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Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit

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SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP) REPORT ON THE SANTA MARGARITA HYDROLOGIC UNIT

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I. ABSTRACT

In order to assess the ecological health of the Santa Margarita Hydrologic Unit (San Diego and Riverside Counties, CA), water chemistry, water and sediment toxicity, fish tissues, benthic macroinvertebrate communities, and physical habitat were assessed at multiple sites. Water chemistry, toxicity, and fish tissues were assessed under SWAMP between 2002 and 2003. Bioassessment samples were collected under other programs between 1998 and 2005. All indicators showed evidence of impact, although for most indicators the impacts were moderate at most sites. Water chemistry constituents at all sites exceeded aquatic life thresholds, ranging from 4 constituents at Deluz Creek and the upstream site on the Santa Margarita River to 9 constituents at the downstream site on the Santa Margarita River. Nutrients were impacted at most sites, except at Deluz and Sandia Creeks. Toxicity was moderate, although samples from all sites were toxic to the freshwater algae *Selenastrum capricornutum* on at least one sampling date. Fish tissues from the downstream Santa Margarita River site showed no evidence of impact. Bioassessment samples indicated that large areas of the watershed are in poor ecological condition, meaning that benthic macroinvertebrate communities at these sites were similar to communities at impaired sites. However, certain areas of the watershed, such as Deluz and Roblar Creeks are in fair or good condition. Physical habitat showed few signs of degradation at any site. Despite a number of limitations of this assessment (e.g., uncertain spatial and temporal variability, low levels of replication, non-probabilistic sampling, and lack of thresholds for several indicators), multiple lines of evidence support the conclusion that parts of the Santa Margarita HU are in moderate to good ecological condition.

2. INTRODUCTION

The Santa Margarita hydrologic unit (HU 902) is in Riverside and San Diego Counties. The hydrologic unit represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the Santa Margarita HU, a comprehensive assessment of the ecological health of these waters has not been conducted at this time. The purpose of this report is to provide such an analysis using data collected in 2003 under the Surface Waters Ambient Monitoring Program (SWAMP), as well as additional sources, such as including data collected by National Pollution Discharge Elimination System (NPDES) permittees. SWAMP monitoring efforts rotated among sets of watersheds, ensuring that each HU is monitored once every 5 years (Table 1). These programs collected data to describe water chemistry, water and sediment toxicity, fish tissues, physical habitat, and macroinvertebrate community structure. By examining these data from multiple sources, this report provides a measure of the ecological integrity of the Santa Margarita HU.

Table 1. Watersheds monitored under the SWAMP program.

Year (Fiscal year)	Sample collection	Hydrologic unit	HUC
1 (2000-2001)	2002	Carlsbad	904
	2002	Peñasquitos	906
2 (2001-2002)	2002-2003	San Juan	901
	2003	Otay	910
3 (2002-2003)	2003	Santa Margarita	902
	2003	San Dieguito	905
4 (2003-2004)	2004-2005	San Diego	907
	2004-2005	San Luis Rey	903
5 (2004-2005)	2005-2006	Pueblo San Diego	908
	2005-2006	Sweetwater	909
	2005-2006	Tijuana	911

There are two objectives for this assessment: 1) To evaluate the condition of SWAMP sites; and 2) To evaluate the overall condition of the watershed. Evaluations were based on multiple indicators of ecological integrity, including water chemistry, water and sediment toxicity, fish tissue bioaccumulation, biological assessment of benthic macroinvertebrate communities, and physical habitat assessment.

This report is organized into four sections. The first section (Introduction) describes the geographic setting in terms of climate, hydrology, and land use within the watershed. The second section (Methods) describes the approach to data collection, assessment indicators, and data analysis. The third section (Results) contains the results of these analyses. The fourth section (Discussion) integrates evidence of impact from multiple indicators, describes the limitations of this assessment, and summarizes the overall health of the watershed.

2.1 Geographic Setting

The Santa Margarita River drains one of the largest unregulated rivers in southern California. The watershed covers 750 mi^2, of which 26.5% is in San Diego County, and 73.5% is in Riverside County. The watershed is bounded by several mountain ranges, including the Santa Ana and Santa Margarita mountains to the North and the Palomar Mountains to the South. Several tributaries originate on the Santa Rosa Plateau, a region known for its biological diversity and its abundant wetland resources (Figure 1).

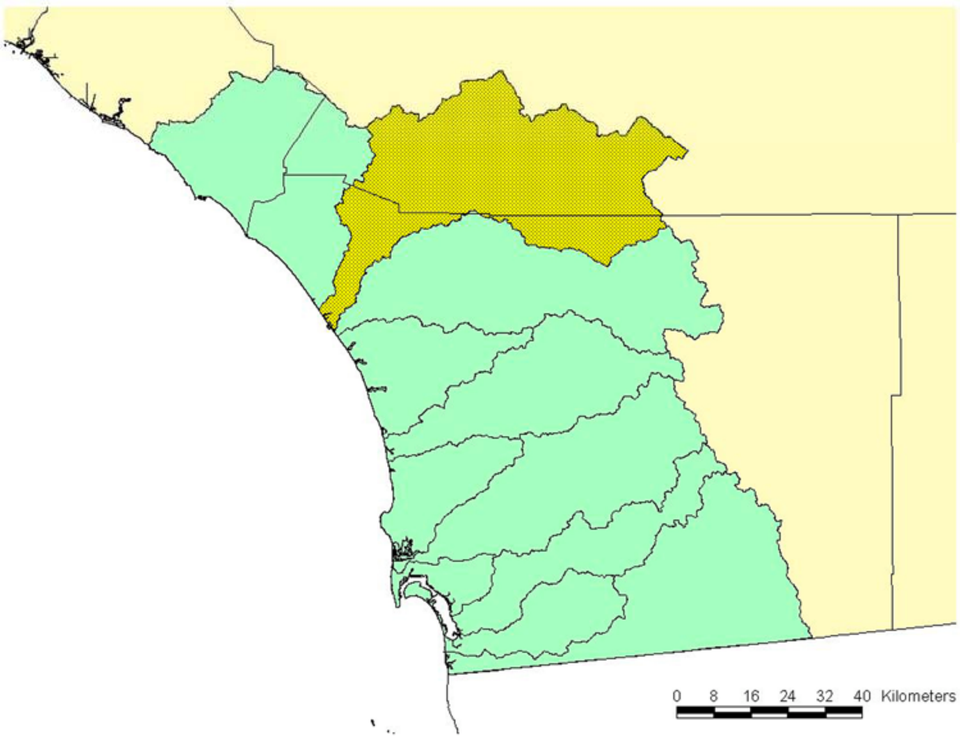

Figure 1. San Diego region (green) includes portions of San Diego, Riverside, and Orange counties. The Santa Margarita HU (yellow, shaded) is located within Orange, Riverside, and San Diego Counties.

2.1.1 Climate

The Santa Margarita HU, like the entire San Diego region, is characterized by a Mediterranean climate, with hot dry summers and cool wet winters. Average monthly rainfalls collected at the Lindberg Airport (SDG) in San Diego, California between 1905 and 2006 show that nearly all rain fell between the months of October and April, with hardly any falling between the months of May and September (California Department of Water Resources 2007). The wettest month was January, with an average rainfall of 2.05"). Average annual rainfall at this station was 10.37". Daily rainfall measured at Palomar Mountain (near the eastern end of the watershed), Temecula (in the northern part of the watershed), and at Fallbrook (near the lower mainstem, close to the coast) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

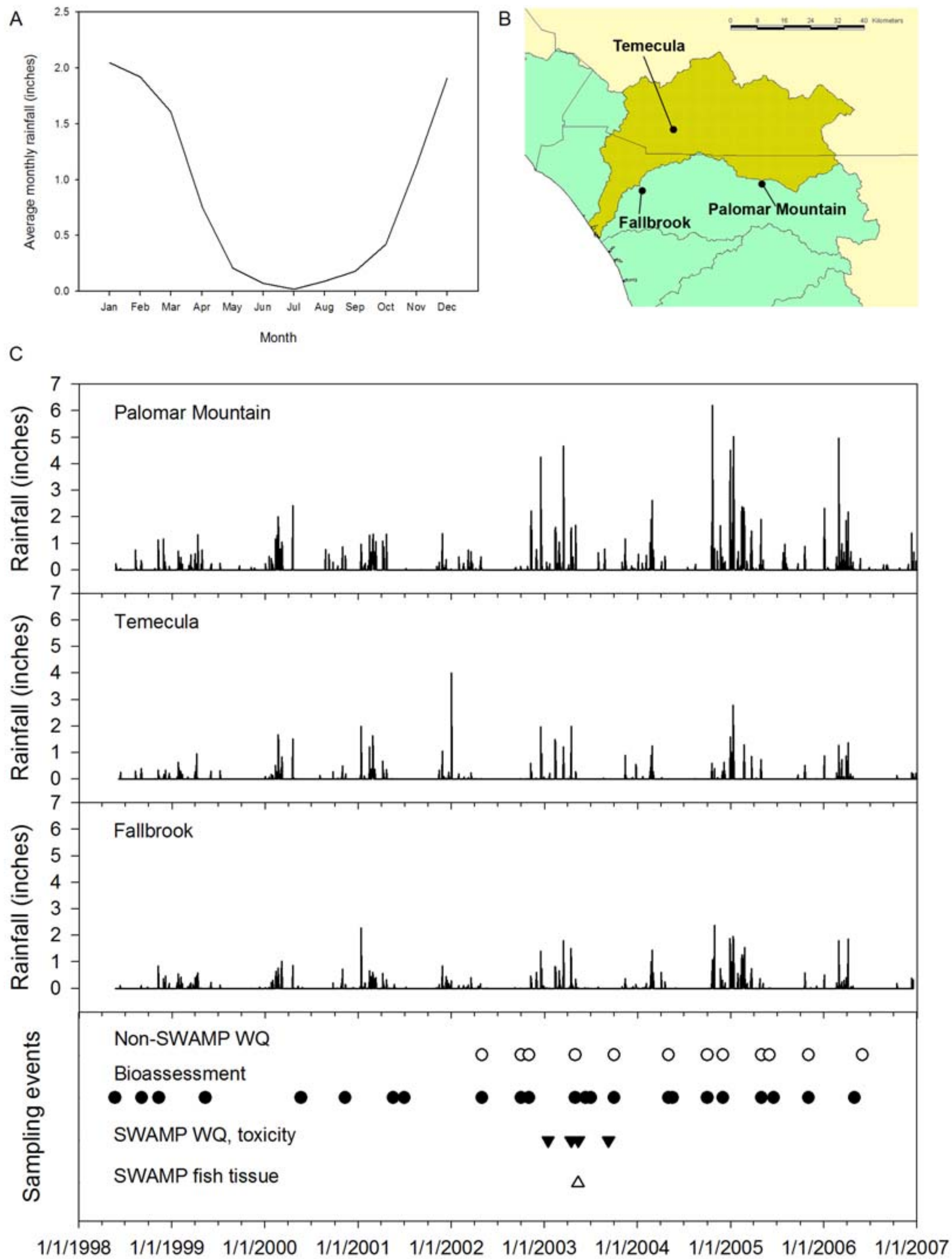

Figure 2. Rainfall and sampling events at three stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Palomar Mountain, Temecula, and Fallbrook gauges. C. Storm events and sampling events in the Santa Margarita HU. The top three plots show daily precipitation between 1998 and 2007 at the three stations. The bottom plot shows the timing of sampling events. SWAMP water chemistry and toxicity samples are shown as black downward triangles. SWAMP fish tissue samples are shown as white upward triangles. Non-SWAMP water chemistry samples are shown as white circles. Bioassessment samples are shown as black circles.

2.1.2 Hydrology

The Santa Margarita HU consists of a single major drainage—the Santa Margarita River—which is comprised of several smaller tributaries. The mainstem begins at the confluence of Murrieta and Temecula Creeks. South-flowing tributaries include Roblar, Deluz, and Sandia Creeks. Tributaries that flow north into the mainstem include Pechanga and Rainbow Creeks. The mainstem enters the Santa Margarita estuary, which is connected to the Pacific Ocean (Figure 3).

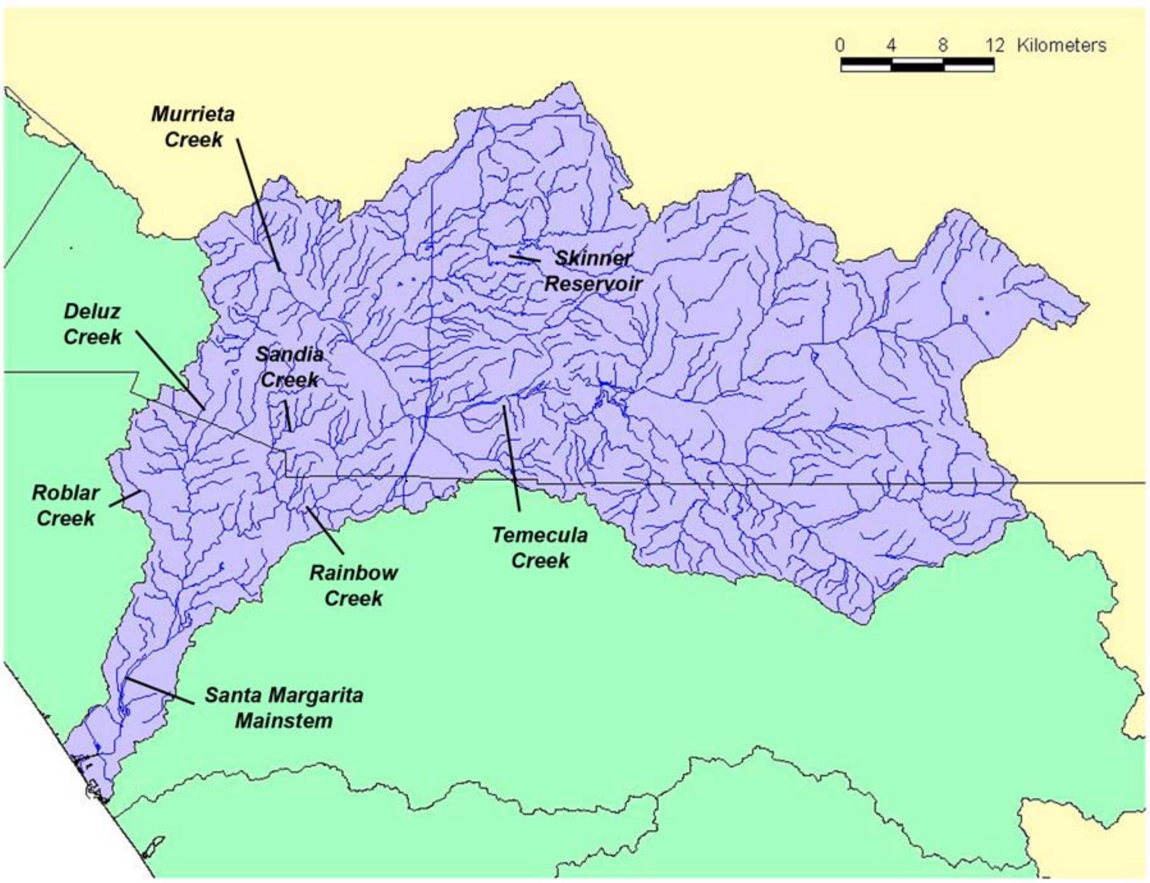

Figure 3. The Santa Margarita HU, including major waterways.

2.1.3 Land Use within the Watershed

Two counties and several municipalities have jurisdiction over portions of the watershed. Riverside County includes the majority (73.5%) of the Santa Margarita HU. This region includes the towns of Murrieta and Temecula. The San Diego County portion of the watershed (26.5%) contains the Camp Pendleton Marine Corps Base, as well as the community of Fallbrook. The Santa Margarita River drains one of the least developed watersheds in southern California. Open space and vacant land occurs in 81% of the watershed. Agricultural land use occupies only 6%, and developed land use occurs in 13% (Figure 4). The United States Military is one of the largest land owners in the region, as is Caltrans, which has jurisdiction over the major freeways in the watershed. The Cleveland National Forest contains large areas of open space in the watershed, as does the Santa Rosa Ecological Preserve, managed by Riverside County Regional Park and Open Space District. (SANDAG 1998, SCAG 2000)

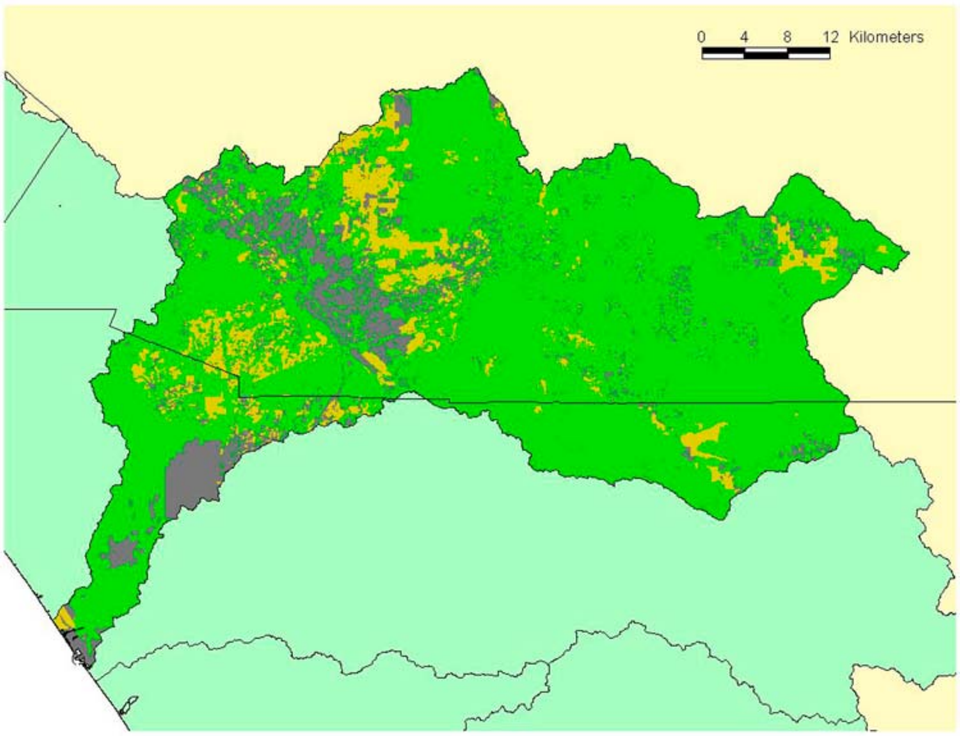

Figure 4. Land use within the Santa Margarita HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

Beneficial uses in the watershed include municipal; agriculture; industrial service and process supply; groundwater recharge; recreation; warm and cold freshwater habitat; wildlife habitat; rare, threatened, or endangered species; and spawning habitat (Appendix I).

Several tributaries in the Santa Margarita HU are listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 102.8 stream miles. These streams include the mainstem of the Santa Margarita, De Luz Creek, Murrieta Creek, Rainbow Creek, Sandia Creek, and Temecula Creek. Known stressors include iron, manganese, nitrogen, phosphorus, sulfates, and total dissolved solids (Appendix I).

3. METHODS

This report combines data collected under SWAMP with data from California Department of Fish and Game (CDFG) and NPDES monitoring (Table 2). Five sites of interest were sampled under SWAMP in the Santa Margarita HU in 2003 (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat was measured at each site. Fish tissue was collected near one site (Sandia Creek). Bioassessment was not included as part of SWAMP monitoring in the Santa Margarita HU, but bioassessment data collected at 15 sites by the CDFG Aquatic Bioassessment Laboratory (ABL), Camp Pendleton, and San Diego County (as part of its NPDES permit) were used in this report. In addition to bioassessment, conventional water chemistry (e.g., temperature, conductivity, dissolved oxygen) was measured at sites sampled by San Diego County NPDES and by Camp Pendleton. When two non-SWAMP sites were located within 500 meters of each other, they were treated as a single site. This distance was based on published measures of spatial correlation of benthic communities in streams (Gebler 2004). Non-SWAMP samples were collected between 1998 and 2005; in some cases, non-SWAMP sites were very close to SWAMP sites (Table 4; Figure 5).

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, fish tissue	2002-2003
CA Department of Fish and Game	Bioassessment	1998-2000
San Diego County NPDES	Water chemistry, bioassessment	2002-2005
Camp Pendleton	Water chemistry, bioassessment	2004-2006

Table 3: SWAMP sampling site locations. Fish tissues were collected at the site marked with (*).

	Site	Description	Latitude (°N)	Longitude (°E)
1	902SMDLZ3	Deluz Creek 3	33.4564	-117.2961
2	902SMRNB4	Rainbow Creek 4	33.4106	-117.2146
3	902SMSMR1	Upper Santa Margarita 1	33.4806	-117.1142
4	902SMSND3*	Sandia Creek 3	33.4153	-117.2466
5	902SSMR10	Lower Santa Margarita 10	33.2367	-117.3918

Table 4. Non-SWAMP sampling site locations. W = sites where conventional water chemistry was sampled. B = sites where benthic macroinvertebrates were sampled.

Site	Description	SWAMP site within 500 m	Sources	W	B	Lat (N)	Long (E)
1	Deluz Creek at Murrieta Road (reference)	902SMDLZ3	CDFG (902DLCDLM) SD NPDES (REF-DLC3)	 X	X X	33.4596	-117.2905
2	Murrieta Creek	None	CDFG (902MCWBxx)		X	33.5683	-117.2392
3	Rainbow Creek	None	CDFG (902RCWGRx)		X	33.4073	-117.1997
4	Roblar Creek above Deluz Creek	None	CDFG (902ROBDLZ) Camp Pendleton (ROB-DL	 X	X X	33.3871	-117.3237
5	Sandia Creek at Deluz Road (reference)	None	CDFG (902SCDLRx) SD NPDES (REF-SC2)	 X	X X	33.4922	-117.2464
6	Sandia Creek	None	CDFG (902SCSCRx) SD NPDES (REF-SC)	 X	X X	33.4243	-117.2481
7	Santa Margarita River at Camp Pendleton	None	CDFG (902SMRCPx) Camp Pendleton (SMR-CP)		X	33.3395	-117.3311
8	Sandia Creek at Santa Margarita River	902SMSND3	CDFG (902SMRDPx)		X	33.4142	-117.2406
9	Downstream site of the Santa Margarita River	902SSMR10	CDFG (902SMRSMB)		X	33.2367	-117.3918
10	Santa Margarita River at Willow Glen Road	None	CDFG (902SMRWGR) SD NPDES (SMR-WGR)		X	33.4304	-117.1953
11	Temecula Creek at 15	902SMSMR1	CDFG (902TCI15x)		X	33.4747	-117.138
12	Deluz Creek downstream (reference)	None	SD NPDES (REF-DLC)	X	X	33.4414	-117.3239
13	Santa Margarita at Deluz Creek	None	SD NPDES (REF-DLR)	X	X	33.3974	-117.2622
14	Santa Margarita downstream	None	Camp Pendleton (SMR-DS	X	X	33.2834	-117.3744
15	Deluz Creek at Camp Pendleton	None	Camp Pendleton	X	X	33.3975	-117.3231

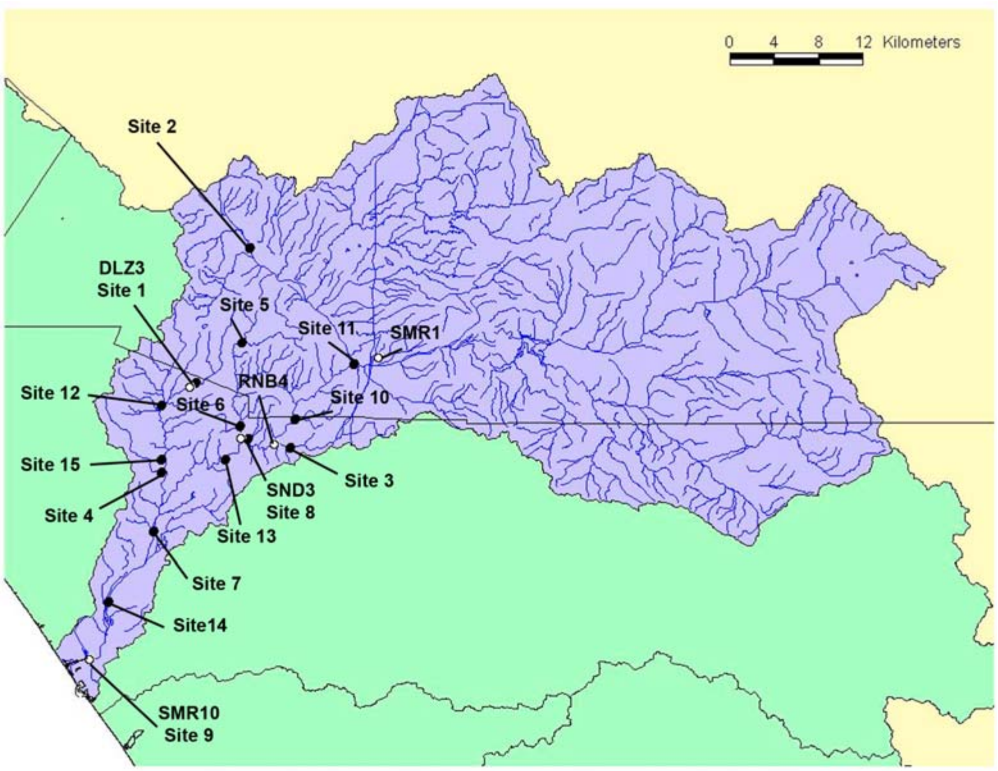

Figure 5. SWAMP (white circles) and non-SWAMP (black circles) sampling locations. The SWAMP site prefix designating the hydrologic unit (i.e., 902SM-) has been dropped to improve clarity.

3.1 Indicators

Multiple indicators were used to assess the sites in the Santa Margarita HU. Water chemistry, water and sediment toxicity, fish tissues, benthic macroinvertebrate communities, and physical habitat.

3.1.1 Water chemistry

To assess water chemistry, samples were collected at each site. Water chemistry was measured as per the SWAMP Quality Assurance Management Plan (QAMP) (Puckett 2002). Measured indicators included conventional water chemistry (e.g., pH, temperature dissolved oxygen, etc.), inorganics, herbicides, pesticides, polycyclic aromatic hydrocarbons (PAHs), dissolved metals, pesticides, and polychlorinated biphenyls (PCBs). Appendix II contains a complete list of constituents that were measured.

Limited water chemistry was collected under non-SWAMP NPDES monitoring as well. This monitoring was restricted to physical parameters, and followed procedures described in annual reports to California Regional Water Quality Control Board, San Diego Region (e.g., Weston Solutions Inc. 2007).

3.1.2 Toxicity

To evaluate water and sediment toxicity to aquatic life in the Santa Margarita HU, toxicity assays were conducted on samples from each site as per the SWAMP QAMP (EPA 1993, Puckett 2002). Water toxicity was evaluated with 7-day exposures on the water flea, *Ceriodaphnia dubia*, and 96-hour exposures to the alga *Selenastrum capricornutum.* Both acute and chronic toxicity to *C. dubia* was measured as decreased survival and fecundity (i.e., eggs per female) relative to controls, respectively. Chronic toxicity to *S. capricornutum* was measured as changes in total cell count relative to controls. Sediment toxicity was evaluated with 10-day exposures on the amphipod *Hyallela azteca.* Both acute and chronic toxicity to *H. azteca* was measured as decreased survival and growth (mg per individual) relative to controls, respectively. Chronic toxicity endpoints (i.e., *C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) were used to develop a summary index of toxicity at each site.

3.1.3 Tissue

To detect contamination in fish tissues in the Santa Margarita HU, catfish tissues were collected at one site (Sandia Creek). Tissues were analyzed for metals and Selenium as per the SWAMP QAMP (Puckett 2002). Wet-weight concentrations of each constituent were recorded.

3.1.4 Bioassessment

To assess the ecological health of the streams in Santa Margarita HU, benthic macroinvertebrate samples were collected at 25 sites by San Diego County, Camp Pendleton, and the California Department of Fish and Game. Four of these sites were designated reference sties. Samples were collected using SWAMP-comparable protocols, as per the SWAMP QAMP (Puckett 2002). Three replicate samples were collected from riffles at each site; 300 individuals were sorted and identified from each replicate, creating a total count of 900 individuals per site. Using a Monte Carlo simulation, all samples were reduced to 500 count for calculation of the Southern California Index of Biotic Integrity (IBI; Ode et al. 2005), a composite of seven metrics summed and scaled from 0 (poor condition) to 100 (good condition).

3.1.5 Physical Habitat

Physical habitat was assessed under SWAMP using semi-quantitative observations of 10 components relating to habitat quality, such as embeddedness, bank stability, and width of riparian zone. The assessment protocols are described in The California Stream Bioassessment Procedure (California Department of Fish and Game 2003). Each component was scored on a scale of 0 (highly degraded) to 20 (not degraded). Sites were assessed by the average component score.

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the Santa Margarita HU, two frequency-based approaches were employed to detecting impacts. First, established aquatic life and human health thresholds for individual constituents were evaluated for frequency of exceedances. Second, the frequency of detection for anthropogenic constituents (such as PCBs, pesticides, and PAHs) were also evaluated.

To evaluate the overall health of each site and of the watershed, three indicators were selected for analysis: number of constituents exceeding aquatic life water chemistry thresholds; frequency of chronic toxicity to *S. capricornutum, C. dubia,* and *H. azteca*; and mean IBI score. Tissue analysis was excluded because tissue samples were collected at only one site. Physical habitat assessment was excluded due to lack of agreed-upon thresholds for evaluation of physical habitat scores. These results were plotted on a map of the watershed, indicating the severity and distribution of human impacts.

Although non-SWAMP sources of water chemistry data were used, this report focuses on SWAMP data in order to maintain consistency of sampling methods and parameters measured at each site. Analyses of non-SWAMP water chemistry data is presented separately. In contrast, bioassessment data from multiple sources is analyzed together because of the high compatibility of sampling protocols used in different programs, and because of the limited availability of bioassessment data from a single source. Toxicity, fish tissue, and physical habitat data were only available from SWAMP monitoring.

3.2.1 Thresholds

In order to use the data to assess the health of the watershed, thresholds were established for each indicator: water quality, toxicity, bioassessment, fish tissue, and physical habitat. Exceedance of appropriate thresholds was considered evidence for impact on watershed health.

Water chemistry data from this study were compared to water quality objectives established by state and federal agencies to protect the most sensitive beneficial uses designated in the Santa Margarita HU. Therefore, the most stringent water quality objectives (e.g., municipal drinking water, aquatic life, etc.) for the measured constituents were used as thresholds points to evaluate the data.

The Water Quality Control Plan For the San Diego Basin (BP) was the primary source of water chemistry thresholds. Other sources for standards used in water chemistry thresholds included the California Toxics Rule (CTR), the Environmental Protection Agency National Aquatic Life Criteria (EPA), the National Academy of Sciences Health Advisory (NASHA), United States Environmental Protection Agency Integrated Risk Information System (IRIS), and the California Code of Regulations §64449 (CCR). The sources for thresholds used in this study are shown in Table 5.

Table 5. Threshold sources

Indicator	Source	Citation
Water chemistry	Water Quality Control Plan For the San Diego Basin (BP)	California Regional Water Quality Control Board, San Diego Region. 1994. Water quality control plan for the San Diego Region. San Diego, CA. http://www.waterboards.ca.gov/sandiego/programs/basinplan.html
	California Toxics Rule (CTR)	Environmental Protection Agency. 1997. Water quality standards: Establishment of numeric criteria for priority toxic pollutants for the state of California: Proposed Rule. *Federal Register* 62:42159-42208.
	EPA National Aquatic Life Criteria (EPA)	Environmental Protection Agency. 2002. National recommended water quality criteria. EPA-822-R-02-047. Office of Water. Washington, DC.
	National Academy of Sciences Health Advisory (NASHA)	National Academy of Sciences. 1977. Drinking Water and Health. Volume 1. Washington, DC.
	US Environmental Protection Agency Integrated Risk Information System (IRIS)	Environmental Protection Agency (EPA). 2007. Integrated Risk Information System. http://www.epa.gov/iris/index.html. Office of Research and Development. Washington, DC.
	California Code of Regulations §64449 (CCR)	California Code of Regulations. 2007. Secondary drinking water standards. Register 2007, No. 8. Title 22, division 4, article 16.
Fish tissue	Office of Environmental Health Hazard Assessment (OEHHA)	Office of Environmental Health Hazard Assessment. 2006. Draft development of guidance tissue levels and screening values for common contaminants in California Sports Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Sacramento, CA.
Bioassessment	Ode et al. 2005	Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Management* 35:493-504.

Although human health thresholds (e.g., drinking water standards) were applied to relevant water chemistry data, this report focuses on aquatic life, and does not address the risks to human health in the Santa Margarita HU. When multiple thresholds were applicable to a single constituent, the most stringent threshold was used. Water chemistry thresholds for aquatic life and human health standards used in this study are presented in Table 6. Impacts were assessed as the total number of constituents exceeding threshold, as opposed to the fraction of constituents. The fraction of constituents exceeding thresholds is not an ecologically meaningful statistic because the number of constituents below thresholds does not degrade or improve the ecological health of a site.

Table 6. Water chemistry thresholds for aquatic life and human health standards. San Diego Basin Plan (BP); California Toxics Rule (CTR); Environmental Protection Agency National Aquatic Life Standards (EPA); National Academy of Science Health Advisory (NASHA); Environmental Protection Agency Integrated Risk Information System (IRIS); California Code of Regulations §64449 (CCR). (*) Sulfate threshold of 300 mg/l applies to the Ysidora, Murrieta, Cave Rocks, Aguanga, and Oakgrove hydrologic areas (HA 902.1, 902.3, 902.7, 902.8, and 902.9).

		Aquatic life			Human health		
Category	**Constituent**	**Threshold**	**Unit**	**Source**	**Threshold**	**Unit**	**Source**
Inorganics	Alkalinity as CaCO3	20000	mg/l	EPA	none	mg/l	none
Inorganics	Ammonia as N	0.025	mg/l	BP	none	mg/l	none
Inorganics	Nitrate + Nitrite as N	10	mg/l	BP	none	mg/l	none
Inorganics	Phosphorus as P,Total	0.1	mg/l	BP	none	mg/l	none
Inorganics	Selenium,Dissolved	5	µg/L	CTR	none	µg/L	none
Inorganics	Sulfate	250*	mg/l	BP	none	mg/l	none
Metals	Aluminum,Dissolved	1000	µg/L	BP	none	µg/L	none
Metals	Arsenic,Dissolved	50	µg/L	BP	150	µg/L	CTR
Metals	Cadmium,Dissolved	5	µg/L	BP	2.2	µg/L	CTR
Metals	Chromium,Dissolved	50	µg/L	BP	none	µg/L	none
Metals	Copper,Dissolved	9	µg/L	CTR	1300	µg/L	CTR
Metals	Lead,Dissolved	2.5	µg/L	CTR	none	µg/L	none
Metals	Manganese,Dissolved	0.05	µg/L	none	none	µg/L	none
Metals	Nickel,Dissolved	52	µg/L	CTR	610	µg/L	CTR
Metals	Silver,Dissolved	3.4	µg/L	CTR	none	µg/L	none
Metals	Zinc,Dissolved	120	µg/L	CTR	none	µg/L	none
PAHs	Acenaphthene	none	µg/L	none	1200	µg/L	CTR
PAHs	Anthracene	none	µg/L	none	9600	µg/L	CTR
PAHs	Benz(a)anthracene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(a)pyrene	0.0002	µg/L	BP	0.0044	µg/L	CTR
PAHs	Benzo(b)fluoranthene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(k)fluoranthene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Chrysene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Dibenz(a,h)anthracene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Fluoranthene	none	µg/L	none	300	µg/L	CTR
PAHs	Indeno(1,2,3-c,d)pyrene	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Pyrene	none	µg/L	none	960	µg/L	CTR
PCBs	PCBs	0.014	µg/L	CTR	0.00017	µg/L	CTR
Pesticides	Aldrin	3	µg/L	CTR	0.00000013	µg/L	CTR
Pesticides	Ametryn	none	µg/L	none	60	µg/L	EPA
Pesticides	Atrazine	3	µg/L	BP	0.2	µg/L	OEHHA
Pesticides	Azinphos ethyl	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	Azinphos methyl	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	DDD(p,p')	none	µg/L	none	0.00083	µg/L	CTR
Pesticides	DDE(p,p')	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	DDT(p,p')	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	Dieldrin	none	µg/L	none	0.00014	µg/L	CTR
Pesticides	Dimethoate	none	µg/L	none	1.4	µg/L	IRIS
Pesticides	Endosulfan sulfate	none	µg/L	none	110	µg/L	CTR
Pesticides	Endrin	0.002	µg/L	BP	0.76	µg/L	CTR
Pesticides	Endrin Aldehyde	none	µg/L	none	0.76	µg/L	CTR
Pesticides	Endrin Ketone	none	µg/L	none	0.85	µg/L	CTR
Pesticides	Heptachlor	0.0038	µg/L	CTR	0.00021	µg/L	CTR
Pesticides	Heptachlor epoxide	0.0038	µg/L	CTR	0.0001	µg/L	CTR
Pesticides	Hexachlorobenzene	1	µg/L	BP	0.00075	µg/L	CTR
Pesticides	Methoxychlor	40	µg/L	BP	none	µg/L	none
Pesticides	Molinate	20	µg/L	BP	none	µg/L	none
Pesticides	Oxychlordane	none	µg/L	none	0.000023	µg/L	CTR
Pesticides	Simazine	4	µg/L	BP	none	µg/L	none
Pesticides	Thiobencarb	70	µg/L	BP	none	µg/L	none
Physical	Oxygen, Dissolved	5	mg/L	BP	none	mg/L	none
Physical	pH	>6 and <8	pH	BP	none	pH	none
Physical	Specific Conductivity	1600	µS/cm	CCR	none	mS/cm	none
Physical	Turbidity	20	NTU	BP	none	NTU	none

Several anthropogenic water chemistry constituents had no applicable threshold (e.g., malathion), and impacts from these constituents would not be detected using the threshold-based approach described above. To assess the impact from these constituents, the number of organic constituents (i.e., PAHs, PCBs, and pesticides) detected at each site were calculated. The total number of sites at which these compounds were detected was recorded.

Thresholds for toxicity assays were determined by comparing study samples to control samples(non-toxic reference samples). Samples meeting the following criteria were considered toxic: 1) treatment responses significantly different from controls, as determined by a statistical t-test; and 2) endpoints less than 80% of controls. To summarize the toxicity at a site using multiple endpoints, the frequency of toxic samples was calculated. To assign equal weight to all three indicators, a single endpoint of chronic toxicity per indicator was used (*C. dubia*: fecundity, *H. azteca*: growth, and *S. capricornutum*: total cell count).

Thresholds for tissue samples shown in Table 7 were derived from the Draft Development of Guidance Tissue Levels and Screening Values for Common Contaminant in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene (OEHHA 2006). Several constituents, including total Mercury, had no applicable threshold. Because Methylmercury accounts for more than 95% of Mercury in fish tissues, the threshold for Methylmercury was applied to Mercury concentrations (OEHHA 2006).

Table 7. Threshold concentrations for fish tissue contaminants established by OEHHA. All thresholds apply to wet-weight concentrations.

Category	Constituent	Source	Threshold	Unit
Inorganics	Selenium	OEHHA	1.94	ppm
PCBs	PCBs	OEHHA	20	ppm
Pesticides	Chlordane	OEHHA	200	ng/g
Pesticides	DDTs	OEHHA	560	ng/g
Pesticides	Dieldrin	OEHHA	16	ng/g
Pesticides	Toxaphene	OEHHA	220	ng/g
Metals	Mercury	OEHHA	0.08	ppm

Thresholds for bioassessment samples were based on a benthic macroinvertebrate index of biological integrity (IBI) that was developed specifically for southern California (Ode et al. 2005). The results of the IBI produces a measure of impairment with scores scaled from 0 to 100, 0 representing the poorest health and 100 the best health. Based on the IBI, samples with scores equal to or below 40 are considered to be in “poor” condition, and samples below 20 are considered to be in “very poor” condition. Therefore, in this study samples with an IBI below 40 were considered impacted.

Thresholds for the evaluation of physical habitat have not been established. Therefore, measurements of physical habitat were excluded from the overall assessment of ecological health. However, because the protocol used to evaluate physical habitat qualitatively assigns scores lower than 10 (out of 20) to streams in poor condition, this number was used to determine sites with severely degraded habitat. Sites with scores below 15 were considered moderately degraded, and those with scores greater than 15 were considered unimpacted (California Department of Fish and Game 2003).

3.2.2 Quality Assurance and Quality Control (QA/QC)

The SWAMP QAMP guided QA/QC for all data collected under SWAMP (See SWAMP QAMP for detailed descriptions of QA/QC protocols, Puckett 2002). QA/QC officers flagged non-compliant physical habitat, water chemistry, toxicity, and tissue results. No chemistry, toxicity, or tissue data were excluded as a result of QA/QC violations. QA/QC procedures for NPDES water chemistry data were similar to those used in SWAMP (Weston Solutions Inc. 2007) Non-SWAMP bioassessment samples were screened for samples containing fewer than 450 individuals. No bioassessment sample was excluded from this analysis.

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated widespread, but moderate impact to water quality from multiple constituents (Table 8). Across the entire watershed, 9 PAHs, and 15 pesticides were detected, but no PCBs. PAHs ranged from two at a site (Deluz Creek and Sandia Creek) to nine (Lower Santa Margarita). Pesticides ranged from one (at Rainbow Creek) to thirteen (again at the Lower Santa Margarita) per site. Means and standard deviations of all constituents are presented in Appendix II.

Table 8. Number of anthropogenic organic compounds detected at each site in Santa Margarita HU.

	PAHs		PCBs		Pesticides	
Site	Tested	Detected	Tested	Detected	Tested	Detected
902SMDLZ3	43	2	50	0	91	2
902SMRNB4	43	4	50	0	91	1
902SMSMR1	43	6	50	0	91	6
902SMSND3	43	2	50	0	91	4
902SSMR10	43	9	50	0	91	13
All sites in watershed	43	9	50	0	91	15

Several organic compounds were widespread throughout the watershed (Table 9). For example, C2-Dibenzothiophenes were detected at every site, and most sites also had the PAHs C1-dibenzothiophenes, C3-fluorenes, C1-phenanthrene/anthracene, as well as the pesticides p,p'-DDE, diazinon, oxadiazon, and simazine.

Table 9. Frequency of detection of anthropogenic organic compounds in the Santa Margarita HU. Constituent not detected at any site (--).

Category	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	5	0	--
PAHs	Acenaphthylene	5	0	--
PAHs	Anthracene	5	0	--
PAHs	Benz(a)anthracene	5	0	--
PAHs	Benzo(a)pyrene	5	0	--
PAHs	Benzo(b)fluoranthene	5	1	0.2
PAHs	Benzo(e)pyrene	5	0	--
PAHs	Benzo(g,h,i)perylene	5	0	--
PAHs	Benzo(k)fluoranthene	5	0	--
PAHs	Biphenyl	5	0	--
PAHs	Chrysene	5	0	--
PAHs	Chrysenes, C1 -	5	0	--
PAHs	Chrysenes, C2 -	5	0	--
PAHs	Chrysenes, C3 -	5	0	--
PAHs	Dibenz(a,h)anthracene	5	0	--
PAHs	Dibenzothiophene	5	0	--
PAHs	Dibenzothiophenes, C1 -	5	4	0.8
PAHs	Dibenzothiophenes, C2 -	5	5	1.0
PAHs	Dibenzothiophenes, C3 -	5	2	0.4
PAHs	Dimethylnaphthalene, 2,6-	5	0	--
PAHs	Fluoranthene	5	0	--
PAHs	Fluoranthene/Pyrenes, C1 -	5	0	--
PAHs	Fluorene	5	0	--
PAHs	Fluorenes, C1 -	5	1	0.2
PAHs	Fluorenes, C2 -	5	0	--
PAHs	Fluorenes, C3 -	5	3	0.6
PAHs	Indeno(1,2,3-c,d)pyrene	5	0	--
PAHs	Methylnaphthalene, 1-	5	0	--
PAHs	Methylnaphthalene, 2-	5	0	--
PAHs	Methylphenanthrene, 1-	5	0	--
PAHs	Naphthalene	5	0	--
PAHs	Naphthalenes, C1 -	5	0	--
PAHs	Naphthalenes, C2 -	5	0	--
PAHs	Naphthalenes, C3 -	5	2	0.4
PAHs	Naphthalenes, C4 -	5	0	--
PAHs	Perylene	5	0	--
PAHs	Phenanthrene	5	0	--
PAHs	Phenanthrene/Anthracene, C1 -	5	4	0.8
PAHs	Phenanthrene/Anthracene, C2 -	5	1	0.2
PAHs	Phenanthrene/Anthracene, C3 -	5	0	--
PAHs	Phenanthrene/Anthracene, C4 -	5	0	--
PAHs	Pyrene	5	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
PAHs	Trimethylnaphthalene, 2,3,5-	5	0	--
PCBs	PCB 005	5	0	--
PCBs	PCB 008	5	0	--
PCBs	PCB 015	5	0	--
PCBs	PCB 018	5	0	--
PCBs	PCB 027	5	0	--
PCBs	PCB 028	5	0	--
PCBs	PCB 029	5	0	--
PCBs	PCB 031	5	0	--
PCBs	PCB 033	5	0	--
PCBs	PCB 044	5	0	--
PCBs	PCB 049	5	0	--
PCBs	PCB 052	5	0	--
PCBs	PCB 056	5	0	--
PCBs	PCB 060	5	0	--
PCBs	PCB 066	5	0	--
PCBs	PCB 070	5	0	--
PCBs	PCB 074	5	0	--
PCBs	PCB 087	5	0	--
PCBs	PCB 095	5	0	--
PCBs	PCB 097	5	0	--
PCBs	PCB 099	5	0	--
PCBs	PCB 101	5	0	--
PCBs	PCB 105	5	0	--
PCBs	PCB 110	5	0	--
PCBs	PCB 114	5	0	--
PCBs	PCB 118	5	0	--
PCBs	PCB 128	5	0	--
PCBs	PCB 137	5	0	--
PCBs	PCB 138	5	0	--
PCBs	PCB 141	5	0	--
PCBs	PCB 149	5	0	--
PCBs	PCB 151	5	0	--
PCBs	PCB 153	5	0	--
PCBs	PCB 156	5	0	--
PCBs	PCB 157	5	0	--
PCBs	PCB 158	5	0	--
PCBs	PCB 170	5	0	--
PCBs	PCB 174	5	0	--
PCBs	PCB 177	5	0	--
PCBs	PCB 180	5	0	--
PCBs	PCB 183	5	0	--
PCBs	PCB 187	5	0	--
PCBs	PCB 189	5	0	--
PCBs	PCB 194	5	0	--
PCBs	PCB 195	5	0	--
PCBs	PCB 200	5	0	--
PCBs	PCB 201	5	0	--
PCBs	PCB 203	5	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
PCBs	PCB 206	5	0	--
PCBs	PCB 209	5	0	--
Pesticides	Aldrin	5	0	--
Pesticides	Ametryn	5	0	--
Pesticides	Aspon	5	0	--
Pesticides	Atraton	5	0	--
Pesticides	Atrazine	5	0	--
Pesticides	Azinphos ethyl	5	0	--
Pesticides	Azinphos methyl	5	0	--
Pesticides	Bolstar	5	0	--
Pesticides	Carbophenothion	5	0	--
Pesticides	Chlordane, cis-	5	0	--
Pesticides	Chlordane, trans-	5	0	--
Pesticides	Chlordene, alpha-	5	0	--
Pesticides	Chlordene, gamma-	5	0	--
Pesticides	Chlorfenvinphos	5	0	--
Pesticides	Chlorpyrifos	5	0	--
Pesticides	Chlorpyrifos methyl	5	0	--
Pesticides	Ciodrin	5	0	--
Pesticides	Coumaphos	5	0	--
Pesticides	Dacthal	5	0	--
Pesticides	DDD(o,p')	5	0	--
Pesticides	DDD(p,p')	5	1	0.2
Pesticides	DDE(o,p')	5	0	--
Pesticides	DDE(p,p')	5	3	0.6
Pesticides	DDMU(p,p')	5	0	--
Pesticides	DDT(o,p')	5	1	0.2
Pesticides	DDT(p,p')	5	2	0.4
Pesticides	Demeton-s	5	0	--
Pesticides	Diazinon	5	3	0.6
Pesticides	Dichlofenthion	5	0	--
Pesticides	Dichlorvos	5	0	--
Pesticides	Dicrotophos	5	0	--
Pesticides	Dieldrin	5	0	--
Pesticides	Dimethoate	5	0	--
Pesticides	Dioxathion	5	0	--
Pesticides	Disulfoton	5	0	--
Pesticides	Endosulfan I	5	1	0.2
Pesticides	Endosulfan II	5	0	--
Pesticides	Endosulfan sulfate	5	1	0.2
Pesticides	Endrin	5	0	--
Pesticides	Endrin Aldehyde	5	0	--
Pesticides	Endrin Ketone	5	0	--
Pesticides	Ethion	5	0	--
Pesticides	Ethoprop	5	0	--
Pesticides	Famphur	5	0	--
Pesticides	Fenchlorphos	5	0	--
Pesticides	Fenitrothion	5	0	--
Pesticides	Fensulfothion	5	0	--

Table 9, continued. Frequency of detection of anthropogenic organic compounds.

Category	Constituent	Tested	Detected	Frequency
Pesticides	Fenthion	5	0	--
Pesticides	Fonofos	5	0	--
Pesticides	HCH, alpha	5	0	--
Pesticides	HCH, beta	5	1	0.2
Pesticides	HCH, delta	5	0	--
Pesticides	HCH, gamma	5	0	--
Pesticides	Heptachlor	5	0	--
Pesticides	Heptachlor epoxide	5	2	0.4
Pesticides	Hexachlorobenzene	5	0	--
Pesticides	Leptophos	5	0	--
Pesticides	Malathion	5	0	--
Pesticides	Merphos	5	0	--
Pesticides	Methidathion	5	0	--
Pesticides	Methoxychlor	5	0	--
Pesticides	Mevinphos	5	0	--
Pesticides	Mirex	5	0	--
Pesticides	Molinate	5	0	--
Pesticides	Naled	5	0	--
Pesticides	Nonachlor, cis-	5	1	0.2
Pesticides	Nonachlor, trans-	5	1	0.2
Pesticides	Oxadiazon	5	3	0.6
Pesticides	Oxychlordane	5	1	0.2
Pesticides	Parathion, Ethyl	5	0	--
Pesticides	Parathion, Methyl	5	0	--
Pesticides	Phorate	5	0	--
Pesticides	Phosmet	5	0	--
Pesticides	Phosphamidon	5	0	--
Pesticides	Prometon	5	0	--
Pesticides	Prometryn	5	0	--
Pesticides	Propazine	5	0	--
Pesticides	Secbumeton	5	1	0.2
Pesticides	Simazine	5	4	0.8
Pesticides	Simetryn	5	0	--
Pesticides	Sulfotep	5	0	--
Pesticides	Tedion	5	0	--
Pesticides	Terbufos	5	0	--
Pesticides	Terbuthylazine	5	0	--
Pesticides	Terbutryn	5	0	--
Pesticides	Tetrachlorvinphos	5	0	--
Pesticides	Thiobencarb	5	0	--
Pesticides	Thionazin	5	0	--
Pesticides	Tokuthion	5	0	--
Pesticides	Trichlorfon	5	0	--
Pesticides	Trichloronate	5	0	--

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted for these PAHs and pesticides (Table 10; Figure 6). In addition, ammonia-N exceeded aquatic life thresholds once at every site, and total phosphorus exceeded thresholds in all samples from three sites (Rainbow Creek and the two sites in the Santa Margarita mainstem). Sulfate, manganese, pH, specific conductivity, and turbidity also exceeded thresholds at multiple sites (Table 11). Exceedances of human health thresholds were observed at three of the sites, with the highest number at the downstream Santa Margarita site. Rainbow Creek and Deluz Creek had no human health threshold exceedances (Figure 7). All sites in Santa Margarita HU failed to achieve several aquatic life thresholds, (Table 12; Figure 6, 7). The Lower Santa Margarita had the highest number of exceedances (9). All other sites exceeded 4 or 5 thresholds.

Table 10. Frequency of water chemistry threshold exceedances. A) Frequency of aquatic life threshold exceedances at SWAMP sites. B) Frequency of human health threshold exceedances at SWAMP sites. C) Frequency of aquatic life threshold exceedances at non-SWAMP sites. D) Frequency of human health thresholds at non-SWAMP sites. Freq = Frequency of samples exceeding applicable thresholds at each site. AL = Aquatic life. HH = Human health. -- = Constituent never exceeded threshold. NA = No applicable thresholds at that site. Empty cells indicate that the constituent was not measured at the site. (*)(*) Sulfate threshold of 300 mg/l applies to the Ysidora, Murrieta, Cave Rocks, Aguanga, and Oakgrove hydrologic areas (HA 902.1, 902.3, 902.7, 902.8, and 902.9).

A. Aquatic life				902SMDLZ3		902SMRNB4		902SMSMR1		902SMSND3		902SSMR10	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	20000 mg/l	EPA	--	4	--	4	--	4	--	4	--	4
Inorganics	Ammonia as N	0.025 mg/l	BP	0.25	4	0.25	4	0.25	4	0.25	4	0.50	4
Inorganics	Nitrate + Nitrite as N	10 mg/l	BP	--	4	0.50	4	--	4	--	4	--	4
Inorganics	Phosphorus as P,Total	0.1 mg/l	BP	--	4	1.00	4	1.00	4	--	4	1.00	4
Inorganics	Selenium,Dissolved	5 µg/L	CTR	--	4	--	4	--	4	--	4	0.25	4
Inorganics	Sulfate	250 mg/l*	BP	0.75	4	0.75	4	--	4	1.00	4	0.50	4
Metals	Aluminum,Dissolved	1000 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Arsenic,Dissolved	50 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	5 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Chromium,Dissolved	50 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	9 µg/L	CTR	--	4	--	4	--	4	--	4	0.25	4
Metals	Lead,Dissolved	2.5 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Manganese,Dissolved	0.05 µg/L	BP	--	4	--	4	0.75	4	--	4	0.75	4
Metals	Nickel,Dissolved	52 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Silver,Dissolved	3.4 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Zinc,Dissolved	120 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0002 µg/L	BP	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.014 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	3 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	3 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.002 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.0038 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0038 µg/L	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	1 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Methoxychlor	40 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Molinate	20 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Simazine	4 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Pesticides	Thiobencarb	70 µg/L	BP	--	4	--	4	--	4	--	4	--	4
Physical	pH	>6 or <8 pH units	BP	0.50	4	--	4	--	4	0.50	4	0.25	4
Physical	SpecificConductivity	1.6 mS/cm	CCR	0.25	4	0.50	4	--	4	0.50	4	0.50	4
Physical	Turbidity	20 NTU	BP	--	4	--	4	0.25	4	0.25	4	0.25	4

Table 10, continued. Frequency of water chemistry threshold exceedances.

B. Human Health				902SMDLZ3		902SMRNB4		902SMSMR1		902SMSND3		902SSMR10	
Category	Constituent	Threshold	Source	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Metals	Arsenic,Dissolved	150 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Cadmium,Dissolved	2.2 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Copper,Dissolved	1300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Metals	Nickel,Dissolved	610 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Acenaphthene	1200 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Anthracene	9600 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benz(a)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Benzo(b)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	0.50	4
PAHs	Benzo(k)fluoranthene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Chrysene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Dibenz(a,h)anthracene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Fluoranthene	300 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	0.0044 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PAHs	Pyrene	960 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
PCBs	PCBs	0.00017 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Aldrin	0.00000013 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Ametryn	60 µg/l	EPA	--	4	--	4	--	4	--	4	--	4
Pesticides	Atrazine	0.2 µg/l	OEHHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos ethyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	Azinphos methyl	87.5 µg/l	NASHA	--	4	--	4	--	4	--	4	--	4
Pesticides	DDD(p,p')	0.00083 µg/l	CTR	--	4	--	4	--	4	--	4	0.25	4
Pesticides	DDE(p,p')	0.00059 µg/l	CTR	--	4	--	4	0.25	4	0.50	4	0.50	4
Pesticides	DDT(p,p')	0.00059 µg/l	CTR	--	4	--	4	0.25	4	--	4	0.25	4
Pesticides	Dieldrin	0.00014 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Dimethoate	1.4 µg/l	IRIS	--	4	--	4	--	4	--	4	--	4
Pesticides	Endosulfan sulfate	110 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Aldehyde	0.76 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Endrin Ketone	0.85 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor	0.00021 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	0.0001 µg/l	CTR	--	4	--	4	0.25	4	--	4	0.25	4
Pesticides	Hexachlorobenzene	0.00075 µg/l	CTR	--	4	--	4	--	4	--	4	--	4
Pesticides	Oxychlordane	0.000023 µg/l	CTR	--	4	--	4	--	4	--	4	0.25	4

C. Aquatic life (non-SWAMP)

Aquatic life (non-SWAMP)	Dissolved oxygen		pH		Specific conductivity		Turbidity	
	5	mg/L	6 or 8		1.6	mS/cm	20	NTU
	BP		BP		CCR		BP	
Site	Frequency	N	Frequency	n	Frequency	n	Frequency	n
Site 1	--	3	0.33	3	0.33	3	n.t.	0
Site 4	--	1	1.00	1	--	1	--	1
Site 5	--	3	0.67	3	0.67	3	n.t.	0
Site 6	--	4	1.00	4	0.50	4	--	1
Site 7	0.13	8	0.63	8	--	8	0.33	3
Site 10	--	6	0.67	6	--	6	--	1
Site 12	--	4	0.50	4	--	4	--	1
Site 13	--	1	1.00	1	--	1	n.t.	0
Site 14	0.33	3	0.33	3	--	3	0.50	2
Site 15	--	1	--	1	--	1	--	1

Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances of each constituent. Number of SWAMP sites included in evaluation (n). Constituent never exceeded threshold at any site (--). No applicable threshold for constituent (NA).

Category	Constituent	n	Aquatic life	Human health
Inorganics	Alkalinity as CaCO3	5	--	NA
Inorganics	Ammonia as N	5	1	NA
Inorganics	Nitrate + Nitrite as N	5	0.2	NA
Inorganics	Phosphorus as P,Total	5	0.6	NA
Inorganics	Selenium,Dissolved	5	0.2	NA
Inorganics	Sulfate	5	0.8	NA
Metals	Aluminum,Dissolved	5	--	NA
Metals	Arsenic,Dissolved	5	--	--
Metals	Cadmium,Dissolved	5	--	--
Metals	Chromium,Dissolved	5	--	NA
Metals	Copper,Dissolved	5	0.2	--
Metals	Lead,Dissolved	5	--	NA
Metals	Manganese,Dissolved	5	0.4	NA
Metals	Nickel,Dissolved	5	--	--
Metals	Silver,Dissolved	5	--	NA
Metals	Zinc,Dissolved	5	--	NA
PAHs	Acenaphthene	5	NA	--
PAHs	Anthracene	5	NA	--
PAHs	Benz(a)anthracene	5	NA	--
PAHs	Benzo(a)pyrene	5	--	--
PAHs	Benzo(b)fluoranthene	5	NA	0.2
PAHs	Benzo(k)fluoranthene	5	NA	--
PAHs	Chrysene	5	NA	--
PAHs	Dibenz(a,h)anthracene	5	NA	--
PAHs	Fluoranthene	5	NA	--
PAHs	Indeno(1,2,3-c,d)pyrene	5	NA	--
PAHs	Pyrene	5	NA	--
PCBs	PCBs	5	--	--
Pesticides	Aldrin	5	--	--
Pesticides	Ametryn	5	NA	--
Pesticides	Atrazine	5	--	--
Pesticides	Azinphos ethyl	5	NA	--
Pesticides	Azinphos methyl	5	NA	--
Pesticides	DDD(p,p')	5	NA	0.2
Pesticides	DDE(p,p')	5	NA	0.6
Pesticides	DDT(p,p')	5	NA	0.4
Pesticides	Dieldrin	5	NA	--
Pesticides	Dimethoate	5	NA	--
Pesticides	Endosulfan sulfate	5	NA	--
Pesticides	Endrin	5	--	--
Pesticides	Endrin Aldehyde	5	NA	--
Pesticides	Endrin Ketone	5	NA	--
Pesticides	Heptachlor	5	--	--
Pesticides	Heptachlor epoxide	5	--	0.4
Pesticides	Hexachlorobenzene	5	--	--
Pesticides	Methoxychlor	5	--	NA
Pesticides	Molinate	5	--	NA
Pesticides	Oxychlordane	5	NA	0.2
Pesticides	Simazine	5	--	NA
Pesticides	Thiobencarb	5	--	NA
Physical	pH	5	0.6	NA
Physical	SpecificConductivity	5	0.8	NA
Physical	Turbidity	5	0.6	NA

Table 12. Number of constituents exceeding thresholds at each SWAMP site.

Site	Aquatic life	Human health
902SMDLZ3	4	0
902SMRNB4	5	0
902SMSMR1	4	3
902SMSND3	5	1
902SSMR10	9	6

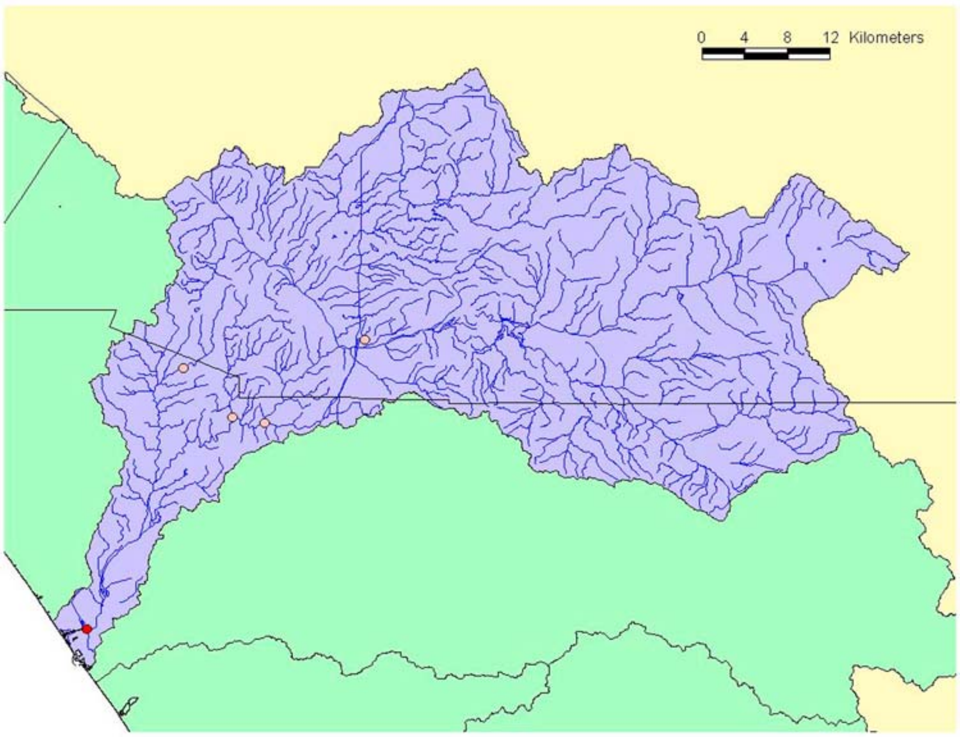

Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At all sites, 31 constituents were assessed.

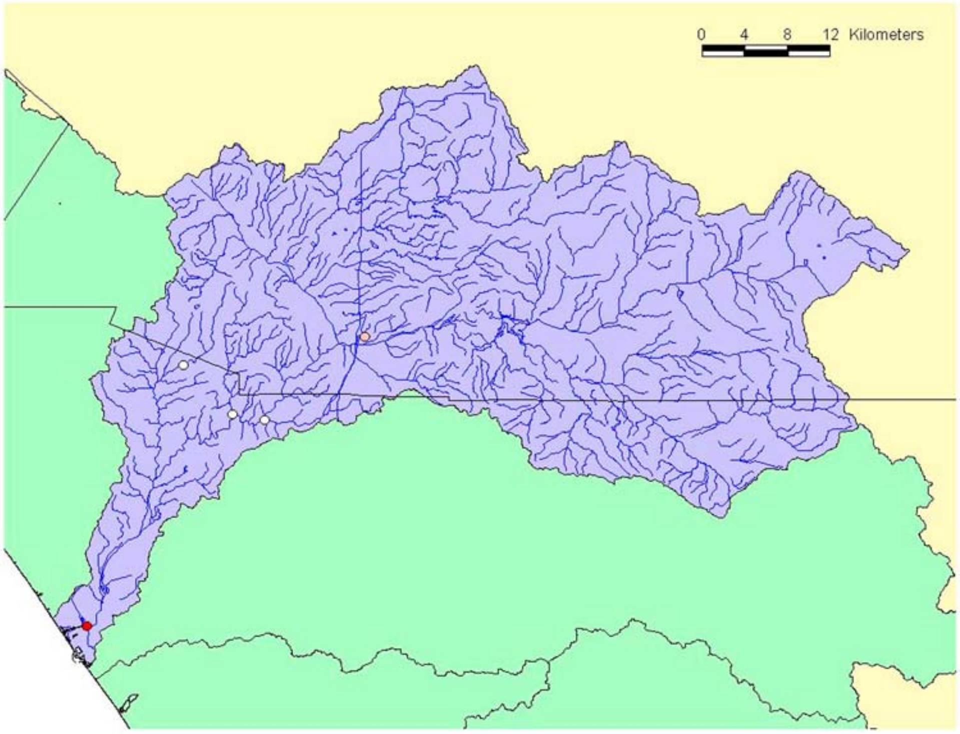

Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At all sites, 34 constituents were assessed.

Results from NPDES water chemistry monitoring at 9 sites were similar to results from SWAMP (Table 10C). For example, pH exceeded thresholds at every site monitored under NPDES. However, exceedances of specific conductivity was less frequent at sites monitored under NPDES. Dissolved oxygen and turbidity rarely exceeded aquatic life thresholds.

4.2 Toxicity

Toxicity was evident at every sites within the watershed, although the results suggest moderate or low levels of toxicity at most sites (Table 13; Figure 8; Appendix III). Severity was highest at the downstream site on the Santa Margarita River. Samples from this site were toxic to all indicators on at least one sampling date, and chronic toxicity was observed in 44% of all samples from this site. Acute toxicity to *C. dubia* was observed in one sample from this site, but from no other sample from the Santa Margarita HU. At the Upper Santa Margarita River, Deluz Creek, and Sandia Creek, *S. capricornutum* was the only sensitive indicator. In contrast, samples from Rainbow Creek, like the Lower Santa Margarita River site, was toxic to *H. azteca* on one sampling date. At no site did toxicity persist on all sampling dates, suggesting that toxicity is not a permanent condition at these sites.

Table 13. Frequency of toxicity detected for each endpoint and at each site. A sample was considered toxic if the percent control of the endpoint was less than 80% of reference samples, and the difference was considered significant at 0.05. Number of samples where the endpoint was evaluated (n). Toxicity not detected in any sample (--).

	C. dubia				*H. azteca*				*S. capricornutum*		Multiple indicators	
Site	Surival	n	Young/Female	n	Survival	n	Growth	n	Total cell count	n	Frequency	n
902SMDLZ3	--	4	--	4	--	4	--	4	0.75	4	0.25	12
902SMRNB4	--	4	--	4	--	4	0.25	4	0.50	4	0.25	12
902SMSMR1	--	4	--	4	--	1	--	1	0.50	4	0.22	9
902SMSND3	--	4	--	4	--	1	--	1	0.25	4	0.11	9
902SSMR10	0.25	4	--	3	--	2	0.50	2	0.75	4	0.44	9
All sites	0.05	20	--	19	--	12	0.17	12	0.55	20	0.25	51

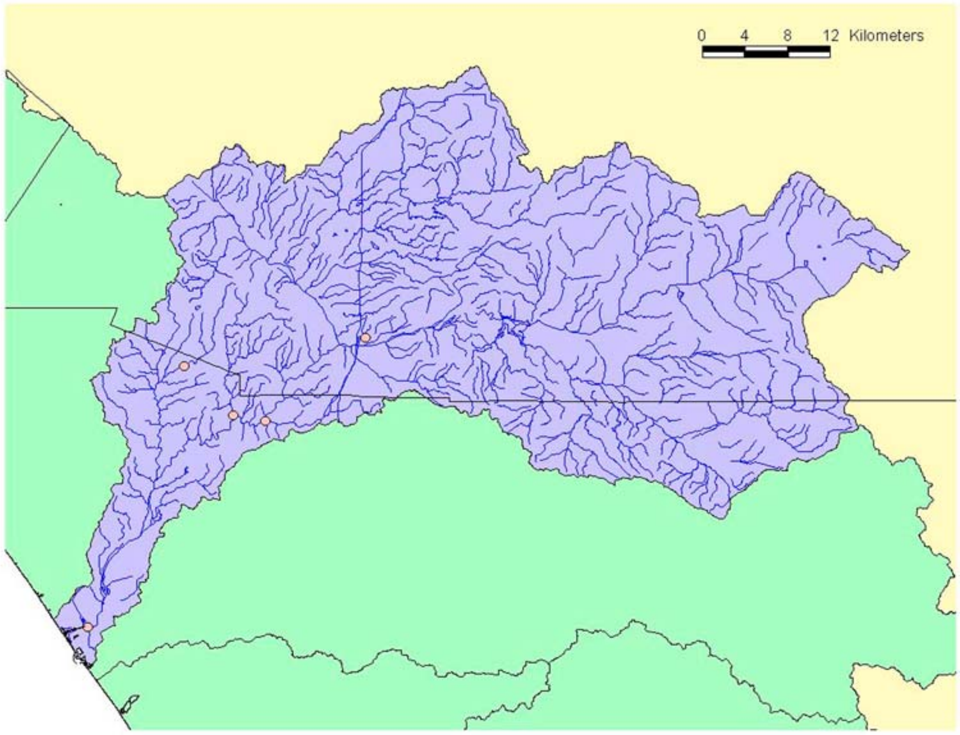

Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity. Red circles indicate high (0.5 to 1.0) frequency of toxicity.

S. capricornutum was the most sensitive indicator, as total cell count was less than 80% of control at all sites in most samples. Toxicity to *S. capricornutum* was least frequent at Sandia Creek and most frequent at Deluz Creek and the Lower Santa Margarita site. Across the watershed, 55% of samples were toxic to this indicator.

Toxicity to arthropod indicators was much less frequent. Only one sample from one site was toxic to *C. dubia* (5% of all samples from the watershed). Toxicity to *H. azteca* was observed at two sites (Rainbow Creek and the Lower Santa Margarita River), and only on one sampling date at each site. Across the watershed, 17% of samples were toxic to *H. azteca.*

4.3 Tissue

Analysis of fish tissue from Sandia Creek did not find evidence of impact (Table 14; Figure 9). Selenium did not exceed OEHHA thresholds. All other measured constituents lacked applicable thresholds. Six constituents (i.e., Aluminum, Arsenic, Chromium, Copper, Manganese, Selenium, and Zinc) were detected in the catfish tissues. Four of the constituents (i.e., Silver, Cadmium, Nickel, and Lead) did not occur at detectable concentrations. Fish tissue concentrations of PCBs, PAHs, and pesticides were not assessed.

Table 14. Concentrations of contaminants in catfish tissues collected at Sandia Creek, compared with OEHHA thresholds.

Constituent	Threshold (ppm)	Concentration (ppm)
Ag		0.00
Al		0.13
As		0.06
Cd		0.00
Cr		0.11
Cu		0.36
Mn		0.1
Ni		0.000
Pb		0.00
Se	1.94	0.17
Zn		3.9

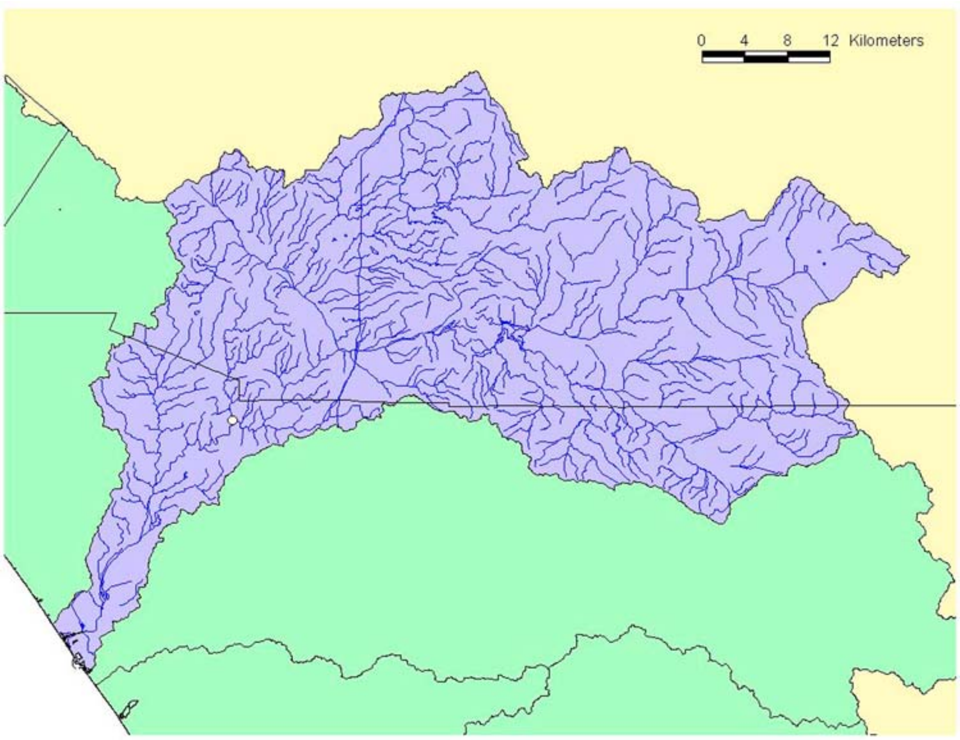

Figure 9. Fish tissue exceedances at SWAMP sites. White circles indicate 1 or fewer exceedances. Pink circles indicate 2 to 3 exceedances (this value did not occur in this watershed). Red circles indicate 4 to 5 exceedances (this value did not occur in this watershed).

4.4 Bioassessment

Biological health varied widely across the watershed. For example, a bioassessment sample from reference site on the Santa Margarita River at

Deluz Creek (site 13) had an IBI score of 72.9—the highest score observed in the watershed (Table 15; Figure 10). Five other sites were in fair condition, with IBI scores greater than 40: Roblar Creek (site 4), Sandia Creek (sites 5 and 6), the Santa Margarita River mainstem (site 12), and Deluz Creek (site 1). The last three of these sites were designated reference sites. Most of the higher IBI scores were clustered around Deluz Creek and other streams draining the Santa Rosa Plateau. Average metric values for each site and season are presented in Appendix IV.

Table 15. Mean and standard deviation of IBI scores at bioassessment sites within the Santa Margarita HU. Number of samples collected within each season (n). Range from first to last year of sampling at each site (Years). Frequency of poor or very poor IBI scores (IBI <40) at each site and season (Frequency). -- = Poor conditions not detected.

				IBI			
Site	Season	n	Years	Mean	SD	Condition	Freq
1	Average	7	2000-2004	56.5	2.1	Fair	--
1	Fall	5	2000-2004	58	9.7	Fair	--
1	Spring	2	2001-2003	55	3	Fair	--
2	Spring	1	1998-1998	12.9		Very poor	1.00
3	Average	12	1998-2005	29.6	11.6	Poor	0.83
3	Fall	4	1998-2003	37.9	10.1	Poor	0.75
3	Spring	8	1998-2005	21.4	14.1	Poor	0.88
4	Spring	4	2001-2006	49.6	5.1	Fair	--
5	Average	6	2000-2005	57.1	15.2	Fair	0.17
5	Fall	2	2000-2004	67.9	1	Good	--
5	Spring	4	2000-2005	46.4	7.8	Fair	0.25
6	Average	14	1998-2003	51.5	8.4	Fair	0.14
6	Fall	6	1998-2003	57.4	9.6	Fair	--
6	Spring	8	1998-2003	45.5	9.3	Fair	0.25
7	Average	17	1998-2006	33.8	0.5	Poor	0.76
7	Fall	7	1999-2005	34.1	10.4	Poor	0.71
7	Spring	10	1998-2006	33.4	9	Poor	0.80
8	Average	8	1998-2001	35.9	9.9	Poor	0.50
8	Fall	3	1998-2000	42.9	2.9	Fair	--
8	Spring	5	1998-2001	28.9	8.3	Poor	0.80
9	Spring	2	1998-1999	8.6	2	Very poor	1.00
10	Average	18	1998-2005	34	6.1	Poor	0.78
10	Fall	6	1998-2004	38.3	9.6	Poor	0.67
10	Spring	12	1998-2005	29.8	12.7	Poor	0.83
11	Average	13	1998-2000	26.7	10.3	Poor	0.85
11	Fall	5	1998-2000	34	11.7	Poor	0.60
11	Spring	8	1998-2000	19.5	12	Very poor	1.00
12	Average	4	2002-2004	50.5	1.3	Fair	--
12	Fall	1	2003-2003	51.4		Fair	--
12	Spring	3	2002-2004	49.5	8.1	Fair	--
13	Fall	1	2002-2002	72.9		Good	--
14	Average	4	2004-2006	31.1	0.5	Poor	1.00
14	Fall	2	2004-2005	30.7	7.1	Poor	1.00
14	Spring	2	2005-2006	31.4	4	Poor	1.00
15	Spring	1	2006-2006	35.7		Poor	1.00

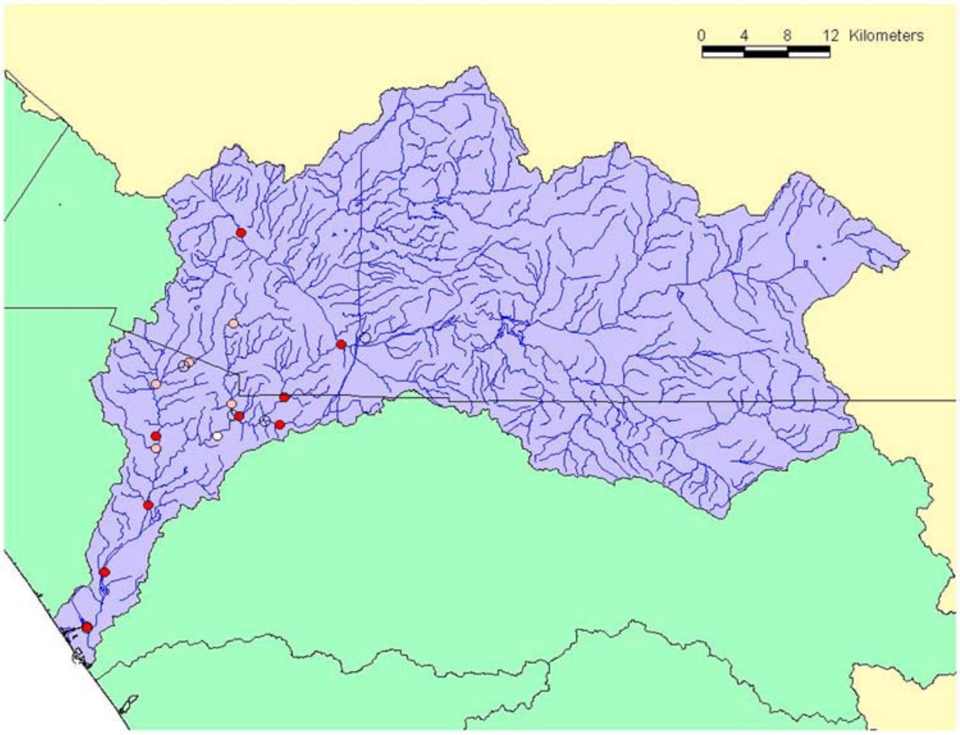

Figure 10. IBI scores at sites in the Santa Margarita HU. White circles indicate good or very good (60 to 100) IBI scores. Pink circles indicate fair (40 to 60) IBI scores. Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites; five of these buffers included bioassessment sites, and six of these buffers did not.

The remaining eight sites were in poor or very poor ecological condition. Most of these sites were on the mainstem of the Santa Margarita River (e.g., site 7, 9, 10, and 14). However, sites at Sandia Creek (site 8), Murrieta Creek (site 2), Temecula Creek (site 11), and Rainbow Creek (site 3) were also in poor ecological condition.

At most sites, IBI scores were lower in Spring than in Fall (Table 15; Figure 11). These differences were small or reversed in the Santa Margarita River and Deluz Creek, but large at Sandia, Temecula, and Rainbow Creeks.

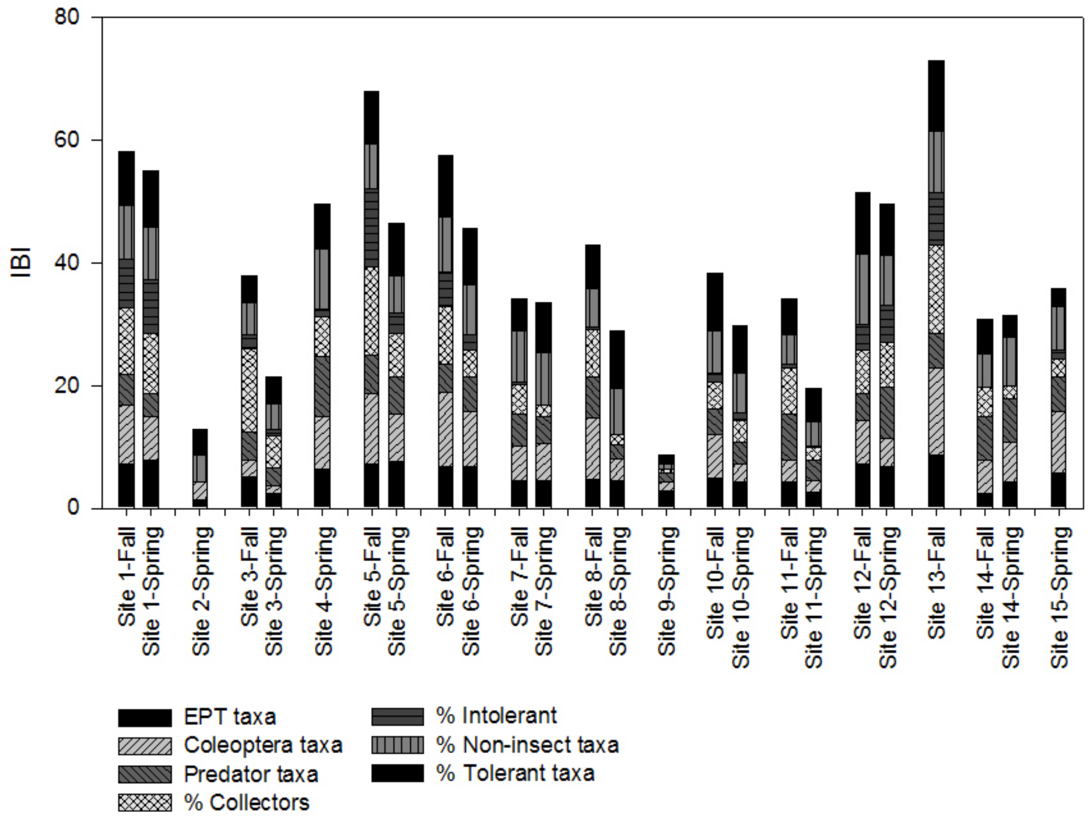

Figure 11. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI.

Examination of IBI scores over time did not indicate a trend towards improving or deteriorating biological condition (Figure 12). Variability among years was high, which may obscure trends in the data. Furthermore, a different set of sites were sampled in the early and late periods of study, increasing spatial variability and obscuring trends.

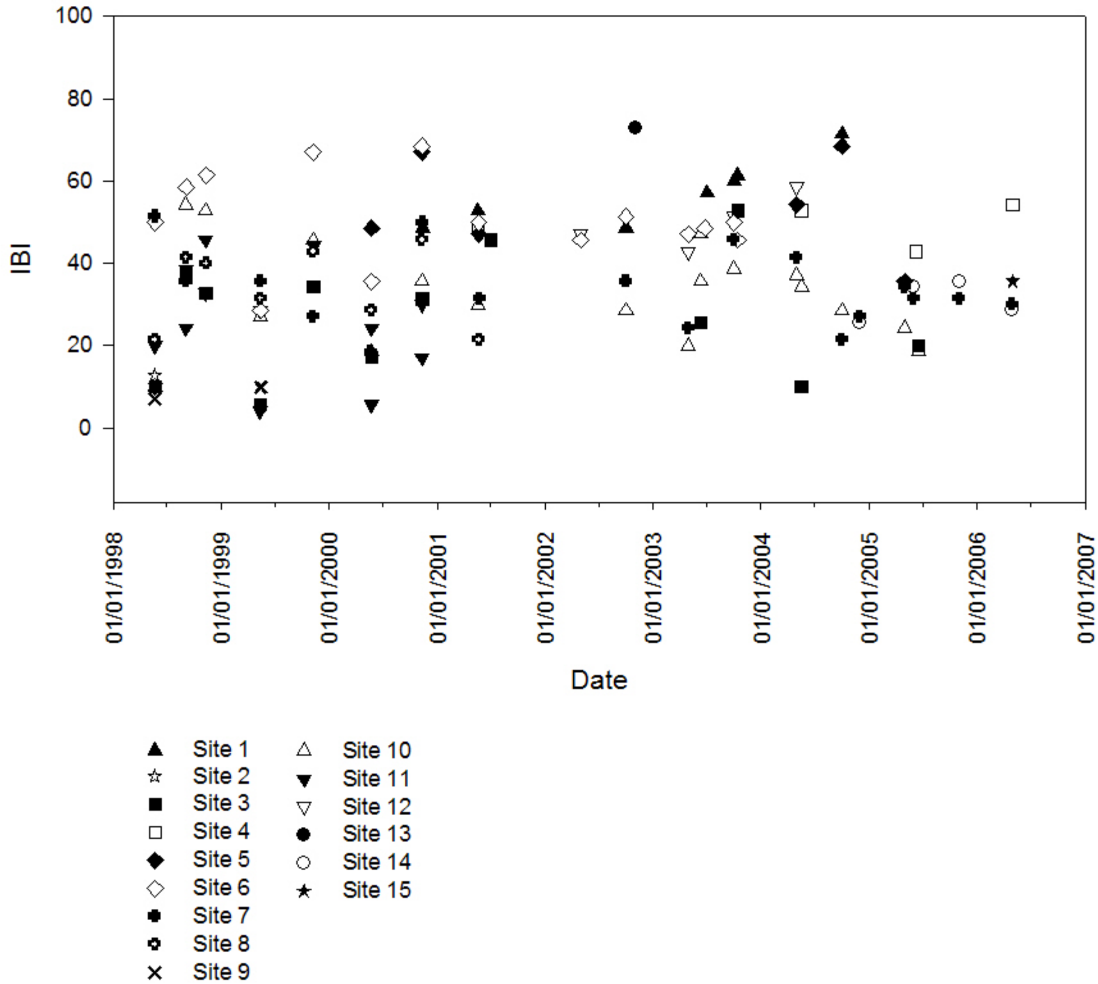

Figure 12. IBI values for each year and site. Each symbol represents a single sample.

None of these sites were monitored under SWAMP, and all bioassessment data came from monitoring efforts by NPDES permittees, Camp Pendleton, or the California Department of Fish and Game.

4.5 Physical Habitat

Physical habitat good or very good at every site in the watershed (Table 16; Figure 13). At four sites, the mean physical habitat score was greater than 15, and no site was the mean score below 10. The greatest degradation was observed at the downstream site in the Santa Margarita River, which had a mean physical habitat score of 14.9.

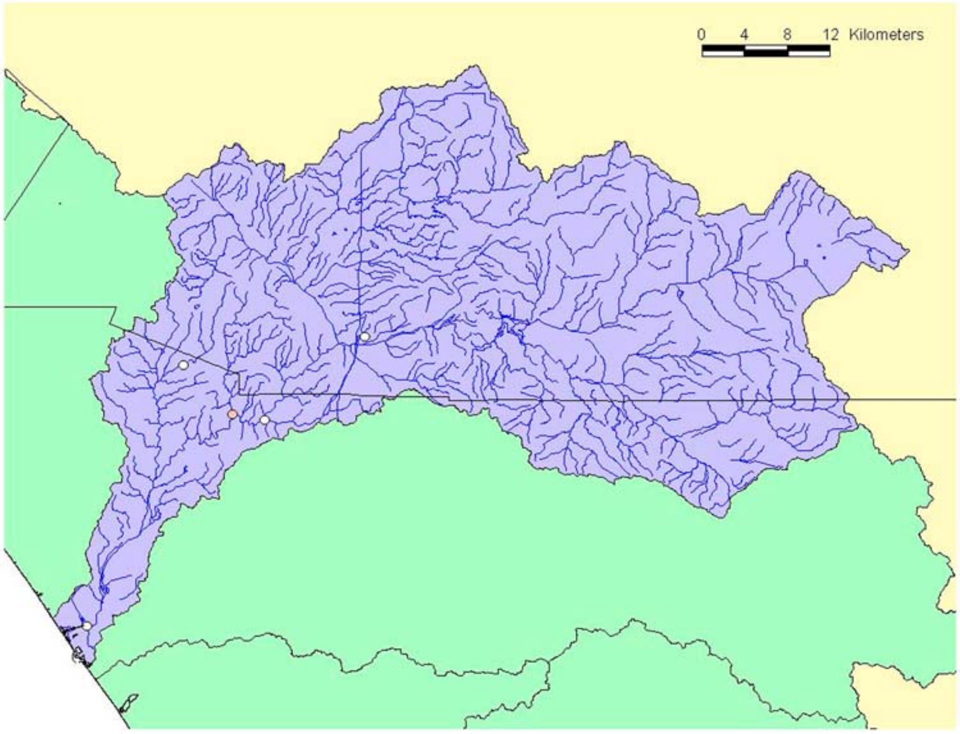

Figure 13. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

At most sites, embeddedness of substrate was high, contributing to poor physical habitat. At four of the five sites, this component of physical habitat received a score of 5 or less. At Roblar Creek, embeddedness was moderate and received a score of 13. All other components of physical habitat received high (i.e., >10) or very high (i.e., >15) scores at all sites.

5. DISCUSSION

This analysis of the Santa Margarita HU suggests that the watershed is in good ecological health, although moderate to severe impacts were evident at every site (Table 17; Figure 14). At most sites, water chemistry was moderately impacts. Toxicity was evident at every site, but generally moderate. Biological communities were severely impacted at many sites, although in some regions these communities were in fair or good condition. Physical habitat showed little evidence of severe degradation at any site in the Santa Margarita HU. Fish tissues collected at one site showed no signs of impact.

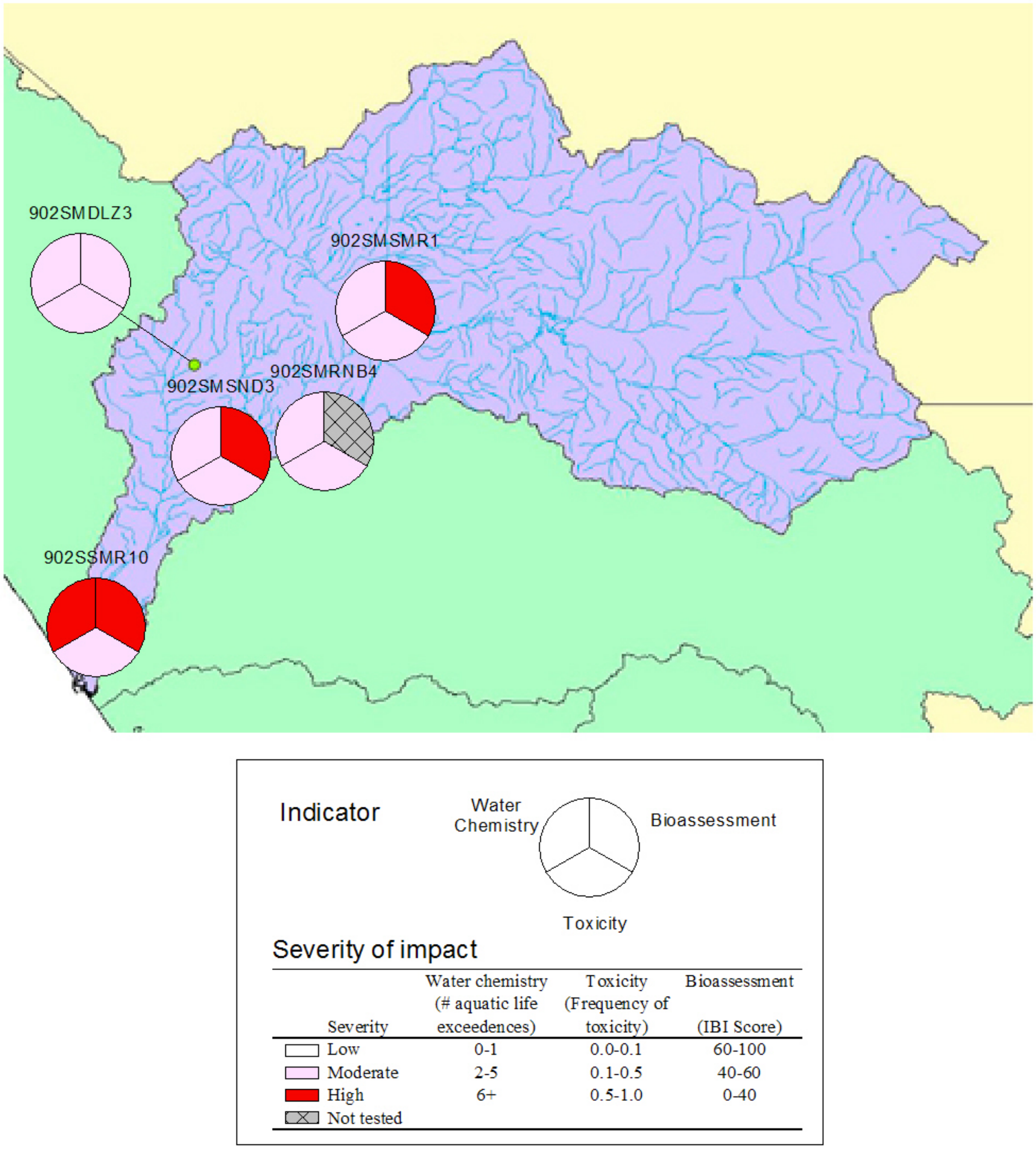

Figure 14. Summary of the ecological health of SWAMP sites in the Santa Margarita HU, as determined by water chemistry, toxicity, and bioassessment indicators. Each pie slice corresponds to a specific indicator, as described in the inset, with darker colors corresponding to more degraded conditions (unmeasured indicators are shown in cross-hatched gray). The top-left slice corresponds to the number of water chemistry constituents exceeding aquatic life thresholds. The bottom slice corresponds to the frequency of toxicity among three endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). The top-right slice corresponds to the IBI of bioassessment samples.

Table 17. Summary of the ecological health for five SWAMP sites in Santa Margarita HU. Aquatic life (AL). Human health (HH). Toxicity frequency is frequency of toxicity for three chronic toxicity endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). Biology frequency is the frequency of IBIs below 40. n.t. = Indicator not tested.

	Water chemistry		Tissue	Toxicity	Biology	Physical habitat
Site	# constituents (AL)	# constituents (HH)	# constituents (OEHHA)	Frequency	Frequency	Mean score
902SMDLZ3	4	0	n.t.	0.25	--*	15.2
902SMRNB4	5	0	n.t.	0.25	n.t.	15.2
902SMSMR1	4	3	n.t.	0.22	0.85*	18.4
902SMSND3	5	1	0	0.11	0.50*	14.9
902SSMR10	9	6	n.t.	0.44	1.00*	15.9

* = Estimated from data collected at nearby (within 500 meters) non-SWAMP sites.

The most severely impacted site was the downstream site on the Lower Santa Margarita River. This site had the highest number of aquatic life (9) and human health (6) exceedances in the watershed. These constituents included nutrients (especially total Phosphorus), Selenium, Sulfate, Copper, Manganese, pH, specific conductivity, and turbidity. Toxicity to all indicator species was evident, and 44% of samples from this site produced chronic toxicity to multiple indicators. Some of the lowest IBI scores observed in the watershed were from samples collected near this site (at site 9).

The Upper Santa Margarita River site was in better ecological health than the downstream site. For example, half as many constituents exceeded aquatic life and human health thresholds. These constituents were limited to nutrients, Manganese, and turbidity. Toxicity was moderate at this site, and was restricted to a single indicator species, *S. capricornutum.* Physical habitat was good at this site, receiving the highest physical habitat score (18.4) in the Santa Margarita HU. However, bioassessment samples collected near this site (at site 11) were in poor ecological condition, having a mean IBI score of 26.7. The high total phosphorus levels at both sites in the Santa Margarita is consistent with the 303(d) list, which specifies phosphorus as a known stressor in the Santa Margarita river.

The tributaries of the Santa Margarita River were in similar ecological health to the upstream site. For example, water chemistry constituents Sandia Creek exceeded 5 aquatic life thresholds. Unlike the mainstem sites, nutrients did not exceed aquatic life thresholds, except for Ammonia-N on a single sampling date. However, sulfate, pH, specific conductivity, and turbidity exceeded these thresholds on at least one sampling date. These data are partially consistent with the 303(d) list, which specifies sulfate as a known stressor in Sandia Creek; however, other known stressors, such as Manganese and Nitrogen, did not exceed thresholds for aquatic life. Toxicity was rarely observed at this site—only one sample from a single sampling date was toxic to a single indicator species, *S. capricornutum.* Many bioassessment samples collected near this site (at site 8) were in poor ecological condition. However, 50% of the bioassessment samples (mostly collected in the Fall) were in fair condition, suggesting that good ecological condition persists for at least part of the year. Furthermore, fish tissue collected at this site did not show evidence of impacts, and physical habitat was in good condition. Physical habitat at this site was good, although the mean physical habitat score was lower than other sites in the Santa Margarita HU.

Rainbow Creek, like Sandia Creek, had moderate impacts for multiple indicators. For example, 5 water chemistry constituents exceeded aquatic life thresholds. These constituents included nutrients, sulfate, and specific conductivity. These data were consistent with the inclusion of Rainbow Creek on the 303(d) list, which specifies nitrogen, phosphorus, and sulfates as known impairments.. Toxicity was evident for two indicator species (*S. capricornutum* and *H. azteca*). Physical habitat was in good condition. Although no bioassessment samples were collected within 500 m of the SWAMP site, samples collected over several years from upstream (at site 3) were in poor ecological condition, with a mean IBI of 29.6; only 17% of samples from this site were in fair condition.

The site at Deluz Creek was in good ecological health, although impacts were evident. It had only 4 water chemistry constituents that exceeded aquatic life thresholds, and none that exceeded human health thresholds. Apart from Ammonia-N on one sampling date, no nutrient exceeded these thresholds. Other exceedances include Sulfate, pH, and specific conductivity. Manganese did not exceed thresholds, although this is a known stressor for De Luz Creek on the 303(d) list. Although toxicity to *S. capricornutum* was frequently observed, no other indicator species was sensitive to samples from this site. Bioassessment samples collected near this site (at site 1) were in fair condition, with a mean IBI of 56.5. Furthermore, none of the 7 bioassessment samples collected over 5 years were ever in poor or very poor ecological condition, which is unique for sites sampled in multiple seasons in the Santa Margarita HU. Physical habitat was good at this site.

This study's assessment of the Santa Margarita HU suggests that the watershed is in moderate to good health, although many impacts were evident, particularly in the lower portions of the mainstem. Multiple lines of evidence support this conclusion. For example, several water chemistry constituents exceeded aquatic life and human health thresholds at all sites. Toxicity was observed at every site, although never on every sampling date. Bioassessment samples suggested that poor ecological conditions were widespread, although conditions were better at Deluz and Roblar Creeks. Physical habitat was good throughout the watershed.

Despite the strength of the evidence, limitations of this study affect the assessment. These limitations include difficulties integrating data from SWAMP and non-SWAMP sources, the non-randomization of sample sites, small sample size, and the lack of applicable thresholds for several indicators. Although these limitations require that results be interpreted with caution, it is unlikely that they would alter the conclusion that the Santa Margarita HU is in moderate to good ecological health.

The geographical approach to integrating SWAMP and non-SWAMP data relies on assumptions about the spatial and temporal variability of the variables measured by these programs. For example, bioassessment data may have been collected up to 500 meters away and up to 4 years before or 3 years after water chemistry, toxicity, and tissue data were collected. This study assumes that anthropogenic impacts do not change across these distances or over these spans of time. There is little published research on either of these assumptions, although there may be greater support for the assumptions about spatial variability (e.g., Gebler 2004) than for temporal variability (e.g., Sandin and Johnson 2000, Bêche et al. 2006).In this study, bioassessment data were observed to be highly variable, and the use of data collected many years before water chemistry data is questionable.

The targeted selection of sites monitored under the SWAMP program facilitated integration of pre-existing data from non-SWAMP sources, but this non-probabilistic approach severely limits the extrapolation of data from these sites to the rest of the watershed. Non-random sampling violates assumptions underlying most statistical analyses, and the sites selected in this study cannot be assumed to represent the entire watershed (Olsen et al. 1999, Stevens Jr. and Olsen 2004). Although reference sites were designated for monitoring under SWAMP and NPDES, it is unclear if the proportion of reference sites sampled reflect the proportion of minimally degraded streams in the HU.

The small number of sites monitored under SWAMP also limits the certainty of this study’s assessment. For example, tissue samples were collected at only one site, and only a small number of constituents were evaluated; therefore, tissue contamination may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the Santa Margarita watershed using limited resources, some indicators (especially those with high variability) may require more extensive sampling to produce more precise and accurate assessments.

Thresholds are an essential tool for assessing water quality and ecological health. However, their use is limited to indicators that have been well studied, and they cannot provide a holistic view watershed health. This limitation is exacerbated by the fact that many constituents and indicators lack applicable thresholds. For example, of the 54 water chemistry constituents, 20 (37%) had no applicable water quality objectives that could be used as thresholds for water quality. No thresholds exist for physical habitat scores. Furthermore, thresholds applied to IBI scores and toxicity were based on statistical distributions and professional judgment (respectively), rather than on risks to ecological health.

For example, the 80% threshold used to identify toxic samples is based on the assumption that this level is ecologically meaningful, although this assumption has not been verified in the field. The development of biocriteria to establish meaningful thresholds for bioassessment is subject of active interest in California (Bernstein and Schiff 2002).

Despite these limitations, the data gathered under SWAMP and other programs strongly support the conclusion that portions of the Santa Margarita HU is in moderate to good ecological health, and that other portions are in poor ecological health. Some of these limitations (such as the lack of applicable thresholds and the small sample size) may in fact have caused this assessment to underestimate the severity of degradation in the watershed. All indicators showed signs of human impacts. Multiple stressors, including degraded water quality, sediment, and physical habitat are the likely cause of the impact. Future research (see final report on the SWAMP monitoring program for further study recommendations) is necessary to determine which stressors are responsible for the impacts seen in the watershed.

6. LITERATURE CITED

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7. APPENDICES

APPENDIX I

A. Beneficial uses of streams in the Santa Margarita HU (California Regional Water Quality Control Board, San Diego Region 1994). B. Streams on the 303(d) list of impaired water bodies in the Santa Margarita. HUC = Hydrologic Unit Code. MUN = Municipal and domestic supply. AGR = Agricultural supply. IND = Industrial service supply. PROC = Industrial process supply. GWR = Groundwater recharge. REC1 = Contact recreation. REC2 = Non-contact recreation. WARM = Warm freshwater habitat. COLD = Cold freshwater habitat. WILD = Wildlife habitat. RARE = Rare, threatened, or endangered species. SPWN = Spawning, reproduction, and/or early development. X = Exempted from municipal supply. E = Existing beneficial use. P = Potential beneficial use.

A. Beneficial uses of streams in the Santa Margarita HU.
Appendix Ia, continued.

Santa Margarita HU (902)	HUC	MUN	AGR	IND	PROC	GWR	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
Santa Margarita River	902.22	E	E	E			E	E	E	E	E	E	
Murrieta Creek	902.31	E	E	E	E		P	E	E		E		
Bundy Canyon	902.31	E	E	E	E		P	E	E		E		
Slaugherhouse Canyon	902.31	E	E	E	E		P	E	E		E		
Murrieta Creek	902.32	E	E	E	E		P	E	E		E		
Murrieta Creek	902.52	E	E	E	E	E	P	E	E		E		
Cole Canyon	902.32	E	E	E	E		P	E	E		E		
Miller Canyon	902.32	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.36	E	E	E	E		P	E	E		E		
Diamond Valley	902.36	E	E	E	E		P	E	E		E		
Goodhart Canyon	902.36	E	E	E	E		P	E	E		E		
Pixley Canyon	902.36	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.35	E	E	E	E		P	E	E		E		
Domenigoni Valley	902.35	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.34	E	E	E	E		P	E	E		E		
Warm Springs Creek	902.33	E	E	E	E		P	E	E		E		
French Valley	902.33	E	E	E	E		P	E	E		E		
Santa Gertrudis Creek	902.42	E	E	E	E	P	E	E	E		E		
Long Valley	902.42	E	E	E	E	P	E	E	E		E		
Glenoak Valley	902.42	E	E	E	E	P	E	E	E	E	E		
Tucalota Creek	902.43	E	E	E	E	P	E	E	E	E	E		
Willow Canyon	902.44	E	E	E	E	P	E	E	E	E	E		
Tucalota Creek	902.41	E	E	E	E	P	E	E	E		E		
Crown Valley	902.41	E	E	E	E	P	E	E	E	E	E		
Rawson Canyon	902.41	E	E	E	E	P	E	E	E	E	E		
Tucalota Creek	902.42	E	E	E	E	P	E	E	E		E		
Santa Gertrudis Creek	902.32	E	E	E	E		P	E	E		E		
Long Canyon	902.32	E	E	E	E	E	P	E	E		E		
Temecula Creek	902.93	E	E	E	E	E	P	E	E		E		
Kohler Canyon	902.93	E	E	E	E	E	P	E	E	E	E		
Rattlesnake Creek	902.93	E	E	E	E	E	P	E	E	E	E		
Temecula Creek	902.92	E	E	E	E	E	P	E	E		E		
Chihuahua Creek	902.94	E	E	E	E	E	P	E	E		E		
Chihuahua Creek	902.92	E	E	E	E	E	P	E	E		E		
Copper Canyon	902.92	E	E	E	E	E	P	E	E		E		
Iron Springs Canyon	902.92	E	E	E	E	E	P	E	E		E		
Temecula Creek	902.91	E	E	E	E	E	P	E	E		E		
Culp Valley	902.91	E	E	E	E	E	P	E	E		E		
Temecula Creek	902.84	E	E	E	E	E	E	E	E	E	E		E
Tule Creek	902.84	E	E	E	E	E	E	E	E		E		
Million Dollar Canyon	902.84	E	E	E	E	E	E	E	E		E		
Cottonwood Creek	902.84	E	E	E	E	E	E	E	E	E	E		E
Temecula Creek	902.83	E	E	E	E	E	E	E	E	E	E		E
Long Canyon	902.83	E	E	E	E	E	E	E	E	E	E		E
Wilson Creek	902.63	E	E	E	E	E	P	E	E		E		
Wilson Creek	902.61	E	E	E	E	E	P	E	E		E		
Cahuila Creek	902.73	E	E	E	E	E	P	E	E		E		
Hamilton Creek	902.74	E	E	E	E	E	P	E	E		E		
Hamilton Creek	902.73	E	E	E	E	E	P	E	E		E		
Cahuila Creek	902.72	E	E	E	E	E	P	E	E		E		

Appendix I, continued.
B. 303(d)-listed streams in the Santa Margarita HU.

Name	HUC	Stressor	Potential source	Affected length
DeLuz Creek	902.21	Iron	Sources unknown	14 miles
		Manganese	Sources unknown	14 miles
Long Canyon Creek	902.83	Total dissolved solids	Sources unknown	8.3 miles
Murrieta Creek	902.52	Iron	Sources unknown	12 miles
		Manganese	Sources unknown	12 miles
		Nitrogen	Sources unknown	12 miles
Rainbow Creek	902.22	Iron	Sources unknown	5 miles
		Nitrogen	Agricultural return flows, other urban runoff, nurseries, onsite wastewater systems (septic tanks), nonpoint/point source	5 miles
		Phosphorus	Agricultural return flows, other urban runoff, nurseries, onsite wastewater systems (septic tanks), nonpoint/point source	5 miles
		Sulfates	Sources unknown	5 miles
		Total dissolved solids	Sources unknown	5 miles
Sandia Creek	902.22	Iron	Sources unknown	1.5 miles
		Manganese	Sources unknown	1.5 miles
		Nitrogen	Sources unknown	1.5 miles
		Sulfates	Sources unknown	1.5 miles
Santa Margarita Rive	902.22	Phosphorus	Urban runoff/storm sewers, unknown nonpoint source, unknown point source	18 miles
Temecula Creek	902.51	Nitrogen	Sources unknown	44 miles
		Phosphorus	Sources unknown	44 miles
		Total dissolved solids	Sources unknown	44 miles

APPENDIX II

Means, standard deviations (SD), and number of samples (n) of water chemistry constituents in (A) SWAMP sites and (B) Non-SWAMP (NPDES) sites. The watershed average was calculated as the mean of the site averages. Blank cells indicate that the constituent was not analyzed at that site. -- = Constituent not detected at that site. SWAMP sites were monitored in (2003). Non-SWAMP sites were monitored in Spring and Fall between 2002 and 2005.

A. SWAMP sites.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Inorganics	Alkalinity as CaCO3	mg/l	189	15	4	180	35	4	221	82	4	163	12	4	169	63	4	184	23	5
Inorganics	Ammonia as N	mg/l	0.01	0.03	4	0.02	0.04	4	0.04	0.09	4	0.02	0.04	4	0.03	0.03	4	0.03	0.01	5
Inorganics	Nitrate + Nitrite as N	mg/l	8.08	0.96	4	11.05	3.14	4	0.43	0.24	4	5.41	0.88	4	0.53	0.74	4	5.1	4.67	5
Inorganics	Nitrate as N	mg/l	8.04	0.96	4	11.04	3.15	4	0.41	0.24	4	5.39	0.87	4	0.52	0.74	4	5.08	4.66	5
Inorganics	Nitrite as N	mg/l	0.03	0.01	4	0.02	0.01	4	0.03	0.01	4	0.02	0.01	4	0.01	0.01	4	0.02	0.01	5
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.27	0.31	4	0.44	0.64	4	0.71	0.35	4	0.42	0.17	4	1.58	1.13	4	0.68	0.53	5
Inorganics	OrthoPhosphate as P	mg/l	0.03	0.01	4	0.2	0.08	4	0.18	0.1	4	0.05	0.02	4	0.34	0.16	4	0.16	0.13	5
Inorganics	Phosphorus as P,Total	mg/l	0.02	0.03	4	0.19	0.08	4	0.26	0.15	4	0.06	0.04	4	0.54	0.21	4	0.21	0.21	5
Inorganics	Selenium,Dissolved	µg/L	1.8	0.3	4	2.2	0.3	4	2	0.4	4	3.2	0.4	4	20.4	38	4	5.9	8.1	5
Inorganics	Sulfate	mg/l	267	20	4	327	63	4	107	21	4	295	15	4	824	800	4	364	271	5
Metals	Aluminum,Dissolved	µg/L	1	1	4	0.5	0.6	4	0.2	0.4	4	1.2	0.9	4	5.2	8.3	4	1.6	2	5
Metals	Arsenic,Dissolved	µg/L	1.1	0.5	4	1.2	0.2	4	1.8	0.2	4	1.6	0.3	4	6.3	8.8	4	2.4	2.2	5
Metals	Cadmium,Dissolved	µg/L	0.02	0.01	4	0.04	0.03	4	0.03	0.01	4	0.03	0	4	0.07	0.06	4	0.04	0.02	5
Metals	Chromium,Dissolved	µg/L	0.11	0.02	4	0.16	0.01	4	0.26	0.18	4	0.11	0.04	4	0.5	0.79	4	0.23	0.17	5
Metals	Copper,Dissolved	µg/L	2.79	0.88	4	4.31	1.36	4	1.78	1.07	4	2.92	0.89	4	4.31	4.95	4	3.22	1.09	5
Metals	Lead,Dissolved	µg/L	0.01	0	4	0.01	0.01	4	0.01	0.01	4	0	0	4	0.02	0.02	4	0.01	0.01	5
Metals	Manganese,Dissolved	µg/L	25	15	4	5	1	4	139	97	4	13	6	4	275	217	4	92	116	5
Metals	Nickel,Dissolved	µg/L	0.2	0.3	4	0.2	0.4	4	0.7	0.7	4	0.3	0.6	4	1.4	2	4	0.5	0.5	5
Metals	Silver,Dissolved	µg/L	--	--	4	--	--	4	0	0.01	4	--	--	4	0.16	0.33	4	0.03	0.07	5
Metals	Zinc,Dissolved	µg/L	2	0.4	4	3.2	1.1	4	1.6	0.9	4	2.2	0.5	4	2.7	3.2	4	2.3	0.6	5
PAHs	Acenaphthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Acenaphthylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benz(a)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(a)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(b)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.005	0.006	4	0.001	0.002	5
PAHs	Benzo(e)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Benzo(k)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Biphenyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysenes, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Chrysenes, C3 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Dibenzothiophene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Dibenzothiophenes, C1 -	µg/L	0.006	0.007	4	0.003	0.005	4	0.009	0.011	4	--	--	4	0.009	0.012	4	0.005	0.004	5
PAHs	Dibenzothiophenes, C2 -	µg/L	0.008	0.009	4	0.008	0.009	4	0.016	0.019	4	0.007	0.008	4	0.014	0.019	4	0.011	0.004	5
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	4	--	--	4	0.006	0.012	4	--	--	4	0.005	0.011	4	0.002	0.003	5
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluorene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluorenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.003	0.006	4	0.001	0.001	5
PAHs	Fluorenes, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Fluorenes, C3 -	µg/L	--	--	4	0.013	0.027	4	0.004	0.009	4	--	--	4	0.004	0.007	4	0.004	0.005	5
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Methylnaphthalene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Methylnaphthalene, 2-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Methylphenanthrene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalenes, C1 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalenes, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Naphthalenes, C3 -	µg/L	--	--	4	--	--	4	0.004	0.007	4	--	--	4	0.005	0.01	4	0.002	0.002	5
PAHs	Naphthalenes, C4 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
PAHs	Perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Phenanthrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	--	4	0.008	0.01	4	0.007	0.009	4	0.003	0.006	4	0.007	0.014	4	0.005	0.003	5
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.003	0.005	4	0.001	0.001	5
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 005	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 008	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 015	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 018	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 027	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 028	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 029	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 031	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 033	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 044	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 049	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 052	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 056	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 060	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 066	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 070	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 074	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 087	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 095	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 097	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 099	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 101	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 105	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 110	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 114	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 118	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 128	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 137	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 138	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 141	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 149	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 151	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 153	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 156	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 157	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 158	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 170	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 174	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 177	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 180	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 183	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 187	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 189	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 194	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 195	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 200	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 201	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 203	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 206	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCB 209	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
PCBs	PCBs	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Aldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ametryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Aspon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Atraton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Atrazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Azinphos ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Azinphos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Bolstar	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Carbophenothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordane, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordane, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordene, alpha-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlordene, gamma-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlorfenvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlorpyrifos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Chlorpyrifos methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ciodrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Coumaphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dacthal	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDD(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDD(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	DDE(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDE(p,p')	µg/L	--	--	4	--	--	4	0.003	0.006	4	0.001	0.001	4	0.001	0.001	4	0.001	0.001	5
Pesticides	DDMU(p,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	DDT(o,p')	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.001	0.001	4	0	0	5
Pesticides	DDT(p,p')	µg/L	--	--	4	--	--	4	0.001	0.001	4	--	--	4	0.002	0.004	4	0	0.001	5
Pesticides	DDTs	µg/L	--	--	4	--	--	4	0.004	0.007	4	0.001	0.001	4	0.004	0.006	4	0.002	0.002	5
Pesticides	Demeton-s	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Diazinon	µg/L	0.002	0.005	4	--	--	4	0.025	0.03	4	--	--	4	0.011	0.023	4	0.008	0.011	5
Pesticides	Dichlofenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dichlorvos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dicrotophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dieldrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dimethoate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Dioxathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Disulfoton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endosulfan I	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Endosulfan II	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endosulfan sulfate	µg/L	--	--	4	--	--	4	--	--	4	0	0.001	4	--	--	4	0	0	5
Pesticides	Endrin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endrin Aldehyde	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Endrin Ketone	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ethion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Ethoprop	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Famphur	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fenchlorphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fenitrothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fensulfothion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fenthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Fonofos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	HCH, alpha	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	HCH, beta	µg/L	--	--	4	--	--	4	--	--	4	0.001	0.001	4	--	--	4	0	0	5
Pesticides	HCH, delta	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	HCH, gamma	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Heptachlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Heptachlor epoxide	µg/L	--	--	4	--	--	4	0	0.001	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Hexachlorobenzene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Leptophos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5

Appendix IIa, continued. Means and standard deviations of water chemistry constituents.

			902SMDLZ3			902SMRNB4			902SMSMR1			902SMSND3			902SSMR10			Entire watershed		
Category	**Constituent**	**Units**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
Pesticides	Malathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Merphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Methidathion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Methoxychlor	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Mevinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Mirex	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Molinate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Naled	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Nonachlor, cis-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Nonachlor, trans-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Oxadiazon	µg/L	--	--	4	0.097	0.142	4	0.009	0.008	4	--	--	4	0.005	0.011	4	0.022	0.042	5
Pesticides	Oxychlordane	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0	0.001	4	0	0	5
Pesticides	Parathion, Ethyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Parathion, Methyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Phorate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Phosmet	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Phosphamidon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Prometon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Prometryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Propazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Secbumeton	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	0.009	0.018	4	0.002	0.004	5
Pesticides	Simazine	µg/L	0.029	0.039	4	--	--	4	0.006	0.012	4	0.036	0.073	4	0.108	0.217	4	0.036	0.043	5
Pesticides	Simetryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Sulfotep	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Tedion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Terbufos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Terbuthylazine	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Terbutryn	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Tetrachlorvinphos	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Thiobencarb	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Thionazin	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Tokuthion	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Trichlorfon	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Pesticides	Trichloronate	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	4	--	--	5
Physical	Fine-ASTM	%																		
Physical	Fine-ASTM,Passing No. 200 Sieve	%	4.2	2.6	4	3.8	2.3	4	23.2	--	1	1.7	--	1	10.4	11.2	2	8.7	8.8	5
Physical	Oxygen, Dissolved	mg/L																		
Physical	Oxygen, Saturation	%	105	12	4	84	6	4	84	9	4	99	17	4	121	48	4	99	16	5
Physical	pH	pH	7.5	0.9	4	7.4	1	4	7.3	0.9	4	7.6	1	4	7.4	0.9	4	7.4	0.1	5
Physical	Salinity	ppt	0.7	0.2	4	0.7	0.2	4	0.5	0.2	4	0.7	0.2	4	10.5	11.7	4	2.6	4.4	5
Physical	SpecificConductivity	mS/cm	1356	354	4	1443	446	4	924	390	4	1390	315	4	16884	18575	4	4399	6982	5
Physical	Suspended Sediment Concentration	%																		
Physical	Temperature	ºC	14.8	3.2	4	14.2	4.3	4	17.2	3.1	4	14.1	3.8	4	20.1	4.1	4	16.1	2.6	5
Physical	Total Organic Carbon	mg/L																		
Physical	Total Suspended Solids	mg/L	11.2	10.1	4	2.3	2.2	4	21.6	20.6	4	26.9	28.1	4	68.8	101.7	4	26.2	25.6	5
Physical	Turbidity	NTU	5.4	7.8	4	2.9	2.7	4	29.1	54	4	10.4	10.8	4	118.1	221.3	4	33.1	48.6	5
Physical	Velocity	ft/s	0.7	0.7	4	0.2	0.4	4	--	--	4	0.7	0.8	4	--	--	4	0.3	0.4	5

IIb. Non-SWAMP sites.

	Dissolved oxygen (mg/l)			pH			Specific conductivity (mS/cm)			Turbidity (NTU)			Water Tempurature (C)		
	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Site 1	12.4	4.6	3	7.9	0.6	3	1.45	0.29	3			0	15.6	1.7	3
Site 3	11.7	3.7	6	8.3	0.3	6	1.04	0.13	6	7.7		1	21.3	2.6	6
Site 5	10.5	1.1	3	8	0.2	3	1.63	0.4	3			0	16	2.3	3
Site 6	10.6	0.8	4	8.4	0.2	4	1.58	0.13	4	13.3		1	16.4	1.5	4
Site 7	11	3.8	8	8.1	0.3	8	1.24	0.19	8	24.9	19.3	3	17.2	6	8
Site 12	9.5	0.8	4	8	0.3	4	1.54	0.04	4	7.5		1	18.4	1.6	4
Site 13	10.7		1	8.9		1	1.26		1			0	15.3		1
Site 14	8.6	5.9	3	7.9	0.6	3	1.15	0.2	3	28.4	15.8	2	12.7	5.4	3
Site 15	9.2		1	8.2		1	1.13		1			0	13.9		1

APPENDIX III

Results from toxicity assays for each endpoint at each site in the watershed. Mean = mean percent control. SD = standard deviation.

	C. dubia						*H. azteca*						*S. capricornutum*		
	Survival			**Young / female**			**Survival**			**Growth**			**Total cell count**		
Site	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
902SMDLZ3	98	5	4	90	27	4	100	8	4	117	33	4	88	57	4
902SMRNB4	100	0	4	78	18	4	99	8	4	103	45	4	96	74	4
902SMSMR1	95	6	4	109	9	4	105		1	83		1	96	49	4
902SMSND3	100	0	4	103	10	4	100		1	104		1	117	61	4
902SSMR10	73	49	4	90	45	3	102	0	2	103	55	2	54	37	4

APPENDIX IV

Mean IBI and metric scores for bioassessment sites in the Santa Margarita HU. Note that the number listed under IBI is the mean IBI for each site, and not the IBI calculated from the mean metric values.

				IBI		Coleoptera taxa		EPT taxa		Predator taxa		% Collectors		% Intolerant		% Non-insect taxa		% Tolerant taxa	
Site	Season	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Site 1	Average	7	2000-2004	56.5	2.1	5.9	1.3	5.3	0.4	3	0.6	7.3	0.4	5.8	0.3	6.1	0.1	6.3	0
Site 1	Fall	5	2000-2004	58	9.7	6.8	1.1	5	1.6	3.4	2.1	7.6	2.9	5.6	3.6	6.2	1.8	6	0.1
Site 1	Spring	2	2001-2003	55	3	5	0	5.5	0.7	2.5	2.1	7	1.4	6	4.2	6	0	6.5	0
Site 2	Spring	1	1998-1998	12.9		2		1		0		0		0		3		3	
Site 3	Average	12	1998-2005	29.6	11.6	1.5	0.7	2.6	1.3	2.6	0.9	6.6	4.2	1.1	0.5	3.3	0.6	3.1	0
Site 3	Fall	4	1998-2003	37.9	10.1	2	1.6	3.5	1.7	3.3	1	9.5	1	1.5	2.4	3.8	2.2	3	0.1
Site 3	Spring	8	1998-2005	21.4	14.1	1	1.5	1.6	1.7	2	2.1	3.6	4	0.8	1.4	2.9	2.4	3.1	0.1
Site 4	Spring	4	2001-2006	49.6	5.1	6	1.8	4.5	1.3	6.8	1.5	4.5	4	1	1.4	6.8	3.2	5.3	0
Site 5	Average	6	2000-2005	57.1	15.2	6.8	1.8	5.1	0.2	4.4	0.2	7.5	3.5	5.6	4.8	4.6	0.5	6	0
Site 5	Fall	2	2000-2004	67.9	1	8	0	5	1.4	4.5	2.1	10	0	9	0	5	2.8	6	0.1
Site 5	Spring	4	2000-2005	46.4	7.8	5.5	1.7	5.3	1	4.3	1.3	5	2.2	2.3	0.5	4.3	0.5	6	0
Site 6	Average	14	1998-2003	51.5	8.4	7.4	1.5	4.8	0.1	3.5	0.5	4.9	2.5	2.9	1.6	6	0.4	6.7	0
Site 6	Fall	6	1998-2003	57.4	9.6	8.5	1.2	4.8	0.8	3.2	2.9	6.7	2.7	4	3	6.3	1.8	7	0
Site 6	Spring	8	1998-2003	45.5	9.3	6.4	1.8	4.8	0.7	3.9	1.6	3.1	1.4	1.8	1.2	5.8	1.8	6.4	0.1
Site 7	Average	17	1998-2006	33.8	0.5	4.1	0.1	3.2	0	3.3	0.3	2.3	1.6	0.1	0.2	5.9	0.3	4.7	0
Site 7	Fall	7	1999-2005	34.1	10.4	4	3.2	3.1	0.7	3.6	3.3	3.4	4.1	0.3	0.5	5.7	3	3.7	0.1
Site 7	Spring	10	1998-2006	33.4	9	4.2	2.9	3.2	0.4	3.1	2.5	1.2	0.6	0	0	6.1	1.4	5.6	0.1
Site 8	Average	8	1998-2001	35.9	9.9	4.7	3.3	3.3	0.1	3.1	2.2	3.3	2.9	0.2	0.2	4.8	0.6	5.8	0
Site 8	Fall	3	1998-2000	42.9	2.9	7	0	3.3	0.6	4.7	2.9	5.3	3.2	0.3	0.6	4.3	0.6	5	0
Site 8	Spring	5	1998-2001	28.9	8.3	2.4	3.4	3.2	0.8	1.6	1.5	1.2	1.6	0	0	5.2	1.9	6.6	0
Site 9	Spring	2	1998-1999	8.6	2	1	1.4	2	1.4	1	1.4	0.5	0.7	0	0	0.5	0.7	1	0
Site 10	Average	18	1998-2005	34	6.1	3.5	2.1	3.3	0.4	2.7	0.2	2.8	0.5	1	0.1	4.7	0.2	6.1	0
Site 10	Fall	6	1998-2004	38.3	9.6	5	3.3	3.5	0.8	2.8	2.3	3.2	2.5	1	0.6	4.8	1.7	6.7	0.1
Site 10	Spring	12	1998-2005	29.8	12.7	2	2.4	3	1	2.6	3	2.4	2.3	0.9	1.7	4.5	1.9	5.5	0.1
Site 11	Average	13	1998-2000	26.7	10.3	1.8	0.8	2.4	0.8	3.9	2.1	3.4	2.6	0.3	0.2	3.1	0.5	3.9	0
Site 11	Fall	5	1998-2000	34	11.7	2.4	1.7	3	0.7	5.4	1.1	5.2	1.5	0.4	0.5	3.4	2.3	4	0.1
Site 11	Spring	8	1998-2000	19.5	12	1.3	1.5	1.9	1.2	2.4	2.4	1.5	2.1	0.1	0.4	2.8	2.6	3.8	0.1
Site 12	Average	4	2002-2004	50.5	1.3	4.2	1.2	5	0	4.5	2.1	5.2	0.2	3.7	0.9	7	1.4	6.5	0
Site 12	Fall	1	2003-2003	51.4		5		5		3		5		3		8		7	
Site 12	Spring	3	2002-2004	49.5	8.1	3.3	1.2	5	0	6	2	5.3	2.1	4.3	1.5	6	0	6	0
Site 13	Fall	1	2002-2002	72.9		10		6		4		10		6		7		8	
Site 14	Average	4	2004-2006	31.1	0.5	4	0.7	2.3	1.1	4.8	0.4	2.3	1.1	0	0	4.5	1.4	3	0
Site 14	Fall	2	2004-2005	30.7	7.1	3.5	2.1	1.5	0.7	4.5	4.9	3	4.2	0	0	3.5	4.9	3.5	0.2
Site 14	Spring	2	2005-2006	31.4	4	4.5	0.7	3	0	5	1.4	1.5	0.7	0	0	5.5	0.7	2.5	0
Site 15	Spring	1	2006-2006	35.7		7		4		4		2		1		5		2	