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STUDY 299: Ambient and Mitigation Monitoring in Urban Areas in Northern California FY 2017/2018

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September 2017

1.0 INTRODUCTION

The Surface Water Protection Program (SWPP), Environmental Monitoring Branch of the California Department of Pesticide Regulation (CDPR) has monitored urban runoff in northern California since 2007 (Kelley, 2007). This monitoring has helped define pesticide runoff patterns from urban neighborhoods and watersheds (Budd et al., 2015; Ensminger et al., 2013). Urban pesticide use remains high (CDPR, 2013a), pesticides occur frequently in urban runoff (Budd et al., 2015; Ensminger et al., 2013; Gan, et al., 2012; Weston and Lydy, 2014), and many urban waterbodies do not meet water quality standards (SWRCB, 2017). These facts justify the need to further monitor the state's waterways.

This study is a continuation of CDPR's urban monitoring in northern California (Ensminger, 2016). SWPP will continue to evaluate sources of pesticide runoff, monitor larger urban watersheds, and evaluate toxicity and mitigation methods. In FY17/18 some changes to monitoring frequency, site locations, and pesticides of interest have been made. Data from this study will be used to evaluate urban pesticide water quality trends.

2.0. OBJECTIVES

For Study 299 (FY17-18), northern California urban monitoring, the objectives are:

1) Identify the presence and concentrations of pesticide contamination in urban waterways;
2) Evaluate the magnitude of measured concentrations relative to water quality or aquatic toxicity thresholds;
3) At selected monitoring sites, determine the toxicity of water samples in laboratory toxicity tests conducted with Hyalella azteca;
4) Evaluate the effectiveness of a stormwater retention (or water quality) pond to reduce pesticides from urban runoff;
5) Evaluate the effectiveness of CDPR's surface water regulation Section 6970 (CDPR, 2013b) through long-term (multi-year) monitoring at selected sampling locations.

3.0 PERSONNEL

The study will be conducted by staff from the CDPR's Environmental Monitoring Branch, Surface Water Protection Program, under the general direction of Kean S. Goh, Ph.D. Environmental Program Manager I (Supervisory). Key personnel are listed below:

- Project Leader: Michael Ensminger, Ph.D.
- Field Coordinator: Kevin Kelley
- Reviewing Scientist: Robert Budd, Ph.D.
- Statistician: Dan Wang, Ph.D.
- Laboratory Liaison: Sue Peoples
- Analytical Chemistry, water: Center for Analytical Chemistry, California Department of Food and Agriculture (CDFA)
- Analytical Chemistry, sediment: California Department of Fish and Wildlife
- Collaborator: Lorence Oki, Ph.D., University of California at Davis, CE Assistant Specialist, Landscape Horticulture, Department of Environmental Horticulture, Phone: (530) 754-4135, Email: lroki@ucdavis.edu

Please direct questions regarding this study to Michael Ensminger, Senior Environmental Scientist (Specialist), at (916) 324-4186 or michael.ensminger@cdpr.ca.gov.

4.0 STUDY PLAN

4.1 Monitoring sites – Ambient monitoring. Using CDPR's Surface Water Prioritization Model (SWPM), Luo et al. (2017) has developed a new method for determining areas of interest (AOIs) for urban monitoring. AOIs are identified by hydrological unit codes (HUC). AOIs are determined at the spatial resolution of HUC 8 subbasin level, with refinement to the HUC12 sub-watershed level if more a detailed analysis is needed. In the priority HUC12s, major streams (receiving waters [RWs]) are listed. There are 168 HUC8s in California; nine priority HUC8s (out of the top 20) are in northern California (Table 1; Luo et al. 2017). Three HUC8s are in the Sacramento area (SAC), four in the San Francisco Bay area (SFB), one in the San Joaquin delta, and one in the Monterey Bay area. Due to resource constraints, SWPP will not monitor in every high ranking HUC8. For FY17/18, SWPP will monitor in five of the eight high ranking HUC8s.

4.1.1 Sacramento HUC8s: Lower American River, Upper Coon-Upper Auburn, and Lower Sacramento. Monitoring will continue in the Lower American River and Upper Coon-Upper Auburn HUC8s. In the Lower American River HUC8, SWPP will continue to monitor Arcade Creek. In the Upper Coon-Upper Auburn HUC8, SWPP will continue to monitor two sites on Pleasant Grove Creek in Roseville (a section 303d listed water body), PGC040 and PGC058 (Figure 1 and Appendix 1). CDPR has monitored PGC040 since 2008 and this site is used for trend analysis and mitigation effectiveness and (SWPP defined long-term monitoring site). PGC058 (downstream site) has been monitored more recently and captures runoff from all of Roseville. PGC058 is typically dry in the summer months so has not been used as a long-term monitoring site.

No monitoring will occur in the Lower Sacramento HUC8 during FY17/18.

Luo et al.'s method does not select monitoring areas for source (stormdrain) monitoring, but they do note that most CDPR source sites are located in HUC12s of monitored RW sites. CDPR's urban monitoring program recommends some of its monitoring sites be source sites (Ensminger et al., in prep.). In the Upper Coon-Upper Auburn watershed, three source sites that drain into Pleasant Grove Creek will be monitored (Appendix 1 and Figure 1); these have been monitored since 2008 and are considered long-term monitoring sites by SWPP. In the Lower American River HUC8, two source sites will be monitored FOL2 and FOL3. FOL2 is also considered a long-term monitoring site, sampled by CDPR since 2009. These sites also serve as mitigation sites (see mitigation monitoring, 4.2, below).

4.1.2 San Francisco Bay area HUC8s: Coyote, San Francisco Bay, Suisun Bay, San Pablo Bay. These four watersheds in the SFB are flagged as high-ranking monitoring areas. CDPR has been monitoring in some of these areas; changes in FY17/18 reflect recommendations from Luo et al. (2017). In the Suisun Bay HUC8, Walnut Creek will be monitored at a downstream site near the mouth of the watershed (site: WAL_CA; Figure 2 and Appendix 1). Walnut Creek is a 303d listed waterbody and a Streams Pollution Trends (SPOT) monitoring program site (SWAMP, 2017; SWQCRB, 2017). WAL_CA will replace the CDPR's site on Grayson Creek (historical CDPR monitoring site); WAL_CA has a higher detection frequency and will serve as the monitoring site in Suisan Bay HUC8.

In the San Francisco Bay HUC8, SWPP will continue to monitor at MCC040. MCC040 is on a tributary creek of South San Ramon Creek, which was listed by Luo et al. (2017) as a top area of interest in this HUC8. SWPP will also sample at a new site further downstream on South San Ramon Creek (SRC_JD; Figure 2 and Appendix 1). SRC_JD is on the mainstem creek and engulfs a larger urban drainage area than MCC040. SWPP will discontinue sampling Arroyo de la Laguna at Verona Road; the drainage area at this site is less than 50% urban (Luo et al. 2017).

In the Coyote HUC8, SWPP will monitor on Guadalupe River near Airport Boulevard (GUA_AB), Figure 2 and Appendix 1). SWPP conducted limited monitoring near this site in FY14_15. This site is a SPOT monitoring program site and contains USGS gage station (SWAMP, 2017; USGS, 2017). GUA_AB will replace SWPP's monitoring site on Coyote Creek in this HUC8; the drainage area of Coyote Creek contains agricultural runoff whereas Guadalupe River is dominated by urban runoff.

No sites will be monitored in the San Pablo Bay HUC8 in FY17/18.

4.1.3 San Joaquin Delta and Monterey Bay HUC8s. These two HUC8s are listed as high-ranking monitoring areas. For FY17/18, SWPP is not planning to monitor in these HUC8s. After consolidation of sampling sites in the San Francisco Bay HUC8, which will free up resources, monitoring sites in these areas could be added in future monitoring.

4.2 Mitigation monitoring. Mitigation monitoring will continue in Folsom at the Marsh Hawk constructed water quality treatment pond (CWQTP) (Figure 3 and Appendix 1). At the CWQTP, two stormdrain outfalls provide input from urban neighborhoods to the CWQTP. Efficacy of the CWQTP will be determined by mass balance at the inlets and outlet (water) and by comparisons between calculated sediment toxicity unit differences (sediment). Mitigation water monitoring will be completed by December 2017, when contract 13-C0052 ends (see http://cdpr.ca.gov/docs/emon/surfwtr/contracts/ucdavis_13-C0052_a-2.pdf)

4.3 Monitoring Candidates
For ambient monitoring, SWPP uses the SWPM to assist in pesticide selection. SWMP is based on current use patterns, aquatic toxicity benchmarks, and physiochemical properties; the output is presented as a relative prioritization (final) score (Budd et al., 2013; Luo et al., 2014). The final score is used as a guideline for monitoring. Actual pesticides selected may vary due to sampling logistics, previous monitoring data, budget constraints, and laboratory analytical capabilities. Pesticides that receive a final score $\geq$ 9 are given priority for monitoring. Pesticides with lower scores have either low urban use or low potential toxicity.

For northern California, SWMP was run for two distinct geographical areas, SAC and SFB. In SAC, SWMP selected 24 pesticides for monitoring with a final score $\geq$ 9. CDFA has analytical methods for 21 of these 24 pesticides. In SFB, SWMP selected 31 pesticides; CDFA has methods for 27 of the 31 pesticides (Appendix 2). SWPP will monitor all of the selected pesticides with a CDFA analytical method except chlorfenapyr, DDVP, and tebuthiuron (Appendixes 2 and 3).

For mitigation monitoring, an additional criterion was added to select pesticides for water monitoring. To ensure that differences between the inlets and outlet can be measured, only pesticides that have had a historical detection frequency of $\geq$ 25% at the inlet mitigation sites (FOL2, FOL3) will be monitored. Bifenthrin, cyfluthrin, permethrin, fipronil, imidacloprid, 2,4-D, dicamba and triclopyr meet this criterion and will be targeted for monitoring. Evaluating these pesticides also gives a wide range of Log P values, which may influence the effectiveness of their removal in the CWQTP.

4.4 Water sampling. Long-term monitoring sites in Roseville and one site in Folsom (FOL2) will be sampled four times during the year (two dry season events and two rainstorm events; Table 2). Dry season events will take place in August 2017 and in June 2018. Rainstorm events will occur in September – December (the first flush rainstorm of the 2017-2018 water year, if possible) and in the winter of 2018 (January – March). Arcade Creek, PGC058, and SFB sites will be monitored during one dry season sampling event (in June) and one early season rain storm event. Mitigation water monitoring at the CWQTP sites in Folsom will occur during one fall rainstorm event (first flush event, if possible).

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. At sites FOL2, FOL3, and FOL5 (mitigation sites), water samples will be collected as time or flow-weighted composite samples using automated sampling equipment (Sisnernoz et al., 2012). Samples will be stored and transported on wet ice or refrigerated at 4°C until analyzed. Approximately 10% of the field samples will be field blanks or field duplicates.

4.5 Sediment sampling. Sediments will be collected two times a year at sampling sites in Roseville and Folsom (Table 3). Sediments will be collected using passive sampling techniques where practical, but substituting 1-quart Mason glass jars with 1-quart stainless steel AirScape® (http://planetarydesign.com) containers (Budd et al., 2009). Otherwise, sediments will be collected with stainless steel scoops from the top bed layer (Mamola, 2005). Sediments will be sieved through a 2-mm sieve to remove gravel and plant material. Sediments will be analyzed for pyrethroids.

4.6 Toxicity. Water samples will be collected from a subset of the sampling sites and sent to the University of Davis, Aquatic Health Program, to be tested for toxicity to *Hyalella azteca* or other organisms such as *Chironomus*. Roseville long-term monitoring sites will be the focus for toxicity testing.

4.7 Field measurements. Water physiochemical properties (dissolved oxygen, electrical conductivity, pH, and temperature) will be measured *in situ* during all grab sampling events with a calibrated YSI EXO 1 multiparameter water quality sonde (https://www.ysi.com/productsdetail.php?EXO1-Water-Quality-Sonde-89). Where feasible, flow rates will be estimated with a Global portable velocity flow probe (Goehring, 2008). At FOL2, FOL3, and FOL5 flow rates will be determined with Hach Sigma 950 flow meters under contract 13-C0052 (Sisnernoz et al., 2012). USGS gaging stations record flow near the sampling sites on Arcade Creek and Guadalupe River (USGS, 2017).

4.8 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.

4.9 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 and Goh, 2011; Ensminger, 2013a). Water samples will also be analyzed for suspended sediment (Lisker and Goh, 2010; Ensminger, 2013b).

4.10 Modifications for FY17/18 The current sampling plan is an extension of urban monitoring in northern California (for details of previous sampling protocols, see http://www.cdpr.ca.gov/docs/emon/pubs/protocol.htm for Studies 269 and 299). The sampling and analysis schedule is similar to that for FY 16/17. Main differences include changes in the sampling schedule in Folsom and changes in sampling sites monitored in SFB (Table 4).

5.0 CHEMICAL ANALYSIS

CDFA will conduct pesticide analysis for water and sediment samples. CDFA will analyze 41 different pesticides and degradates in six different analytical screens (Appendixes 4 and 5). All 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 to a Microsoft® Office Access database that holds site information, field measurements, and laboratory analytical data. All ambient monitoring analytical data will also be uploaded into the CDPR Surface Water Database (SURF) (http://cdpr.ca.gov/docs/emon/surfwtr/surfdata.htm). Previous analysis of CDPR's urban monitoring data has shown that the data contains numerous non-detections and that the data is heavily skewed (non-normal distribution) (Ensminger et al., 2013). Analyzing the data using parametric statistics may violate the normality and equal variance assumptions. Also, the presence of non-detections and multiple RLs limit the application of some widely-used parametric procedures, such as analysis of variance (ANOVA) and *t*-tests. Helsel (2012) has shown that the substitution of non-detections can result in inaccuracy of estimate and test result. While some other parametric procedures, such as the censored regression by using maximum likelihood estimate (MLE), are capable of handling censored data with multiple RLs, the validity of their results depends on the selection of correct distribution. Therefore, we will analyze the data with various non-parametric statistical procedures (Table 5).

7.0 TIMETABLE

Field Sampling:	August 2017 – June 2018
Chemical Analysis:	August 2017 – December 2018
Summary Report:	February 2019
SURF Data Upload:	March 2019

8.0 LABORATORY BUDGET

The estimate cost (for planning purposes) for the CDFA chemical analyses of water samples for ambient monitoring is estimated below. These costs are slightly less than total estimated costs for FY16/17 ($171,092):

Monitoring Project		Projected Cost	
Water	Ambient	$150,840	
	Mitigation	$ 5,980	
	Total		$ 156,820
Sediment	Ambient	$ 8,800	
	Mitigation	$ 1,600	
	Total		$ 10,400
Grand Total			$167,220

All costs are estimated and include field QC sample analysis (field blanks and field duplicates) but not laboratory QC.

9.0 LITERATURE CITED

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Table 1. Top areas of interests in Northern California based on HUC8s (Luo et al., 2017).

HUC8	HUC8 Name	Area[1]
18020111	Lower American	SAC
18020161	Upper Coon-Upper Auburn	SAC
18020163	Lower Sacramento	SAC
18040003	San Joaquin Delta	SJD
18050001	Suisun Bay	SFB
18050002	San Pablo Bay	SFB
18050003	Coyote	SFB
18050004	San Francisco Bay	SFB
18060015	Monterey Bay	CC

[1] CC, Central Coast; SAC, Sacramento area, SFB, San Francisco Bay area; SJD, San Joaquin delta. Highlighted rows are monitored HUC8s

Table 2. Sampling schedule for FY17/18. For chemical screens, see Appendix 4.

Site*	Dry Season Monitoring		Rainstorm Monitoring		Total Number Samples	Total Cost**
	Aug 2017	June 2018	Fall 2017	Winter 2018		
ARC_DP		X	X		2	$ 8380
PGC010	X	X	X	X	4	$16,760
PGC021	X	X	X	X	4	$16,760
PGC022	X	X	X	X	4	$16,760
PGC040	X	X	X	X	4	$16,760
PGC058		X	X		4	$ 8380
FOL2	X	X	X	X	4	$16,760
FOL3[§]			X		1	$ 2990
FOL5[§]			X		1	$ 2990
WAL_CA		X	X		2	$ 8380
MCC040		X	X		2	$ 8380
SRC_JD		X	X		2	$ 8380
GUA_AB		X	X		2	$ 8380
10% QC	X	X	X	X	4	$16,760
Grand Total					40	$156,820

*For more information on sites, see Appendix 1

**Total number of samples consists of five analytical screens (estimated costs for planning): CY = carbaryl ($480; CY maybe be included in LC screen); DN = dinitroaniline herbicides + oxyfluorfen (short screen; $720); LC = liquid chromatography (short screen, $1700); PY-6 = pyrethroid (six analyte screen; $600); SA = synthetic auxin herbicides ($690).

[§]FOL3 and FOL5, mitigation monitoring only, no CY or DN screens

Table 3. Sediment monitoring, FY17/18.

Expected Sampling Period	Sites	No. of Samples	Cost per Sample*	Cost	Grand Total
Fall 2016	PCC010, PGC021/22, PGC040, FOL2, FOL3, FOL5	6	$4800	$4,333.50	
Spring 2016	PCC010, PGC021/22, PGC040, FOL2, FOL3, FOL5	6	$4800	$4,333.50	
Field duplicate	(one site)	1	$800	$1,444.50	$10,400

*Cost per sample, $800; costs are estimates and used for allocating lab time at CDFA

Table 4. Listed below are modifications for FY17/18 (from FY 16/17 Study 299 protocol, http://cdpr.ca.gov/docs/emon/pubs/protocol/study299_2016_17.pdf).

Change from FY 16/17	Justification
Discontinue sampling GRY030 (WAL_CA will be the sampling site in Suisun Bay HUC 8)	Walnut creek is the only mainstem creek in this HUC8; Grayson Creek is a tributary creek. Walnut Creek is 303d listed and a SPOT monitoring program sediment sampling site. WAL_CA has more detections than GRY030 in side-by-side comparisons. Dropping GRY030 will provide additional resources for sampling at other sites
Add sampling site on South San Ramon Creek (dependent on accessibility)	Waters draining from AL_VER are from an area with less than 50% urban population, thus it may not be appropriate for urban monitoring. South San Ramon Creek is a mainstem and tributary site in this HUC8
Discontinue sampling Arroyo de la Laguna at Verona Road (AL_VER; SFB)	
Add Guadalupe River sampling site (sampled in FY15/16); discontinue sampling Coyote River	Coyote Creek site has agricultural inputs for monitored pesticides. Guadalupe River is 303d listed; monitoring site is near a USGS gage station and a SPOT monitoring program sediment sampling site
Add CY and DN (short) screens to FOL2 and SFB monitoring	Pesticides in these screens have $\geq$ 9 ranking in SWPM for northern California (Appendixes 2, 3)
Discontinue monitoring FOL3 and FOL5 in 2018	These sites were monitored as mitigation sites at the CWQTP in Folsom. As contract 13-C0052 expires, there is no longer funding to collect flow weighted samples for measuring the efficacy of the pond

Table 5. 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

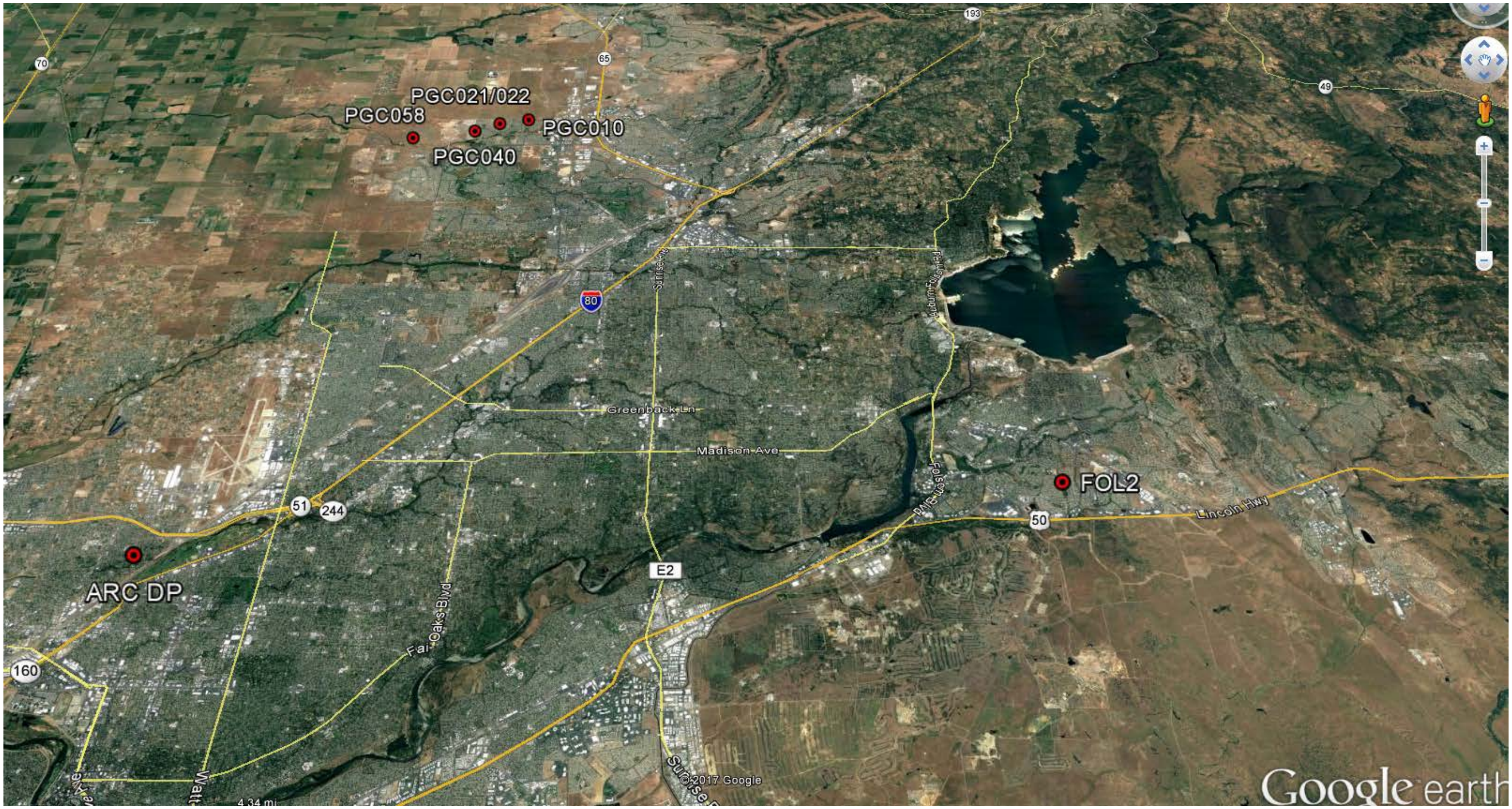

Figure 1. Sacramento area ambient monitoring sites for FY17/18 (PGC021/022 are two distinct sites).

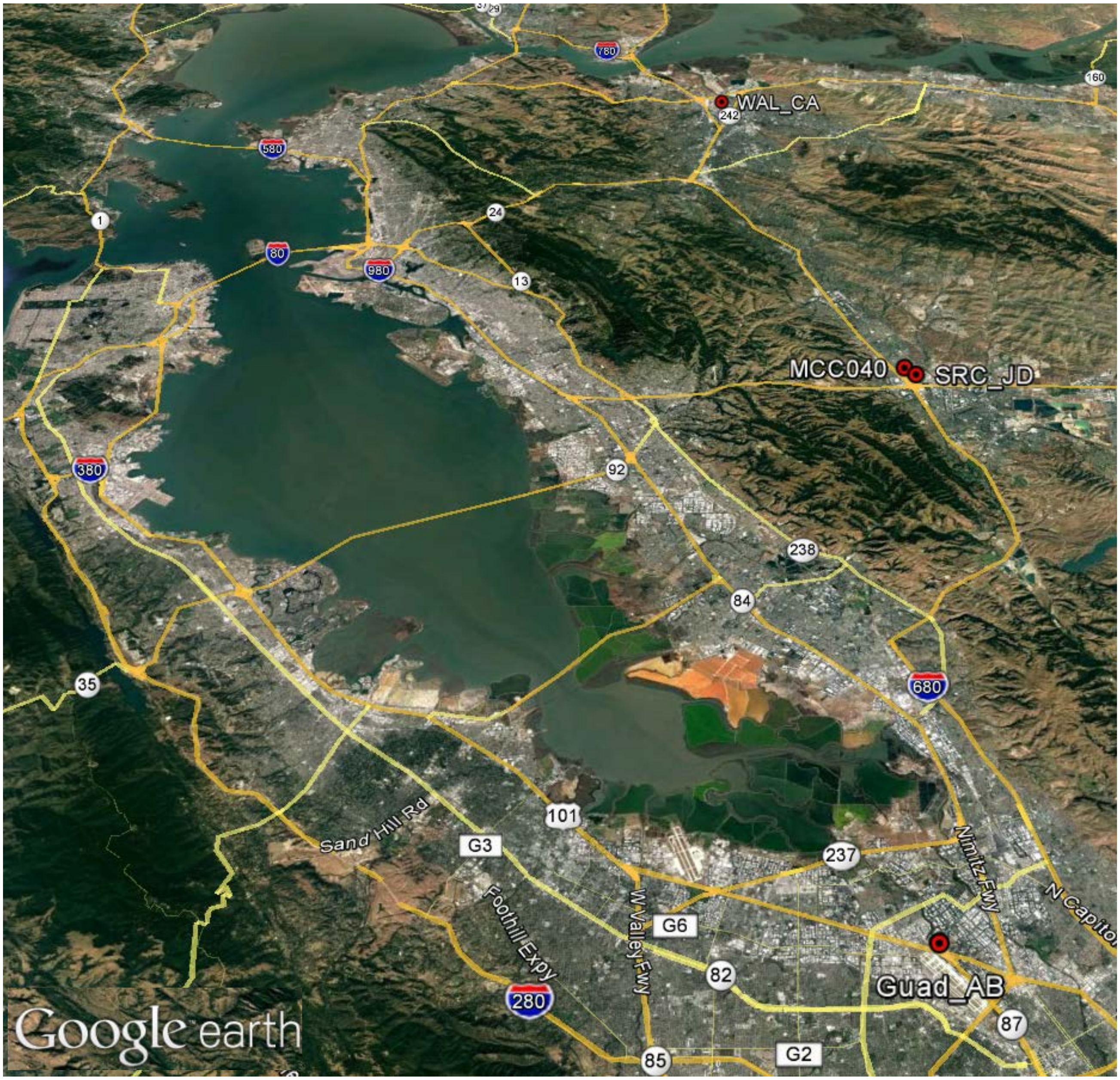

Figure 2. San Francisco Bay area ambient monitoring sites for FY17/18.

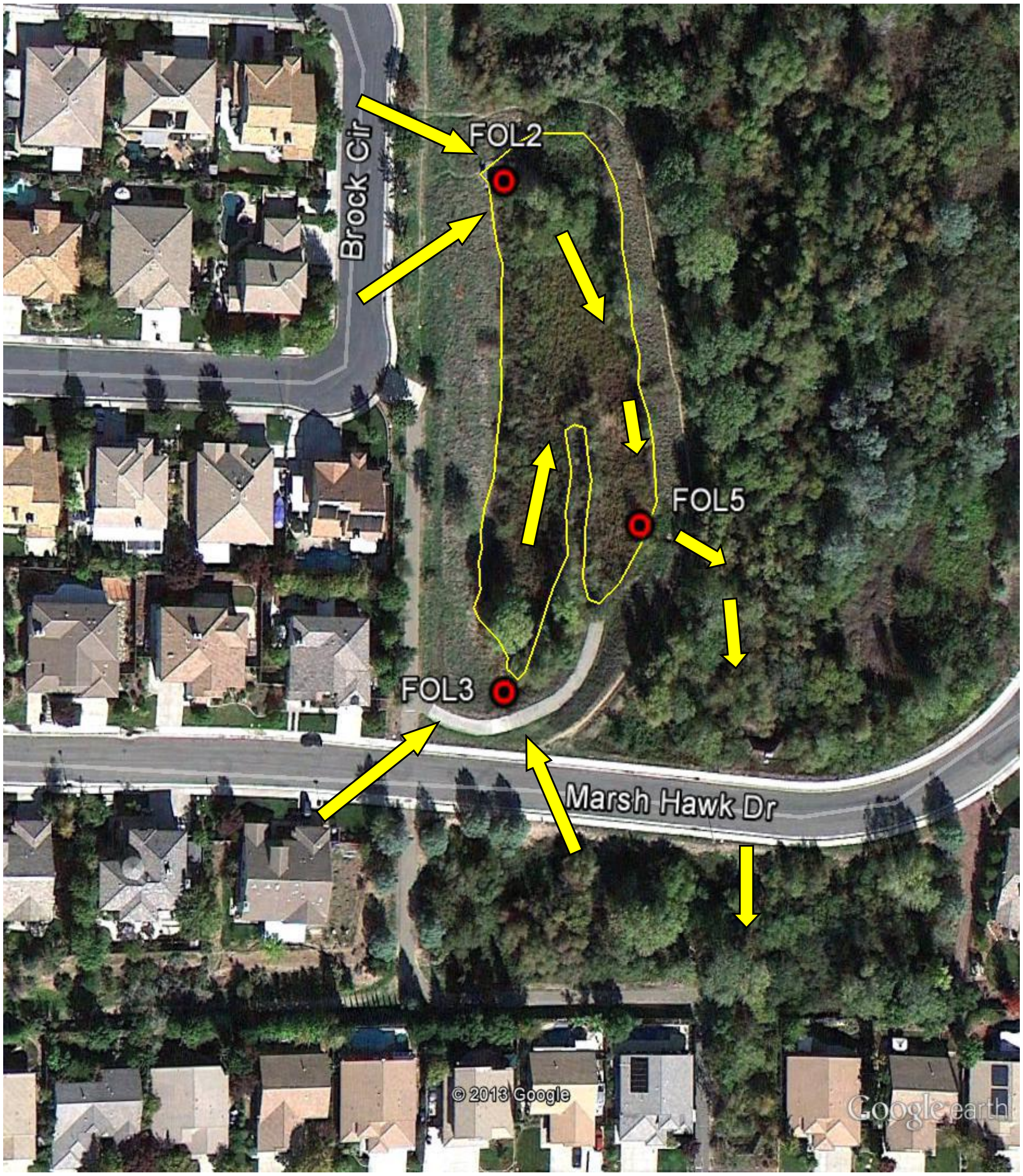

Figure 3. Constructed water quality treatment pond (CWQTP) in Folsom, California. The CWQTP is outlined in yellow with arrows indicating water flow direction (inputs at FOL2 and FOL3; outfall at FOL5). Flow gaging equipment has been installed at the CWQTP on Marsh Hawk Drive with contract 13-C0052 (http://cdpr.ca.gov/docs/emon/surfwtr/contracts.htm).

Appendix 1. Sampling site details for FY17/18.

Site Id	Site Type*	Sample Type	Description	City	HUC8	GPS Coordinates (NAD83)	
						Latitude	Longitude
PGC010	Source§	Water Sediment	Stormdrain outfall at Diamond Woods Circle,	Roseville	Upper Coon-Upper Auburn	38.80477	-121.32733
PGC021	Source§	Water Sediment	Single storm drain outfall at Opal and Northpark Drive	Roseville	Upper Coon-Upper Auburn	38.80267	-121.338551
PGC022	Source§	Water Sediment	Dual stormdrain outfall at Opal and Northpark Drive	Roseville	Upper Coon-Upper Auburn	38.802599	-121.338787
PGC040	RW§	Water Sediment	Pleasant Grove Creek at Veteran's Park	Roseville	Upper Coon-Upper Auburn	38.79857	-121.34802
PGC058	RW	Water	Pleasant Grove Creek at Hayden Pkwy and Blue Oaks Blvd	Roseville	Upper Coon-Upper Auburn	38.79477	-121.37251
ARC_DP	RW	Water	Arcade Creek at Del Paso	Sacramento	Lower American	38.628216	-121.420606
FOL2+	Source§ MT	Water Sediment	Brock Circle at open space	Folsom	Lower American	38.6503	-121.14494
FOL3+	Source MT	Water Sediment	Marsh Hawk Dr. at open space	Folsom	Lower American	38.64938	-121.14494
FOL5+	MT	Water Sediment	CWQTP outfall near Marsh Hawk Dr.	Folsom	Lower American	38.64969	-121.14459
WAL_CA	RW	Water	Walnut Creek near Concord Avenue	Concord	Suisun Bay	37.980630	-122.0516
MCC040	RW	Water	Big Canyon/Martin Canyon Creek near Dublin Boulevard and I-680	Dublin	San Francisco Bay	37.706412	-121.926687
SRC_JD	RW	Water	South San Ramon Creek at Johnson Drive	Dublin	San Francisco Bay	37.700976	-121.919837
GUA_AB	RW	Water	Guadalupe River at Airport Green Parking lot access near Airport Blvd	San Jose	Coyote	37.373560	-121.932830

*Source, stormdrain outfall; RW, receiving water on creek or stream; MT, mitigation site

§Long-term monitoring site (sampled by CDPR ≥ 5 years)

+limited, see protocol; CWQTP, constructed water quality treatment pond

Appendix 2. Priority pesticides for Placer and Sacramento Counties. Listed, pesticides with priorities greater or equal to the priority score of 9, with a "TRUE" monitoring recommendation from SWPM (based on acute toxicity). Priority model does not include homeowner pesticide use.

Pesticides with available analytical methods (CDFA)						
Pesticide	CDFA Screen*	3 Yr Average Use (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score
Bifenthrin	PY	28970	5	0.075	6	30
Permethrin	PY	15533	5	0.0106	6	30
Fipronil	LC	8633	5	0.11	5	25
Lambda-Cyhalothrin	PY	909	3	0.0035	7	21
Deltamethrin	PY	663	3	0.055	6	18
Cyfluthrin	PY	634	3	0.0125	6	18
Pendimethalin	DN	4134	4	5.2	4	16
Chlorfenapyr**	CF	2008	4	2.915	4	16
Cypermethrin	PY	1472	3	0.195	5	15
Oryzalin	LC	5256	4	15.4	3	12
Imidacloprid	LC	3756	4	34.5	3	12
2,4-D	SA	3702	4	13.1	3	12
Prodiamine	DN	1778	3	6.5	4	12
Diuron	LC	1112	3	2.4	4	12
Isoxaben	LC	758	3	10	4	12
Trifluralin	DN	437	3	7.52	4	12
Esfenvalerate	PY	72	2	0.025	6	12
Carbaryl	CY	204	2	0.85	5	10
Triclopyr	SA	1074	3	70	3	9
Tebuthiuron**	PI	701	3	50	3	9
Propiconazole	LC	570	3	21	3	9
Pesticides with no analytical methods for surface water (CDFA) - these pesticides will not be monitored						
Dichlobenil[ƚ]	none	8156	4	30	3	12
Dithiopyr	none	2841	4	20	3	12
Sulfometuron-methyl	none	178	2	0.45	5	10

*CY, carbaryl; CF, chlorfenapyr; DN, dinitroaniline herbicides+oxyfluorfen; LC, LC multi-analyte screen, PI, photosynthetic inhibitor; PY, pyrethroid; SA, synthetic auxin herbicides. See http://cdpr.ca.gov/docs/emon/pubs/em_methd_main.htm

**Will not be monitored. For chlorfenapyr, there have been no detections in 64 previous samples, and it is being monitored in southern California which has higher use. For tebuthiuron, there were no detections in 21 previous samples; it will be monitored when added to CDFA's LC multi-analyte screen.

[ƚ]Applied in Sacramento County only, by one applicator: Root Tamers in 2014. Root Tamers injects dichlobenil into sewers to prevent root clogging and growth.

Appendix 3. Priority pesticides for San Francisco Bay area sampling sites. Listed, pesticides with priorities greater or equal to the priority score of 9, with a "TRUE" monitoring recommendation from SWPM. Priority model does not include homeowner pesticide use.

Pesticides with available analytical methods (CDFA)						
Pesticide	CDFA Screen*	3 Yr Average Use (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score
Permethrin	PY	31732	5	0.0106	6	30
Fipronil	LC	15870	5	0.11	5	25
Bifenthrin	PY	8898	4	0.075	6	24
Cyfluthrin	PY	8219	4	0.0125	6	24
Deltamethrin	PY	5392	4	0.055	6	24
Lambda-cyhalothrin	PY	1566	3	0.0035	7	21
Diuron	LC	10892	5	2.4	4	20
Cypermethrin	PY	3214	4	0.195	5	20
Bromacil	LC	7678	4	6.8	4	16
Pendimethalin	DN	5076	4	5.2	4	16
Imidacloprid	LC	6110	4	34.5	3	12
Triclopyr	SA	5190	4	70	3	12
2,4-D	SA	2470	4	13.1	3	12
Chlorfenapyr**	CF	2141	3	2.915	4	12
Chlorantraniliprole	LC	1755	3	4.9	4	12
Prodiamine	DN	1657	3	6.5	4	12
Isoxaben	LC	748	3	10	4	12
DDVP**	OP	174	2	0.035	6	12
Esfenvalerate	PY	89	2	0.025	6	12
Carbaryl	CY	182	2	0.85	5	10
Diazinon	OP	104	2	0.105	5	10
Oxyfluorfen	DN	83	2	0.29	5	10
Malathion	LC	70	2	0.295	5	10
Oryzalin	LC	2157	3	15.4	3	9
Indoxacarb	LC	916	3	84	3	9
Propiconazole	LC	751	3	21	3	9
Pyriproxyfen	LC	588	3	56	3	9
Pesticides with no analytical methods for surface water (CDFA) - these pesticides will not be monitored						
Sulfometuron-methyl	none	331	2	0.45	5	10
PCNB	none	2177	3	50	3	9
Spinosad	none	1067	3	90	3	9
Dithiopyr	none	915	3	20	3	9

*CY, carbaryl; CF, chlorfenapyr; DN, dinitroaniline herbicides+oxyfluorfen; LC, multi-analyte LC screen, OP, Organophosphorus; PY, pyrethroid; SA, synthetic auxin herbicides. See http://cdpr.ca.gov/docs/emon/pubs/em_methd_main.htm
**Will not be monitored. For chlorfenapyr, there have been no detections in 64 previous samples, and it is being monitored in southern California which has higher use. For DDVP, there have been no detections in 206 previous samples.

Appendix 4. Chemical analysis of pesticides in the Northern California urban monitoring Study 299. The California Department of Food and Agriculture (CDFA) will analyze all water samples. Specific methods can be found at http://www.cdpr.ca.gov/docs/emon/pubs/em_methd_main.htm.

Analyte Screen (Method ID)	Pesticide	Method Detection Limit ($\mu g\ L^{-1}$)	Reporting Limit ($\mu g\ L^{-1}$)
Carbaryl (CY)* (EMON-SM11.3)	carbaryl	0.0111	0.05
Dinitroaniline (DN) (EMON-SM-05-006)	oxyfluorfen	0.0101	0.05
	pendimethalin	0.012	0.05
	prodiamine	0.0124	0.05
	trifluralin	0.0144	0.05
LC-multi screen (LC)* (EMON-SM-05-032)	azoxystrobin	0.0012	0.02
	bensulide	0.00066	0.02
	bromacil	0.00097	0.02
	chlorantraniliprole	0.00182	0.02
	carbaryl	0.0111	0.05
	chlorpyrifos	0.00123	0.02
	diazinon	0.004925	0.02
	etofenprox	0.00184	0.02
	diuron	0.0116	0.02
	fipronil	0.000864	0.01
	fipronil amide	0.00157	0.01
	fipronil desulfinyl	0.00110	0.01
	fipronil desulfinyl amide	0.00244	0.01
	fipronil sulfide	0.00111	0.01
	fipronil sulfone	0.000732	0.01
	imidacloprid	0.01135	0.02
	indoxacarb	0.00066	0.02
	isoxaben	0.0014	0.02
	malathion	0.00103	0.02
	oryzalin	0.0035	0.02
	oxadiazinon	0.00071	0.02
	propiconazole	0.00142	0.02
	pyraclostrobin	0.000535	0.02
	pyriproxyfen	0.00114	0.02
Pyrethroid (PY-6) (EMON-SM-05-022)	bifenthrin	0.00176	0.005
	cyfluthrin	0.00173	0.015
	cypermethrin	0.00175	0.015
	deltamethrin/tralomethrin	0.00177	0.005
	esfenvalerate/fenvalerate	0.00167	0.005
	lambda-cyhalothrin	0.00115	0.015
	permethrin cis	0.00352	0.015
	permethrin trans	0.00768	0.015
Synthetic Auxin Herbicides (SA) EMON-SM-05-012)	2,4-D	0.015	0.05
	dicamba	0.017	0.05
	MCPA	0.022	0.05
	triclopyr	0.020	0.05

*carbaryl may be added to the LC multi-analyte screen and trifloxystrobin dropped.

Appendix 5. Chemical analysis of pyrethroids in the Northern California urban monitoring Study 299. The Department of Food and Agriculture will analyze sediment samples (Method EMON-SM 52-9).

Pesticide	Method Detection Limit (ng g^{-1} dry wt)	Reporting Limit (ng g^{-1} dry wt)
Bifenthrin	0.1083	1.0
Cyfluthrin	0.183	1.0
Cypermethrin	0.107	1.0
Deltamethrin/Tralomethrin	0.0661	1.0
Esfenvalerate/Fenvalerate	0.143	1.0
Fenpropathrin	0.1094	1.0
Lambda-cyhalothrin	0.1154	1.0
Permethrin cis	0.1159	1.0
Permethrin trans	0.1352	1.0
Resmethrin	0.8702	1.5