta (appendices 1a, 1b). The sampling locations are classified into river and tributary sites for the purpose of summarizing the data. The classification scheme is somewhat arbitrary (e.g., delta sloughs are classified as tributaries although they do not fit the typical description of a tributary).

Most of the sampling sites reflect primarily agricultural inputs, although a few represent mixed urban and agricultural inputs (Livingston Canal; Dry Creek at Gallo Road), and two tributary sites in Modesto are essentially 100 percent urban: McHenry and Farabuindo storm drains (Kratzer et al., 2002).

Eighty-seven percent of the data were collected since January 2000, and 38 percent were collected in the years 2002 and 2003 (Table 1). Nearly all urban chlorpyrifos uses and a few agricultural uses were eliminated as of December 31, 2001 (U.S. EPA, 2000). Consequently, these most recent 2002-2003 monitoring data are particularly important because they reflect water quality conditions in relation to current chlorpyrifos use patterns.

**Table 1. Total number of samples by year.**

YEAR	Tributary	River	Total
1996	2	0	2
1997	25	37	62
1998	27	38	65
1999	44	81	125
2000	112	207	319
2001	201	413	614
2002	228	120	348
2003	230	149	379
<b>Grand Total</b>	<b>869</b>	<b>1045</b>	<b>1914</b>

Sixty nine percent of the monitoring data were collected in the San Joaquin Valley, followed by 18 percent in the Sacramento Valley, and 9 percent in the Sacramento/San Joaquin Delta (Table 2). The Monterey County data (3.3 percent of all data) were collected in a very recent DPR study of four Salinas River tributaries during summer 2003 (Kelley, 2003).

**Table 2. Total Number of samples by region**

Sampling Area	Number Samples
San Joaquin Valley	1258
Sacramento Valley	315
Sacramento/San Joaquin Delta	172
Monterey County	64

Chlorpyrifos use data

The most current chlorpyrifos use data are from DPR's 2002 pesticide use report database. Total reported chlorpyrifos use in that year was higher in the San Joaquin Valley than in the Monterey County or Sacramento Valley (Table 3). However, 2002 use intensity - as expressed by [lbs chlorpyrifos applied in a region]/[total harvested acres of cropland in a region] - was highest in Monterey County followed by the San Joaquin Valley. The 2000 and 2001 use data similarly indicate that chlorpyrifos use intensity is generally much higher in Monterey County and the San Joaquin Valley than in the Sacramento Valley.

**Table 3. 2000 - 2002 chlorpyrifos use and harvested acreage in sampling regions.**

	San Joaquin Valley <sup>1</sup>	Sacramento Valley <sup>2</sup>	Monterey Co.
<b>2000 use<sup>3</sup></b>	656,800 lbs	154,200	55,800
<b>2001 use</b>	563,500	145,100	54,900
<b>2002 use</b>	430,600	134,000	53,000
<b>harvested cropland<sup>4</sup></b>	2,701,000 acres	1,604,000 acres	286,000 acres
<b>2002 mean lbs/acre<sup>5</sup></b>	0.159	0.084	0.185

<sup>1</sup> Fresno, Madera, Merced, San Joaquin and Stanislaus Counties

<sup>2</sup> Butte, Colusa, Glenn, Placer, Sacramento, Sutter, Tehema, Yolo and Yuba Counties

<sup>3</sup> Total pounds active ingredient all reported uses, DPR Pesticide Use Report

<sup>4</sup> USDA National Agricultural Statistics Service, 1997, Census of Agriculture - latest available data

<sup>5</sup> [2002 chlorpyrifos applied in region]/[total harvested acres in region]

While chlorpyrifos is applied to a wide variety of California crops, the dominant 2002 uses in the San Joaquin Valley were nuts, alfalfa, and cotton (Table 4). The highest 2002 uses in the Sacramento Valley were nuts and alfalfa (Table 4). In contrast, the row crops broccoli and cauliflower accounted for almost three-quarters of 2002 chlorpyrifos use in Monterey County.

**Table 4. 2002 chlorpyrifos use in top 10 commodities of each sampling region**

San Joaquin Valley			Sacramento Valley			Monterey County		
commodity	lbs applied	percent of use	commodity	lbs applied	percent of use	commodity	lbs applied	percent of use
almond	99296	23.1%	walnut	70517	52.6%	broccoli	29688	56.0%
cotton	90034	20.9%	alfalfa	26203	19.6%	cauliflower	9815	18.5%
walnut	53401	12.4%	almond	16783	12.5%	grapes, wine	3399	6.4%
alfalfa	39747	9.2%	structural	10659	8.0%	lemon	2744	5.2%
orange	38441	8.9%	prune	2082	1.6%	brussel sprout	1653	3.1%
structural	21795	5.1%	dried beans	1086	0.8%	structural	1491	2.8%
peach	14270	3.3%	sunflower	748	0.6%	cabbage	1389	2.6%
nectarine	11520	2.7%	peach	708	0.5%	walnut	479	0.9%
grapes	11261	2.6%	grapes, wine	624	0.5%	kale	466	0.9%
corn	10963	2.5%	orange	586	0.4%	broccoli raab	358	0.7%
<b>TOTAL</b>		<b>90.7%</b>	<b>TOTAL</b>		<b>97.0%</b>	<b>TOTAL</b>		<b>97.1%</b>

Juxtaposition of use and sampling data

Mid-summer is the peak chlorpyrifos application period in the Sacramento and San Joaquin Valleys, where approximately 50-60 percent of 2002 use occurred in the months of July and August (Figure 1, attached). The number of San Joaquin Valley samples ranged from about 100-150 during the summer months. The San Joaquin Valley summer sampling sites were distributed over several locations in San Joaquin Valley rivers and tributaries. Consequently, these San Joaquin monitoring data provide a representative indication of recent chlorpyrifos concentrations across the sampling region during the summer peak use season. In contrast, there were fewer than 20 in the Sacramento Valley data during each summer month (Figure 1), and the spatial distribution of sampling locations was much more limited. Consequently, the data provide only very limited information on Sacramento Valley chlorpyrifos concentrations during the peak season.

While chlorpyrifos use in Monterey County is distributed somewhat more evenly over the year, summer was still the dominant use season (Figure 1). The sampling data here were collected during three of four peak summer use months in Monterey County. Only four tributary sites in Monterey County were sampled; no river sites were sampled so these data provide no information on chlorpyrifos concentrations in the Salinas River.

The number of samples collected at Sacramento/San Joaquin Delta sites was relatively low (< 20) for every month except May. A total of only four samples were collected in the Delta during the months of January through March, 48 in May, and 10-20 samples during the remaining months (Figure 1).

### Detections and Exceedances

The CVRWQCB use DFG WQC as the basis for setting chlorpyrifos total maximum daily loads (CVRWQCB, 2003). The WQC are time-averaged concentrations (Table 5), and were directly compared to grab sample analytical results here because there were relatively few frequent sampling data (i.e., hourly or daily) for any of the sites. Frequent sampling data is required to calculate time-averaged concentration at a site. In reality, this is not too important because of the high autocorrelation that is typically present in daily sampling data. Autocorrelation means that concentrations measured on any particular day are correlated to those measured on proximate days. Consequently, a “high” chlorpyrifos concentration at a site on any particular day is generally associated with high concentrations at that site on subsequent (and previous) days. This pattern was observed in the data here in several of the cases where chlorpyrifos WQC exceedances occurred in conjunction with frequent sampling episodes at a particular site (e.g., Figure 2, attached). Autocorrelation is generally common in sampling data, and appears typical in the San Joaquin Valley based on chlorpyrifos and diazinon concentration data at Orestimba Creek, and diazinon, simazine, metolachlor, and cyanazine concentration data at the San Joaquin River near Vernalis. All of these San Joaquin Valley data sets are autocorrelated for lag periods up to several days (Shumway, 2001; Spurlock, 2002; Figure 3, attached). From a practical standpoint, this indicates that instantaneous grab samples provide a reasonable estimate of one-hour average concentrations, and that grab sample chronic exceedances often represent extended excursions above chronic WQC.

**Table 5. Water quality criteria<sup>1</sup>**

Criterion (ug L <sup>-1</sup> )	Type	Recurrence period
0.014	chronic	4-day average; not to be exceeded more than once in 3 years
0.02	acute	1-hr average; not to be exceeded more than once in 3 years

<sup>1</sup>Water quality criteria for diazinon and chlorpyrifos, 2000, DFG administrative report 00-3

A few of the sampling data at certain sites were collected as part of “storm-chasing” type monitoring, where multiple samples are collected at a single site over short time intervals to determine the time series of chlorpyrifos concentration during runoff events. Maximum daily chlorpyrifos concentrations were determined for each such site. **Detection and exceedance frequencies discussed below are based on these maximum daily measured concentrations at a site and the number of distinct sampling dates at each site.**

### Tributaries

Based on the daily maximum detection data for each site, chlorpyrifos was detected in 258 of 686 tributary sampling days (Appendix 2). One hundred of the detections (~15 percent of tributary sampling days at distinct sites) were equal to or greater than the DFG acute water quality criterion, while an additional 18 detections (~3 percent) exceeded the chronic criterion (Appendices 3, 4).

There were only a few tributary exceedances in the Sacramento Valley; the vast majority occurred in the San Joaquin Valley and Monterey County (Table 6). The difference between regions reflects several factors, two of the most important being the low in-season (summer) sampling frequency in the Sacramento Valley, and the somewhat lesser chlorpyrifos use in the Sacramento Valley as compared to the San Joaquin Valley (Table 6).

While the number of San Joaquin Valley tributary exceedances were highest at Orestimba Creek (32) and Del Puerto Creek (13), the remaining 28 were distributed over several sites in different areas of the San Joaquin Valley (Appendix 3a). Approximately ten percent of the San Joaquin tributary exceedances (7 of 73, daily maximum concentration data) were more than five times greater than the DFG acute WQC of  $0.02 \text{ ug L}^{-1}$ ; the highest concentration was  $2.42 \text{ ug L}^{-1}$ , occurring at Orestimba Creek in August, 2003.

Exceedance frequencies were especially high in the Monterey County data, where the overall exceedance frequency in the May-September sampling period was greater than 45 percent (Table 6). Ninety-three percent of exceedances in the Monterey County study occurred at two sites: Quail Creek and Chualar Creek. Concentrations at these two sites were relatively high. Seventy percent of exceedances were more than five times greater than the DFG acute WQC of  $0.02 \text{ ug L}^{-1}$  (Appendix 4). The highest measured concentration was  $3.96 \text{ ug L}^{-1}$ , occurring at Quail Creek in July, 2003.

### Rivers

Based on the daily maximum detection data for each site, chlorpyrifos was detected in 296 of 850 daily river sampling events (Appendix 2). Twenty-two of the detections (2.6 percent of river sampling days at distinct sites) were equal to or greater than the DFG acute water quality criterion, while an additional 18 detections (2.1 percent) exceeded the chronic criterion (Appendices 3, 4).

Thirty-six of the exceedances occurred in the San Joaquin Valley, and four in the Sacramento/San Joaquin delta (Table 7). River exceedances in the San Joaquin Valley were distributed throughout the basin, occurring at several locations in the San Joaquin River, Tuolumne River, Merced River, and Stanislaus Rivers. Concentrations were lower than in the tributary data, with a maximum observed concentration of  $0.1 \text{ ug L}^{-1}$  observed at the Stanislaus River, Caswell park site in June, 2001.

While there were no river exceedances at Sacramento Valley sites, the number and spatial distribution of Sacramento Valley river sampling during the peak summer use period was very limited (Figure 1). There were no Monterey County river data in this data set.

**Table 6. Tributary exceedances summarized by month and region**

**A. # exceedances / # of sampling days at distinct sampling sites**

Month	Sac/SJ delta	Monterey Co.	Sacramento Valley	San Joaquin Valley	Grand Total
1	0 / 0	0 / 0	0 / 7	3 / 36	3 / 43
2	0 / 1	0 / 0	0 / 12	5 / 63	5 / 76
3	0 / 0	0 / 0	1 / 9	10 / 29	11 / 38
4	0 / 7	0 / 0	0 / 6	3 / 23	3 / 36
5	3 / 43	0 / 0	0 / 5	11 / 38	14 / 86
6	0 / 8	8 / 12	0 / 4	10 / 70	18 / 94
7	0 / 10	8 / 16	1 / 5	14 / 78	23 / 109
8	0 / 10	7 / 16	0 / 4	13 / 60	20 / 90
9	2 / 11	7 / 20	0 / 4	3 / 34	12 / 69
10	0 / 10	0 / 0	0 / 3	1 / 2	1 / 15
11	0 / 10	0 / 0	0 / 5	0 / 0	0 / 15
12	8 / 10	0 / 0	0 / 4	0 / 1	8 / 15
<b>Grand Total</b>	13 / 120	30 / 64	2 / 68	73 / 434	118 / 686

**B. Percent of sampling days that were exceedances**

Month	Sac/SJ delta	Monterey Co.	Sacramento Valley	San Joaquin Valley	All data
1	--	--	0.0%	8.3%	7.0%
2	0.0%	--	0.0%	7.9%	6.6%
3	--	--	11.1%	34.5%	28.9%
4	0.0%	--	0.0%	13.0%	8.3%
5	7.0%	--	0.0%	28.9%	16.3%
6	0.0%	66.7%	0.0%	14.3%	19.1%
7	0.0%	50.0%	20.0%	17.9%	21.1%
8	0.0%	43.8%	0.0%	21.7%	22.2%
9	18.2%	35.0%	0.0%	8.8%	17.4%
10	0.0%	--	0.0%	50.0%	6.7%
11	0.0%	--	0.0%	--	0.0%
12	80.0%	--	0.0%	0.0%	53.3%
<b>Grand Total</b>	10.8%	46.9%	2.9%	16.8%	17.2%

**Table 7. River exceedances summarized by month and region**

**A. # exceedances / # of sampling days at distinct sampling sites**

Month	region			Grand Total
	Sac/SJ delta	Sacramento Valley	San Joaquin Valley	
1	0 / 1	0 / 35	4 / 78	4 / 114
2	0 / 1	0 / 60	3 / 145	3 / 206
3	0 / 1	0 / 10	17 / 75	17 / 86
4	0 / 4	0 / 14	0 / 37	0 / 55
5	1 / 5	0 / 11	2 / 66	3 / 82
6	0 / 5	0 / 12	4 / 54	4 / 71
7	0 / 6	0 / 13	2 / 64	2 / 83
8	0 / 6	0 / 11	4 / 48	4 / 65
9	0 / 7	0 / 13	0 / 13	0 / 33
10	0 / 3	0 / 7	0 / 3	0 / 13
11	0 / 4	0 / 11	0 / 3	0 / 18
12	3 / 8	0 / 11	0 / 5	3 / 24
<b>Grand Total</b>	4 / 51	0 / 208	36 / 591	40 / 850

**B. Percent of sampling days that were exceedances**

Month	region			All data
	Sac/SJ delta	Sacramento Valley	San Joaquin Valley	
1	0.0%	0.0%	5.1%	3.5%
2	0.0%	0.0%	2.1%	1.5%
3	0.0%	0.0%	22.7%	19.8%
4	0.0%	0.0%	0.0%	0.0%
5	20.0%	0.0%	3.0%	3.7%
6	0.0%	0.0%	7.4%	5.6%
7	0.0%	0.0%	3.1%	2.4%
8	0.0%	0.0%	8.3%	6.2%
9	0.0%	0.0%	0.0%	0.0%
10	0.0%	0.0%	0.0%	0.0%
11	0.0%	0.0%	0.0%	0.0%
12	37.5%	0.0%	0.0%	12.5%
<b>Grand Total</b>	7.8%	0.0%	6.1%	4.7%



Effect of recent U.S. EPA regulatory actions

There was no obvious effect on chlorpyrifos water quality exceedances due to the elimination of urban-use product sales in late 2001 in either the tributary or river data. Thirty-eight percent of the total number of tributary exceedances occurred in 2002 and 2003. This percentage is approximately equal to the percentage of tributary samples collected in 2002-2003. Twenty river exceedances (50 percent of total river exceedances) occurred in 2002 and 2003 even though these two years accounted for only 13 percent of river sampling days (Table 8). The lack of any effect of the termination of urban uses on exceedances is consistent with fact that the majority of sampling sites are dominated by agricultural inputs.

**Table 8. Chlorpyrifos river and tributary water quality exceedances by year**

Year - tributaries -	number acute exceedances	number chronic exceedances	number total sampling events	percent exceedances <sup>A</sup>
1997	5	3	25	32.0%
1998	4	0	23	17.4%
1999	4	2	38	15.8%
2000	6	4	81	12.3%
2001	23	4	182	14.8%
2002	20	2	168	13.1%
2003	38	3	167	24.6%
<b>trib total</b>	<b>100</b>	<b>18</b>	<b>686</b>	<b>17.2%</b>
<b>- rivers -</b>				
1997	0	0	37	0.0%
1998	0	0	38	0.0%
1999	0	0	75	0.0%
2000	1	6	162	4.3%
2001	7	5	344	3.5%
2002	10	2	114	10.5%
2003	4	4	80	10.0%
<b>river total</b>	<b>22</b>	<b>18</b>	<b>850</b>	<b>4.7%</b>

<sup>A</sup> percent of samples in a year that exceeded DFG acute or chronic WQC.

**Observations in Specific Sampling Regions**

San Joaquin Valley

Water quality exceedances in the San Joaquin Valley were observed in virtually every month with significant sampling activity (Tables 6 and 7). Although San Joaquin Valley chlorpyrifos use is greatest during summer months (Figure 1), exceedances were most frequent during March. Based on 2002 use data, the principal San Joaquin Valley sites of chlorpyrifos application are alfalfa (48 percent of 2002 March applications) and grapes (24 percent of 2002 March applications). The dominant application sites during other periods with frequent exceedances

include fruit orchard crops (58 percent) and nut orchards (20 percent) during January and February, and nut orchard (48 percent), cotton (23 percent), citrus (14 percent) and alfalfa (7 percent) during the months of May-August. Applications to particular commodities indicates that those commodities are a potential source of chlorpyrifos in surface water. Further study would be required to identify the specific locations and commodities that are responsible WQC exceedances. Additional San Joaquin use data is provided in Appendix 5.

In numerous instances, chlorpyrifos detections - and exceedances - occurred at multiple sites on the same day (Appendix 6). Such detection episodes indicate that chlorpyrifos occurrence in San Joaquin Valley surface water is regional. Multiple daily detections at different sites have occurred in several years, and are particularly frequent in January-March. This pattern of detections is not unexpected under conditions of widespread regional use and rainfall-driven offsite movement in runoff. This appears to be the case for many of the January-March episodes based on the co-occurrence of rainfall with the detections.

There were also several instances where multiple detections and exceedances at various locations were observed on the same day during non-rainy periods in late spring and summer months. While the source in these cases is apparently irrigation tailwater runoff, further detailed study is required to identify the particular commodities and practices responsible.

#### Sacramento River

As previously noted, the total number of Sacramento Valley samples was limited, the number of sampling sites was low, and their distribution over months of the year was skewed relative to monthly chlorpyrifos use. In addition, reporting limits for many of the samples were higher than the DFG WQC. Consequently, these data provide only very limited information regarding chlorpyrifos concentrations in Sacramento Valley surface waters.

#### Sacramento/San Joaquin Delta

Two episodes of detections at multiple sites on the same day occurred in the Sacramento/San Joaquin Delta on December 19, 2002 and December 23, 2002. Detections were observed at four Delta sites on December 19, and 7 Delta sites on December 23. All of the detections exceeded DFG acute WQC. Four and one-half inches of rain were recorded at Stockton between December 17 and December 23, so these detections are probably a result of rainfall runoff-driven off-site movement. There was no monitoring conducted during this period in either the Sacramento River or the San Joaquin Valley River which flow into the Delta.

#### Monterey County

The Monterey County data analyzed here came from a single four-month study of four agriculturally-dominated tributaries to the Salinas River, and so are somewhat geographically and temporally limited. However, the Chualar Creek and Quail Creek data demonstrated the highest concentrations and exceedance frequencies of any water body monitored by far (Table 9).

**Table 9. Summary statistics for Chualar and Quail Creek sampling data**

Sampling location	DFG WQC exceedance frequency	median concentration ( $\mu\text{g L}^{-1}$ )	maximum concentration ( $\mu\text{g L}^{-1}$ )
Chualar Creek	75%	0.116	0.684
Quail Creek	100%	0.128	3.96

Numerous other recent studies have examined the presence and effects of chlorpyrifos in the waters and sediments of the Salinas River and its tributaries (Phillips, 2004; Kozlowski et al., 2003; Anderson et al., 2003a; Anderson et al., 2003b; Hunt et al., 2002). Most of the analytical data from these studies were obtained using enzyme-linked immunosorbent assay methods (ELISA). ELISA methods have sometimes been observed to yield positively biased concentration measurements relative to convention gas chromatographic analytical methods (e.g., Kozlowski et al., 2003). For this reason the analytical data from these studies were not included in the present data analysis. However, taken in aggregate, the studies provide strong weight-of-evidence that (a) chlorpyrifos is frequently present in water and sediment of the Salinas lagoon, the Salinas River and its tributaries, (c) chlorpyrifos frequently co-occurs with diazinon in water samples, and (c) chlorpyrifos frequently and substantially contributes to acute aquatic toxicity as indicated by *Hyalella azteca* and *Ceriodaphnia dubia* in the Salinas River and its tributaries. The latter observations are based on the results of detailed toxicity identification evaluation procedures in conjunction with toxicity bioassays and chemical analysis. Most of the sampling sites are in areas where the dominant input to receiving water is agricultural runoff.

## Conclusion

Recent chlorpyrifos monitoring data were analyzed. In contrast to the previous analysis (Spurlock, 2002), these monitoring data reflect water quality in agriculturally-dominated waterways of the San Joaquin Valley, the Sacramento/San Joaquin Delta, and the Salinas River Basin under current use conditions throughout much of the year. The data demonstrate that chlorpyrifos has recently been observed in both rivers and tributaries of the San Joaquin Valley, the Sacramento/San Joaquin Delta, and Monterey County tributaries, frequently at levels that exceed DFG's WQC.

Two Monterey County tributary sites displayed very high chlorpyrifos concentrations and WQC exceedance frequencies. When these data are combined with published results from numerous peer-review studies and an data from an additional on-going DPR-funded study, it is evident that Salinas River tributary chlorpyrifos concentrations are generally high and essentially continuous, and likely that Salinas River WQC exceedances may be common. Additional data to characterize seasonal chlorpyrifos concentrations in the Salinas River would be useful.

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Although pesticide concentrations sometimes tend to be lower in the Sacramento/San Joaquin Delta than in the upstream sections of the major rivers due to dilution and other effects, eleven WQC exceedances were observed at several sites on two occasions in December, 2002. These acute exceedances were associated with rain runoff events, but the source is not obvious from pesticide use data, and there was no additional monitoring data in the Sacramento or San Joaquin Valleys during this time.

The San Joaquin Valley sampling region had the most comprehensive data. These data documented 109 WQC exceedances (based on maximum daily concentration data at each site) since 1997, with approximately 70 percent occurring since 2001. WQC exceedances occur throughout the San Joaquin Valley, having been observed in the San Joaquin River (seven sites), Stanislaus River, Merced River, the Tuolumne River (three sites), and thirteen tributary sites.

Although exceedances in the San Joaquin Valley were most frequent in March, and May through August, WQC exceedances were observed in every month with significant sampling activity. There was no apparent effect on exceedances due to recent Federal regulatory actions that terminated the production and sale of urban use chlorpyrifos products; the many of the WQC exceedances occurred during the most recent sampling years of 2002 and 2003 after sales of such products had ended.

San Joaquin Valley WQC exceedances appear regional in nature, often occurring at multiple sites on the same day. Transport to surface water occurs in both wet and dry seasons, and apparently from a variety of agricultural uses. Further detailed data analysis in conjunction with field studies will be required to quantitatively identify contributions from different uses and elucidate various pathways by which chlorpyrifos arrives in California surface waters.

Attachments

bcc: Spurlock Surname File (w/o Attachments)

## References

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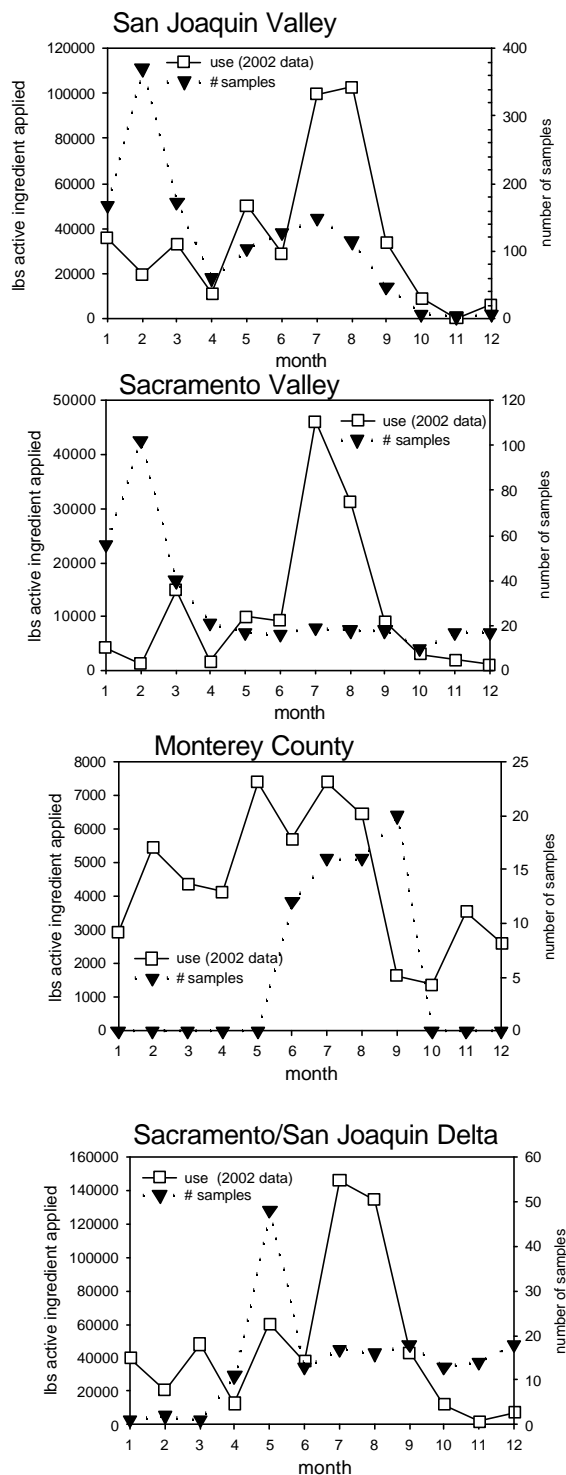
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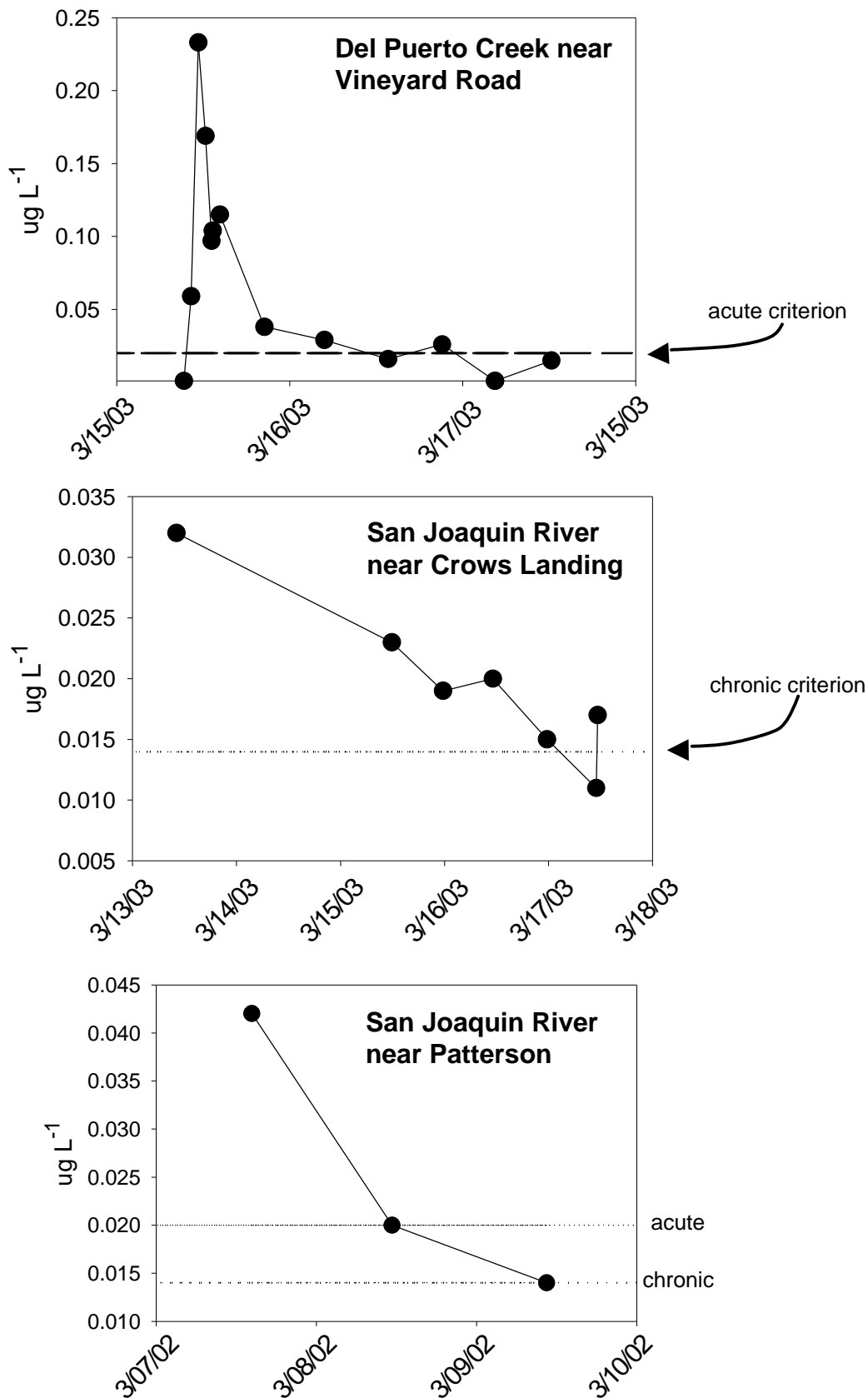
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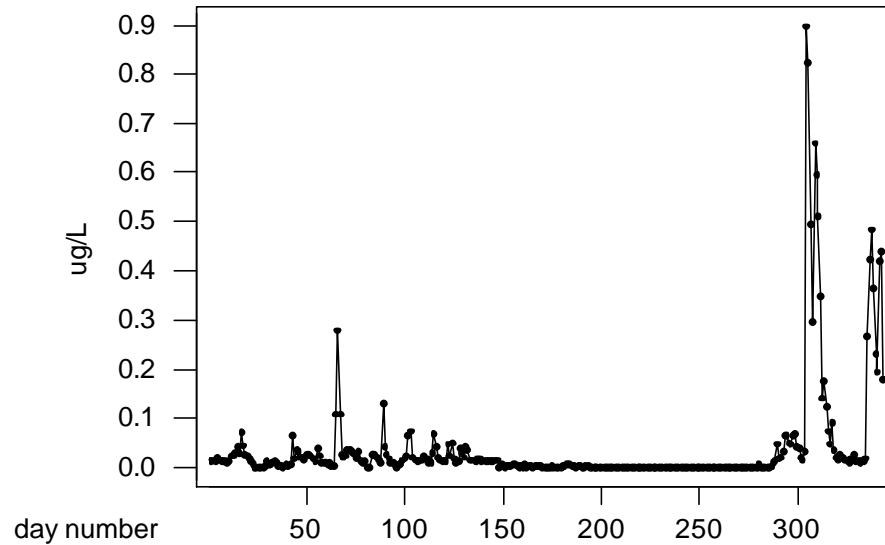




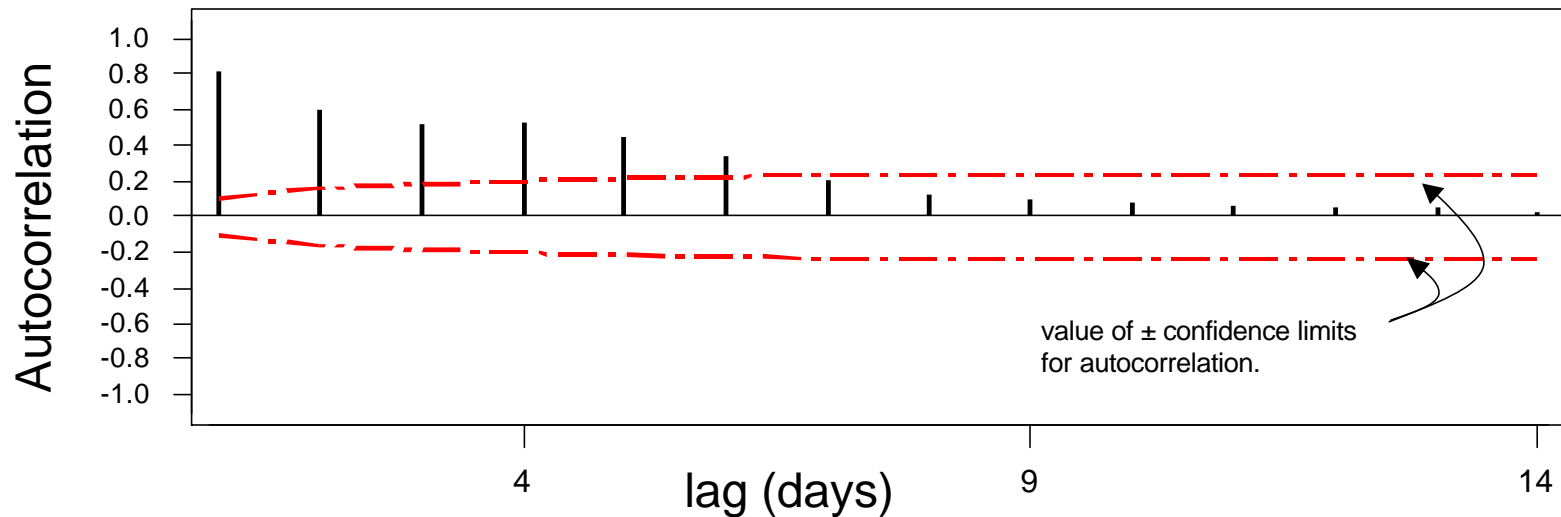
**Figure 2.** Examples of extended excursions above criteria observed during frequent sampling episodes



**Figure 3.** Chlorpyrifos time series plot, Orestimba Creek at State Hwy. 33  
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Autocorrelation function for chlorpyrifos data, Orestimba Creek at State Hwy. 33  
5/23/96 to 4/30/97, nondetections assigned value of zero



**Appendix 1a. Tributary sites and number of samples**

Sampling Location	designation	area	1996	1997	1998	1999	2000	2001	2002	2003	Total
Alisal Slough/Reclamation Ditch, Monterey County	Tributary	Monterey Co.								16	16
Bear C A Bert Crane Rd Nr Merced Ca	Tributary	San Joaquin Valley					1	2			3
Blanco Drain @ Cooper Rd	Tributary	Monterey Co.								16	16
Cache Sl	Tributary	Sac/SJ delta					1		6		7
Chualar Creek, Monterey County	Tributary	Monterey Co.								16	16
Colusa Basin Drain	Tributary	Sacramento Valley		15	4	8	5				32
Del Puerto C At Vineyard Road Nr Patterson	Tributary	San Joaquin Valley					11	23	16	42	92
Dry C A Claus Rd Bridge A Modesto Ca	Tributary	San Joaquin Valley					14				14
Dry Crk @ Gallo Bridge In Modesto	Tributary	San Joaquin Valley					8		13	21	42
Dry Crk Near Snelling	Tributary	San Joaquin Valley							1		1
Duck Sl	Tributary	Sac/SJ delta							7		7
Farabuindo Stormdrain, Modesto	Tributary	San Joaquin Valley			1	1					2
Five Mile Sl	Tributary	Sac/SJ delta			1			4	7		12
French Camp Sl	Tributary	Sac/SJ delta				1			7		8
Georgiana Sl	Tributary	Sac/SJ delta						6			6
Highline Cn Spill Nr Hilmar Ca	Tributary	San Joaquin Valley					10	2	18		30
Hospital C A River Rd Nr Patterson Ca	Tributary	San Joaquin Valley						2			2
Ingalsbe Crk Near Snelling	Tributary	San Joaquin Valley							12		12
Ingram C A River Rd Nr Patterson Ca	Tributary	San Joaquin Valley						2			2
Jack Slough	Tributary	Sacramento Valley							18	17	35
Livingston Cn A Lvngstn Trmnt Plant Nr Lvngstn Ca	Tributary	San Joaquin Valley					10	2			12
Los Banos C A 140 Ca	Tributary	San Joaquin Valley						2			2
Marsh Ck	Tributary	Sac/SJ delta							7		7
Mchenry Stormdrain A Bodem St A Modesto Ca	Tributary	San Joaquin Valley			3	6		10			19
Mid Roberts Is Drain	Tributary	Sac/SJ delta						5	7		12
Mosher Sl	Tributary	Sac/SJ delta						6	7		13
Mud Slough Nr Gustine Ca	Tributary	San Joaquin Valley				1		22			23
Newman Wasteway A Hwy 33 Nr Gustine Ca	Tributary	San Joaquin Valley					9	2			11
Olive Ave Dr Nr Patterson Ca	Tributary	San Joaquin Valley						2			2
Orestimba Cr At River Rd Nr Crows Landing Ca	Tributary	San Joaquin Valley		10	14	16	28	44	41	33	186
Paradise Cut	Tributary	Sac/SJ delta						5	7		12
Quail Creek, Monterey County	Tributary	Monterey Co.								16	16
Sac Slough	Tributary	Sacramento Valley	2			8	4	9			23
Salt Slough A Hwy 165 Nr Stevinson Ca	Tributary	San Joaquin Valley						22	14		36
Salt Slough At Lander Ave	Tributary	San Joaquin Valley								2	2
Spanish Grant Combined Drain Nr Patterson Ca	Tributary	San Joaquin Valley						2			2
Steamboat Sl	Tributary	Sac/SJ delta						6	7		13
Sutter Sl	Tributary	Sac/SJ delta						2			2
Tom Paine Sl	Tributary	Sac/SJ delta						5			5
Turlock Irr Dist Lateral No 5 Nr Patterson Ca	Tributary	San Joaquin Valley				1	9	2			12
Ulati Ck	Tributary	Sac/SJ delta							7		7
Unamed Drain At Pomelo Near Paradise, Stanislaus Co.	Tributary	San Joaquin Valley								17	17
Wadsworth Canal	Tributary	Sacramento Valley							18	17	35
Walker Sl	Tributary	Sac/SJ delta						5			5
Westport Drain (Jennings At Taylor), Stanislaus Co.	Tributary	San Joaquin Valley						2	8	17	27
Whiskey Sl	Tributary	Sac/SJ delta						5			5
Yolo Bypass	Tributary	Sacramento Valley			4	2	2				8
<b>Total Samples - Tributary Sites</b>			<b>2</b>	<b>25</b>	<b>27</b>	<b>44</b>	<b>112</b>	<b>201</b>	<b>228</b>	<b>230</b>	<b>869</b>

**Appendix 1b. River sites and number of samples by year**

Sampling Location	designation	region	1997	1998	1999	2000	2001	2002	2003	Total
Calaveras R	River	Sac/SJ delta					5	5		10
Feather R Nr Outlet	River	Sacramento Valley				15	10			25
Merced R A River Road Bridge Nr Newman Ca	River	San Joaquin Valley	10	15	15	32	42	9	16	139
Merced River Near Snelling	River	San Joaquin Valley						2		2
Mokelumne R	River	Sac/SJ delta						7		7
Old R	River	Sac/SJ delta						7		7
Sac R At Alamar	River	Sacramento Valley			13	10	22	1		46
Sac R At Colusa	River	Sacramento Valley			8	5	10			23
Sac R At Freeport	River	Sacramento Valley	16	11	19	16	20	1		83
Sac R At Hamilton	River	Sacramento Valley			8	5				13
Sac R At Rio Vista	River	Sac/SJ delta						7		7
Sac R At Sacramento	River	Sacramento Valley				16	12			28
Sac R Mile 44	River	Sac/SJ delta			6	3	10	1		20
San Joaquin R A Patterson Br Nr Patterson Ca	River	San Joaquin Valley				1	40	8		49
San Joaquin R At Maze Rd Bridge Nr Modesto Ca	River	San Joaquin Valley					20			20
San Joaquin R BI Wsid Pmp Ab Tuol R Nr Westley Ca	River	San Joaquin Valley					2			2
San Joaquin R Nr Crows Landing Ca	River	San Joaquin Valley					23	7	17	47
San Joaquin R Nr Stevinson Ca	River	San Joaquin Valley				20	43			63
San Joaquin R Nr Vernalis Ca	River	San Joaquin Valley	11	12	12	44	64	25	22	190
San Joaquin River At Lander Ave	River	San Joaquin Valley							1	1
Stanislaus R A Caswell State Park Nr Ripon Ca	River	San Joaquin Valley				20	41	9	17	87
Stanislaus R At Jacob Meyers Park	River	San Joaquin Valley							21	21
Stanislaus R.@ O.B.	River	San Joaquin Valley							19	19
Tuolumne R A Tuolumne City Nr Grayson Ca	River	San Joaquin Valley				20	49			69
Tuolumne River At Santa Fe Ave, Modesto	River	San Joaquin Valley							20	20
Tuolumne River At Shiloh Rd.	River	San Joaquin Valley						31	16	47
<b>Total Samples - River Sites</b>			<b>37</b>	<b>38</b>	<b>81</b>	<b>207</b>	<b>413</b>	<b>120</b>	<b>149</b>	<b>1045</b>

**Appendix 2a. Monthly sampling and detection summary, tributary sites**

MONTH													Total samples <sup>A</sup>	Total sampling days <sup>B</sup>	fraction days w/ detection	Sampling Site
1	2	3	4	5	6	7	8	9	10	11	12					
					3	4	4	5					16	16	0.063	Alisal Slough/Reclamation Ditch, Monterey Co.
	1				1		1						3	3	0.667	Bear C A Bert Crane Rd Nr Merced Ca
					3	4	4	5					16	16	0.063	Blanco Drain @ Cooper Rd
	1					1	1	1	1	1	1		7	7	0.143	Cache Sl
					3	4	4	5					16	16	0.750	Chualar Creek, Monterey County
3	3	3	4	3	2	3	3	2	2	2	2		32	31	0.194	Colusa Basin Drain
4	16	16	4	7	13	16	11	5					92	70	0.429	Del Puerto C At Vineyard Road Nr Patterson
3	11												14	9	1.000	Dry C A Claus Rd Bridge A Modesto Ca
3	14	12		3	4	4	2						42	28	0.464	Dry Crk @ Gallo Bridge In Modesto
			1										1	1	0.000	Dry Crk Near Snelling
					1	1	1	1	1	1	1		7	7	0.143	Duck Sl
1									1				2	2	0.000	Farabuindo Stormdrain, Modesto
			2	3	1	1	1	1	1	1	1		12	12	0.083	Five Mile Sl
					1	1	1	2	1	1	1		8	8	0.125	French Camp Sl
			1	5									6	6	0.000	Georgiana Sl
1	9	8		3	4	4	1						30	18	0.611	Highline Cn Spill Nr Hilmar Ca
					1		1						2	2	0.000	Hospital C A River Rd Nr Patterson Ca
			1	1	4	4	2						12	11	0.000	Ingalsbe Crk Near Snelling
					1		1						2	2	0.500	Ingram C A River Rd Nr Patterson Ca
8	17	10											35	5	0.000	Jack Slough
1	9				1		1						12	8	0.875	Livingston Cn A Lvngstn Trmnt Plant Nr Lvngstn Ca
					1		1						2	2	0.000	Los Banos C A 140 Ca
					1	1	1	1	1	1	1		7	7	0.143	Marsh Ck
16									3				19	6	0.667	Mchenry Stormdrain A Bodem St A Modesto Ca
				5	1	1	1	1	1	1	1		12	12	0.250	Mid Roberts Is Drain
			1	5	1	1	1	1	1	1	1		13	13	0.077	Mosher Sl
			3	5	5	5	4	1					23	23	0.870	Mud Slough Nr Gustine Ca
3	6				1		1						11	10	1.000	Newman Wasteway A Hwy 33 Nr Gustine Ca
					1		1						2	2	1.000	Olive Ave Dr Nr Patterson Ca
18	41	23	11	14	21	27	18	12			1		186	151	0.483	Orestimba Cr At River Rd Nr Crows Landing Ca
				5	1	1	1	1	1	1	1		12	12	0.167	Paradise Cut
					3	4	4	5					16	16	1.000	Quail Creek, Monterey County
2	1	2	2	2	2	2	2	2	2	1	3	2	23	23	0.000	Sac Slough
			3	5	5	10	8	5					36	36	0.250	Salt Slough A Hwy 165 Nr Stevinson Ca
		2											2	1	1.000	Salt Slough At Lander Ave
					1		1						2	2	1.000	Spanish Grant Combined Drain Nr Patterson Ca
			1	5		2	1	1	1	1	1		13	12	0.083	Steamboat Sl
			1	1									2	2	0.000	Sutter Sl
				5									5	5	0.000	Tom Paine Sl
3	6				1		1	1					12	10	1.000	Turlock Irr Dist Lateral No 5 Nr Patterson Ca
					1	1	1	1	1	1	1		7	7	0.143	Ulatis Ck
					3	5	4	5					17	17	0.000	Unamed Drain, Pomelo Nr Paradise, Stanislaus Co.
8	17	10											35	5	0.000	Wadsworth Canal
			1	4									5	5	0.400	Walker Sl
		8			4	5	5	5					27	20	0.150	Westport Drain (Jennings At Taylor), Stanislaus Co.
				5									5	5	0.000	Whiskey Sl
	4	4											8	4	0.000	Yolo Bypass
74	156	98	36	86	96	112	95	69	17	15	15		869	686	0.376	Grand Total

A - Total number of ALL tributary samples, including multiple samples taken at one site in one day

B- number of unique days each site was sampled

**Appendix 2a**

**Appendix 2b. Monthly sampling and detection summary, river sites**

MONTH													Total samples <sup>A</sup>	Total sampling days <sup>B</sup>	fraction days w/ detection	Sampling Site
1	2	3	4	5	6	7	8	9	10	11	12					
			1	4	1	1	1	1			1		10	10	0.100	Calaveras R
8	17												25	25	0.040	Feather R Nr Outlet
20	40	18	10	15	14	13	7	1			1		139	116	0.431	Merced R A River Road Bridge Nr Newman Ca
			1	1									2	2	0.000	Merced River Near Snelling
					1	1	1	1	1	1	1		7	7	0.143	Mokelumne R
					1	1	1	1	1	1	1		7	7	0.000	Old R
8	8	3	4	2	2	4	3	4	1	3	4		46	40	0.000	Sac R At Alamar
6	6	1	1	1	1	1	1	1	1	2	1		23	23	0.000	Sac R At Colusa
6	6	6	9	8	8	8	7	8	4	6	7		83	80	0.013	Sac R At Freeport
1	1	1	1	1	1	1	2	1	1	1	1		13	12	0.000	Sac R At Hamilton
						1	1	1	1	1	2		7	7	0.286	Sac R At Rio Vista
6	22												28	28	0.107	Sac R At Sacramento
1	1	1	3	1	2	2	2	3		1	3		20	20	0.000	Sac R Mile 44
8	13	3	3	8	5	5	4						49	43	0.581	San Joaquin R A Patterson Br Nr Patterson Ca
			3	5	4	5	3						20	20	0.700	San Joaquin R At Maze Rd Bridge Nr Modesto Ca
					1		1						2	2	1.000	San Joaquin R Bl Wsid Pmp Ab Tuol R Nr Westley Ca
1	11	12	3	5	4	7	4						47	35	0.514	San Joaquin R Nr Crows Landing Ca
15	26		3	5	5	5	4						63	47	0.532	San Joaquin R Nr Stevinson Ca
38	61	17	8	11	9	14	13	9	3	3	4		190	145	0.503	San Joaquin R Nr Vernalis Ca
		1											1	1	1.000	San Joaquin River At Lander Ave
14	37	11	3	8	5	5	4						87	65	0.538	Stanislaus R A Caswell State Park Nr Ripon Ca
	10	11											21	9	0.000	Stanislaus R At Jacob Meyers Park
	9	10											19	9	0.000	Stanislaus R.@ O.B.
18	29		3	5	5	5	4						69	50	0.780	Tuolumne R A Tuolumne City Nr Grayson Ca
	11	9											20	9	0.111	Tuolumne River At Santa Fe Ave, Modesto
1	10	11		3	4	9	6	3					47	38	0.105	Tuolumne River At Shiloh Rd.
151	318	115	56	83	73	88	69	34	13	19	26		1045	850	0.348	Grand Total

A - Total number of ALL river samples, including multiple samples taken at one site in one day

B- number of unique days each site was sampled

**Appendix 3a. Exceedances by month in tributaries**

MONTH														Total exceedances <sup>A</sup>	Total sampling days <sup>B</sup>	fraction days w/ exceedance	Sampling Site
1	2	3	4	5	6	7	8	9	10	11	12						
					1									1	16	0.063	Alisal Slough/Reclamation Ditch, Monterey Co
					1									1	3	0.333	Bear C A Bert Crane Rd Nr Merced Ca
					1									1	16	0.063	Blanco Drain @ Cooper Rd
											1			1	7	0.143	Cache Sl
					3	4	3	2						12	16	0.750	Chualar Creek, Monterey County
		1				1								2	31	0.065	Colusa Basin Drain
		3	1	4	2	2	1							13	70	0.186	Del Puerto C At Vineyard Road Nr Patterson
	1													1	9	0.111	Dry C A Claus Rd Bridge A Modesto Ca
1		3		1	1									6	28	0.214	Dry Crk @ Gallo Bridge In Modesto
												1		1	7	0.143	Duck Sl
												1		1	12	0.083	Five Mile Sl
								1						1	8	0.125	French Camp Sl
				1		1								2	18	0.111	Highline Cn Spill Nr Hilmar Ca
					1									1	2	0.500	Ingram C A River Rd Nr Patterson Ca
											1			1	7	0.143	Marsh Ck
2									1					3	6	0.500	Mchenry Stormdrain A Bodem St A Modesto Ca
				1										1	12	0.167	Mid Roberts Is Drain
														1	13	0.077	Mosher Sl
							1	1						2	23	0.087	Mud Slough Nr Gustine Ca
	3													3	10	0.300	Newman Wasteway A Hwy 33 Nr Gustine Ca
	1	3	2	5	5	8	6	2						32	151	0.212	Orestimba Cr At River Rd Nr Crows Landing Ca
									1					1	12	0.083	Paradise Cut
					3	4	4	5						16	16	1.000	Quail Creek, Monterey County
						1	4							5	36	0.139	Salt Slough A Hwy 165 Nr Stevinson Ca
	1													1	1	1.000	Salt Slough At Lander Ave
											1			1	12	0.083	Steamboat Sl
											1			1	7	0.143	Ulati Ck
				2										2	5	0.400	Walker Sl
						2	1							3	20	0.150	Westport Drain (Jennings At Taylor), Stanislaus Co
3	5	11	3	14	18	23	20	12	1	0	8		118	686	0.172	Grand Total	

A - maximum daily measured concentration equal or greater than chronic or acute DFG criteria

B- number of days samples were collected at distinct sites

**Appendix 3b. Exceedances by month in rivers**

MONTH													Total exceedances <sup>A</sup>	Total sampling days <sup>B</sup>	fraction days w/ exceedance	Sampling Site
1	2	3	4	5	6	7	8	9	10	11	12					
				1									1	10	0.100	Calaveras R
1					1	1							3	116	0.026	Merced R A River Road Bridge Nr Newman Ca
											1		1	7	0.143	Mokelumne R
											2		2	7	0.286	Sac R At Rio Vista
		3											3	43	0.070	San Joaquin R A Patterson Br Nr Patterson Ca
				1									1	20	0.050	San Joaquin R At Maze Rd Bridge Nr Modesto Ca
		7					1						8	35	0.229	San Joaquin R Nr Crows Landing Ca
1	2						1						4	47	0.085	San Joaquin R Nr Stevinson Ca
	1	3					1						5	145	0.034	San Joaquin R Nr Vernalis Ca
		1											1	1	1.000	San Joaquin River At Lander Ave
1					2								3	65	0.046	Stanislaus R A Caswell State Park Nr Ripon Ca
1				1	1		1						4	50	0.080	Tuolumne R A Tuolumne City Nr Grayson Ca
		1											1	9	0.111	Tuolumne River At Santa Fe
		2				1							3	38	0.079	Tuolumne River At Shiloh Rd.
4	3	17	0	3	4	2	4	0	0	0	26		40	850	0.047	Grand Total

A - maximum daily measured concentration greater than chronic or acute DFG criteria

B- number of unique days each site was sampled



**Appendix 4. All DFG water quality exceedances sorted by sampling region, date.**

(based on maximum daily concentration data at each site - see text)

site	date	chlorpyrifos ug/L	type	region
French Camp Sl	09/22/99	0.036	trib	Sac/SJ Delta
Mid Roberts Is Drain	05/01/01	0.017	trib	Sac/SJ Delta
Walker Sl	05/08/01	0.035	trib	Sac/SJ Delta
Calaveras R	05/15/01	0.025	river	Sac/SJ Delta
Walker Sl	05/29/01	0.023	trib	Sac/SJ Delta
Paradise Cut	09/17/02	0.020	trib	Sac/SJ Delta
Ulatis Ck	12/19/02	0.032	trib	Sac/SJ Delta
Sac R At Rio Vista	12/19/02	0.030	river	Sac/SJ Delta
Marsh Ck	12/19/02	0.024	trib	Sac/SJ Delta
Mid Roberts Is Drain	12/19/02	0.023	trib	Sac/SJ Delta
Mosher Sl	12/23/02	0.040	trib	Sac/SJ Delta
Cache Sl	12/23/02	0.036	trib	Sac/SJ Delta
Sac R At Rio Vista	12/23/02	0.036	river	Sac/SJ Delta
Steamboat Sl	12/23/02	0.033	trib	Sac/SJ Delta
Mokelumne R	12/23/02	0.031	river	Sac/SJ Delta
Five Mile Sl	12/23/02	0.030	trib	Sac/SJ Delta
Duck Sl	12/23/02	0.026	trib	Sac/SJ Delta
Chualar Creek, Monterey County	06/16/03	0.243	trib	Monterey Co
Quail Creek, Monterey County	06/16/03	0.113	trib	Monterey Co
Blanco Drain @ Cooper Rd	06/17/03	0.044	trib	Monterey Co
Quail Creek, Monterey County	06/23/03	1.297	trib	Monterey Co
Chualar Creek, Monterey County	06/23/03	0.179	trib	Monterey Co
Alisal Slough/Reclamation Ditch, Monterey County	06/23/03	0.040	trib	Monterey Co
Quail Creek, Monterey County	06/30/03	0.197	trib	Monterey Co
Chualar Creek, Monterey County	06/30/03	0.114	trib	Monterey Co
Chualar Creek, Monterey County	07/07/03	0.144	trib	Monterey Co
Quail Creek, Monterey County	07/07/03	0.107	trib	Monterey Co
Chualar Creek, Monterey County	07/14/03	0.215	trib	Monterey Co
Quail Creek, Monterey County	07/14/03	0.179	trib	Monterey Co
Quail Creek, Monterey County	07/21/03	3.960	trib	Monterey Co
Chualar Creek, Monterey County	07/21/03	0.118	trib	Monterey Co
Quail Creek, Monterey County	07/28/03	0.344	trib	Monterey Co
Chualar Creek, Monterey County	07/28/03	0.127	trib	Monterey Co

site	date	chlorpyrifos ug/L	type	region
Chualar Creek, Monterey County	08/04/03	0.188	trib	Monterey Co
Quail Creek, Monterey County	08/04/03	0.156	trib	Monterey Co
Quail Creek, Monterey County	08/11/03	0.371	trib	Monterey Co
Chualar Creek, Monterey County	08/11/03	0.097	trib	Monterey Co
Quail Creek, Monterey County	08/18/03	0.123	trib	Monterey Co
Chualar Creek, Monterey County	08/19/03	0.684	trib	Monterey Co
Quail Creek, Monterey County	08/25/03	0.132	trib	Monterey Co
Quail Creek, Monterey County	09/02/03	0.059	trib	Monterey Co
Quail Creek, Monterey County	09/08/03	0.106	trib	Monterey Co
Quail Creek, Monterey County	09/15/03	0.073	trib	Monterey Co
Chualar Creek, Monterey County	09/15/03	0.044	trib	Monterey Co
Quail Creek, Monterey County	09/22/03	0.094	trib	Monterey Co
Quail Creek, Monterey County	09/29/03	0.066	trib	Monterey Co
Chualar Creek, Monterey County	09/29/03	0.039	trib	Monterey Co
Colusa Basin Drain	03/18/97	0.016	trib	Sacramento Valley
Colusa Basin Drain	07/28/97	0.015	trib	Sacramento Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	04/07/97	0.021	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	05/06/97	0.112	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	06/10/97	0.029	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	06/30/97	0.018	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/30/97	0.030	trib	San Joaquin Valley
San Joaquin R Nr Vernalis Ca	08/07/97	0.014	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	08/27/97	0.022	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	05/11/98	0.030	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/28/98	0.051	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	08/11/98	0.068	trib	San Joaquin Valley
Mchenry Stormdrain A Bodem St A Modesto Ca	10/24/98	0.050	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	03/18/99	0.021	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	03/23/99	0.042	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	08/03/99	0.031	trib	San Joaquin Valley
Mud Slough Nr Gustine Ca	09/21/99	0.016	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	09/21/99	0.015	trib	San Joaquin Valley
Dry Crk @ Gallo Bridge In Modesto	01/12/00	0.020	trib	San Joaquin Valley
Tuolumne R A Tuolumne City Nr Grayson Ca	01/25/00	0.018	river	San Joaquin Valley
San Joaquin R Nr Stevinson Ca	01/27/00	0.014	river	San Joaquin Valley
Newman Wasteway A Hwy 33 Nr Gustine Ca	02/04/00	0.019	trib	San Joaquin Valley

site	date	chlorpyrifos ug/L	type	region
San Joaquin R Nr Stevinson Ca	02/09/00	0.015	river	San Joaquin Valley
Dry C A Claus Rd Bridge A Modesto Ca	02/11/00	0.025	trib	San Joaquin Valley
San Joaquin R Nr Stevinson Ca	02/12/00	0.073	river	San Joaquin Valley
Newman Wasteway A Hwy 33 Nr Gustine Ca	02/13/00	0.017	trib	San Joaquin Valley
Newman Wasteway A Hwy 33 Nr Gustine Ca	02/14/00	0.037	trib	San Joaquin Valley
San Joaquin R Nr Vernalis Ca	02/14/00	0.016	river	San Joaquin Valley
San Joaquin R Nr Vernalis Ca	03/09/00	0.017	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	04/26/00	0.019	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	05/16/00	0.023	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	05/30/00	0.022	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/06/00	0.179	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/20/00	0.015	trib	San Joaquin Valley
Merced R A River Road Bridge Nr Newman Ca	07/20/00	0.015	river	San Joaquin Valley
Stanislaus R A Caswell State Park Nr Ripon Ca	01/04/01	0.038	river	San Joaquin Valley
Mchenry Stormdrain A Bodem St A Modesto Ca	01/25/01	0.035	trib	San Joaquin Valley
Mchenry Stormdrain A Bodem St A Modesto Ca	01/26/01	0.033	trib	San Joaquin Valley
Merced R A River Road Bridge Nr Newman Ca	01/27/01	0.016	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	02/01/01	0.068	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	04/25/01	0.077	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	05/02/01	0.120	trib	San Joaquin Valley
Tuolumne R A Tuolumne City Nr Grayson Ca	05/16/01	0.015	river	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	05/23/01	0.050	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	05/23/01	0.026	trib	San Joaquin Valley
San Joaquin R At Maze Rd Bridge Nr Modesto Ca	05/23/01	0.015	river	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	05/30/01	0.025	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	06/19/01	0.035	trib	San Joaquin Valley
Stanislaus R A Caswell State Park Nr Ripon Ca	06/19/01	0.014	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	06/20/01	0.149	trib	San Joaquin Valley
Merced R A River Road Bridge Nr Newman Ca	06/20/01	0.025	river	San Joaquin Valley
Bear C A Bert Crane Rd Nr Merced Ca	06/20/01	0.018	trib	San Joaquin Valley
Stanislaus R A Caswell State Park Nr Ripon Ca	06/21/01	0.100	river	San Joaquin Valley
Ingram C A River Rd Nr Patterson Ca	06/21/01	0.021	trib	San Joaquin Valley
Tuolumne R A Tuolumne City Nr Grayson Ca	06/21/01	0.021	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	06/26/01	0.035	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/03/01	0.024	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/17/01	0.059	trib	San Joaquin Valley

site	date	chlorpyrifos ug/L	type	region
Orestimba Cr At River Rd Nr Crows Landing Ca	07/24/01	0.023	trib	San Joaquin Valley
Salt Slough A Hwy 165 Nr Stevinson Ca	07/24/01	0.017	trib	San Joaquin Valley
Westport Drain (Jennings At Taylor), Stanislaus County	08/02/01	0.015	trib	San Joaquin Valley
Salt Slough A Hwy 165 Nr Stevinson Ca	08/07/01	0.400	trib	San Joaquin Valley
Tuolumne R A Tuolumne City Nr Grayson Ca	08/07/01	0.020	river	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	08/09/01	0.028	river	San Joaquin Valley
Salt Slough A Hwy 165 Nr Stevinson Ca	08/14/01	0.072	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	08/14/01	0.028	trib	San Joaquin Valley
Salt Slough A Hwy 165 Nr Stevinson Ca	08/21/01	0.055	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	08/21/01	0.040	trib	San Joaquin Valley
Mud Slough Nr Gustine Ca	08/21/01	0.026	trib	San Joaquin Valley
San Joaquin R Nr Stevinson Ca	08/21/01	0.014	river	San Joaquin Valley
San Joaquin R A Patterson Br Nr Patterson Ca	03/07/02	0.042	river	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/07/02	0.038	river	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/08/02	0.035	river	San Joaquin Valley
San Joaquin R A Patterson Br Nr Patterson Ca	03/08/02	0.020	river	San Joaquin Valley
Tuolumne River At Shiloh Rd.	03/09/02	0.019	river	San Joaquin Valley
San Joaquin R A Patterson Br Nr Patterson Ca	03/09/02	0.014	river	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/11/02	0.051	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	03/11/02	0.039	trib	San Joaquin Valley
San Joaquin R Nr Vernalis Ca	03/11/02	0.023	river	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	05/22/02	0.028	trib	San Joaquin Valley
Highline Cn Spill Nr Hilmar Ca	05/22/02	0.014	trib	San Joaquin Valley
Dry Crk @ Gallo Bridge In Modesto	05/30/02	0.022	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	06/17/02	0.019	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	06/18/02	0.022	trib	San Joaquin Valley
Dry Crk @ Gallo Bridge In Modesto	06/25/02	0.020	trib	San Joaquin Valley
Tuolumne River At Shiloh Rd.	07/08/02	0.056	river	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	07/08/02	0.022	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	07/15/02	0.040	trib	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	07/16/02	0.066	trib	San Joaquin Valley
Highline Cn Spill Nr Hilmar Ca	07/16/02	0.022	trib	San Joaquin Valley
Salt Slough A Hwy 165 Nr Stevinson Ca	08/19/02	0.046	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	09/09/02	0.071	trib	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/13/03	0.032	river	San Joaquin Valley
San Joaquin R Nr Vernalis Ca	03/13/03	0.018	river	San Joaquin Valley

site	date	chlorpyrifos ug/L	type	region
Tuolumne River At Santa Fe	03/13/03	0.017	river	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	03/15/03	0.233	trib	San Joaquin Valley
Dry Crk @ Gallo Bridge In Modesto	03/15/03	0.050	trib	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/15/03	0.023	river	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	03/16/03	0.029	trib	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/16/03	0.020	river	San Joaquin Valley
Dry Crk @ Gallo Bridge In Modesto	03/16/03	0.018	trib	San Joaquin Valley
Tuolumne River At Shiloh Rd.	03/16/03	0.015	river	San Joaquin Valley
Dry Crk @ Gallo Bridge In Modesto	03/17/03	0.021	trib	San Joaquin Valley
San Joaquin R Nr Crows Landing Ca	03/17/03	0.017	river	San Joaquin Valley
Del Puerto C At Vineyard Road Nr Patterson	03/17/03	0.015	trib	San Joaquin Valley
San Joaquin River At Lander Ave	03/27/03	0.060	river	San Joaquin Valley
Salt Slough At Lander Ave	03/27/03	0.016	trib	San Joaquin Valley
Westport Drain (Jennings At Taylor), Stanislaus County	07/22/03	0.045	trib	San Joaquin Valley
Westport Drain (Jennings At Taylor), Stanislaus County	07/29/03	0.058	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	08/12/03	0.042	trib	San Joaquin Valley
Orestimba Cr At River Rd Nr Crows Landing Ca	08/19/03	2.420	trib	San Joaquin Valley

**Appendix 5. Monthly summary of 2002 San Joaquin Valley chlorpyrifos use data by site**

commodity	month												commodity totals
	1	2	3	4	5	6	7	8	9	10	11	12	
<b>Nut</b>	8946	2073	247	4513	32382	12184	71327	19071	1964			96	152802
<b>Cotton</b>					78		3383	60054	22670	3848			90034
<b>Citrus</b>		0		253	9988	9214	14839	5681	1704	994	52		42725
<b>Fruit orchard</b>	23327	8837	3567	79	475	26	59	25		43		5767	42205
<b>Alfalfa</b>		176	16015	1006	395	488	6085	11852	3593	137			39747
<b>Structural</b>	3343	3426	2754	4020	2860	1750	933	364	244	1740	188	173	21795
<b>Corn</b>		732	2559	688	3914	4946	1762	2257	1144				18002
<b>Grapes</b>		4215	7875					100		1			12191
<b>Row crops</b>	69	133	230	514	134	158	1220	3159	2356	2010		64	10046
<b>Landscape</b>	24	1	7	27	101	12	43	161	70	127	0	1	574
<b>misc</b>			4	15	8	35	68	139				0	270
<b>Nursery</b>	16	6	21	28	0	14	8	30	42	9	1	15	191
<b>Monthly Totals</b>	35725	19598	33280	11144	50335	28828	99727	102892	33787	8909	241	6116	430583

Citrus: orange, lemon, tangelo, grapefruit, tangerine

Fruit Orchard: peach, plum, nectarine, apple, prune, cherry, pear

Nut: almond, walnut, pecan

Row crops: asparagus, sugarbeet, sweet potato, broccoli, onion, cabbage, strawberry

**Appendix 6. Selected examples of exceedances/detections at multiple San Joaquin Valley sites on the same day. Rain = average of rainfall data for Stockton, Modesto, Madera and Fresno on sampling day**

based on maximum daily concentration data at each site

site	date	chlorpyrifos ug/L	rain
Dry Crk @ Gallo Bridge In Modesto	03/17/03	<b>0.021</b>	0.35
San Joaquin R Nr Crows Landing Ca	03/17/03	<b>0.017</b>	0.35
Del Puerto C At Vineyard Road Nr Patterson	03/17/03	<b>0.015</b>	0.35
San Joaquin R Nr Vernalis Ca	03/17/03	<b>0.013</b>	0.35
Del Puerto C At Vineyard Road Nr Patterson	03/15/03	<b>0.233</b>	0.6375
Dry Crk @ Gallo Bridge In Modesto	03/15/03	<b>0.05</b>	0.6375
San Joaquin R Nr Crows Landing Ca	03/15/03	<b>0.023</b>	0.6375
San Joaquin R Nr Vernalis Ca	03/15/03	<b>0.012</b>	0.6375
Orestimba Cr At River Rd Nr Crows Landing Ca	03/15/03	<b>0.01</b>	0.6375
Del Puerto C At Vineyard Road Nr Patterson	07/16/02	<b>0.066</b>	0
Highline Cn Spill Nr Hilmar Ca	07/16/02	<b>0.022</b>	0
Dry Crk @ Gallo Bridge In Modesto	07/16/02	<b>0.011</b>	0
Tuolumne River At Shiloh Rd.	07/08/02	<b>0.056</b>	0
Orestimba Cr At River Rd Nr Crows Landing Ca	07/08/02	<b>0.022</b>	0
Tuolumne River At Shiloh Rd.	05/29/02	<b>0.013</b>	0
Highline Cn Spill Nr Hilmar Ca	05/29/02	<b>0.012</b>	0
Orestimba Cr At River Rd Nr Crows Landing Ca	05/29/02	<b>0.012</b>	0
Del Puerto C At Vineyard Road Nr Patterson	05/29/02	<b>0.011</b>	0
San Joaquin R Nr Vernalis Ca	05/29/02	<b>0.011</b>	0
San Joaquin R Nr Crows Landing Ca	03/11/02	<b>0.051</b>	0
Orestimba Cr At River Rd Nr Crows Landing Ca	03/11/02	<b>0.039</b>	0
San Joaquin R Nr Vernalis Ca	03/11/02	<b>0.023</b>	0
Merced R A River Road Bridge Nr Newman Ca	03/11/02	<b>0.01</b>	0

site	date	chlorpyrifos ug/L	rain
Salt Slough A Hwy 165 Nr Stevinson Ca	08/21/01	<b>0.055</b>	0
Del Puerto C At Vineyard Road Nr Patterson	08/21/01	<b>0.04</b>	0
Mud Slough Nr Gustine Ca	08/21/01	<b>0.026</b>	0
San Joaquin R Nr Stevinson Ca	08/21/01	<b>0.014</b>	0
Orestimba Cr At River Rd Nr Crows Landing Ca	08/21/01	<b>0.013</b>	0
San Joaquin R At Maze Rd Bridge Nr Modesto Ca	08/21/01	<b>0.01</b>	0
Stanislaus R A Caswell State Park Nr Ripon Ca	08/21/01	<b>0.01</b>	0
Merced R A River Road Bridge Nr Newman Ca	08/21/01	<b>0.009</b>	0
San Joaquin R A Patterson Br Nr Patterson Ca	08/21/01	<b>0.009</b>	0
Tuolumne R A Tuolumne City Nr Grayson Ca	08/21/01	<b>0.009</b>	0
San Joaquin R Nr Crows Landing Ca	08/21/01	<b>0.008</b>	0
San Joaquin R Nr Vernalis Ca	08/21/01	<b>0.006</b>	0
Newman Wasteway A Hwy 33 Nr Gustine Ca	02/14/00	<b>0.037</b>	0.39
San Joaquin R Nr Vernalis Ca	02/14/00	<b>0.016</b>	0.39
Turlock Irr Dist Lateral No 5 Nr Patterson Ca	02/14/00	<b>0.013</b>	0.39
Livingston Cn A Lvngstn Trmnt Plant Nr Lvngstn Ca	02/14/00	<b>0.012</b>	0.39
Highline Cn Spill Nr Hilmar Ca	02/14/00	<b>0.011</b>	0.39
Merced R A River Road Bridge Nr Newman Ca	02/14/00	<b>0.011</b>	0.39
Orestimba Cr At River Rd Nr Crows Landing Ca	02/14/00	<b>0.008</b>	0.39
San Joaquin R Nr Stevinson Ca	02/14/00	<b>0.008</b>	0.39
Tuolumne R A Tuolumne City Nr Grayson Ca	02/14/00	<b>0.008</b>	0.39
Dry C A Claus Rd Bridge A Modesto Ca	02/14/00	<b>0.006</b>	0.39
Stanislaus R A Caswell State Park Nr Ripon Ca	02/14/00	<b>0.006</b>	0.39
Dry Crk @ Gallo Bridge In Modesto	02/14/00	<b>0.004</b>	0.39
Del Puerto C At Vineyard Road Nr Patterson	02/14/00	<b>0.002</b>	0.39