Surface Water Ambient Monitoring Program

Stream Pollution Trends (SPoT) Monitoring Program

First Report – Field Year 2008

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The SWAMP Stream Pollution Trends monitoring program was designed to address statewide water quality information needs by a SWAMP Roundtable committee of monitoring coordinators and program partners. Committee members included Jeanne Chilcott, Val Connor, Terry Fleming (USEPA), Michael Lyons, Chris Sommers (EOA, Inc.), Karen Taberski, Alisha Wenzel, and Karen Worcester. The assessment questions, objectives, design, indicators, and methods were reviewed by the SPoT Scientific Review Committee: Ken Belitz (USGS), Kathy Kuivila (USGS), and Lester McGee (SFEI). We thank all committee members and members of the SWAMP Roundtable for their considerable insights and support. We also thank three external reviewers for their thoughtful and thorough comments.

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List of Acronyms

BOG: Bioassessment Oversight Group that directs the SWAMP bioaccumulation monitoring program.

DDT: Dichlorodiphenyltrichloroethane, synthetic organochlorine pesticide known for its persistent toxicity and banned in the United States in 1972

DFG: California Department of Fish and Game

GIC: The Geographic Information Center at California State University, Chico.

MPSL: Marine Pollution Studies Laboratory, consisting of the toxicology laboratory at Granite Canyon, and the logistics, data management, and trace metal analytical laboratory at Moss Landing.

NAWQA: National Water Quality Assessment, a program of the US Geological Survey.

NLCD: National Land Cover Dataset

PAH: Polycyclic aromatic hydrocarbons, a suite of organic pollutants produced through combustion of fossil fuels

PBDE: Polybrominated diphenyl ethers, which are widely employed as flame-retardants. In 2006 the State of California began prohibiting the manufacture, distribution, and processing of pentaBDE and octaBDE products.

PCB: Polychlorinated biphenyls, a group of industrial compounds widely used for their insulating properties. PCB production was banned in the United States in 1979.

PEC: Probable effect concentration, an empirically derived sediment quality objective that sets a concentration above which toxicity is expected to occur (MacDonald et al., 2000). PEC values are shown in Appendix 3, Table 14.

PSA: Perennial Streams Assessment, the SWAMP statewide program measuring ecological indicators at probabilistically selected sites in California streams.

SPoT: Stream Pollution Trends monitoring program.

SWAMP: Surface Water Ambient Monitoring Program

TEC: Threshold effect concentrations, an empirically derived sediment quality objective that sets a concentration below which toxicity is not expected to occur (MacDonald et al., 2000). TEC values are shown in Appendix 3, Table 14.

TMDL: Total Maximum Daily Load

TOC: Total organic carbon

USGS: United States Geological Survey

Executive Summary

The California Surface Waters Ambient Monitoring Program (SWAMP) is tasked with assessing water quality in all of California's surface waters. The program conducts monitoring directly and through collaborative partnerships, and provides numerous information products designed to support water resource management in California. The Stream Pollution Trends (SPoT) program is a statewide monitoring effort focused on the SWAMP priority of assessing the levels to which aquatic life beneficial uses are supported in California streams (SWAMP 2010). The program has three primary goals:

1. Determine long-term trends in stream contaminant concentrations and effects statewide.
2. Relate water quality indicators to land-use characteristics and management effort.
3. Establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, & federal monitoring.

The SPoT program is specifically designed to fill critical information needs for state, regional and local resource management programs, including Clean Water Act §303d impaired waters listing, CWA §305b condition assessment, total maximum daily load (TMDL) assessment and allocation, non-point source program water quality assessment, stormwater and agricultural runoff management, pesticide registration and labeling, and local land use planning.

SPoT is a long-term trends monitoring program that will help managers understand how water quality conditions are changing over time in relation to land use change and resource management practice implementation. This report covers the first annual survey, so trends assessment will not begin until the second and third year surveys are included in the next SPoT report (due in 2012). The focus of this report is on identifying chemicals of concern and the watershed land uses associated with their presence in California streams. The data collected can be used in a space-for-time-swap approach to estimate the effect that further land use change (such as increasing urbanization) would have on stream water quality in California.

The results indicate that, on a statewide basis, levels of most measured pollutants in stream sediment increased as urban land cover in their watersheds increased. Industrial compounds, some metals, and many pesticides were found at higher concentrations in urban watersheds than in agricultural or other watersheds statewide. Pyrethroid pesticides were detected in stream sediments from more than half the SPoT watersheds, and were measured at concentrations associated with toxicity in more than a quarter of the total samples. DDTs and PCBs, both banned for more than three decades, are still commonly detected in California streams, with DDTs frequently exceeding sediment quality guidelines. PBDEs and PAHs were common in urban areas, and mercury was above guideline values in a small number of samples from urban watersheds and watersheds where it is geologically abundant.

The data presented here describe the baseline condition for the SPoT long-term trends assessment. They also demonstrate a significant relationship between land use and stream pollution, and provide data directly relevant to a number of agency water quality protection programs.

Introduction

Clean freshwater is California's most precious natural resource. It flows through streams that drain watersheds subject to constantly changing levels of human activity. Understanding the connections between these human activities, the changing landscape, and the quality of our waters is essential for the preservation of aquatic life, human health, and the prosperity of California's economy. As the population grows, foothills are converted to residential and agricultural use, agricultural lands are converted through urban and suburban development, and regulatory programs and conservation practices are implemented to maintain and restore stream condition in this ever changing environment.

The Stream Pollution Trends (SPoT) program is designed to improve our understanding of watersheds and water quality by monitoring changes in both over time, evaluating impacts of development, and assessing the effectiveness of regulatory programs and conservation efforts at a watershed scale. The overall goal of this long-term trends assessment program is to detect meaningful change in the concentrations of stream-borne contaminants and their biological effects in large watersheds at time scales appropriate to management decision making.

The three specific program goals are to:

1. Determine long-term trends in stream contaminant concentrations and effects statewide.
2. Relate water quality indicators to land-use characteristics and management effort.
3. Establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, & federal monitoring.

SPoT sampling locations were selected to provide a statewide network of sites at the drainage points of large watersheds to support collaboration with watershed-based monitoring programs throughout the state. To establish this network, SPoT staff met with Regional Board monitoring coordinators and stormwater agencies to develop a coordinated monitoring design. The Southern California Stormwater Monitoring Coalition participated in site selection for the southern California SPoT sites. A representative from the Bay Area Stormwater Management Agencies Association served on the SWAMP committee that designed the program, and all SPoT sites in the San Francisco Bay Region are aligned with monitoring sites for the Municipal Regional Stormwater NPDES Permit (CRWQCB-SFR, 2011). SPoT sites in the Central Coast and Central Valley Regions are shared by the Cooperative Monitoring Program for agriculture and Irrigated Lands Program, respectively (Appendix 1). In most cases, the SPoT assessments of sediment toxicity and chemistry complement water column measurements made by cooperating programs.

The SPoT program indicators are measured in stream sediment because this matrix best accommodates program goals. Most trace metal and organic pollutants that enter streams adhere to suspended sediment particles and organic matter, and this sediment-associated phase is the major pathway for contaminant loading in streams and downstream waterways (Karickhoff 1984, DiToro *et al.* 1991, Foster and Charlesworth 1996). In addition, sediment measurements are appropriate for long-term trend monitoring because pollutants that accumulate in depositional sediment on the stream bed are much more stable over time (~months to years) than dissolved or suspended pollutants that move downstream in pulses that are highly variable over short time scales (~hours). SPoT surveys are timed to collect sediment from recent stream bed deposits during base flow periods after the high water season when most sediment and pollutant transport takes place.

The SPoT program complements the other three SWAMP statewide monitoring programs: the Perennial Streams Assessment (PSA), the Reference Condition Management Program (RCMP), and the bioaccumulation monitoring program of the Bioaccumulation Oversight Group (BOG). The PSA measures ecological endpoints related to macroinvertebrate and algal communities, and uses a probabilistic design to assess aquatic health in perennial, wadeable streams statewide. PSA and RCMP provide a baseline assessment of high quality streams, and provides direct evidence of aquatic life condition statewide. The BOG program measures contaminant concentrations in sport fish collected on a rotating basis from streams, lakes and coastal waters.

SPoT complements the PSA by focusing on the magnitude of pollution in streams, using toxicological endpoints to establish causal connections between these chemicals and biological impacts, and by analyzing land cover as part of a watershed-scale evaluation of the sources of pollutants affecting aquatic life. The PSA contributes to the attainment of SPoT goals by assessing the overall health of wadeable perennial streams, and by testing assumptions about the status of reaches upstream of the intensive land uses that might be found associated with pollutants measured by SPoT. SPoT complements the BOG by identifying watershed sources for contaminants measured in fish from downstream water ways. The BOG complements SPoT by providing perspectives on the fate and human health aspects of pollutants in streams, particularly as related to their uptake in fish tissue and risk associated with human consumption. PSA, RCMP, BOG, and SPoT together provide freshwater data similar to those used in other programs to develop sediment quality objectives (SQOs) in marine and estuarine habitats. Co-location of sites or addition of specific indicators across the PSA, BOG, and SPoT programs could allow for development of freshwater SQOs for California in the near future (SWAMP 2010).

SPoT was specifically designed to provide data directly useful for regulatory programs and conservation initiatives. SPoT data can be incorporated directly into Clean Water Act § 303[d] listing of impaired waters, as well as into the statewide status assessments required by § 305[b]. Eight SPoT sites are located in priority watersheds for the US EPA Measure W program (also known as the Watershed Improvement Measure (WIM) or SP-12). The focus on causes and sources of pollutants in watersheds feeds directly into Total Maximum Daily Load program efforts to quantify pollutant loadings and understand sources and activities that contribute to those loadings. By coordinating with local and regional programs, SPoT provides statewide context for local results, and provides information useful for local management and land use planning activities. SPoT is also specifically designed to assist with the watershed-scale effectiveness evaluation of management actions implemented to improve water quality, such as pesticide reduction or irrigation management on farms, and installation of stormwater treatment devices or low impact development in urban areas. Use of SPoT data for watershed scale evaluations of management practice effectiveness is currently limited by the lack of a comprehensive and standardized reporting system for practice implementation, as will be discussed further in this report.

Assessment Questions and Links to Water Quality Programs:

SPoT in the SWAMP Assessment Framework

The following is a summary of SPoT program elements in the context of the SWAMP Assessment Framework (Bernstein, 2010), with linkages to regulatory and resource management programs that can incorporate SPoT data. The SWAMP Assessment Framework provides guidance and context for developing question-driven monitoring to provide water quality information directly useful for resource management. This summary specifies the beneficial uses and water body types targeted by SPoT, states the assessment questions SPoT addresses, and lists the resource management programs to which SPoT provides essential information. Level 1 questions are the highest level, as adopted by SWAMP and the California Water Quality Monitoring Council (Bernstein, 2010; page 8 and Figure 2). The Level 2 assessment questions apply to each of the two Level 1 questions.

Beneficial use assessed: Aquatic life protection

Water body type assessed: Streams, ranging from ephemeral creeks to large rivers

Level 1 Assessment Questions:

I. **Are our aquatic ecosystems healthy?**

II. **What stressors and processes affect our water quality?**

Level 2 Assessment Questions for both of the Level 1 questions stated above:

Are beneficial uses impaired?

Management goal: Determine whether aquatic life beneficial uses in California streams are impaired by sediment-associated chemical pollutants.

Supports: 303(d) listing and 305(b) reporting

Monitoring strategy: Analyze pollutant concentrations and toxicity in sediments collected from targeted depositional areas in 100 large watersheds statewide. Compare toxicity results to narrative standards; compare chemical concentrations to available sediment quality guidelines and threshold effects values.

Certainty / precision: Analytical precision for chemical and toxicological measurements is high. Level of representativeness for all possible sites in the watersheds at all times of the year is moderate and being evaluated through integrated special studies.

Reference conditions: Five reference sites in large watersheds across the state.

Spatial scale: State of California. Results are interpreted on a statewide basis to allow perspective for local and regional analyses by partner programs.

Temporal scale: Surveys on an annual basis over an extended period (>10 years).

Are conditions getting better or worse?

Management goal: Determine the magnitude and direction of change in concentrations of sediment-associated chemical pollutants and toxicity.

Supports: Basin Planning, implementation of urban and agricultural management practices, permit reissuance, EPA Measure W.

Monitoring strategy: Survey stream sites in 100 large watersheds statewide annually for an extended period (> 10 years). Evaluate temporal trends at each site.

Certainty / precision: Precision is evaluated through integrated special studies that survey three to four additional sites in each of a rotating subset of selected watersheds during three seasons within each year.

Reference conditions: as described above.

Spatial scale: State of California, as described above.

Temporal scale: Surveys on an annual basis over an extended period (> 10 years) to evaluate long-term trends.

What is the magnitude and extent of any problems?

Management goal: Determine the number of large California watersheds potentially impaired by sediment-associated chemical pollutants and toxicity, and the magnitude of observed impairment.

Supports: 303(d), TMDL, stormwater permit monitoring, agricultural permit/waiver monitoring

Monitoring strategy: Survey stream sites in 100 large watersheds statewide, provide statewide perspective for local and regional permit and Basin Plan monitoring. Collaborate with statewide and local programs to determine upstream extent of observed impairment.

Certainty / precision: as described above.

Reference conditions: as described above.

Spatial scale: as described above.

Temporal scale: as described above.

What's causing the problem?

Management goal: Determine relationships between stream pollution and watershed land cover. Compare chemical concentrations to observed toxicity, known toxicity thresholds and guideline values.

Supports: 305(b), TMDL, Basin Planning, County land use planning, pesticide surface water regulations and DPR pesticide registration (especially for pyrethroids).

Monitoring strategy: Analyze geospatial and statistical correlations between in-stream pollutant concentrations/toxicity and land cover data extracted for the watersheds draining to the stream sites. Evaluate statistical relationships between measured chemicals and observed toxicity.

Certainty / precision: high (n = 92 for year 2008 correlation analyses).

Reference conditions: Data from reference sites included in correlation gradients.

Spatial scale: as described above.

Temporal scale: as described above.

Are solutions working?

Management goal: Relate changes in concentrations and toxicity of sediment-associated pollutants with implementation of water quality management programs and practices.

Supports: TMDL, management practice implementation programs, EPA Measure W, urban and agricultural regulatory programs.

Monitoring strategy: Compare changes in in-stream chemical concentrations and implementation of management strategies and practices.

Certainty / precision: Currently low, due to the limited amount and standardization of quantitative information on implementation of management practices statewide. Efforts are underway to support and standardize reporting of practices implemented, land area affected, volume of water treated, and effectiveness of treatment. It is anticipated that improvements in this area will improve precision of analyses to determine whether implemented solutions are effective.

Reference conditions: Reference sites provide data for watersheds in which solutions are less necessary and fewer new management practices will be implemented.

Spatial scale: as described above.

Temporal scale: as described above.

Methods

Monitoring Objectives

Program methods were selected to meet six monitoring objectives:

1. Determine concentrations of a suitable suite of contaminants in depositional sediment collected near the base of large California watersheds;
2. Determine whether these depositional sediments are toxic to representative organisms;
3. Quantify ancillary parameters such as land cover and impervious surface area, available from the National Land Cover Dataset and other public sources;
4. Conduct surveys once per year on a continuing basis;
5. Analyze data to evaluate relationships between contaminant concentrations, toxicity, and land cover metrics;
6. In future years (when data from multiple annual surveys are available) conduct trends analyses to detect the direction, magnitude, and significance of change in the above parameters over time.

Monitoring Design

The monitoring design benefitted from experience and information available from the US Geological Survey's National Water Quality Assessment (USGS – NAWQA: http://water.usgs.gov/nawqa/). The NAWQA program is designed to increase understanding of water-quality conditions, of whether conditions are getting better or worse over time, and how natural features and human activities affect those conditions. The NAWQA integrator site concept provided the basis for the SPoT monitoring design. NAWQA integrator sites are established near the base (discharge point) of larger, relatively heterogeneous drainage basins with complex combinations of environmental settings. Sediments collected from depositional areas at integrator sites provide a composite record of pollutants mobilized from throughout the watershed. While many hydrologic, engineering, and environmental variables affect the ability of this record to adequately characterize all pollutant-related activities, sediment samples collected from such areas are considered to be a relatively good and logistically feasible means of assessing large watersheds for long-term trends.

SPoT employs a targeted monitoring design to enable trend detection on a site-specific basis. To serve their purpose as integrator sites, SPoT sites were located at the base of large watersheds containing a variety of land uses. Because depositional sediment is needed for sample collection, sites were targeted in locations with slow water flow and appropriate micro-morphology, to allow deposition and accumulation. The SPoT program considered creating a sample frame that included all possible sites that fit this description, but the necessary information to generate such a frame did not exist.

SPoT and NAWQA use integrator sites because both programs focus on understanding causes of water quality impairment. The connection with land use is a major part of the assessment, and targeted sites allow greater discretion to adjust to significant land cover variation in low watershed areas. One of the three main goals of SPoT was to form a statewide network of sites that provides statewide context for the findings of local and regional programs. A targeted approach allowed the SPoT program flexibility to link to established sites from other programs.

Site Selection

In 2008, 92 sites were surveyed to census about half of the nearly 200 major hydrologic units (8-digit HUCs) in California. Site selection criteria included:

1. Availability of fine-grained depositional sediment (see note below);
2. Location in a large watershed with heterogeneous land cover, in most cases on the order of an 8-digit hydrologic unit code (8-digit HUC = USGS Cataloging Unit);
3. One site per large watershed (except in some very large watersheds, such as the Sacramento, in which sites were selected in large sub-watersheds);
4. Location at or near the base of a watershed, defined as the confluence with either an ocean, lake, or another stream of equal or greater stream order;
5. Availability of previous data on sediment contaminant concentrations, biological impacts, or other relevant water quality data;
6. Location where site-specific conditions are appropriate for the indicators selected (e.g., depositional areas, sufficient flow, appropriate channel morphology, substrate);
7. Availability of safe access, either by boat or wading;
8. Location near stream gauges where possible;
9. Co-location, where possible and appropriate, with key sites from cooperative programs;
10. Priority ranking assigned by SWAMP Regional Monitoring Coordinator for cooperation with Regional SWAMP monitoring programs;
11. Preference given to large tributaries rather than multiple main stem sites on multi-HUC rivers.

Note on targeting of fine sediments

During field surveys at most SPoT sites, fine sediment particles were found in thin layers throughout the channel. Some sites were dominated by deep deposits of fine sediment. At many sites, however, there were fewer locations where fine sediment accumulated in layers thick enough to allow efficient sample collection (> 2 cm). Hall et al. mapped fine sediment distributions at 99 transects in three California streams, each designated as either agricultural, urban or residential. They estimated that an average of 17% of the stream bed was characterized as "depositional" (Hall et al. 2010; Hall et al. in press). SPoT results should not be construed as a characterization of the entire stream in which study sites were located. Rather they are intended as relative indicators of the annual pollutant mobilization and transport within target watersheds, which is a useful matrix for evaluating annual trends.

Reference Sites

Reference sites were included in the monitoring design for quality assurance purposes, and to provide information on temporal trends in the absence of significant contaminant-related land use change. Reference site data were also expected to anchor the low end of contaminant gradients for correlation analyses. Five large watersheds with relatively low levels of human activity were selected across the state, representing the north coast, Bay Area, Sierra foothills, Coast Range, and southern inland areas. Sites in these watersheds were selected based on the same criteria as above for other SPoT sites. The SPoT Scientific Review Committee recommended using the USGS NAWQA reference sites for the Santa Ana, San Joaquin, and Sacramento study units. Of these NAWQA sites, two were used for SPoT: Tuolumne River at Old La Grange bridge 535STC210 (San Joaquin) and San Jacinto River Reference Site 802SJCREF (Santa Ana). The Sacramento study unit site was abandoned for lack of access to locations with sufficiently fine-grained sediment.

Survey timing

SPoT surveys were timed so that sediment was collected from recent stream bed deposits during base flow periods after the high water season when most sediment and pollutant transport takes place. In general, surveys preceded from coastal southern California in late spring, to coastal central California in early summer, the Central Valley in mid-summer, the eastern Sierra in late summer, and the North Coast and Colorado River Basins in the fall. Surveys began April 28 and ended October 29, 2008 (Appendix 1).

Indicators and Measurement Parameters

SPoT indicators were selected to measure contaminants previously demonstrated to be of concern in California streams, as well as assess toxicity to a representative benthic crustacean of a resident genus. The criteria for indicator selection included

1. Stability over intermediate time scales (weeks to months) to minimize the effects of intra-annual variability on the evaluation of long-term trends;
2. Biological indicators sensitive to contaminants;
3. Feasibility;
4. Reasonable cost;
5. Use of established methods comparable to SWAMP indicators and widely accepted in the scientific and regulatory communities;
6. Usefulness for investigating relationships between contaminants and effects;
7. Coverage of analyte lists that are sufficient for statewide application in order to detect relevant trends in different regions; and
8. Usefulness for investigating sources and causes of impairment.

Based on these criteria, the following indicators were selected:

1. Sediment trace metals: Ag, Al, As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn;
2. Sediment trace organics: organophosphate, organochlorine, and pyrethroid pesticides, and PCBs;
3. Total phosphorus, total organic carbon, and sediment grain size;
4. Sediment toxicity, using the 10-d growth and survival test with the representative freshwater amphipod *Hyalella azteca*, to estimate biological effects of contaminants;
5. At a subset of 32 primarily urban sites (labeled Tier 2 sites), sediments were also measured for polycyclic aromatic hydrocarbons (PAHs) and polybrominated diphenyl ethers (PBDEs).

Because of the large number of sites and analytes, chemicals were grouped into classes for most statistical analyses. DDTs, PCBs, PBDEs, and PAHs were summed, in accordance with previous studies evaluating sediment quality guidelines, where appropriate (MacDonald et al., 2000). All detected pyrethroids were summed together where indicated, and pyrethroids were also summed as carbon normalized toxic units (Amweg et al. 2005). For many analyses, 8 relatively toxic trace metals (As, Cd, Cr, Cu, Pb, Hg, Ag, Zn; Mahler et al., 2006) were summed to provide an overall characterization of measured levels in sediment. Trace metals were also interpreted as the sum of four metals commonly released into the environment by human activity, and less affected by geologic abundance in California (Cd, Cu, Pb, Zn; Mahler et al., 2006; Bonifacio et al., 2010; Topping and Kuwabara, 2003).

A subset of the sediment sample was sieved to 63 um so that trace metal concentrations could be measured in both sieved (fine grained) and unsieved (whole) sediment. Sediments were dry sieved on Nytex screens, with separate sieves used for each sample.

Analytical Chemistry and Toxicity Test Methods

All chemical analyses and toxicity tests were performed by SWAMP laboratories: the DFG Water Pollution Control Laboratory (trace organics), the Marine Pollution Studies Laboratory at Moss Landing (MPSL, trace metals), and the UC Davis MPSL at Granite Canyon (toxicity). Analytical methods are listed in Table 4 of the SPoT Quality Assurance Project Plan (QAPP): http://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/qapp_spot_strms_pollute_final.pdf

Field Methods

Detailed field methods are described in the SPoT Quality Assurance Project Plan: http://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/qapp_spot_strms_pollute_final.pdf

Quality Assurance and Quality Control (QA/QC)

The QA/QC requirements for the SPoT program are described in detail in the appendix to the SPoT Quality Assurance Project Plan: http://www.waterboards.ca.gov/water_issues/programs/swamp/qapp/qapp_spot_strms_pollute_final.pdf**.** The results of QA measurements for the 2008 surveys are provided in Appendix 3 of this report.

Data Management

All data collected for this study are maintained in the SWAMP database, which is managed by the data management team at Moss Landing Marine Laboratories (http://swamp.mpsl.mlml.calstate.edu/). The complete dataset includes QA data (quality control samples and blind duplicates) and additional ancillary information (specific location information, and site and collection descriptions). The complete dataset from this study is also available on the web at https://ceden.waterboards.ca.gov/AdvancedQueryTool. The procedure for obtaining only SPoT data is as follows: 1. Press the "Select" button next to the Project link. 2. Highlight the “SWAMP Stream Pollution Trends” and click on “Done”. 3. At the bottom of the screen determine whether to include QA data or not as well as whether to download the data as an Excel or text file. By selecting "Toxicity" in the Result Category, one can go through the same steps to download SPoT Toxicity data as well.

Geographic Information System Analyses

Anthropogenic contaminant concentrations in streams are influenced by the mobilization of pollutants in their watersheds. The analyses described here evaluate the strength of relationships between human activity in watersheds, as indicated by land cover, and pollutant concentrations in recently deposited stream sediment. Watershed delineations and land cover data extractions were conducted by the Geographic Information Center at CSU, Chico (http://www.gic.csuchico.edu/index.html). The entire drainage area specific to each SPoT site was delineated using automated scripts based on digital elevation models (DEMs). Each delineation file was reviewed by GIC and SPoT program staff for accuracy. Reviews included comparisons to National Hydrologic Dataset catchments, and Google Earth® images of drainage areas as kml files. Drainage areas near the site were delineated with 1 km and 5 km radius buffers to create the 1K and 5K drainage areas for analysis (along with analyses of the entire drainage area and whole watershed; Figures 1 and 2). Semi-circular buffers were used because engineered drainage structures and other low-watershed features made more precise delineation impossible within the scope of this analysis.

Drainage area shapefiles were used to extract land cover grids from the National Land Cover Dataset (NLCD, Figure 3). The following NLCD categories were used in the analyses relating land cover to water quality:

NLCD 21: Developed, open space, including areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses, such as large-lot single-family housing units, parks, and golf courses.

NLCD 22, 23, 24: Low, Medium, and High Intensity Developed. These were combined to represent “urban” land cover for the report analyses.

NLCD: 82: Cultivated crops. This was the category used to represent “agricultural” land cover for the report analyses.

All other NLCD categories were combined into the “other” category for the report analyses.

Impervious surface area data were obtained from the National Land Cover Dataset (Imperv_nlc; NLCD2006 Percent Developed Imperviousness).

In correlation analyses, pollutant concentrations were compared to continuous percent land cover data (as % urban, % agricultural, and % other land cover types). For analyses based on comparisons among watersheds types, watershed areas were characterized as “urban” if they had greater than 10% urban cover (NLCD categories 22+23+24). This characterization is in line with studies indicating stream degradation where impervious surface cover exceeds 10% (e.g., Schueler 1994). Watershed areas were characterized as “agricultural” if they had greater than 25% crop cover (82).

Watershed areas were characterized as “urban-ag” if they had greater than both 10% urban and 25% agricultural land cover. At the whole watershed scale, the Tembladero Slough site was the only site meeting the urban-ag criteria.

Statistical Analyses

Multivariate Spearman rank correlations were used for all statistical evaluations of relationships between pollutants, toxicity, land cover, TOC, and/or grain size. The Wilcoxon test was used to determine the statistical significance of differences in results binned by land use category. All analyses were done using JMP ® 9.0.0 software (SAS Institute, Inc., 2010). The statistical significance of observed toxicity was determined according to the methods described in Anderson et al. (2011).

Tables in the Results section provide probability (p) values indicating the strength of relationship among variables in the multiple correlations. These p values have not been adjusted to account for the number of simultaneous comparisons made (e.g., Bonferroni adjustment). There is debate in the statistical literature about the value of adjusting alpha values to account for inference based on many simultaneous tests (Perneger 1998). Alpha adjustments were not made here because we are not interested in whether all null hypotheses are true simultaneously, but rather which relationship are of greatest interest in exploring connections between land use and stream pollution.

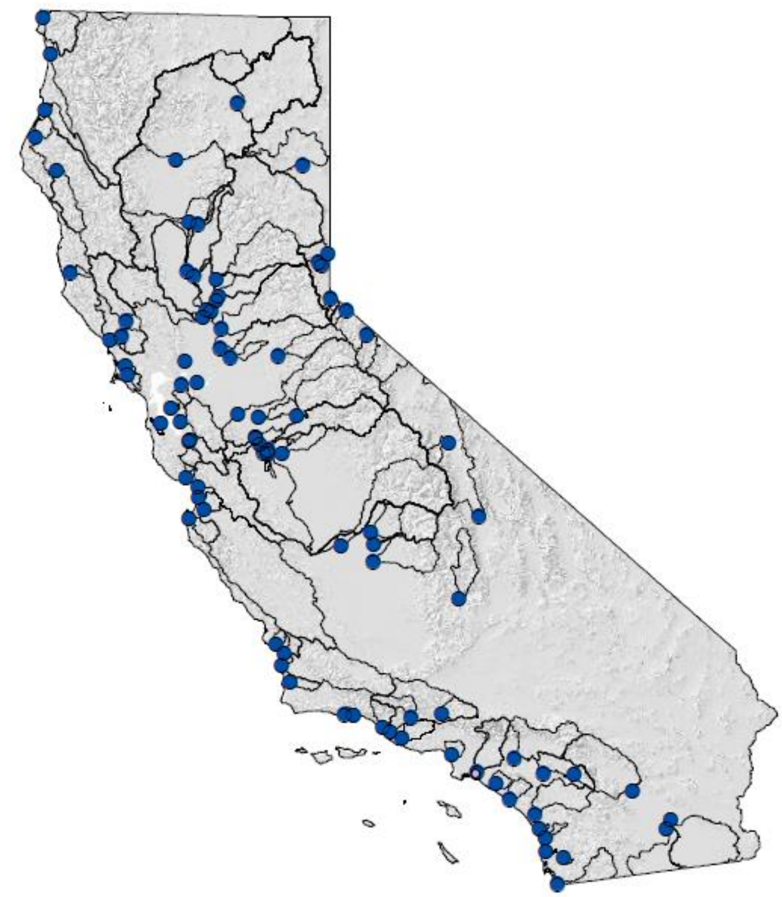

Figure 1. SpoT sites and watersheds. Additional site information is found in Appendices 1 and 2.

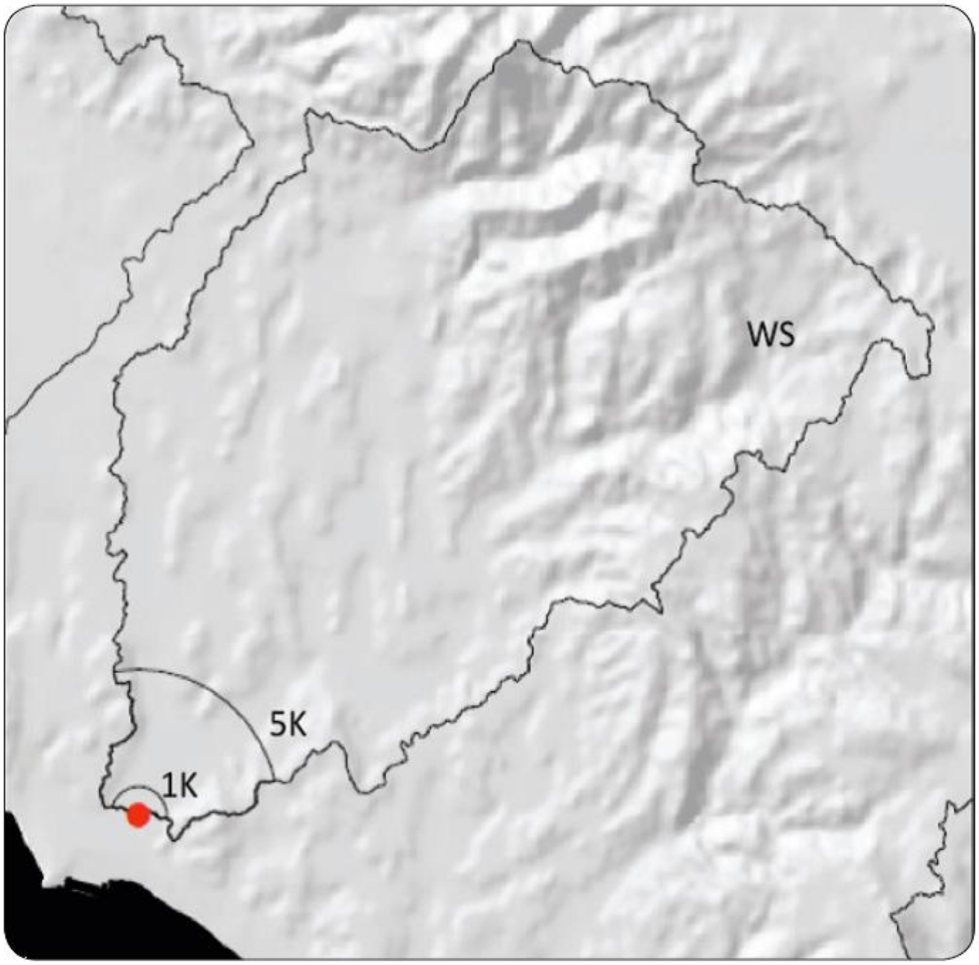

Figure 2. Drainage area delineation for watershed areas draining to SPoT sites. The larger polygon is the site's whole watershed (WS). The semi-circular smaller areas are watershed areas 1 km (1K) and 5 km (5K) upstream.

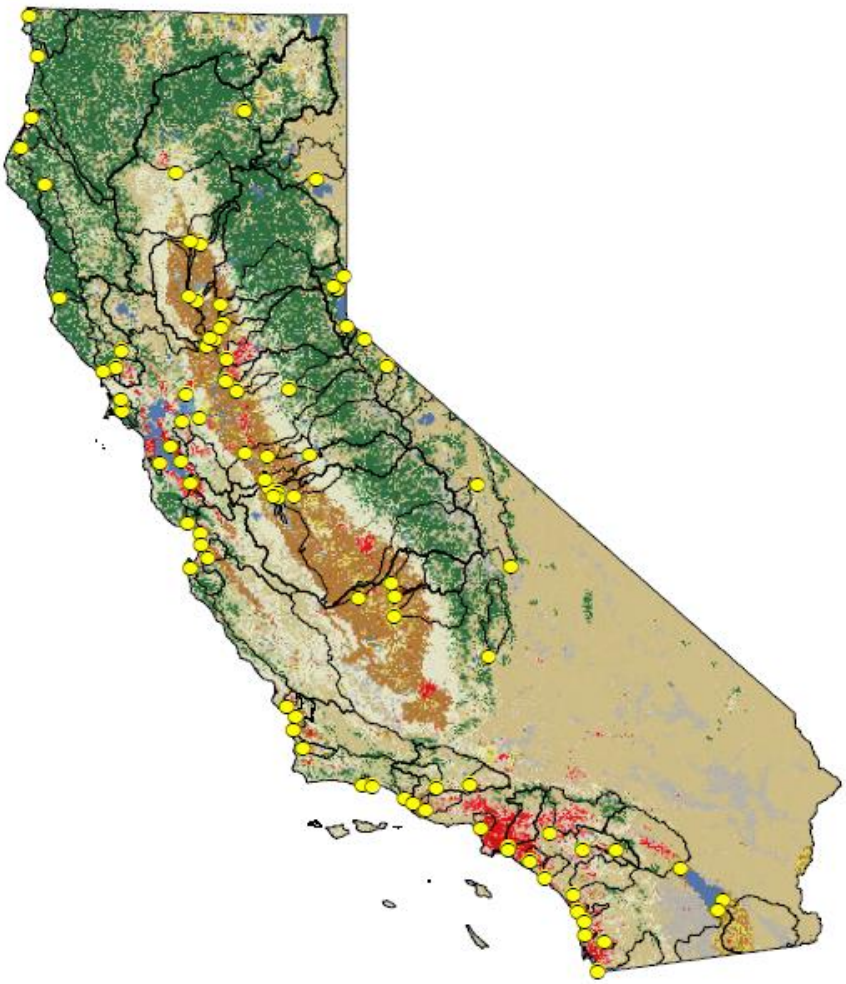

Figure 3. National Land Cover Dataset grids overlaying SPoT watersheds. Each color represent one of the 36 NLCD categories.

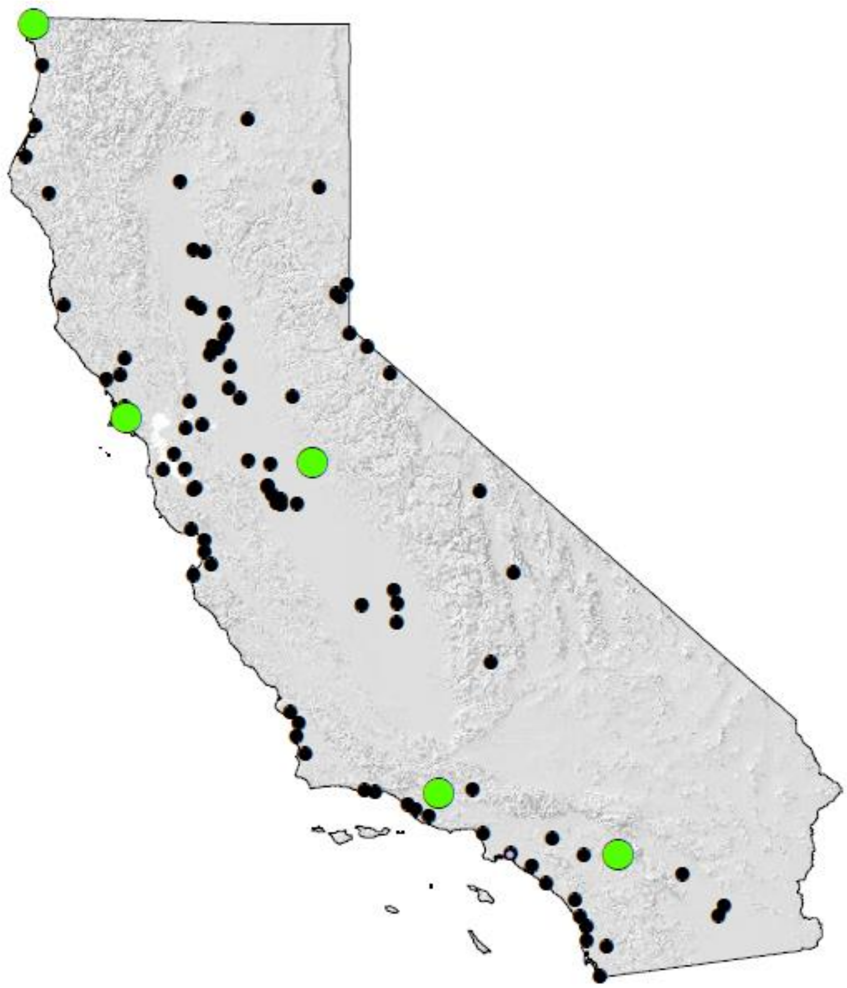

Figure 4. Location of SPoT reference sites (green circles), and additional SPoT sites (black circles). Additional site information is found in Appendices 1 and 2.

Figure 5. Land cover distributions in reference sites compared to other SPoT sites at the three watershed scales of analysis. Legend colors from left to right are shown clockwise from noon.

Results

Comparison of Reference Sites to Other SPoT Sites

All classes of chemicals had lower concentrations in sediments collected from designated reference sites than in sediments from other SPoT sites (Figures 6 - 12).

<u>Trace metals</u>
The sum concentration of cadmium, copper, lead and zinc, the four primarily anthropogenic metals of concern, was lower in reference site sediments than elsewhere (Fig. 7). The mean concentration for the sum of eight metals is slightly higher at reference sites than at other sites. These eight metals include the four above plus mercury, nickel, and chromium, and their distributions are often determined by geological abundance. All reference sites were located relatively short distances downstream of mountainous areas within their watersheds. The Lagunitas Creek reference site watershed contains serpentine outcroppings of the Franciscan formation, and the other reference site watersheds had moderate to high levels of historic mining activity.

Total phosphorus concentrations were lower in reference site sediments. Phosphorus can be geologically abundant in certain areas, and can also be elevated by urban and agricultural fertilizer applications or soil disturbance associated with land development.

<u>Trace organics</u>
Concentrations of organic pollutants were generally low in reference site sediments, with means lower than the means for other SPoT sites (Figs. 8 - 10). PCBs and DDTs were low for all reference sites. Total pyrethroid pesticide concentrations were elevated in sediment from the Lagunitas Creek reference site (201LAG125), with just over 1 toxic unit measured there (Figs. 10 and 19). This watershed has low urban and agricultural land coverage (< 1%) and approximately 5% urban open space. There are clusters of residential areas upstream. (A sample with one toxic unit has a concentration equal to the LC50 for the measured chemical, and thus should cause mortality in half the test organisms exposed to it.)

Tier 2 analyte classes (PBDEs and PAHs) were detected in sediment from only one reference site (San Jacinto Creek, 802SJCREF). The San Jacinto Creek PBDE concentration was 0.586 ng/g dw, compared to the overall mean of 16.4 ng/g dw. The San Jacinto Creek PAH concentration was 144.63 ng/g dw, compared to the overall mean of 757.27 ng/g dw.

<u>Toxicity</u>
No significant toxicity was observed in sediments collected from reference sites, compared to a range of toxicity levels observed in sediments from other SPoT sites (Fig. 11).

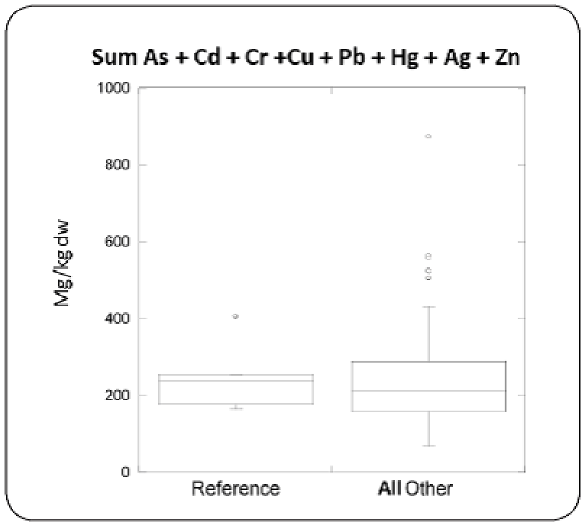

Figure 6. Sediment concentrations of 8 trace metals in reference and other SPoT sites.

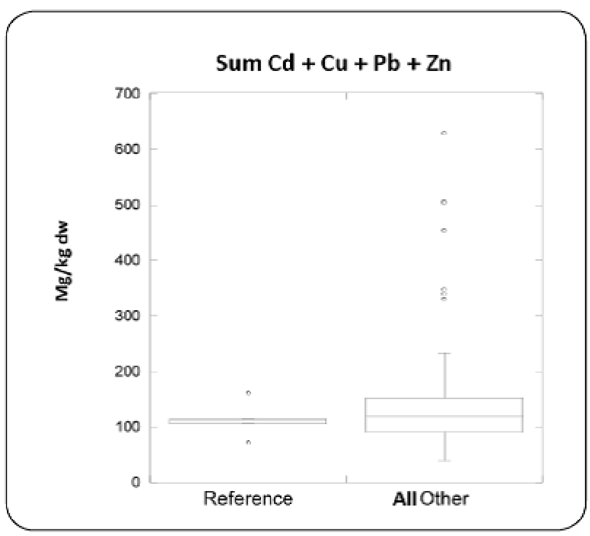

Figure 7. Sediment concentrations of 4 trace metals in reference and other SPoT sites.

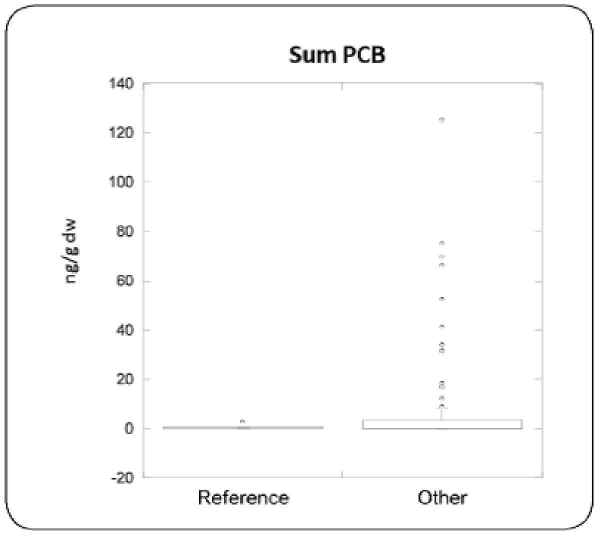

Figure 8. Sediment concentrations of PCBs in reference and other SPoT sites.

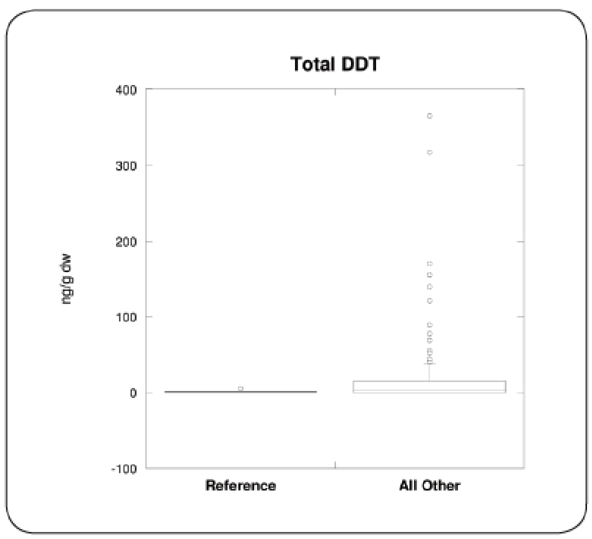

Figure 9. Sediment concentrations of DDTs in reference and other SPoT sites.

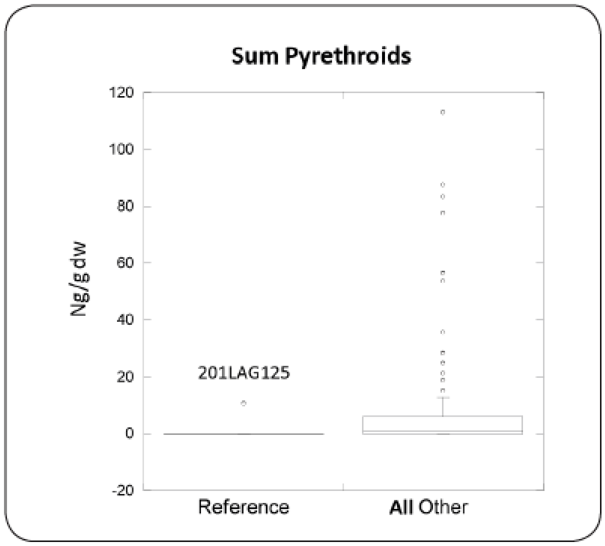

Figure 10. Sediment concentrations of pyrethroids in reference and other SPoT sites.

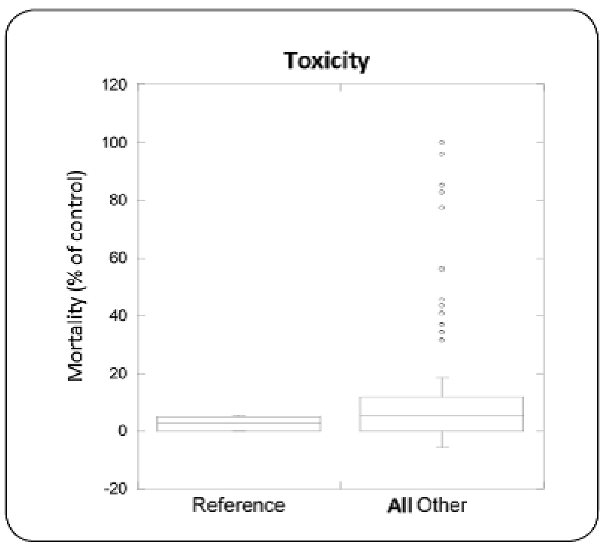

Figure 11. Sediment toxicity in reference and other SPoT sites.

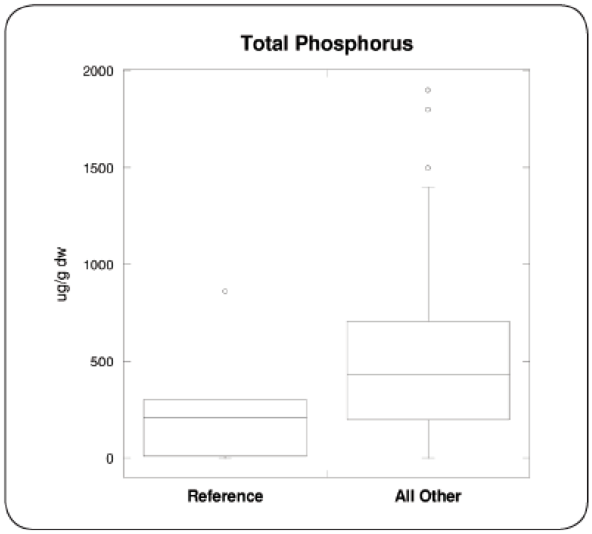

Figure 12. Sediment concentrations of total phosphorus in reference and other SPoT sites.

Sediment characteristics: grain size and TOC

At the majority of SPoT sites, fine sediment particles were found throughout the channel in thin layers covering other dominant substrate, including sand, cobble, boulders, concrete, and woody debris. This fine sediment formed deeper layers in pockets and larger depressions where micro-hydrological and geomorphic conditions favored deposition. These deeper depositional areas were targeted for sample collection because they allowed the most effective collection of fine material. In some sampling areas, fine sediments formed large and deep deposits across the channel.

While field teams were trained to collect the finest material available, a number of samples were composed primarily of grains larger than 63 um (Figure 13a). None of these samples contained substantial amounts of coarse sand or larger particles, but grains larger than 63 um made up the larger fraction in 37% of the samples.

Field teams were also trained to avoid or remove conspicuous debris, including leaves and other large organic material. TOC content cannot be readily determined in the field, and the sampling protocol has no set criterion for TOC concentration. Measured TOC values ranged from 0.23% to 16.29%, with a mode between 1 and 1.5% (Fig. 13b). There were three samples with TOC greater than 7.6%: San Leandro Creek (11.6%), Ballona Creek (12.5%), and Lower Owens River (16.3%).

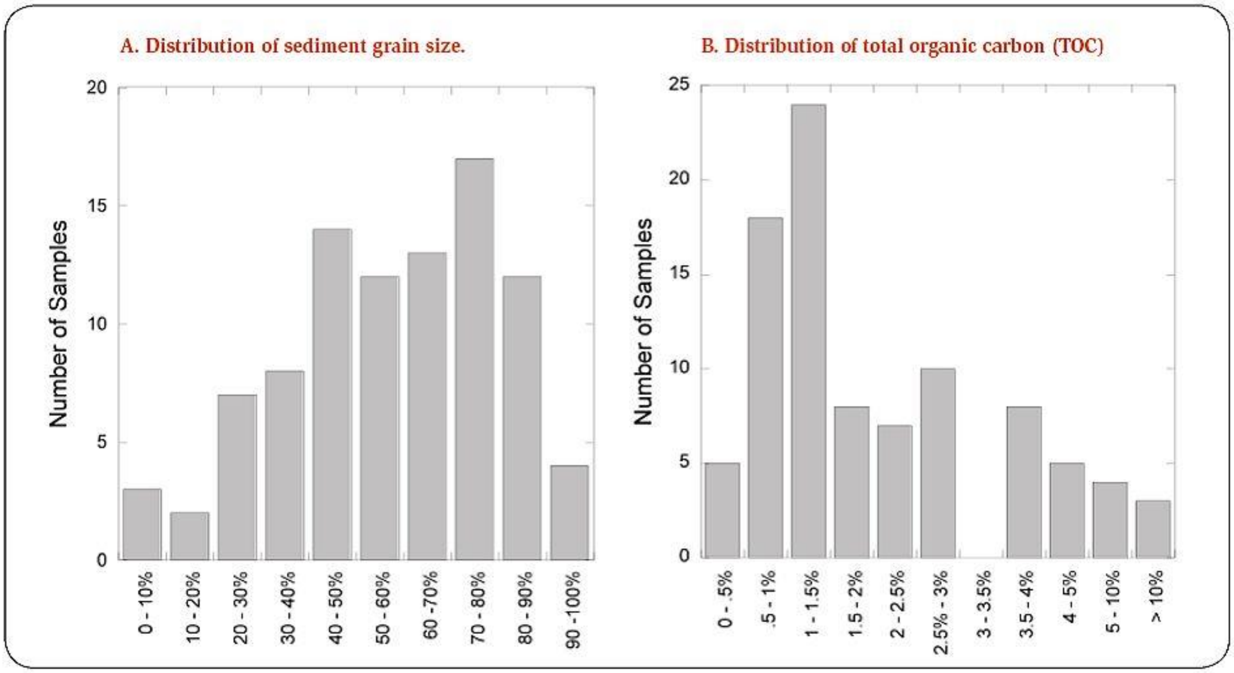

Figure 13. Sediment characteristics. (A) Percent fines: numbers of samples with given percentages of sediment < 63 um. (B) Percent TOC: numbers of samples with given percentages of TOC content.

Statewide spatial distribution of pollutants

Trace metals

Stream sediment concentrations of cadmium, copper, lead and zinc tended to be highest in the San Francisco Bay and Los Angeles area watersheds (Fig. 14). Sediments from San Leandro Creek (SF Bay area), and Ballona Creek and San Gabriel River (Los Angeles area) were in the highest quartile for the range of concentrations. The distribution of second and third quartile metals concentrations was not as strongly related to urban land cover.

Mercury concentrations exceeding probable effects concentrations (PECs) were found in sediments from watersheds with geologic abundance and historic mining activity (Fig. 15). This was also the case for samples exceeding the lower TECs (threshold effects concentrations), though the Ballona Creek sample also exceeded TECs, even though it came from an urban area isolated from geologic sources.

Trace organics

Total PCBs exceeded TECs in urban watersheds near San Francisco and Los Angeles (Fig. 16). Most PCB detections were in sediments from coastal and urban watersheds, though they were also detected in a few more remote locations, such as in the Kern and San Jacinto Rivers. PCBs were seldom detected in sediments from agricultural and rural areas.

Despite being banned in California for nearly 40 years, persistent DDTs were found in sediments from most urban and agricultural watersheds, including many samples that exceeded TECs (Fig. 17). None of the DDT concentrations exceeded the LC50 for *H. azteca*. Samples in which DDTs were not detected were predominantly located within rural and mountainous watersheds.

Organophosphate pesticides were detected in relatively few samples. Chlorpyrifos was detected in 11 samples, with only three of these above reporting limits. The highest chlorpyrifos concentration was in the Santa Maria River sample (71 ng/g), though this was below known toxic concentrations for *Hyalella* (LC50 = 399 ng/g; Brown et al. 1997). Diazinon and malathion were detected in only one sample each (Santa Maria River and Tule River, respectively), neither of which exceeded known toxic concentrations.

Pyrethroid pesticides were detected in 55% of the samples statewide (51 of 92). The highest concentrations were measured in sediments collected from urban watersheds, plus two agricultural watersheds along the central coast (Santa Maria River and Tembladero Slough; Fig. 18).

Sediment total pyrethroid concentrations were also viewed in terms of organic carbon normalized toxic units (TUs; Fig. 20). A sample with one toxic unit has a concentration equal to the LC50 for the measured chemical, and thus should cause mortality in half the test organisms exposed to it. The pyrethroid toxic unit data show a different spatial pattern than the dry weight data because of variation in sample total organic carbon content (TOC) and differences in the contributions of individual pyrethroids to each sample's total. For example, the Tijuana River sample (southernmost site on the maps) had a relatively high total pyrethroid dry weight concentration, but a relatively low toxic unit value because of the high TOC content (7.6%) and the high proportion of permethrin relative to the other pyrethroids. (Permethrin is less toxic than the other pyrethroids measured.) On the other hand, the highest pyrethroid toxic unit value (10.96 TU) was measured in a sample from Packwood Creek (Tulare basin). This sample had low TOC and was comprised entirely of cypermethrin, which is more toxic. Viewing the pyrethroid data as toxic units also shows high levels in urban and many agricultural areas, and lower TUs in rural or mountainous watersheds.

PBDEs and PAHs were measured only at Tier II SPoT sites located mostly in urban areas. As with the four trace metals, the highest PBDE concentrations were measured in sediments from San Leandro Creek (SF Bay area) and Ballona Creek (Los Angeles area; Fig. 20). Most other sites were in the lower two quartiles of the concentration range, having less than half the highest concentration measured (121 ng/g at Ballona Creek).

Sediment PAH concentrations were generally highest in the San Francisco Bay area, with one surprising exception: the highest total PAH value was measured in sediment from the Mokelumne River site in the Sierra foothills (Fig. 21). The total PAH concentration was 3567 ng/g dw, and the sum for 13 PAHs (Swartz 1999) was 2836 ng/g, which exceeds the TEC value of 1610 ng/g. Two other sites (marked by the other two cross symbols on Fig. 21) exceeded the TEC: Walnut Creek at Concord Ave (2536 ng/g total) and Guadalupe Creek at the USGS gauging station (2624 ng/g total). Samples from these three sites also exceeded TEC levels for a number of individual PAH compounds, including benz[a]anthracene, benzo[a]pyrene, fluoranthene (except Walnut Creek), and pyrene (except Guadalupe). For confirmation, the Mokelumne River sample was re-extracted and re-measured, with similar results. This site is on a relatively high gradient reach with a natural streambed and ample riparian vegetation. Sparse development upstream includes a hydroelectric power house (5 km upstream) and widely separated rural communities much further up in the foothills. The two-lane Highway 49 crosses the Mokelumne just upstream of the site, and the high PAH result may have been due to a spill or dumping incident. Further investigation is planned.

Toxicity

Significant toxicity was observed in 24% of the sediment samples collected, with 6.5% (6 of 92) identified as highly toxic (Fig. 22). Highly toxic samples were collected from agricultural watersheds in the Tulare basin and central coast, in urban areas of southern California, and in the Tijuana River. Other toxic samples were collected from a wide range of watershed types, including those along the north coast, the Sierra Nevada and urban and agricultural areas across the state.

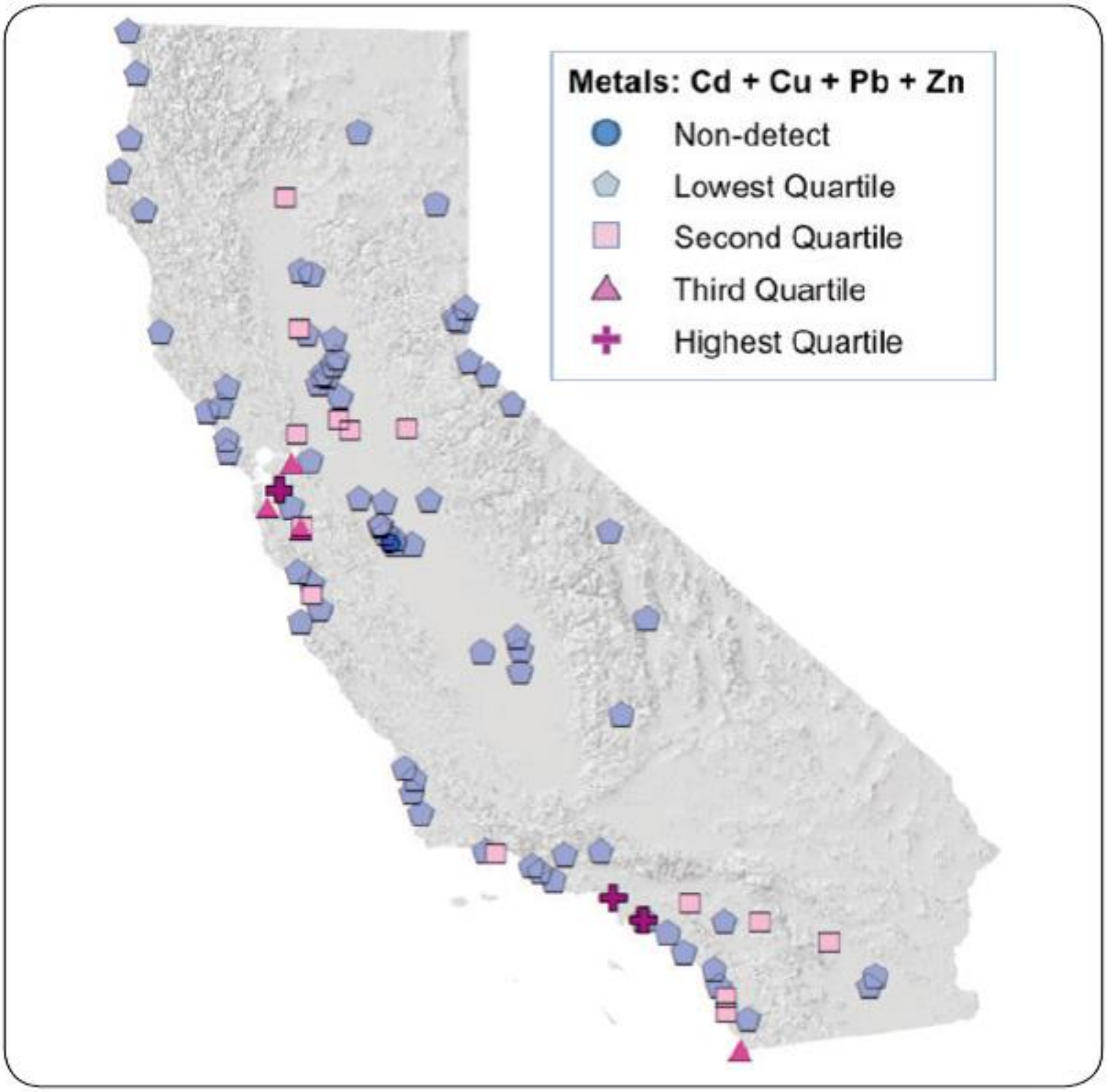

Figure 14. Distribution of sum of Cd, Cu, Pb, and Zn in unsieved stream sediment. "Quartile" cutoffs are at 25%, 50% and 75% of the maximum concentration.

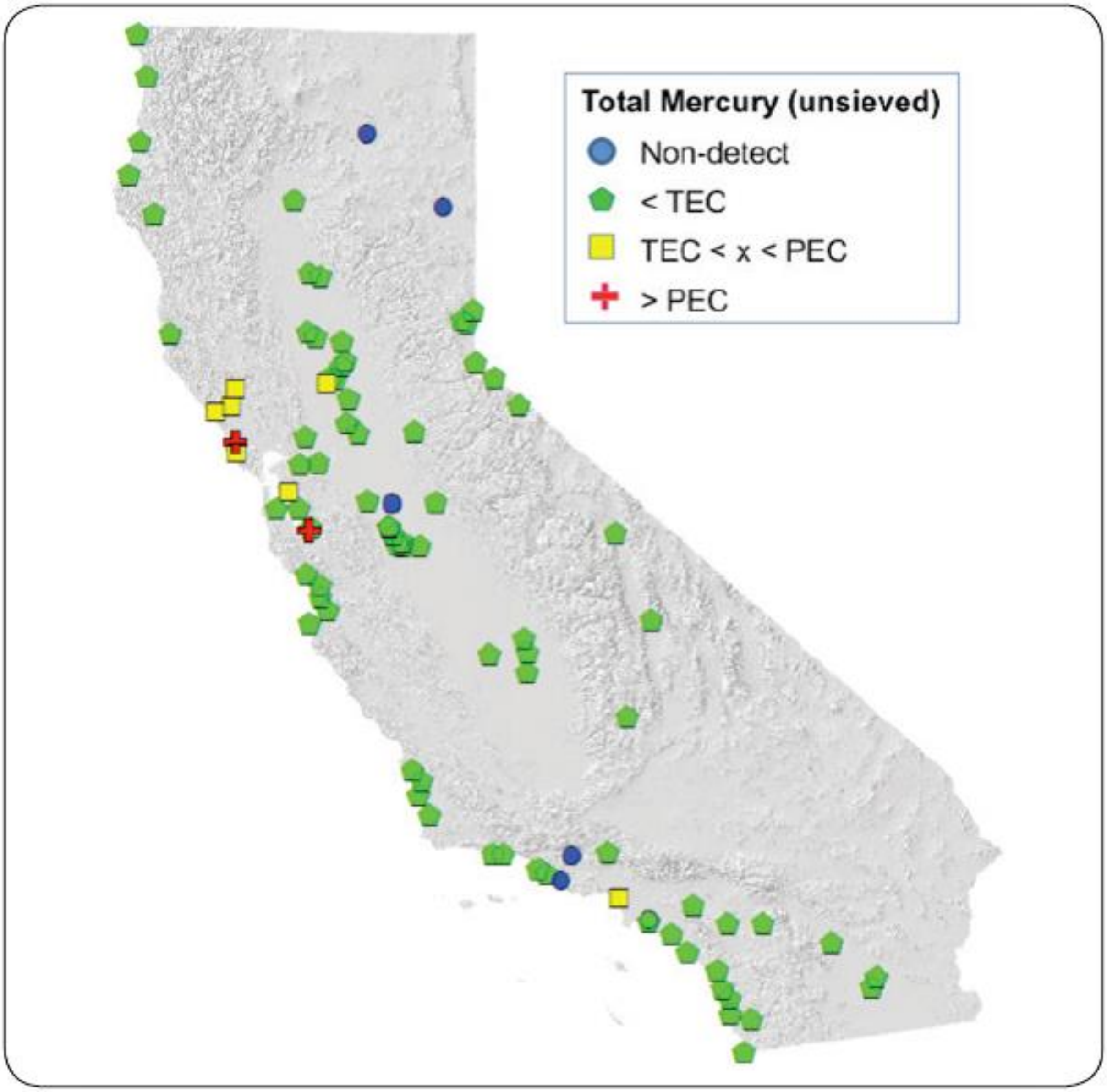

Figure 15. Distribution of mercury in unsieved stream sediment.

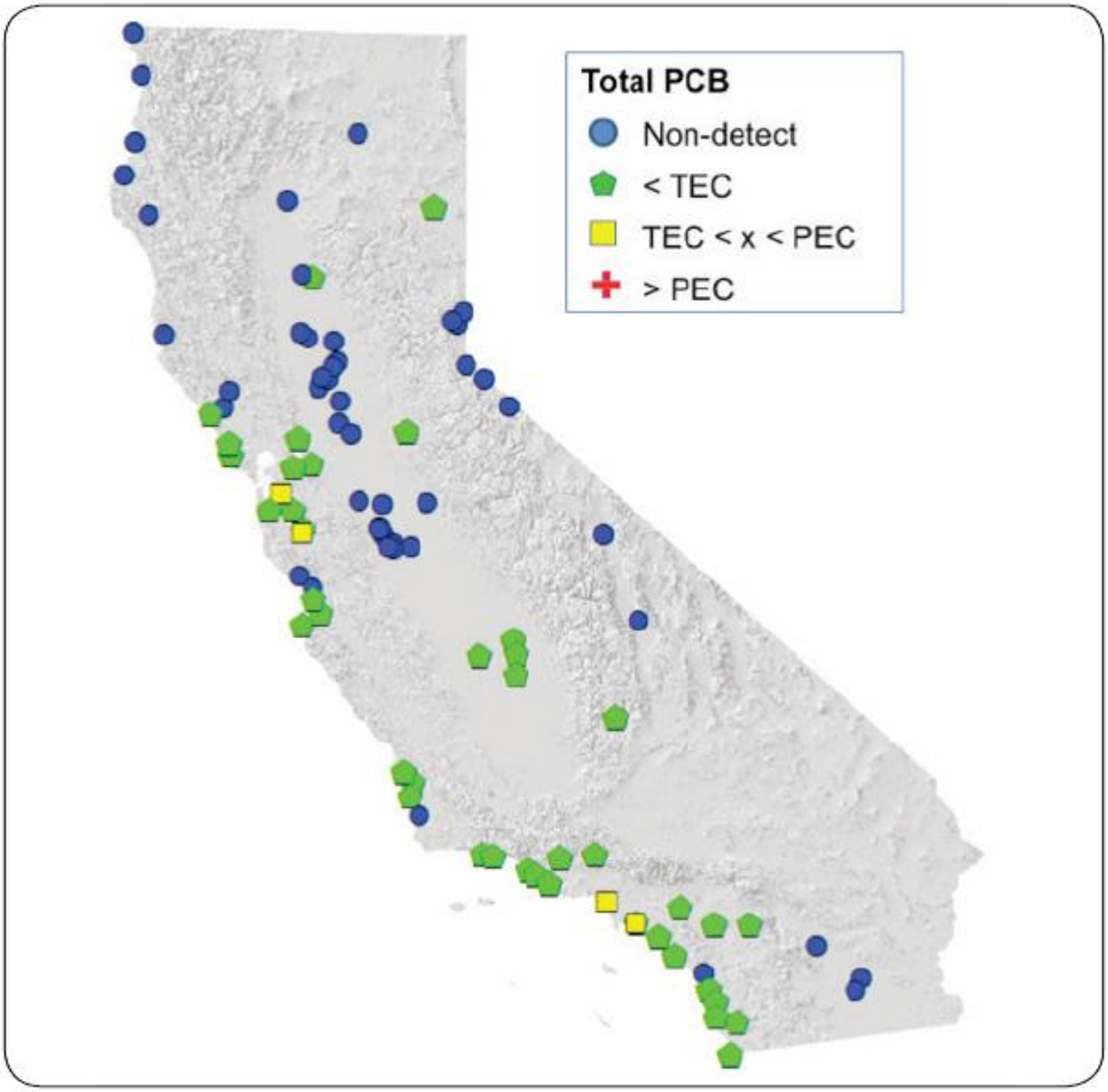

Figure 16. Distribution of PCBs in stream sediment.

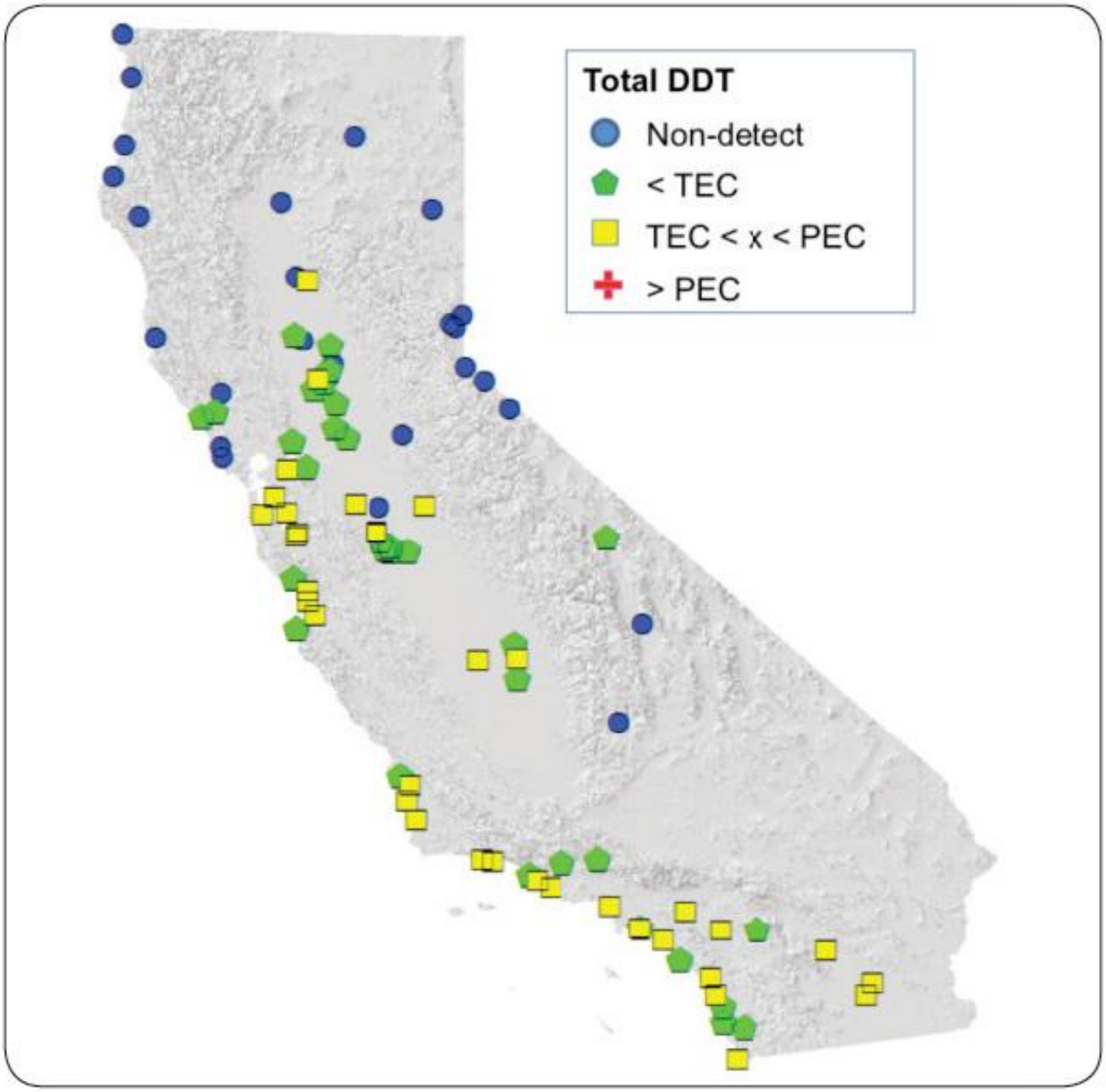

Figure 17. Distribution of DDTs in stream sediment.

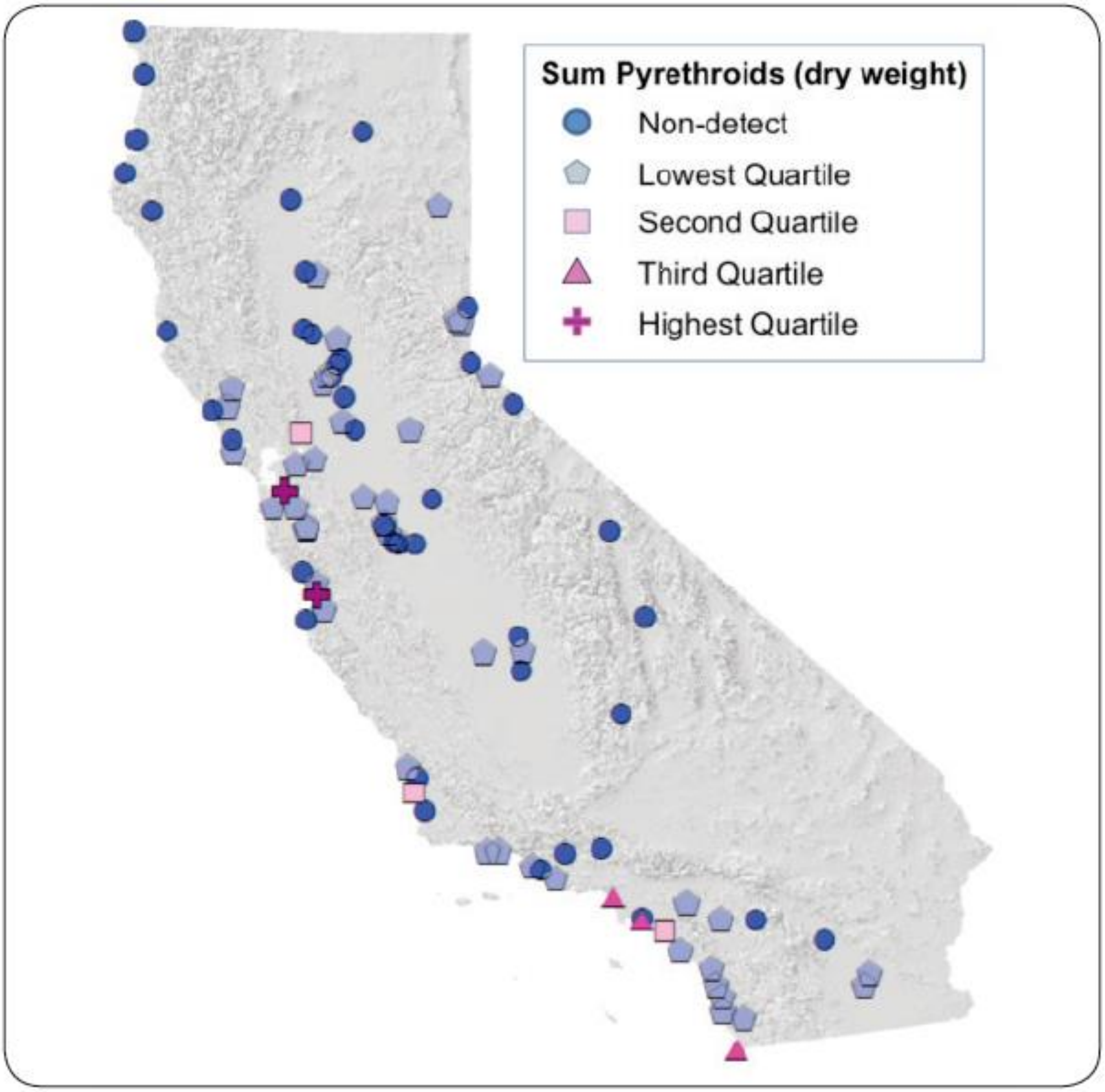

Figure 18. Distribution of pyrethroids in stream sediment. "Quartile" cutoffs are at 25%, 50% and 75% of the maximum concentration.

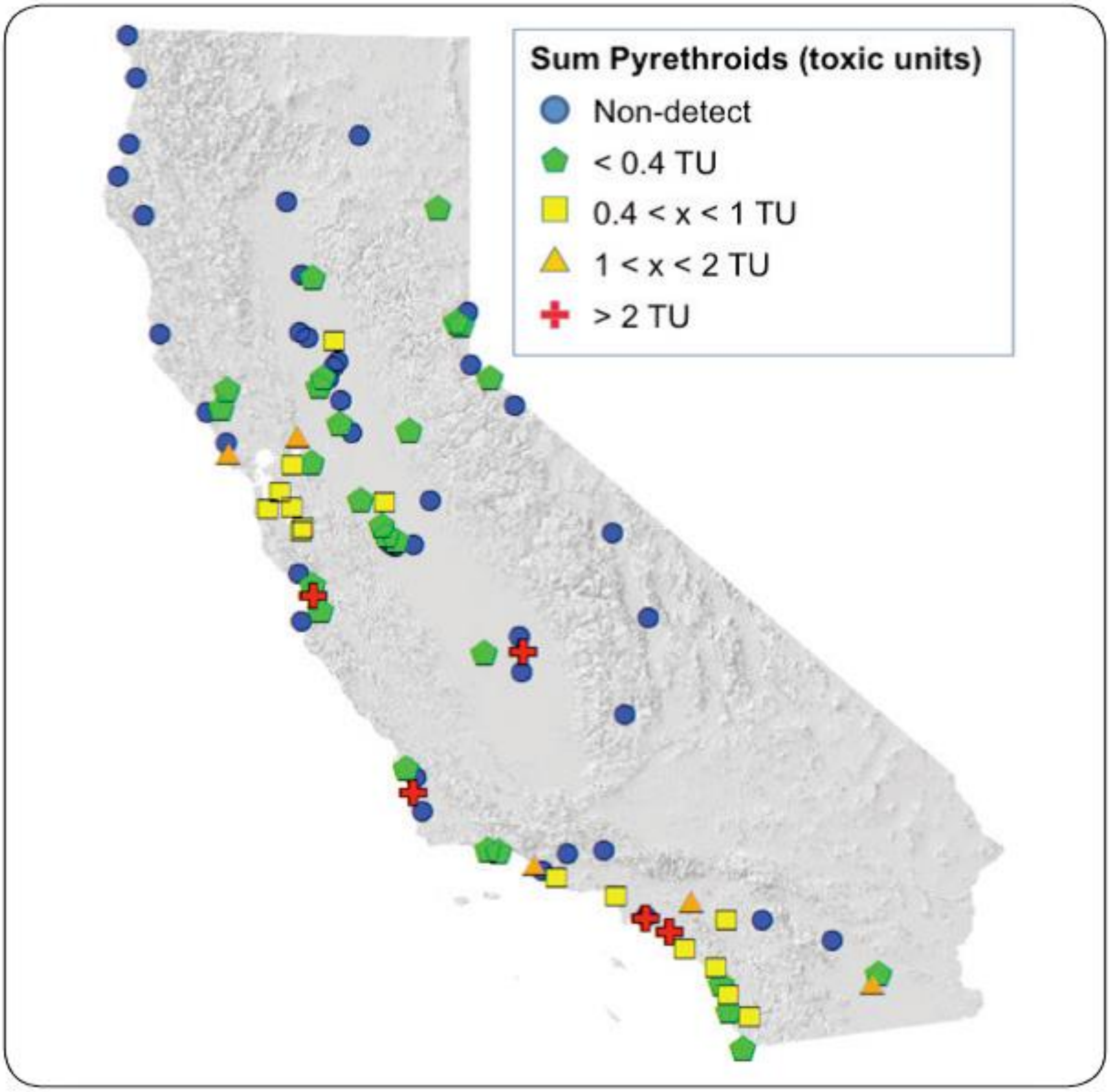

Figure 19. Distribution of pyrethroids as toxic units in stream sediment.

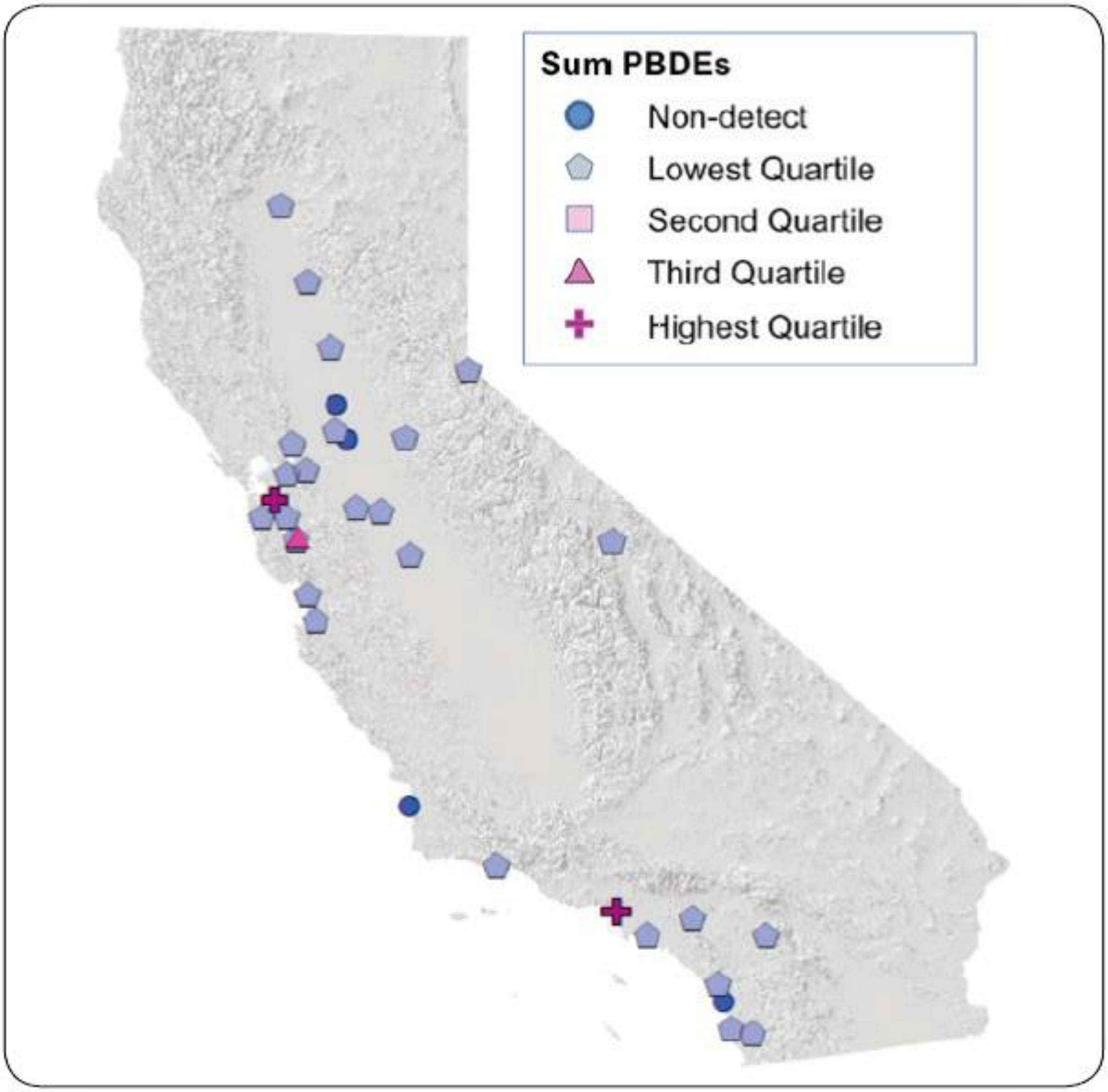

Figure 20. Distribution of PBDEs in stream sediment. “Quartile” cutoffs are at 25%, 50% and 75% of the maximum concentration.

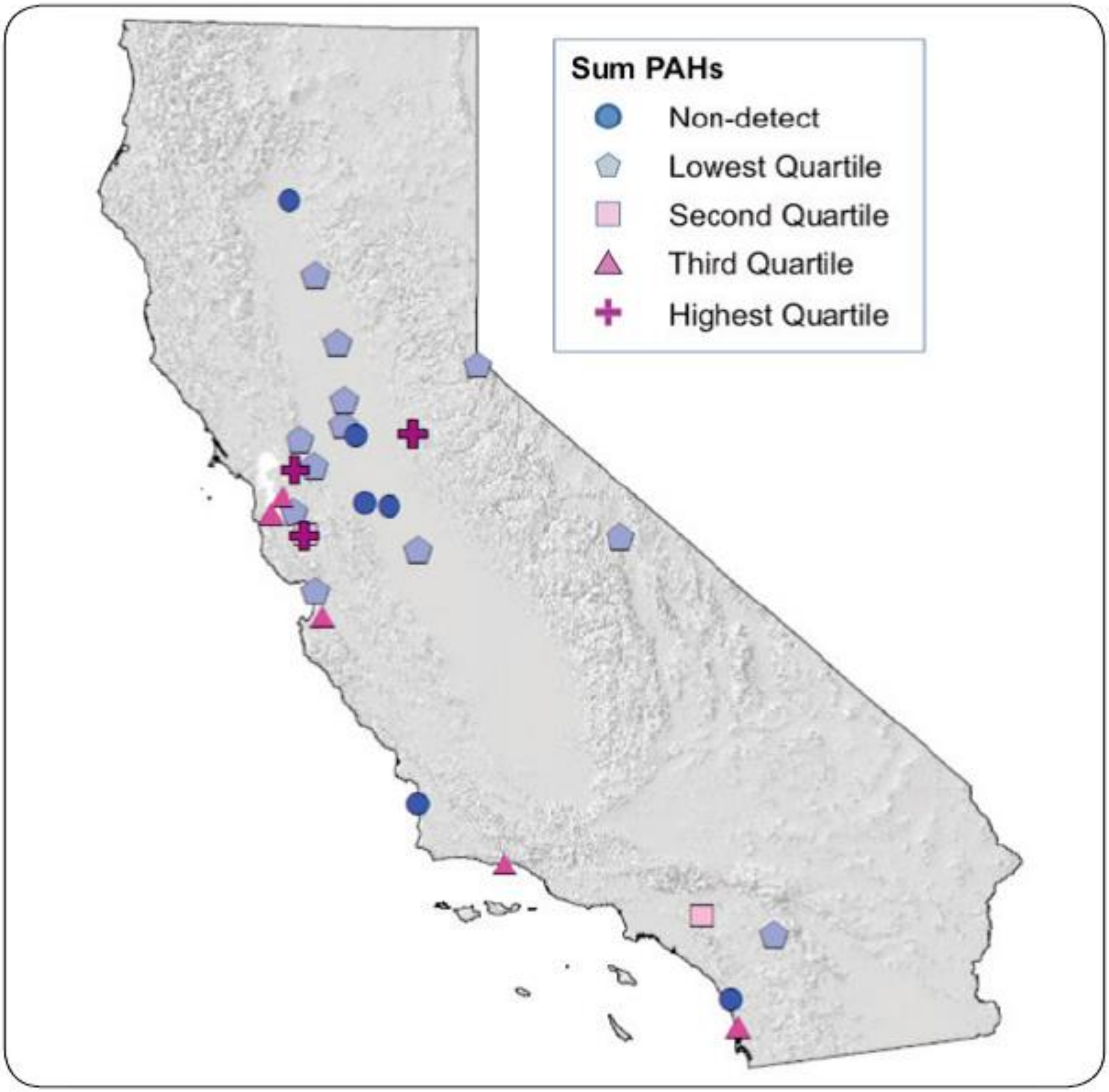

Figure 21. Distribution of PAHs in stream sediment. "Quartile" cutoffs are at 25%, 50% and 75% of the maximum concentration.

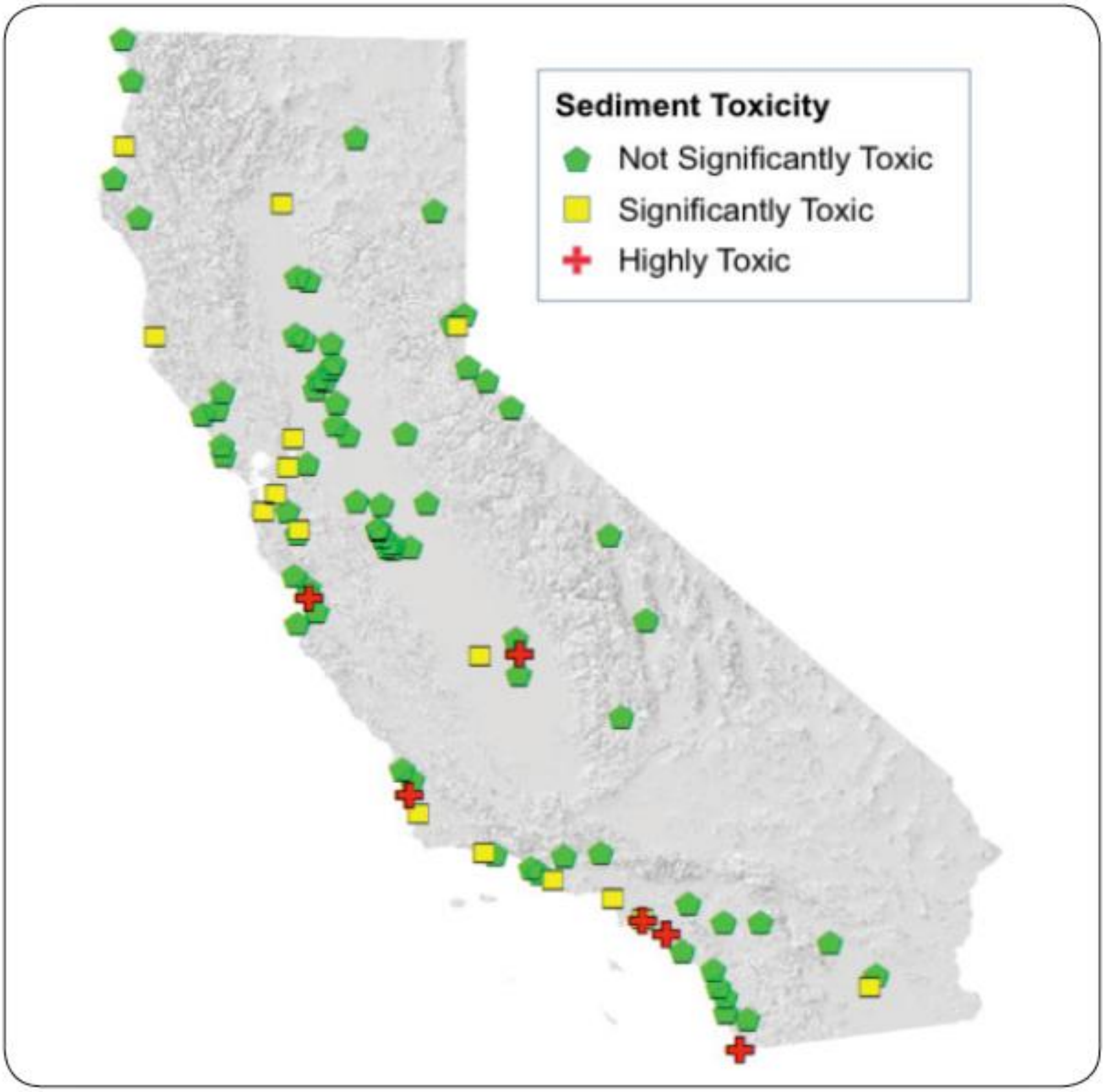

Figure 22. Distribution of observed toxicity in stream sediment.

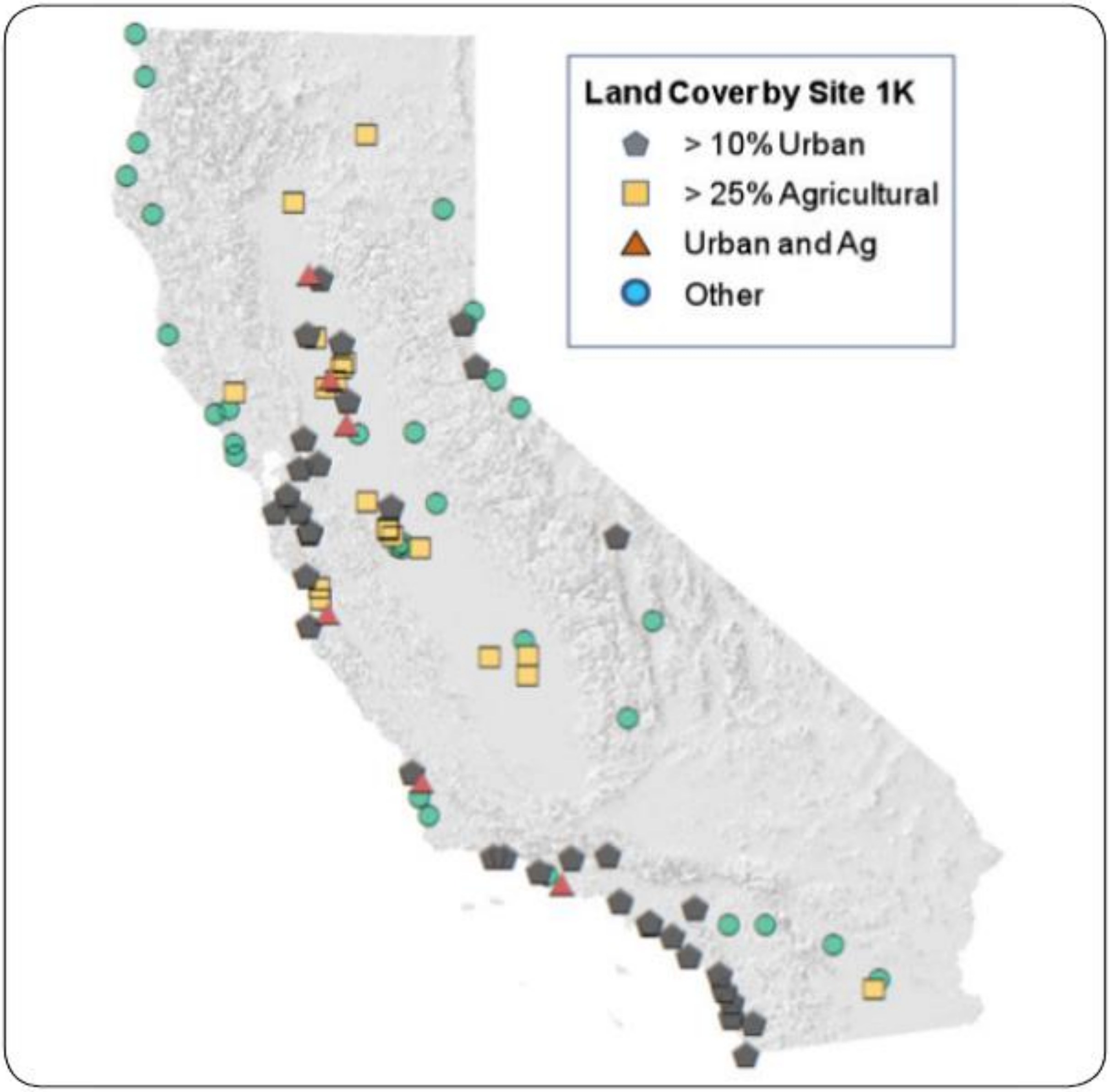

Figure 23. Characterization of land cover in the 1 km drainage area to each site.

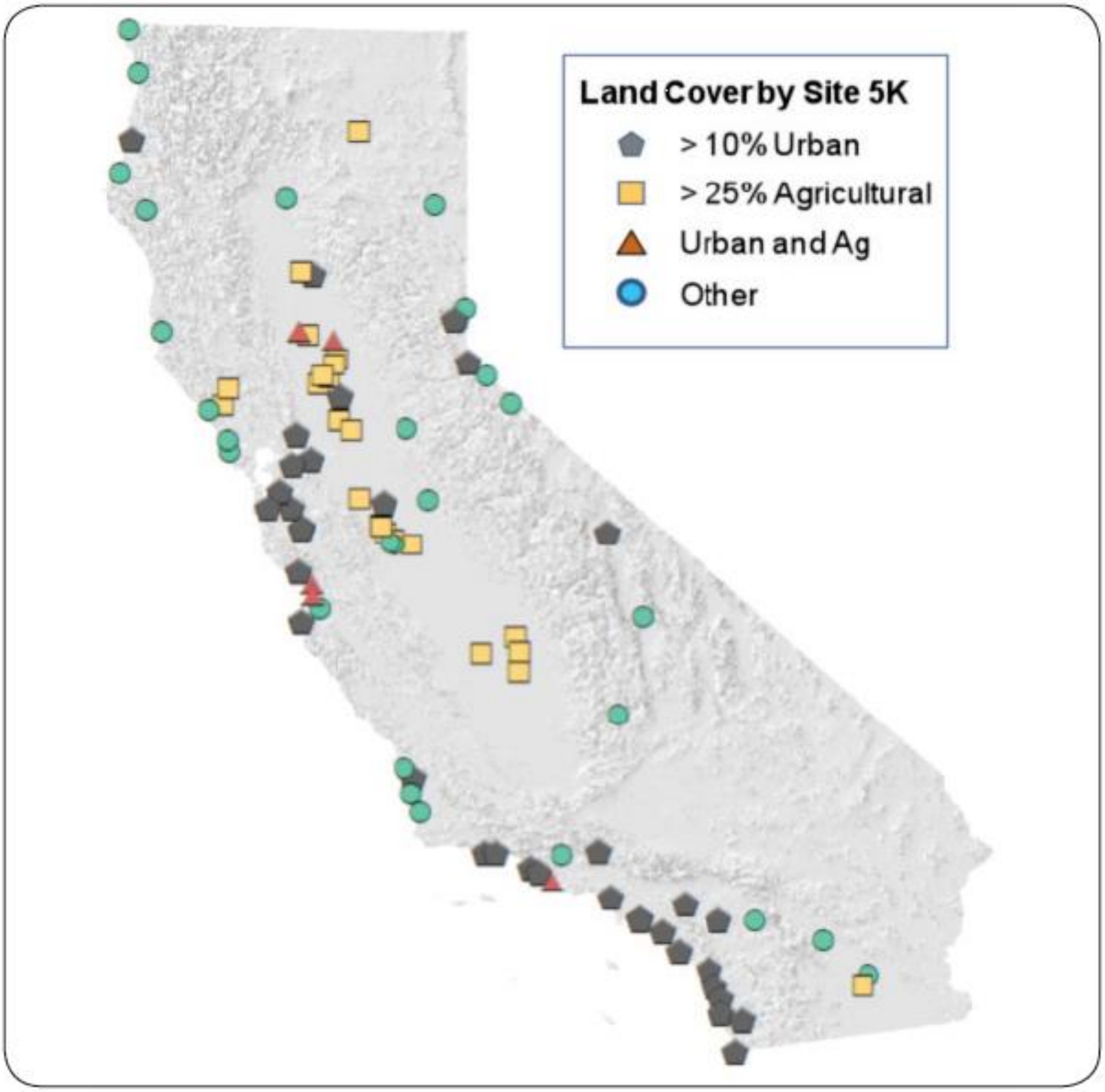

Figure 24. Characterization of land cover in the 5 km drainage area to each site.

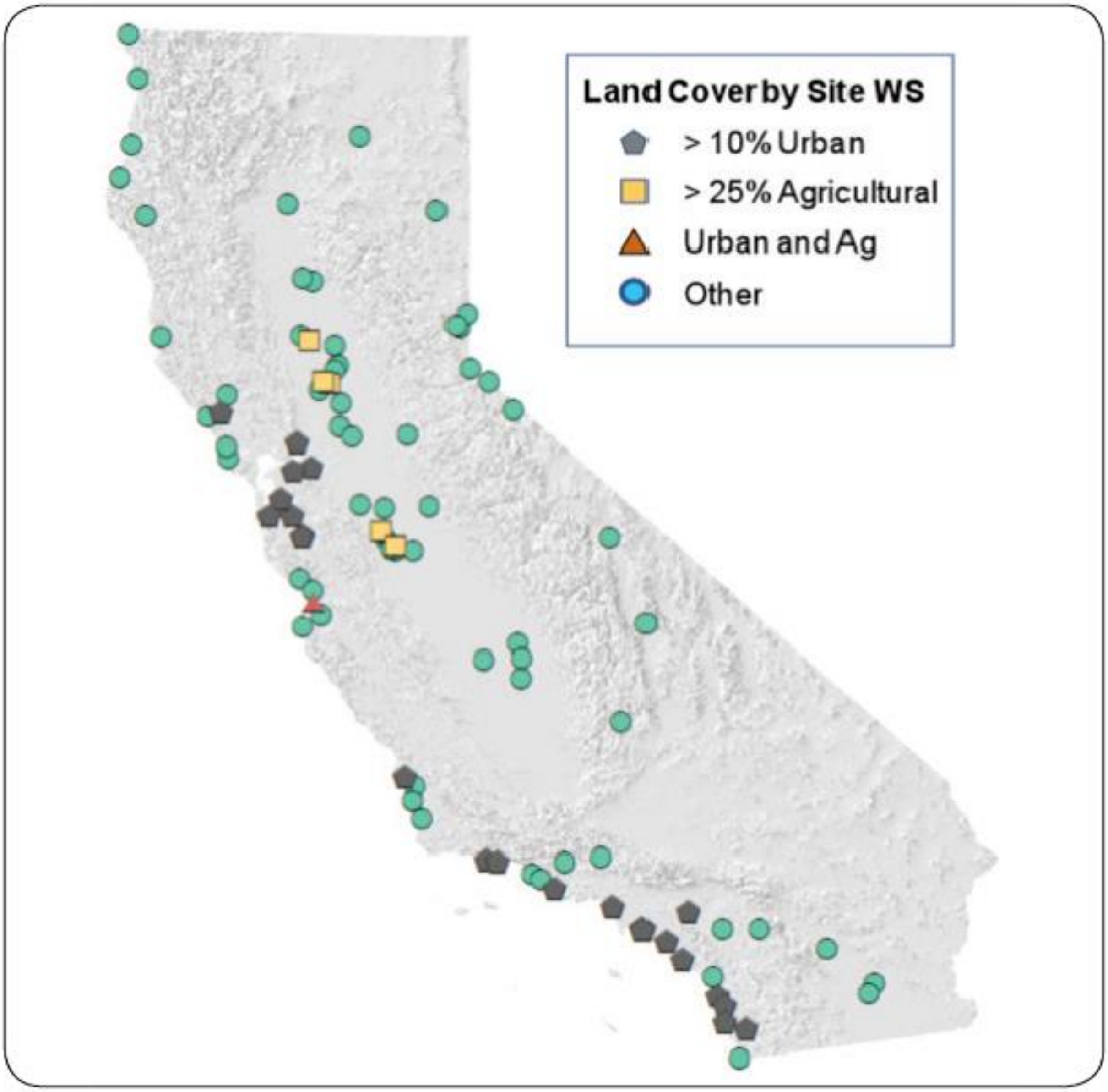

Figure 25. Characterization of land cover in the entire watershed drainage area to each site.

Chemical Concentrations relative to Thresholds

Pyrethroid pesticides show cause for concern in terms of potential for acute biological effects. At least one pyrethroid pesticide was detected in 55% of the sediment samples collected statewide, and 26 of 92 samples (28%) exceeded 0.4 toxic units, a value associated with acute toxicity in previous studies (Holmes et al. 2008). Bifenthrin, one of the more toxic pyrethroids, was detected in 44 of 92 samples (48%).

Organophosphate pesticides were detected in 12 of 92 sediment samples, and were not measured at concentrations associated with toxicity in any samples from this survey. Organophosphates are generally more water soluble and less persistent than pyrethroids, and thus less likely to accumulate in sediments deposited far downstream of application areas.

Legacy DDTs continue to be found at concentrations above TEC values in a large number of watersheds across the state. From a statewide perspective, these appear to remain a concern for biological effects associated with bioaccumulation (Davis et al. 2010). While mercury, PCBs, and other compounds have been shown to be of concern in local or regional studies, they were not measured at sediment concentrations above TECs in many of the low watershed sites in this study.

The herbicide oxadiazon was detected in 35 samples with a high concentration of 140 ng/g, though all but two samples had concentrations less than 20 ng/g. These concentrations are below known toxicity levels for aquatic organisms. This oxadiazole herbicide is registered for commercial use on golf courses (~77% of total use) and in apartment/condominium complexes, parks, athletic fields, playgrounds, and cemeteries. It is not registered for use on food crops (USEPA, 2011). As shown below, increased sediment oxadiazon concentrations correlated with increased developed open space land cover.

Trace metal concentrations exceeded sediment quality guidelines at many sites (Table 1). Nickel and chromium had the highest numbers of exceedences for both TECs and PECs. Both metals are geologically abundant, particularly in areas of serpentine soils, such as those common in the Franciscan formation of the central and northern coast ranges (Bonifacio et al., 2010; Topping and Kuwabara, 2003). Both are also used in various industrial applications, so natural sources cannot be assumed for all elevated samples. Arsenic exceeded the PEC in the Lower Owens River sample. Lead exceeded the PEC in the San Gabriel River sample. The mercury PEC was exceeded in samples from two Bay area watersheds, and the San Leandro Creek sample exceeded the PEC for zinc.

Table 1. Number of sites with measured sediment concentrations of trace metals above sediment quality guidelines. TEC = threshold effect concentration. PEC = probable effects concentration (MacDonald et al., 2000). Site names given in Appendix 1. Note: TEC and PEC values are shown in Appendix 3, Table 14.

	Number of Sites Exceeding		
	TEC	PEC	Sites > PEC
Arsenic	17	1	603LOWSED
Cadmium	11	0	None
Chromium	68	30	Many
Copper	34	0	None
Lead	7	1	845SGRDRE
Mercury	9	2	205GUA020 201WLK160
Nickel	65	34	Many
Zinc	19	1	204SLE030

Stream Pollution and Watershed Land Cover

Many pollutants tend to covary with each other and with sediment grain size and TOC content (Karickhoff 1984, DiToro *et al.* 1991, Foster and Charlesworth 1996). This can be explained generally by the affinity of organic chemicals for TOC, by the tendency of organic matter and fine sediment to deposit in similar areas of slower moving water, and by the economic forces that aggregate pollutant-generating activities in certain watershed locations, such as in urban or agricultural areas. Trace metals generally associate with fine sediment, and fine sediment (% fines, < 63 um) was significantly correlated with sediment TOC content in this data set ($p = 0.0001$).

Impervious surfaces

Percentage of watershed area covered by impervious surfaces at all three scales were positively correlated with increases in sediment toxicity and sediment concentrations of all pollutant classes. These correlations were statistically significant for all indicators except total phosphorus and the sum of eight metals at the larger watershed scales (Table 2, Figures 26 – 27).

Table 2. Probability values for multivariate Spearman rank correlations comparing impervious surface cover with pollution indicators at the three watershed scales. Correlation coefficients were positive for all pollutants, and negative for amphipod survival, indicating increased impact with increased impervious surface cover for all comparisons. Asterisks indicate statistical significance (α = 0.05). Note that alpha values are not adjusted for multiple comparisons (see Methods).

Chemical Class	**Watershed Scale**		
	1K	5K	WS
Sum 8 Metals	0.0160*	0.0662	0.1255
Sum 8 Metals Sieved	0.0015*	0.0317*	0.1148
Cd+Cu+Pb+Zn	0.0002*	0.0010*	<0.0001*
Cd+Cu+Pb+Zn Sieved	<0.0001*	<0.0001*	<0.0001*
Total DDT	0.0011*	<0.0001*	<0.0001*
Total PCB	<0.0001*	<0.0001*	<0.0001*
Sum Pyrethroids	<0.0001*	<0.0001*	<0.0001*
Sum PAH	0.0018*	0.0145*	0.0561
PBDEs	<0.0001*	<0.0001*	0.0008*
Total Phosphorus	0.5156	0.3127	0.2736
Amphipod Survival	0.0051*	0.0001*	0.0290*

Land Cover Categories

Characterizations of overall land cover in the watershed areas draining to each site are shown in Figures 23 - 25. At all watershed scales, there were significant positive correlations between increased urban land cover and increased stream sediment toxicity and concentrations of total DDTs, total PCBs, total PAHs, PBDEs, bifenthrin, total pyrethroids, and trace metals (as sum Cd, Cu, Pb, Zn; sieved and unsieved; Table 3).

Some pollution indicators correlated significantly with increasing crop cover at some watershed scales: DDT and toxicity at the whole watershed scale, and oxadiazon at the 1K and 5K scales. The herbicide oxadiazon correlated significantly with developed open space at all watershed scales, reflecting its use for golf courses, parks, and similar open space.

It is important to note that these correlations are observed at the statewide level over a population of integrator sites located at the base of large watersheds with heterogeneous land use. Other types of relationships might emerge from data collected within a single region or watershed.

Relationships between pollutant indicators and urban land use were similar among the chemical classes, and were similar to pollutant relationships with impervious surface cover (e.g., Figs. 26-29). For each of these relationships, the larger the drainage area analyzed, the stronger the correlation between pollutant and land cover variables. The trend line slopes increase from 1K to 5K to whole watershed comparisons. This is consistent with the reasoning that if a watershed area 1 km upstream of a site was characterized by a high proportion of urban land cover, it is still possible that much of the rest of the watershed could be in open space or other land cover. The 5 km-scale land cover characterizations are intermediate. At the whole watershed scale of land cover characterization (WS), a high proportion of urban cover indicates substantially greater urban influence throughout the entire area draining to the stream site, and this is reflected in stronger relationships with pollutant concentrations and toxicity.

Space for time analysis

The SPoT program is designed to measure long-term trends in stream pollution. However, this report covers the first annual survey, so temporal trends cannot be evaluated. In the absence of time series data, the relationships between pollution levels and land use can be used to estimate how stream pollution levels might change over time with change in land use (NRC 2002). On the statewide level, the strongest relationships observed for nearly all pollution indicators were with urban land cover. It is reasonable to assume, all else remaining equal, that increasing urbanization will be associated with increasing pollutant levels in streams draining these watersheds.

For example, as a rough approximation, and assuming continued levels of pyrethroid use as a function of urban area, a watershed that develops from 20% to 40% urban land cover might expect to see stream sediment pyrethroid concentrations rise from about 15 ng/g to about 25 ng/g over that period (see Fig. 28). Given that samples from sites in many watersheds had pyrethroid concentrations near threshold levels for toxicity, such a change would result in increased potential for acute adverse effects to aquatic life in these streams. There are many factors that may change over time, and this is not meant as a quantitative prediction, but the space for time analysis approach can be used to identify processes of concern for resource management and land use planning.

Table 3. Correlations between water quality parameters and land cover categories generated using nonparametric multivariate Spearman's test Statistically significant relationships (α < 0.05) are marked with asterisks. Positive coefficients indicate that the measured chemical concentration increased as the specified land cover type increased (labeled with an "s" when significant). Correlations between water quality parameters and land cover categories generated using nonparametric multivariate Spearman's ρ test. Negative coefficients for survival in toxicity tests indicate test organism survival decreased as the specified land cover type increased (labeled with an "s" when significant). Dev_Open = developed open space, such as urban parks; Past = pasture/hay.

Variable	by Variable	Spearman ρ	Prob>|ρ|
Sum 8 Metals	Urban_1K	0.2327	0.0256s*
Sum 8 Metals	Dev_Open	-0.0031	0.9764
Sum 8 Metals	Past_1k	-0.2116	0.0429*
Sum 8 Metals	Crop_1K	0.0454	0.6673
Sum 8 Metals	Urban_5K	0.1912	0.0679
Sum 8 Metals	21_5K	0.0244	0.8178
Sum 8 Metals	Past_5K	-0.1621	0.1226
Sum 8 Metals	Crops_5K	0.0486	0.6457
Sum 8 Metals	Urban_WS	0.1327	0.2072
Sum 8 Metals	21_WS	0.1339	0.2033
Sum 8 Metals	Past_WS	-0.1137	0.2803
Sum 8 Metals	Crops_WS	-0.0618	0.5583
Sum 8 Metals Sieved	Urban_1K	0.3035	0.0033s*
Sum 8 Metals Sieved	Dev_Open	0.0929	0.3785
Sum 8 Metals Sieved	Past_1k	-0.2230	0.0326*
Sum 8 Metals Sieved	Crop_1K	0.0591	0.5758
Sum 8 Metals Sieved	Urban_5K	0.2272	0.0294s*
Sum 8 Metals Sieved	21_5K	0.1519	0.1484
Sum 8 Metals Sieved	Past_5K	-0.1552	0.1395
Sum 8 Metals Sieved	Crops_5K	-0.0028	0.9788
Sum 8 Metals Sieved	Urban_WS	0.1367	0.1937
Sum 8 Metals Sieved	21_WS	0.2028	0.0525
Sum 8 Metals Sieved	Crops_WS	-0.0650	0.5380
Sum 8 Metals Sieved	Past_WS	-0.1367	0.1938
Cd+Cu+Pb+Zn	Urban_1K	0.3401	0.0009s*
Cd+Cu+Pb+Zn	Dev_Open	0.0145	0.8907
Cd+Cu+Pb+Zn	Past_1k	-0.2767	0.0076*
Cd+Cu+Pb+Zn	Crop_1K	-0.0997	0.3446
Cd+Cu+Pb+Zn	Urban_5K	0.3259	0.0015s*
Cd+Cu+Pb+Zn	21_5K	0.0514	0.6263
Cd+Cu+Pb+Zn	Past_5K	-0.1740	0.0971
Cd+Cu+Pb+Zn	Crops_5K	-0.0536	0.6120
Cd+Cu+Pb+Zn	Urban_WS	0.3764	0.0002s*
Cd+Cu+Pb+Zn	21_WS	0.2099	0.0446*
Cd+Cu+Pb+Zn	Past_WS	-0.1242	0.2382
Cd+Cu+Pb+Zn	Crops_WS	-0.1275	0.2258
Cd+Cu+Pb+Zn Sieved	Urban_1K	0.4746	<0.0001s*
Cd+Cu+Pb+Zn Sieved	Dev_Open	0.1486	0.1574
Cd+Cu+Pb+Zn Sieved	Past_1k	-0.3189	0.0019*

Variable	by Variable	Spearman ρ	Prob>|ρ|
Cd+Cu+Pb+Zn Sieved	Crop_1K	-0.0802	0.4475
Cd+Cu+Pb+Zn Sieved	Urban_5K	0.4063	<.00001s*
Cd+Cu+Pb+Zn Sieved	21_5K	0.2126	0.0418s*
Cd+Cu+Pb+Zn Sieved	Past_5K	-0.1955	0.0618
Cd+Cu+Pb+Zn Sieved	Crops_5K	-0.1035	0.3260
Cd+Cu+Pb+Zn Sieved	Urban_WS	0.3823	0.0002s*
Cd+Cu+Pb+Zn Sieved	21_WS	0.3045	0.0032s*
Cd+Cu+Pb+Zn Sieved	Past_WS	-0.2140	0.0405*
Cd+Cu+Pb+Zn Sieved	Crops_WS	-0.1759	0.0934
Sum DDT	Urban_1K	0.3329	0.0012s*
Sum DDT	Dev_Open	-0.0340	0.7479
Sum DDT	Past_1k	-0.0016	0.9879
Sum DDT	Crop_1K	0.1749	0.0954
Sum DDT	Urban_5K	0.4528	<0.0001s*
Sum DDT	21_5K	0.2780	0.0073s*
Sum DDT	Past_5K	0.0729	0.4899
Sum DDT	Crops_5K	0.1971	0.0596
Sum DDT	Urban_WS	0.4828	<0.0001s*
Sum DDT	21_WS	0.3716	0.0003s*
Sum DDT	Past_WS	0.0972	0.3565
Sum DDT	Crops_WS	0.2897	0.0051s*
Sum PCB	Urban_1K	0.4993	<0.0001s*
Sum PCB	Dev_Open	0.1671	0.1113
Sum PCB	Past_1k	-0.1207	0.2516
Sum PCB	Crop_1K	-0.2097	0.0448*
Sum PCB	Urban_5K	0.5723	<.0001s*
Sum PCB	21_5K	0.4392	<.0001s*
Sum PCB	Past_5K	-0.2065	0.0483*
Sum PCB	Crops_5K	-0.2961	0.0042*
Sum PCB	Urban_WS	0.5113	<0.0001s*
Sum PCB	21_WS	0.5387	<0.0001s*
Sum PCB	Past_WS	-0.3483	0.0007*
Sum PCB	Crops_WS	-0.2571	0.0134*
Pyrethroids	Urban_1K	0.4812	<0.0001s*
Pyrethroids	Dev_Open	0.0686	0.5156
Pyrethroids	Past_1k	-0.0777	0.4617
Pyrethroids	Crop_1K	-0.0968	0.3588
Pyrethroids	Urban_5K	0.5579	<0.0001s*
Pyrethroids	21_5K	0.2915	0.0048*
Pyrethroids	Past_5K	-0.1355	0.1977
Pyrethroids	Crops_5K	-0.1375	0.1914
Pyrethroids	Urban_WS	0.5399	<0.0001s*
Pyrethroids	21_WS	0.4342	<0.0001s*
Pyrethroids	Past_WS	-0.1771	0.0913
Pyrethroids	Crops_WS	-0.1080	0.3055
Bifenthrin	Urban_1K	0.5765	<0.0001s*
Bifenthrin	Dev_Open	0.1449	0.1681

Variable	by Variable	Spearman ρ	Prob>|ρ|
Bifenthrin	Past_1k	-0.0794	0.4517
Bifenthrin	Crop_1K	-0.1460	0.1651
Bifenthrin	Urban_5K	0.6270	<0.0001s*
Bifenthrin	21_5K	0.4414	<0.0001s*
Bifenthrin	Past_5K	-0.0992	0.3470
Bifenthrin	Crops_5K	-0.1892	0.0708
Bifenthrin	Urban_WS	0.6536	<0.0001s*
Bifenthrin	21_WS	0.5760	<0.0001s*
Bifenthrin	Past_WS	-0.0772	0.4645
Bifenthrin	Crops_WS	-0.0370	0.7264
Oxadiazon	Urban_1K	0.5206	<0.0001s*
Oxadiazon	Dev_Open	0.1518	0.1487
Oxadiazon	Past_1k	-0.1055	0.3170
Oxadiazon	Crop_1K	-0.2397	0.0214*
Oxadiazon	Urban_5K	0.6010	<0.0001s*
Oxadiazon	21_5K	0.4781	<0.0001s*
Oxadiazon	Past_5K	-0.1890	0.0712
Oxadiazon	Crops_5K	-0.2831	0.0062*
Oxadiazon	Urban_WS	0.6154	<0.0001s*
Oxadiazon	21_WS	0.6326	<0.0001s*
Oxadiazon	Past_WS	-0.2067	0.0481*
Oxadiazon	Crops_WS	-0.1845	0.0784
Sum PAH	Urban_1K	0.4702	0.0116s*
Sum PAH	Dev_Open	0.1056	0.5927
Sum PAH	Past_1k	-0.4512	0.0160*
Sum PAH	Crop_1K	-0.3871	0.0418*
Sum PAH	Urban_5K	0.4598	0.0138s*
Sum PAH	21_5K	0.2956	0.1268
Sum PAH	Past_5K	-0.5663	0.0017*
Sum PAH	Crops_5K	-0.4906	0.0080*
Sum PAH	Urban_WS	0.3799	0.0462s*
Sum PAH	21_WS	0.3859	0.0425s*
Sum PAH	Past_WS	-0.6590	0.0001*
Sum PAH	Crops_WS	-0.5961	0.0008*
Sum PBDE	Urban_1K	0.6784	<0.0001s*
Sum PBDE	Dev_Open	-0.0460	0.8024
Sum PBDE	Past_1k	-0.2914	0.1057
Sum PBDE	Crop_1K	-0.3652	0.0399*
Sum PBDE	Urban_5K	0.6751	<0.0001s*
Sum PBDE	21_5K	0.2510	0.1659
Sum PBDE	Past_5K	-0.4287	0.0144*
Sum PBDE	Crops_5K	-0.3716	0.0362*
Sum PBDE	Urban_WS	0.5672	0.0007s*
Sum PBDE	21_WS	0.4546	0.0090s*
Sum PBDE	Past_WS	-0.3838	0.0301*
Sum PBDE	Crops_WS	-0.3743	0.0348*
Total Phosphorus	Urban_1K	0.0458	0.6646

Variable	by Variable	Spearman ρ	Prob>|ρ|
Total Phosphorus	Dev_Open	-0.0171	0.8713
Total Phosphorus	Past_1k	0.0267	0.8004
Total Phosphorus	Crop_1K	-0.1476	0.1603
Total Phosphorus	Urban_5K	0.1166	0.2685
Total Phosphorus	21_5K	0.0760	0.4718
Total Phosphorus	Past_5K	-0.0135	0.8983
Total Phosphorus	Crops_5K	-0.0913	0.3866
Total Phosphorus	Urban_WS	0.1314	0.2117
Total Phosphorus	21_WS	0.0528	0.6172
Total Phosphorus	Past_WS	-0.0776	0.4624
Total Phosphorus	Crops_WS	-0.1459	0.1654
Amphipod Survival	Urban_1K	-0.2739	0.0083s*
Amphipod Survival	Dev_Open	-0.0051	0.9617
Amphipod Survival	Past_1k	0.1372	0.1923
Amphipod Survival	Crop_1K	0.1015	0.3357
Amphipod Survival	Urban_5K	-0.3784	0.0002s*
Amphipod Survival	21_5K	-0.2059	0.0489s*
Amphipod Survival	Past_5K	0.0753	0.4754
Amphipod Survival	Crops_5K	0.1763	0.0928
Amphipod Survival	Urban_WS	-0.2215	0.0339s*
Amphipod Survival	21_WS	-0.2381	0.0223s*
Amphipod Survival	Past_WS	0.1997	0.0563
Amphipod Survival	Crops_WS	0.2350	0.0241*

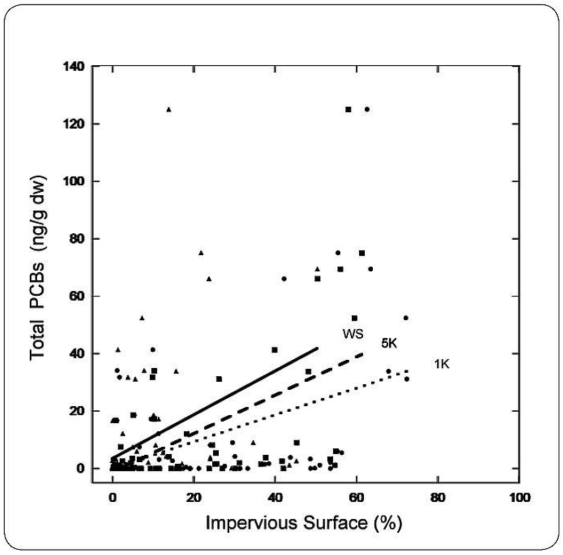

Figure 26. Sediment total PCB concentration plotted against impervious surface cover. Correlation coefficients given in Table 3. ▲ = whole watershed, ■ = 5K, ● = 1K.

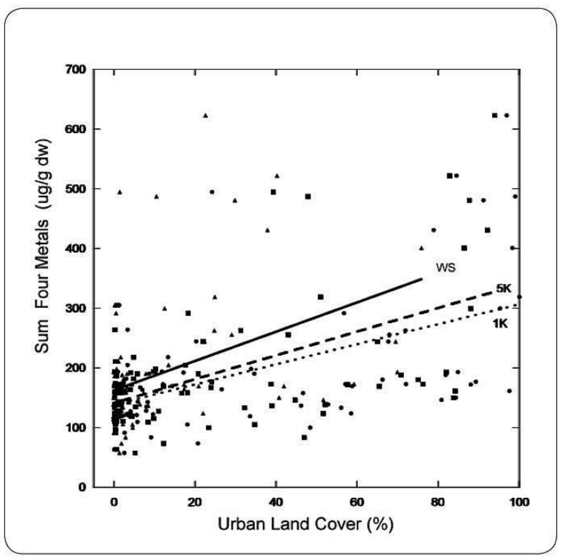

Figure 27. Four metals in sieved sediment plotted against urban land cover. Coefficients given in Table 3. ▲ = whole watershed, ■ = 5K, ● = 1K.

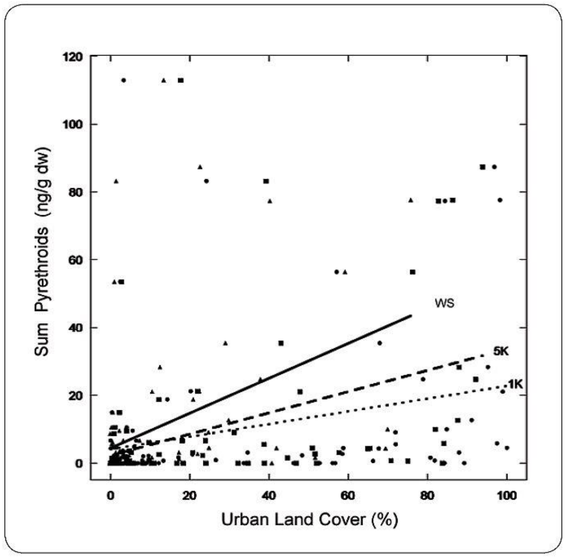

Figure 28. Sediment pyrethroid concentration plotted against urban cover. Correlation coefficients given in Table 3. ▲ = whole watershed, ■ = 5K, ● = 1K.

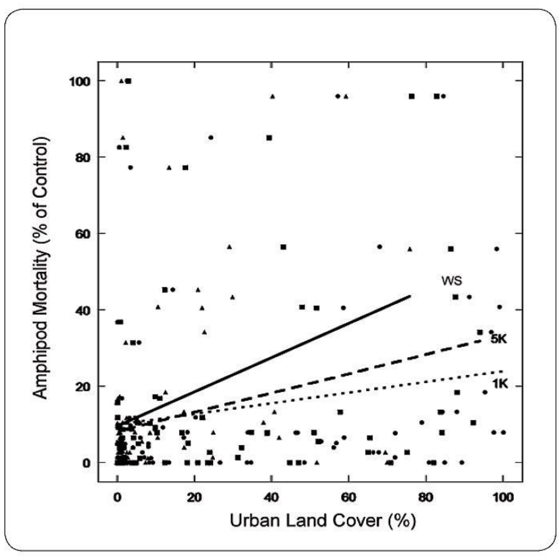

Figure 29. Sediment toxicity plotted against urban cover. Correlation coefficients given in Table 3. ▲ = whole watershed, ■ = 5K, ● = 1K.

Stream Pollution Indicators by Land Cover Category

On a statewide basis, watershed areas with greater than 10% urban land cover had consistently higher sediment toxicity and pollutant concentrations than did watersheds characterized by agricultural or other land cover types (Figures 30 – 38). Differences among land cover categories were statistically significant for PCBs, metals, pyrethroids, DDTs, and PBDEs (Wilcoxon test, $\alpha < 0.05$; Table 4).

Table 4. Probability values for non-parametric Wilcoxon test comparisons among land cover categories at the 1 km scale. Data are the same as displayed in the 1K graphs in Figures 30 – 38. Asterisks indicate significant differences among land cover categories.

Total PCBs	<0.0001
Cd+Cu+Pb+Zn sieved	0.0003
Sum Pyrethroids	0.0016
Total DDTs	0.0057
Total PBDEs	0.0273
Sum PAH	0.1673
Toxicity	0.1720
Mercury Sieved	0.8577

Trace metals as a sum of four elements commonly used in commercial, industrial, and transportation applications (cadmium, copper, lead, and zinc) were markedly higher in urban watersheds than in those with greater than 25% agricultural land cover or those with less urban or agricultural cover (Fig. 31). These metals tend to be more acutely toxic to many aquatic organisms. Sediment concentrations of mercury tended to reflect local watershed conditions rather than evidence strong statewide trends (Fig. 32). Differences among watersheds were not as pronounced for the sum of eight trace metals (Fig. 30). Some of these eight metals are locally abundant geologically (e.g., chromium, nickel, and mercury) or associated with historic mining activity (e.g., mercury and silver).

The legacy pesticide DDT (as total DDT) was found at higher sediment concentrations in urban watersheds than in agricultural or other watersheds (Fig. 33). This may reflect past urban use relative to agricultural applications, but perhaps is more reflective of urban development over previously agricultural lands during the years since DDTs were banned in the early 1970s. Early mosquito abatement programs may also have contributed substantial DDT to urban environments. Like other relatively insoluble organic compounds, DDTs adhere to soil particles, and DDTs persist for many decades, perhaps later mobilized by soil disturbance associated with urban and residential development.

It is not surprising that PCBs, PAHs and PBDEs were measured at higher sediment concentrations in urban watersheds (Figs. 34 – 36). PCBs were used primarily in industrial applications, petrogenic PAHs are by products of fossil fuel combustion, and

PBDEs are industrially manufactured and commercially used flame retardants. PCB use has been banned for decades and PBDEs are subject to strict recent regulation, so the trend analysis of these classes of chemicals should provide interesting markers of pollutant fate and transport.

Pyrethroids are current use insecticides for agricultural, residential, commercial and industrial applications. Given this variety of usage, the higher sediment concentrations in urban watersheds are striking (Fig. 37). This is a statewide analysis of the sum of all pyrethroids measured, and different pyrethroid pesticides are used in different applications (e.g. commercial vs. agricultural (Spurlock and Lee 2008). However, when summed on a toxic unit basis (indicating potential for acute adverse biological effects), sediment pyrethroids appear to be of greater concern in urban watersheds (Fig. 19). Given the higher sediment pollutant concentrations, it's not surprising that stream sediment toxicity was also highest in urban watersheds (Fig. 38). These results can be compared to the statewide evaluation of toxicity results from nine years of SWAMP studies which demonstrates more comparable levels of toxicity between urban and agricultural areas (Anderson et al. 2011).

Initial results from subsequent SPoT surveys indicate that the level of sediment toxicity presented here may be an underestimate. The test temperature for the present study was 23°C, the standard temperature for the *Hyalella* test protocol. Many California streams are much cooler, particularly during and after winter runoff events. Tests conducted at 15°C in subsequent SPoT surveys indicated substantially higher observed amphipod mortality, a result consistent with toxicity due to pyrethroid pesticides (data forthcoming). In addition, toxicity was measured using 10-day tests, while the amphipod life-cycle is on the order of two months. Longer exposures typically result in greater observed toxicity.

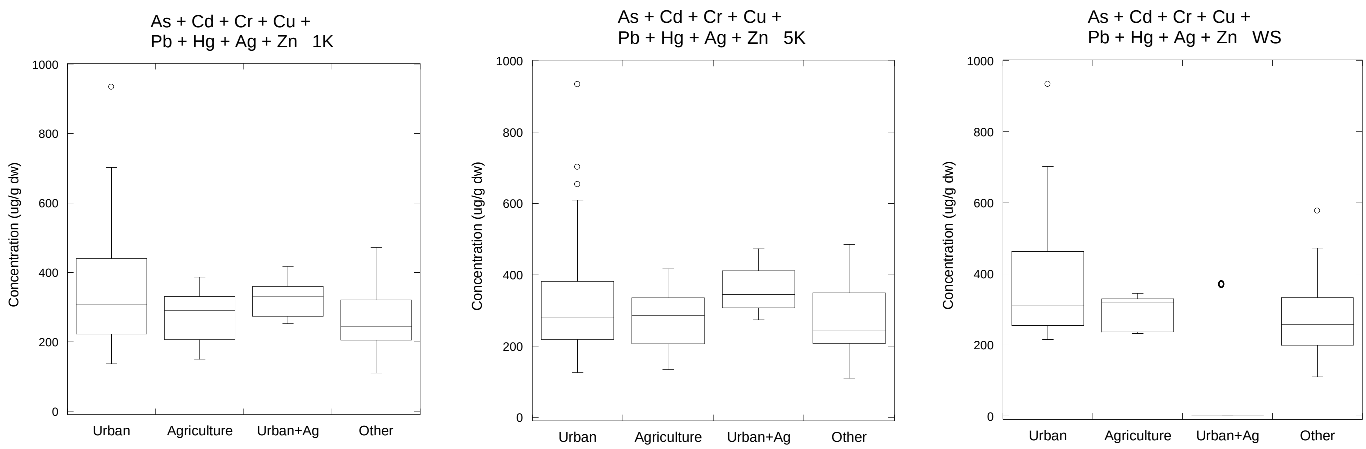

Figure 30. Concentrations of eight metals in sieved sediment by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

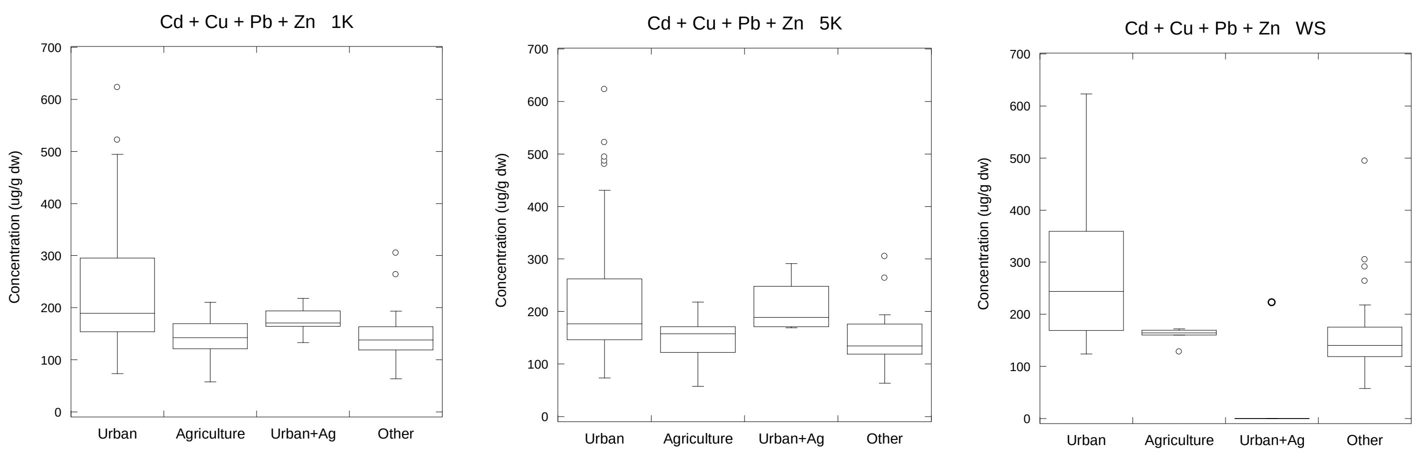

Figure 31. Concentrations of four metals in sieved sediment by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

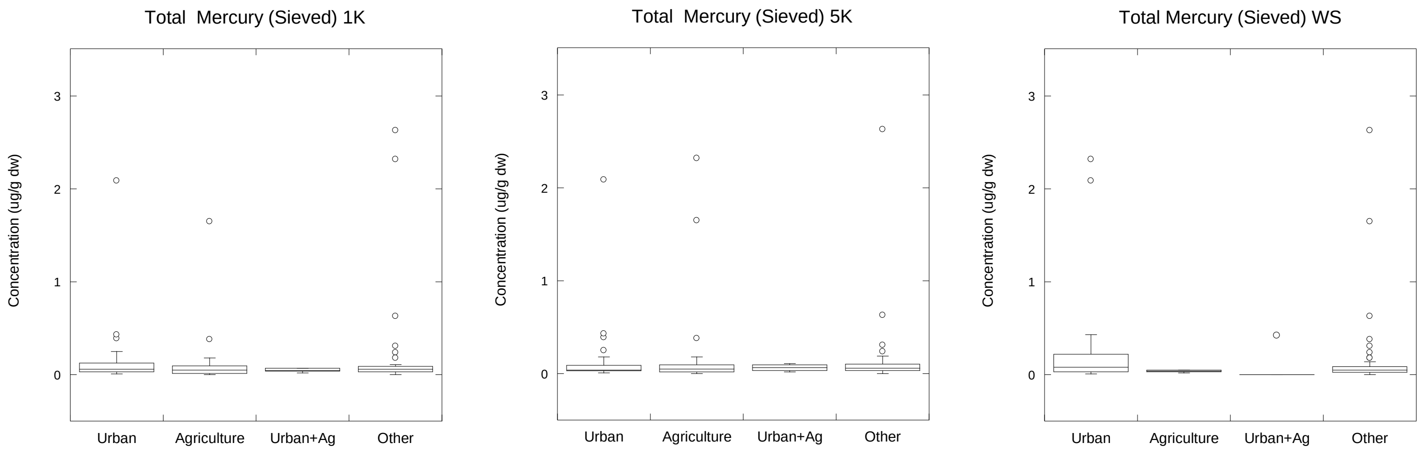

Figure 32. Concentrations of mercury in sieved sediment by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

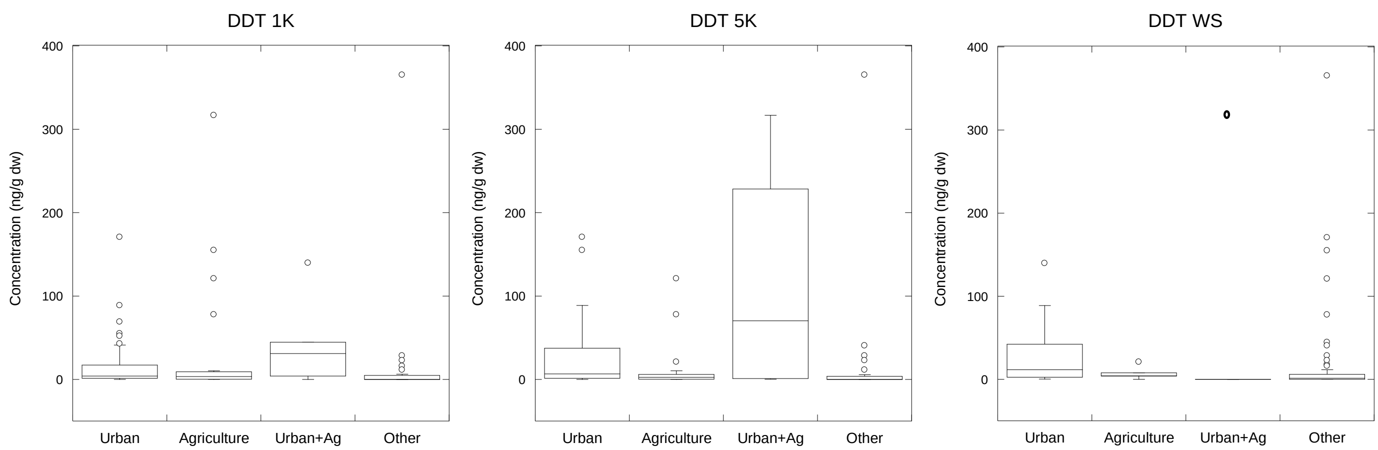

Figure 33. Sediment concentrations of DDTs by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

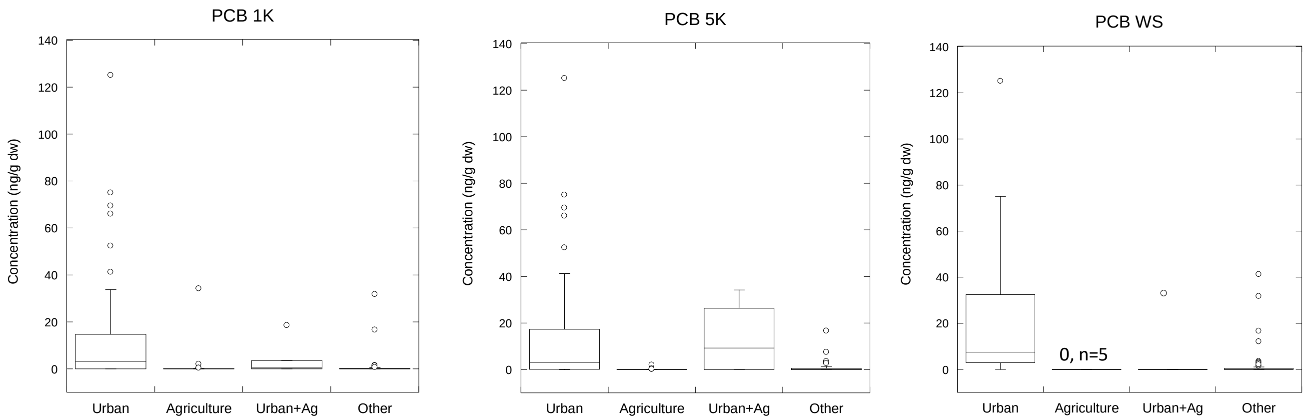

Figure 34. Sediment concentrations of PCBs by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

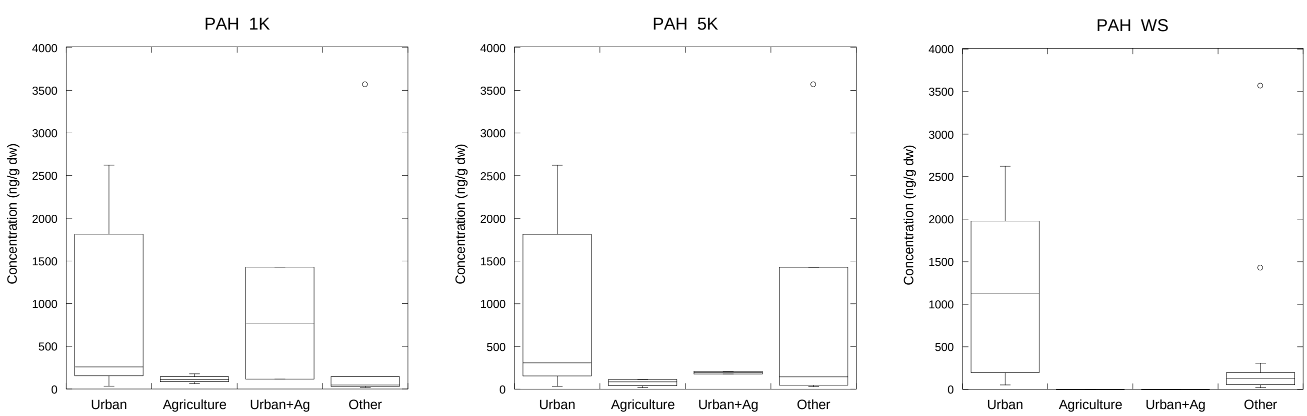

Figure 35. Sediment concentrations of PAHs by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

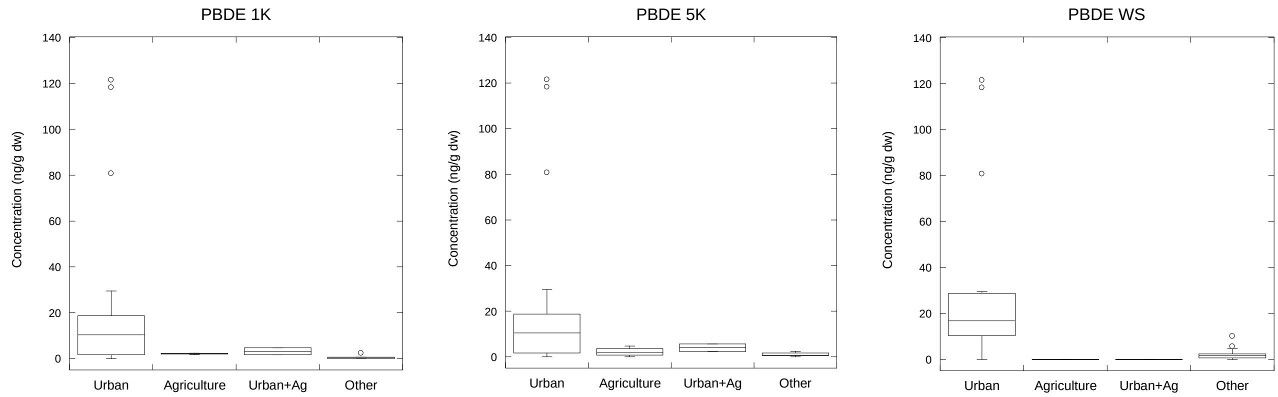

Figure 36. Sediment concentrations of PBDEs by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

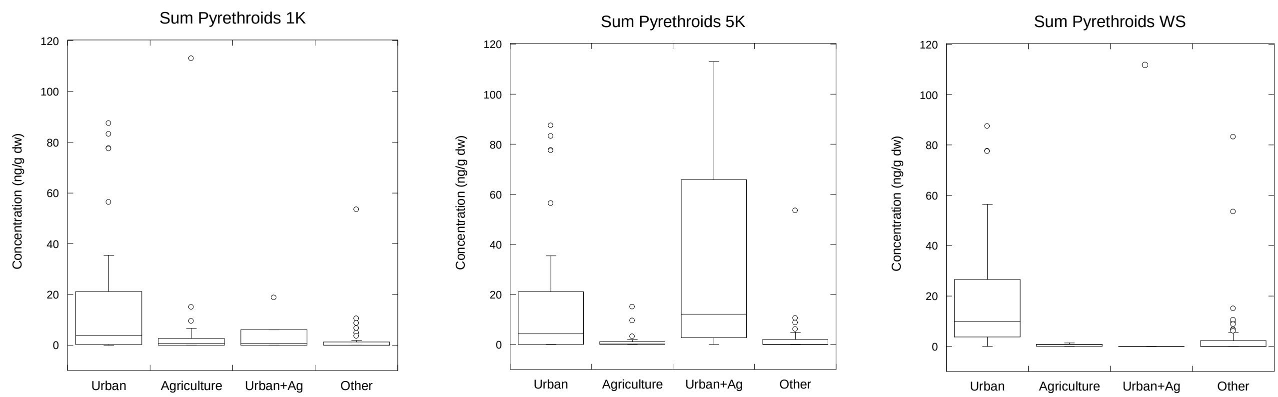

Figure 37. Sediment concentrations of pyrethroids by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

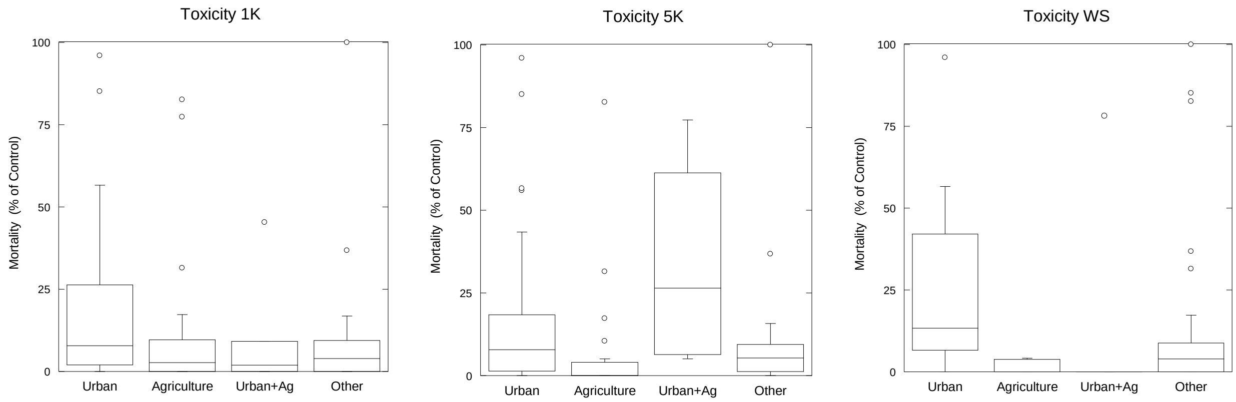

Figure 38. Observed sediment toxicity by land cover category. Box and whiskers represent mean, quartiles, and 95% confidence limits.

Effects of Sieving

Trace metals were measured on both whole sediments and sediments sieved to less than 63 um. Because trace metals bind preferentially to smaller sediment size fractions, particularly clays, concentrations measured on sieved sediment can be compared across watersheds with less variability related to differences in grains sizes among samples. Concentrations in unsieved sediments are the total metal concentrations and can be compared to thresholds for biological effects.

In a comparison of concentrations of the 11 trace metals measured in 92 field samples plus duplicates (n = 1128), the sieved sediment had higher metal concentrations in 83% of the sample/element combinations. The average relative percent difference (RPD) between sieved and unsieved measurements from the same sample was 25% (± 36% sd), with a RPD range of -125% to +163%. In the two cases where the sum of eight metals had a significant positive correlation with a land cover type, sieved sediments correlated more strongly (Table 3). The same was true for all five cases in which the sum of four metals had significant positive correlations with a land cover type.

Toxicity

Sediment toxicity was significantly correlated with the proportion of urban land cover at all three watersheds scales (Table 5). Toxicity was greater in samples from urban and urban/agricultural watersheds than in samples from agricultural or other watersheds (Fig. 38). Toxicity was significantly correlated with PCBs, pyrethroids, TOC, PBDEs, DDTs, PAHs and with some metals (Table 5). Toxicity did correlate significantly with sediment TOC, a common result in sediment assessments, because organic pollutants accumulate with TOC in stream depositional areas. The correlation between toxicity and grain size was not significant ($\alpha = 0.05$).

Table 5. Probability values for multivariate Spearman rank correlations of observed toxicity and measured pollutant concentrations. Asterisks indicate statistically significant correlations at the $\alpha = 0.05$ level.

Total PCBs	<0.0001
Sum Pyrethroid	<0.0001
Total Organic Carbon	<0.0001
Total PBDEs	0.014
Total DDTs	0.021
Cd+Cu+Pb+Zn sieved	0.031
Cd+Cu+Pb+Zn unsieved	0.036
Sum PAH	0.040
% Fines	0.052
Total 8 metals unsieved	0.055
Total 8 metals sieved	0.065
Total Phosphorus	0.067

Phosphorus

Phosphorus is more abundant in some geologic formations than others, which confounds correlation with human activities linked to transport into streams. Phosphate, along with nitrate, is a primary ingredient in fertilizers applied to agricultural, residential, and other watershed areas, and can be mobilized by grading and other soil disturbance related to land development.

In this survey, total phosphorus did not correlate significantly with any land cover type, grain size, TOC, or pollutant. For most of the State, there was no obvious pattern in the spatial distribution of total phosphorus, with low concentrations adjacent to higher concentrations in many areas (Fig. 39). However, concentrations were consistently high in the Los Angeles area, and moderately high in the Sierra and southern mountain ranges.

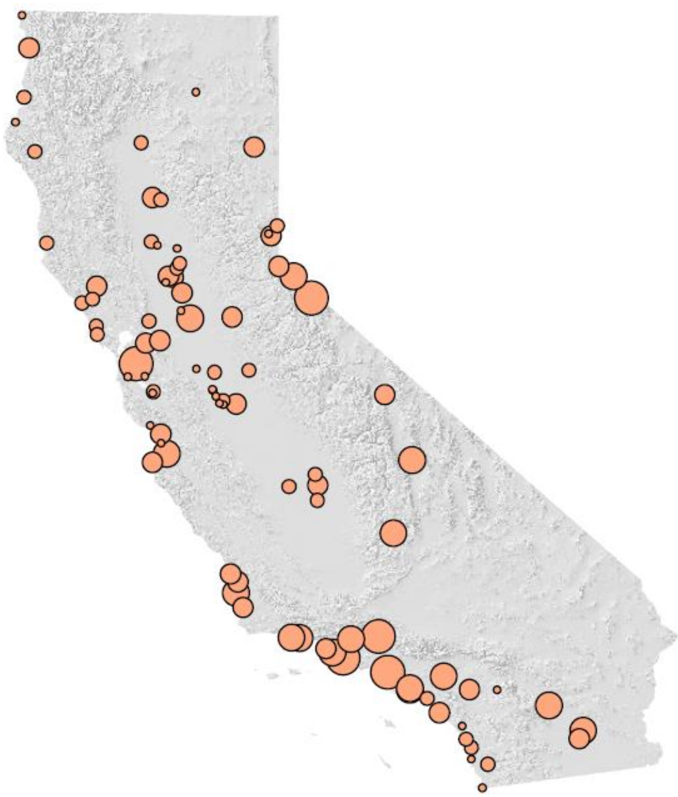

Figure 39. Distribution of total phosphorus, with concentrations ranging from 0 to 1900 mg/kg.

Discussion

One of the SPoT program's primary goals is to provide statewide perspective for local and regional monitoring, and the SPoT program staff coordinates with many of these programs to make data available across scales to address a number of assessment questions. From the statewide perspective, a number of patterns emerge from this first year of SPoT monitoring. Primary among these themes are that stream sediment pollutant concentrations and toxicity were greatest at sites draining urban watersheds, many SPoT sites across the state yielded elevated concentrations of a number of pollutants, and pyrethroid pesticides frequently exceeded concentrations previously linked directly to acute toxicity to amphipods.

Most elevated pyrethroid concentrations were in samples from watersheds classified as urban (>10% urban land cover). This general result differs from results of a recent SWAMP report summarizing nine years of SWAMP toxicity data statewide. That report did not find a significant difference in sediment toxicity between urban and agriculturally-influenced sites (Anderson et al. 2011).

In considering results presented here, it is important to note that the sampling sites and survey timing were specifically targeted to low watershed depositional sites during base flow conditions following seasonal high water. This targeted approach was implemented in order to most efficiently address the SPoT assessment objectives of characterizing long-term trends and understanding linkages between land cover and stream pollution. The sites and times were not selected probabilistically. With probabilistic designs, it is possible to make inferences about un-sampled areas, which is a major advantage when addressing questions about the overall condition of areas too large or sites too numerous to sample completely. Therefore, the data from targeted sites presented here should not be extrapolated to draw conclusions about un-sampled watersheds, or generalized to make assumptions about larger regional patterns. However, the consistent base-of-the-watershed targeted sampling approach allows for improved understanding of the relationships between land use and stream condition as these change over time.

It should also be noted that the potential for toxic effects in these sediments is likely greater than estimated by these results, for two reasons. First, amphipod toxicity tests employed standard 10-day exposures, whereas the persistence in sediment of most of the measured pollutants is much longer. Second, the toxicity tests were conducted at the standard temperature of 23°. Most of the streams sampled run at temperatures closer to 15° (unpublished data). Subsequent SPoT analyses (data forthcoming) measured greater toxicity in 15° tests than in 23° tests, a likely result of pyrethroid effects.

Chemicals of concern

Previous studies have shown that statistically significant toxicity to amphipods generally occurs in sediments with greater than 0.4 toxic units of pyrethroid pesticides (Trimble et al. 2010, Holmes et al. 2008). In this survey, 28% of all samples (26 of 92) exceeded 0.4 toxic units of pyrethroid pesticides, which were detected in samples from 55% of the streams. On a statewide basis, pyrethroids were more strongly associated with urban areas than with agricultural or other areas. Pyrethroids are used in commercial and residential pest extermination (Spurlock and Lee 2008), and the high impervious surface cover in urban areas likely facilitates transport to streams. The use restrictions on pyrethroid pesticides are currently being re-evaluated in California, and the results of this study should add to the body of knowledge upon which management decisions are based. The SPoT program is designed to evaluate stream pollution trends as new pyrethroid labeling restrictions take effect.

Organophosphate pesticides, particularly diazinon and chlorpyrifos, have been linked to water column toxicity in many California waterways (deVlaming et al. 2000, Hunt et a. 2003), and chlorpyrifos has also been linked to sediment toxicity (Anderson et al. 2010, Phillips et al. 2010). These compounds were seldom detected in the present study, however, and were not measured at known toxic concentrations in any of the samples. Chlorpyrifos has been found in elevated sediment concentrations in California streams in previous studies (e.g., Anderson et al. 2006, 2011). Had SPoT program sampling occurred over the past decade, it may have been possible to document a decline in chlorpyrifos concentrations in urban stream sediments as regulatory programs implemented additional restrictions on non-agricultural use of this pesticide.

It is perhaps expected but still of concern to find DDTs and PCBs widely distributed in California streams nearly 40 years after their usage was banned by law. DDTs in particular were found in a number of stream samples above threshold effects concentrations (TECs; MacDonald et al., 2000). While strict usage regulations are in place, enhanced measures may be necessary to restrict mobilization of contaminated soils through activities such as grading of old agricultural lands for development.

PBDEs and PAHs were measured only at Tier II SPoT sites, which were mostly in urban areas. Both chemical classes were widely detected. In sea otters, liver concentrations of PBDE 028 have been significantly correlated with the presence of specific infectious diseases, as well as traumatic death (Miller et al. 2007). PBDEs are expected to be an important trend indicator for the SPoT program because recent regulation is expected to decrease use of certain PBDE compounds.

Probable effect concentrations (PECs) were exceeded for arsenic (Lower Owens River), lead (San Gabriel River), mercury (two San Francisco Bay area watersheds), and zinc (San Leandro Creek).

TEC and PEC values are shown in Appendix 3, Table 14.

Pollutant associations with toxicity

Concentrations of many chemicals, especially organic compounds, co-varied across samples analyzed in this survey, and these also co-varied with TOC. The strongest correlations between pollutants and toxicity were observed for PCBs and pyrethroids, with pyrethroids having the better established basis for asserting causality. Numerous recent studies have linked pyrethroids with sediment toxicity to amphipods (e.g., Holmes et al. 2008.). In addition, subsequent SPoT surveys have shown increased sediment toxicity with decreased test temperature, a result consistent with the non-metabolically influenced mode of action for these compounds (Harwood et al. 2009, Holmes et al. 2008.; SPoT data forthcoming in second program report).

Because trend monitoring will focus on contaminant concentrations, the biological effects to be measured are the responses of a contaminant-sensitive, representative, benthic invertebrate species (*Hyalella azteca*) that has been the subject of numerous studies linking its response to the composition of in situ benthic communities (e.g., Anderson et al. 2003a, 2003b, 2006; Kedwards et al. 1999; Phillips et al. 2004; Schulz 2004; Tucker and Burton 1999).

Pollutant associations with land cover

Two analytical approaches were taken to investigate relationships between stream pollution and land cover in the watersheds surveyed. Correlation analyses indicated statistically significant relationships between increasing concentrations of most pollutants and increasing levels of both urban land cover and impervious surfaces (e.g., Fig. 26-27). Multiple comparisons among results grouped by land cover classification showed significantly higher pollutants concentrations in urban watersheds than in agricultural or other watersheds (Tables 3-4; Figs. 30–38). On a statewide basis, both approaches indicated higher stream pollution in watersheds with more urban land cover.

It is important to note two potential confounding factors that were not included in the land cover analyses: the effects of dams on sediment transport and the contributions of point sources to measured pollutant concentrations. The great majority of rivers in California have dams, often many dams, and these are very effective at impeding downstream sediment transport, essentially breaking the hydrologic-sediment connectivity to large watershed areas upstream of sampled sites. Dam locations were frequently considered in selecting SPoT site locations, but the effect of dams was not accounted for in GIS analyses of drainage areas to sites. That is, land cover from all areas upstream was considered equally, whether there was an intervening dam or not. The effect of this factor is most likely to influence analyses at the whole watershed scale (as opposed to the 1 km and 5 km drainage area scales). It was not within the scope of this study to identify and assess the sediment transport effects of dams in 92 watersheds, especially because of the many small dams with uncertain hydrologic impacts, particularly with fine sediment during high flows. Many point sources discharge to streams, and many data are available about chemical concentrations in their effluents; but accurately assessing all these data was again beyond the scope of this analysis.

Space for time swaps

While there is substantial scatter in correlation analyses relating land cover to pollutant concentrations, significant relationships were detected for many pollutants. These relationships indicate that, all other factors remaining equal, the expected trend of increasingly developed land cover in California watersheds will result in increased pollutant concentrations and toxicity in streams (Figs. 26-29). Corroboration of this finding with subsequent SPoT survey results will better establish whether these relationships are seen repeatedly, and whether temporal trend analyses yield results that support the link between increasing urbanization and stream pollution.

Recommendations

This report covers results from one statewide survey comprising the first year of a long-term trends monitoring program. Field experience has already led to some adjustments in site location and timing. Based on program objectives and first year results, the following recommendations are made to maximize the value of this statewide stream pollution trends monitoring program:

(1) Continue the annual SPoT surveys to develop time-series data to investigate trends in stream pollution. Social, economic, technical, and resource management activities evolve and change unpredictably, with uncertain ramifications for the sustainability of California's most important natural resource. Trend monitoring is the only way to evaluate whether human activities and natural events lead to further impairment or to preservation and restoration of water quality.

(2) Continue to build SPoT partnerships with stormwater, agricultural and other monitoring programs, as well as with regulatory agency priority programs. Communicate SPoT trend data from Measure W priority watersheds to US EPA for use in the Measure W program.

(3) Compare trends over time with relationships between land cover and stream pollution. Analysis of data from continued surveys will indicate whether currently observed relationships with urban land cover reflect changes concomitant with urbanization over time.

(4) Evaluate spatial and temporal variability in pollution indicators around SPoT sites. The primary program design is limited to collecting one sediment sample from one site once a year in the target watersheds. To understand how well that sample represents the stream and its watershed, measure samples from additional low watershed locations, each collected at different times of the year, to characterize variance in space and time and provide estimates of confidence in statistical results.

(5) Improve tracking of management activities through General Permit language and alignment of grant projects. Many conservation practices are currently being implemented in urban, residential, and agricultural areas to improve water quality. To evaluate the effectiveness of this substantial effort, specific and standardized information must be collected to record the number of projects per watershed, the area affected, the water volume treated, chemical load reductions achieved, and continuity of practices. Resource Conservation Districts along the California central coast are developing standardized reporting formats in cooperation with the Agricultural Water Quality Alliance (AWQA: http://www.awqa.org/), and this effort should be expanded.

(6) Implement SPoT-type monitoring in smaller watersheds with more homogeneous land cover to better understand causal relationships between human activities and stream pollution. The SPoT watersheds were selected to represent large, mixed-use areas to better characterize general conditions in California. While this is good for understanding the overall situation, the heterogeneity in land use and economic activity adds noise to the analysis of relationships with water quality. A suite of small drainage areas dominated by similar human activities (e.g., row crops or high density residential) could be studied to more specifically understand the causes of water quality impairments.

(7) Conduct sediment toxicity tests at two temperatures: 15° C as well as the standard 23° C. This would better cover the range of ambient temperatures at study sites (which are generally closer to 15° C), and also provide compelling data to evaluate the biological effects of pyrethroids, which are among the few classes of compounds exhibiting greater toxicity at lower temperatures.

(8) Use data from this and future SPoT surveys to inform regulatory review of pyrethroid pesticide usage and the long-term effectiveness of labeling changes.

(9) Use *Hyalella azteca* amphipod tests in water column monitoring. Commonly used *Ceriodaphnia dubia* test organisms are sensitive to and useful for detecting toxicity due to organophosphate pesticides. As OP pesticide use decreases and pyrethroids become more pervasive, *H. azteca* will likely better detect the potential for toxic effects on aquatic invertebrates.

(10) Continue to participate in and promote coordination efforts and data sharing through the California Environmental Data Exchange Network (CEDEN) to link local, regional, and statewide monitoring programs to address assessment questions at multiple scales.

(11) Continue to develop cross-program monitoring designs that optimally leverage data from California's statewide monitoring programs and address broadly applicable assessment questions. Encourage use of ecological endpoints and probabilistic monitoring designs to determine the status of large upstream areas and high quality streams. These data can be used to test hypotheses about the upstream extent of impairments that are identified by targeted studies focused on pollution causes and sources.

(12) Encourage Regional SWAMP programs to take advantage of SPOT sites by adding water column toxicity testing, chemical analysis or measurement of other regionally valuable parameters.

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Appendices

Appendix 1: SPoT 2008 Station Information

Appendix 2: Maps of Site Locations by Station Code

Appendix 3: Quality Assurance Information

Appendix 1: SPoT 2008 Station Information

Station Code	Station Name	Sample Date	Latitude	Longitude	Coordination
103SMHSAR	Smith River at Sarina Road	15/Oct/2008	41.91357	-124.17160	None Specified
105KLAMKK	Klamath River at Kamp Klamath	15/Oct/2008	41.51695	-124.03893	None Specified
109MAD101	Mad River upstream Hwy 101	15/Oct/2008	40.91770	-124.08811	None Specified
111EELFRN	Eel River at Fernbridge	15/Oct/2008	40.61213	-124.20457	None Specified
111EELMYR	S Fork Eel River at Meyers Flat	14/Oct/2008	40.26266	-123.87965	None Specified
113NAVDMC	Fork Navarro River at Dimmick	14/Oct/2008	39.15703	-123.63474	None Specified
114LAGMIR	Laguna de Santa Rosa at Mirabel	14/Oct/2008	38.49385	-122.89214	None Specified
114RRAXRV	Russian River at Alexander RV Park	14/Oct/2008	38.65888	-122.83305	None Specified
114RRDSDM	Russian River downstream Duncan Mills	14/Oct/2008	38.44797	-123.05640	None Specified
201LAG125	Lagunitas Creek at Coast Guard Station	13/Aug/2008	38.07038	-122.79876	Reg Bd
201WLK160	Walker Creek at WC Ranch	18/Jun/2008	38.17584	-122.81949	Reg Bd
204ALA020	Alameda Creek E. of Alvarado Blvd	17/Jun/2008	37.58049	-122.05260	R2 MRP
204SLE030	San Leandro Creek at Empire Road	17/Jun/2008	37.72838	-122.18818	R2 MRP
204SMA020	San Mateo Creek at Gateway Park	18/Jun/2008	37.56951	-122.31669	R2 MRP
205COY060	Coyote Creek at Montague	17/Jun/2008	37.39601	-121.91512	R2 MRP
205GUA020	Guadalupe Creek at USGS Gaging Station	17/Jun/2008	37.37553	-121.93266	R2 MRP
207KIR020	Kirker Creek at Floodway	17/Jun/2008	38.01658	-121.83883	R2 MRP
207LAU020	Laurel Creek at Pintail Drive	17/Jun/2008	38.24836	-122.00650	R2 MRP
207WAL020	Walnut Creek at Concord Ave O.C.	17/Jun/2008	37.98082	-122.05154	R2 MRP
304SOKxxx	Soquel Creek at Knob Hill	21/Jul/2008	36.97930	-121.95690	Reg Bd
305THUxxx	Pajaro River at Thurwachter Bridge	21/Jul/2008	36.87917	-121.79364	Reg Bd
307CMLxxx	Carmel River at Hwy 1	17/Jun/2008	36.53561	-121.91145	Reg Bd
309DAVxxx	Salinas River at Davis Road	17/Jun/2008	36.64606	-121.70135	R3 CMP
309TDWxxx	Tembladero Slough at Monterey Dunes Way	21/Jul/2008	36.77142	-121.78652	R3 CMP
310ARGxxx	Arroyo Grande Creek at 22nd Street	11/Jun/2008	35.09517	-120.61145	Reg Bd
310SLBxxx	San Luis Obispo Creek at San Luis Bay Drive	11/Jun/2008	35.18826	-120.71879	Reg Bd
312SMAxxx	Santa Maria River at Estuary	11/Jun/2008	34.96145	-120.64115	R3 CMP
313SAIxxx	San Antonio Creek at San Antonio Rd West	10/Jun/2008	34.78239	-120.53015	Reg Bd
315ATAxxx	Atascadero Creek at Ward Dr	22/May/2008	34.42354	-119.81846	Reg Bd
315MISxxx	Mission Creek at Montecito St	10/Jun/2008	34.41376	-119.69544	Reg Bd
402VRB0xx	Ventura River at Hwy 101 Campground	19/May/2008	34.28270	-119.30864	SMC
403STCBQU	Santa Clara River at Bouquet Creek	19/May/2008	34.42403	-118.53811	None Specified
403STCEST	Santa Clara River at Estuary	19/May/2008	34.23597	-119.21704	None Specified
403STCSSP	Sespe Creek at Hwy 126	22/May/2008	34.39312	-118.94227	None Specified
404BLNAxx	Ballona Creek at Sawtelle	20/May/2008	33.98659	-118.41575	SMC

Station Code	Station Name	Sample Date	Latitude	Longitude	Coordination
405SGRA2x	San Gabriel River RA-2	20/May/2008	33.79036	-118.09195	SMC
408CAL006	Calleguas Creek At Hwy 1	19/May/2008	34.16538	-119.06118	SMC
504BCHROS	Big Chico Creek at Rose Ave	30/Jun/2008	39.72704	-121.86348	Regional
504SACHMN	Sacramento River at Hamilton City	30/Jun/2008	39.75071	-121.99632	Regional
508SACBLF	Sacramento River at Balls Ferry	30/Jun/2008	40.41690	-122.19377	Regional
510LSAC08	Sacramento River at Hood	16/Jul/2008	38.38330	-121.51926	Regional
511CAC113	Cache Creek at Hwy 113	20/Aug/2008	38.72078	-121.76482	Regional
515SACKNK	Sacramento Slough at Karnak	16/Jul/2008	38.78443	-121.65344	Regional
515YBAMVL	Yuba River at Maryville	19/Aug/2008	39.13393	-121.59273	Regional
519AMNDVY	American River at Discovery Park	16/Jul/2008	38.59910	-121.50709	Regional
519BERBRY	Bear River at Berry Road	19/Aug/2008	38.95440	-121.55126	Regional
519FTRNCS	Feather River at Nicolaus	19/Aug/2008	38.89898	-121.58805	Regional
520BUTEMR	Butte Slough at Meridian	19/Aug/2008	39.17024	-121.90069	Regional
520CBDKLD	Colusa Basin Drain at Knights Landing	20/Aug/2008	38.80077	-121.72352	Regional
520SACLSA	Sacramento River at Colusa	19/Aug/2008	39.21457	-122.00016	Regional
526P00008	Pit River at Pittville Bridge	30/Jun/2008	41.04513	-121.33258	Reg Bd
531SAC001	Cosumnes River at Twin Cities Road	22/Jul/2008	38.29075	-121.37574	Reg Bd
532CAL004	Mokelumne River at Hwy 49	22/Jul/2008	38.31222	-120.72120	None Specified
535MER007	Bear Creek near Bert Crane Road	23/Jul/2008	37.25620	-120.65187	R5 ILRP
535MER546	Merced River at River Road	23/Jul/2008	37.35024	-120.96220	R5 ILRP
535STC206	Dry Creek at La Loma Road	22/Jul/2008	37.64395	-120.98420	R5 ILRP
535STC210	Tuolumne River at Old LaGrange Bridge	22/Jul/2008	37.66599	-120.46205	Regional
535STC504	San Joaquin River at Crows Landing	16/Jul/2008	37.43324	-121.01756	Reg Bd
541MER522	San Joaquin River at Lander Avenue	16/Jul/2008	37.29522	-120.85146 R5	R5 ILRP
541MER531	Salt Slough at Lander Avenue	23/Jul/2008	37.24764	-120.85235 R5	R5 ILRP
541MER542	Mud Slough downstream of San Luis Drain	23/Jul/2008	37.26333	-120.90613	Reg Bd
541SJC501	San Joaquin River at Airport Way	16/Jul/2008	37.67573	-121.26509	Reg Bd
541STC019	Orestimba Creek at River Road	22/Jul/2008	37.41402	-121.01556	R5 ILRP
551LKI040	Fork Kings River	29/Apr/2008	36.25619	-119.85482	Reg Bd
554SKR010	S Fork Kern River at Fay Ranch Road	28/Apr/2008	35.67262	-118.28982	None Specified
558CCR010	Cross Creek at Road 60 and Hwy 99	29/Apr/2008	36.40368	-119.45497	Reg Bd
558PKC010	Packwood Creek at Road 68	29/Apr/2008	36.26852	-119.41846	Reg Bd
558TUR090	Tule River at Road	29/Apr/2008	36.08777	-119.42645	Reg Bd
603BSP002	Bishop Creek at East Line St	17/Sep/2008	37.36234	-118.38637	None Specified
603LOWSED	Lower Owens River near mouth	17/Sep/2008	36.55967	-117.99298	None Specified
631WWK008	West Walker River at Topaz	23/Sep/2008	38.54677	-119.49496	Reg Bd
633WCRSED	West Fork Carson River at Paynesville	22/Sep/2008	38.80883	-119.77720	None Specified
634UTRSED	Upper Truckee River near inlet to Lake Tahoe	22/Sep/2008	38.93439	-120.00034	Other
635MARSED	Martis Creek near mouth	22/Sep/2008	39.30185	-120.12118	None Specified

Station Code	Station Name	Sample Date	Latitude	Longitude	Coordination
635TRKSED	Lower Truckee River near CA/NV state line	22/Sep/2008	39.42285	-120.03366	None Specified
635TROSED	Trout Creek (Truckee) near mouth	22/Sep/2008	39.33049	-120.16854	None Specified
637SUS001	Susan River near Litchfield	22/Sep/2008	40.37743	-120.39532	Reg Bd
719CVSCOT	Coachella Valley Stormwater Channel Outlet	29/Oct/2008	33.52430	-116.07836	Reg Bd
723ARGRB1	Alamo River Outlet	28/Oct/2008	33.19896	-115.59727	Reg Bd
723NROTWM	New River Outlet	28/Oct/2008	33.10460	-115.66475	Reg Bd
801SARVRx	Santa Ana River at River Road	04/Jun/2008	33.92379	-117.59770	SMC
801SDCxxx	San Diego Creek at Campus	20/May/2008	20/May/2008	33.65641	SMC
802SJCREF	San Jacinto River - Reference Site	04/Jun/2008	33.73648	-116.82622	USGS NAWQA
802SJRGxx	San Jacinto River at Goetz/TMDL site	03/Jun/2008	33.75159	-117.22351	SMC
845SGRDRE	Tributary channel to San Gabriel River	20/May/2008	33.77352	-118.09769	SMC
901SJSJC9	San Juan Creek 9 at Mariner Drive	21/May/2008	33.48157	-117.67761	None Specified
902SSMR07	Santa Margarita at Basilone Road	21/May/2008	33.31108	-117.34616	None Specified
904CBAHC6	Agua Hedionda Creek at El Camino Real	21/May/2008	33.14992	-117.29649	None Specified
904ESCOxx	Escondido Creek at Camino del Norte	21/May/2008	33.04799	-117.22643	SMC
906LPSOL4	Los Penasquitos Creek 6 at Hwy 5	21/May/2008	32.90244	-117.22529	None Specified
907SDFRC2	Forrester Creek 2 at Carlton Hills Blvd	21/May/2008	32.83940	-116.99782	None Specified
911TJHRxx	Tijuana River at Hollister Rd	22/May/2008	32.55114	-117.08411	SMC

CMP – Cooperative Monitoring Program
ILRP – Irrigated Lands Regulatory Program
MRP – Municipal Regional Permit Monitoring
Regional – Independent Regional Monitoring
Reg Bd – SWAMP monitoring by Regional Board
SMC – Stormwater Monitoring Coalition
USGS NAWQA – USGS National Water Quality Assessment Program

Program Coordination Codes	
R2 MRP Region 2 Municipal Regional Permit Monitoring	R2 MRP Region 2 Municipal Regional Permit Monitoring
R3 CMP Region 3 Cooperative Monitoring Program	R3 CMP Region 3 Cooperative Monitoring Program
R5 ILP Region 5 Irrigated Lands Program	R5 ILP Region 5 Irrigated Lands Program
Reg Bd SWAMP Monitoring by Regional Board	Reg Bd SWAMP Monitoring by Regional Board
Regional Independent Regional Monitoring Programs	Regional Independent Regional Monitoring Programs
SMC Stormwater Monitoring Coalition	SMC Stormwater Monitoring Coalition
USGS NAWQA USGS National Water Quality Assessment Program	USGS NAWQA USGS National Water Quality Assessment Program
YTEP Yurok Tribe Environmental Program	YTEP Yurok Tribe Environmental Program

Appendix 2: Maps of Site Locations by Station Code

Map 1. Northern California Sites for Regions 1, 5, and 6.

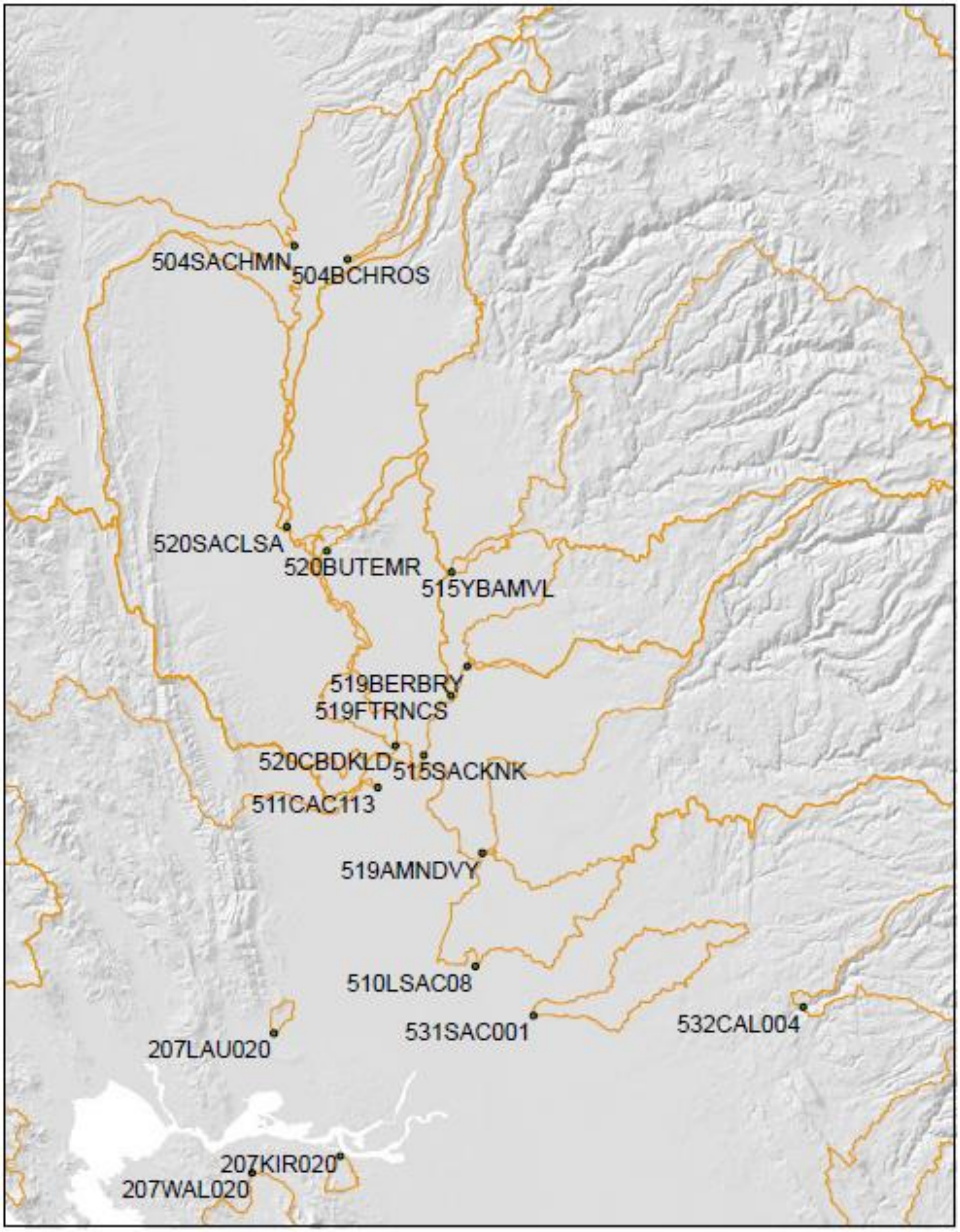
Map 2. North Coast Region - Southern Sites

Map 3. San Francisco Bay Region

Map 4. Central Coast Region

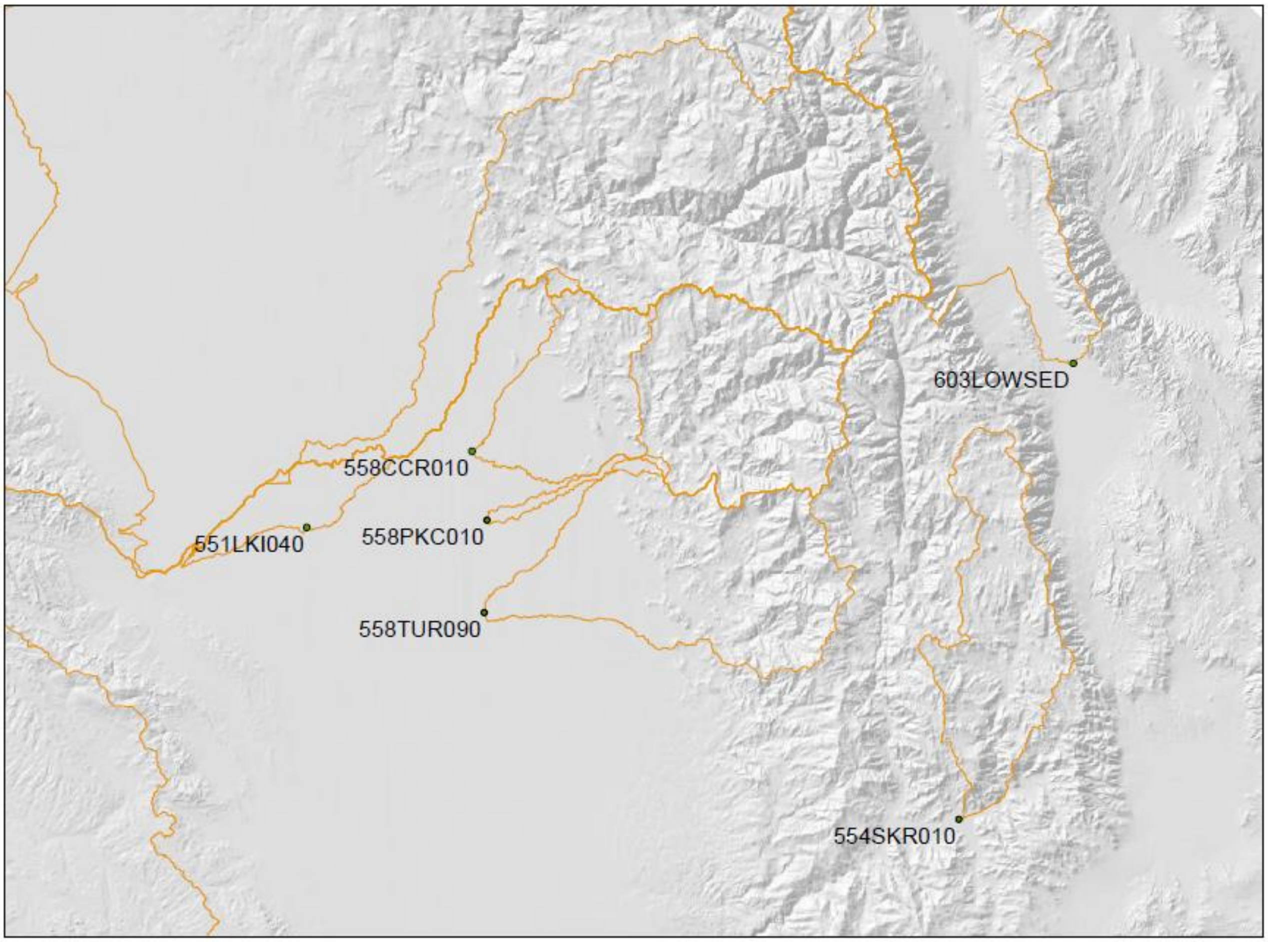
Map 5. Los Angeles and Santa Ana Regions

Map 6. Central Valley Region – Northern Sites

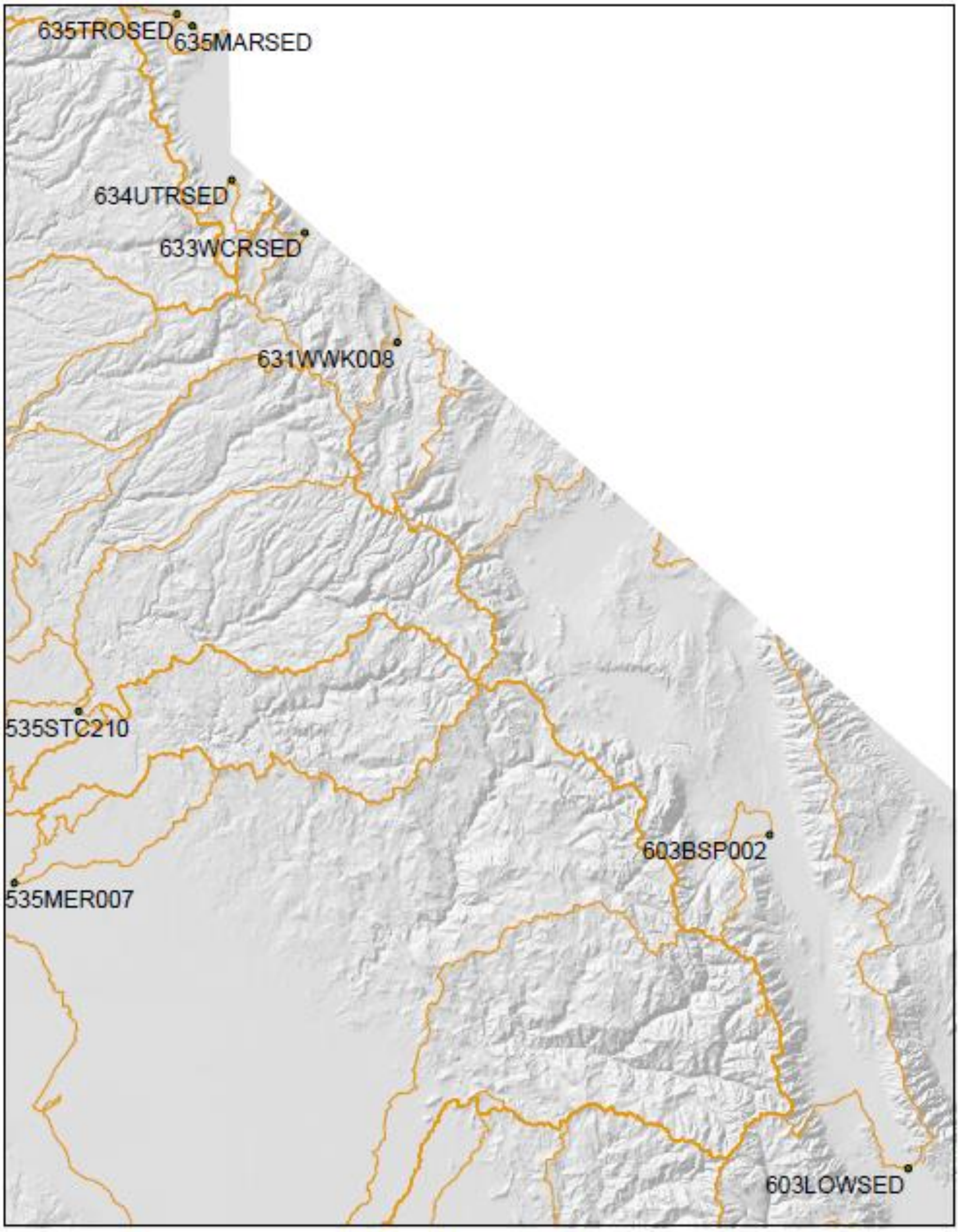


Map 7. Central Valley Region – San Joaquin Basin

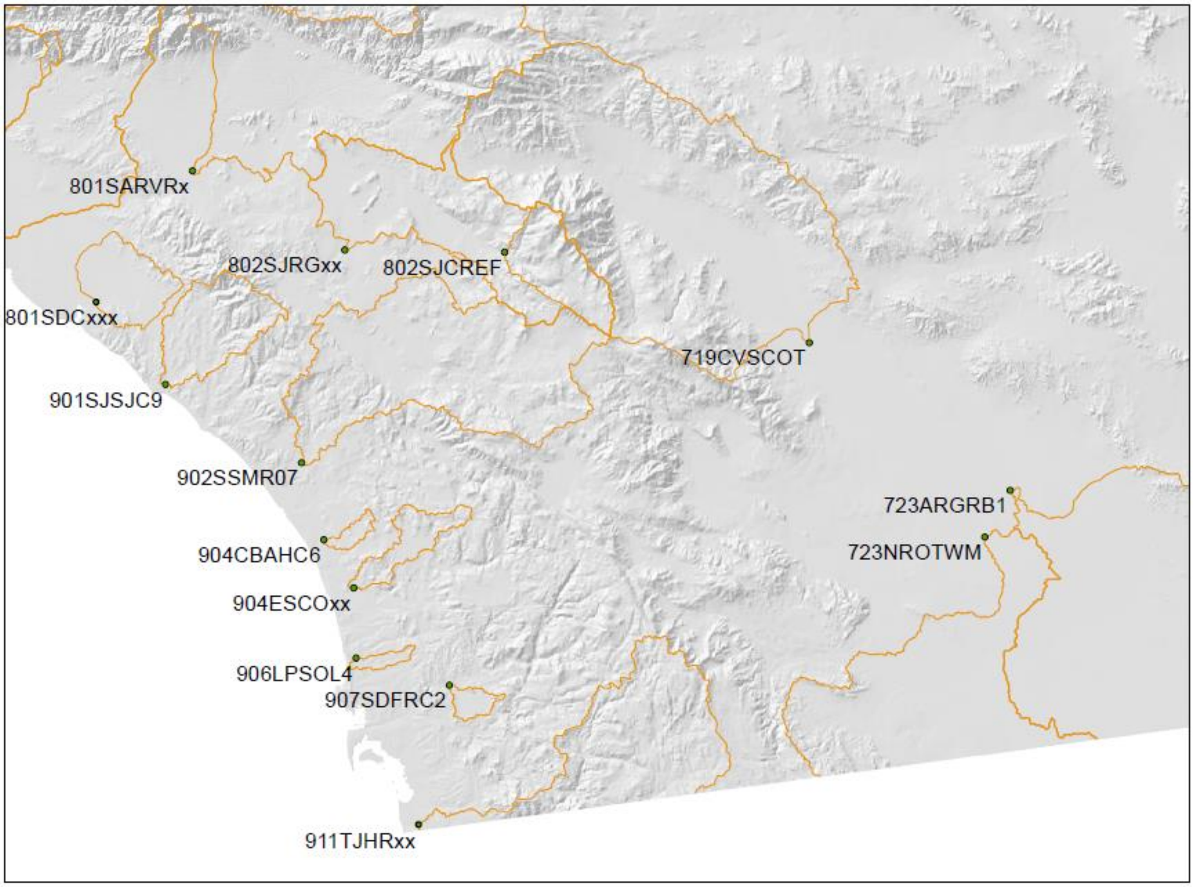
Map 8. Central Valley Region – Tulare Basin



Map 9. Lahontan Region – Southern Sites



Map 10. San Diego and Colorado River Regions



Appendix 3: Quality Assurance Information

Narrative Description: Quality Assurance/Quality Control (QA/QC) Documentation

All data for this report were produced in accordance with the SWAMP Statewide Stream Pollution Trends Monitoring Program Quality Assurance Project Plan, found at the following web address:
http://www.swrcb.ca.gov/water_issues/programs/swamp/qapp/qapp_spot_strms_pollute_final.pdf

The data for the Statewide Stream Pollution Trend (SPoT) 2008 report were evaluated to determine document data quality relative to SWAMP data quality objectives. Thorough objectives for achieving quality data are outlined in the SWAMP Quality Assurance Management Plan (QAMP). In general, data quality is demonstrated through analysis of the following Data Quality Indicators:

- Laboratory method blanks
- Surrogate spikes
- Matrix spikes and matrix spike duplicates
- Certified reference materials/laboratory control spikes
- Laboratory duplicates
- Field duplicates

Data Usability Criteria

Data were considered acceptable for use in this assessment if they were produced in accordance with the SWAMP Statewide Stream Pollution Trends Monitoring Program Quality Assurance Project Plan (QAPP). The QAPP describes methods and establishes data acceptability criteria for the participating laboratories. Data meeting these criteria were of sufficient quality for use in the California Integrated Report, which satisfies Clean Water Act section 303[d] for listing of impaired water bodies and section 305[b] for surface water quality condition assessment. Sample with results not meeting laboratory QA criteria were re-analyzed, and all scheduled analyses were successfully completed, with the exception of PAH analyses on a subset of samples. Those data were rejected and are not included in this report.

Verification

Data for Project ID SWB_SPoT_2008 have been verified according to SWAMP Standard Operating Procedures (SOPs) for chemistry and toxicity data verification. The data verification process determines whether the data are compliant with the individual measurement quality objectives (MQOs) specified in the SWAMP QAMP.). The counts in the following sections represent metal, Mercury, Total Phosphorus as P, Total

Organic Carbon, Grain Size, Organochlorine pesticide, Organophosphorus pestcide, Pyrethroid pesticide, Polybrominated Diphenyl Ether, Polychlorinated Biphenyl as Congener (PCB) and Aroclor and Hyalella Azteca results from 2008 survey of the Statewide Stream Pollution Trend Study (SPoT). Data were classified into one of the following classification levels:

Compliant
Data classified as “compliant” meet or exceed all of the MQOs and other data quality requirements specified in the SWAMP QAMP. These data are considered usable for their intended purpose without additional scrutiny.

Qualified
Data classified as “qualified” do not meet one or more of the MQOs and other data quality requirements specified in the SWAMP QAMP. These data are considered usable for its intended purpose following an additional assessment to determine the scope and impact of the quality control failure.

Rejected
Data classified as “rejected” do not meet the minimum data quality requirements specified in the SWAMP QAMP. These data are not considered usable for its intended purpose.

Not applicable
Data classified as “not applicable” refers to data that were not verified since there were no project MQOs or QC requirements for the specific parameter, or a failure result was reported and could not be verified.

No data have been validated. This section does not attempt to determine whether or not data should be used. Decisions regarding data use can only be made after data validation and comparison to project-specific data quality objectives (DQOs) is performed.

SWAMP criteria for percent recovery (%R) of surrogates, matrix spikes, and Certified Reference Materials and relative percent difference (RPD) for field and laboratory duplicates for sediments are presented in Appendix X, Table 1.

3.1 Laboratory Method Blanks

Laboratory method blanks are used to evaluate laboratory contamination during sample preparation and analysis. Blank samples undergo the same analytical procedure as samples with at least one blank analyzed per 20 samples. The required frequency was met for all 95 batches.

Acceptable data are those with values less than the method detection limit (MDL) for that particular analyte. All laboratory method blanks were acceptable with the exception of 8 blanks in which concentrations of target analytes were above the MDL but less than the reporting limit (RL) (Appendix X, Table 2). These data were classified as compliant with regard to the SWAMP QAMP MQO for laboratory blanks.

3.2 Surrogate Spikes

Surrogate spikes are used to assess analyte losses during sample extraction and clean-up procedures, and must be added to every field and quality control sample prior to extraction. Whenever possible, isotopically-labeled analogs of the analytes should be used.

All field samples and QC were spiked with surrogates as required with the exception of batch WPCL-L-024-09_S_PYD-PYN for pyrethroid pesticides. Surrogate Dibromocotafluorophenyl was not added to the samples or associated laboratory QA/QC samples. All associated analytes in the field samples and laboratory QA/QC samples were classified as qualified with regard to the SWAMP QAMP MQO for surrogates (Appendix X Table 3).

All surrogate percent recoveries were within the acceptance criteria listed in Appendix X, Table 1, with the exception of surrogates spiked in samples analyzed for Polynuclear Aromatic Hydrocarbons, Polybrominated Diphenyl Ethers and Organochlorine Pesticides (Appendix X, Table 4). The associated analytes in these samples were classified as qualified with regard to the SWAMP QAMP MQO for surrogates.

3.3 Matrix Spikes and Matrix Spike Duplicates

A laboratory-fortified sample matrix (matrix spike, or MS) and a laboratory fortified sample matrix duplicate (MSD) are both used to evaluate the effect of the sample matrix on the recovery of the target analyte(s). Individually, these samples are used to assess the bias from an environmental sample matrix plus normal method performance. In addition, these duplicate samples can be used collectively to assess analytical precision.

Aliquots of randomly selected field samples were spiked with known amounts of target analytes. The %R of each spike was calculated as follows:

%R= (MS Result – Sample Result)/ (Expected Value – Sample Result) * 100

The %R acceptance criteria vary according to analyte groups (Appendix X, Table1).

This process was repeated on the same native samples to create a laboratory fortified sample matrix spike duplicate (MSD). MSDs were used to assess laboratory precision and accuracy. MS/MSD RPDs were calculated as:

RPD = (|(Value1-Value2)|/(AVERAGE(Value1+Value2)))*100
where:
Value1=matrix spike value
Value2=matrix spike duplicate value.

According to the SWAMP QAMP for conventional, organic and inorganic analyses, at least one MS/MSD pair should be performed per 20 samples or one per batch, whichever is more frequent. One percent of the batches (one out of 84 total batches) for Total Phosphorus as P did not include MS/MSDs performed at the required frequency. This batch was classified as qualified (Appendix X, Table 5).

Laboratory batches with MS/MSD %R and RPD values outside of acceptance criteria were either classified as compliant or qualified based on number of QC elements outside criteria. These are presented in Appendix X, Table 6. All other MS/MSD %Rs and RPDs were within acceptance criteria.

3.4 Certified Reference Materials and Laboratory Control Samples

Certified reference materials (CRMs) and laboratory control samples (LCSs) are analyzed to assess the accuracy of a given analytical method. As required by the SWAMP QAMP, one CRM or LCS should be analyzed per 20 samples or one per batch, whichever is more frequent. All batches met the frequency with the exception of batch WPCL_L-499-08_BS534_S_PCB. Per the laboratory a tissue CRM was mistakenly analyzed with the sediments. This batch was classified as qualified (Appendix X, Table 7).

Laboratory batches with CRM or LCS %R or RPD values outside of acceptance criteria were either classified as compliant or qualified based on number of QC elements outside criteria. These are presented in Appendix X, Table 8. All other CRM and LCS %Rs and RPDs were within acceptance criteria.

3.5 Laboratory Duplicates

Laboratory duplicates (DUPs) were analyzed to assess laboratory precision. As required by the SWAMP QAMP a duplicate of at least one field sample per batch was processed and analyzed. Ten percent of the batches (8 out of 84 total batches) did not include DUPs performed at the required frequency. These 8 Total Phosphorus as P batches were classified as qualified (Appendix X, Table 9).

The duplicates were compared and an RPD was calculated as described in Section 3.3. RPDs <25% were considered acceptable as specified in the QAMP. All RPDs >25% were classified as qualified and are presented in Appendix X, Table 10.

3.6 Field Duplicates

Field duplicates are analyzed to assess field homogeneity and field sampling procedures. Field duplicates were sampled at stations 205COY060 and 504BCHROS in June 2008, station 515YBAMVL in August 2008, station 723NROTWM in April 2008 and stations 845SGRDRE and 907SDFRC2 in May 2008. Sediment duplicates were obtained from homogenized field samples.

Field duplicate values were compared to field sample values from each site and RPDs were calculated as described in Section 3.3. RPDs <25% were considered acceptable as specified in the QAMP. RPDs >25% are presented in Appendix X, Table 11. All other RPDs were acceptable.

3.7 Toxicity Tests

All Hyalella Azteca data were classified as compliant with regard to the SWAMP QAMP MQO for toxicity tests.

3.8 Holding times

Four percent of the results (1045 out of 28066 total results) in 3968 samples (sample per method) were classified as qualified due to holding time exceedances. These results consisted of metals, TOC, grain size, organochlorine pesticides, PCBs, and PAHs. Sediment metal samples exceeded the 1-year holding time criteria until analysis. Sediment TOC and grain size exceeded the 28 day holding time criteria until analysis. Sediment organic samples exceeded the 1-year holding time criteria until extraction. Although data were classified qualified it was considered usable for the intended purposes and for this report.

Some sediment samples analyzed for Hyalella Azteca were outside the recommended 14 day holding time criteria, however they met the 3 week holding time criteria and were classified compliant with regard to the SWAMP QAMP MQO.

3.9 QA/QC Summary

There were 28,345 sample results, including; field observations, integrated samples, and field duplicates and laboratory QA/QC samples. Of these:

21,895 (77%) were classified as “compliant”
6170 (22%) were classified as “qualified”
0 (0%) were classified as “rejected”; and
280 (1%) were classified as “NA”, since the field observation results were not verified and one result was not reported by the laboratory and could not be verified.

Classification of this dataset is summarized as follows:

All data presented in Table 2 were classified as SWAMP-compliant since the analytes detected in the laboratory blanks met the QAMP criteria of less than the RL for laboratory blank contamination.

All data presented in Tables 3, 5, 7, and 9 was classified as qualified due to insufficient QC samples performed.

All data presented in Table 4 were classified as qualified due to surrogate recovery exceedances.

All data presented in Tables 6, 10, and 11 were classified as qualified due to RPD exceedances.

All data presented in Table 8 were classified as either compliant or qualified due to recovery exceedances.

1,045 results for samples presented in Table 12 were classified as qualified due to holding time exceedances.

1,058 screening level results (PAH analytes that could not be quantified or PCB aroclors) were classified as qualified.

Data that meet all SWAMP MQOs as specified in the QAMP are classified as "SWAMP-compliant" and considered usable without further evaluation. Data that fail to meet all program MQOs specified in the SWAMP QAMP, have analytes not covered in the SWAMP QAMP, or are insufficiently documented such that supplementary information is required for them to be used in reports are classified as "qualified" non-compliant with the SWAMP QAMP. No data were classified as rejected for this project During the Data Quality Assessment (DQA) phase of reporting, end users may find qualified data batches meet project data quality objectives A 100% completeness level was attained which met the 90% project completeness goal specified in the SWAMP QAMP.

4.0 Detection and Reporting Limits

Minimum detection limits and reporting limits for all analytes measured are shown in Table 14.

Table 1. Percent recovery (%R) and relative percent difference (RPD) acceptance criteria for different categories of analytes in water and sediment

Analyte Category	% Surrogate Recovery Acceptance Criteria	% MS/MSD Recovery Acceptance Criteria	% CRM & LCS Acceptance Criteria	RPD Criteria (MS/MSD, Laboratory Duplicate, Field Duplicate)
Conventional Constituents	NA	80-120	80-120	25
Trace Metals (Including Mercury)	NA	75-125	75-125	25
Organics (PCBs, OCHs, OPs)	50-150	50-150	50-150	25

Table 2. Laboratory method blanks in which analytes were detected.

Analyte	Result	MDL	RL	Detected	Analysis Date	Method Name	Laboratory	Batch ID
Dieldrin,Total ng/g dw	0.666	0.418	0.836	DNQ	1/8/2010	EPA 8081BM	DFG-WPCL	WPCL_L-024-717-09_BS569_S_OCH
Dieldrin,Total ng/g dw	0.756	0.687	0.800	DNQ	8/17/2009	EPA 8081BM	DFG-WPCL	WPCL_L-024-09_BS558_S_OCH
Methoxychlor,Total ng/g dw	0.297	0.262	1.80	DNQ	8/17/2009	EPA 8081BM	DFG-WPCL	WPCL_L-024-09_BS557_S_OCH
Methoxychlor,Total ng/g dw	0.482	0.220	1.51	DNQ	6/17/2009	EPA 8081BM	DFG-WPCL	WPCL_L-499-08_BS534_S_OCH
Methoxychlor,Total ng/g dw	0.635	0.281	5.78	DNQ	11/5/2008	EPA 8081BM	DFG-WPCL	WPCL_L-326-415-08_BS526_S_OCH
Methoxychlor,Total ng/g dw	0.635	0.204	4.19	DNQ	10/23/2008	EPA 8081BM	DFG-WPCL	WPCL_L-326-08_BS525_S_OCH
Methoxychlor,Total ng/g dw	1.19	0.232	1.59	DNQ	8/17/2009	EPA 8081BM	DFG-WPCL	WPCL_L-024-09_BS558_S_OCH
PCB 070,Total ng/g dw	0.222	0.181	0.362	DNQ	10/30/2008	EPA 8082M	DFG-WPCL	WPCL_L-326-08_BS525_S_PCB
PCB 087,Total ng/g dw	0.110	0.106	0.212	DNQ	10/30/2008	EPA 8082M	DFG-WPCL	WPCL_L-326-08_BS525_S_PCB
PCB 095,Total ng/g dw	0.228	0.153	0.306	DNQ	10/30/2008	EPA 8082M	DFG-WPCL	WPCL_L-326-08_BS525_S_PCB
PCB 101,Total ng/g dw	0.209	0.173	0.347	DNQ	10/30/2008	EPA 8082M	DFG-WPCL	WPCL_L-326-08_BS525_S_PCB
PCB 110,Total ng/g dw	0.298	0.237	0.474	DNQ	10/30/2008	EPA 8082M	DFG-WPCL	WPCL_L-326-08_BS525_S_PCB
PCB AROCLOR 1254,Total ng/g dw	3.00	2.92	14.6	DNQ	6/13/2009	Newman, et al., 1988	DFG-WPCL	WPCL_L-499-08_BS535_S_PCB
PCB AROCLOR 1254,Total ng/g dw	3.00	2.79	14.0	DNQ	10/30/2008	Newman, et al., 1988	DFG-WPCL	WPCL_L-326-08_BS525_S_PCB

Table 3. Batches for which surrogates were not spiked in the samples**.**

Surrogate	Batch ID	Notes	Laboratory
Dibromooctafluorobiphenyl(Surrogate),Total	WPCL_L-024-09_S_PYD-PYN	Surrogate was not added to the samples	DFG-WPCL

Table 4. Surrogate recoveries that did meet quality control acceptance criteria**.**

Surrogate	Station Code	Batch ID	% Recovery	Laboratory
Benz(a)anthracene-d12(Surrogate),Total %	515YBAMVL	WPCL_L-024-226-09_BS559_S_PAH	156	DFG-WPCL
DDD(p,p')(Surrogate),Total %	634UTRSED	WPCL_L-024-09_BS557_S_PBDE	47.5	DFG-WPCL
DDD(p,p')(Surrogate),Total %	LABQA	WPCL_L-024-09_BS557_S_PBDE	48.3	DFG-WPCL
DDD(p,p')(Surrogate),Total %	LABQA	WPCL_L-024-09_BS557_S_OCH	47.2	DFG-WPCL
Naphthalene-d8(Surrogate),Total %	LABQA	WPCL_L-326-415-08_BS547_S_PAH	44.8	DFG-WPCL
Benzo(g,h,i)perylene-d12(Surrogate),Total %	LABQA	WPCL_L-024-226-09_BS559_S_PAH	40.9	DFG-WPCL
DBCE(Surrogate),Total %	LABQA	WPCL_L-024-09_BS558_S_OCH	38.9	DFG-WPCL
Perylene-d12(Surrogate),Total %	LABQA	WPCL_L-326-415-08_BS547_S_PAH	38.7	DFG-WPCL
DBCE(Surrogate),Total %	LABQA	WPCL_L-326-08_BS525_S_OCH	0	DFG-WPCL
DBCE(Surrogate),Total %	LABQA	WPCL_L-415-455-08_BS527_S_OCH	0	DFG-WPCL
DBCE(Surrogate),Total %	LABQA	WPCL_L-326-415-08_BS526_S_OCH	0	DFG-WPCL

Table 5. Batches for which matrix spikes (MS) or matrix spike duplicates (MSD) were not run**.**

Analyte	Batch ID	Notes	Laboratory
Phosphorus as P,Total mg/Kg dw	CLS_4066_S_TPHOS	No MS/MSD performed.	CLS

Table 6. Matrix spikes (MS), matrix spike duplicates (MSD), percent recoveries (%R), and relative percent differences (RPD) that did not meet quality control acceptance criteria. Values with a "q" did not meet the quality control objective**.**

Analyte	Station Code	Sample Date	Lab Batch ID	MS %R	MSD %R	RPD	Laboratory
Aldrin,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	67.2	104	44q	DFG-WPCL
Aldrin,Total ng/g dw	904CBAHC6	5/21/2008	WPCL_L-326-415-08_BS526_S_OCH	262q	276q	5	DFG-WPCL
Benzo(k)fluoranthene,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS536_S_PAH	111	69.8	43q	DFG-WPCL
Bifenthrin,Total ng/g dw	111EELMYR	10/14/2008	WPCL_L-024-09_S_PYD-PYN	129	76.7	51q	DFG-WPCL
Chlordane, cis-,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	66.5	111	49q	DFG-WPCL
Chlordane, trans-,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	65.4	105	43q	DFG-WPCL
Chlorpyrifos,Total ng/g dw	304SOKxxx	7/21/2008	WPCL_L-499-08_S_OP	66.7	88.6	28q	DFG-WPCL
Cyfluthrin, total,Total ng/g dw	111EELMYR	10/14/2008	WPCL_L-024-09_S_PYD-PYN	99.2	75.5	27q	DFG-WPCL
Cypermethrin, total,Total ng/g dw	111EELMYR	10/14/2008	WPCL_L-024-09_S_PYD-PYN	88.9	68.7	26q	DFG-WPCL
DDD(o,p'),Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	60.4	91.5	42q	DFG-WPCL
DDD(p,p'),Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_OCH	166q	209q	12	DFG-WPCL
DDD(p,p'),Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	91.7	35q	35	DFG-WPCL
DDE(o,p'),Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	60.7	96.5	47q	DFG-WPCL
DDE(p,p'),Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_OCH	123	197s	16	DFG-WPCL

Analyte	Station Code	Sample Date	Lab Batch ID	MS %R	MSD %R	RPD	Laboratory
DDMU(p,p'),Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	64.8	99.7	44q	DFG-WPCL
DDT(o,p'),Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	58.3	90.1	44q	DFG-WPCL
DDT(p,p'),Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_OCH	103	166q	29q	DFG-WPCL
DDT(p,p'),Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	58.1	89.5	38q	DFG-WPCL
Deltamethrin,Total ng/g dw	111EELMYR	10/14/2008	WPCL_L-024-09_S_PYD-PYN	88.7	66.7	28q	DFG-WPCL
Deltamethrin,Total ng/g dw	520BUTEMR	8/19/2008	WPCL_L-024-09_S_PYD-PYN	102	78.3	26q	DFG-WPCL
Dieldrin,Total ng/g dw	109MAD101	10/15/2008	WPCL_L-024-09_BS558_S_OCH	46.9q	78.1	39q	DFG-WPCL
Endosulfan I,Total ng/g dw	109MAD101	10/15/2008	WPCL_L-024-09_BS558_S_OCH	0s	0s	0	DFG-WPCL
Endosulfan I,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_OCH	16.4q	63.1	120q	DFG-WPCL
Endrin,Total ng/g dw	109MAD101	10/15/2008	WPCL_L-024-09_BS558_S_OCH	11.3q	17.6q	44q	DFG-WPCL
Endrin,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_OCH	45.9q	63.5	30q	DFG-WPCL
Fenpropathrin,Total ng/g dw	111EELMYR	10/14/2008	WPCL_L-024-09_S_PYD-PYN	73.4	50.7	37q	DFG-WPCL
Fenpropathrin,Total ng/g dw	541MER522	7/16/2008	WPCL_L-499-08_S_PYD-PYN	61.2	81.8	29q	DFG-WPCL
Fluoranthene,Total ng/g dw	515YBAMVL	8/19/2008	WPCL_L-024-226-09_BS559_S_PAH	101	153q	13	DFG-WPCL
Fonofos,Total ng/g dw	304SOKxxx	7/21/2008	WPCL_L-499-08_S_OP	102	74.6	32q	DFG-WPCL
HCH, alpha ,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	60.7	91	42q	DFG-WPCL
HCH, beta,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	66.2	97.1	40q	DFG-WPCL
HCH, gamma,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	64	93.5	40q	DFG-WPCL
Heptachlor epoxide,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	67.6	94.9	35q	DFG-WPCL
Heptachlor,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	56.4	90.4	47q	DFG-WPCL
Hexachlorobenzene,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	48.1q	77.7	29q	DFG-WPCL
Lead,Total mg/Kg dw	541MER542	7/23/2008	MPSL-DFG_2009Dig11_S_TM	76.6	73.8q	3	MPSL-DFG
Methoxychlor,Total ng/g dw	109MAD101	10/15/2008	WPCL_L-024-09_BS558_S_OCH	151q	158q	4	DFG-WPCL
Methoxychlor,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	67.2	101	42q	DFG-WPCL
Methoxychlor,Total ng/g dw	904CBAHC6	5/21/2008	WPCL_L-326-415-08_BS526_S_OCH	42.5q	39.4q	8	DFG-WPCL
Methylfluoranthene, 2-,Total ng/g dw	906LPSOL4	5/21/2008	WPCL_L-326-415-08_BS547_S_PAH	154q	150	5	DFG-WPCL
Mirex,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	64.2	93	39q	DFG-WPCL
Nonachlor, cis-,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	66.9	108	49q	DFG-WPCL
Nonachlor, trans-,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	65	99.6	43q	DFG-WPCL
Oxychlordane,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_OCH	68.4	95.7	35q	DFG-WPCL
Parathion, Methyl,Total ng/g dw	304SOKxxx	7/21/2008	WPCL_L-499-08_S_OP	46.4q	59.8	25	DFG-WPCL
PBDE 017,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_PBDE	218q	198q	12	DFG-WPCL
PBDE 017,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_PBDE	202q	192q	3	DFG-WPCL
PBDE 028,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_PBDE	208q	184q	14	DFG-WPCL
PBDE 028,Total ng/g dw	531SAC001	7/22/2008	WPCL_L-499-08_BS534_S_PBDE	233q	165q	32q	DFG-WPCL
PBDE 047,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_PBDE	143	111	26q	DFG-WPCL
PBDE 085,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_PBDE	155q	147	8	DFG-WPCL
PBDE 099,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_PBDE	145	249q	51	DFG-WPCL
PBDE 153,Total ng/g dw	508SACBLF	6/30/2008	WPCL_L-499-08_BS535_S_PBDE	144	166q	12	DFG-WPCL

Analyte	Station Code	Sample Date	Lab Batch ID	MS %R	MSD %R	RPD	Laboratory
PCB 101,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	130	159q	13	DFG-WPCL
PCB 110,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	133	165q	13	DFG-WPCL
PCB 138,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	139	189q	15	DFG-WPCL
PCB 149,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	148	210q	17	DFG-WPCL
PCB 153,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	157q	223q	17	DFG-WPCL
PCB 180,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	138	171q	11	DFG-WPCL
PCB 187,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_PCB	128	159q	14	DFG-WPCL
Permethrin, trans-,Total ng/g dw	520BUTEMR	8/19/2008	WPCL_L-024-09_S_PYD-PYN	53.8q	90	50q	DFG-WPCL
Phosphorus as P,Total mg/Kg dw	204SLE030	6/17/2008	CLS_4170_S_TPHOS	0	0	0	CLS
Phosphorus as P,Total mg/Kg dw	304SOKxxx	7/21/2008	CLS_4255_S_TPHOS	56.4q	59q	2	CLS
Phosphorus as P,Total mg/Kg dw	526P00008	6/30/2008	CLS_4256_S_TPHOS	226q	202q	6	CLS
Selenium,Total mg/Kg dw	531SAC001	7/22/2008	MPSL-DFG_2009Dig13_S_TM	88.7	71.6q	18	MPSL-DFG
Selenium,Total mg/Kg dw	541MER542	7/23/2008	MPSL-DFG_2009Dig11_S_TM	81.8	73.2q	5	MPSL-DFG
Selenium,Total mg/Kg dw	558CCR010	4/29/2008	MPSL-DFG_2008Dig25_S_TM	70.7	70.9q	1	MPSL-DFG
Selenium,Total mg/Kg dw	901SJSJC9	5/21/2008	MPSL-DFG_2009Dig01_S_TM	79.8	74.1q	2	MPSL-DFG
Silver,Total mg/Kg dw	207LAU020	6/17/2008	MPSL-DFG_2009Dig04_S_TM	106	127q	16	MPSL-DFG
Tedion,Total ng/g dw	205GUA020	6/17/2008	WPCL_L-415-455-08_BS527_S_OCH	262q	249q	3	DFG-WPCL
Tedion,Total ng/g dw	904CBAHC6	5/21/2008	WPCL_L-326-415-08_BS526_S_OCH	26q3	275q	4	DFG-WPCL
Tedion,Total ng/g dw	907SDFRC2	5/21/2008	WPCL_L-326-08_BS525_S_OCH	305q	328q	7	DFG-WPCL

Table 7. Batches for which certified reference material (CRM) or laboratory control spike (LCS) samples were not run.

Analyte	Batch ID	Notes	Laboratory
Polychlorinated Biphenyls	WPCL_L-499-08_BS534_S_PCB	Tissue SRM was mistakenly analyzed with this set of sediments	DFG-WPCL

Table 8. Batches containing certified reference material (CRM) or laboratory control spike (LCS) that did not meet quality control acceptance criteria.

Analyte	StationCode	Batch ID	% Recovery	Laboratory
Aldrin,Total ng/g dw	L-326-415-08-LCS-BS 526	WPCL_L-326-415-08_BS526_S_OCH	259	DFG-WPCL
Aldrin,Total ng/g dw	L-717-09-LCS-BS 569	WPCL_L-024-717-09_BS569_S_OCH	160	DFG-WPCL
Aluminum,Total mg/Kg dw	srm pac2 81	MPSL-DFG_2009Dig13_S_TM	150	MPSL-DFG
Benz(a)anthracene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	50	DFG-WPCL

Analyte	StationCode	Batch ID	% Recovery	Laboratory
Benzo(a)pyrene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	54.8	DFG-WPCL
Benzo(b)fluoranthene,Total ng/g dw	L-024-09-SRM 1944-BS 559	WPCL_L-024-226-09_BS559_S_PAH	179	DFG-WPCL
Benzo(e)pyrene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	64.5	DFG-WPCL
Benzo(g,h,i)perylene,Total ng/g dw	L-024-09-SRM 1944-BS 559	WPCL_L-024-226-09_BS559_S_PAH	165	DFG-WPCL
Benzo(k)fluoranthene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	59.3	DFG-WPCL
Chlordane, cis-,Total ng/g dw	L-326-415-08-SRM 1944-BS 526	WPCL_L-326-415-08_BS526_S_OCH	156	DFG-WPCL
Chlordane, cis-,Total ng/g dw	L-415-455-08-SRM 1944-BS 527	WPCL_L-415-455-08_BS527_S_OCH	184	DFG-WPCL
Chrysene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	54.8	DFG-WPCL
Copper,Total mg/Kg dw	srm mess3 22	MPSL-DFG_2008Dig25_S_TM	71.9	MPSL-DFG
DDT(p,p'),Total ng/g dw	L-326-415-08-SRM 1944-BS 526	WPCL_L-326-415-08_BS526_S_OCH	150	DFG-WPCL
DDT(p,p'),Total ng/g dw	L-717-09-SRM 1944-BS 569	WPCL_L-024-717-09_BS569_S_OCH	160	DFG-WPCL
Deltamethrin,Total ng/g dw	L-415-08-LCS	WPCL_L-415-08_S_PYD-PYN	45.2	DFG-WPCL
Deltamethrin,Total ng/g dw	L-499-08-LCS-1	WPCL_L-499-08_S_PYD-PYN	28.8	DFG-WPCL
Deltamethrin,Total ng/g dw	L-499-08-LCS-2	WPCL_L-499-08_S_PYD-PYN	30.8	DFG-WPCL
Dieldrin,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_OCH	155	DFG-WPCL
Endosulfan I,Total ng/g dw	L-024-09-LCS-BS 557	WPCL_L-024-09_BS557_S_OCH	40.2	DFG-WPCL
Endosulfan I,Total ng/g dw	L-024-09-LCS-BS 558	WPCL_L-024-09_BS558_S_OCH	7.6	DFG-WPCL
Endosulfan I,Total ng/g dw	L-326-415-08-LCS-BS 526	WPCL_L-326-415-08_BS526_S_OCH	36.1	DFG-WPCL
Endosulfan I,Total ng/g dw	L-499-08-LCS-BS 535	WPCL_L-499-08_BS535_S_OCH	48.9	DFG-WPCL
Endrin,Total ng/g dw	L-024-09-LCS-BS 558	WPCL_L-024-09_BS558_S_OCH	11.2	DFG-WPCL
Indeno(1,2,3-c,d)pyrene,Total ng/g dw	L-024-09-SRM 1944-BS 559	WPCL_L-024-226-09_BS559_S_PAH	251	DFG-WPCL
Manganese,Total mg/Kg dw	srm pac2 72	MPSL-DFG_2008Dig25_S_TM	140	MPSL-DFG
Manganese,Total mg/Kg dw	srm pac2 73	MPSL-DFG_2008Dig26_S_TM	140	MPSL-DFG
Manganese,Total mg/Kg dw	srm pac2 74	MPSL-DFG_2009Dig01_S_TM	144	MPSL-DFG
Methoxychlor,Total ng/g dw	L-326-415-08-LCS-BS 526	WPCL_L-326-415-08_BS526_S_OCH	35.2	DFG-WPCL
Methoxychlor,Total ng/g dw	L-415-455-08-LCS-BS 527	WPCL_L-415-455-08_BS527_S_OCH	157	DFG-WPCL
Mirex,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_OCH	0	DFG-WPCL
Nonachlor, trans-,Total ng/g dw	L-024-09-SRM 1944-BS 558	WPCL_L-024-09_BS558_S_OCH	145	DFG-WPCL
Nonachlor, trans-,Total ng/g dw	L-326-08-SRM 1944-BS 525	WPCL_L-326-08_BS525_S_OCH	145	DFG-WPCL
Nonachlor, trans-,Total ng/g dw	L-326-415-08-SRM 1944-BS 526	WPCL_L-326-415-08_BS526_S_OCH	174	DFG-WPCL
Nonachlor, trans-,Total ng/g dw	L-415-455-08-SRM 1944-BS 527	WPCL_L-415-455-08_BS527_S_OCH	216	DFG-WPCL

Analyte	StationCode	Batch ID	% Recovery	Laboratory
Oxychlordane,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_OCH	0	DFG-WPCL
PBDE 138,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_PBDE	169	DFG-WPCL
PBDE 153,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_PBDE	160	DFG-WPCL
PBDE 154,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_PBDE	166	DFG-WPCL
PBDE 183,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_PBDE	169	DFG-WPCL
PBDE 190,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_PBDE	180	DFG-WPCL
PCB 008,Total ng/g dw	L-717-09-SRM 1944-BS 569	WPCL_L-024-717-09_BS569_S_PCB	146	DFG-WPCL
PCB 018,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 028,Total ng/g dw	L-499-08-SRM 1944-BS 535	WPCL_L-499-08_BS535_S_PCB	147	DFG-WPCL
PCB 028,Total ng/g dw	L-717-09-SRM 1944-BS 569	WPCL_L-024-717-09_BS569_S_PCB	141	DFG-WPCL
PCB 031,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 033,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 049,Total ng/g dw	L-499-08-SRM 1944-BS 535	WPCL_L-499-08_BS535_S_PCB	147	DFG-WPCL
PCB 070,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 114,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 128,Total ng/g dw	L-326-08-SRM 1944-BS 525	WPCL_L-326-08_BS525_S_PCB	143	DFG-WPCL
PCB 128,Total ng/g dw	L-415-455-08-SRM 1944-BS 527	WPCL_L-415-455-08_BS527_S_PCB	139	DFG-WPCL
PCB 128,Total ng/g dw	L-499-08-SRM 1944-BS 535	WPCL_L-499-08_BS535_S_PCB	156	DFG-WPCL
PCB 128,Total ng/g dw	L-717-09-SRM 1944-BS 569	WPCL_L-024-717-09_BS569_S_PCB	155	DFG-WPCL
PCB 137,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 138,Total ng/g dw	L-024-09-SRM 1944-BS 558	WPCL_L-024-09_BS558_S_PCB	66.3	DFG-WPCL
PCB 141,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	151	DFG-WPCL
PCB 151,Total ng/g dw	L-024-09-SRM 1944-BS 558	WPCL_L-024-09_BS558_S_PCB	65.6	DFG-WPCL
PCB 157,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 158,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 170,Total ng/g dw	L-024-09-SRM 1944-BS 558	WPCL_L-024-09_BS558_S_PCB	57.1	DFG-WPCL
PCB 170,Total ng/g dw	L-326-415-08-SRM 1944-BS 526	WPCL_L-326-415-08_BS526_S_PCB	59.3	DFG-WPCL
PCB 174,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 177,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL

Analyte	StationCode	Batch ID	% Recovery	Laboratory
PCB 189,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 194,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 195,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 203,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 206,Total ng/g dw	L-024-09-SRM 1944-BS 558	WPCL_L-024-09_BS558_S_PCB	177	DFG-WPCL
PCB 206,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
PCB 209,Total ng/g dw	L-024-09-SRM 1944-BS 557	WPCL_L-024-09_BS557_S_PCB	197	DFG-WPCL
PCB 209,Total ng/g na	L-499-08-SRM 1588b-BS 534	WPCL_L-499-08_BS534_S_PCB	0	DFG-WPCL
Perylene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	46.9	DFG-WPCL
Pyrene,Total ng/g dw	L-499-08-SRM 1944-BS 536	WPCL_L-499-08_BS536_S_PAH	64.3	DFG-WPCL
Tedion,Total ng/g dw	L-024-09-LCS-BS 558	WPCL_L-024-09_BS558_S_OCH	184	DFG-WPCL
Tedion,Total ng/g dw	L-326-08-LCS-BS 525	WPCL_L-326-08_BS525_S_OCH	310	DFG-WPCL
Tedion,Total ng/g dw	L-326-415-08-LCS-BS 526	WPCL_L-326-415-08_BS526_S_OCH	268	DFG-WPCL
Tedion,Total ng/g dw	L-415-455-08-LCS-BS 527	WPCL_L-415-455-08_BS527_S_OCH	256	DFG-WPCL
Tedion,Total ng/g dw	L-499-08-LCS-BS 534	WPCL_L-499-08_BS534_S_OCH	156	DFG-WPCL
Tedion,Total ng/g dw	L-499-08-LCS-BS 535	WPCL_L-499-08_BS535_S_OCH	163	DFG-WPCL
Tedion,Total ng/g dw	L-717-09-LCS-BS 569	WPCL_L-024-717-09_BS569_S_OCH	152	DFG-WPCL
Zinc,Total mg/Kg dw	srm pac2 72	MPSL-DFG_2008Dig25_S_TM	69.9	MPSL-DFG
Zinc,Total mg/Kg dw	srm pac2 73	MPSL-DFG_2008Dig26_S_TM	69.5	MPSL-DFG
Zinc,Total mg/Kg dw	srm pac2 75	MPSL-DFG_2009Dig02_S_TM	71.8	MPSL-DFG

Table 9. Batches for which laboratory duplicates (DUP) were not run**.**

Analyte	Batch ID	Notes	Laboratory
Phosphorus as P,Total mg/Kg dw	CLS_4066_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS
Phosphorus as P,Total mg/Kg dw	CLS_4170_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS
Phosphorus as P,Total mg/Kg dw	CLS_4255_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS
Phosphorus as P,Total mg/Kg dw	CLS_4256_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS
Phosphorus as P,Total mg/Kg dw	CLS_4803_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS
Phosphorus as P,Total mg/Kg dw	CLS_4804_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS

Analyte	Batch ID	Notes	Laboratory
Phosphorus as P,Total mg/Kg dw	CLS_5286_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS
Phosphorus as P,Total mg/Kg dw	CLS_5415_S_TPHOS	No sample duplicate (LCS, LCSD performed).	CLS

Table 10. Laboratory duplicate samples that did not meet quality control acceptance criteria**.**

Analyte	Station Code	Sample Date	Parent Value	Duplicate Value	RPD	Laboratory	Batch ID
Acenaphthene,Total ng/g dw	515YBAMVL	8/19/2008	-0.894	1.18	200	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Acenaphthylene,Total ng/g dw	515YBAMVL	8/19/2008	1.3	2.33	57	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Aluminum,Total mg/Kg dw	309TDWxxx	7/21/2008	70909	106570	40	MPSL-DFG	MPSL-DFG_2009Dig12_S_TM
Aluminum,Total mg/Kg dw	531SAC001	7/22/2008	98021	69828	34	MPSL-DFG	MPSL-DFG_2009Dig13_S_TM
Anthracene,Total ng/g dw	305THUxxx	7/21/2008	1.04	-0.831	200	DFG-	WPCL_L-499-08_BS536_S_PAH
Anthracene,Total ng/g dw	515YBAMVL	8/19/2008	5	9.53	62	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Benz(a)anthracene,Total ng/g dw	515YBAMVL	8/19/2008	9.03	18.5	69	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Benz(a)anthracene,Total ng/g dw	904CBAHC6	5/21/2008	1.93	2.59	29	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Benzo(a)pyrene,Total ng/g dw	515YBAMVL	8/19/2008	5.86	11.5	65	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Benzo(b)fluoranthene,Total ng/g dw	515YBAMVL	8/19/2008	21	37.1	55	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Benzo(e)pyrene,Total ng/g dw	515YBAMVL	8/19/2008	10.1	16.7	49	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Benzo(g,h,i)perylene,Total ng/g dw	515YBAMVL	8/19/2008	6.23	8.08	26	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Benzo(k)fluoranthene,Total ng/g dw	515YBAMVL	8/19/2008	6.51	12.8	65	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Bifenthrin,Total ng/g dw	504BCHROS	6/30/2008	1	1.34	29	DFG-	WPCL_L-499-08_S_PYD-PYN
Biphenyl,Total ng/g dw	305THUxxx	7/21/2008	3.61	2.51	36	DFG-	WPCL_L-499-08_BS536_S_PAH
Biphenyl,Total ng/g dw	515YBAMVL	8/19/2008	-0.894	1.23	200	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Biphenyl,Total ng/g dw	904CBAHC6	5/21/2008	1.6	0.71	77	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Chrysene,Total ng/g dw	515YBAMVL	8/19/2008	16.4	34.8	72	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Chrysenes, C1-,Total ng/g dw	515YBAMVL	8/19/2008	9.21	16	54	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Chrysenes, C2-,Total ng/g dw	515YBAMVL	8/19/2008	6.43	11.2	54	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Chrysenes, C2-,Total ng/g dw	904CBAHC6	5/21/2008	2.47	4.11	50	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Chrysenes, C3-,Total ng/g dw	515YBAMVL	8/19/2008	4.99	9.26	60	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Chrysenes, C3-,Total ng/g dw	904CBAHC6	5/21/2008	2.6	3.47	29	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Dacthal,Total ng/g dw	902SSMR07	5/21/2008	-0.094	0.173	200	DFG-	WPCL_L-326-415-08_BS526_S_OCH

Analyte	Station Code	Sample Date	Parent Value	Duplicate Value	RPD	Laboratory	Batch ID
DDD(o,p'),Total ng/g dw	205COY060	6/17/2008	4.15	3.07	30	DFG-	WPCL_L-415-455-08_BS527_S_OCH
DDD(o,p'),Total ng/g dw	515YBAMVL	8/19/2008	-0.157	0.186	200	DFG-	WPCL_L-024-09_BS557_S_OCH
DDD(p,p'),Total ng/g dw	515YBAMVL	8/19/2008	0.361	0.517	36	DFG-	WPCL_L-024-09_BS557_S_OCH
DDD(p,p'),Total ng/g dw	902SSMR07	5/21/2008	0.406	1.55	120	DFG-	WPCL_L-326-415-08_BS526_S_OCH
DDE(o,p'),Total ng/g dw	902SSMR07	5/21/2008	-0.174	0.183	200	DFG-	WPCL_L-326-415-08_BS526_S_OCH
DDT(o,p'),Total ng/g dw	845SGRDRE	5/20/2008	1.1	0.85	26	DFG-	WPCL_L-326-08_BS525_S_OCH
DDT(p,p'),Total ng/g dw	902SSMR07	5/21/2008	5.05	6.56	26	DFG-	WPCL_L-326-415-08_BS526_S_OCH
Dibenz(a,h)anthracene,Total ng/g dw	515YBAMVL	8/19/2008	1.81	3.86	72	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Dibenzothiophenes, C1-,Total ng/g dw	904CBAHC6	5/21/2008	0.61	-0.607	200	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Dibenzothiophenes, C2-,Total ng/g dw	515YBAMVL	8/19/2008	4.96	6.8	31	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Dibenzothiophenes, C3-,Total ng/g dw	515YBAMVL	8/19/2008	5.98	9.89	49	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Dibenzothiophenes, C3-,Total ng/g dw	904CBAHC6	5/21/2008	0.87	1.77	68	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Dieldrin,Total ng/g dw	515YBAMVL	8/19/2008	0.736	-0.715	200	DFG-	WPCL_L-024-09_BS557_S_OCH
Dieldrin,Total ng/g dw	845SGRDRE	5/20/2008	5.06	3.48	37	DFG-	WPCL_L-326-08_BS525_S_OCH
Endrin,Total ng/g dw	305THUxxx	7/21/2008	-0.295	0.312	200	DFG-	WPCL_L-499-08_BS534_S_OCH
Fluoranthene,Total ng/g dw	515YBAMVL	8/19/2008	53.1	90.9	53	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Fluoranthene/Pyrenes, C1-,Total ng/g dw	515YBAMVL	8/19/2008	27.7	60.1	74	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Fluoranthene/Pyrenes, C1-,Total ng/g dw	904CBAHC6	5/21/2008	3.44	5.72	50	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Fluorene,Total ng/g dw	515YBAMVL	8/19/2008	2.05	2.82	32	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Fluorenes, C1-,Total ng/g dw	904CBAHC6	5/21/2008	0.83	-0.607	200	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Fluorenes, C2-,Total ng/g dw	904CBAHC6	5/21/2008	2.69	1.88	35	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Hexachlorobenzene,Total ng/g dw	205COY060	6/17/2008	1.43	0.917	44	DFG-	WPCL_L-415-455-08_BS527_S_OCH
Indeno(1,2,3-c,d)pyrene,Total ng/g dw	515YBAMVL	8/19/2008	6.78	12.8	61	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Manganese,Total mg/Kg dw	207LAU020	6/17/2008	1727	2605	40	MPSL-DFG	MPSL-DFG_2009Dig04_S_TM
Mercury,Total mg/Kg dw	000NONPJ	3/16/2009	0.111	0.197	56	MPSL-DFG	MPSL-DFG_FIMS09Dig19_S_Hg
Mercury,Total mg/Kg dw	307CMLxxx	6/17/2008	0.022	0.013	51	MPSL-DFG	MPSL-DFG_FIMS08Dig38_S_Hg
Mercury,Total mg/Kg dw	551LKI040	4/29/2008	0.05	0.035	35	MPSL-DFG	MPSL-DFG_FIMS08Dig35_S_Hg
Methoxychlor,Total ng/g dw	105KLAMKK	10/15/2008	-0.238	0.285	200	DFG-	WPCL_L-024-09_BS558_S_OCH
Methoxychlor,Total ng/g dw	902SSMR07	5/21/2008	0.209	-0.15	200	DFG-	WPCL_L-326-415-08_BS526_S_OCH

Analyte	Station Code	Sample Date	Parent Value	Duplicate Value	RPD	Laboratory	Batch ID
Methyldibenzothiophene, 4-,Total ng/g dw	515YBAMVL	8/19/2008	-0.894	0.88	200	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Methylfluoranthene, 2-,Total ng/g dw	515YBAMVL	8/19/2008	4.58	8.57	61	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Methylfluoranthene, 2-,Total ng/g dw	904CBAHC6	5/21/2008	-0.603	0.67	200	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Methylnaphthalene, 2-,Total ng/g dw	904CBAHC6	5/21/2008	1.05	0.78	30	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Methylphenanthrene, 1-,Total ng/g dw	515YBAMVL	8/19/2008	2.9	4.11	35	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Naphthalene,Total ng/g dw	904CBAHC6	5/21/2008	2.48	1.42	54	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Naphthalenes, C1-,Total ng/g dw	904CBAHC6	5/21/2008	1.69	1.22	32	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Naphthalenes, C2-,Total ng/g dw	305THUxxx	7/21/2008	25.8	15.4	50	DFG-	WPCL_L-499-08_BS536_S_PAH
Naphthalenes, C4-,Total ng/g dw	305THUxxx	7/21/2008	16.7	12.2	31	DFG-	WPCL_L-499-08_BS536_S_PAH
Oxadiazon,Total ng/g dw	305THUxxx	7/21/2008	0.948	-0.892	200	DFG-	WPCL_L-499-08_BS534_S_OCH
Oxadiazon,Total ng/g dw	902SSMR07	5/21/2008	2.94	4.85	49	DFG-	WPCL_L-326-415-08_BS526_S_OCH
PBDE 017,Total ng/g dw	305THUxxx	7/21/2008	0.664	-0.228	200	DFG-	WPCL_L-499-08_BS534_S_PBDE
PBDE 028,Total ng/g dw	515YBAMVL	8/19/2008	-0.242	0.616	200	DFG-	WPCL_L-024-09_BS557_S_PBDE
PBDE 028,Total ng/g dw	845SGRDRE	5/20/2008	-0.137	0.186	200	DFG-	WPCL_L-326-08_BS525_S_PBDE
PBDE 047,Total ng/g dw	205COY060	6/17/2008	15.1	11.3	29	DFG-	WPCL_L-415-08_BS527_S_PBDE
PBDE 047,Total ng/g dw	504BCHROS	6/30/2008	2.71	-0.314	200	DFG-	WPCL_L-499-08_BS535_S_PBDE
PBDE 085,Total ng/g dw	205COY060	6/17/2008	1.99	1.18	51	DFG-	WPCL_L-415-08_BS527_S_PBDE
PBDE 085,Total ng/g dw	504BCHROS	6/30/2008	-0.288	0.363	200	DFG-	WPCL_L-499-08_BS535_S_PBDE
PBDE 099,Total ng/g dw	205COY060	6/17/2008	39.9	27.3	28	DFG-	WPCL_L-415-08_BS527_S_PBDE
PBDE 100,Total ng/g dw	205COY060	6/17/2008	8.33	5.74	37	DFG-	WPCL_L-415-08_BS527_S_PBDE
PBDE 100,Total ng/g dw	305THUxxx	7/21/2008	0.477	-0.257	200	DFG-	WPCL_L-499-08_BS534_S_PBDE
PBDE 100,Total ng/g dw	515YBAMVL	8/19/2008	0.834	-0.26	200	DFG-	WPCL_L-024-09_BS557_S_PBDE
PBDE 138,Total ng/g dw	515YBAMVL	8/19/2008	0.537	-0.331	200	DFG-	WPCL_L-024-09_BS557_S_PBDE
PBDE 138,Total ng/g dw	845SGRDRE	5/20/2008	0.489	-0.309	200	DFG-	WPCL_L-326-08_BS525_S_PBDE
PBDE 153,Total ng/g dw	515YBAMVL	8/19/2008	0.397	-0.307	200	DFG-	WPCL_L-024-09_BS557_S_PBDE
PBDE 190,Total ng/g dw	504BCHROS	6/30/2008	-0.71	1.63	200	DFG-	WPCL_L-499-08_BS535_S_PBDE
PBDE 190,Total ng/g dw	515YBAMVL	8/19/2008	0.922	-0.723	200	DFG-	WPCL_L-024-09_BS557_S_PBDE
PCB 028,Total ng/g dw	845SGRDRE	5/20/2008	-0.312	0.229	200	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 033,Total ng/g dw	205COY060	6/17/2008	-0.27	0.255	200	DFG-	WPCL_L-415-455-08_BS527_S_PCB

Analyte	Station Code	Sample Date	Parent Value	Duplicate Value	RPD	Laboratory	Batch ID
PCB 056,Total ng/g dw	845SGRDRE	5/20/2008	0.239	0.182	27	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 056,Total ng/g dw	902SSMR07	5/21/2008	-0.053	0.055	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 060,Total ng/g dw	845SGRDRE	5/20/2008	-0.122	0.09	200	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 064,Total ng/g dw	845SGRDRE	5/20/2008	-0.099	0.078	200	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 066,Total ng/g dw	845SGRDRE	5/20/2008	0.442	0.303	37	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 066,Total ng/g dw	902SSMR07	5/21/2008	-0.095	0.109	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 070,Total ng/g dw	845SGRDRE	5/20/2008	0.854	0.655	26	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 070,Total ng/g dw	902SSMR07	5/21/2008	-0.127	0.215	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 074,Total ng/g dw	515YBAMVL	8/19/2008	-0.327	0.357	200	DFG-	WPCL_L-024-09_BS557_S_PCB
PCB 077,Total ng/g dw	845SGRDRE	5/20/2008	0.225	0.172	27	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 087,Total ng/g dw	902SSMR07	5/21/2008	-0.074	0.117	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 095,Total ng/g dw	902SSMR07	5/21/2008	-0.108	0.205	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 097,Total ng/g dw	902SSMR07	5/21/2008	-0.061	0.086	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 099,Total ng/g dw	902SSMR07	5/21/2008	-0.083	0.088	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 101,Total ng/g dw	902SSMR07	5/21/2008	-0.122	0.229	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 105,Total ng/g dw	902SSMR07	5/21/2008	-0.131	0.138	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 110,Total ng/g dw	902SSMR07	5/21/2008	-0.167	0.284	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 118,Total ng/g dw	902SSMR07	5/21/2008	-0.207	0.279	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 137,Total ng/g dw	205COY060	6/17/2008	0.15	0.11	31	DFG-	WPCL_L-415-455-08_BS527_S_PCB
PCB 149,Total ng/g dw	902SSMR07	5/21/2008	-0.078	0.092	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
PCB 194,Total ng/g dw	845SGRDRE	5/20/2008	1.18	0.912	26	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 195,Total ng/g dw	845SGRDRE	5/20/2008	0.31	0.239	26	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB 209,Total ng/g dw	845SGRDRE	5/20/2008	0.116	0.088	27	DFG-	WPCL_L-326-08_BS525_S_PCB
PCB AROCLOR 1248,Total ng/g dw	205COY060	6/17/2008	-11.4	13	200	DFG-	WPCL_L-415-455-08_BS527_S_PCB
PCB AROCLOR 1254,Total ng/g dw	902SSMR07	5/21/2008	-1.96	3	200	DFG-	WPCL_L-326-415-08_BS526_S_PCB
Phenanthrene,Total ng/g dw	515YBAMVL	8/19/2008	21.3	27.6	26	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Phenanthrene/Anthracene, C1-,Total ng/g dw	515YBAMVL	8/19/2008	13.7	20.5	40	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Phenanthrene/Anthracene, C2-,Total ng/g dw	515YBAMVL	8/19/2008	18	29.9	50	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Phenanthrene/Anthracene, C2-,Total ng/g dw	904CBAHC6	5/21/2008	2.05	4.96	83	DFG-	WPCL_L-326-415-08_BS547_S_PAH

Analyte	Station Code	Sample Date	Parent Value	Duplicate Value	RPD	Laboratory	Batch ID
Phenanthrene/Anthracene, C3-,Total ng/g dw	515YBAMVL	8/19/2008	16	30.4	62	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Phenanthrene/Anthracene, C3-,Total ng/g dw	904CBAHC6	5/21/2008	1.31	4.99	120	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Phenanthrene/Anthracene, C4-,Total ng/g dw	515YBAMVL	8/19/2008	11.4	17.8	44	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Phenanthrene/Anthracene, C4-,Total ng/g dw	904CBAHC6	5/21/2008	-0.603	1.3	200	DFG-	WPCL_L-326-415-08_BS547_S_PAH
Pyrene,Total ng/g dw	515YBAMVL	8/19/2008	33.7	62	60	DFG-	WPCL_L-024-226-09_BS559_S_PAH
Selenium,Total mg/Kg dw	207LAU020	6/17/2008	0.63	1.37	74	MPSL-DFG	MPSL-DFG_2009Dig04_S_TM
Selenium,Total mg/Kg dw	309TDWxxx	7/21/2008	0.82	1.13	32	MPSL-DFG	MPSL-DFG_2009Dig12_S_TM
Selenium,Total mg/Kg dw	531SAC001	7/22/2008	-0.27	0.53	200	MPSL-DFG	MPSL-DFG_2009Dig13_S_TM
Selenium,Total mg/Kg dw	911TJHRxx	5/22/2008	2.72	1.58	53	MPSL-DFG	MPSL-DFG_2009Dig02_S_TM
Silver,Total mg/Kg dw	207LAU020	6/17/2008	0.28	0.09	103	MPSL-DFG	MPSL-DFG_2009Dig04_S_TM
Silver,Total mg/Kg dw	309TDWxxx	7/21/2008	0.19	0.32	49	MPSL-DFG	MPSL-DFG_2009Dig12_S_TM

Table 11. Field duplicate samples that did not meet quality control acceptance criteria**.**

Analyte	Station Code	Date	Field Sample	Field Duplicate	RPD	Laboratory
Anthracene,Total ng/g dw	205COY060	17/June/2008	9.08	6.11	39	DFG-WPCL
Cyhalothrin, lambda, total,Total ng/g dw	205COY060	17/June/2008	1.94	3.5	57	DFG-WPCL
DDD(o,p'),Total ng/g dw	205COY060	17/June/2008	4.15	3.06	30	DFG-WPCL
DDE(o,p'),Total ng/g dw	205COY060	17/June/2008	0.482	0.367	27	DFG-WPCL
DDE(p,p'),Total ng/g dw	205COY060	17/June/2008	18.8	14.2	28	DFG-WPCL
DDMU(p,p'),Total ng/g dw	205COY060	17/June/2008	1.44	1.07	29	DFG-WPCL
DDT(o,p'),Total ng/g dw	205COY060	17/June/2008	0.892	0.676	28	DFG-WPCL
DDT(p,p'),Total ng/g dw	205COY060	17/June/2008	5.25	3.48	41	DFG-WPCL
Granule 2.0 to <4.0 mm %	205COY060	17/June/2008	1.52	0.24	145	AMS
Methylfluorene, 1-,Total ng/g dw	205COY060	17/June/2008	4.47	3.37	28	DFG-WPCL
Naphthalenes, C4-,Total ng/g dw	205COY060	17/June/2008	6.09	4.4	32	DFG-WPCL
PBDE 017,Total ng/g dw	205COY060	17/June/2008	0.205	0.13	45	DFG-WPCL
Permethrin, cis-,Total ng/g dw	205COY060	17/June/2008	14.8	3.98	115	DFG-WPCL
Phenanthrene/Anthracene, C4-,Total ng/g dw	205COY060	17/June/2008	39.5	28.5	32	DFG-WPCL
Phosphorus as P,Total mg/Kg dw	205COY060	17/June/2008	25.07	17.75	34	CLS
Sand	205COY060	17/June/2008	4.08	3.35	20	AMS
Bifenthrin,Total ng/g dw	504BCHROS	30/June/2008	0.758	1	28	DFG-WPCL
Chlordane, cis-,Total ng/g dw	504BCHROS	30/June/2008	0.681	1.79	90	DFG-WPCL
Chlordane, trans-,Total ng/g dw	504BCHROS	30/June/2008	0.761	1.45	62	DFG-WPCL
DDD(o,p'),Total ng/g dw	504BCHROS	30/June/2008	12.1	20.2	50	DFG-WPCL
DDD(p,p'),Total ng/g dw	504BCHROS	30/June/2008	97.3	42.4	79	DFG-WPCL

Analyte	Station Code	Date	Field Sample	Field Duplicate	RPD	Laboratory
DDE(o,p'),Total ng/g dw	504BCHROS	30/June/2008	-0.289	0.339	200	DFG-WPCL
DDE(p,p'),Total ng/g dw	504BCHROS	30/June/2008	6.62	10	41	DFG-WPCL
DDMU(p,p'),Total ng/g dw	504BCHROS	30/June/2008	1.29	1.95	41	DFG-WPCL
DDT(o,p'),Total ng/g dw	504BCHROS	30/June/2008	2.78	7	86	DFG-WPCL
DDT(p,p'),Total ng/g dw	504BCHROS	30/June/2008	51.9	39.5	27	DFG-WPCL
Dieldrin,Total ng/g dw	504BCHROS	30/June/2008	0.885	1.5	52	DFG-WPCL
Granule 2.0 to <4.0 mm %	504BCHROS	30/June/2008	0.36	0.03	169	AMS
Mercury,Total mg/Kg dw	504BCHROS	30/June/2008	0.137	0.079	54	MPSL-DFG
Nonachlor, trans-,Total ng/g dw	504BCHROS	30/June/2008	0.745	1.68	77	DFG-WPCL
PCB 052,Total ng/g dw	504BCHROS	30/June/2008	-0.325	0.348	200	DFG-WPCL
PCB 095,Total ng/g dw	504BCHROS	30/June/2008	-0.488	0.51	200	DFG-WPCL
PCB 101,Total ng/g dw	504BCHROS	30/June/2008	-0.488	0.652	200	DFG-WPCL
PCB 105,Total ng/g dw	504BCHROS	30/June/2008	-0.325	0.412	200	DFG-WPCL
PCB 110,Total ng/g dw	504BCHROS	6/30/2008	0.609	0.902	20	DFG-WPCL
PCB 118,Total ng/g dw	504BCHROS	6/30/2008	0.536	0.738	32	DFG-WPCL
PCB 138,Total ng/g dw	504BCHROS	6/30/2008	0.378	0.708	61	DFG-WPCL
PCB 149,Total ng/g dw	504BCHROS	6/30/2008	-0.325	0.417	200	DFG-WPCL
PCB 153,Total ng/g dw	504BCHROS	6/30/2008	-0.325	0.509	200	DFG-WPCL
PCB AROCLOR 1254,Total ng/g dw	504BCHROS	6/30/2008	4	7	55	DFG-WPCL
PCB AROCLOR 1260,Total ng/g dw	504BCHROS	6/30/2008	6	8	29	DFG-WPCL
Pebble 4 to <64 mm,Small 4 to <8 mm %	504BCHROS	6/30/2008	0.29	1	110	AMS
Selenium,Total mg/Kg dw	504BCHROS	6/30/2008	0.29	0.65	77	MPSL-DFG
Selenium,Total mg/Kg dw	504BCHROS	6/30/2008	0.55	1.08	65	MPSL-DFG
Silver,Total mg/Kg dw	504BCHROS	6/30/2008	0.19	0.44	79	MPSL-DFG
Arsenic,Total mg/Kg dw	515YBAMVL	8/19/2008	13	9.92	27	MPSL-DFG
Biphenyl,Total ng/g dw	515YBAMVL	8/19/2008	0.83	-0.894	200	DFG-WPCL
Chrysene,Total ng/g dw	515YBAMVL	8/19/2008	12.4	16.4	28	DFG-WPCL
Cyhalothrin, lambda, total,Total ng/g dw	515YBAMVL	8/19/2008	2.61	-1	200	DFG-WPCL
Dibenzothiophene,Total ng/g dw	515YBAMVL	8/19/2008	0.94	1.22	26	DFG-WPCL
Dibenzothiophenes, C2-,Total ng/g dw	515YBAMVL	8/19/2008	3.7	4.96	29	DFG-WPCL
Dieldrin,Total ng/g dw	515YBAMVL	8/19/2008	0.736	-0.788	200	DFG-WPCL
Dimethylnaphthalene, 2,6-,Total ng/g dw	515YBAMVL	8/19/2008	2.84	1.93	38	DFG-WPCL
Fluorenes, C2-,Total ng/g dw	515YBAMVL	8/19/2008	10	7.45	29	DFG-WPCL
Fluorenes, C3-,Total ng/g dw	515YBAMVL	8/19/2008	16.4	24.1	38	DFG-WPCL
Granule 2.0 to <4.0 mm %	515YBAMVL	8/19/2008	0.2	0.54	92	AMS
Lead,Total mg/Kg dw	515YBAMVL	8/19/2008	16.7	11.8	34	MPSL-DFG
Mercury,Total mg/Kg dw	515YBAMVL	8/19/2008	0.159	0.49	102	MPSL-DFG
Methylphenanthrene, 1-,Total ng/g dw	515YBAMVL	8/19/2008	2.13	2.9	31	DFG-WPCL
Naphthalenes, C2-,Total ng/g dw	515YBAMVL	8/19/2008	4.87	3.75	26	DFG-WPCL

Analyte	Station Code	Date	Field Sample	Field Duplicate	RPD	Laboratory
PBDE 099,Total ng/g dw	515YBAMVL	8/19/2008	1.46	1.02	35	DFG-WPCL
PBDE 100,Total ng/g dw	515YBAMVL	8/19/2008	0.834	-0.287	200	DFG-WPCL
PBDE 138,Total ng/g dw	515YBAMVL	8/19/2008	0.537	-0.365	200	DFG-WPCL
PBDE 153,Total ng/g dw	515YBAMVL	8/19/2008	0.397	-0.338	200	DFG-WPCL
PBDE 154,Total ng/g dw	515YBAMVL	8/19/2008	0.44	-0.3	200	DFG-WPCL
PBDE 190,Total ng/g dw	515YBAMVL	8/19/2008	0.922	-0.797	200	DFG-WPCL
Permethrin, trans-,Total ng/g dw	515YBAMVL	8/19/2008	-4	4.14	200	DFG-WPCL
Phenanthrene,Total ng/g dw	515YBAMVL	8/19/2008	15.6	21.3	31	DFG-WPCL
Phenanthrene/Anthracene, C3-,Total ng/g dw	515YBAMVL	8/19/2008	16.2	16	1	DFG-WPCL
Phosphorus as P,Total mg/Kg dw	515YBAMVL	8/19/2008	44	160	114	CLS
Selenium,Total mg/Kg dw	515YBAMVL	8/19/2008	-0.27	2.79	200	MPSL-DFG
Silver,Total mg/Kg dw	515YBAMVL	8/19/2008	0.09	0.19	71	MPSL-DFG
Total Organic Carbon % dw	515YBAMVL	8/19/2008	1.12	1.55	32	AMS
Bifenthrin,Total ng/g dw	845SGRDRE	05/20/2008	36.3	11.9	101	DFG-WPCL
Granule 2.0 to <4.0 mm %	845SGRDRE	05/20/2008	0.05	0.15	100	AMS
Mercury,Total mg/Kg dw	845SGRDRE	05/20/2008	0.041	0.079	63	MPSL-DFG
Methoxychlor,Total ng/g dw	845SGRDRE	05/20/2008	0.425	-0.308	200	DFG-WPCL
PCB 008,Total ng/g dw	845SGRDRE	05/20/2008	0.231	-0.239	200	DFG-WPCL
PCB 018,Total ng/g dw	845SGRDRE	05/20/2008	0.352	-0.196	200	DFG-WPCL
PCB 028,Total ng/g dw	845SGRDRE	05/20/2008	0.535	-0.312	200	DFG-WPCL
PCB 031,Total ng/g dw	845SGRDRE	05/20/2008	0.444	-0.251	200	DFG-WPCL
PCB 033,Total ng/g dw	845SGRDRE	05/20/2008	0.391	-0.251	200	DFG-WPCL
PCB 044,Total ng/g dw	845SGRDRE	05/20/2008	0.701	0.427	49	DFG-WPCL
PCB 049,Total ng/g dw	845SGRDRE	05/20/2008	0.448	0.265	51	DFG-WPCL
PCB 052,Total ng/g dw	845SGRDRE	05/20/2008	1.42	0.758	61	DFG-WPCL
PCB 056,Total ng/g dw	845SGRDRE	05/20/2008	0.311	0.239	26	DFG-WPCL
PCB 060,Total ng/g dw	845SGRDRE	05/20/2008	0.149	-0.122	200	DFG-WPCL
PCB 064,Total ng/g dw	845SGRDRE	05/20/2008	0.139	-0.099	200	DFG-WPCL
PCB 070,Total ng/g dw	845SGRDRE	05/20/2008	1.29	0.854	41	DFG-WPCL
PCB 074,Total ng/g dw	845SGRDRE	05/20/2008	0.344	0.23	40	DFG-WPCL
PCB 087,Total ng/g dw	845SGRDRE	05/20/2008	1.66	1.15	36	DFG-WPCL
PCB 095,Total ng/g dw	845SGRDRE	05/20/2008	2.52	1.81	33	DFG-WPCL
PCB 097,Total ng/g dw	845SGRDRE	05/20/2008	1.17	0.814	36	DFG-WPCL
PCB 099,Total ng/g dw	845SGRDRE	05/20/2008	1.31	0.866	41	DFG-WPCL
PCB 101,Total ng/g dw	845SGRDRE	05/20/2008	3.46	2.34	39	DFG-WPCL
PCB 105,Total ng/g dw	845SGRDRE	05/20/2008	1.87	1.37	31	DFG-WPCL
PCB 110,Total ng/g dw	845SGRDRE	05/20/2008	4.97	3.7	29	DFG-WPCL
PCB 118,Total ng/g dw	845SGRDRE	05/20/2008	4.07	2.83	36	DFG-WPCL
PCB 128,Total ng/g dw	845SGRDRE	05/20/2008	1.58	1.1	36	DFG-WPCL
PCB 137,Total ng/g dw	845SGRDRE	05/20/2008	0.413	0.277	39	DFG-WPCL
PCB 138,Total ng/g dw	845SGRDRE	05/20/2008	6.17	4.15	39	DFG-WPCL
PCB 141,Total ng/g dw	845SGRDRE	05/20/2008	1.17	0.802	37	DFG-WPCL
PCB 146,Total ng/g dw	845SGRDRE	05/20/2008	0.421	0.308	31	DFG-WPCL

Analyte	Station Code	Date	Field Sample	Field Duplicate	RPD	Laboratory
PCB 149,Total ng/g dw	845SGRDRE	05/20/2008	3.7	2.63	34	DFG-WPCL
PCB 151,Total ng/g dw	845SGRDRE	05/20/2008	0.889	0.641	32	DFG-WPCL
PCB 153,Total ng/g dw	845SGRDRE	05/20/2008	4.68	3.27	35	DFG-WPCL
PCB 156,Total ng/g dw	845SGRDRE	05/20/2008	0.726	0.457	45	DFG-WPCL
PCB 157,Total ng/g dw	845SGRDRE	05/20/2008	0.194	0.134	37	DFG-WPCL
PCB 158,Total ng/g dw	845SGRDRE	05/20/2008	1.06	0.675	44	DFG-WPCL
PCB 170,Total ng/g dw	845SGRDRE	05/20/2008	1.24	0.938	28	DFG-WPCL
PCB 177,Total ng/g dw	845SGRDRE	05/20/2008	0.738	0.57	26	DFG-WPCL
PCB AROCLOR 1248,Total ng/g dw	845SGRDRE	05/20/2008	16	-10.6	200	DFG-WPCL
PCB AROCLOR 1254,Total ng/g dw	845SGRDRE	05/20/2008	47	29	47	DFG-WPCL
Pebble 4 to <64 mm,Small 4 to <8 mm %	845SGRDRE	05/20/2008	3.38	0	200	AMS
Permethrin, cis-,Total ng/g dw	845SGRDRE	05/20/2008	22.6	7.38	102	DFG-WPCL
Permethrin, trans-,Total ng/g dw	845SGRDRE	05/20/2008	13.1	4.1	105	DFG-WPCL
Silver,Total mg/Kg dw	845SGRDRE	05/20/2008	0.46	0.76	49	MPSL-DFG
Dieldrin,Total ng/g dw	907SDFRC2	05/21/2008	-0.804	0.899	200	DFG-WPCL
Granule 2.0 to <4.0 mm %	907SDFRC2	05/21/2008	0.11	0.32	98	AMS
Mercury,Total mg/Kg dw	907SDFRC2	05/21/2008	0.018	0.01	57	MPSL-DFG
Oxadiazon,Total ng/g dw	907SDFRC2	05/21/2008	1.84	1.29	35	DFG-WPCL

Table 12. Samples with holding time exceendances

Station	Sample Date	Analyte Group
000NONPJ	3/16/2009	Mercury
114RRDSDM	10/14/2008	Organochlorine Pesticides
114RRDSDM	10/14/2008	Polychlorinated Biphenyls
201LAG125	8/13/2008	Total Organic Carbon
201WLK160	6/18/2008	Trace Metals
207LAU020	6/17/2008	Trace Metals
305THUxxx	7/21/2008	Polynuclear Aromatic Hydrocarbons
307CMLxxx	6/17/2008	Mercury
403STCEST	5/19/2008	Total Phosphate as Phosphorus
408CAL006	5/19/2008	Mercury
504BCHROS	6/30/2008	Polynuclear Aromatic Hydrocarbons
504BCHROS	6/30/2008	Total Organic Carbon
504SACHMN	6/30/2008	Total Organic Carbon
508SACBLF	6/30/2008	Mercury
508SACBLF	6/30/2008	Polynuclear Aromatic Hydrocarbons
508SACBLF	6/30/2008	Total Organic Carbon
510LSAC08	7/16/2008	Polynuclear Aromatic Hydrocarbons
511CAC113	8/20/2008	Total Organic Carbon
515YBAMVL	8/19/2008	Total Organic Carbon

Station	Sample Date	Analyte Group
519AMNDVY	7/16/2008	Polynuclear Aromatic Hydrocarbons
519BERBRY	8/19/2008	Total Organic Carbon
519BERBRY	8/19/2008	Total Phosphate as Phosphorus
519FTRNCS	8/19/2008	Total Organic Carbon
520BUTEMR	8/19/2008	Total Organic Carbon
520CBDKLD	8/20/2008	Total Organic Carbon
520SACLSA	8/19/2008	Total Organic Carbon
526P00008	6/30/2008	Total Organic Carbon
531SAC001	7/22/2008	Polynuclear Aromatic Hydrocarbons
532CAL004	7/22/2008	Polynuclear Aromatic Hydrocarbons
535MER007	7/23/2008	Polynuclear Aromatic Hydrocarbons
535MER546	7/23/2008	Mercury
535STC206	7/22/2008	Polynuclear Aromatic Hydrocarbons
541SJC501	7/16/2008	Polynuclear Aromatic Hydrocarbons
551LKI040	4/29/2008	Mercury
554SKR010	4/28/2008	Total Phosphate as Phosphorus
558CCR010	4/29/2008	Total Phosphate as Phosphorus
558PKC010	4/29/2008	Total Phosphate as Phosphorus
558TUR090	4/29/2008	Total Phosphate as Phosphorus
719CVSCOT	10/29/2008	Plumb, 1981, GS
723ARGRB1	10/28/2008	Grain Size
723ARGRB1	10/28/2008	Total Phosphate as Phosphorus
723NROTWM	10/28/2008	Grain Size
801SDCxxx	5/20/2008	Mercury
801SDCxxx	5/20/2008	Total Phosphate as Phosphorus
901SJSJC9	5/21/2008	Total Phosphate as Phosphorus
902SSMR07	5/21/2008	Total Phosphate as Phosphorus
904ESCOxx	5/21/2008	Total Phosphate as Phosphorus
907SDFRC2	5/21/2008	Total Phosphate as Phosphorus
911TJHRxx	5/22/2008	Total Phosphate as Phosphorus
000NONPJ	3/16/2009	Mercury
LABQA	12/10/2009	Polychlorinated Biphenyls

Table 13. Number and type of quality assurance samples measured during the study.

Analyte Grouping		Method	Matrix	# of Samples	# of Batches	MS/ MSD Pairs	Non-project MS/MSD Pairs	Number of Duplicates	Non-project Duplicates	Certified Reference Materials	Laboratory Control Samples	Lab Blanks
Conventionals	Grain Size	Plumb 1981	sediment	97	11	NA	NA	11	0	NA	NA	NA
	Total Phosphorus as P	SM 4500-P E	sediment	97	8	7	0	0	0	7	8 prs	8
	Total Organic Carbon	EPA 9060A	sediment	97	11	NA	NA	11	0	11	NA	11
	Mercury	DFG SOP 103	unsieved	99	11	10	1	11	0	11	NA	11
			sieved	97								
	Total Metals	EPA 200.8	unsieved	97	10	10	0	10	0	10	NA	10
			sieved	97								
Organics	Organo-chlorine Pesticides	EPA 8081B M	sediment	97	8		0	7	0	8	8	8
	Organopho-sphorus Pesticides	EPA 8141A M	sediment	97	4	5	0	6	0	0	5	6
	Polybrominated Diphenyl Ethers	EPA 8081 BM	sediment	97	6	6	0	6	0	0	6	6
	Polychlorinated Biphenyls as Congeners	EPA 8082M	sediment	97	8	7	0	7	0	8	8	8
	Polychlorinated Biphenyls as Aroclors	New-man, et al., 1988	sediment	97	8	NA	0	7	0	NA	NA	8
	Polynuclear Aromatic Hydrocarbons	EPA 8270M	sediment	97	3	3	0	3	0	3	3	3
	Pyrethroids	EPA 8081B M	sediment	97	4	6	0	6	0	0	6	6
Toxicity	Hyalella azteca, 10- day test	EPA 600/R-99-064	sediment	97	11	NA	NA	NA	NA	NA	NA	NA

Table 14. Minimum detection limits (MDL) and reporting limits (RL) for measured analytes. Analyses were conducted in batches during the study, so the lowest (min) and highest (max) MDLs and RLs are shown from across all batches. Metals are in units of ug/g dry weight, organic chemicals in ng/g dry weight. TEC is threshold effect concentration and PEC is probable effect concentration, which are consensus based sediment quality guidelines (MacDonald 2000), as described in the List of Acronyms for this report.

Analyte/Units	Min MDL	Max MDL	Min RL	Max RL	TEC	PEC
Acenaphthene	0.603	2.43	0.603	2.43		
Aldrin	0.383	2.37	0.925	5.72		
Aluminum	219	220	500	500		
Anthracene	0.603	220	0.603	500	57.2	845
Arsenic	0.1	0.1	0.3	0.3	9.79	33
Benz(a)anthracene	0.603	2.43	0.603	2.43	1081	1050
Benzo(a)pyrene	0.603	2.43	0.603	2.43	150	1450
Benzo(b)fluoranthene	0.603	2.43	0.603	2.43		
Benzo(e)pyrene	0.603	2.43	0.603	2.43		
Benzo(g,h,i)perylene	0.603	2.43	0.603	2.43		
Benzo(k)fluoranthene	0.603	2.43	0.603	2.43		
Bifenthrin	0.185	0.5	0.37	1		
Biphenyl	0.185	2.43	0.37	2.43		
Cadmium	0.03	0.03	0.1	0.1	0.99	4.98
Chlordane	0.37	2.57	0.925	5.72	3.24	17.6
Chlorpyrifos methyl	25	40.2	50	80.4		
Chlorpyrifos	5	8.04	10	16.1		
Chromium	0.29	0.29	1	1	43.4	111
Chrysene	0.603	2.43	0.603	2.43	166	1290
Copper	0.54	0.54	1.5	1.5	31.6	149
Cyfluthrin	0.148	2	0.296	4		
Cyhalothrin, lambda	0.111	1	0.222	2		
Cypermethrin	0.222	2	0.444	4		
Dacthal	0.089	1.07	0.24	5.72		
DDD(o,p')	0.089	1.07	0.24	5.72		
DDD(p,p')	0.115	1.07	0.31	5.72		
DDE(o,p')	0.165	1.07	0.44	8.2		
DDE(p,p')	0.444	2.75	1.18	8.2		
DDMU(p,p')	0.1	2.14	0.27	9.33		
DDT(o,p')	0.2	2.14	0.53	9.33		
DDT(p,p')	0.144	2.14	0.38	9.98		
Deltamethrin/Tralomethrin	0.148	2	0.296	4		
Diazinon; Total	5	8.04	10	16.1		
Dibenz(a,h)anthracene	0.603	2.43	0.603	2.43		
Dibenzothiophenes	0.603	2.43	0.603	2.43		
Dichlofenthion	25	40.2	50	80.4		
Dieldrin	0.346	2.47	0.463	9.57	1.9	61.8

Analyte/Units	Min MDL	Max MDL	Min RL	Max RL	TEC	PEC
Dimethylphenanthrene	0.603	2.43	0.603	2.43		
Dioxathion	25	40.2	50	80.4		
Endosulfan I	0.518	3.2	1.38	8.2		
Endrin	0.167	2.14	0.62	8.2	2.22	207
Esfenvalerate/Fenvalerate	0.148	1	0.296	2		
Ethion	25	40.2	50	80.4		
Ethoprop	25	40.2	50	80.4		
Fenchlorphos	25	40.2	50	80.4		
Fenitrothion	25	40.2	50	80.4		
Fenpropathrin	0.592	2	1.185	4		
Fluoranthen	0.603	2.43	0.603	2.43	423	2230
Fonofos	25	40.2	50	80.4		
HCH, alpha	0.242	1.5	0.463	2.91		
HCH, beta	0.194	1.2	0.52	5.72		
HCH, gamma	0.133	1.07	0.35	2.86		
Heptachlor epoxide	0.228	1.41	0.61	5.72	2.47	
Heptachlor	0.329	2.14	0.88	5.72		
Hexachlorobenzene	0.32	1.98	0.32	3.85		
Indeno(1,2,3-c,d)pyrene	0.32	2.43	0.32	3.85		
Lead	0.21	0.21	0.5	0.5	35.8	128
Malathion	25	40.2	50	80.4		
Manganese	1.08	1.08	3	3		
Mercury	0.004	0.004	0.012	0.013	0.18	1.06
Merphos	25	40.2	50	80.4		
Heptachlor epoxide	0.228	1.41	0.61	5.72	2.47	
Methoxychlor	0.135	2.14	1.23	9.33		
Methyldibenzothiophene	0.603	2.43	0.603	2.43		
Methylfluoranthene, 2	0.603	2.43	0.603	2.43		
Methylfluorene, 1	0.603	2.43	0.603	2.43		
Methylnaphthalenes	0.603	2.43	0.603	2.43		
Methylphenanthrene	0.603	2.43	0.603	2.43		
Mirex	0.278	2.14	0.74	8.58		
Naphthalenes	0.603	2.43	0.603	2.43	176	560
Nickel	0.12	0.12	0.4	0.4	22.7	48.6
Nonachlor, cis	0.285	2.14	0.76	5.72		
Nonachlor, trans-	0.179	1.11	0.48	5.72		
Oxadiazon	0.503	3.11	0.925	6.05		
Oxychlordane	0.438	2.71	0.925	5.72		
Parathion, Ethyl	10	16.1	20	32.2		
Parathion, Methyl	10	16.1	20	32.2		
PBDE (All)	0.039	2.5	0.59	9.15		
PCB (All Aroclors)	1.85	9.98	10.2	80.8		

Analyte/Units	Min MDL	Max MDL	Min RL	Max RL	TEC	PEC
PCB All Congeners	0.024	1.67	0.049	5		
Permethrin, cis	0.518	4	1.037	8		
Permethrin, trans	0.889	4	1.777	8		
Perylene	0.603	2.43	0.603	2.43		
Phenanthrene/Anthracene (All)	0.603	2.43	0.603	2.43		
Phenanthrene	0.603	2.43	0.603	2.43	204	1170
Phosphamidon	25	40.2	50	80.4		
Phosphorus, Total as P	10	96	100	99		
Pyrene	0.603	2.43	0.603	2.43	195	1520
Selenium	0.27	0.27	1	1		
Silver	0.08	0.08	0.2	0.2		
Sulfotep	25	40.2	50	80.4		
Tedion	0.986	6.1	1.85	8.55		
Thionazin	25	40.2	50	80.4		
Tokuthion	25	40.2	50	80.4		
Trichloronate	10	40.2	20	80.4		
Trimethylnaphthalene	0.603	2.43	0.603	2.43		
Zinc	3.2	3.2	10	10	121	459
Total DDTs					5.28	572
Total PAHs					1610	22800
Total PCBs					59.8	676

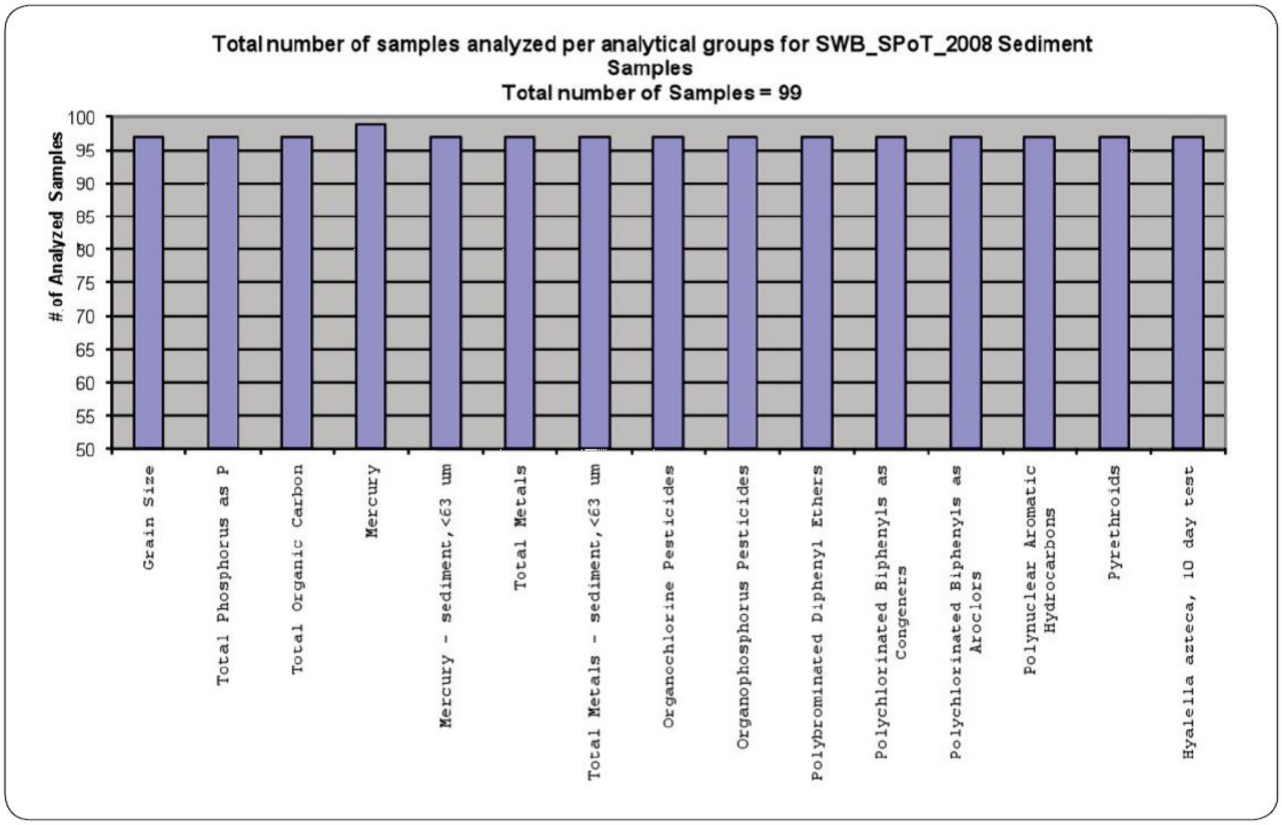


Figure 1. Total number of samples analyzed per analytical group

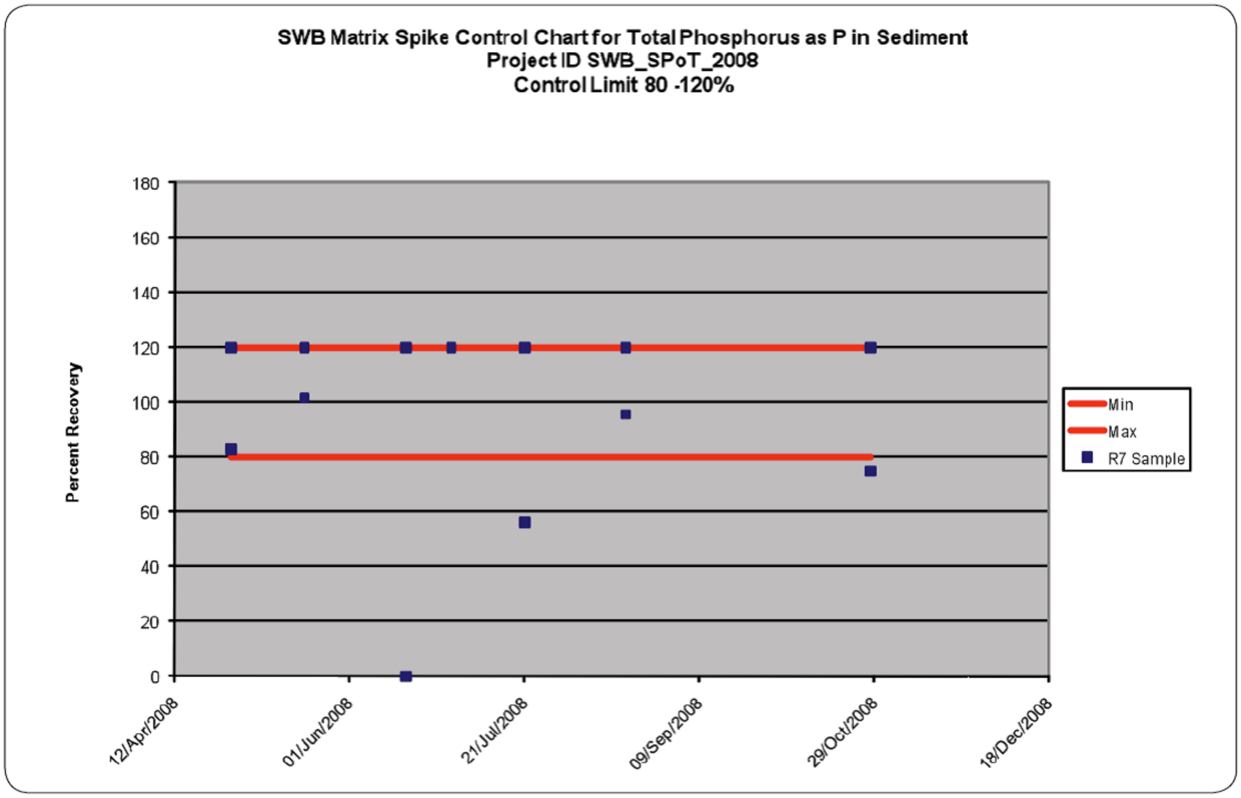


Figure 2: Matrix spike control chart for total phosphorus as P in sediment.

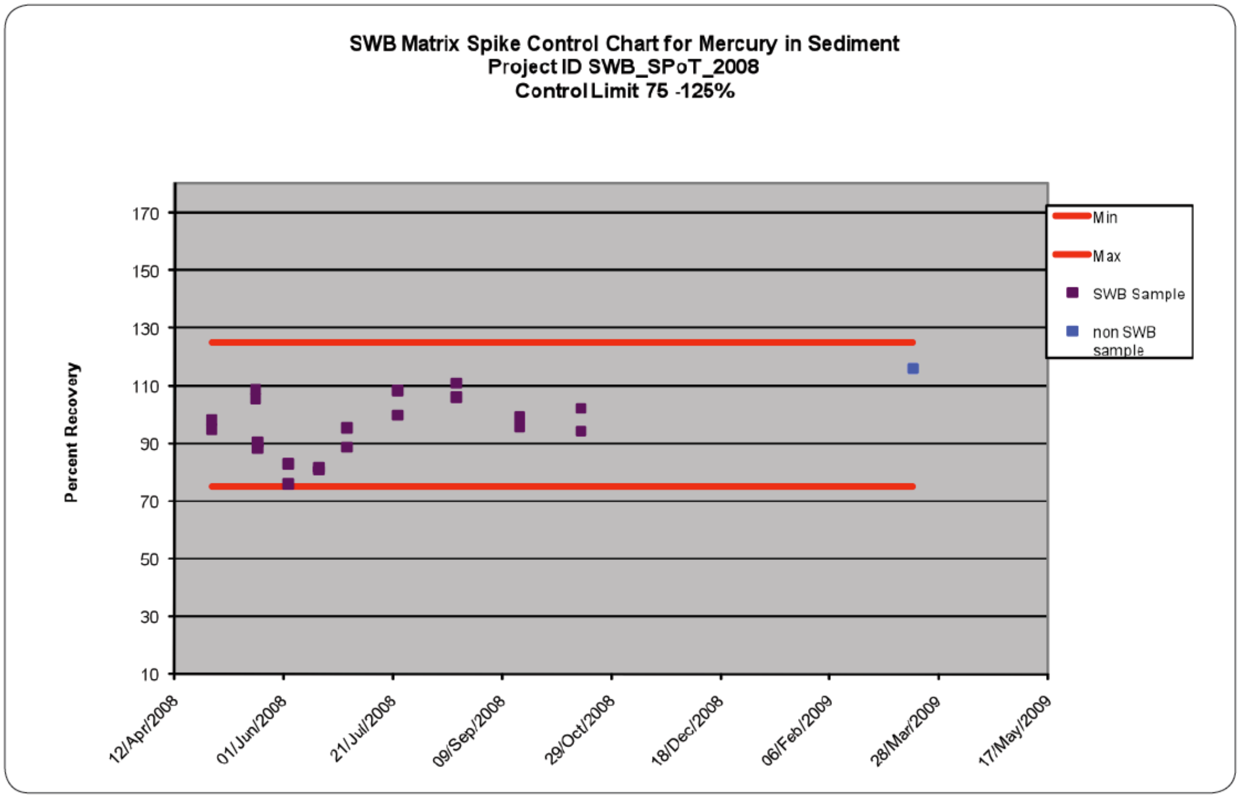


Figure 3. Matrix spike control chart for Mercury in sediment.

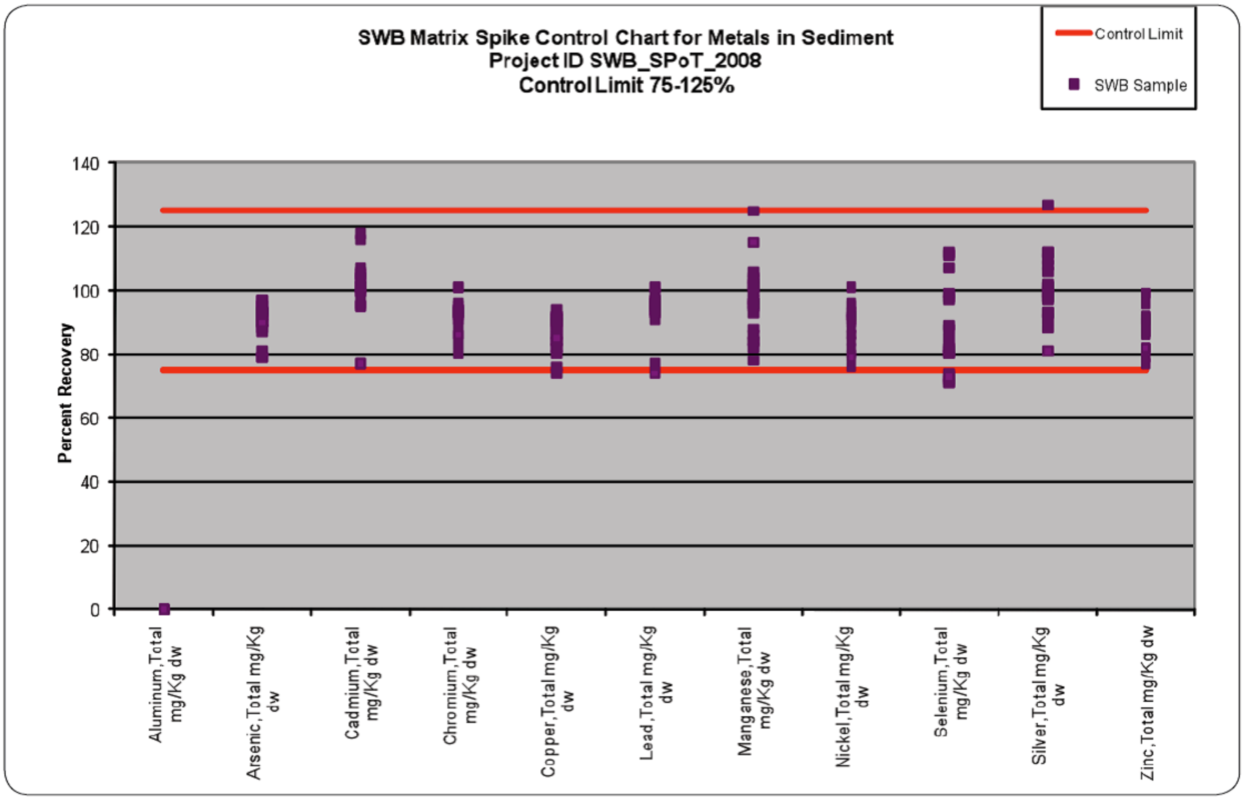


Figure 4. Matrix spike control chart for metals in sediment.

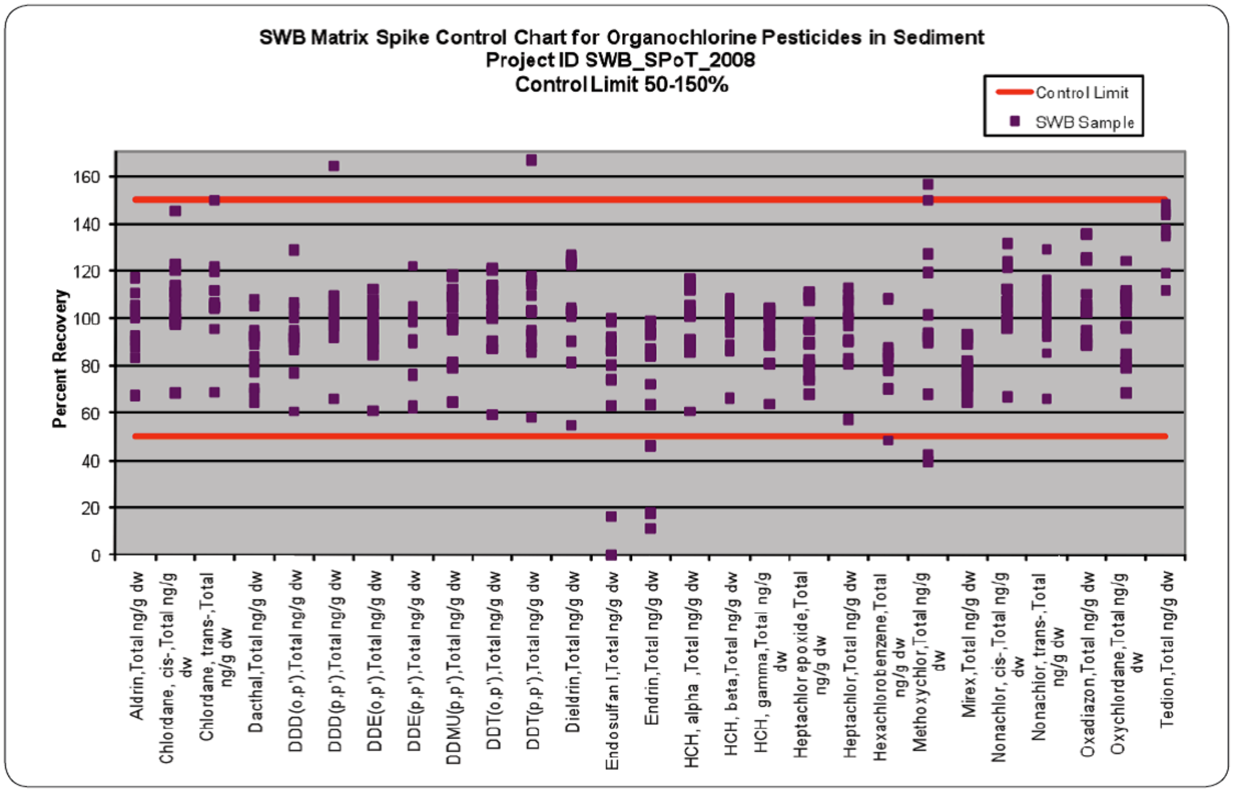


Figure 5. Matrix spike control chart for organochlorine pesticides in sediment..

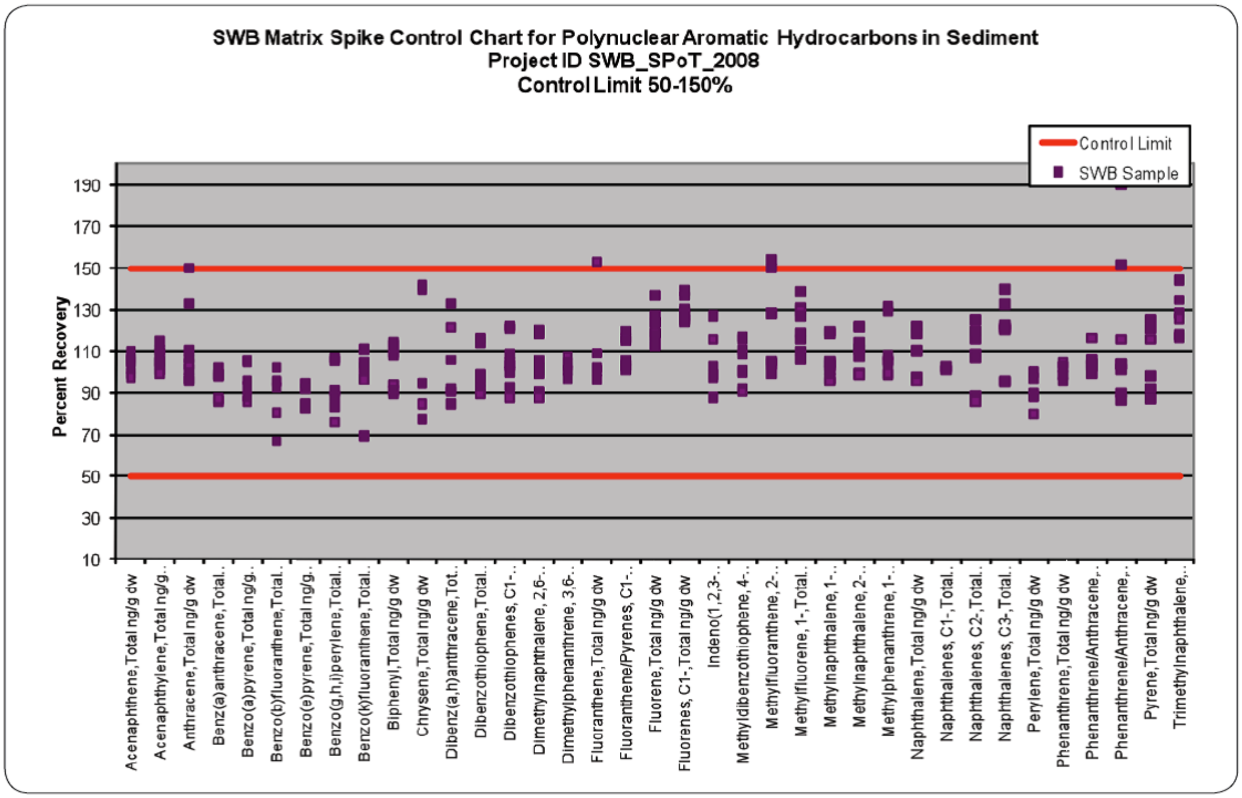


Figure 6. Matrix spike control chart for polynuclear aromatic hydrocarbons in sediment.

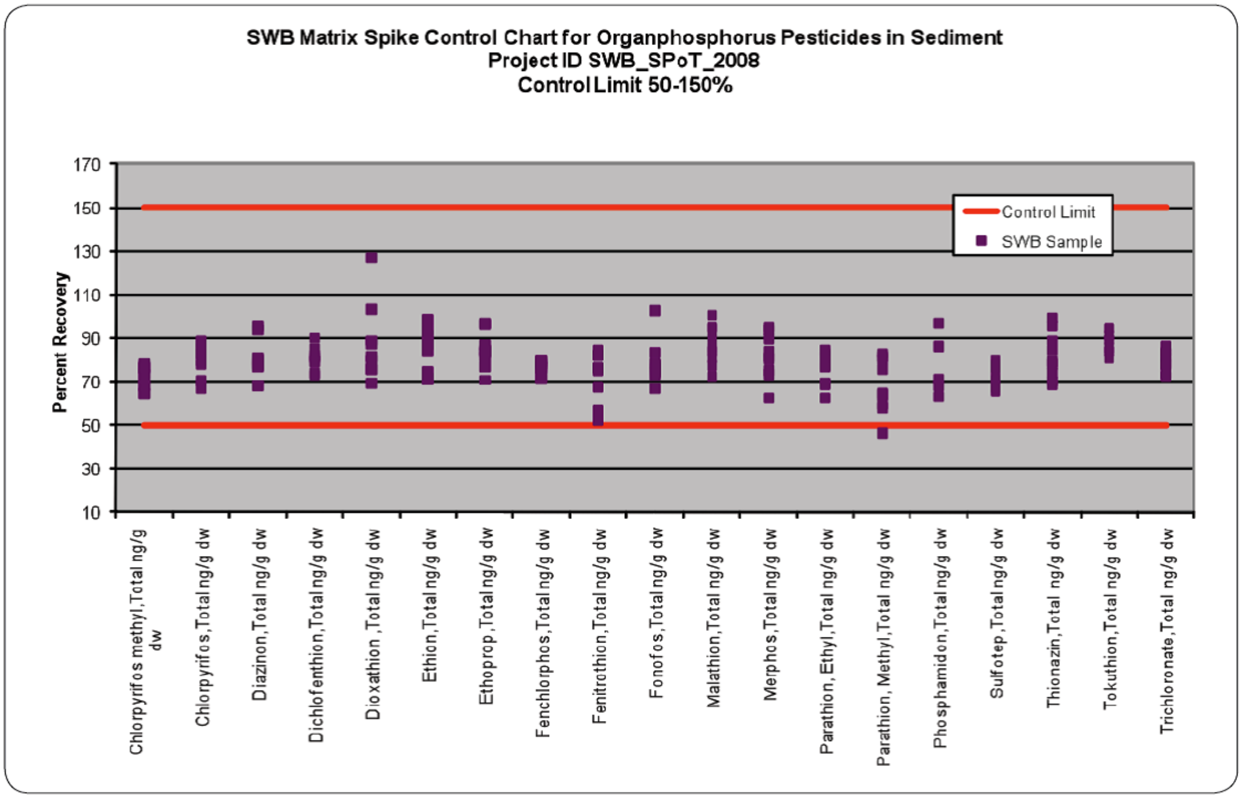


Figure 7. Matrix spike control chart for organophosphorus pesticides in sediment.

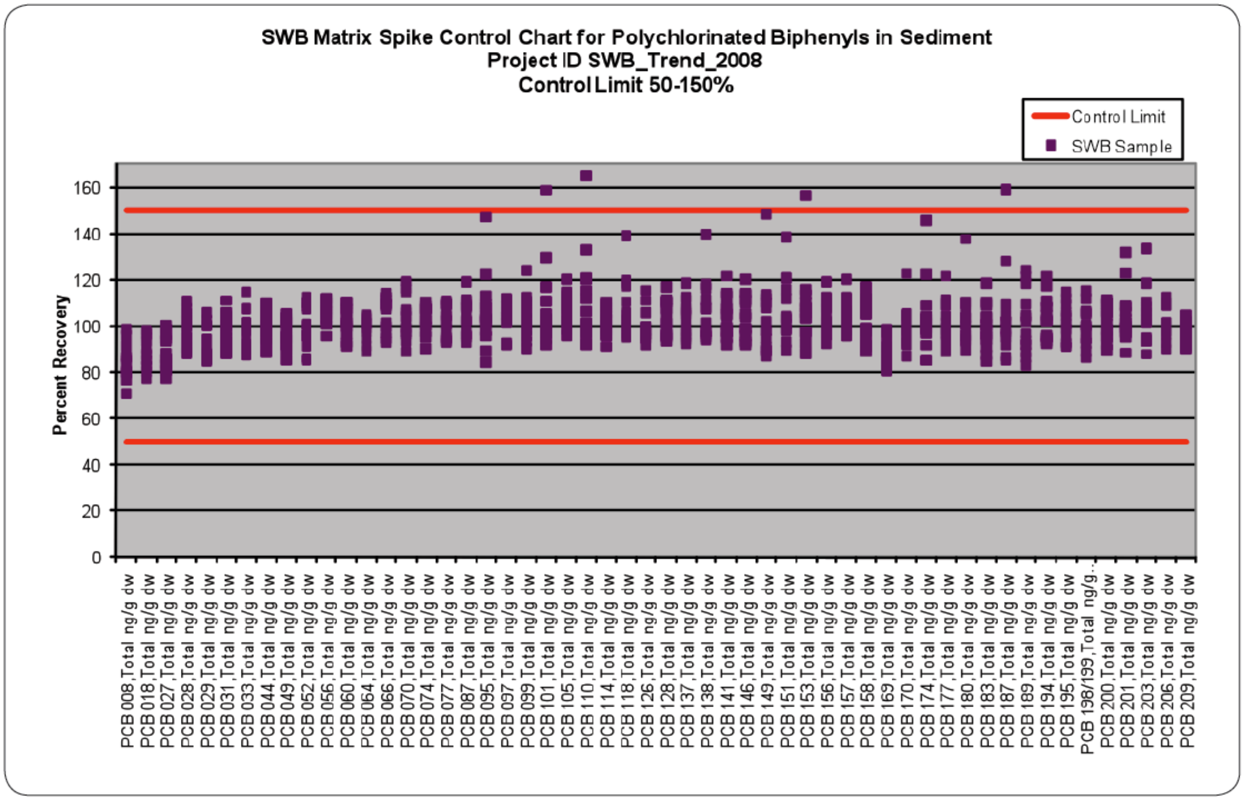


Figure 8. Matrix spike control chart for polychlorinated biphenyls in sediment.

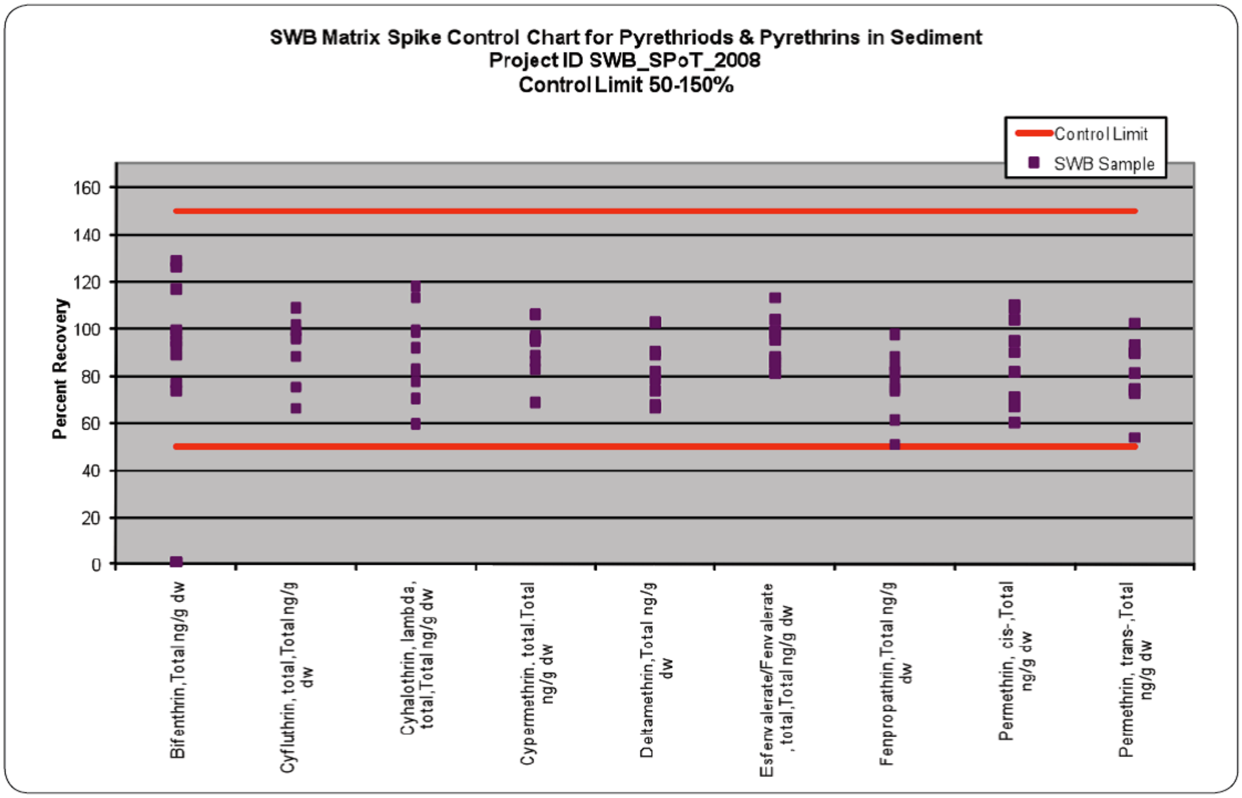


Figure 9. Matrix spike control chart for pyrethroids and pyrethrins in sediment.

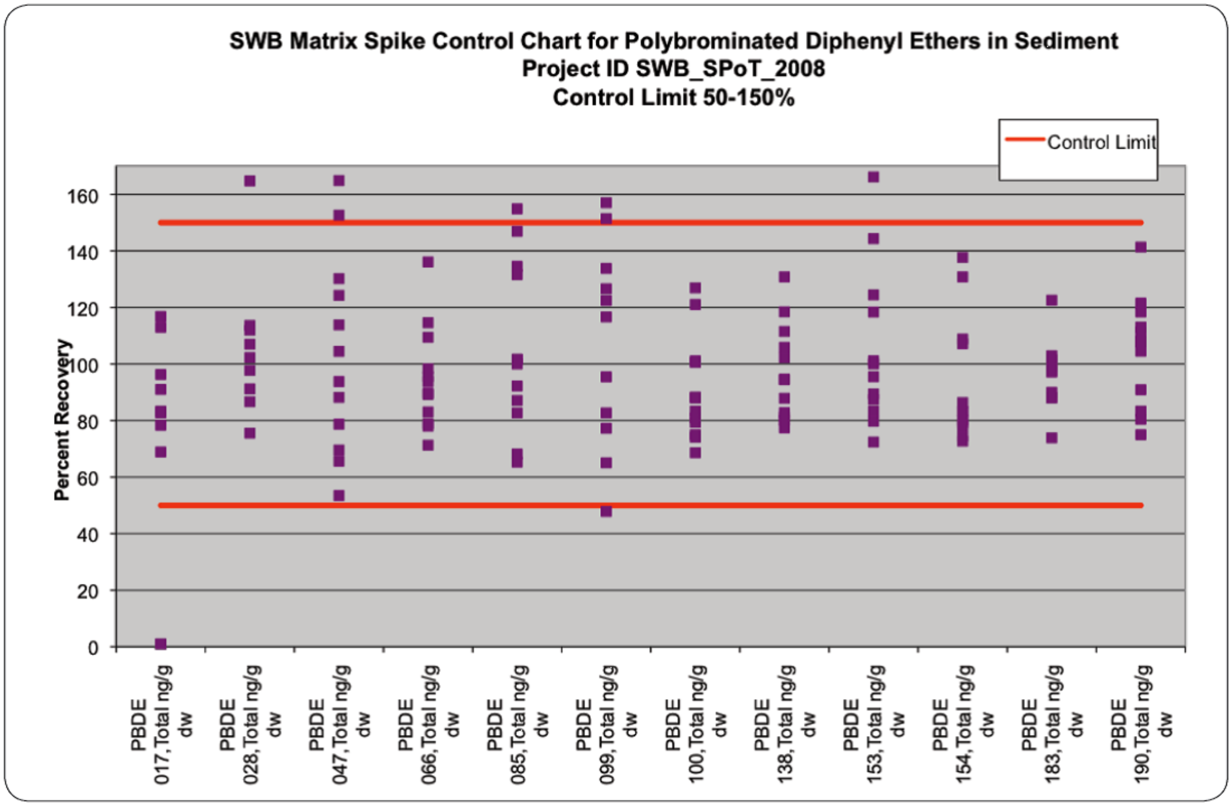


Table 9. Matrix spike control chart for polybrominated diphenyl ethers in sediment.