

Evaluation of First Flush Pollutant Loading and Implications for Water Resources and Urban Runoff Management

*Jeffrey Soller, Julie Stephenson, Kendra Olivieri,
James Downing, and Adam W. Olivieri*

ABSTRACT

A “first flush” phenomenon of pollutants in stormwater occurs when rainfall after a dry period entrains a greater pollutant load from catchment surfaces than that of subsequent rainfall. The occurrence and magnitude of first flush events may influence the effective management of urban runoff pollution. To facilitate the understanding of the first flush phenomenon on a seasonal scale, the City of San Jose, CA carried out an investigation between May 1997 and April 2000 to characterize concentrations of pollutants in local waterbodies during eight storms events.

The purpose of the investigation was twofold: (1) To determine if concentrations of specific constituents in stormwater runoff are elevated during storms preceded by an extended dry period and (2) If so, to identify the environmental conditions surrounding such events (first flush events). Concentration data for total and dissolved metals, pesticides, PAHs, anions, TSS, TOC, conductivity, gasoline and diesel, and volatile and semi-volatile organics were collected at over twenty-five sites within the Guadalupe River and Coyote Creek watersheds (City of San Jose, CA). The numerical analysis of the monitoring data focused on identifying combinations of circumstances yielding increased levels of pollutants during the first substantial storms of the rainy season compared to other storm events. Factors potentially impacting the occurrence of a first flush event were grouped according to whether they pertained to pollutant, site, and/or storm characteristics.

Quantitative analysis focused on metals and anions because most observations for other constituents were below detectable levels. The results of the investigation suggest that first flush phenomena did not occur consistently throughout most of the stations investigated for either (total or dissolved) metals or anions. The results do however suggest that there are specific combinations of site and storm circumstances that result in a first flush effect with respect to dissolved metals. Based on the results of this and related investigations, implications for water resource and urban runoff management are discussed.

INTRODUCTION

Effective urban runoff management requires an in depth understanding of the environmental processes within a watershed. In order to gain such understanding with respect to pollutant loading during rainfall events, urban runoff research has identified the first flush of contaminants as a potentially important watershed phenomenon. These phenomena occur when the initial portion of rainfall after a dry period entrains greater pollutant concentrations from catchment surfaces than that of subsequent rainfall. Urban runoff managers may be better able to mitigate urban runoff pollution with the knowledge that specific site and storm conditions facilitate entrainment of above normal pollutant loads.

The City of San Jose conducted an investigation to characterize the process and nature of pollutant entrainment between May 1997 and April 2000. The objectives of this investigation were framed by two questions: 1) Do first flush phenomena occur within the catchments in San Jose? and 2) If so, what are the conditions surrounding those occurrences? The study defined a potential first flush event as the first substantial storm of the rainy season and carried out the

investigation to determine if relatively high pollutant concentrations are entrained during those storm events. This seasonal scale investigation was employed because of San Jose's climate, which has characteristically dry summers and wet winters, and the potential for control measures to mitigate first flush phenomena, if they occur. Over twenty-five stations within the Guadalupe River and Coyote Creek watersheds were sampled during eight storms. Stormwater samples were analyzed for total and dissolved metals, pesticides, polycyclic aromatic hydrocarbons (PAHs), anions, total suspended solids (TSS), total organic carbon (TOC), conductivity, gasoline and diesel, and/or volatile and semi-volatile organics. Subsequent numerical analysis focused on identifying the combinations of circumstances, which resulted in a "first flush" of pollutants, as defined above. Factors potentially impacting the occurrence of a first flush were grouped according to whether they pertained to pollutant, site or storm characteristics.

The first flush phenomenon has been studied previously, however, it remains an important research topic due to the potential implications it may have for urban runoff management. Part of the debate surrounding the first flush concept stems from the fact that studies have defined the phenomenon in different ways. For example, Lee et al. (2002) define it as the runoff of a large percentage of the pollutant load during the initial stages of a storm event. Further, Bertrad-Krajewski et al. (1998) proposed to define the occurrence of a first flush as an event in which at least 80% of the pollutant mass is transported in the first 30% of the volume.

Previous studies report that various combinations of factors may be responsible for the occurrence of first flush events. For example, Lee et al. (2002) conclude that occurrence of the first flush phenomenon is dependent upon the type of pollutant, catchment area, contributing impervious area, and rainfall intensity. Gupta and Saul (1996) identified the maximum inflow, rainfall duration and antecedent dry weather period in combination with the maximum rainfall intensity as the most important parameters influencing the occurrence of a first flush event. Finally, Sansalone and Glenn (2000) found that dissolved fractions of metals exhibit stronger evidence of first flush behavior than those in particulate form.

Setting

The City of San Jose sits along the easterly side of the Santa Clara Valley in Northern California, bordered to the east by the Diablo Range and to the southwest by the Santa Cruz Mountains. Undeveloped areas support a variety of natural communities ranging from salt and fresh water marshes to scrub brush, foothill woodlands, and coniferous forest. A number of perennial and intermittent streams in both the Coyote Creek and Guadalupe River watersheds flow northward through the valley to the South San Francisco Bay. These streams include the upper and lower Penitencia Creeks, Silver Creek, Fisher Creek, Los Gatos and Alamos Creeks. The valley generally experiences warm, dry summers and cool, wet winters. Approximately 1,000,000 people currently live in San Jose. Residential developments comprise roughly 50% of San Jose's developed urban land area, commercial developments cover 5%, industrial developments cover 15 %, parks cover 10%, vacant land covers 5% with the remainder of land coverage (15%) serving as rights of way (City of San Jose, 1999).

METHODS

Sampling and Analytical Procedures

City of San Jose staff collected stormwater samples at over twenty-five stations within the Guadalupe River and Coyote Creek watersheds during eight storms (Figure 1). Four samples were collected at each station during each storm and composited to yield the concentration values used for the numerical analysis. Teams of two people were each assigned 4-5 sampling stations to visit four times during each storm event. Thus, teams attempted to cycle through the stations four times, as quickly as possible, in order to obtain samples from the first part of each storm. Samples were collected at the catchment's discharge point or at the nearest accessible point.

The composited samples were analyzed by the City of San Jose laboratory for total and dissolved metals (Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, and Zn), pesticides, polycyclic aromatic hydrocarbons (PAHs), anions, total suspended solids (TSS), total organic carbon (TOC), conductivity, gasoline and diesel, and/or volatile and semi-volatile organics. Samples collected during each storm were not analyzed for every constituent, however every constituent was monitored at least once during the study period.

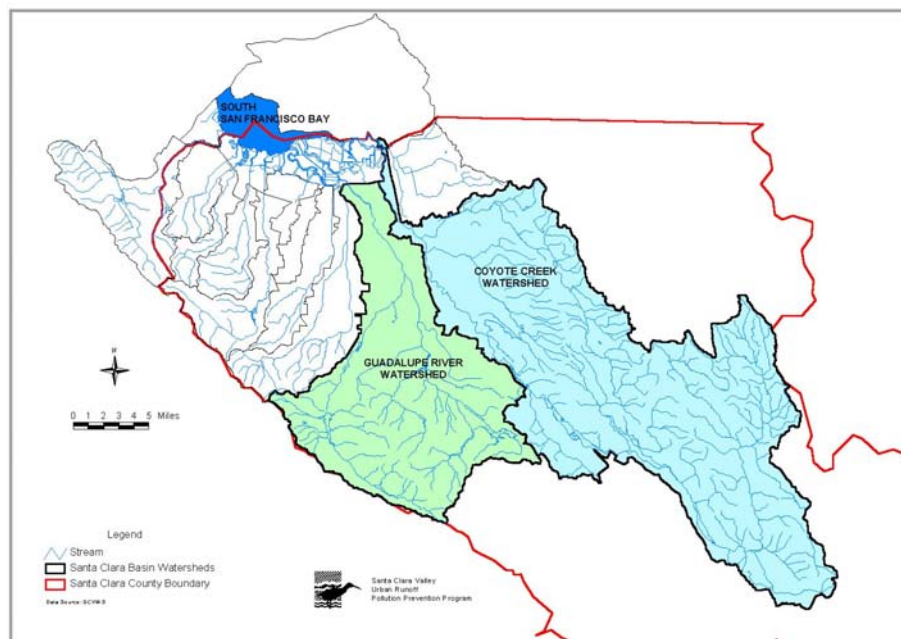


Figure 1. Map of Guadalupe River and Coyote Creek Watersheds

Data Analysis

The means and ranges of detected constituent concentrations were computed and compared to urban runoff data previously reported for both national (US EPA, 1983) and local conditions (BASMAA, 1996). The data were then numerically analyzed to determine if, when, and where a first flush of pollutants occurred. Three of the eight storms sampled were designated as potential first flush storms (first flush storm) because they were the first substantial storms of the

respective 1997/98, 1998/99, and 1999/00 wet seasons (10/9/97, 11/7/98, and 11/7/99). Data from these potential first flush storms were compared to the data collected during the other five monitored storms (5/23/97, 1/18/99, 1/16/00, 4/12/00, and 4/17/00) which were not potential first flush storm events (these are referred to as background storms herein).

Monitoring data for organophosphorous, triazine and chlorinated pesticides, PAHs, gasoline and diesel, and volatile and semi-volatile organics were primarily below detectable limits (discussed in the Results section). Those data were summarized in tables presenting the number of samples collected, the total number of compounds analyzed, the number and names of compounds detected, the number of times each compound was detected, and the ranges of the detected values. Further quantitative analyses on these data was not carried out.

The quantitative analysis performed on the total and dissolved metals and anions data was structured to answer two questions. (1) Does a first flush phenomenon occur? and (2) If so, what were the conditions surrounding such an occurrence? To answer the first question, data from each storm was analyzed. Graphs were created for each constituent depicting pollutant concentrations during each storm at each site. Similar graphs were then created to compare the pollutant concentrations at each site for the various storms. Spatial and temporal analysis was carried out including an outlier analysis.

To address the second question, scatter plots showing the influence of land use on pollutant concentrations for each storm were created and reviewed. Storm size and antecedent dry period data were also compared to pollutant concentrations in scatter plots isolating each relationship during first flush and background storm events.

RESULTS

COMPARISON TO PREVIOUSLY REPORTED STORMWATER CONCENTRATIONS

The observed results for dissolved metals from this investigation were compared to results reported previously in both local and national investigations. A summary of representative results are presented in Table 1. Inspection of Table 1 indicates that the dissolved metal concentrations reported during this investigation are comparable to, albeit consistently at the lower end of those previously reported in stormwater. The only exception to this observation is that the dissolved lead concentrations reported in this investigation are substantially lower than those reported previously. This may be a function of the elimination of leaded gasoline between the 1980s and 2000.

Table 1
Dissolved Metals National and Regional Background Comparison

Constituent		NURP ¹	Nationwide	SF Bay Area	Current Investigation	
		(ug/L)	Statistics ²	1988-1995 ³	All Events	First Flush
Copper	Mean	114	34	46.6	15.76	15.94
	Range		4 - 560	NS - 46.6	3.4 - 64.5	4.0 - 47.0
Nickel	Mean	28	12	46.9	9.44	9.3
	Range		<2 - 126	34.1 - 77.3	2.0 - 37.0	2 - 33.8
Lead	Mean	653	140	114.6	2.68	3
	Range		3 - 28,000	51.7 - 151	0.05 - 18.5	0.7 - 18.5
Zinc	Mean	528	160	312.8	85.56	91.4
	Range		10 - 5,750	188 - 371	10 - 269	25 - 260
Cadmium	Mean		0.7	2.21	0.43	0.5
	Range		0.7 - 30	1.66 - 3.07	0.1 - 1.1	0.5 - 0.6
Chromium	Mean		7	23.45	2.07	1.88
	Range		<10 - 110	NS - 35.4	0.5 - 15	0.9 - 6.4

1. Pitt and Shawley, 1981
2. Horner et al., 1884
3. BASMAA, 1996

ORGANICS

The monitoring results for PAHs, volatile and semi-volatile organics, pesticides, gasoline and diesel, and PCBs are summarized in Table 2 and discussed briefly below.

Table 2
Summary of Organics Monitoring for First Flush and Baseline Storms

Type of Constituent	Type of Sample	Storm Date	Analytical Method	# Stations Sampled	# Compounds		Total # of Observations	# Detected Observations	% Observations Detected
					Analyzed in Each Sample				
PAHs	Potential First Flush	10/9/97	610/8310	25	16				
		11/7/98	625	11	16	912	94	10%	
		11/7/99	610/8270C	21	16				
	Baseline	1/18/99	625	14	9				
		4/17/00	625	4	9	162	15	9%	
Semi-volatile organics	Potential First Flush	10/9/97	625	25	52	1300	3	0.2%	
Volatile organics	Potential First Flush	11/7/99	624	3	34				
		11/7/99	601	1	25	136	0	0%	
		11/7/99	602	1	9				
Chlorinated Pesticides	Potential First Flush	10/9/97	608	25	29				
		11/7/98	608	11	29	1160	8	0.7%	
		11/7/99	608	4	29				
	Baseline	1/18/99	608	14	29				
		4/12/00	608	6	29	696	5	0.7%	
4/17/00		608	4	29					
Organophosphorous Pesticides	Potential First Flush	10/9/97	614	25	2				
		10/9/97	8141/8140	25	1				
		11/7/98	614	11	2				
		11/7/99	614	21	2	171	58	34%	
		11/7/98	8141/8141	11	1				
		11/7/99	622	21	1				
	Baseline	5/23/97	614	12	2				
		1/18/99	614	14	2				
		1/18/99	8141/8142	15	1				
		1/16/00	614	5	2				
	1/16/00	622	5	1	112	57	51%		
	4/12/00	614	6	2					
	4/12/00	622	6	1					
	4/17/00	614	4	2					
	4/17/00	622	4	1					
Triazine	Potential First Flush	10/9/97	619	25	1				
		11/7/98	619	11	1	36	1	3%	
Diesel	Potential First Flush	10/9/97	601	30	1	30	0	0%	
Gasoline	Potential First Flush	10/9/97	601	25	1	25	0	0%	
PCBs	Potential First Flush	10/9/97	601	25	1	25	0	0%	

PAHs: A total of 57 samples from the three first flush storms were analyzed for PAHs (EPA Methods 610/8310, 625, 610/8270C). Each sample was analyzed for 16 compounds. The results indicate that 94 of the 912 total observations for PAHs were reported above detectable limits (10%). A total of 18 samples from 2 of the baseline (non-first flush) storm events were also analyzed for PAHs. Each of those samples was analyzed for 9 compounds. The results indicate that 15 of the 162 total observations were reported above detectable limits (9%).

Semi-volatile and volatile organics: A total of 25 samples from one first flush storm event were analyzed for semi-volatile organics (EPA Method 625). Each of those samples was analyzed for 52 compounds. The results indicate that 3 of the 1300 total observations were reported above detectable limits (0.2%). Butyl benzyl phthalate was detected once (21.2 ug/L) and bis-2-ethylhexyl phthalate was detected two times (20.6 and 34.6 ug/L).

A total of 5 samples from one first flush storm were analyzed for volatile organics (EPA methods 624,601, and 602). The samples resulted in a total of 136 observations, none of which were above detectable limits.

Pesticides: Samples were analyzed for chlorinated, organophosphorous and triazine pesticides.

A total of 40 samples from three first flush storms were analyzed for chlorinated pesticides. Results indicate that 8 of the 1160 observations were above detectable limits (0.7%). A total of 24 samples from three baseline storms were also analyzed for chlorinated pesticides, with 5 of the 696 observations above detectable limits (0.7%).

Organophosphorous pesticides were analyzed by several methods including EPA Methods 614, 8141/8140, and 622. A total of 114 samples were analyzed from the three first flush storms for organophosphorous pesticides, resulting in 171 observations. Of those 171, 58 were above detectable limits (34%). A total of 71 samples were analyzed from the baseline storms for organophosphorous pesticides, resulting in 112 observations. Of those 112 observations, 57 were above detectable limits (51%). The detected compounds and ranges were as follows for first flush and baseline storms, respectively: Chlorpyrifos (0.06-0.23 ug/L; 0.01-0.12 ug/L), Diazanone (0.02-2.56 ug/L; 0.01-1.22ug/L), and Malathion (0.03-1.17 ug/L; 0.02-0.4 ug/L).

A total of 36 samples from two first flush storm events were analyzed for simazine (triazine pesticide). Results indicate that 1 of the 36 observations was above detectable limits (3%) at a concentration of 0.69 ug/L.

Other constituents: A total of 25 samples from one first flush storm event were analyzed for PCBs and gasoline. None of those observations were reported above detectable limits. A total of 30 samples from one first flush storm event were analyzed for diesel. Results indicate that there were no observations above detectable limits.

Qualitative comparison: Because, the majority of samples analyzed for organic compounds yielded results below detectable limits, a more comprehensive quantitative analysis of the data was not performed. A qualitative comparison of the results for these constituents indicates that there was very little difference between first flush and background events in terms of the percent

of detected observations. This general observation also holds for organophosphorous pesticides. Those compounds were detected in 34% of the first flush samples and 51% of the background samples, with slightly higher concentration ranges reported in the first flush observations.

TOTAL AND DISSOLVED METALS

Analyses were carried out for total and dissolved metals during 2 background storms (May 1997 and January 1999) and 3 first flush storms (October 1997, November 1998, November 1999).

Site Characteristic Analysis

A consistently strong correlation between catchment land use percentages and pollutant concentrations was not exhibited in the observed data for either total or dissolved metals. This observation is representatively illustrated by the relationship between the percent residential land use and concentrations of dissolved zinc reported for first flush and non first flush storms during this investigation (Figure 2).

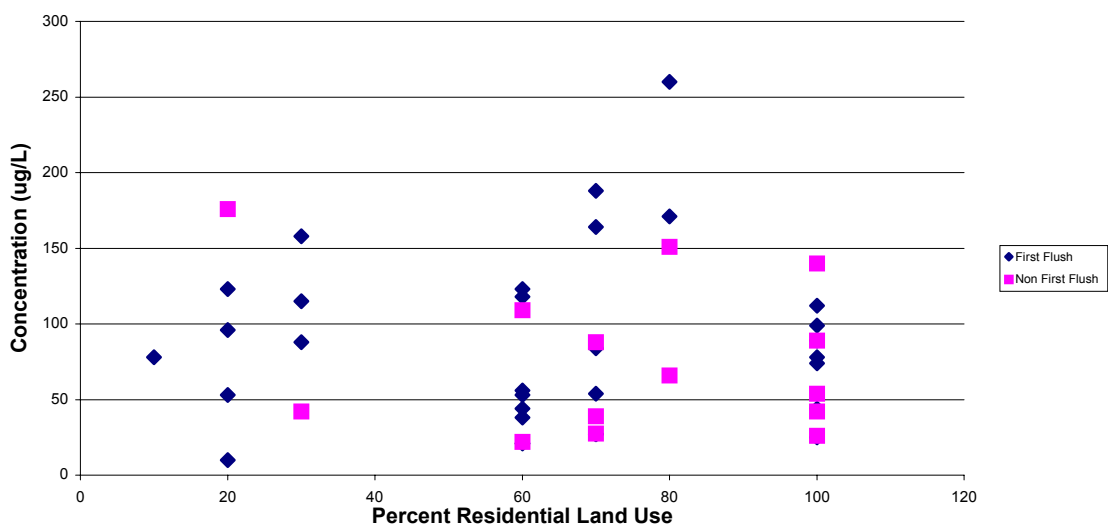


Figure 2. Influence of Residential Land Use on Dissolved Zinc Concentrations

Storm Characteristic Analysis

Metal concentrations (dissolved and total) were evaluated to determine if the presence of a first flush phenomenon was influenced by storm size. No consistent relationship was found between storm size and the occurrence of a first flush phenomenon for total or dissolved metals. Representative results from this analysis are presented in Figure 3 for dissolved lead concentrations for first flush and baseline storms.

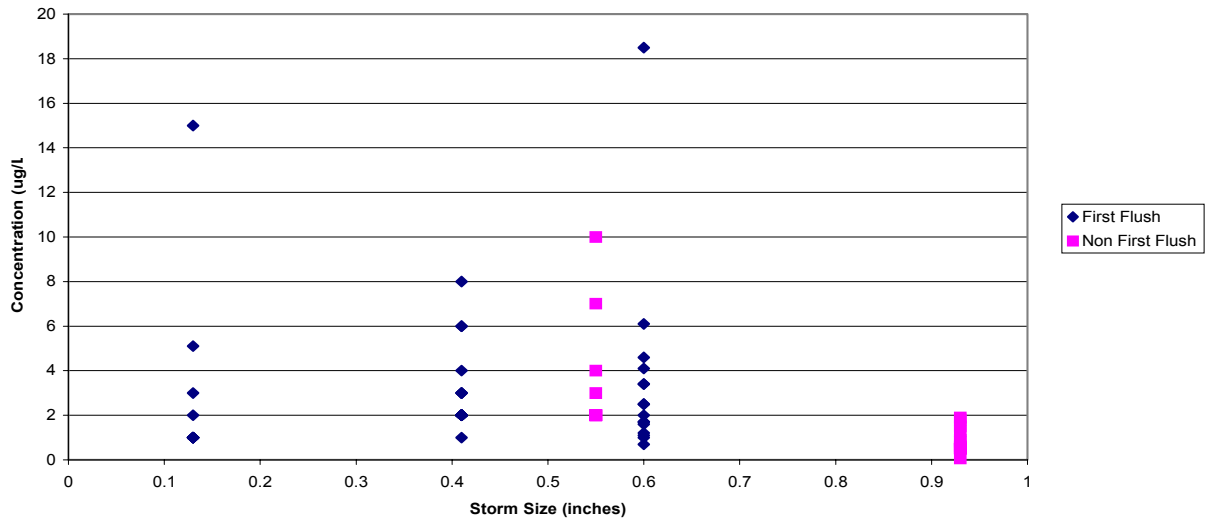


Figure 3. Influence of Storm Size on Dissolved Lead Concentrations

Storm Event Evaluation

Concentrations of total and dissolved metals were compared on a storm by storm basis to identify any trends relevant to first flush phenomena. When the data from all sites were grouped together, characteristics of first flush phenomena were generally not noted. Representative results from this analysis are presented in Figure 4, which shows dissolved zinc concentrations from 2 background storms (May 1997 and January 1999), and the 3 first flush storms.

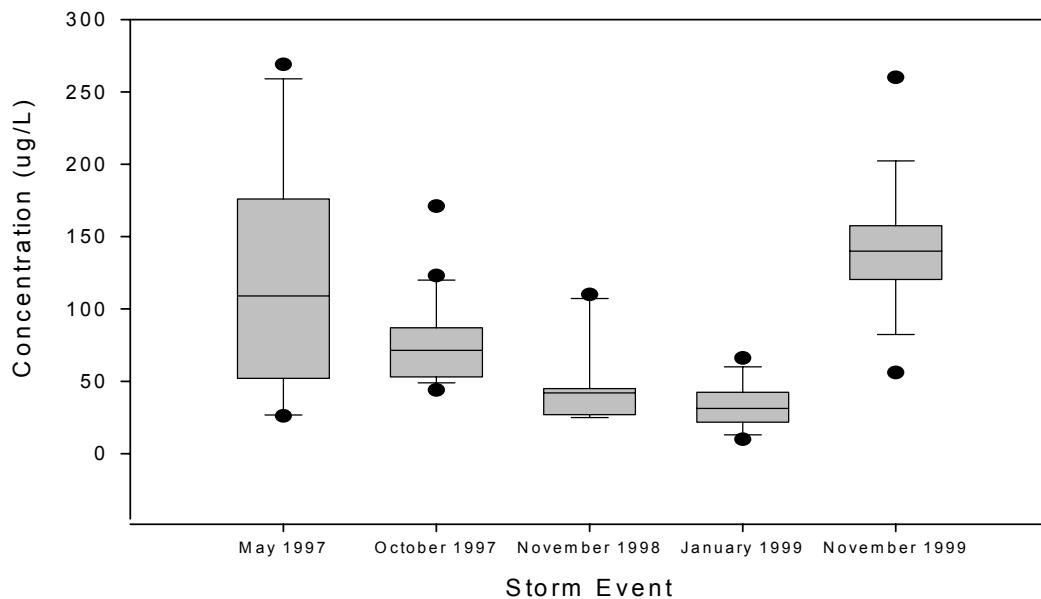


Figure 4. Dissolved Zinc Monitoring Results

To further investigate potential trends in the data, graphs were generated showing results from individual monitoring stations over the course of the investigation. As an example of this analysis, dissolved zinc concentrations at representative sites are presented in Figure 5. In general, total metals did not show a tendency for first flush behavior in the watersheds investigated. However, the concentration of total mercury in the first flush storm samples was slightly elevated relative to background storms. Results from the dissolved metals data analysis were more difficult to interpret.

As shown in Figure 5 for dissolved zinc concentrations and Figure 6 for dissolved copper concentrations, the May 1997 background storm event yielded relatively high dissolved metals concentrations. During this storm event, the highest concentrations for most constituents occurred at the River Oaks station. Relatively high dissolved metals concentrations were also observed for many constituents during the November 1999 first flush storm event.

Overall, the three first flush storm events resulted in concentrations of dissolved metals similar to those from the May 1997 and January 1999 background storm events. The January 1999 background storm event at most stations produced the lowest dissolved metal concentrations of all storm events. The exceptions to this observation were concentrations of dissolved zinc, nickel and lead at the Tully, San Pedro, Oakmead, Old Oakland and Lincoln stations. Observations at these stations during the January 1999 sampling event were high relative to those measured during the same storm at other stations and to those measured at the same stations during other storms. Also of note was that observed concentrations of dissolved copper, zinc, nickel and lead at the Edwards station were higher during first flush events than those during non first flush events (Figures 5 and 6).

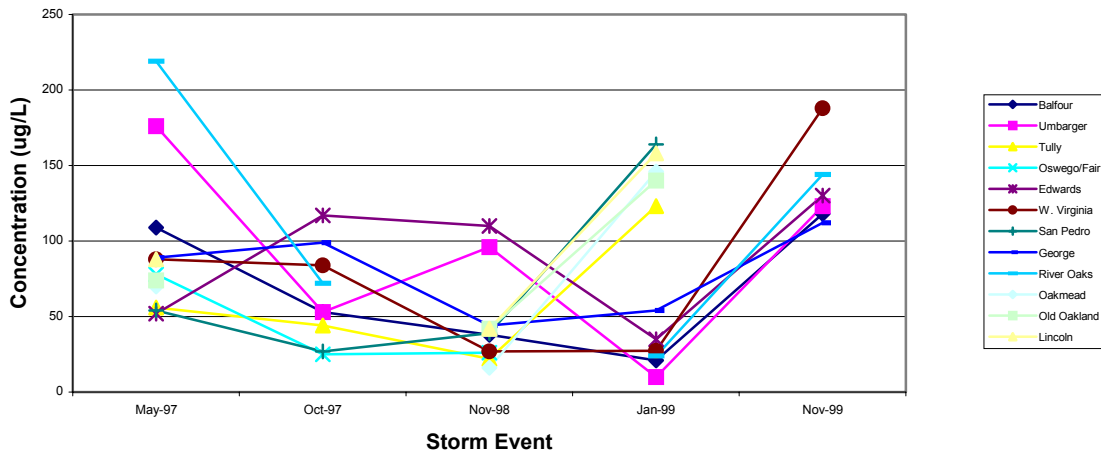


Figure 5. Dissolved Zinc Concentrations for Each Storm Event

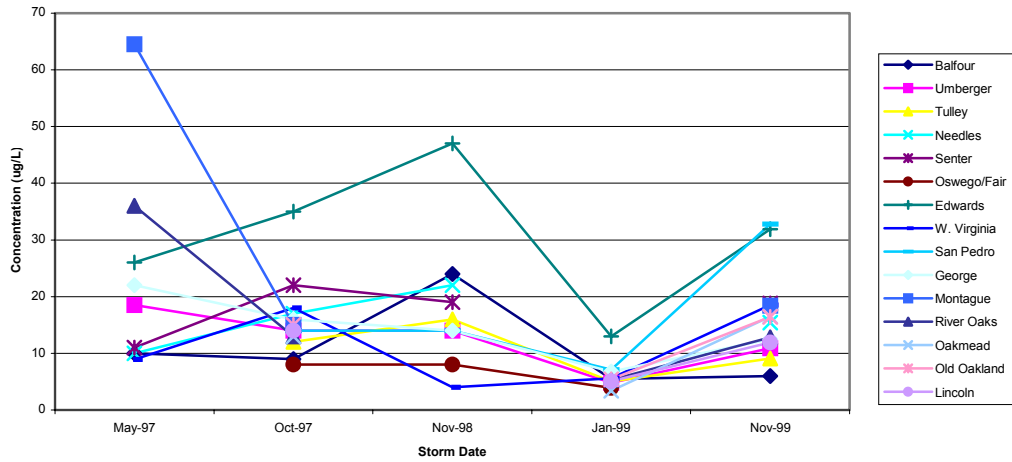


Figure 6. Dissolved Copper Concentrations for Each Storm Event

ANIONS

Data from four storms, three first flush storms and one background storm event, were compiled and analyzed for chloride, phosphate, nitrite, nitrate and sulfate in much the same manner as the dissolved and total metals. The results of this analysis did not suggest any strong relationships between anion concentrations and storm size. However, comparisons of anion concentrations with associated land uses suggested a relation between sulfate concentrations and catchments consisting partially of agricultural land uses. The data analysis indicates that the sulfate concentrations running off catchments associated with agricultural land uses are higher than those running off catchments characteristic of either commercial, residential or mixed land uses (Figure 7). The environmental basis and interpretation of this observation is unknown.

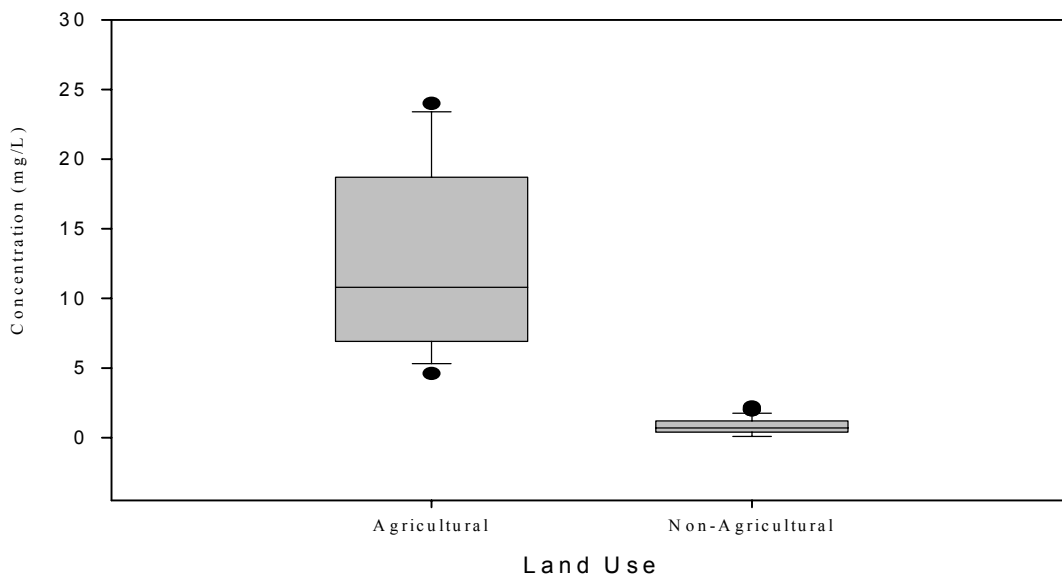


Figure 7. Influence of Agricultural Land Use on Sulfate Concentrations

DISCUSSION

The results from this investigation suggest that a first flush phenomenon did not occur consistently for those constituents detected sufficiently to carry out the numerical analysis (total and dissolved metals and anions). There do however seem to be specific combinations of site and storm circumstances that appear to foster an occurrence of a first flush effect for dissolved metals. A discussion of this finding is presented below along with a discussion regarding the potential limitations of the investigation.

Monitoring Conditions

Although this study was designed to investigate first flush phenomena on a seasonal scale, the monitoring protocol employed may have served to offset evidence of a first flush phenomenon. Lee and Bang (2000) note that runoff quality during the initial stages of a storm is characterized by a positive pollutant concentration-flowrate relationship. Furthermore, peak pollutant concentrations tend to precede peak runoff flowrates and thus result in the runoff of a greater pollutant load during early storm stages. Sample values reported for the purposes of our study may not have been indicative of the magnitude of the differences in pollutant concentrations found in first flush and background storms because the analysis was performed on composites of four samples taken at various times throughout the storm event. High concentrations due to the runoff of accumulated pollutants during the initial stages may have been attenuated by lower concentrations at later stages in the storm.

Pollutant Characteristics

For this study, semi-volatile and volatile organics, gasoline and diesel, PCBs, pesticides, total and dissolved metals and anions were sampled and analyzed numerically. The first flush phenomenon occurred only for dissolved metals under specific circumstances and for total mercury. These dissolved metal results are consistent with previous studies (Sansalone and Glenn (2000) and Sansalone and Buchberger (1997)), which found that the strongest evidence of a first flush of pollutants is exhibited by dissolved metals, in particular zinc, cadmium and copper. Because dissolved metals are more easily eroded from impervious surfaces and entrained in surface water runoff, pollutant concentrations are less dependent upon storm duration and intensity. The reasons for the anomalous total mercury results, compared to other metals, are not known. Differences in sources and transport processes between mercury and the other metals may contribute to the observed difference. An example of one process unique to mercury in the study area is that sediments may be enriched with mercury due to cycling in the local environment because of the nearby former mercury mines. However, a more detailed explanation of this observation is beyond the scope of this investigation.

Site Characteristics

Various catchment characteristics may contribute to specific urban runoff processes. Lee et al. (2002) suggest that the first flush phenomenon is exhibited more prominently in smaller catchments and that there is a slight correlation between occurrence and impervious coverage within the drainage area. This finding is due to the fact that pollutants are more easily loaded and scoured off impervious surfaces and more rapidly delivered to the point of discharge within

smaller catchments. Such factors seem only to be relevant when examining the speed with which pollutants reach the point of discharge as compared to rainfall duration.

Because samples were taken throughout the duration of the storm event for this study and composited, the effects of catchment area on the occurrence of a first flush would have to be studied simultaneously with storm duration and intensity. This type of analysis was beyond the scope of the investigation. An analysis was however carried out, examining the relationship between the occurrence of a first flush phenomenon and land uses associated with each catchment. The results did not show a strong relation between any land use characteristics and the occurrence of a first flush in metals. However, the concentrations of sulfate discharging from catchments associated with agricultural land uses did appear to be higher than those discharging from catchments associated with other land uses during first flush events.

Monitoring data for dissolved metals seems to exhibit first flush behavior at the Edwards station. The data suggest that a first flush phenomenon occurred for every dissolved metal at this station. Pollutant concentrations during the first flush storm events at Edwards station are high even when compared to data from the same events at other stations (Figure 8). It is also of note that the pollutant concentrations sampled during the May 1997 and January 1999 background storms are noticeably lower than those sampled during the first flush storms at the Edwards station.

Dissolved metals data also show evidence of a distinct split between stations at which low pollutant concentrations were observed and those at which higher pollutant concentrations were observed during the background storm event of January 1999. This trend is seen most prominently in the increase in concentrations of lead, zinc and nickel at the Tully, San Pedro, Oakmead, Old Oakland and Lincoln stations. At most other stations, January 1999 pollutant concentrations are the lowest sampled of all storms. We are unable to determine why these stations show such a trend.

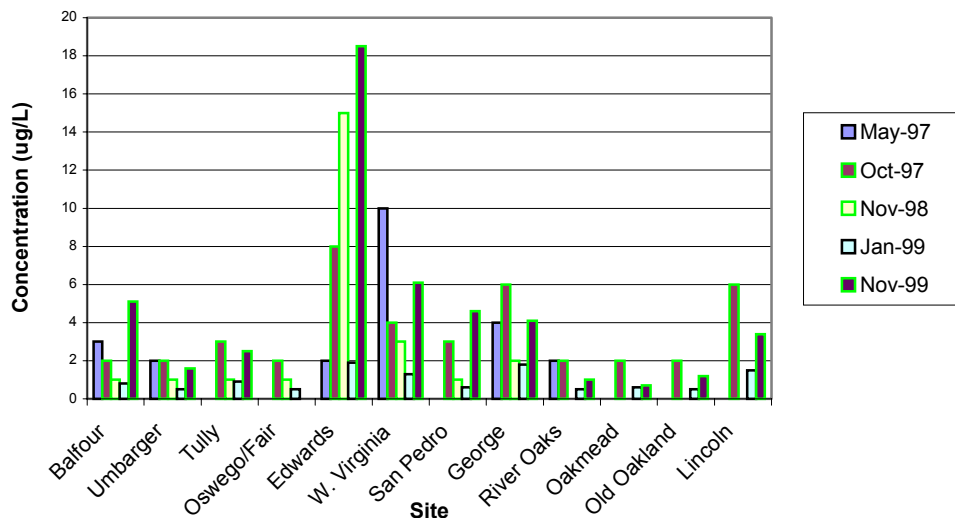


Figure 8. Dissolved Lead Concentrations By Station

Storm Characteristics

The five storms during which samples were analyzed for metals and anions differed widely in rainfall volume and antecedent dry period (Table 3). Previous studies note varying relationships between storm characteristics and runoff concentrations during first flush events. Lee and Bang (2002) identify a slight correlation between storm intensity and the concentration of pollutants entrained in runoff but do not conclude that there is a relation between pollutant concentrations and the antecedent dry period.

Table 3. Characteristics of Storms Events Analyzed for Metals and Anions

Storm Date	May 23, 1997**	October 9, 1997*	November 7, 1998*	January 18, 1999*	November 7, 1999*
Storm Size (volume in inches)	0.55	0.41	0.13	0.93	0.6
Antecedent Dry Period (days)	>60	7	14	3	9

*Data from the Santa Clara Valley Water Districts Past Rainfall and Reservoir Status Reports

**Data from the National Weather Service Forecast Office San Francisco Bay Area Climate Archives

For this investigation, pollutant concentrations were evaluated relative to storm volume and antecedent dry period. The May 1997 storm yielded the greatest dissolved and total metal concentrations of any storm sampled. The storm was very intense and resulted in a relatively large volume of rainfall, which was preceded by a dry period of approximately 2 months. Because of the last condition, the storm may have many characteristics in common with a first flush storm. The observed results of this storm may be a function of high storm intensity, and long antecedent dry period.

The November 1999 storm event resulted in the second greatest pollutant concentrations. Sampled as a first flush storm, the event was rather large in volume and was preceded by a dry period of 9 days. The rain preceding event was so small in volume that pollutant entrainment is suspected to be minimal, which if true, effectively lengthens the antecedent dry period to at least two months. Thus, the substantial rainfall after a long antecedent dry period may have resulted in generally high pollutant concentrations.

The January 1999 storm event was the largest in volume yet yielded consistently low pollutant concentrations. Three days prior to the sampling there was a storm event, which delivered 0.26 inches of rain. Results indicate that such a preceding rain event could have washed the surfaces clean of pollutant loads and left little to be entrained during the January 18th event. During such an occurrence, the short antecedent dry period may be responsible for such low pollutant concentrations.

The October 1997 and November 1998 storm events, although different in size and associated antecedent dry periods, yielded similar pollutant concentrations. They were consistently lower than the November 1999 and May 1997 storm samples but higher than the January 1999 storm

samples. It is possible that the longer antecedent period of the November 1998 storm event effectively balanced out the greater rainfall volume of the October 1997 storm event.

These results suggest the possibility a slight relation between antecedent dry period and dissolved metals concentrations. To investigate this possibility, a literature review was carried out to better understand pollutant loading thresholds relative to dry periods. Most relevant were the studies carried out in Castro Valley, California (Pitt and Shawley, 1981) and Reno/Sparks, Nevada (CH2MHill, 1982). Those studies reported that dissolved pollutant loads on streets reach equilibrium within approximately one to two weeks, after which the mass of pollutants deposited onto surfaces does not increase. It may therefore be expected that greater pollutant loads may be washed off surfaces following dry periods of more than one to two weeks than those during storms immediately following a substantial rainfall. The results of this investigation are consistent with those described above. Pollutant concentrations during the storm preceded by a 3-day dry period were lowest, those from storms preceded by 7-14 day dry periods were intermediate, and those during the storms preceded by 60 day dry periods were highest. This observation is illustrated in Figure 9, which presents dissolved copper concentration as a function of antecedent dry period.

Urban Runoff Management Implications

This investigation comprised a substantial data collection effort over a three year time period. The results of the investigation indicate that concentrations of dissolved metals in stormwater may be higher in storms that are preceded by an extended dry period than in storms preceded by a shorter time period. Other contaminants investigated either did not demonstrate first flush phenomena or were not detected in sufficient quantities to carry out quantitative analysis.

Based on the results of the investigation, implications to urban runoff management are inextricably linked to the contaminants of concern. For example, if total metals concentrations are the primary contaminant of concern, it would not seem prudent to alter current urban runoff management strategies to reduce pollutant loading from “first flush” storm events. If on the other hand, dissolved metals are of principal concern, it may be worthwhile to optimize existing control strategies to minimize pollutant loading from storms that are preceded by an extended dry period. Finally, based on the results of this investigation, it seems unlikely that additional first flush monitoring would provide substantial additional information.

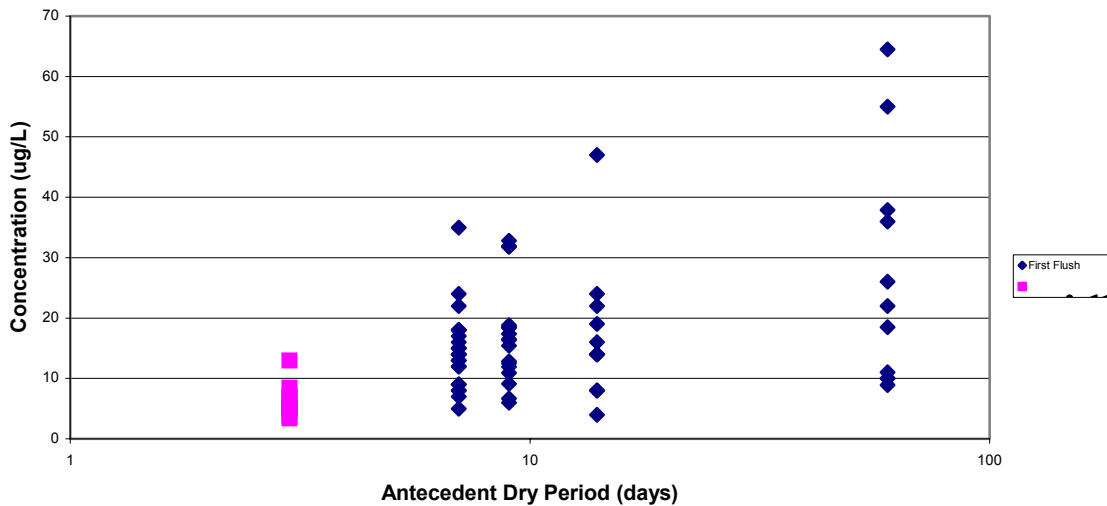


Figure 9. Influence of Antecedent Dry Period on Dissolved Copper Concentrations

CONCLUSIONS

From monitoring eight storm events over a three and a half-year period, the principal conclusions of this investigation are as follows:

- 1) Concentrations of dissolved metals from storms surveyed in this study were consistently lower than those from previous studies.
- 2) A first flush phenomenon did not occur consistently for total metals, dissolved metals or anions. There do however seem to be specific combinations of site and storm circumstances that result in a first flush effect of dissolved metals. For example, a first flush phenomenon is observed at the Edwards station as the dry period between storms increases. Total mercury also exhibited a first flush phenomenon.
- 3) There was no relation between metal concentrations in storm runoff and land use. One anion, sulfate, showed a relation between stormwater concentrations and agricultural land use within the catchment. The interpretation of increased levels of sulfate with agricultural land use is unclear.
- 4) The Edwards station exhibited relatively high dissolved metal concentrations relative to other stations during first flush storm events.
- 5) Urban runoff dissolved metal concentrations do not have a strong relationship with storm size however there does seem to be a relation with the antecedent dry weather period.
- 6) It seems unlikely that additional first flush monitoring would provide substantial additional information. Rather it is suggested that urban runoff management focus on optimizing existing control strategies to minimize pollutant concentrations in stormwater for storms that are preceded by an extended dry period.

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Summary of Data Collected for First Flush Study
 (Numbers in Table Cross Reference to Dates on Attached Footnotes)

Site Name	Metals			Anions			610/8270c			625			608			614			619		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
1 Blossom Hill W	1			1			1			1			1			1			1		
2 Blossom Hill E	1			1			1			1			1			1			1		
3 Cottle N.	1, 2			1			1			1			1			1,2			1		
4 Cottle S.	2			1			1			1			1			1,2			1		
5 Fontanoso	1,2			1			1			1			1			1,2			1		
6 Umbarger	1,2	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1,2	3	4,5	1	3	
7 Balfour	1,2	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1,2	3	4,5	1	3	
8 Tully	1,2	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1,2	3	4,5	1	3	
9 Needles	1,2	3	5	1	3	5	1		5	1	3		1	3	5	1,2	3	5	1	3	
10 Oswego/Fair	1,2	3	4	1	3	4	1			1	3	4	1	3	4	1,2	3	4	1	3	
11 Senter	1,2	3	5	1	3	5	1		5	1	3		1	3	5	1,2	3	5	1	3	
12 Story	1	3	5	1	3	5	1		5	1	3		1	3	5	1	3	5	1	3	
13 Alma	1			1			1			1			1			1			1		
14 Edwards	1	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1,2	3	4,5	1	3	
15 W. Virginia	1	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1	3	4,5	1	3	
16 Lincoln	1		4,5	1		4,5	1		5	1		4	1		4,5	1		4,5	1		
17 San Carlos	1																				
18 Kearney	1																				
19 George	1	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1	3	4,5	1	3	
20 San Pedro	1	3	4,5	1	3	4,5	1		5	1	3	4	1	3	4,5	1	3	4,5	1	3	
21 Old Oakland	1		4,5	1		4,5	1		5	1		4	1		4,5	1		4,5	1		
22 Commercial	1			1			1			1			1			1			1		
23 Brokaw	1			1			1			1			1			1			1		
24 Montague	1,2		5	1		5	1		5	1			1		5	1,2		5	1		
25 River Oaks	1,2		4,5	1		4,5	1		5	1		4	1		4,5	1		4,5	1		
26 Ringwood	1		5	1		5	1		5	1			1		5	1,2		5	1		
27 Oakmead	1	3	4,5	1	3	4,5	1		5	1		4	1		4,5	1		4,5	1		
28 Guadalupe			4			4						4			4			4			
29 Trade Zone			4			4						4			4			4			
30 Lucrecia			5			5			5						5			5			
39 Empire	2																				
40 Airport/ Newhall	2																				
41 A1	1																				
42 A2	1																				
43 A3	1																				

Site Name	8141			Diesel			Gasoline			PCB			622			624			601 + 602		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
1 Blossom Hill W	1			1			1			1											
2 Blossom Hill E	1			1			1			1											
3 Cottle N.	1			1			1			1											
4 Cottle S.	1			1			1			1											
5 Fontanoso	1			1			1			1											
6 Umbarger	1	3	4	1			1			1					5						
7 Balfour	1	3	4	1			1			1					5						
8 Tully	1	3	4	1			1			1					5						
9 Needles	1	3		1			1			1					5						
10 Oswego/Fair	1	3	4	1			1			1											
11 Senter	1	3		1			1			1					5					3	
12 Story	1	3		1			1			1					5						
13 Alma	1			1			1			1											
14 Edwards	1	3	4	1			1			1					5						
15 W. Virginia	1	3	4	1			1			1					5						
16 Lincoln	1		4	1			1			1					5						
17 San Carlos				1																	
18 Kearney				1																	
19 George	1	3	4	1			1			1					5						
20 San Pedro	1	3	4	1			1			1					5						
21 Old Oakland	1		4	1			1			1					5						
22 Commercial	1			1			1			1											
23 Brokaw	1			1			1			1											
24 Montague	1			1			1			1					5						
25 River Oaks	1		4	1			1			1					5						
26 Ringwood	1			1			1			1					5						
27 Oakmead	1		4	1			1			1					5						
28 Guadalupe			4																		
29 Trade Zone			4																		
30 Lucrecia															5						
39 Empire																					
40 Airport/ Newhall																					
41 A1				1																	1
42 A2				1																	1
43 A3				1																	1

Footnotes:

1. 10-9-97:

- a. Method 625: all N.D. except 11, 12, 20
- b. Method 624: all N.D.
- c. Method 610/8270c: all N.D.
- d. Gasoline: all N.D.
- e. Diesel: all N.D.
- f. PCB: all N.D.
- g. Method 608: all N.D. except 22
- a. Method 614: Diazinon- all detected except 5, 12, 13, 14, 20, 24, 26
Chlorpyrifos- all N.D. except 8
- h. Method 619: all N.D.
- i. Method 8141: all N.D. except 2, 8, 6, 13, 14, 15, 19, 22, 23

2. 5-23-97

- a. Method 614: all N.D. (uncertified testing)

3. 11-7-98

- a. Method 625: all N.D.
- b. Method 608: all N.D. except 6, 8, 9, 10, 12
- c. Method 614: Diazinon- all detected except 7, 9, 11
Chlorpyrifos- all N.D. except 6, 8
- d. Method 619: all N.D. except 7
- e. Method 8141: all N.D. except 8, 10, 11, 14, 19
- f. Methods 601 and 602: all N.D.

4. 1-18-99

- a. Method 625: all N.D. except 6, 7 have majority detected
- b. Method 608: all N.D. except 6, 7, 10
- c. Method 614: Diazinon- all detected except 14, 15, 20, 25, 28
Chlorpyrifos- all detected
- d. Method 8141: all N.D. except 7, 8, 10, 14, 16, 19, 20

5. 11-7-99.

- a. Method 608: all N.D. except 24
- b. Method 622: all N.D. except 6, 8, 15, 16, 19, 26, 31
- c. Method 610/8270c: all detected except 31, 32
- d. Method 614: Diazinon- all detected except 9, 11, 14, 15, 16, 19, 20, 21, 25, 26, 35
Malathion- all N.D.

6. 1/16/00

- a. Method 622: all N.D. except 31, 34
- b. Method 614: Diazinon- all detected except 32
Malathion- all N.D. except 33, 34

7. 4/12/00

- a. Method 622: all N.D. except 31, 34
- b. Method 614: Diazinon- all detected except 32, 35
Malathion- all N.D. except 34

c. Method 608: all N.D.

8. 4/17/00

a. Method 625: all N.D.

d. Method 622: all N.D. except 31, 34

e. Method 614: Diazinon- all detected

Malathion- all N.D. except 34

e. Method 608P: all N.D.

1997 Total Metals Data (mg/L)

10/9/97 First Flush

	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	TSS	TOC	Cond	Oil and Grease
Blossom Hill W	0.0007	0.0147	0.043	0.027	0.00137	0.024	< 0.0005	< 0.001	0.334	88	49	100	
Blossom Hill E	0.0005	0.0044	0.011	0.006	7.12E-05	0.006	< 0.0005	< 0.001	0.085	20	15	260	
Cottle N.	0.0007	0.018	0.074	0.02	0.00015	0.035	< 0.0005	< 0.001	0.278	140	52	660	
Fontanoso	< 0.0005	0.024	0.018	0.012	0.00015	0.06	< 0.0005	< 0.001	0.189	110	28	130	
Umbarger	< 0.0005	0.0154	0.026	0.013	3.53E-05	0.034	< 0.0005	< 0.001	0.145	70	28	150	
Balfour	0.0011	0.025	0.043	0.031	0.00018	0.059	< 0.0005	< 0.001	0.268	160	47	260	
Tully	< 0.0005	0.0102	0.027	0.019	3.66E-05	0.018	< 0.0005	< 0.001	0.136	80	44	120	
Needles	0.0006	0.017	0.031	0.013	3.59E-05	0.038	< 0.0005	< 0.001	0.174	67	31	160	
Oswego/Fair	0.0006	0.0089	0.021	0.015	0.000043	0.016	< 0.0005	< 0.001	0.165	65	39	190	
Senter	0.0016	0.037	0.067	0.047	0.00022	0.078	< 0.0005	< 0.001	0.296	260	46	260	
Story	< 0.0005	0.0083	0.017	0.006	0.000013	0.009	< 0.0005	< 0.001	0.071	28	24	65	
Alma	0.0011	0.0139	0.038	0.023	4.65E-05	0.024	< 0.0005	< 0.001	0.16	50	39	110	
Edwards	0.0009	0.0145	0.078	0.051	0.00016	0.027	< 0.0005	< 0.001	0.241	69	39	120	
W. Virginia	0.0006	0.0096	0.034	0.025	0.0001	0.016	< 0.0005	< 0.001	0.156	60	38	97	
Lincoln	< 0.0005	0.0088	0.027	0.046	3.55E-05	0.014	< 0.0005	< 0.001	0.184	56	33	130	
San Carlos	0.0012	0.0095	0.016	0.038		0.015		< 0.001	0.15	14	25	77	
Kearney	0.0009	0.0074	0.03	0.026		0.016		< 0.001	0.21	17	26	87	
George	0.0007	0.0109	0.039	0.046	0.00009	0.016	< 0.0005	< 0.001	0.25	89	59	190	
San Pedro	0.001	0.017	0.095	0.055	0.00014	0.026	< 0.0005	< 0.001	0.369	150	55	280	
Old Oakland	< 0.0005	0.008	0.026	0.007	2.08E-05	0.011	< 0.0005	< 0.001	0.144	55	20	250	
Commercial	0.0009	0.023	0.043	0.03	0.00007	0.05	< 0.0005	< 0.001	0.317	170	42	170	
Brokaw	< 0.0005	0.0061	0.025	0.007	0.000023	0.01	< 0.0005	< 0.001	0.09	32	21	510	
Montague	0.0005	0.0112	0.028	0.011	3.79E-05	0.015	< 0.0005	< 0.001	0.0144	56	26	150	
River Oaks	< 0.0005	0.0054	0.022	0.0005	3.88E-05	0.007	< 0.0005	< 0.001	0.113	32	16	120	
Ringwood	< 0.0005	0.0043	0.026	0.005	1.32E-05	0.007	< 0.0005	< 0.001	0.197	16	18	490	
Oakmead	< 0.0005	0.021	0.038	0.012	0.00026	0.036	< 0.0005	< 0.001	0.272	180	30	440	
A1	< 0.0005	0.0019	0.014	0.003		0.004		< 0.001	0.108	7	20	64	13
A2	0.0013	0.011	0.021	0.008		0.014		< 0.001	0.116	20	15	150	11
A3	0.002	0.0088	0.017	0.003		0.017		< 0.001	0.156	45	17	280	< 10

5/23/97 Non-First Flush

George	0.0018	0.095	0.168	0.214	0.00061	0.144		< 0.001	0.898				< 30
Empire	0.0015	0.051	0.205	0.215	0.00044	0.109		< 0.001	0.816				< 30
W. Virginia	0.007	0.095	0.248	0.349	0.00086	0.154		< 0.001	1.44				< 30
Edwards	0.003	0.052	0.198	0.299	0.00119	0.127		< 0.001	0.817				< 30
Senter	0.0013	0.052	0.085	0.148	0.00028	0.138		< 0.001	0.534				< 30
Needles	0.002	0.052	0.16	0.14	0.00058	0.259		< 0.001	0.865				< 30
Senter/Umbarger	0.0017	0.065	0.101	0.056	0.00014	0.105		< 0.001	0.657				< 30
Lonebluff/Balfour	0.004	0.103	0.176	0.16	0.00029	0.189		< 0.001	0.983				< 30
Montague	0.0013	0.089	0.172	0.091	0.00029	0.162		< 0.001	0.846				< 30
River Oaks	0.0017	0.107	0.166	0.105	0.00079	0.189		< 0.001	0.89				< 30
Airport & Newhall	0.003	0.037	0.109	0.115	0.00016	0.06		< 0.001	0.587				< 30

1998 Total Metals Data (mg/L)

	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	TSS	TOC	Cond
Umbarger	< 0.0005	0.0374	0.028	0.043	0.00004	0.042	0.000546	< 0.001	0.404			
Balfour	0.001	0.036	0.047	0.026	0.000071	0.058	0.000898	< 0.001	0.261			
Tully	< 0.0005	0.0112	0.028	0.029	4.32E-05	0.023	0.000355	< 0.001	0.161			
Needles	< 0.0005	0.018	0.037	0.01	0.000048	0.017	0.002044	< 0.001	0.163			
Oswego/Fair	0.0007	0.021	0.031	0.038	0.000089	0.036	0.00049	< 0.001	0.26			
Senter	0.0008	0.017	0.037	0.027	0.000079	0.032	0.000547	< 0.001	0.22			
Story	< 0.0005	0.0087	0.015	0.017	0.000022	0.009	0.000264	< 0.001	0.09			
Edwards	0.0029	0.032	0.174	0.132	0.000306	0.053	0.000966	< 0.001	0.443			
W. Virginia	0.0019	0.041	0.072	0.152	0.000286	0.058	0.000884	< 0.001	0.515			
George	0.0009	0.018	0.045	0.053	0.000083	0.028	0.001062	< 0.001	0.289			
San Pedro	0.0012	0.025	0.097	0.07	0.000138	0.046	0.001154	< 0.001	0.416			
Oakmead	< 0.0005	0.0134	0.012	0.003	< 0.00008	0.018	< 0.00005	< 0.001	0.019	67		1200

1999 Total Metals Data (mg/L)

1/18/99 Non-First Flush Event

	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Blossom Hill W									
Blossom Hill E									
Cottle N.									
Fontanoso									
Umbarger	0.001	0.0435	0.0426	0.038	0.00012	0.0863	0.00032	0.00084	0.236
Balfour	0.0026	0.0456	0.055	0.0734	0.000018	0.0855	0.000333	0.00356	0.046
Tully	0.003	0.00214	0.031	0.0312	0.00011	0.0321	0.000197	0.0037	0.133
Needles									
Oswego/Fair	< 0.0005	0.0151	0.021	0.0196	0.000052	0.0235	0.000208	< 0.00025	0.137
Senter									
Story									
Alma									
Edwards	0.0011	0.0368	0.12	0.119	0.00042	0.0617	0.00181	0.00054	0.274
W. Virginia	0.0008	0.0237	0.0468	0.0939	0.000161	0.0352	0.000175	< 0.00025	0.54
Lincoln	< 0.0005	0.0149	0.0315	0.0525	0.000088	0.023	1.48E-05	< 0.00025	0.177
San Carlos									
Kearney									
George	< 0.0005	0.0148	0.0333	0.0482	0.000088	0.0218	0.000588	< 0.00025	0.199
San Pedro	0.0006	0.0404	0.0801	0.0515	0.000118	0.0623	0.000156	< 0.00025	0.329
Old Oakland	< 0.0005	0.016	0.0262	0.0117	0.000029	0.024	0.000251	< 0.00025	0.137
Commercial									
Brokaw									
Montague									
River Oaks	< 0.0005	0.0117	0.0189	0.0098	0.000044	0.0161	1.37E-05	< 0.00025	0.103
Ringwood									
Oakmead	< 0.0005	0.0309	0.0262	0.0178	0.000072	0.0463	0.000289	< 0.00025	0.135
Guadalupe	< 0.0005	0.0168	0.0265	0.0151	0.000058	0.0245	0.000146	< 0.00025	0.131
Trade Zone	< 0.0005	0.0098	0.0309	0.0152	0.000019	0.0292	0.000275	< 0.00025	0.165
Lucrecia									

11/7/99 First Flush Event

	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	TSS	TOC
Blossom Hill W										230	44
Blossom Hill E										530	96
Cottle N.										290	77
Fontanoso										200	69
Umbarger		0.0333	0.0663	0.0552	0.000134	0.0767			0.481		
Balfour		0.0547	0.147	0.187	0.000323	0.123			1.11	240	73
Tully		0.0226	0.069	0.0529	0.0004	0.0527			0.374	190	93
Needles		0.0267	0.0914	0.0693	0.000158	0.0537			0.469		
Oswego/Fair										480	120
Senter		0.0234	0.0609	0.0608	0.000165	0.0635			0.359	370	110
Story		0.0241	0.0593	0.0593	0.00007	0.0393			0.394	220	79
Alma											
Edwards		0.0577	0.185	0.268	0.000667	0.131			0.74		
W. Virginia		0.0282	0.077	0.121	0.000353	0.0486			0.583	260	120
Lincoln		0.0175	0.0656	0.0727	0.000139	0.0419			0.443	220	88
San Carlos										220	58
Kearney											
George		0.0267	0.0819	0.0831	0.000252	0.464			0.025		
San Pedro		0.0171	0.148	0.0593	0.000285	0.0391			0.449	140	44
Old Oakland		0.0333	0.138	0.0566	0.000101	0.0605			0.708	270	53
Commercial										82	35
Brokaw										800	100
Montague		0.0163	0.0596	0.0292	0.000102	0.047			0.435		
River Oaks		0.0248	0.412	0.0343	0.00021	0.0461			0.597		
Ringwood		0.009	0.0673	0.0185	0.000044	0.0218			0.448		
Oakmead		0.0603	0.139	0.0623	0.000355	0.106			1.01		
Guadalupe											
Trade Zone											
Lucrecia		0.0398	0.0794	0.0837	0.000241	0.0712			0.711		

Dissolved Copper (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		8			
Balfour	10	9	24	5.5	6
Umberger	18.5	14	14	4.8	10.9
Tulley		12	16	5	9.1
Needles	10	17	22		15.4
Senter	11	22	19		18.8
Oswego/Fair		8	8	3.9	
Story		12	8		17.4
Commercial		7			
Cottle N.		15			
Blossom Hill W.		9			
Blossom Hill E.		5			
Alma		24			
Edwards	26	35	47	13	31.9
W. Virginia	8.9	18	4	5.6	18.5
San Pedro		14	14	7.1	32.8
George	22	16	14	6.8	12.5
Airport/Newhall	37.9				
Brokaw		18			
Montague	64.5	15			18.4
River Oaks	36	13		5.3	12.8
Oakmead		13		3.4	16.5
Old Oakland		15		5.4	16.4
Ringwood		18			31.8
Lincoln		14		5.1	11.9
Lucretia					6.7
Guadalupe				5.7	
Trade Zone				8.5	
Empire	55				

Dissolved Cadmium Data (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		0.5			
Balfour	0.5	0.5	0.5	0.1	
Umberger	0.5	0.5	0.5	0.1	
Tully		0.5	0.5	0.1	
Needles	0.5	0.5	0.5		
Senter	0.5	0.5	0.5		
Oswego/Fair		0.5	0.5	0.1	
Story		0.5	0.5		
Commercial		0.5			
Cottle N.		0.5			
Blossom Hill W.		0.5			
Blossom Hill E.		0.5			
Alma		0.5			
Edwards	0.5	0.5	0.6	0.1	
W. Virginia	0.5	0.5	0.5	0.1	
San Pedro		0.5	0.5	0.1	
George	0.5	0.5	0.5	0.1	
Airport/Newhall	1.1				
Brokaw		0.5			
Montague	0.5	0.5			
River Oaks	0.5	0.5		0.1	
Oakmead		0.5		0.1	
Old Oakland		0.5		0.1	
Ringwood		0.5			
Lincoln		0.5		0.1	
Lucretia					
Guadalupe				0.1	
Trade Zone				0.1	
Empire	0.5				

Dissolved Chromium Data (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		1.4			
Balfour	2.3	1.5	2.2	0.9	1.8
Umbarger	2.7	1.3	3.7	0.8	1.7
Tully		1.6	1.4	1.1	1.6
Needles	3.6	2.9	2.7		3.7
Senter	0.5	2.5	1.8		1.9
Oswego/Fair		1.1	1.3	0.8	
Story		2.9	2.6		2.2
Commercial		1.9			
Cottle N.		1.6			
Blossom Hill W.		1			
Blossom Hill E.		1			
Alma		3.5			
Edwards	2.4	2.3	2.6	1.3	6.4
W. Virginia	1.3	1.2	0.9	0.7	1.9
San Pedro		1.6	1.2	0.9	1.5
George	15	1.3	1.1	1.3	1.6
Airport/Newhall	2				
Brokaw		1.5			
Montague	5.5	2			1.9
River Oaks	10.4	1.2		1	1.4
Oakmead		1.3		1.4	1.5
Old Oakland		1.1		0.9	1.5
Ringwood		1.7			1.9
Lincoln		1.3		1	1.6
Lucretia					1.3
Guadalupe				0.9	
Trade Zone				1.2	
Empire	1.9				

Dissolved Lead Data (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		2			
Balfour	3	2	1	0.8	5.1
Umberger	2	2	1	0.5	1.6
Tully		3	1	0.9	2.5
Needles	2	2	1		1.7
Senter	2	2	1		2.5
Oswego/Fair		2	1	0.5	
Story		2	1		3.4
Commercial		3			
Cottle N.		2			
Blossom Hill W.		2			
Blossom Hill E.		2			
Alma		2			
Edwards	2	8	15	1.9	18.5
W. Virginia	10	4	3	1.3	6.1
San Pedro		3	1	0.6	4.6
George	4	6	2	1.8	4.1
Airport/Newhall	2				
Brokaw		2			
Montague	2	2			2
River Oaks	2	2		0.5	1
Oakmead		2		0.6	0.7
Old Oakland		2		0.5	1.2
Ringwood		2			1.1
Lincoln		6		1.5	3.4
Lucretia					1.7
Guadalupe				0.05	
Trade Zone				0.5	
Empire	7				

Dissolved Nickel Data (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		5			
Balfour	27	9	10	4.4	33.8
Umbarger	18	6	8	4.3	16.1
Tully		5	6	3	14.3
Needles	7	5	5		15
Senter	4	6	5		19.1
Oswego/Fair		5	5	2.7	
Story		4	2		15.1
Commercial		7			
Cottle N.		6			
Blossom Hill W.		6			
Blossom Hill E.		3			
Alma		9			
Edwards	7	7	8	7.3	29.3
W. Virginia	13	5	5	3.4	19.5
San Pedro		5	3	4.4	18.3
George	8	5	4	4.1	13.9
Airport/Newhall	13				
Brokaw		4			
Montague	24	4			23.7
River Oaks	37	3		2.8	10.6
Oakmead		3		5.8	19
Old Oakland		4		22.1	12.7
Ringwood		4			12.9
Lincoln		4		3.2	10.4
Lucretia					14.7
Guadalupe				3.1	
Trade Zone				2.7	
Empire	12				

Dissolved Silver Data (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		<1			
Balfour	<1	<1	<1	0.05	
Umberger	<1	<1	<1	0.05	
Tully		<1	<1	0.28	
Needles	<1	<1	<1		
Senter	<1	<1	<1		
Oswego/Fair		<1	<1	0.05	
Story		<1	<1		
Commercial		<1			
Cottle N.		<1			
Blossom Hill W.		<1			
Blossom Hill E.		<1			
Alma		<1			
Edwards	<1	<1	<1	0.05	
W. Virginia	<1	<1	<1	0.05	
San Pedro		<1	<1	0.2	
George	<1	<1	<1	0.05	
Airport/Newhall	<1				
Brokaw		<1			
Montague	<1	<1			
River Oaks	<1	<1		0.05	
Oakmead		<1		0.05	
Old Oakland		<1		0.05	
Ringwood		<1			
Lincoln		<1		0.05	
Lucretia					
Guadalupe				0.05	
Trade Zone				0.05	
Empire	<1				

Dissolved Zinc Data (ug/L)

Site	May-97	Oct-97	Nov-98	Jan-99	Nov-99
Fontanoso		51			
Balfour	109	53	38	21	118
Umbarger	176	53	96	10	123
Tully		56	44	22	123
Needles	26	62	45		134
Senter	30	53	42		56
Oswego/Fair		78	25	26	
Story		49	25		157
Commercial		123			
Cottle N.		78			
Blossom Hill W.		115			
Blossom Hill E.		44			
Alma		71			
Edwards	52	117	110	35	130
W. Virginia	88	84	27	27.43	188
San Pedro		54	27	39	164
George	89	99	44	54	112
Airport/Newhall	151				
Brokaw		49			
Montague	269	74			150
River Oaks	219	72		24	144
Oakmead		70		16	146
Old Oakland		74		42	140
Ringwood		171			260
Lincoln		88		42	158
Lucretia					89
Guadalupe				44	
Trade Zone				66	
Empire	158				

Anion Data (mg/L)

10/9/97 Data					
	Chloride	Nitrite	Phosphate	Nitrate	Sulfate
Blossom Hill W	10.1	< 0.1	0.5	0.65	12.7
Blossom Hill E	12.6	< 0.1	< 0.1	0.7	16.7
Cottle N.	10.2	< 0.1	0.8	< 0.1	9.5
Cottle S.	6.4	< 0.1	0.4	< 0.1	6.4
Fontanoso	4.5	< 0.1	< 0.1	0.93	6.64
Umbarger	7.5	< 0.1	< 0.1	0.92	11.1
Balfour	12.5	< 0.1	0.5	< 0.1	24
Tully	17.2	0.13	1.5	0.13	14.2
Needles	5.6	< 0.1	< 0.1	0.4	6.3
Oswego/Fair	0.8	< 0.1	< 0.1	< 0.1	9
Senter	5	< 0.1	< 0.1	< 0.1	7.4
Story	2.88	< 0.1	< 0.1	0.4	4.6
Alma	4.2	< 0.1	0.1	0.9	7.13
Edwards	5.2	< 0.1	< 0.1	< 0.1	8.4
W. Virginia	6.4	< 0.1	< 0.1	0.88	8.9
Lincoln	61.1	0.2	0.7	0.22	5
George	9.3	0.26	0.64	0.41	11.4
San Pedro	9.8	< 0.1	< 0.1	0.5	16.4
Old Oakland	9.5	< 0.1	< 0.1	< 0.1	13.4
Commercial	7.8	0.3	< 0.1	0.7	10.6
Brokaw	21.9	< 0.1	< 0.1	2.1	44.6
Montague	7.3	< 0.1	< 0.1	0.8	17.4
River Oaks	7	< 0.1	< 0.1	0.7	10.3
Ringwood	15.6	< 0.1	< 0.1	0.58	21.4
Oakmead	35.3	0.12	< 0.1	< 0.1	35.7

1998 Data : 11/7/98					
	Chloride	Nitrite	Phosphate	Nitrate	Sulfate
Blossom Hill W					
Blossom Hill E					
Cottle N.					
Fontanoso					
Umbarger	11.4	< 0.1	< 0.1	1	12
Balfour	10.9	< 0.1	< 0.1	0.9	20.7
Tully	6.7	< 0.1	1.3	0.82	8.8
Needles	6.8	< 0.1	< 0.1	0.7	14.4
Oswego/Fair	13.4	2.3	3.2	1.3	24.3
Senter	10.9	< 0.1	< 0.1	0.7	15.9
Story	4.8	< 0.1	< 0.1	0.4	7.2
Alma					
Edwards	6.7	< 0.1	0.1	0.6	12
W. Virginia	7.1	< 0.1	< 0.1	0.5	9.6
Lincoln					
San Carlos					
Kearney					
George	9.5	< 0.1	< 0.1	0.5	11.1
San Pedro	10.2	< 0.1	< 0.1	0.7	18.7
Old Oakland					
Commercial					
Brokaw					
Montague					
River Oaks					
Ringwood					
Oakmead	116	< 0.05	1.7	2.2	186
Guadalupe					
Trade Zone					

1999 Data									
	1/18/1999					11/7/1999			
	Chloride	Nitrite	Phosphate	Nitrat	Sulfate	Chloride	Phosphate	Nitrate	Sulfate
Umbarger	2	0.1	< 1	0.6	6	10.3	< 1	1.3	15.2
Balfour	3	0.1	< 1	0.4	7.5	15.4	< 1	0.3	22.5
Tully	4	< 0.05	< 1	0	2	10.2	< 1	0.4	10.8
Needles						8.1	2.3	1.3	11.3
Oswego/Fair	6	< 0.05	< 1	0.4	5	6	< 1	0.4	5
Senter						11.3	< 1	1.3	16.2
Story						15.4	< 1	0.9	9.2
Edwards	15	0.1	< 1	2.4	28	21.3	< 1	2	40
W. Virginia	2	0.1	< 1	0.4	4	11.2	< 1	0.6	15.9
Lincoln	14	< 0.05	< 1	0.2	5	56.6	< 1	1.2	13.8
George	9	0.1	< 1	0.5	9	85.7	5.3	< 0.1	51.4
San Pedro	8	0.1	< 1	0.6	14	23	1	1	36.7
Old Oakland	3	0.1	< 1	0.5	5	6.9	< 1	1.3	11.5
Montague						40.8	< 1	2	63.2
River Oaks	7	0.1	< 1	0.4	15	6.2	< 1	1.5	13.8
Ringwood						10.9	< 1	1.2	16
Oakmead	71	0.1	< 1	0.8	76	28.3	< 1	1.2	40.7
Lucrecia						9.7	< 1	0.5	12.8
Guadalupe	9	0.1	< 1	0.4	10	9	< 1	0.4	10
Trade Zone	3	< 0.05	< 1	0.2	5	3	< 1	0.2	5

Organic Summary

The following is a summary of the results for the organic analysis of First Flush water samples. Sample values analyzed in units of ppb (ug/L).

EPA Method 610/8310/8270c/625 PAH

- On October 9, 1997, 1 sample of EPA Method 610/8310 was collected at the 25 separate sampling stations. A total of 16 compounds were analyzed and all were not detected.
- On November 11, 1999, 1 sample of EPA Method 610/8270c was collected at 21 sampling stations. A total of 16 compounds were analyzed. Of the 16 compounds analyzed, 14 were detected.
 - Naphthalene was detected 8 times with sample values ranging from 0.13 to 0.40, and a mean of 0.20.
 - Acenaphthene was detected twice with sample values of 0.12 and 0.19.
 - Fluorine was detected twice with sample values of 0.12 and 0.16.
 - Phenanthrene was detected 19 times ranging from 0.11 to .45 with a mean of 0.32.
 - Anthracene was detected once with a value of 0.20.
 - Fluoranthene was detected 14 times ranging from 0.11 to 0.41 with a mean of 0.21.
 - Pyrene was detected 17 times ranging from 0.11 to 0.39, with a mean of 0.21.
 - Benzo(a)anthracene was detected 3 times with sample values of 0.13, 0.10, and 0.12.
 - Chrysene was detected 16 times ranging from 0.11 to 0.31, with a mean of 0.18.
 - Benzo(b)fluoroanthene was detected 5 times with values ranging from 0.14 to 0.26, with a mean of 0.18.
 - Benzo(k)fluoroanthene was detected 3 times with sample values of 0.17, 0.10, and 0.24.
 - Benzo(a)pyrene was detected once with a sample value of 0.16.
 - Ideno(1,2,3-cd)pyrene was detected with a sample of value of 0.23.
 - Benzo(g,h,i)perylene was detected once with a sample value of 0.21.
- On November 11, 1998, 1 sample of EPA Method 625 PAH was collected at 11 sampling stations. A total of 16 compounds were analyzed. Of the 16 compounds analyzed, 1 compound was detected.
 - Fluoranthene was detected once with sample value of 0.28. The detection limit was 0.059 and the reporting limit was 0.18.
- On January 18, 1999, 1 sample of EPA Method 625 PAH was collected at 14 sampling stations. A total of 16 compounds were analyzed. Of the 16 compounds analyzed, 9 compounds were detected.
 - Naphthalene was detected once with a sample value of 0.4
 - Fluoranthene was detected twice with sample values of 0.4 and 1.0
 - Acenaphthylene was detected once with a sample value of 0.4
 - Acenaphthene was detected twice with sample values of 0.4 and 0.5
 - Phenanthrene was detected twice with sample values of 0.4 and 1.0.
 - Fluorene was detected twice, both with sample values of 0.4
 - Pyrene was detected twice with sample values of 0.6 and 0.8
 - Benzo(a)anthracene was detected twice with sample values of 0.4 and 0.2
 - Chrysene was detected once with a sample value of 0.3
- On April 7, 2000, 1 sample of EPA Method 625 PAH was collected at 4 sampling stations. A total of 16 compounds were analyzed. Of the 16 compounds analyzed, all of the compounds were not detected.

EPA Method 625 Semi-volatile Organics

- On October 9, 1997, 1 sample of EPA Method 625 was collected at 25 sampling stations. A total of 52 compounds were analyzed. Of the 52 compounds analyzed, 2 compounds were detected.
 - Butyl benzyl phthalate was detected once with sample value of 21.2. The detection limit was 1.0 and the reporting limit was 10.
 - bis(2-Ethylhexyl) phthalate was detected twice with sample values of 20.6 and 34.6. The detection limit was 2.8 and reporting limit was 15.

EPA Method 608 Chlorinated Pesticides

- On October 9, 1997, 1 sample of EPA Method 608 was collected at 25 sampling stations. A total of 29 compounds were analyzed. Of the 29 compounds analyzed, 3 compounds were detected.
 - Aldrin was detected once with sample value of 4.72. The detection limit was 0.00168 and the reporting limit was 0.025.
 - 4,4'-DDE was detected once with sample value of 7.60. The detection limit was 0.00221 and the reporting limit was 0.050.
 - 4,4'-DDD was detected once with sample value of 3.11. The detection limit was 0.00167 and the reporting limit was 0.050
- On November 7, 1998, 1 sample of EPA Method 608 was collected at 11 sampling stations. A total of 29 compounds were analyzed. Of the 29 compounds analyzed, 1 compound was detected.
 - gamma-BHC was detected 4 times with sample values ranging from 0.0267 to 0.0503, with a mean of 0.361.
- On January 18, 1999, 1 sample of EPA Method 608 was collected at 14 sampling stations. A total of 29 compounds were analyzed. Of the 29 compounds analyzed, 1 compound was detected.
 - gamma-BHC was detected 5 times with sample values ranging from 0.022 to 0.038, with a mean of 0.033.
- On November 7, 1999, 1 sample of EPA Method 608 was collected at 4 sampling stations. A total of 29 compounds were analyzed. Of the 29 compounds analyzed, 1 compound was detected.
 - delta-BHC was detected once with a sample value of 0.026
- On April 12, 2000, 1 sample of EPA Method 608 was collected at 6 sampling stations. A total of 29 compounds were analyzed and all were not detected.
- On April 17, 2000, 1 sample of EPA Method 608 was collected at 4 sampling stations. A total of 29 compounds were analyzed and all were not detected.

EPA Method 614 Organo-Phosphorous Pesticides

- On October 9, 1997, 1 sample of EPA Method 614 was collected at 25 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected.
 - Diazinon was detected 18 times with sample values ranging from 0.223 to 2.56, with a mean of 0.636.
 - Chlorpyrifos was detected once with a sample value of 0.231.
- On May 23, 1997, 1 sample of EPA Method 614 was collected at 12 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected. The testing was uncertified.
 - Diazinon was detected 5 times.
 - Chlorpyrifos was detected once.
- On November 7, 1998, 1 sample of EPA Method 614 was collected at 11 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected.
 - Diazinon was detected 8 times with sample values ranging from 0.114 to 1.11, with a mean of 0.317.
 - Chlorpyrifos was detected twice with sample values of 0.0668 and 0.109.
- On January 18, 1999, 1 sample of EPA Method 614 was collected at 14 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected.
 - Diazinon was detected 9 times with sample values ranging from 0.01 to 0.18, with a mean of 0.09
 - Chlorpyrifos was detected 14 times with sample values ranging from 0.01 to 0.12, with a mean of 0.34.
- On November 7, 1999, 1 sample of EPA Method 614 was collected at 21 sampling stations. A total of 2 compounds were analyzed. Of the 2 compounds analyzed, 1 compound was detected.
 - Diazinon was detected 9 times with sample values ranging from 0.02 to 0.38, with a mean of 0.14
 - Malathion was not detected (method changed from analyzing Chlorpyrifos to Malathion).
- On January 16, 2000, 1 sample of EPA Method 614 was collected at 5 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected.

- Diazinon was detected 4 times with sample values ranging from 0.11 to 1.22, with a mean of 0.64
- Malathion was detected twice with a sampling values of 0.04 and 0.05
- On April 12, 2000, 1 sample of EPA Method 614 was collected at 6 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected.
 - Diazinon was detected 3 times with sample values ranging from 0.10 to 0.24, with a mean of 0.16
 - Malathion was detected once with a sampling value of 0.40
- On April 17, 2000, 1 sample of EPA Method 614 was collected at 4 sampling stations. A total of 2 compounds were analyzed. Both compounds analyzed were detected.
 - Diazinon was detected 4 times with sample values ranging from 0.05 to 0.20, with a mean of 0.14
 - Malathion was detected once with a sampling value of 0.18

EPA Method 619

- On October 9, 1997, 1 sample of EPA Method 619 was collected at 25 sampling stations. A total of 1 compound was analyzed. The compound analyzed (Simazine) was not detected.
- On November 7, 1998, 1 sample of EPA Method 619 was collected at 11 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Simazine was detected once with a sampling value of 0.688

EPA Method 8141/8140

- On October 9, 1997, 1 sample of EPA Method 8141 was collected at 25 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected 8 times, with samples ranging from 0.267 to 1.17, with a mean of 0.650. One data sample was disregarded due to inconsistencies in the data
- On November 7, 1998, 1 sample of EPA Method 8141 was collected at 11 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected 5 times, with samples ranging from 0.0612 to 0.123, with a mean of 0.1075
- On January 18, 1999, 1 sample of EPA Method 8140 was collected at 15 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected 7 times, with samples ranging from 0.02 to 0.10, with a mean of 0.046

EPA Method 622

- On November 7, 1999, 1 sample of EPA Method 622 was collected at 21 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected 7 times, with samples ranging from 0.03 to 0.11, with a mean of 0.054
- On January 16, 2000, 1 sample of EPA Method 622 was collected at 5 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected twice with sample values of 0.13 and 0.17
- On April 12, 2000, 1 sample of EPA Method 622 was collected at 6 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected twice with sample values of 0.04 and 0.03
- On April 17, 2000, 1 sample of EPA Method 622 was collected at 4 sampling stations. A total of 1 compound was analyzed. The compound analyzed was detected.
 - Malathion was detected twice with sample values of 0.02 and 0.02

EPA Method 624/601/624 Volatile Organics

- On November 11, 1999, 1 sample of EPA Method 624 was collected at 3 sampling stations. A total of 34 compounds were analyzed and all were not detected.

- On November 11, 1999, 1 sample of EPA Method 601 was collected at 1 sampling station. A total of 25 compounds were analyzed and all were not detected.
- On November 11, 1999, 1 sample of EPA Method 602 was collected at 1 sampling station. A total of 9 compounds were analyzed and all were not detected.

EPA Method 8015 Diesel

- On October 9, 1997, 1 sample of EPA Method 601 was collected at 30 sampling stations. A total of 1 compound was analyzed and was not detected.

EPA Method 8015G Gasoline

- On October 9, 1997, 1 sample of EPA Method 601 was collected at 25 sampling stations. A total of 1 compound was analyzed and was not detected.

PCB

- On October 9, 1997, 1 sample of EPA Method 601 was collected at 25 sampling stations. A total of 1 compound was analyzed and was not detected.

CONSTITUENT CATEGORY	EPA SAMPLE METHOD	DATE OF SAMPLING	NUMBER OF STATIONS SAMPLED	COMPONENTS DETECTED (number of detections)	DETECTED VALUE RANGE (ppb)	
Polycyclic Aromatic Hydrocarbons (PAHs)	610/8310	10/9/97	25	None	---	
	625	11/11/98	11	Fluoranthene (1)	0.28	
	610/8270c	11/11/99	21	Naphthalene (8)	0.13 - 0.40	
				Acenaphthene (2)	0.12 - 0.19	
				Fluorine (2)	0.12 - 0.16	
				Phenanthrene (19)	0.11 - 0.45	
				Anthracene (1)	0.2	
				Fluoranthene (14)	0.11 - 0.41	
				Pyrene (17)	0.11 - 0.39	
				Benzo(a)anthracene (3)	0.10 - 0.13	
				Chrysene (16)	0.11 - 0.31	
				Benzo(b)fluoranthene (5)	0.14 - 0.26	
				Benzo(k)fluoranthene (3)	0.10 - 0.24	
				Benzo(a)pyrene (1)	0.16	
				Ideno(1,2,3-cd)pyrene (1)	0.23	
	Benzo(g,h,i)perylene (1)	0.21				
	625	1/18/99	14	Naphthalene (1)	0.4	
				Fluoranthene (2)	0.4 - 1.0	
				Acenaphthylene (1)	0.4	
				Acenaphthene (2)	0.4, 0.5	
				Phenanthrene (2)	0.4, 1.0	
Fluorene (2)				0.4, 0.4		
Pyrene (2)				0.6, 0.8		
Benzo(a)anthracene (2)				0.2 - 0.4		
625	4/7/00	4	Chrysene (1)	0.3		
			None	---		
Pesticides Chlorinated Pesticides	608	10/9/97	25	Aldrin (1)	4.72	
				DDE (1)	7.6	
				DDD (1)	3.11	
		11/7/98	11	gamma-BHC (4)	0.027 - 0.05	
		1/18/99	14	gamma-BHC (5)	0.022 - 0.038	
		11/7/99	4	delta-BHC (1)	0.026	
		4/12/00	6	None	---	
	4/17/00	4	None	---		
	Organophosphorous Pesticides	614	5/23/97	12	Diazinon (5)	uncertified
					Chlorpyrifos (1)	uncertified
			10/9/97	25	Diazinon (18)	0.22 - 2.56
					Chlorpyrifos (1)	0.23
			11/7/98	11	Diazinon (8)	0.114 - 1.11
					Chlorpyrifos (2)	0.067 - 0.109
			1/18/99	14	Diazinon (9)	0.01 - 0.18
					Chlorpyrifos (14)	0.01 - 0.12
			11/7/99	21	Diazinon (9)	0.02 - 0.38
1/16/00			5	Diazinon (4)	0.11 - 1.22	
4/12/00	6	Malathion (2)	0.04, 0.05			
		Diazinon (3)	0.10 - 0.24			
		Malathion (1)	0.4			
		4/17/00	4	Diazinon (4)	0.05 - 0.14	
		Malathion (1)	0.18			
8141/8140	10/9/97	25	Malathion (8)	0.267 - 1.17		
	11/7/98	11	Malathion (5)	0.612 - 0.123		

Triazine Pesticides	622	1/18/99	15	Malathion (7)	0.02 - 0.1
		11/7/99	21	Malathion (7)	0.03 - 0.11
		1/16/00	5	Malation (2)	0.13, 0.17
		4/12/00	6	Malathion (2)	0.04, 0.03
		4/17/00	4	Malathion (2)	0.02, 0.02
	619	10/9/97	25	None	---
		11/7/98	11	Simazine (1)	0.69
Semi-volatile Organics	625	10/9/97	25	Butyl benzyl phthalate (1)	21.2
				bis(2-Ethylhexyl)phthalate (2)	20.6, 34.6
Volatile Organics	624	11/11/99	3	None	---
	601	11/11/99	1	None	---
	602	11/11/99	1	None	---
Diesel	8015	10/9/97	30	None	---
Gasoline	8015G	10/9/97	25	None	---
PCB	601	10/9/97	25	None	---

Table 1. Organics Monitoring Data Results