Department of Pesticide Regulation
Environmental Monitoring Branch
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STUDY 299: Ambient and Mitigation Monitoring in Urban Areas in Northern California. FY 2016/2017

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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 (Ensminger et al., 2013; Budd et al., 2015). Urban pesticide use remains high (CDPR, 2013a), pesticides occur frequently in urban runoff (Budd et al., 2015; Weston and Lydy, 2014; Ensminger et al., 2013; Gan, 2012), and many urban waterbodies do not meet water quality standards (State Water Resources Control Board, 2015).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, 2015). SWPP will continue to evaluate sources of pesticide runoff, monitor larger urban watersheds, and evaluate toxicity and mitigation methods. In FY16/17 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 (FY16-17), Northern California urban monitoring, the objectives are:

1) Identify the presence and concentrations of pesticide contamination in urban waterways;
2) Increase the spatial distribution of urban monitoring by monitoring at the watershed level;
3) Determine the toxicity of water samples at selected monitoring sites;
4) Evaluate the effectiveness of a stormwater retention (or water quality) pond to reduce pesticides from urban runoff;
5) Evaluate the magnitude of measured concentrations relative to water quality or aquatic toxicity thresholds; and
6) Evaluate the effectiveness of CDPR's surface water regulation Section 6970 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 (SWPP), 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

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4.0 STUDY PLAN

4.1 Monitoring sites. Ambient surface water monitoring will occur in the Sacramento and San Francisco Bay areas (SFB). Monitoring sites are selected to determine presence of pesticide runoff and pesticide contamination at the urban watershed level. In keeping with this last goal, the Northern California monitoring program will begin to look at additional receiving water sites at the mouth of urban watersheds.

In the Sacramento area, four long-term monitoring sites have been established in Roseville at three stormdrain outfalls and at one downstream sampling site in the Pleasant Grove Creek Watershed (Appendix 1). The Roseville sites have been sampled since 2008, providing a baseline for observing trends. Also in Roseville, one additional receiving water site (PGC058) will be added during rainstorm events and compared to the more upstream receiving water site (PGC040). PGC058 is ponded or dry in late spring and summer months. However, it is the furthest urban downstream monitoring site for Pleasant Grove Creek watershed. PGC058 is also a SPoT monitoring site (SWAMP, 2016) and has briefly been sampled in CDPR's urban monitoring program in 2011. In water samples, 2,4-D, dicamba, bifenthrin, and imidacloprid have been previously detected at PGC058.

Also in the Sacramento area, Arcade Creek will be monitored, albeit at an upstream site due to safety and flow issues at the Norwood site (Figure 1; Appendix 1). The Arcade Creek site on Del Paso is the furthest downstream site in the Arcade Creek watershed that is not affected by backup due to the Natomas Drain and Sacramento River.

Monitoring sites in SFB will center on Alameda, Contra Costa, and Santa Clara counties, where total use of monitored pesticides is high (CDPR, 2013a). Monitoring will occur at the watershed level (rather than storm drain level) to further characterize watershed pesticide pollution.

Watersheds with higher population densities or total population will be targeted and will include multi-year analysis of watersheds in SFB. The current monitoring site on Coyote Creek (COY060) will remain as a major SFB site, measuring runoff from a large watershed in Santa Clara County. COY060 is also a SPoT monitoring site (SWAMP, 2016) and is about two miles upstream of USGS gaging site (USGS, 2016b). DPR initiated water monitoring at this site in 2014 because it was a SPoT sampling. As in FY15/16, MCC040 and GRY030 will also be monitored, but results will be compared to two new sites that are further downstream in the watershed and may be more reasonable monitoring sites for future monitoring as they encompass larger urban population areas (Figures 2 – 3; Appendix 2). In Contra Costa County, Walnut Creek will be monitored at Concord Avenue, a current SPoT sampling site (SWAMP, 2016). In Alameda County, Arroyo de la Laguna will be monitored at Verona Road. Based on outcomes from the CDPR's Urban Strategy workgroup, additional sites may be added to increase spatial distribution in SFB.

Mitigation monitoring will continue in Folsom at the Marsh Hawk constructed water quality treatment pond (CWQTP) (Figure 4; Appendix 3). At this CWQTP, two stormdrain outfalls provide input from urban neighborhoods to supply 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 between the inlets and outlet (sediment).

4.2 Monitoring Candidates. SWPP uses the Surface Water Prioritization Model (SWPM) to assist in pesticide selection for ambient monitoring. SWMP is based on current use patterns and aquatic toxicity benchmark data; the output is presented as a relative prioritization (final) score (Budd et al., 2013; Luo et al., 2015). The final score is used as a guideline for monitoring. Actual pesticides selected may vary due to budget constraints, sampling logistics, and laboratory resource. However, SWPP has commonly used the final score of 9 or greater to select pesticides for ambient monitoring as pesticides with this ranking have higher use (use score $\geq$ 3) and are potentially more toxic (tox score $\geq$ 3) (Ensminger, 2015; Deng, 2016; DaSilva, 2016). The final score of 9 was used for the selecting pesticides in Roseville and at Arcade Creek, as shown below:

	Criteria	Number of pesticides	
		Roseville sites	Arcade Creek
1.	Urban use Score $\geq$ 2 (excluding Rights of Way)[1]	70	65
2.	"TRUE" recommendation[2]	55	51
3.	Final Score $\geq$ 9 (based on acute toxicity)	25	25

[1]Roseville is located in Placer County but pesticide use likely mimics use in Sacramento. Both counties are used for prioritization. For Arcade Creek, monitoring priority was limited to Sacramento County.

[2] A TRUE recommendation removes pesticides that may have a high final score but are not likely to be detected based on physiochemical properties.

Twenty-five pesticides met the criteria for the Roseville and Arcade Creek sites (Appendix 3). Other pesticides may also be monitored if the selected pesticides are present in the CDFA's analytical screens, especially when CDFA's new multi-residue analytical method becomes available (Sue Peoples, personal communication). Some pesticides may not have an associated CDFA analytical method available and therefore will not be monitored. Chlorfenapyr was selected by SWMP. In monitoring for this pesticide in 52 water samples since August 2014, it has never been detected (Appendix 4). To maximize resources, chlorfenapyr will not be monitored in Northern California monitoring in FY16/17 until CDFA's multi-residue analytical method becomes available (LC screen, fall 2016).

Monitoring in SFB will take place in three counties (Alameda, Contra Costa, and Santa Clara counties). These counties were used to set pesticide priorities with SWPM. Because of limited resources and sampling logistics, SFB will only be sampled twice a year (one dry, one rain event). Therefore SWMP was run by season, looking at pesticide use three months prior to expected sampling dates (October 2016 and June 2017).

The below listed criteria were used to select pesticides.

	Criteria	Number of pesticides	
		Fall rain event	Spring dry event
1.	Urban use Score $\geq$ 2 (excluding Rights of Way)	77	72
2.	"TRUE" recommendation	61	60
3.	Final Score $\geq$ 9 (based on acute toxicity)	23	18

Fewer pesticides were selected for SFB than for the Sacramento Area (Appendix 5). Other pesticides may also be monitored if the selected pesticides are present in the CDFA's analytical methods, especially when CDFA's new multi-residue analytical method becomes available. Some selected pesticides may not have CDFA analytical methods available and therefore will not be monitored. Of pesticides recommended by SWMP, chlorfenapyr (explained previously), carbaryl, malathion, and DDVP will not be monitored in SFB. Carbaryl and malathion will not be monitored because, despite meeting the first criterion, their total use was the low. DDVP will not be monitored because its detection frequency is very low. DDVP has been monitored for 198 times in CDPR's urban monitoring program and has never been detected. In the Surface Water database, DDVP has been monitored for 6,424 times with only 9 detections (0.14% detection frequency). All 9 detections were alongside agricultural fields and most (8) were detected in small creeks likely containing agricultural runoff. In addition, it is known that DDVP has a very short half-life, ranging from less than 1 day to 4 days (NPIC, 1994; PPPD, 2016). Thus, it is highly unlikely that DDVP will be detected in larger urban creeks and rivers that will be monitored in SFB. It will not be monitored for in Northern California until the CDFA's multi-residue analytical method becomes available (GC screen, early 2017).

For mitigation monitoring, an additional criteria was added to select pesticides for 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 criteria 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 (Ensminger, 2015).

4.3 Water sampling. Roseville sites will be sampled four times during the year (two dry season events and two rainstorm events). Dry season events will take place in August 2016 and in June 2017 (Table 1). The rainstorm events will occur in September – November (the first flush rainstorm of the 2016-2017 water year, if possible) and in the winter of 2017 (February – March). Arcade Creek and SFB sites will be monitored for only one dry season sampling event (in June) and during one early season rain storm event due to resource constraints and logistics of sampling multiple sites during rain events (Tables 1, 2).

Folsom sites at the CWQTP will be sampled during two rainstorm events (Table 3). Flow-weighted samples will be taken during the entire storm event such that the total mass of pesticides into and out of the CWQTP can be measured. Rain storms will coincide with the rain event sampling in Roseville. Flow-weighted samples are not readily taken during dry events.

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 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. At least 10% of the field samples will be field blanks or field duplicates.

4.4 Sediment sampling. Sediments will be collected two times a year at sampling sites in Roseville and Folsom (Table 4). 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.

4.5 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*. The Roseville long-term monitoring sites will be the main focus for toxicity testing. One additional site in Folsom (FOL100) will be monitored to provide toxicity testing to support USGS's Reconnaissance study of surface waters in California (USGS, 2016a). USGS will analyze for 152 pesticides and degradates.

4.6 Field measurements. Water physiochemical properties (dissolved oxygen, electrical conductivity, pH, turbidity, 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 by using Hach Sigma 950 flow meters

(Sisnernoz et al., 2012). A USGS gauging station records flow near the sampling sites on Arcade and Coyote Creeks (USGS, 2016b).

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

4.9 Modifications for FY16/17. 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 15/16. Main differences include changes in the sampling schedule in Folsom, change in sampling site at Arcade Creek, and changes in sampling sites and analytes monitored in SFB (Table 5).

5.0 CHEMICAL ANALYSIS

CDFA will conduct the pesticide analysis for water samples. CDFA will analyze seven different analyte groups which will include 33 pesticides and degradates (Table 6). During FY 16/17, CDFA will have available a multi-residue analytical method that may include over 65 analytes; some monitoring will switch to this method as it becomes available (within the budget of this study; Tables 1, 2 and 3). The California Department of Fish and Wildlife (CDFW) will conduct pesticide analyses for eight pyrethroids in sediment (Table 7). 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 field 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).

Initial analysis of urban monitoring data has shown that the data is heavily skewed and contains numerous non-detects often with different reporting limits (RL) which may violate the normality and equal variance assumptions of the parametric procedures (e.g., ANOVA and *t*-tests) (Ensminger et al., 2013). The non-normal structure posits a violation of the normality assumption of the commonly-used parametric procedures (tests based on the estimate of mean and standard deviation). Although some parametric procedures may be robust to the normality assumption, the use of these procedures on non-normal data will still lead to bias and low power. In addition, the substitution of non-detections can result in inaccuracy of estimate and test result (Helsel, 2012).

The presence of non-detections and multiple RLs limits the application of some widely-used parametric procedures, such as analysis of variance (ANOVA) and *t*-tests. 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. In other words, the procedure is not distribution free and may lose power if the data does not follow a specific distribution.

In order to appropriately address the aforementioned characteristics of the sample data, a more generic and distribution-free approach, non-parametric statistics, will be used in this study. Helsel (2012) illustrated the application of non-parametric procedures to skewed and censored environmental data. The data will be analyzed by using R statistical program (http://www.r-project.org/), the Nondetects and Data Analysis for environmental data (NADA) package for R (http://cran.r-project.org/web/packages/NADA/NADA.pdf), and/or 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 8):

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., fipronil, 2,4-D, etc.; Table 6) at multiple locations (i.e., Folsom, Roseville, Sacramento, and San Francisco Bay; Appendixes 1 and 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 different 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. The ambient monitoring data from the Roseville sites and from FOL2 and FOL3 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.
4) Finally, we will attempt to develop 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 households drains water into the storm drain outfall/creek, residential density (percent of impervious areas), season, year, regulation, and so on. Further literature review will be conducted to identify possible explanatory variables in favor of the model.

7.0 TIMETABLE

Field Sampling:	August 2016 – June 2017
Chemical Analysis:	August 2016 – December 2017
Summary Report:	March 2018
SURF Data	March 2018

8.0 LABORATORY BUDGET

The cost for the CDFA chemical analyses of water samples for ambient monitoring is estimated below:

Monitoring Project		Projected Cost
Ambient Monitoring		
Sacramento area	$100,980	
San Francisco Bay Area	$ 42,570	
Ambient Monitoring Sub-total		$143,550
Mitigation Monitoring (Folsom)		$ 17,430
Grand Total		$160,980

CDFA's new multi-residue analytical method should be available in FY16/17 and this will alter CDFA's cost per sample. However, the total budgeted amount for ambient monitoring will not exceed these limits for water sample analysis (Tables 1, 2, 3). For sediment analysis, CDFW chemical analysis is estimated at $10,111.50 (Table 4); this funded supplied through contract 15-C0104. All costs are estimated and include field QC sample analysis (field blanks and field duplicates) but not laboratory QC.

9.0 LITERATURE CITED

Bennett, K. 1997. California Department of Pesticide Regulation SOP FSWA002.00: Conducting surface water monitoring for pesticides. http://www.cdpr.ca.gov/docs/emon/pubs/sops/fswa002.pdf

Budd, R., A. O'Geen, K. S. Goh, S. Bondarenko, J. Gan. 2009. Efficacy of constructed wetlands in pesticide removal from tailwaters in the Central Valley, California. Environmental Science and Technology 43: 2925-2930

Budd, R., X. Deng, M. Ensminger, K. Starner, and Y. Luo. 2013. Method for Prioritizing Urban Pesticides for Monitoring California's Urban Surface Waters http://cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/budd_et_al_2013.pdf

Budd, R., M.P. Ensminger, D. Wang, K.S. Goh. 2015. Journal of Environmental Quality. DOI: 10.2134/jeq2015.01.0018

CDPR. 2013a. California Pesticide Information Portal (CALPIP)

CDPR. 2013b. California Code of Regulations. Section 6970. http://www.cdpr.ca.gov/docs/legbills/calcode/040501.htm#a6970

DaSilva, A.2016. Study 306. Surface water monitoring for pesticides in Agricultural areas of Northern California. http://cdpr.ca.gov/docs/emon/pubs/protocol/study306_dasilva_2016.pdf

Deng, X. 2016. Study 304. Surface water monitoring for pesticides in agricultural areas in central coast and Southern California, 2016. http://cdpr.ca.gov/docs/emon/pubs/protocol/study304_deng_2016.pdf

Ensminger, M. and K.S. Goh. 2011. Total organic carbon analysis for sediment samples.
Ensminger, M. 2013a. Analysis of whole sample suspended sediments in water http://cdpr.ca.gov/docs/emon/pubs/sops/meth010.01.pdf.
Ensminger, M. 2013b. Water TOC analysis using the Shimadzu TOC-VCSN and ASI-V autosampler. http://cdpr.ca.gov/docs/emon/pubs/sops/meth01100.pdf
Ensminger, M. P., R. Budd, K. C. Kelley, and K.S. Goh. 2013. Pesticide occurrence and aquatic benchmark exceedances in urban surface waters and sediments in three urban areas of California, USA, 2008-2011.
Ensminger, M. 2015. Ambient and mitigation monitoring in urban areas in Northern California. http://cdpr.ca.gov/docs/emon/pubs/protocol/study299_ambient_mitigation_urban_areas.pdf
Gan, J., S. Bondarenko, L. Oki, D. Haver, and J.X. Li. 2012. Occurrence of fipronil and its biologically active derivatives in urban residential runoff. Environmental Science and Technology 46:1489-1495.
Goehring, M. 2008. California Department of Pesticide Regulation SOP FSWA014.00: Instructions for the use of the Global FP101 and FP201 flow probe for estimating velocity in wadable streams. http://www.cdpr.ca.gov/docs/emon/pubs/sops/fswa01401.pdf
Helsel, D. R. (2012). *Statistics for censored environmental data using Minitab® and R. 2nd ed.* Hoboken, NJ: John Wiley & Sons, Inc.
Jones, D. 1999. California Department of Pesticide Regulation SOP QAQC004.01: Transporting, packaging, and shipping samples from the field to the warehouse or laboratory. http://www.cdpr.ca.gov/docs/emon/pubs/sops/qaqc0401.pdf
Kelley, K. 2007. Pilot monitoring of pesticides residues in urban creeks of Sacramento County. http://cdpr.ca.gov/docs/emon/pubs/protocol/study247protocol.pdf
Lisker, E. and K.S. Goh. 2010. Total suspended solids analysis. https://www.youtube.com/watch?v=bs0I-jkZ658&index=4&list=PL6E5EB26821530A26
Mamola, M. 2005. California Department of Pesticide Regulation SOP FSWA016.00: Collecting sediment samples for pesticide analysis. http://www.cdpr.ca.gov/docs/emon/pubs/sops/fswa016.pdf
Luo, Y., M. Ensminger, R. Budd, X. Deng, and A. DaSilva. 2015. Methodology for prioritizing pesticides for surface water monitoring in agricultural and urban areas II: Refined priority list. http://cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/prioritization_report_2.pdf or http://cdpr.ca.gov/docs/emon/surfwtr/sw_models.htm
Segawa, R. 1995. California Department of Pesticide Regulation SOP QAQC001.00: Chemistry laboratory quality control. http://www.cdpr.ca.gov/docs/emon/pubs/sops/qaqc001.pdf
Sisneroz, J., Q. Xiao, L.R. Oki, B.J. Pitton, D.L. Haver, T. J. Majcherek, R.L. Mazalewski, and M. Ensminger. 2012. Automated sampling of storm runoff from residential areas. http://cdpr.ca.gov/docs/emon/surfwtr/swposters/auto_sampling_residential_areas.pdf
State Water Resources Control Board. 2015. Impaired water bodies. http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2012.shtml
SWAMP. 2016. SPoT: Stream Pollution Trends Monitoring Program. Trends in chemical contamination, toxicity and land use in Californial watersheds. http://www.waterboards.ca.gov/water_issues/programs/swamp/spot/
USGS. 2015. Water Resources of the United States. Hydrologic Units. http://water.usgs.gov/GIS/huc.html
USGS. 2016a. Reconnaissance study of surface waters in California. http://ca.water.usgs.gov/projects/PFRG/CurrentProjects.html#2014-20
USGS. 2016b. National Water Information System: Web interface, current conditions for California: streamflow. http://waterdata.usgs.gov/ca/nwis/current/?type=flow
Weston, D.P. and M.J. Lydy. 2014. Toxicity of the insecticide fipronil and its degradates to benthic macroinvertebrates of urban streams. Environmental Science and Technology 48:1290-1297.

Table 1. Ambient monitoring schedule and analytical cost estimates for water samples collected in Sacramento area, FY 16/17 and analyzed by CDFA

Site*	Analyte Group**	Dry Season Monitoring§		Rainstorm Monitoring§		QC Field samples	Total Number Samples	Cost/ Sample	Total Cost
		Ag 16	Ju 17	S-D 16	W 17				
		-------- Number of Samples ---------							
ARC_DP PGC010 PGC021 PGC022 PGC040 PGC058	CY	4	5	6	5	2	22	$480	$10,560
	DN short	4	5	6	5	2	22	$840	$18,480
	FP/OP	4	5	6	5	2	22	$840	$18,480
	IMD	4	5	6	5	2	22	$600	$13,200
	PI short	4	5	6	5	2	22	$540	$11,880
	PY-6	4	5	6	5	2	22	$600	$13,200
	SA	4	5	6	5	2	22	$690	$15,180
Total		140				14	154		$100,980

*PGC058 will only be sampled in two rain events and Arcade Creek will only be sampled in one dry and one rain event.

**CY = carbaryl; FP = fipronil + degradates; OP = organophosphates (chlorpyrifos, diazinon, and malathion); IMD = imidacloprid; DN = dinitroaniline herbicides + oxyfluorfen (short screen); PI = photosynthetic inhibitor herbicides (short screen); PY-6 = pyrethroid (six analyte screen); SA = synthetic auxin herbicides

§Ag 16, August 2016; Ju 17, June 2017; S-D 16, September - December 2016; W 17, Winter 2017.

Table 2. Ambient monitoring schedule and analytical cost estimates for water samples collected in the San Francisco Bay Area, California, FY 2016-2017 and analyzed by CDFA

Site	Analyte Group*	Rainstorm Monitoring**	Dry Season Monitoring	QC Field samples	Total Number Samples	Cost/ Sample	Cost
		-------- Number of Samples --------					
COY060 GYR030 MCC040 Walnut Creek Arroyo de la Laguna	DN Short	5	5	1	11	$840	$9,240
	FP	5	5	1	11	$600	$6,600
	IMD	5	5	1	11	$600	$6,600
	PI short	5	5	1	11	$540	$5,940
	PY-6	5	5	1	11	$600	$6,600
	SA	5	5	1	11	$690	$7,590
Totals		60		6	66		$42,570

*DN = dinitroaniline herbicides + oxyfluorfen (short screen); FP = fipronil + degradates; IMD = imidacloprid; PI = photosynthetic inhibitor herbicides (short screen); PY-6 = pyrethroid (six analyte screen); SA = synthetic auxin herbicides.

** First flush rain event in fall 2016 is targeted. Dry sampling will be in June 2017

Table 3. Monitoring schedule and analytical cost estimates for mitigation monitoring water samples collected in Folsom, California, FY 16/17 and analyzed by CDFA

Site	Analyte Group*	Rainstorm Monitoring[§]		QC Samples	Total Number Samples	Cost/ Sample	Total Cost
		S-D 16	W 17				
		---------- Number of Samples ----------					
FOL2 FOL3 FOL5	FP	3	3	1	7	$600	$4200
	IMD	3	3	1	7	$600	$4200
	PY-6	3	3	1	7	$600	$4200
	SA	3	3	1	7	$690	$4830
Totals		24		4	28		$17,430

[§]S-D 16, September - December 2016; W 17 = winter 2017; monitoring will only occur in rainy season to allow for flow weighted sample collection.

*FP = fipronil + degradates; IMD = imidacloprid; PY-6 = pyrethroid (six analyte screen); SA = synthetic auxin herbicides

Table 4. Monitoring schedule and analytical cost estimates for sediment samples collected during FY 2016-2017, and analyzed by CDFW for pyrethroids

Expected Sampling Period	Sites	No. of Samples	Cost per Sample*	Cost	Grand Total
Fall 2016	PCC010, PGC019**, PGC040, FOL2, FOL3, FOL5	6	$722.25	$4,333.50	
Spring 2016	PCC010, PGC019, PGC040, FOL2, FOL3, FOL5	6	$722.25	$4,333.50	
Field duplicates	Selected sites	2	$722.25	$1,444.50	$10,111.50

*$535 per sample + 35% overhead

**A combination of PGC021 and PGC022

Table 5. Listed below are modifications from FY 15/16 Study 299 protocol (http://www.cdpr.ca.gov/docs/emon/pubs/protocol/study299_ambient_mitigation_urban_areas.pdf)

Change from FY 15/16	Justification
Discontinue sampling at FOL100 (analytical chemistry)	FOL100 was sampled to support bioassessment contract 13-C0029 (http://cdpr.ca.gov/docs/emon/surfwtr/contracts.htm) which ended in June 2016. FOL will be monitored for toxicity to support USGS's pesticide study (USGS, 2016a)
Monitor Marsh Hawk (Folsom) CWQTP (FOL2, FOL3, FOL5) only during two rain events	The purpose of these sites is to investigate the effectiveness of the CWQTP by observing differences in mass loading of pesticides between the inlets and outlet. Flow-weighted samples have been shown to best sampled during rain events. Sufficient grab sample data already exists for dry season monitoring; currently there are 937 data points from 50 different dry season sampling events (2009-2015)
Terminate sediment sampling at Folsom sites TRP1 and TPR2 (a second CWQTP in Folsom)	Lack of funding; contract 10-C0116 ended, which supported this work
Move Arcade Creek site ≈2 miles upstream	New site is not influenced by backup by Natomas Drain, has safer access, and is closer to USGS gage station 11447360
Drop chlorfenapyr dropped from sampling (until CDFA multi-reside analytical method becomes available)	Dropped due to resource constraints and due to lack of detections in previous monitoring. In monitoring for this pesticide in 52 water samples since August 2014, it has never been detected
In the San Francisco Bay area, add sampling sites on Walnut Creek (Contra Costa County) and on Arroyo de la Laguna (Alameda County); drop site on Guadalupe River	Increase spatial distribution in San Francisco Bay area; site on Guadalupe River suspended due to budget and proximity to sampling site on Coyote Creek
Number of analytes monitored from San Francisco Bay area sites increased	More fully characterize pesticide contamination in Bay area.
Add PGC058 to Roseville sampling during rain event	Determine inputs from Kaseberg Creek and South Branch of Pleasant Grove Creek during rain events.
Measure dissolved organic carbon in water samples	Factor to estimate pyrethroid bioavailability in water samples.

Table 6. 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.

Pesticide	Analyte Screen (Method ID)	Method Detection Limit (µg L^{-1})	Reporting Limit (µg L^{-1})
Carbaryl	Carbaryl (CY) (EMON-SM11.3)	0.0111	0.05
Fipronil	Fipronil (FP) + Organophosphate (OP) (EMON-SM-05-013)	0.004	0.05
Fipronil sulfide		0.003	0.05
Fipronil sulfone		0.005	0.05
Fipronil desulfinyl		0.003	0.05
Fipronil desulfinyl amide		0.005	0.05
Fipronil amide		0.005	0.05
Diazinon		0.0012	0.01
Chlorpyrifos		0.0079	0.01
Malathion		0.0117	0.04
Imidacloprid	Imidacloprid (IMD)	0.0101	0.05
Bifenthrin	Pyrethroid (PY-6) (EMON-SM-05-022)	0.00176	0.005
Cyfluthrin		0.00173	0.015
Cypermethrin		0.00175	0.015
Deltamethrin/Tralomethrin		0.00177	0.005
Lambda-cyhalothrin		0.00115	0.015
Permethrin cis		0.00352	0.015
Permethrin trans		0.00768	0.015
Benfluralin	Dinitroaniline (DN) (EMON-SM-05-006)	0.012	0.05
Ethalfluralin		0.015	0.05
Oryzalin		0.021	0.05
Oxyfluorfen		0.0101	0.05
Pendimethalin		0.012	0.05
Prodiamine		0.0124	0.05
Trifluralin		0.0144	0.05
Bromacil	Photosynthetic Inhibitor Herbicides (PI) (EMON-SM-62.9)	0.031	0.05
Diuron		0.022	0.05
Prometon		0.016	0.05
Simazine		0.013	0.05
Tebuthiuron		0.014	0.05
2,4-D	Synthetic Auxin Herbicides (SA) EMON-SM-05-012)	0.015	0.05
Dicamba		0.017	0.05
MCPA		0.022	0.05
Triclopyr		0.020	0.05

Table 7. Chemical analysis of pyrethroids in the Northern California urban monitoring Study 299. The Department of Fish and Wildlife (DFW) will analyze sediment samples.

Pesticide	Method Detection Limit (ng g^{-1} dry wt)	Reporting Limit (ng g^{-1} dry wt)
Bifenthrin	0.063	0.25
Cyfluthrin	0.129	1.25
Cypermethrin	0.131	1.25
Deltamethrin/Tralomethrin	0.222	1.0
Esfenvalerate/Fenvalerate	0.131	0.5
Fenpropathrin	0.044	0.25
Lambda cyhalothrin	0.053	0.5
Permethrin, cis	0.484	1.25
Permethrin, trans	0.8	2.5

The procedures for pyrethroid extraction and analysis in sediment can be found at http://www.cdpr.ca.gov/docs/emon/pubs/anl_methds/wpcl_pr_008.pdf and http://www.cdpr.ca.gov/docs/emon/pubs/anl_methds/wpcl_ms_67.pdf, respectively

Table 8. 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

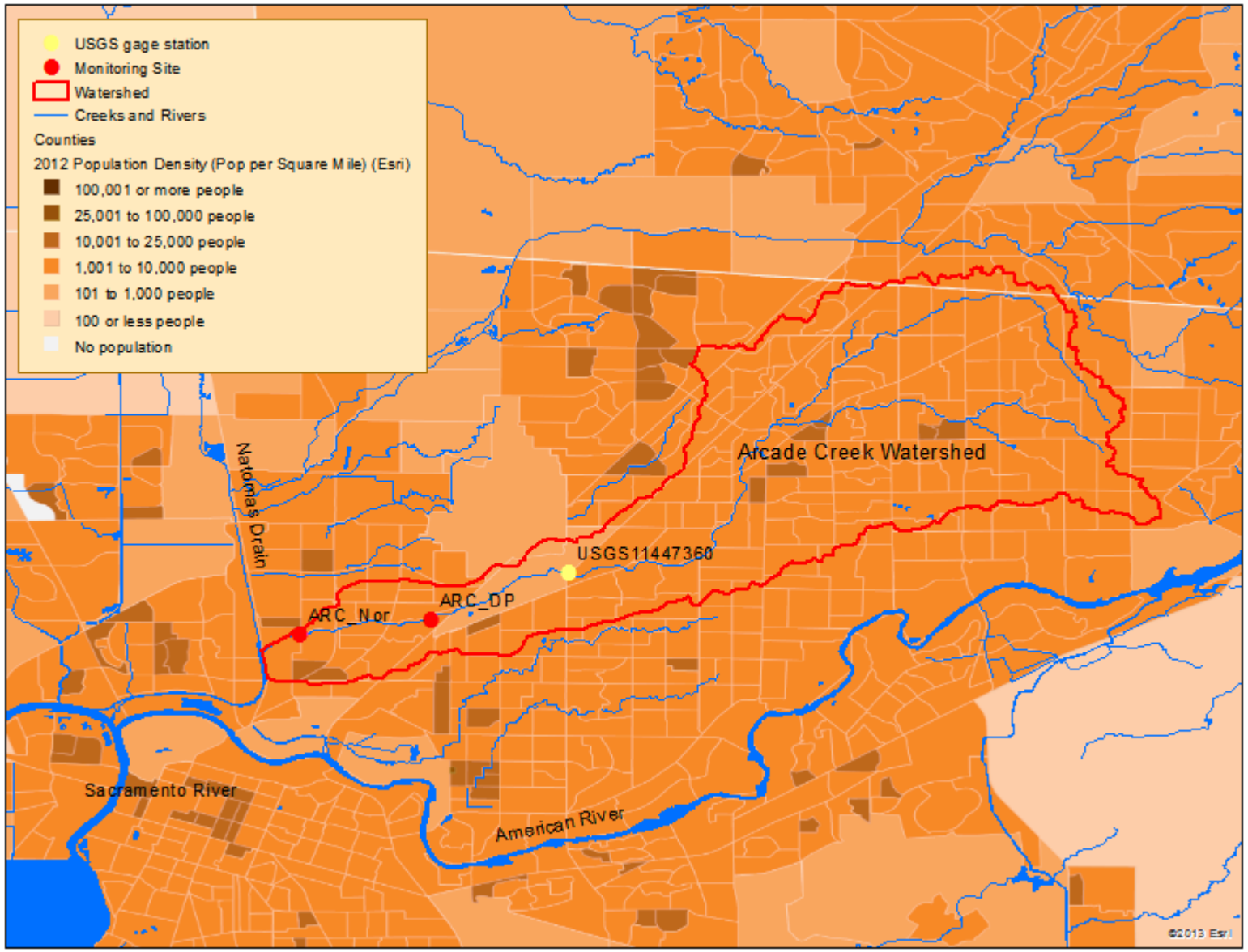

Figure 1. FY16/17 monitoring site on Arcade Creek (ARC_DP) in relation to original Arcade Creek watershed monitoring site (ARC_Nor). The USGS gaging station11447360 is upstream of ARC_DP monitoring site.

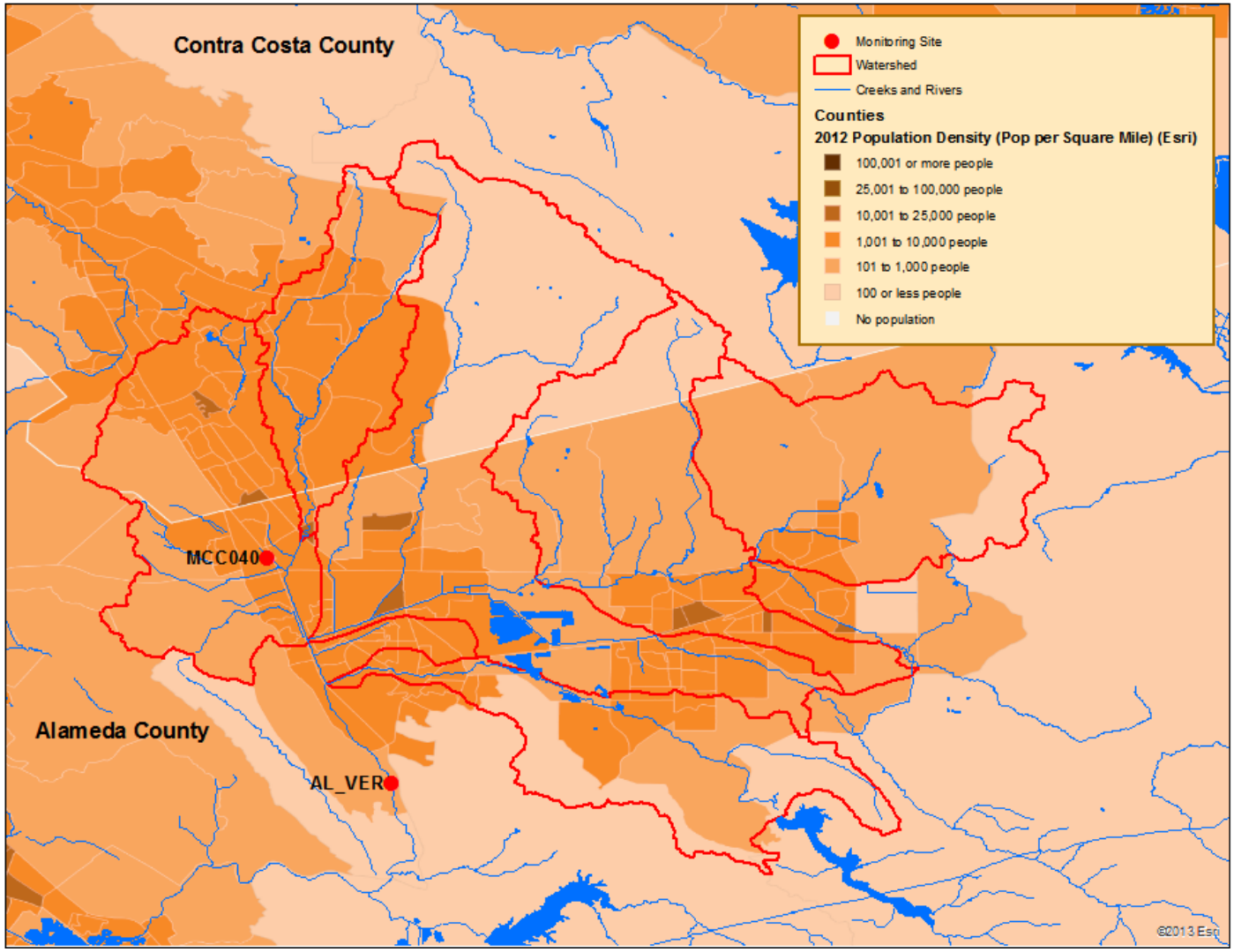

Figure 2. Location of MCC040 compared to new monitoring site AL_VER in the Tri-Valley area of the San Francisco Bay area (AL_VER, Arroyo de la Laguna at Verona Road). AL_VER encompasses runoff from several urban HUC12 watersheds; MCC040 encompasses urban runoff from part of one watershed (USGS, 2015). USGS gaging station11176900 is present at AL_VER.

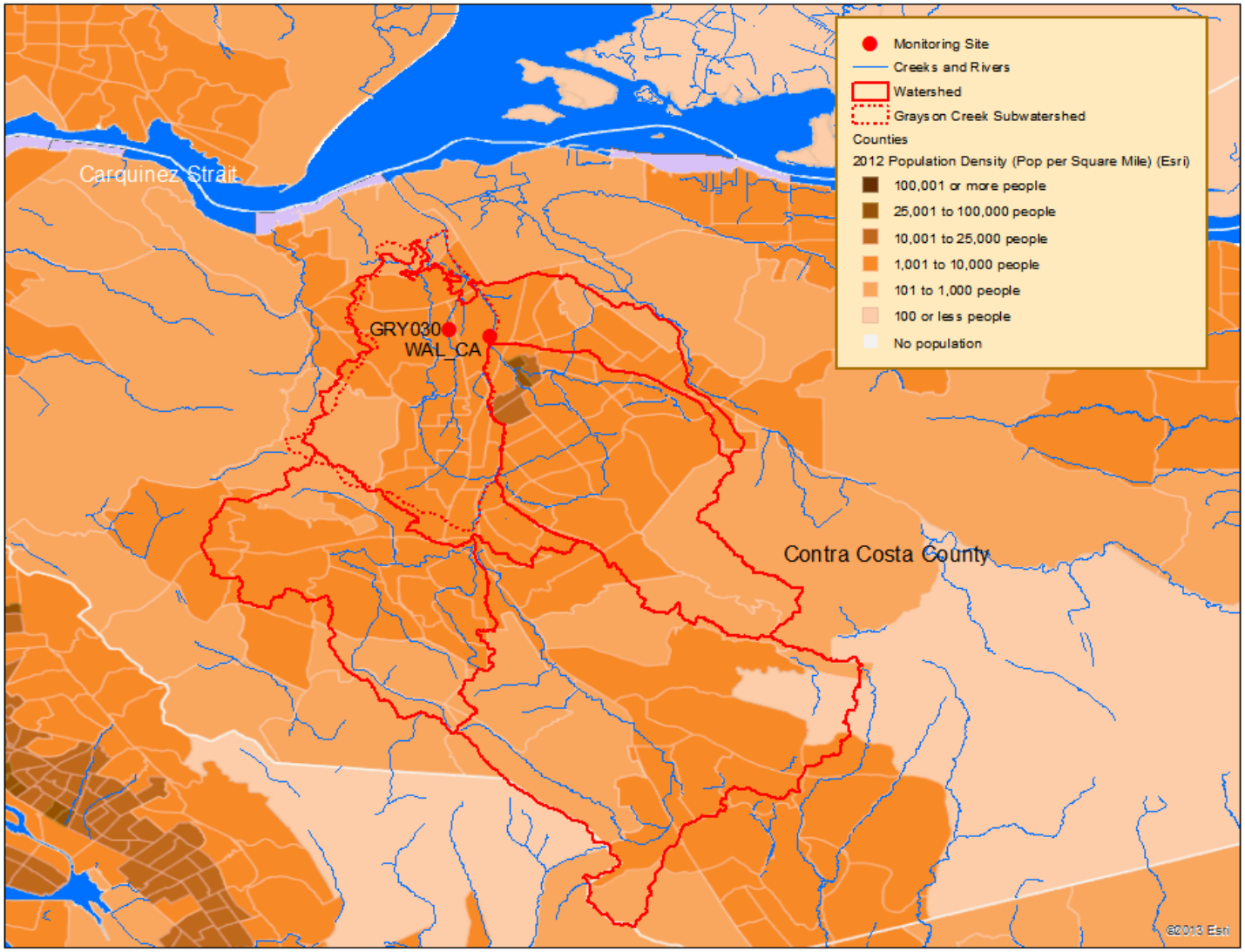

Figure 3. Location of GRY030 compared to monitoring site WAL_CA in east Contra Costa of the San Francisco Bay area (WAL_CA, Walnut Creek at Concord Avenue). WAL_CA encompasses urban runoff from four watersheds except for the Grayson Creek subwatershed of the Walnut Creek watershed. GRY030 encompasses urban runoff only from the Grayson Creek subwatershed (USGS, 2015). WAL_CA is a SPoT sampling site (SWAMP, 2016).

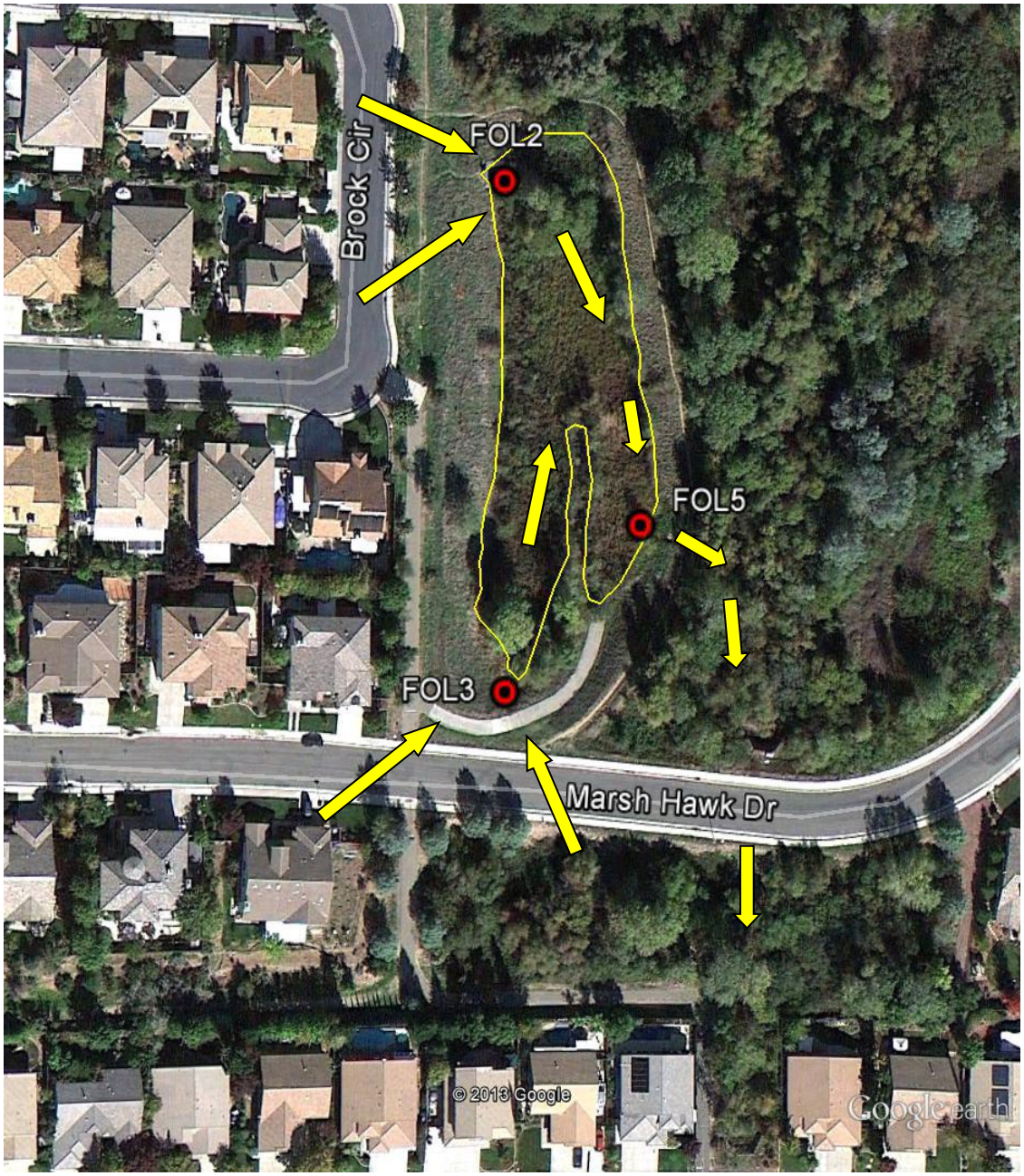

Figure 4. Constructed water quality treatment pond (CWQTP) in Folsom, California. The CWQTP is outlined in yellow with arrows indicating water flow direction (inputs at FOL2 and FOL3; outfall at FOL5). Flow gaging equipment has been installed at the CWQTP on Marsh Hawk Drive with contract 13-C0052 (http://cdpr.ca.gov/docs/emon/surfwtr/contracts.htm).

Appendix 1. Sampling site details for Study 299, Sacramento area

Site	Type/Description	No. Homes§	Area§ (Acres)	GPS Coordinates (NAD83)	
				Latitude	Longitude
Ambient Monitoring: Roseville, California (sediment and water sampling)					
PGC010	Stormdrain outfall at Diamond Woods Circle, Roseville	250	56	38.80477	-121.32733
PGC021	Single storm drain outfall at Opal and Northpark Drive, Roseville	130	44	38.80267	-121.338551
PGC022	Dual stormdrain outfall at Opal and Northpark Drive, Roseville	375	112	38.802599	-121.338787
PGC040	Pleasant Grove Creek at Veteran's Park (receiving water)			38.79857	-121.34802
PGC058	Pleasant Grove Creek at Hayden Pkwy and Blue Oaks Blvd (receiving water)**			38.79477	-121.37251
Ambient Monitoring: Sacramento, California (water sampling only)					
ARC Creek	Arcade Creek at Del Paso (receiving water)			38.628216	-121.420606
Mitigation Monitoring: Folsom, California					
CWQTP* at Marsh Hawk Drive (sediment and water sampling)					
FOL2	Stormdrain outfall; input at Brock Circle	252	65	38.6503	-121.14494
FOL3	Stormdrain outfall; input at Marsh Hawk Dr.	91	27	38.64938	-121.14494
FOL5	CWQTP* outfall near Marsh Hawk Dr. (CWQTP area: ≈0.7 acres)			38.64969	-121.14459

§Approximate number of homes and area (Goggle Earth Pro, Mountain View, CA)
*Constructed water quality treatment pond as defined by the city of Folsom, CA
**SPoT sampling site (SWAMP, 2016)

Appendix 2. Sampling site details for Study 299, San Francisco Bay area

Site Code	Site Location	County	Watershed*	GPS Coordinates (NAD83)	
				Latitude	Longitude
COY060	Coyote Creek near Montague Expressway*	Santa Clara	Metcalfe-Coyote Creek	37.3954	-121.91485
GRY030	Grayson Creek at Center Avenue	Contra Costa	Walnut Creek-Frontal Suisan Bay Estuaries	37.983549	-122.068498
WAL_CA	Walnut Creek near Concord Avenue*	Contra Costa		37.980630	-122.0516
MCC040	Big Canyon/Martin Canyon Creek near Dublin Boulevard and I-680	Alameda	South San Ramon Creek	37.706412	-121.926687
AL_VER	Arroyo de la Laguna Creek at Verona Rd	Alameda	Arroyo de la Laguna	37.62672	-121.88258

*USGS HUC12 watershed (USGS, 2015)
** SPoT sampling site (SWAMP, 2016)

Appendix 3. 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*	Use (lb ai)	Use Score	Benchmark (µg/L)	Tox Score	Final Score
Permethrin	PY	15456	5	0.0106	6	30
Bifenthrin	PY	19761	5	0.075	6	30
Fipronil	FP	9027	5	0.11	5	25
Cyfluthrin	PY	6861	4	0.0125	6	24
Lambda-cyhalothrin	PY	555	3	0.0035	7	21
Cypermethrin	PY	1623	4	0.195	5	20
Deltamethrin	PY	492	3	0.055	6	18
Pendimethalin	DN	3978	4	5.2	4	16
Chlorfenapyr**	CF	1683	4	2.915	4	16
Carbaryl	CY	1534	3	0.85	5	15
Imidacloprid	IMD	2486	4	34.5	3	12
Oryzalin	DN	1693	4	15.4	3	12
Diuron	PI	1097	3	2.4	4	12
Prodiamine	DN	1565	3	6.5	4	12
Esfenvalerate	PY	88	2	0.025	6	12
Malathion	OP	170	2	0.295	5	10
Oxyfluorfen	DN	114	2	0.29	5	10
Tebuthiuron	PI	455	3	50	3	9
2,4-D	SA	1401	3	13.1	3	9
Triclopyr	SA	1099	3	70	3	9
Pesticides with no analytical methods for surface water (CDFA) - these pesticides will not be						
Dithiopyr	N/A	2861	4	20	3	12
Dichlobenil***	N/A	8156	4	30	3	12
Isoxaben	N/A	644	3	10	4	12
Sulfometuron-methyl	N/A	111	2	0.45	5	10
Propiconazole	N/A	586	3	21	3	9

*CY, carbaryl; CF, chlorfenapyr; DN, dinitroaniline herbicides+oxyfluorfen; FP, fipronil + degradates; IMD, imidacloprid; OP, organophosphates; PI, photosynthetic inhibitor herbicides; PY, pyrethroid; SA, synthetic auxin herbicides

**Will not be monitored in FY16/17. See text.

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

Appendix 4. Chlorfenapyr results in CDPR's urban monitoring program. Monitoring began in August 2014

Region*	Area*	Event Type	Sample Date	Site**	Site Type	Result (ug/L)***	Reporting limit (µg/L)
NorCal	SAC	Nonstorm	8/6/2014	31_29	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	8/6/2014	31_30	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	8/6/2014	31_31	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	8/6/2014	31_26	Receiving Water	nd	0.1
NorCal	SAC	Nonstorm	8 /6 /2014	31_26	Receiving Water	nd	0.1
NorCal	SAC	Storm	10/31/2014	31_29	Stormdrain	nd	0.1
NorCal	SAC	Storm	10/31/2014	31_30	Stormdrain	nd	0.1
NorCal	SAC	Storm	10/31/2014	31_31	Stormdrain	nd	0.1
NorCal	SAC	Storm	10/31/2014	31_26	Receiving Water	nd	0.1
NorCal	SAC	Storm	2/6/2015	31_29	Stormdrain	nd	0.1
NorCal	SAC	Storm	2/6/2015	31_30	Stormdrain	nd	0.1
NorCal	SAC	Storm	2/6/2015	31_31	Stormdrain	nd	0.1
NorCal	SAC	Storm	2/6/2015	31_26	Receiving Water	nd	0.1
NorCal	SAC	Nonstorm	6/8/2015	31_29	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	6/8/2015	31_29	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	6/8/2015	31_30	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	6/8/2015	31_31	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	6/8/2015	31_26	Receiving Water	nd	0.1
NorCal	SAC	Nonstorm	8/3/2015	34_15	Receiving Water	nd	0.1
NorCal	SAC	Nonstorm	8/3/2015	31_29	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	8/3/2015	31_29	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	8/3/2015	31_30	Stormdrain	nd	0.1
NorCal	SAC	Nonstorm	8/3/2015	31_31	Stormdrain	nd	0.1
NorCal	SAC	Storm	11/1/2015	31_30	Stormdrain	nd	0.1
NorCal	SAC	Storm	11/1/2015	31_31	Stormdrain	nd	0.1
NorCal	SAC	Storm	11/2/2015	34_15	Receiving Water	nd	0.1
NorCal	SAC	Storm	11/2/2015	34_15	Receiving Water	nd	0.1
NorCal	SAC	Storm	11/2/2015	31_29	Stormdrain	nd	0.1
NorCal	SAC	Storm	11/2/2015	31_26	Receiving Water	nd	0.1
NorCal	SAC	Storm	2/17/2016	31_29	Stormdrain	nd	0.1
NorCal	SAC	Storm	2/17/2016	31_30	Stormdrain	nd	0.1
NorCal	SAC	Storm	2/17/2016	31_31	Stormdrain	nd	0.1
NorCal	SAC	Storm	2/17/2016	31_26	Receiving Water	nd	0.1
SoCal	LA	Nonstorm	8/28/2014	19_157	Receiving Water	nd	0.1
SoCal	LA	Storm	11/1/2014	19_157	Receiving Water	nd	0.1
SoCal	LA	Nonstorm	6/3/2015	19_157	Receiving Water	nd	0.1

Region*	Area*	Event Type	Sample Date	Site**	Site Type	Result (ug/L)***	Reporting limit (µg/L)
SoCal	LA	Nonstorm	8/11/2015	19_158	Receiving Water	nd	0.1
SoCal	LA	Nonstorm	8/11/2015	19_205	Receiving Water	nd	0.1
SoCal	LA	Storm	12/13/2015	19_158	Receiving Water	nd	0.1
SoCal	LA	Storm	12/13/2015	19_205	Receiving Water	nd	0.1
SoCal	OC	Nonstorm	8/27/2014	30_24	Stormdrain	nd	0.1
SoCal	OC	Nonstorm	8/27/2014	30_26	Receiving Water	nd	0.1
SoCal	OC	Storm	11/1/2014	30_24	Stormdrain	nd	0.1
SoCal	OC	Storm	11/1/2014	30_26	Receiving Water	nd	0.1
SoCal	OC	Storm	3/1/2015	30_24	Stormdrain	nd	0.1
SoCal	OC	Storm	3/1/2015	30_26	Receiving Water	nd	0.1
SoCal	OC	Nonstorm	6/2/2015	30_24	Stormdrain	nd	0.1
SoCal	OC	Nonstorm	6/2/2015	30_26	Receiving Water	nd	0.1
SoCal	OC	Nonstorm	8/10/2015	30_24	Stormdrain	nd	0.1
SoCal	OC	Nonstorm	8/10/2015	30_44	Receiving Water	nd	0.1
SoCal	OC	Storm	12/13/2015	30_24	Stormdrain	nd	0.1
SoCal	OC	Storm	12/13/2015	30_44	Receiving Water	nd	0.1

*NorCal, Northern California; SoCal, southern California; SAC, Sacramento area; OC, Orange County; LA, Los Angeles County

**Site codes, see http://cdpr.ca.gov/docs/emon/surfwtr/surfcont.htm

***nd=not detected

Appendix 5. 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*	Use Score (Spring/Fall)	Benchmark (µg/L)	Tox Score (Spring/Fall)	Final Score (Spring/Fall)
Permethrin	PY	5/5	0.0106	6/6	30/30
Bifenthrin	PY	4/4	0.075	6/6	24/24
Fipronil	FP	4/4	0.11	5/5	20/20
Cyfluthrin	PY	3/4	0.0125	6/6	18/24
Lambda-cyhalothrin	PY	3/3	0.0035	7/7	21/21
Deltamethrin	PY	3/4	0.055	6/6	18/24
Diuron	PI	4/5	2.4	4/4	16/20
Cypermethrin	PY	3/4	0.195	5/5	15/20
Pendimethalin	DN	4/3	5.2	4/4	16/12
Chlorfenapyr**	CF	3/3	2.915	4/4	12/12
Imidacloprid	IMD	4/4	34.5	3/3	12/12
Prodiamine	DN	3/3	6.5	4/4	12/12
Triclopyr	SA	4/4	70	3/EX	12/12
Bromacil	PI	EX/5	6.8	EX/4	EX/20
Sulfometuron-methyl**	None	EX/3	0.45	EX/5	EX/15
2,4-D	SA	4/3	13.1	3/3	12/9
DDVP**	OP	EX/2	0.035	EX/6	EX/12
Malathion**	OP	2/2	0.295	5/5	10/10
Carbaryl**	CB	2/2	0.85	5/5	10/10
Esfenvalerate	PY	EX/2	0.025	EX/6	EX/12
Oryzalin	DN	3/3	15.4	3/3	9/9
Dithiopyr**	None	3/EX	20	3/EX	9/EX
Propiconazole	None	EX/3	21	EX/3	EX/9
Indoxacarb**	None	EX/3	84	EX/3	EX/9

*CY, carbaryl; CF, chlorfenapyr; DN, dinitroaniline herbicides+oxyfluorfen; FP, fipronil + degradates; IMD, imidacloprid; OP, organophosphates; PI, photosynthetic inhibitor herbicides; PY, pyrethroid; SA, synthetic auxin herbicides

**Will not be monitored, see text. CDFA does not currently have an analytical method for sulfometuron-methyl, dithiopyr, propiconazole, or Indoxacarb in surface water

***EX=not in top final score Of ≥ 9