Department of Pesticide Regulation
Environmental Monitoring Branch
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STUDY 270 (2016-17): Ambient and Mitigation Monitoring in Urban Areas in Southern California during Fiscal Year 2016 – 2017

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1.0 INTRODUCTION

Urban runoff is an important source of pesticide loading into surrounding waterways, justifying monitoring efforts to characterize pesticide composition in surface waters receiving urban inputs. In California, the Department of Pesticide Regulation (CDPR) receives pesticide use reports for urban applications by licensed applicators. Reported use is categorized into agricultural and non-agricultural use. Agricultural use includes both production and non-production agricultural (i.e. golf courses, rights-of way, parks) applications. Non-agricultural use includes applications for residential, industrial, institutional, structural, or vector control purposes (CDPR, 2010). However, urban pesticide use by individual homeowners is not reported, so that total use is greater than reported use. It has been estimated that urban pesticide use accounts for over 70% of the total pesticide use in California (UP3 Project, 2006). Approximately 4,744,000 pounds of pesticides were applied in 2014 for landscape maintenance and structural pest control in Los Angeles, Orange and San Diego Counties (CDPR, 2014a).

With this high volume of urban pesticide use there is a potential for pesticide runoff into urban creeks and rivers via storm drains. Numerous urban creeks are listed on the 2010 Federal Clean Water Act Section 303(d) list due to the presence of pyrethroid and organophosphate (OP) pesticides (Cal/EPA, 2014). While urban uses of OPs have been sharply curtailed due to Federal regulatory actions, recent monitoring has continued to identify the presence of OPs in some samples (Oki and Haver, 2009). Additionally, recent monitoring has shown that urban waterways are frequently contaminated with pyrethroids, OPs, and fipronil. Many of the detected pesticides are at concentrations that exceed the acute toxicity to sensitive aquatic organisms (Gan et al., 2012; Oki and Haver, 2009; Weston et al., 2014; Weston et al., 2005; Weston et al., 2009). In 2008 CDPR initiated a statewide urban monitoring project to more fully characterize the presence of pesticides in urban waterways (CDPR, 2008). Preliminary monitoring data has been previously summarized. Several pyrethroids, imidacloprid, and fipronil (and breakdown products) insecticides, as well as synthetic auxin herbicides have been detected at high frequency at CDPR monitoring locations in southern California (Ensminger et al., 2013).

Study 270 is a continuation of monitoring efforts of DPR Studies 249 and 265. Data from this study will be used to evaluate urban pesticide water quality trends and efficacy of implemented best management practices (BMPs). For example, surface water regulations were implemented in California in July 2012, with the intent of reducing pyrethroid concentrations in California surface waters (CDPR, 2012). Long term monitoring will help determine the effectiveness of these regulations on the presence of pyrethroids in urban waterways. This project will continue to monitor storm drains and urban waterways at selected monitoring sites from CDPR's 2008 study as well as at monitoring stations established by the University of California (Oki and Haver, 2009). This long-term monitoring may be used to track the performance of local mitigation measures or public outreach programs. Modifications from the FY 15-16 sampling plan is presented in section 4.9.

2.0 OBJECTIVE

The overall goal of this project is to assess pesticide concentrations found in runoff at drainages and receiving waters within typical southern California urbanized areas during rain events and dry season conditions. Specific objectives include:

1) Determine presence and concentrations of selected pesticides in urban runoff under dry and storm conditions;
2) Evaluate the magnitude of measured concentrations relative to water quality or aquatic toxicity thresholds;
3) Evaluate the effectiveness of surface water regulations through long term (multiple year) monitoring at selected sampling locations;
4) Observe effects of a small constructed wetland to mitigate pesticide concentrations in urban runoff to surrounding receiving waters;
5) Observe the mitigation effects of a small water treatment facility receiving dry weather runoff flow;
6) Monitor deposition of sediment-bound pyrethroids within the watershed;
7) Determine the toxicity of water samples using toxicity tests conducted with *Hyalella azteca*.

3.0 PERSONNEL

The study will be conducted by staff from the CDPR's Environmental Monitoring Branch under the general direction of Kean S. Goh, Environmental Program Manager. Key personnel are listed below:

Project Leader: Robert Budd, Ph.D.
Field Coordinator: KayLynn Newhart.
Reviewing Scientist: Michael Ensminger, Ph.D.
Statistician: Dan Wang, Ph.D.
Laboratory Liaison: Sue Peoples
Analytical Chemistry, water: Center for Analytical Chemistry, Department of Food and Agriculture (CDFA)

Analytical Chemistry, sediment: California Department of Fish and Wildlife (CDFW)

Collaborator: Darren Haver, Ph.D., University of California at Davis, Center Director/Water Resources and Water Quality Advisor, South Coast Research and Extension Center, 7601 Irvine Blvd., Irvine, CA, 92618, Phone: (949) 653-1814, email: dlhaver@ucdavis.edu

Please direct questions regarding this study to Robert Budd, Senior Environmental Scientist, at (916) 445-2505 or rbudd@cdpr.ca.gov.

4.0 STUDY PLAN

4.1 Monitoring Sites. Ambient water quality monitoring will be conducted at six sampling locations within Salt Creek (SC) in Orange County (Figure 1), one each within Ballona (BAL), Bouquet (BOQ), Los Angeles River (LAR), San Gabriel River (SGR), and Dominguez Channel (DC) watersheds in Los Angeles County (Figure 2), and within San Diego River (SDR) and Tecolote Canyon (TCC) watersheds in San Diego County (Figure 3) (Table 1). Mitigation monitoring will be conducted at the inlet and outlet of a small constructed wetland located within Wood Creek watershed (Figure 4) and at the outlet of a small treatment facility at the base of Salt Creek. Details of site descriptions are provided in Appendix 1.

Sampling stations within Salt Creek have been monitored consistently since 2009 as part of CDPRs urban monitoring program. The surrounding drainage areas within the Salt Creek watershed consist of single family dwellings, multiple family dwellings, light commercial buildings, parks, schools, and two golf courses. SC5 and SC7are located at the receiving waters of several urban inputs and will serve to evaluate pesticide concentrations in the watershed as well as downstream transport of pesticides. SC7A is located adjacent to SC7. During the dry season water is pumped from an intake at SC7 through a small ozone water treatment facility and returning through an outlet at SC7A. Samples are collected at SC7A during the dry season to determine the effect of the ozone treatment system on pesticide removal from the water column. Sampling locations within the four watersheds in Los Angeles County and two in San Diego County are located near the base of their respective watersheds. Ballona Creek, Los Angeles River, Dominguez Channel, and San Gabriel River are large watersheds with mixed residential and commercial land use.

Monitoring locations within Wood Creek have also been monitored since 2009 as part of Surface Water Protection Program’s mitigation evaluation monitoring. The monitoring sites are situated at the inlet (WC1) and outlet (WC2) of a small (~0.18 acres) constructed wetland designed to mitigate pollutants in the urban runoff. The wetland receives urban runoff from a drainage area consisting of entirely single and multiple family residential units. The primary objective of monitoring at these stations is to observe the efficacy of pesticide removal within the wetland system. Efficacy will be evaluated through comparisons in average pesticide concentrations between outlet and inlet.

DPR has engaged in a collaborative effort with the Stream Pollution Trends (SPOT) Monitoring Program to increase the data available for trend analysis of current used pesticides (SWAMP, 2016). The synergistic partnership allows each agency to maximize information gained with limited resources. DPR has initiated a contract to support the continual monitoring of SPOT locations in highly urbanized centers. The SPOT program collects sediments throughout California for pyrethroid and fipronil analysis, which greatly adds to the spatial representation of pesticide monitoring data. Several sites described in this protocol also serve as SPOT monitoring locations, including BAL, BOQ, LAR1, SGR, and SC5.

4.2 Monitoring Candidates. The Surface Water Prioritization Model was utilized to assist in pesticide selection for ambient monitoring (Budd et al., 2013; Luo et al., 2013). The model is based on current use patterns and aquatic toxicity benchmark data. The product of the use and toxicity scores produces a final score that represents a relative prioritization of pesticides. In addition, the output also generates a recommendation to monitor or not based on physiochemical properties such as half-life and solubility. The output provides guidance to EM staff on pesticides to consider for monitoring. However, the decision to monitor for a pesticide is influenced by additional factors such as previous monitoring data, budgetary constraints, and analytical capabilities. Pesticides that receive a final score of nine or higher are given priority for monitoring. Pesticides with lower scores have either low use in urban environments and/or low associated toxicity. Thirty pesticides received a final score equal to or greater than nine using 2012-2014 use data for Los Angeles, San Diego, and Orange counties, California and acute and chronic aquatic benchmarks benchmarks (Appendix 2). Twenty-seven of these will be monitored under the current sampling plan (Appendix 3). Analytical methods are currently being developed for PCNB, dithiopyr and sulfometuron-methyl. All suites cannot be analyzed at every monitoring location due to budgetary constraints. Four sampling locations (SC3, SC7, BOQ and LAR) will serve as representative watersheds for analytical methods containing pesticides with lower detection frequencies (CB, CF, DN, TR).

4.3 Water sampling. Samples will be collected for both ambient and mitigation monitoring during two dry season and two storm sampling events. Dry season sampling will occur between August - September, 2016 and May-June, 2017. DPR will attempt to collect storm samples during the first major storm (rain) event of fiscal year 2016-2017 and during a second major storm in the winter or early spring of 2017 (Table 2a,b).

Most water samples will be collected as grab samples directly into 1-L amber bottles (Bennett, 1997). Where the stream is too shallow to collect water directly into these bottles, a secondary stainless steel container will be used to initially collect the water samples. Water samples collected during storm events at SC1, SC2, SC3, SC4, WC1, and WC2 may be collected as composite samples utilizing automated sampling equipment set up by UC Cooperative Extension (CDPR, 2014b; Sisneroz et al., 2012). Samples will be stored and transported on wet ice or refrigerated at 4°C until analyzed.

4.4 Sediment sampling. Sediment samples will be collected at a subset of locations and sampling events (Table 3). Where applicable, sediment samples will be collected in 1 quart glass Mason Jars using passive sediment collection samplers (Budd, 2009) and analyzed for pyrethroids. Otherwise, enough sediment will be collected using stainless steel scoops from the top of the bed layer, biasing for fine sediments where possible. All sediments will be sieved through a 2-mm sieve to remove plant debris and then homogenized.

4.5 Toxicity sampling. Water samples will be collected at a subset of sampling sites for toxicity analysis during the first two events of FY 16-17. Grab samples will be collected in 1 L amber I-Chem certified 200 bottles (or equivalent) and transported to the Aquatic Health Program at the University of California, Davis. Toxicity testing will measure percent survival of the amphipod *Hyalella azteca* in water (96-hr).

4.6 Field Measurements. Physiochemical properties of water column will be determined using a YSI-EXO 1 multiparameter Sonde according to the methods describe by Doo and He (2008). At each site, water parameters measured *in situ* will include pH, temperature, conductivity, turbidity, salinity, total dissolved solids, and dissolved oxygen. Stormdrain discharge or stream flow rates will be measured to characterize the flow regime and to estimate the total loading of target pesticides. Discrete time flow estimations will be determined using either a Global portable velocity flow probe (Goehring, 2008), utilizing a float, or fill-bucket method. Continuous flow rates will be obtained at SC2, SC3, and WC2 using an installed Hach Sigma 950 flow meter (Sisneroz et al., 2012; Oki and Haver, 2009).

4.7 Sample transport. CDPR staff will transport samples following the procedures outlined in CDPR SOP QAQC004.01 (Jones, 1999). A chain-of-custody record will be completed and accompany each sample.

4.8 Organic carbon and suspended sediment analysis. CDPR staff will analyze water and sediment samples for total organic carbon (TOC) and dissolved organic carbon (DOC) using a TOC-V CSH/CNS analyzer (Shimadzu Corporation, Kyoto, Japan) (Ensminger, 2013a). Water samples will also be analyzed for suspended sediment (Ensminger, 2013b). Lab blanks and calibration standards will be run before every sample set to ensure the quality of the data.

4.9 Modifications from FY 15-16. The current sampling plan is an extension of sampling conducted during fiscal years 2010-2016. Details of the previous sampling are described in the document titled Study 270: Urban pesticide monitoring in southern California, available at: http://www.cdpr.ca.gov/docs/emon/pubs/protocol/study270protocol2015_16.pdf. The sampling and analysis schedule is similar to that for FY 15-16, with a few notable modifications (Table 4).

An exploratory monitoring location is being added within the Dominguez Channel watershed. Dominguez Channel is a 16 mile long concrete lined channel within a highly urbanized (>90% developed) watershed that receives inputs from the cities of Hawthorne, Gardena, and Lawndale (Figure 2) within Los Angeles county.

5.0 CHEMICAL ANALYSIS

Water samples will be sent to the Center for Analytical Chemistry, California Department of Food and Agriculture, Sacramento, CA (CDFA) for pesticide analysis. They will analyze nine different analyte groups which will include up to 41 chemical compounds for analysis (Table 5). Many of the pesticides in the current analytical suites will be combined into a single liquid chromatograph (LC) multi-analyte screen (Appendix 3). Sediment samples will be sent to the California Department of Fish and Wildlife, Sacramento, CA (CDFW). Sediment samples will be analyzed for pyrethroid pesticides (Table 5). Laboratory QA/QC will follow CDPR guidelines and will consist of laboratory blanks, matrix spikes, matrix spike duplicates, surrogate spikes, and blind spikes (Segawa, 1995). Laboratory blanks and matrix spikes will be included in each extraction set.

6.0 DATA ANALYSIS

All data generated by this project will be entered into a central database that holds all data including field information, field measurements, and laboratory analytical data. We will use various nonparametric and parametric statistical methods to analyze the data. The data collected from this project may be used to develop or calibrate an urban pesticide runoff model.

Our preliminary analysis (Ensminger and Budd, 2014) indicated that the sample data is heavily skewed and contains a number of non-detects with multiple reporting limits, which may violate the normality and equal variance assumptions of the parametric procedures (e.g., ANOVA and *t*-tests). In order to appropriately address the characteristics of the sample data, a more generic and distribution-free approach, the non-parametric statistics, will be used in this study. Helsel (2012) illustrated the application of non-parametric procedures to skewed and censored environmental data. We will primarily reference Helsel as a general guideline for data analysis of this study. The data will be analyzed by using R statistical program (R Core Team, 2014), the Nondetects And Data Analysis for environmental data (NADA) package for R (http://cran.r-project.org/web/packages/NADA/NADA.pdf), and Minitab (http://www.minitab.com/en-us/).

Based on the study objectives, preliminary analysis, and data availability, we propose the following statistical procedures for data analysis (Table 6).

1) Explanatory data analysis will be performed to summarize the characteristics of the sample data. Urban monitoring data has been collected since 2008 for a variety of analytes (i.e., Table 5, Appendix 3) at multiple locations (i.e., Salt Creek, Wood Creek; Table 2) with different site types (i.e., stormdrain outfalls and receiving water), and between different seasons (i.e., dry and wet seasons). Plots, such as boxplots, histograms, probability plots, and empirical distribution functions, will be produced to explore any potential patterns implied by the data.
2) Hypothesis tests will be conducted to compare the concentration between groups of interest. For example, we will test whether or not there is significant difference in concentration between the dry and wet season, or between the difference locations. Non-parametric procedures will be used to compute the statistics for hypothesis test. For data with multiple reporting limits, it will be censored at the highest limit before proceeding if the test procedure allows only one RL.
3) Trend analysis will be included to depict the change in concentration over time. We are specifically interested in determining the effectiveness of CDPR regulation 6970 which went into effect July 19, 2012 to mitigate pyrethroid contamination in urban waters. Ambient monitoring data from Salt Creek monitoring locations, as well as WC1 in Wood Creek will be used. For the trend analysis, we will use Akritas-Thenil-Sen non-parametric regression, which regresses the censored concentration on time, or the Kaplan-Meier method, which tests the effects of year, month and location by developing a mixed linear model between the censored concentration and the spatial-temporal factors.

Finally, we will attempt to develop complicated statistical models to assess the factors potentially impacting pesticide concentration in surface water. One possible attempt is to develop a logistic regression model to estimate and predict the likelihood of detection or exceedance. The response variable will be the probability of the concentration being greater than or equal to the RLs or the toxicity benchmark. A series of explanatory variables will be examined, including: rainfall, field measurements (e.g., flow rate, pH, water TOC, sediment TOC, and TSS), number of household drains water into the storm drain outfall/creek, residential density (percent of impervious areas), season (or month), year, regulation, and so on. Further literature review will be conducted to identify possible explanatory variables in favor of the model.

7.0 TIMELINE

Field Sampling: Jul 2016 – Jun 2017
Chemical Analysis: Jul 2016 – Oct 2017
Report to Management: Jan 2017 – Mar 2017
Data Entry into SURF: Mar 2017 – Jun 2017

8.0 LABORATORY BUDGET

The estimated total cost for chemical analyses for water samples is $161,460 (Table 2a,b). The estimated cost for chemical analysis of sediment samples is $6,500.25 (Table 3).

9.0 LITERATURE CITED

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Table 1. Summary of urban pesticide monitoring locations in southern California.

Watershed	Stormdrain Outfall	Receiving Water/ Mitigation Outfall	Total Sites
Ambient Monitoring			
Salt Creek	4	2	6
Ballona Creek	-	1	1
Bouquet Creek	-	1	1
Los Angeles River	-	1	1
San Gabriel River	-	1	1
Dominguez Channel	-	1	1
San Diego River	-	1	1
Tecolote Canyon Creek	-	1	1
Mitigation Monitoring			
Wood Creek	1	1	2
Salt Creek	-	1	1
Total	**5**	**11**	**16**

Table 2a. Ambient and mitigation sampling schedule for first dry season monitoring event.

Site	Screen*	Sites	Cost/Sample	Budget
Ambient Monitoring				
SC3, SC7, BOQ, LAR1	CB	4	$480	$1,920
	CF	4	$540	$2,160
	FPOP	4	$840	$3,360
	IM	4	$600	$2,400
	DN	4	$840	$3,360
	PX	4	$690	$2,760
	PY6	4	$600	$2,400
	TR	4	$540	$2,160
SC1, SC2, SC4, SC5, BAL, SGR, SDR, TCC	FP	8	$600	$4,800
	IM	8	$600	$4,800
	PX	8	$690	$5,520
	PY6	8	$600	$4,800
	Ambient Monitoring Sub-total			$40,440
Mitigation Monitoring				
SC7a, WC1, WC2	FP	3	$600	$1,800
	IM	3	$600	$1,800
	PX	3	$690	$2,070
	PY6	3	$600	$1,800
	Mitigation Monitoring Sub-total			$7,470

Table 2b. Ambient and mitigation sampling schedule for storm event and second dry season monitoring events.

Site	Screen*	Sites	First Storm	Second Storm	Second Dry	Cost/ Sample	Budget
Ambient Monitoring							
SC1, SC2, SC4	LC	3	1	1	1	$1,700	$15,300
	PX	3	1	1	1	$690	$6,210
	PY6	3	1	1	1	$600	$5,400
SC3, SC7	CB	2	1	0	1	$480	$1,920
	CF	2	1	0	1	$540	$2,160
	DN	2	1	0	1	$840	$3,360
	LC	2	1	1	1	$1,700	$10,200
	PX	2	1	1	1	$690	$4,140
	PY6	2	1	1	1	$600	$3,600
BOQ, LAR1	CB	2	1	0	1	$480	$1,920
	CF	2	1	0	1	$540	$2,160
	DN	2	1	0	1	$840	$3,360
	LC	2	1	0	1	$1,700	$6,800
	PX	2	1	0	1	$690	$2,760
	PY6	2	1	0	1	$600	$2,400
SC5, BAL	LC	2	1	0	1	$1,700	$6,800
	PX	2	1	0	1	$690	$2,760
	PY6	2	1	0	1	$600	$2,400
SGR, SDR, TCC, DC	LC	4	0	0	1	$1,700	$6,800
	PX	4	0	0	1	$690	$2,760
	PY6	4	0	0	1	$600	$2,400
				Ambient Monitoring Sub-total			$95,610
Mitigation Monitoring							
WC1, WC2	LC	2	1	1	1	$1,700	$10,200
	PX	2	1	1	1	$690	$4,140
	PY6	2	1	1	1	$600	$3,600
				Mitigation Monitoring Sub-total			$17,940
				Ambient Monitoring Total			$136,050
				Mitigation Monitoring Total			$25,410

*Pesticides included in screens detailed in Appendix 3. CB=carbaryl, CF=chlorfenapyr, DN=dinitroanaline, FP=fipronil, IM=imidacloprid, LC=liquid chromatography, PX=phenoxy, a,PY=pyrethroid.

Table 3. Monitoring schedule and analytical cost estimates for sediment samples collected during FY 2016-2017, and analyzed by CDFW for pyrethroids.

Sampling Period	Sites	No. of Samples	Cost per Sample*	Cost	Total
Fall 2016	SC3, SC5, WC1, WC2	4	\$722.25	\$2,889	\$6,500.25
Spring 2016	SC3, SC5, WC1, WC2	4	\$722.25	\$2,889	
Field duplicates	SC3	1	\$722.25	\$722.25	

*\$535 per sample + 35% overhead

Table 4. Modifications from sampling plan for fiscal year 2016-2017.

Change from FY 15-16	Justification
Added sampling site at Dominguez Channel (DC)	Identified as potential watershed with significant urban runoff contributions
Adding LC multi-analyte screen	Significantly increases analytical capabilities of monitoring program
SC7a monitored only during first dry event	Sufficient data points to draw conclusions of effectiveness of WWTP

Table 5. Chemical analysis of pesticides in the Southern California urban monitoring study.

Analyte Group	Media	Analytical Method	Method Detection Limit (µg L^{-1})	Reporting Limit (µg L^{-1})
Carbaryl	Water[a]	HPLC	0.011	0.05
Chlorfenapyr	Water	GC-MS/MS	0.0624	0.1
Dinitroaniline herbicides	Water	LC-MS/MS	0.01 – 0.015	0.05
Fipronil & degradates	Water	GC-MSD (SIM)	0.003 – 0.005	0.05
Imidacloprid	Water	GC-MS	0.01	0.05
Organophosphate insecticides	Water	GC-FPD	0.008 – 0.0142	0.05
	Water	GC-MS	0.0012 – 0.0079	0.01
Synthetic auxin herbicides	Water	GC-MS	0.064	0.1
Pyrethroid insecticides	Water	GC-ECD	1.09 – 7.68 (ng L^{-1})	5 – 15 (ng L^{-1})
	Sediment	GC-ECD	-	0.02 – 0.2 (ng g^{-1})
Photosynthetic inhibitor herbicides	Water	LC-MS/MS	0.0063 – 0.043	0.05

[a] Water samples analyzed by California Department of Food and Agriculture, sediment samples analyzed by the California Department of Fish and Wildlife.

Table 6: Non-parametric procedures frequently used for comparing paired data, two samples and three or more samples.

Data	Non-Parametric Procedure
Paired data	*Wilcoxon signed-rank test* for uncensored data *Sign test* (modified for ties) for censored data with one RL *Score tests* for censored data with multiple RLs (the PPW test and the Akritas test)
Two samples	*Wilcoxon rank-sum (or Mann-Whitney) test* or *Kolmogorov-Smirnov test* for censored data with one RL *Score tests* for censored data with multiple RLs (the *Gehan test* and generalized *Wilcoxon test*)
Three or more samples in one-way layout	*Kruskal-Wallis test* (for unordered alternative) or *Jonckheere-Terpstra test* (for ordered alternative) for censored data with one RL *Generalized Wilcoxon score test* for censored data with multiple RLs *Multiple comparison* to detect which group is different
Three or more samples in two-way layout	*Friedman's test* (for unordered alternative) or *Page's test* (for ordered alternative) for censored data with one RL Multiple comparison to detect which group is different

Figure 1. Sampling locations within Salt Creek watershed, Orange County, CA.

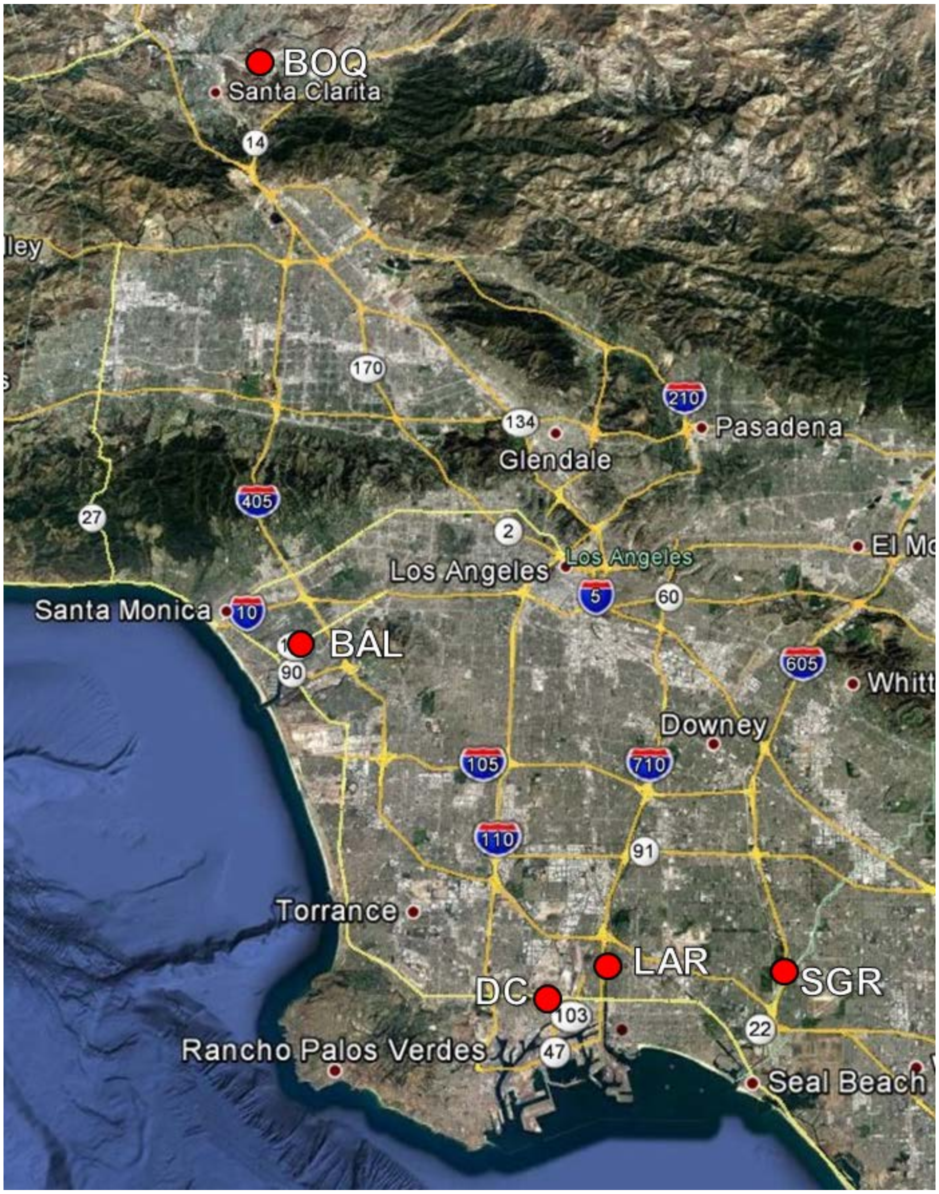

Figure 2. Sampling locations within Los Angeles County, CA.

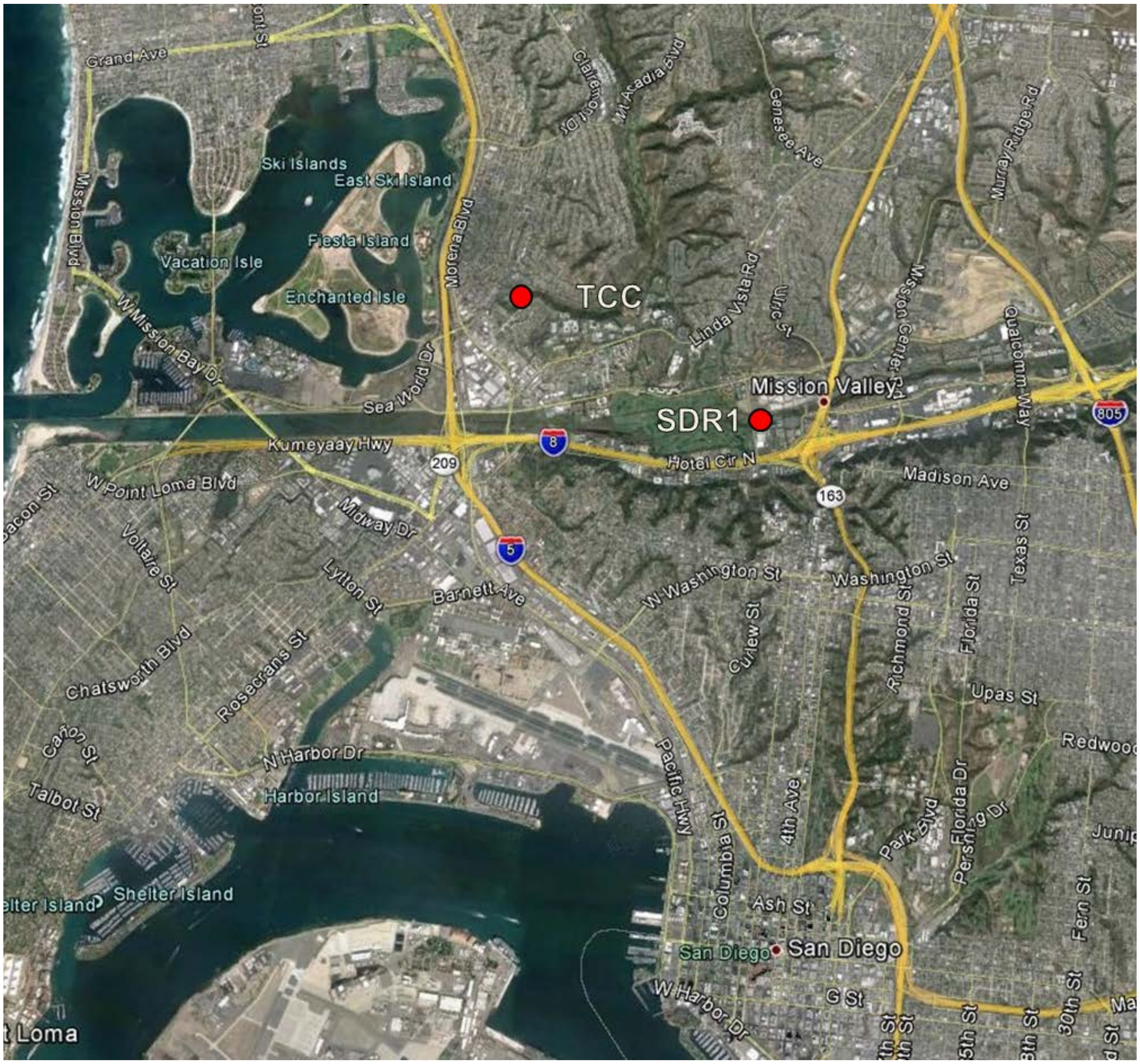

Figure 3. Sampling locations within San Diego County, CA.

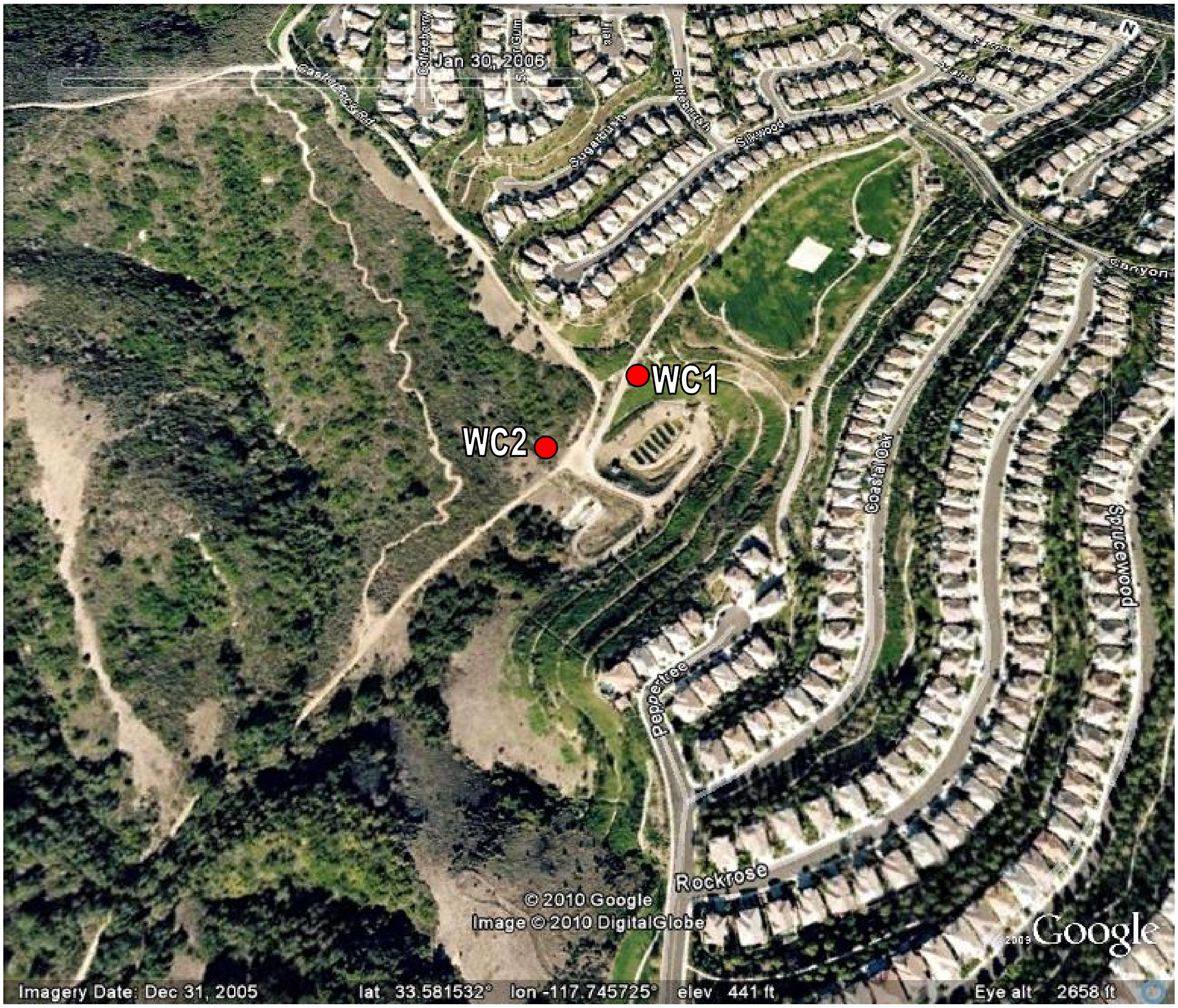

Figure 4. Sampling locations within Wood Creek watershed, Orange County, CA.

Appendix 1. Detailed sampling site information.

Watershed	Site ID	Northing	Easting	Site type
Salt Creek	SC1	33 30 32.92	117 41 26.53	Stormdrain
Salt Creek	SC2	33 30 40.57	117 41 40.67	Stormdrain
Salt Creek	SC3	33 30 43.02	117 41 49.55	Stormdrain
Salt Creek	SC4	33 30 31.00	117 42 26.34	Stormdrain
Salt Creek	SC5	33 30 20.23	117 42 30.87	Receiving water
Salt Creek	SC7	33 28 53.97	117 43 26.55	Receiving water
Salt Creek	SC7A	33 28 54.12	117 43 27.37	Receiving water
Ballona Creek	BAL	33 59 12.92	118 24 55.90	Receiving water
Bouquet Creek	BOQ	34 25 42.05	118 32 23.45	Receiving water
Los Angeles River	LAR-1	33 80 58.09	118 20 54.53	Receiving water
San Gabriel River	SGR	33 77 51.08	118 09 74.18	Receiving water
Dominguez Channel	DC	Unknown*	Unknown	Receiving water
San Diego River	SDR	32 45 51.79	117 10 12.24	Receiving water
Tecolote Canyon Creek	TCC	32 77 54.93	117 20 04.84	Receiving water
Wood Creek	WC1	33 34.56.56	117 44 43.02	Stormdrain
Wood Creek	WC2	33 34 53.70	117 44 44.65	Wetland outfall

*Exploratory site, needs access confirmation.

Appendix 2. Priority model pesticides (Final Score≥9) based on acute and chronic aquatic benchmarks and 2012-2014 urban pesticide usage in Los Angeles, Orange, and San Diego counties, California. All pesticides recommended to monitor based on physiochemical properties. All pesticides are either within current analytical screens or are undergoing method development.

Pesticide	Use (lbs)	Use score	Benchmark (ug/L)	Tox score	Final score
Permethrin	71,606	5	0.0014	7	35
Bifenthrin	26,739	5	0.0013	7	35
Fipronil	27,028	5	0.011	6	30
Cyfluthrin	21,374	4	0.0074	7	28
Cypermethrin	5,944	4	0.069	6	24
Lambda-cyhalothrin	4,107	3	0.002	7	21
Deltamethrin	3,476	3	0.0041	7	21
Imidacloprid	24,855	5	1.05	4	20
Pyriproxyfen	1,203	3	0.015	6	18
Malathion	1,141	3	0.035	6	18
Diuron	6,474	4	2.4	4	16
Prodiamine	17,496	4	1.5	4	16
Chlorfenapyr	10,206	4	2.915	4	16
Sulfometuron-methyl	1,785	3	0.45	5	15
DDVP	734	2	0.0058	7	14
Esfenvalerate	785	2	0.017	6	12
Triclopyr, butoxyethyl ester	5,222	4	19	3	12
2,4-D	4,906	4	13.1	3	12
Bromacil	3,696	3	6.8	4	12
Chlorpyrifos	341	2	0.04	6	12
Pendimethalin	2,720	3	5.2	4	12
PCNB	4,924	4	13	3	12
Oxadiazon	689	2	0.88	5	10
Etofenprox	149	2	0.17	5	10
Carbaryl	308	2	0.5	5	10
Oryzalin	4,645	3	15.4	3	9
Propiconazole	3,334	3	21	3	9
Indoxacarb	1,755	3	75	3	9
Azoxystrobin	871	3	44	3	9
Dithiopyr	1,413	3	20	3	9

Appendix 3. Active ingredients within analytical chemical suites.

CB	**PY**	**LC**
Carbaryl **CF** Chlorfenapyr **IM** Imidacloprid **DN** Oryzalin Pendimethalin Prodiamine Trifluralin **FPOP** Desulfinyl fipronil Desulfinyl fipronil amide Fipronil Fipronil amide Fipronil sulfide Fipronil sulfone Chlorpyrifos Dichlorvos Malathion	Bifenthrin Cyfluthrin Cypermethrin Deltamethrin/Tralomethrin Fenvalerate/Esfenvalerate λ-Cyhalothrin/epimer cis-Permethrin trans-Permethrin **PX** 2,4-D Dicamba MCPA Triclopyr **TR** Bromacil Diuron Atrazine Diflubenzuron Simazine	Abamectin Atrazine Azoxystrobin Bromacil Chlorantraniliprole Chlorpyrifos Diazinon Diflubenzuron Dimethoate Diuron Etofenprox Fipronil Imidacloprid Indoxacarb Isoxaben Malathion Methomyl Oryzalin Oxadiazon Propiconazole Pyraclostrobin Pyriproxyfen Simazine Trifloxystrobin