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Surface Water Ambient Monitoring Program (SWAMP) Report on the San Luis Rey Hydrologic Unit

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SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP) REPORT ON THE SAN LUIS REY HYDROLOGIC UNIT

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1. ABSTRACT

In order to assess the ecological health of the San Luis Rey Hydrologic Unit (San Diego County, 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 2004 and 2006. Bioassessment samples were collected under other programs between 1998 and 2006. Although potential impacts to human health were also assessed, the primary goal of this monitoring program was to examine impacts to aquatic life in the watershed. Most of these ecological indicators showed evidence of widespread impacts to the watershed. For example, all sites (n = 7) exceeded aquatic life thresholds for several water chemistry constituents (up to 10 at one site). Toxicity was evident at all sites, although frequency varied from moderate (e.g., at Iron Springs Creek) to severe (e.g., at Gird Creek); chronic toxicity was evident at 70% of all samples with *Selenastrum capricornutum* and *Hyallela azteca* being the most sensitive indicators of toxicity. However, acute toxicity to *H. azteca* or *Ceriodaphnia dubia* was not observed. Fish tissue collected at one site did not indicate impairment, although accumulation of PCBs was evident. Bioassessment samples collected at 14 sites ranged from very poor to very good condition. The sites in the best biological condition were located on the eastern slope of Palomar Mountain, where mean IBI scores ranged from 60 to 85. Sites in poor condition were found throughout the watershed. At these sites, benthic assemblages were typical of impacted communities with few sensitive taxa. Physical habitat was in moderate condition at most sites in the watershed, but in good condition at Iron Springs Creek. Embeddedness was a widespread impact on physical habitat, receiving an average score of 5.5 out of 20. Multiple stressors, such as contaminated water and sediment, and alteration of physical habitat, were likely responsible for the poor health of the watershed. Despite 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 large portions of the San Luis Rey watershed were in poor condition and that conditions are better, though still degraded, for some tributaries, particularly on Palomar Mountain.

2. INTRODUCTION

The San Luis Rey hydrologic unit (HU 903) is in northern San Diego County and is home to about 250,000 people. The watershed represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the San Luis Rey HU, a comprehensive assessment of the ecological health of these waters has not been conducted. The purpose of this study was assess the health of the watershed using data collected in 2004 and 2006 under the Surface Waters Ambient Monitoring Program (SWAMP), and 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; in the sixth year (2006) samples were collected from all watersheds (Table 1). These programs collected data to describe water chemistry, water and sediment toxicity, physical habitat, fish or invertebrate tissue, and macroinvertebrate community structure. By examining data from multiple sources, this report provides a measure of the ecological integrity of the San Luis Rey HU (SANDAG 1998).

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.

Table 1. Watersheds monitored under the SWAMP program.

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

2.1 Geographic Setting

The San Luis Rey HU is a large coastal watershed in San Diego County draining into the Pacific Ocean (Figure 1). Located almost entirely within San Diego County, the watershed covers 560 mi^2 and ranges from the Palomar and Monserate Mountains in the interior to the Pacific Coast.

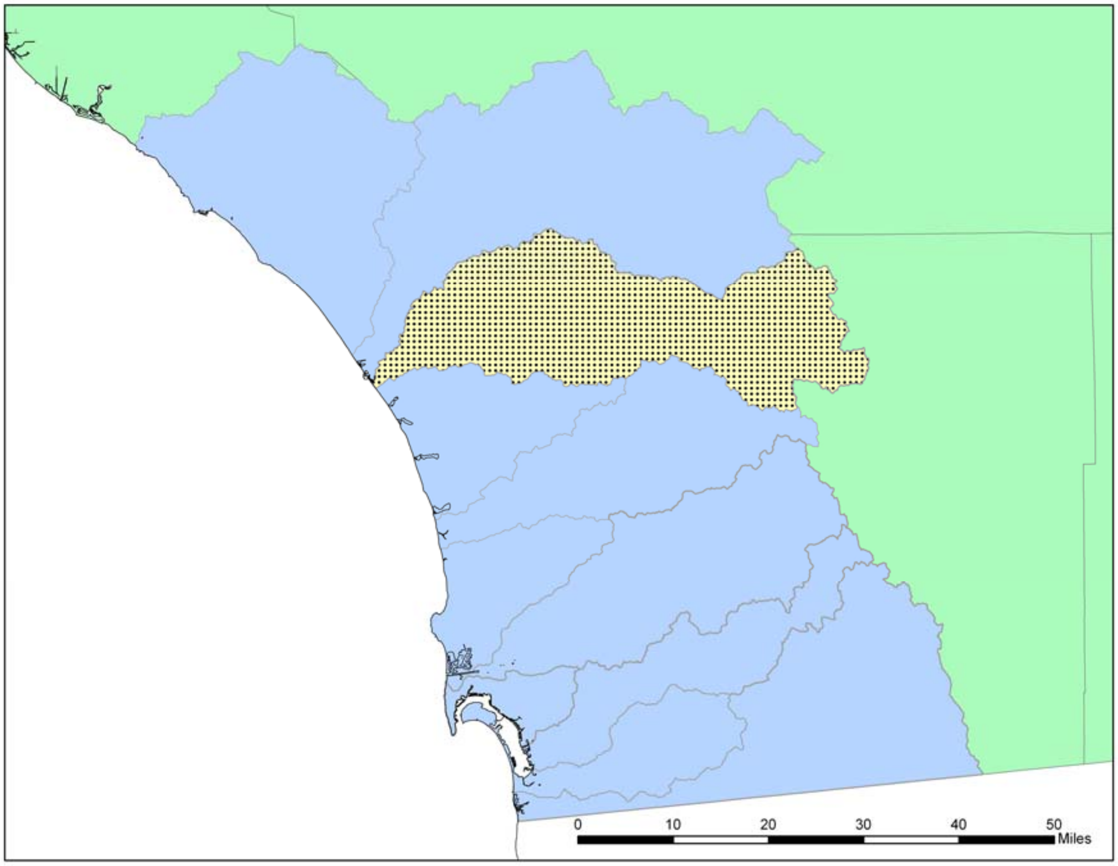


Figure 1. San Diego region (purple) includes portions of San Diego, Riverside, and Orange counties. The San Luis Rey HU (tan, shaded) is located entirely within San Diego County.

2.1.1 Climate

The San Luis Rey HU, like the entire San Diego region, is characterized by a mediterranean climate, with hot dry summers and cool wet winters. Average monthly rainfalls measured 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 (near the inland end of the HU), Fallbrook (in the middle of the HU) and at Carlsbad APT (near the coast within the HU) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

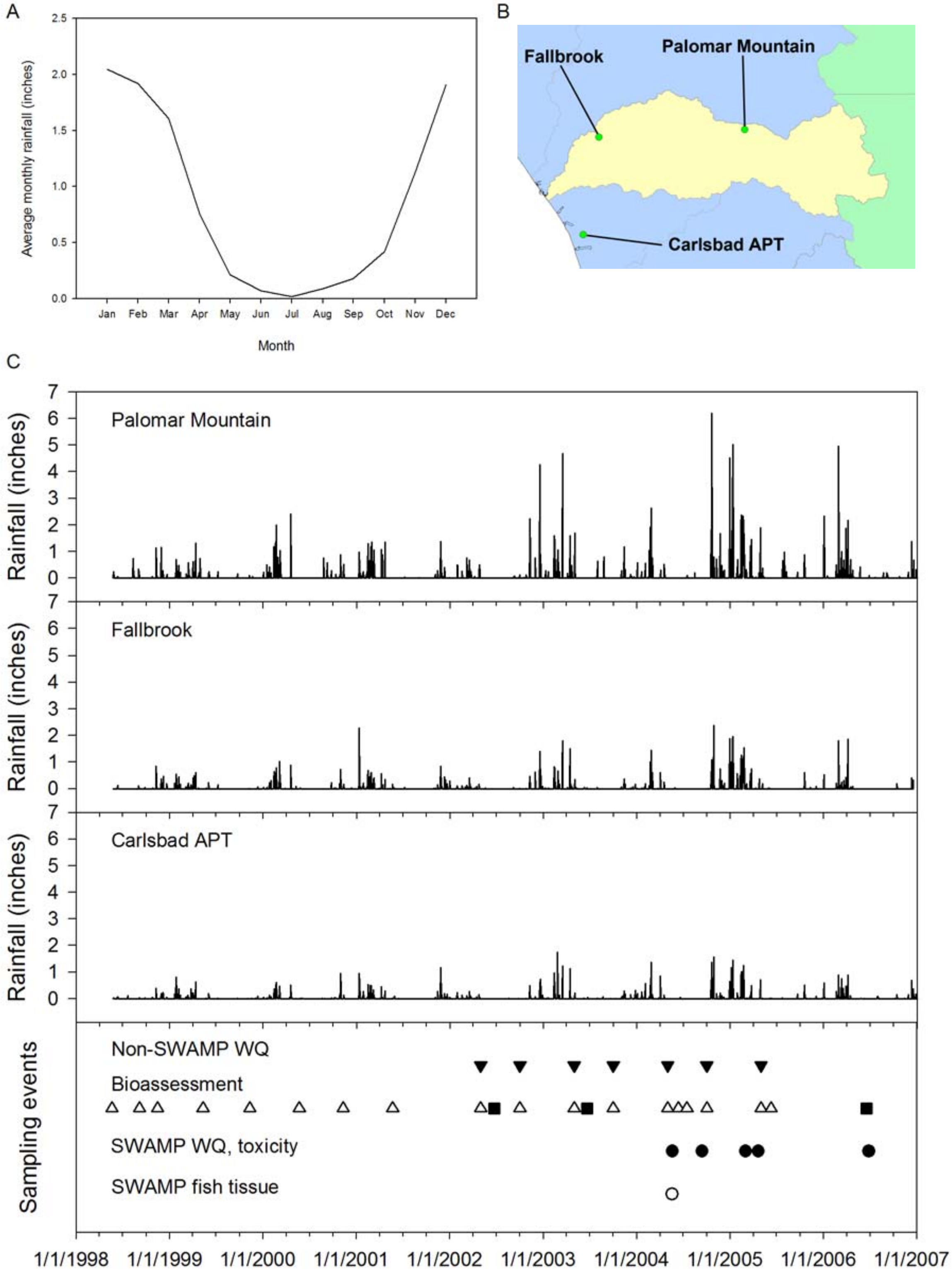


Figure 2. Rainfall and sampling events at stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Palomar Mountain, Fallbrook, and Carlsbad APT gauges. C. Storm events and sampling events in the San Luis Rey HU. The top three plots show daily precipitation between 1998 and 2007 at the stations. The

bottom plot shows the timing of sampling events. Non-SWAMP water chemistry is shown as black downward triangles. Non-SWAMP bioassessment is shown as white upward triangles. SWAMP bioassessment is shown as black squares. SWAMP water chemistry and toxicity is shown as black circles. SWAMP fish tissue assessment is shown as white circles.

2.1.2 Hydrology

The San Luis Rey HU consists of the San Luis Rey River and its tributaries (Figure 3). The mainstem is approximately 50 miles long, and is interrupted by a large dam, creating the Henshaw Reservoir. Other hydrologic alterations include the Escondido Canal, which diverts most of the water below the dam, and the importation of Colorado River water. Important tributaries above the dam include the West Fork and Agua Caliente Creek. Below the dam, Pauma Creek, Moosa Creek, and Keys Creek drain important agricultural areas. Along most of its length, the San Luis Rey River remains unchannelized, except for a portion in the City of Oceanside, where it enters the San Luis Rey estuary.

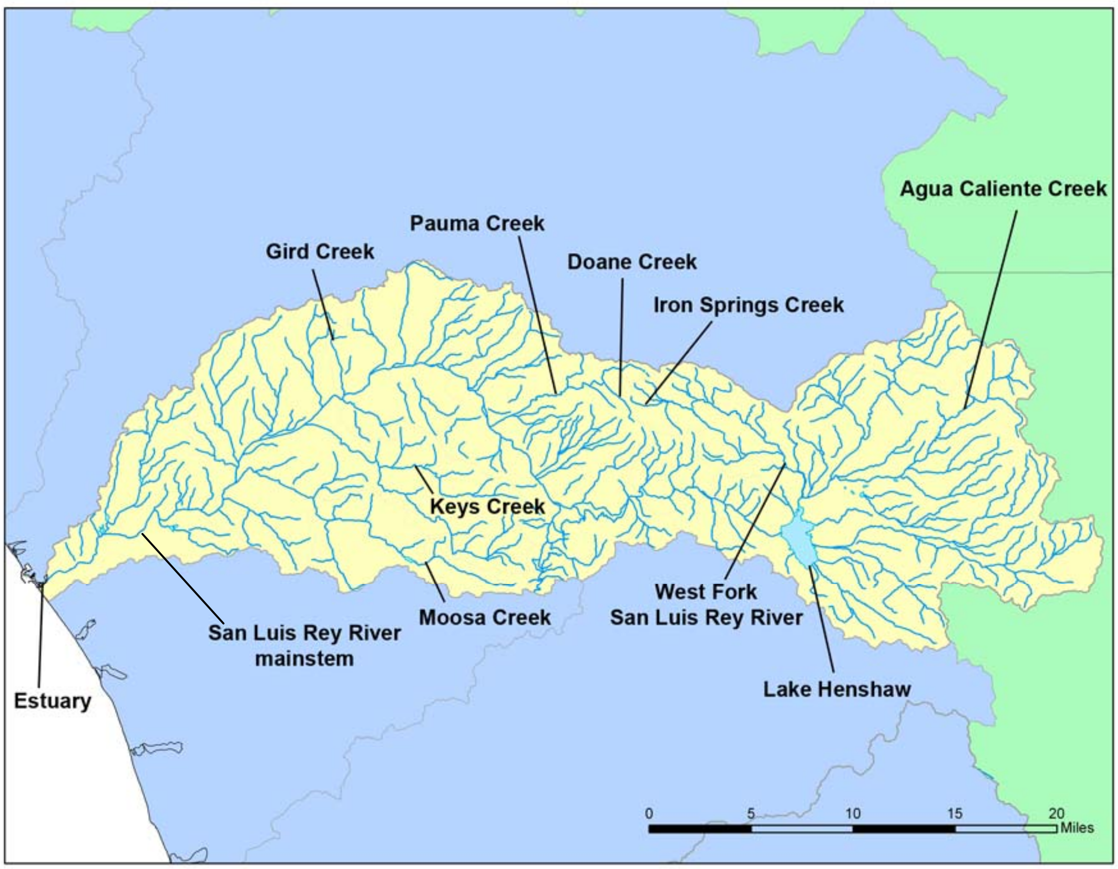


Figure 3. The San Luis Rey watershed, including major waterways.

2.1.3 Land Use within the Watershed

Agriculture is more extensive in the San Luis Rey HU than any other watershed in San Diego, with agricultural land use occupying 24% of the watershed area. Developed land covers another 15%, and the remaining 61% is open space. The upper portions of the watershed are located within the Cleveland National Forest. Other important protected areas include Palomar Mountain State Park, which includes the headwaters of the West Fork, as well as Doane and Pauma Creeks. Smaller protected areas include Wilderness Gardens Park and Hellhole Canyon Preserve, both operated by the County of San Diego.

Several municipalities have jurisdiction over portions of the watershed, although the vast majority (95%) is unincorporated San Diego County. The city of Oceanside occupies less than 5% of the HU. The cities of Escondido and Vista, as well as unincorporated portions of Riverside County account for less than 1% of the watershed area. Caltrans is another large public landowner, having jurisdiction over major freeways and highways. Large private landowners include several indigenous nations (e.g., the Pala, La Jolla, Rincon, San Pasqual, Pauma and Yuima Reservations), most of which are located in the middle portions of the watershed. A small portion of the lower watershed is within the Camp Pendleton Marine Corps Base (SANDAG 1998). A potential impact on the San Luis Rey River is the proposed Gregory Canyon Landfill, a 1700-acre sold waste disposal facility located near the mainstem in Pala (San Diego County Department of Health 2007).

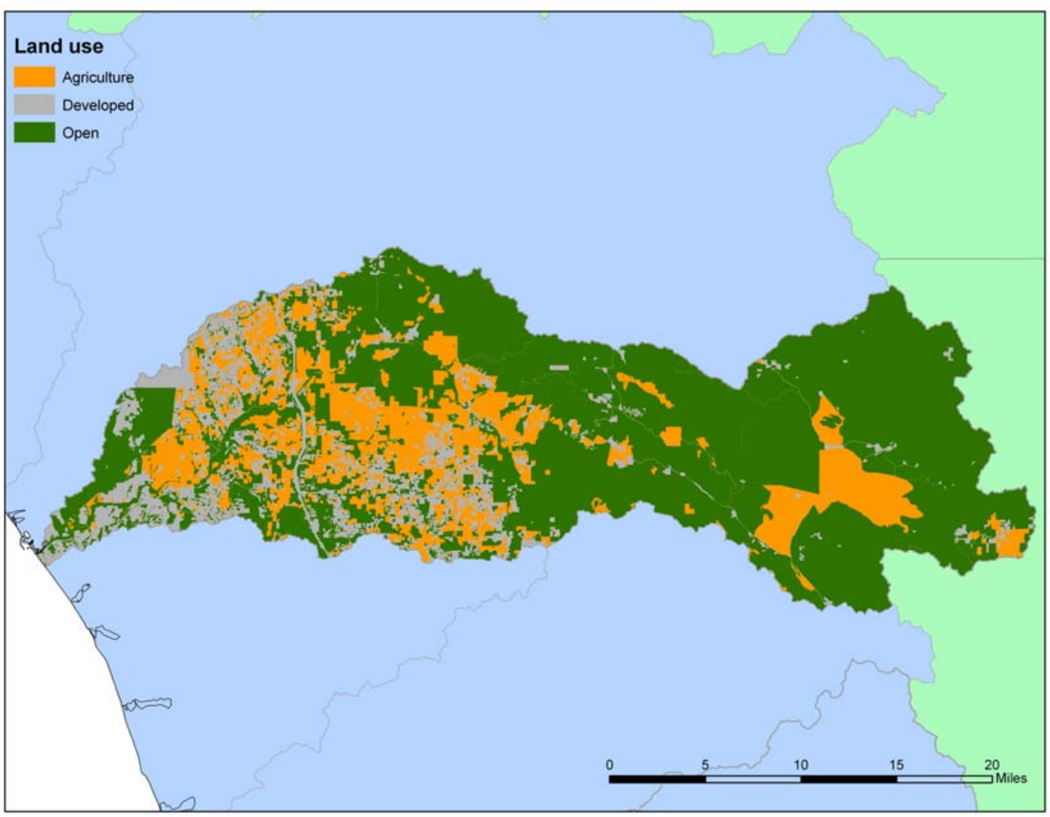


Figure 4. Land use within the San Luis Rey HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

The San Luis Rey HU is designated to support many beneficial uses. Beneficial uses in the watershed include municipal; agriculture; industrial service supply; freshwater replenishment; hydropower generation; recreation; warm and cold freshwater habitat; wildlife habitat; rare, threatened, or endangered species; and spawning habitat. Some streams in the San Luis Rey HU have been exempted from municipal uses (Appendix Ia).

The lower 19 miles of the San Luis Rey River mainstem are listed as impaired on the 303(d) list of water quality limited segments. Known stressors include chloride and total dissolved solids (Appendix Ib).

3. METHODS

This report combines data collected under SWAMP with data from California Department of Fish and Game (CDFG) and NPDES monitoring (Table 2). Ten sites of interest were sampled under SWAMP in the San Luis Rey HU in 2002 (Table 3; Figure 5). Water chemistry, water and sediment toxicity, and physical habitat were measured at seven sites. Fish tissues were collected at Moosa Creek (MSA2) to assess bioaccumulation. Bioassessment samples were collected at six of these sites. Bioassessment samples were also collected by the CDFG Aquatic Bioassessment Laboratory (ABL) and the County of San Diego as part of its NPDES permit (from 2002 to 2005) and these samples were also used in this report. Two of the sites sampled under non-SWAMP programs were located within 500 m of SWAMP sites, and were used to infer biological integrity of sites sampled under SWAMP. 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). In addition to bioassessment, conventional water chemistry (e.g., temperature, conductivity, dissolved oxygen) was also measured at sites sampled by San Diego County NPDES. 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, bioassessment, and physical habitat	2004-2006
CA Department of Fish and Game	Bioassessment	1998-2005
San Diego County NPDES	Water chemistry, bioassessment	2002-2005

Table 3: SWAMP sampling site locations. Types of samples collected at each site are indicated by an X. W: Water chemistry. T: Toxicity. F: Fish tissue. B: Bioassessment samples collected under SWAMP. N: Bioassessment samples collected under a non-SWAMP program. P: Physical habitat.

	SWAMP site	Name	Latitude (°N)	Longitude (°E)	W	T	F	B	N	P
1	903SLGRD1	Gird Creek 1	33.3613	-117.2044	X	X				
2	903SLGRD2	Gird Creek 2	33.3355	-117.1884	X	X		X		X
3	903SLIRS2	Iron Springs Creek 2	33.3333	-116.8719	X	X		X		X
4	903SLKYS3	Keys Creek 3	33.2904	-117.0723	X	X				X
5	903SLMSA2	Moosa Creek 2	33.2863	-117.2093	X	X	X			X
6	903SLSLR2/3*	San Luis Rey River 2	33.2619	-116.8089	X	X		X	X	X
7	903SLSLR6	San Luis Rey River 6	33.2879	-117.2234				X		
8	903SLSLR8	San Luis Rey River 8	33.2147	-117.3704	X	X				X
9	903SLWVR1	Weaver Creek	33.2939	-117.0873				X	X	
10	903SLLGC2	Little Gopher Canyon	33.2635	-117.2230				X		

*Sites 903SLSLR2 and 903SLSLR3 share identical geographic coordinates and are treated as representing the same site.

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	Lattitude (N)	Longitude (E)
1	Fry Creek at Fry Creek Campground	none	CDFG (903FCFCCx)		X	33.3442	-116.8803
2	French Creek at Palomar State Park	none	CDFG (903FCPSPx, 903PCPMPx)		X	33.3503	-116.9117
3	Keys Creek (reference)	903SLWVR1	CDFG (903KCLRxx)		X	33.2939	-117.0862
			NPDES (REF-KC)	X	X		
4	San Luis Rey River at Old Highway 395	none	CDFG (903SLRR39)		X	33.3244	-117.1578
5	San Luis Rey River upstream at Fousat Road	none	CDFG (903SLRRFR)		X	33.2262	-117.3442
6	San Luis Rey River upstream of Mission Road	none	CDFG (903SLRRMR)		X	33.2616	-117.2350
			NPDES (SLRR-MR)	X	X		
7	San Luis Rey River near Highway 76	903SLSLR2	CDFG (903SLRRPG)		X	33.2624	-116.8082
8	West fork of the San Luis Rey River	none	CDFG (903WE0798)		X	33.3367	-116.8285
9	Doane Creek (reference)	none	NPDES (REF-DC)	X	X	33.3354	-116.8916
10	San Luis Rey River near Bennet Road	none	NPDES (SLRR-BR)	X	X	33.2183	-117.3595

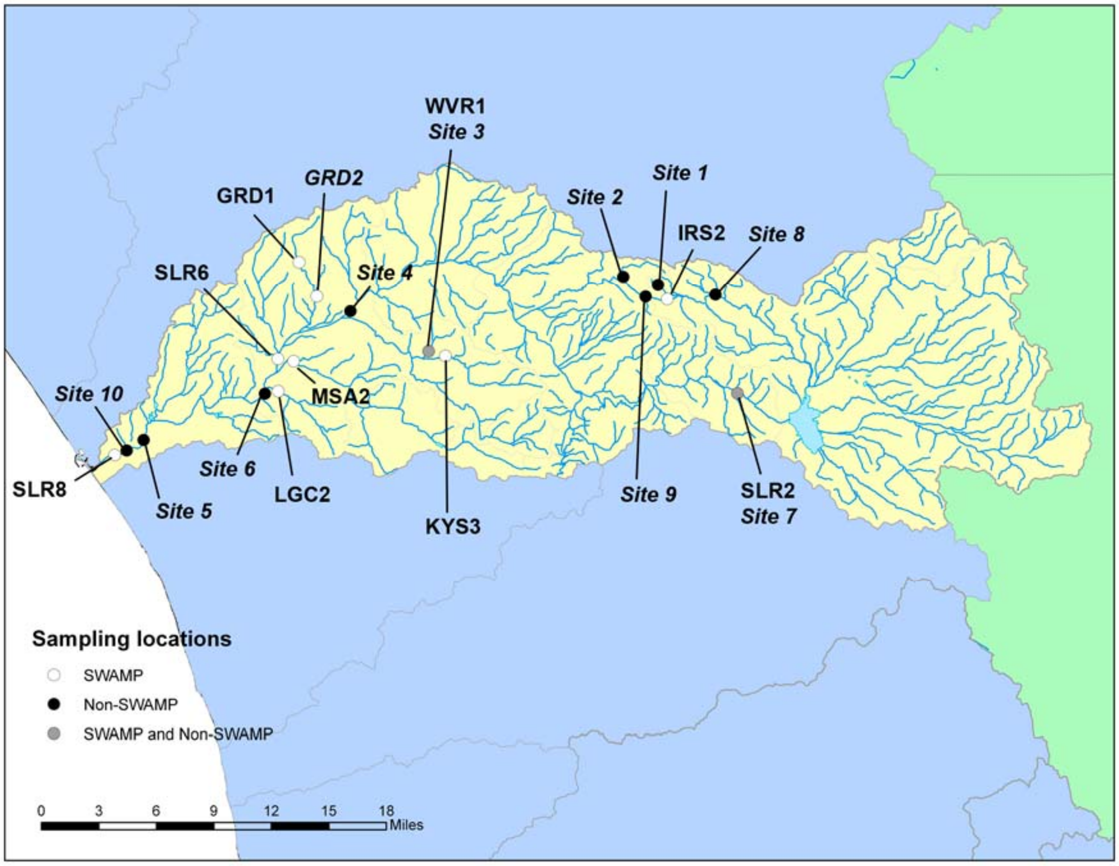


Figure 5. Sampling locations in the San Luis Rey HU. White circles represent sites sampled under SWAMP. Black circles represent sites sampled under non-SWAMP programs. Gray circles represent sites sampled under both SWAMP and non-SWAMP programs. The SWAMP site prefix designating the hydrologic unit (i.e., 903SL-) has been dropped to improve clarity.

3.1 Indicators

Multiple indicators were used to assess the sites in the San Luis Rey 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 San Luis Rey 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 San Luis Rey HU, fish tissues were collected from the site at Moosa Creek. One orange-spotted sunfish (*Lepomis humilis*) was collected. Tissues were analyzed for metals and PCBs 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 San Luis Rey HU, benthic macroinvertebrate samples were collected at 14 sites. 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 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 San Luis Rey 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 San Luis Rey 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.

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 San Luis Rey 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.

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 selenium and PCBs in fish tissues 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 lacked thresholds (OEHHA 2006) (Table 7).

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).

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.

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).

		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	Nitrate as NO_3 (MUN)	none	mg/l	none	45	mg/l	BP
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
Inorganics	Chloride	250	mg/l	BP	230	mg/l	EPA
Metals	Aluminum,Dissolved	1000	µg/L	BP	none	µg/L	none

Table 6, continued. Water chemistry thresholds for aquatic life and human health.

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
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	mg/l	BP	none	mg/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	1.3E-07	µg/L	CTR
Pesticides	Alpha-BHC	none	µg/L	none	0.0039	µg/L	CTR
Pesticides	Beta-BHC	none	µg/L	none	0.014	µg/L	CTR
Pesticides	Gamma-BHC (Lindane)	0.95	µg/L	CTR	0.019	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	Chlordanes	0.0043	µg/L	CTR	0.00057	µg/L	CTR
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	Toxaphene	0.0002	µg/L	CTR	0.0002	µg/L	CTR
Pesticides	Thiobencarb	70	µg/L	BP	none	µg/L	none
Physical	Oxygen, Dissolved	5 or 6*	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

*Dissolved oxygen threshold is 5 mg/l in streams with warm water habitat designated use, and 6 mg/l in streams with cold water habitat designated use.

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

Category	Constituents	Source	Thresholds	Units
Inorganics	Selenium	OEHHA	1.94	ppm
PCBs	PCBs	OEHHA	20	ppm

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 impacts to water quality for multiple constituents at all sites. Across the entire watershed, eight pesticides and six PAHs were detected; no PCBs were detected at any site (Table 8). Pesticides were found at every site, with the highest number (8) detected at the lower mainstem. Fewer PAHs were detected, and none were detected at two sites (the lower mainstem and on Keys Creek). Means and standard deviations of all constituents are presented in Appendix II.

Table 8. Number of anthropogenic organic compounds detected at each site in San Luis Rey HU.

	PAHs		PCBs		Pesticides	
	Tested	Detected	Tested	Detected	Tested	Detected
903SLGRD1	48	1	50	0	90	1
903SLGRD2	44	2	50	0	90	3
903SLIRS2	48	1	50	0	90	2
903SLKYS3	52	0	57	0	92	3
903SLMSA2	48	2	50	0	90	3
903SLSLR2	48	2	50	0	90	2
903SLSLR8	48	0	50	0	90	5
All sites	52	6	57	0	92	8

Some organic compounds were widespread throughout the watershed (Table 9). For example, the terbuthylazine was detected at five sites, and oxadiazon was found at four sites. Other constituents were detected at a minority of sites, including pesticides like secbumeton, diazinon, and simazine, as well as PAHs, like naphthalene.

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

Type	Constituent	Tested	Detected	Frequncy
PAHs	Acenaphthene	7	0	--
PAHs	Acenaphthylene	7	0	--
PAHs	Anthracene	7	0	--
PAHs	Benz(a)anthracene	7	0	--
PAHs	Benzo(a)pyrene	7	0	--
PAHs	Benzo(b)fluoranthene	7	0	--
PAHs	Benzo(e)pyrene	7	0	--
PAHs	Benzo(g,h,i)perylene	7	1	0.14
PAHs	Benzo(k)fluoranthene	7	0	--
PAHs	Biphenyl	7	0	--
PAHs	Chrysene	7	0	--
PAHs	Chrysenes, C1 -	7	0	--
PAHs	Chrysenes, C2 -	7	0	--
PAHs	Chrysenes, C3 -	7	0	--

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

Type	Constituent	Tested	Detected	Frequncy
PAHs	Dibenz(a,h)anthracene	7	0	--
PAHs	Dibenzothiophene	7	1	0.14
PAHs	Dibenzothiophenes, C1 -	7	0	--
PAHs	Dibenzothiophenes, C2 -	7	0	--
PAHs	Dibenzothiophenes, C3 -	7	0	--
PAHs	Dichlofenthion	7	0	--
PAHs	Dimethylnaphthalene, 2,6-	7	1	0.14
PAHs	Dimethylphenanthrene, 3,6-	6	0	--
PAHs	Fluoranthene	7	0	--
PAHs	Fluoranthene/Pyrenes, C1 -	7	0	--
PAHs	Fluorene	7	0	--
PAHs	Fluorenes, C1 -	7	0	--
PAHs	Fluorenes, C2 -	7	0	--
PAHs	Fluorenes, C3 -	7	0	--
PAHs	Indeno(1,2,3-c,d)pyrene	7	0	--
PAHs	Methyldibenzothiophene, 4-	6	0	--
PAHs	Methylfluoranthene, 2-	6	0	--
PAHs	Methylfluorene, 1-	6	0	--
PAHs	Methylnaphthalene, 1-	7	0	--
PAHs	Methylnaphthalene, 2-	7	0	--
PAHs	Methylphenanthrene, 1-	7	0	--
PAHs	Naphthalene	7	1	0.14
PAHs	Naphthalenes, C1 -	7	1	0.14
PAHs	Naphthalenes, C2 -	7	3	0.43
PAHs	Naphthalenes, C3 -	7	0	--
PAHs	Naphthalenes, C4 -	7	0	--
PAHs	Perylene	7	0	--
PAHs	Phenanthrene	7	0	--
PAHs	Phenanthrene/Anthracene, C1 -	7	0	--
PAHs	Phenanthrene/Anthracene, C2 -	7	0	--
PAHs	Phenanthrene/Anthracene, C3 -	7	0	--
PAHs	Phenanthrene/Anthracene, C4 -	7	0	--
PAHs	Pyrene	7	0	--
PAHs	Trimethylnaphthalene, 2,3,5-	7	0	--
PAHs	alpha-BHC	1	0	--
PAHs	beta-BHC	1	0	--
PAHs	delta-BHC	1	0	--
PAHs	gamma-BHC (Lindane)	1	0	--
PCBs	PCB 005	7	0	--
PCBs	PCB 008	7	0	--
PCBs	PCB 015	7	0	--
PCBs	PCB 018	7	0	--
PCBs	PCB 027	7	0	--
PCBs	PCB 028	7	0	--
PCBs	PCB 029	7	0	--
PCBs	PCB 031	7	0	--
PCBs	PCB 033	7	0	--
PCBs	PCB 044	7	0	--
PCBs	PCB 049	7	0	--

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

Type	Constituent	Tested	Detected	Frequncy
PCBs	PCB 052	7	0	--
PCBs	PCB 056	7	0	--
PCBs	PCB 060	7	0	--
PCBs	PCB 066	7	0	--
PCBs	PCB 070	7	0	--
PCBs	PCB 074	7	0	--
PCBs	PCB 087	7	0	--
PCBs	PCB 095	7	0	--
PCBs	PCB 097	7	0	--
PCBs	PCB 099	7	0	--
PCBs	PCB 101	7	0	--
PCBs	PCB 105	7	0	--
PCBs	PCB 110	7	0	--
PCBs	PCB 114	7	0	--
PCBs	PCB 118	7	0	--
PCBs	PCB 128	7	0	--
PCBs	PCB 137	7	0	--
PCBs	PCB 138	7	0	--
PCBs	PCB 141	7	0	--
PCBs	PCB 149	7	0	--
PCBs	PCB 151	7	0	--
PCBs	PCB 153	7	0	--
PCBs	PCB 156	7	0	--
PCBs	PCB 157	7	0	--
PCBs	PCB 158	7	0	--
PCBs	PCB 170	7	0	--
PCBs	PCB 174	7	0	--
PCBs	PCB 177	7	0	--
PCBs	PCB 180	7	0	--
PCBs	PCB 183	7	0	--
PCBs	PCB 187	7	0	--
PCBs	PCB 189	7	0	--
PCBs	PCB 194	7	0	--
PCBs	PCB 195	7	0	--
PCBs	PCB 200	7	0	--
PCBs	PCB 201	7	0	--
PCBs	PCB 203	7	0	--
PCBs	PCB 206	7	0	--
PCBs	PCB 209	7	0	--
PCBs	PCB-1016	1	0	--
PCBs	PCB-1221	1	0	--
PCBs	PCB-1232	1	0	--
PCBs	PCB-1242	1	0	--
PCBs	PCB-1248	1	0	--
PCBs	PCB-1254	1	0	--
PCBs	PCB-1260	1	0	--

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

Type	Constituent	Tested	Detected	Frequncy
Pesticide	Toxaphene	1	0	--
Pesticides	Aldrin	7	0	--
Pesticides	Ametryn	7	0	--
Pesticides	Aspon	7	0	--
Pesticides	Atraton	7	0	--
Pesticides	Atrazine	7	1	0.14
Pesticides	Azinphos ethyl	7	0	--
Pesticides	Azinphos methyl	7	0	--
Pesticides	Bolstar	7	0	--
Pesticides	Carbophenothion	7	0	--
Pesticides	Chlordane, cis-	7	1	0.14
Pesticides	Chlordane, trans-	7	0	--
Pesticides	Chlordene, alpha-	7	0	--
Pesticides	Chlordene, gamma-	7	0	--
Pesticides	Chlorfenvinphos	7	0	--
Pesticides	Chlorpyrifos	7	0	--
Pesticides	Chlorpyrifos methyl	7	0	--
Pesticides	Ciodrin	7	0	--
Pesticides	Coumaphos	7	0	--
Pesticides	Dacthal	7	0	--
Pesticides	DDD(o,p')	7	0	--
Pesticides	DDD(p,p')	7	0	--
Pesticides	DDE(o,p')	7	0	--
Pesticides	DDE(p,p')	7	1	0.14
Pesticides	DDMU(p,p')	7	0	--
Pesticides	DDT(o,p')	7	0	--
Pesticides	DDT(p,p')	7	0	--
Pesticides	Demeton-s	7	0	--
Pesticides	Diazinon	7	2	0.29
Pesticides	Dichlorvos	7	0	--
Pesticides	Dicrotophos	7	0	--
Pesticides	Dieldrin	7	0	--
Pesticides	Dimethoate	7	0	--
Pesticides	Dioxathion	7	0	--
Pesticides	Disulfoton	7	0	--
Pesticides	Endosulfan I	7	0	--
Pesticides	Endosulfan II	7	0	--
Pesticides	Endosulfan sulfate	7	0	--
Pesticides	Endrin	7	0	--
Pesticides	Endrin Aldehyde	7	0	--
Pesticides	Endrin Ketone	7	0	--
Pesticides	Ethion	7	0	--
Pesticides	Ethoprop	7	0	--
Pesticides	Famphur	7	0	--
Pesticides	Fenchlorphos	7	0	--
Pesticides	Fenitrothion	7	0	--
Pesticides	Fensulfothion	7	0	--
Pesticides	Fenthion	7	0	--
Pesticides	Fonofos	7	0	--

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

Type	Constituent	Tested	Detected	Frequncy
Pesticides	HCH, alpha	7	0	--
Pesticides	HCH, beta	7	0	--
Pesticides	HCH, delta	7	0	--
Pesticides	HCH, gamma	7	0	--
Pesticides	Heptachlor	7	0	--
Pesticides	Heptachlor epoxide	7	0	--
Pesticides	Hexachlorobenzene	7	0	--
Pesticides	Leptophos	7	0	--
Pesticides	Malathion	7	0	--
Pesticides	Merphos	7	0	--
Pesticides	Methidathion	7	0	--
Pesticides	Methoxychlor	7	0	--
Pesticides	Mevinphos	7	0	--
Pesticides	Mirex	7	0	--
Pesticides	Molinate	7	0	--
Pesticides	Naled	7	0	--
Pesticides	Nonachlor, cis-	7	0	--
Pesticides	Nonachlor, trans-	7	0	--
Pesticides	Oxadiazon	7	4	0.57
Pesticides	Oxychlordane	7	0	--
Pesticides	Parathion, Ethyl	7	0	--
Pesticides	Parathion, Methyl	7	0	--
Pesticides	Phorate	7	0	--
Pesticides	Phosmet	7	0	--
Pesticides	Phosphamidon	7	0	--
Pesticides	Prometon	7	0	--
Pesticides	Prometryn	7	0	--
Pesticides	Propazine	7	0	--
Pesticides	Secbumeton	7	3	0.43
Pesticides	Simazine	7	2	0.29
Pesticides	Simetryn	7	0	--
Pesticides	Sulfotep	7	0	--
Pesticides	Tedion	7	0	--
Pesticides	Terbufos	7	0	--
Pesticides	Terbuthylazine	7	5	0.71
Pesticides	Terbutryn	7	0	--
Pesticides	Tetrachlorvinphos	7	0	--
Pesticides	Thiobencarb	7	0	--
Pesticides	Thionazin	7	0	--
Pesticides	Tokuthion	7	0	--
Pesticides	Trichlorfon	7	0	--
Pesticides	Trichloronate	7	0	--
Pesticides	Chlordane (tech)	1	0	--

Comparison with applicable aquatic life thresholds support the conclusion that water quality is impacted by these constituents (Table 10). All sites showed some impacts, at least on some sampling dates. Some constituents, like total phosphorus, exceeded aquatic life thresholds at every site in nearly every sample. Specific conductivity exceeded thresholds at most sites on most dates.

However, most measured constituents were below aquatic life thresholds, or exceeded thresholds on only a few sampling dates, such as dissolved oxygen (Table 10A, Table 11, Figure 6).

Very few exceedances of human health thresholds were observed. The lower mainstem site on the San Luis Rey River exceeded thresholds for nitrate and nitrite N on one occasion. The upper site on Gird Creek (903SLGRD1) exceeded thresholds for chloride on one occasion, and the lower site (903GRD2) exceeded thresholds for chlordanes and p,p'-DDE, each on one occasion (Table 10B, Figure 7).

Monitoring at non-SWAMP sites was consistent with the results observed by SWAMP. Specific conductivity, pH, and dissolved oxygen exceeded aquatic life thresholds at all sites, although the reference site at Doane Creek (REF-DC) had only one exceedance on one occasion (Table 10C).

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. No human health thresholds applied to constituents measured at non-SWAMP sites. Freq = Frequency of samples exceeding applicable thresholds at each site. -- = Constituent never exceeded threshold. NA = No applicable thresholds at that site. nt = constituent was not measured at the site.

A. Aquatic life thresholds at SWAMP sites.

		903SLGRD1		903SLGRD2		903SLIRS2		903SLKYS3		903SLMSA2		903SLSLR2		903SLSLR8	
Category	Constituent	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Alkalinity as CaCO3	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Inorganics	Ammonia as N	--	3	1.00	1	0.25	4	0.40	5	0.75	4	0.75	4	0.75	4
Inorganics	Chloride	--	1	nt	0	--	1	nt	0	nt	0	--	1	nt	0
Inorganics	Phosphorus as P,Total	0.67	3	1.00	1	0.25	4	0.20	5	1.00	4	0.50	4	1.00	4
Inorganics	Selenium,Dissolved	0.33	3	--	1	--	4	0.40	5	0.25	4	--	4	0.75	4
Inorganics	Sulfate	0.67	3	1.00	1	--	4	1.00	5	1.00	4	--	4	1.00	4
Inorganics	Total N	0.67	3	1.00	1	0.25	4	1.00	5	1.00	4	0.50	4	0.75	4
Metals	Aluminum,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Arsenic,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Cadmium,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Chromium,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Copper,Dissolved	--	3	--	1	--	4	0.20	5	--	4	--	4	--	4
Metals	Lead,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Manganese,Dissolved	0.33	3	--	1	--	4	0.20	5	0.25	4	0.75	4	1.00	4
Metals	Nickel,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Silver,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Zinc,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PCBs	PCBs	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Chlordanes	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Endrin	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Heptachlor	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Methoxychlor	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Molinate	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Simazine	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Thiobencarb	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Physical	Oxygen, Dissolved	0.33	3	--	1	--	4	--	5	0.25	4	--	4	0.25	4
Physical	pH	--	3	--	1	--	4	0.20	5	0.25	4	0.25	4	--	4
Physical	SpecificConductivity	0.67	3	1.00	1	--	4	0.80	5	0.75	4	--	4	0.75	4
Physical	Turbidity	--	3	--	1	--	4	0.20	5	--	4	0.25	4	0.25	4

Table 10, continued. Frequency of water chemistry threshold exceedances.
B. Human health thresholds at SWAMP sites

		903SLGRD1		903SLGRD2		903SLIRS2		903SLKYS3		903SLMSA2		903SLSLR2		903SLSLR8	
Category	Constituent	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n	Freq	n
Inorganics	Chloride	1.00	1	nt	0	--	1	nt	0	nt	0	--	1	nt	0
Inorganics	Nitrate + Nitrite as N	--	3	--	1	--	4	--	5	--	4	--	4	0.25	4
Inorganics	Nitrate as NO3 (either)	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Inorganics	Nitrite as N	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Arsenic,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Cadmium,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Copper,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Metals	Nickel,Dissolved	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Acenaphthene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Anthracene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Benz(a)anthracene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Benzo(a)pyrene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Benzo(b)fluoranthene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Benzo(k)fluoranthene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Chrysene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Dibenz(a,h)anthracene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Fluoranthene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PAHs	Pyrene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
PCBs	PCBs	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Aldrin	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Ametryn	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Atrazine	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Azinphos ethyl	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Azinphos methyl	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Chlordanes	--	3	1.00	1	--	4	--	5	--	4	--	4	--	4
Pesticides	DDD(p,p')	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	DDE(p,p')	--	3	1.00	1	--	4	--	5	--	4	--	4	--	4
Pesticides	DDT(p,p')	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Dieldrin	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Dimethoate	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Endosulfan sulfate	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Endrin	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Endrin Aldehyde	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Endrin Ketone	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Heptachlor	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Heptachlor epoxide	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Hexachlorobenzene	--	3	--	1	--	4	--	5	--	4	--	4	--	4
Pesticides	Oxychlordane	--	3	--	1	--	4	--	5	--	4	--	4	--	4

Table 10, continued. Frequency of water chemistry threshold exceedances.
C. Aquatic life thresholds at non-SWAMP sites.

`	Site 3 (REF-KC)		Site 6 (SLRR-MR)		Site 9 (REF-DC)		Site 10 (SLRR-BR)	
Constituent	Freq	n	Freq	n	Freq	n	Freq	n
Dissolved Oxygen	--	2	--	7	--	3	0.29	7
pH	0.50	2	0.29	7	0.33	3	--	7
Specific conductivity	1.00	2	0.86	7	--	3	0.86	7
Turbidity	n.t.	0	--	1	n.t.	0	--	1

Table 11. Frequency of SWAMP sites with aquatic life and human health threshold exceedances for 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	Aquatic life	Human Health	n
Inorganics	Alkalinity as CaCO3	--	na	7
Inorganics	Ammonia as N	0.86	na	7
Inorganics	Chloride	--	0.33	3
Inorganics	Nitrate + Nitrite as N	na	0.14	7
Inorganics	Nitrate as NO3 (either)	na	--	7
Inorganics	Nitrite as N	na	--	7
Inorganics	Phosphorus as P,Total	1.00	na	7
Inorganics	Selenium,Dissolved	0.57	na	7
Inorganics	Sulfate	0.71	na	7
Inorganics	Total N	1.00	na	7
Metals	Aluminum,Dissolved	--	na	7
Metals	Arsenic,Dissolved	--	--	7
Metals	Cadmium,Dissolved	--	--	7
Metals	Chromium,Dissolved	--	na	7
Metals	Copper,Dissolved	0.14	--	7
Metals	Lead,Dissolved	--	na	7
Metals	Manganese,Dissolved	0.71	na	7
Metals	Nickel,Dissolved	--	--	7
Metals	Silver,Dissolved	--	na	7
Metals	Zinc,Dissolved	--	na	7
PAHs	Acenaphthene	na	--	7
PAHs	Anthracene	na	--	7
PAHs	Benz(a)anthracene	na	--	7
PAHs	Benzo(a)pyrene	--	--	7
PAHs	Benzo(b)fluoranthene	na	--	7
PAHs	Benzo(k)fluoranthene	na	--	7
PAHs	Chrysene	na	--	7
PAHs	Dibenz(a,h)anthracene	na	--	7
PAHs	Fluoranthene	na	--	7
PAHs	Indeno(1,2,3-c,d)pyrene	na	--	7
PAHs	Pyrene	na	--	7
PCBs	PCBs	--	--	7
Pesticides	Aldrin	na	--	7
Pesticides	Ametryn	na	--	7
Pesticides	Atrazine	na	--	7
Pesticides	Azinphos ethyl	na	--	7
Pesticides	Azinphos methyl	na	--	7
Pesticides	Chlordanes	--	0.14	7
Pesticides	DDD(p,p')	na	--	7
Pesticides	DDE(p,p')	na	0.14	7
Pesticides	DDT(p,p')	na	--	7
Pesticides	Dieldrin	na	--	7
Pesticides	Dimethoate	na	--	7
Pesticides	Endosulfan sulfate	na	--	7
Pesticides	Endrin	--	--	7
Pesticides	Endrin Aldehyde	na	--	7
Pesticides	Endrin Ketone	na	--	7
Pesticides	Heptachlor	--	--	7
Pesticides	Heptachlor epoxide	--	--	7
Pesticides	Hexachlorobenzene	--	--	7
Pesticides	Methoxychlor	--	na	7
Pesticides	Molinate	--	na	7
Pesticides	Oxychlordane	na	--	7
Pesticides	Simazine	--	na	7
Pesticides	Thiobencarb	--	na	7
Physical	Oxygen, Dissolved	0.43	na	7
Physical	pH	0.43	na	7
Physical	SpecificConductivity	0.71	na	7
Physical	Turbidity	0.43	na	7

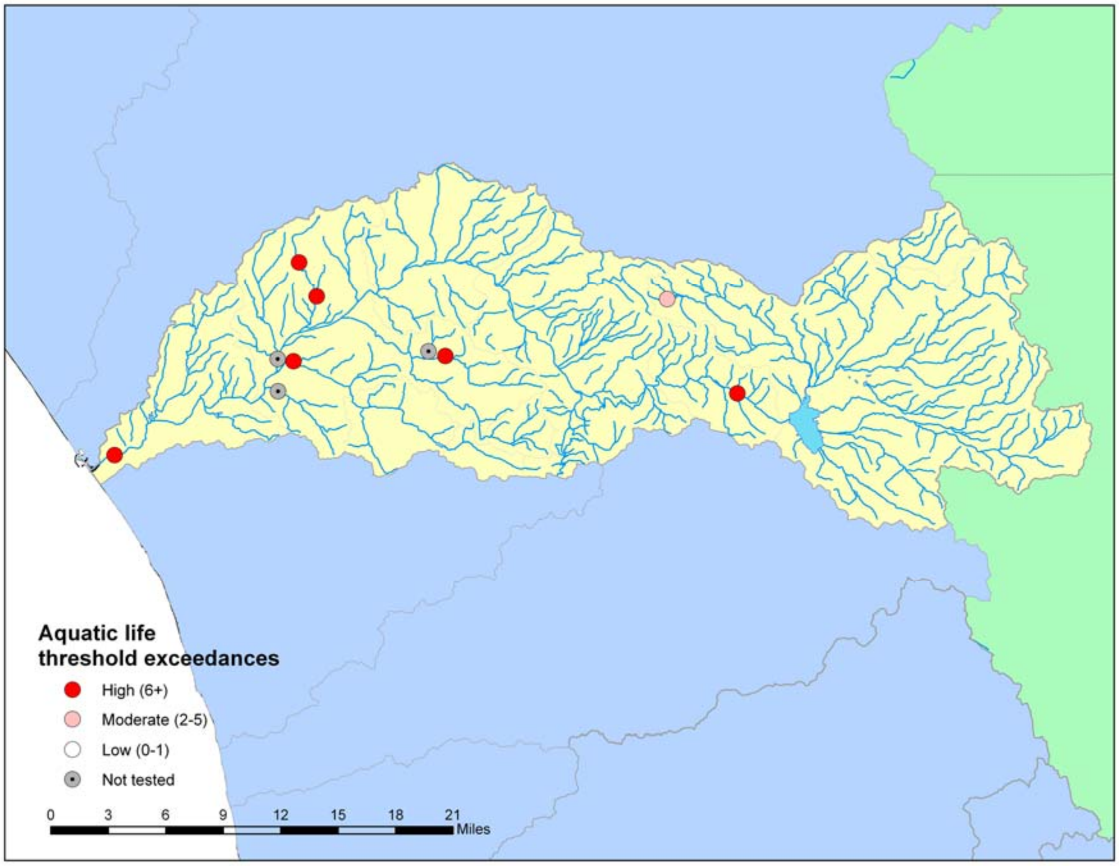


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances (this value did not occur in this watershed). Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At GRD2, KYS3, MSA2, and SLR8, 31 constituents were assessed. At GRD1, IRS2, and SLR2, 32 constituents were assessed.

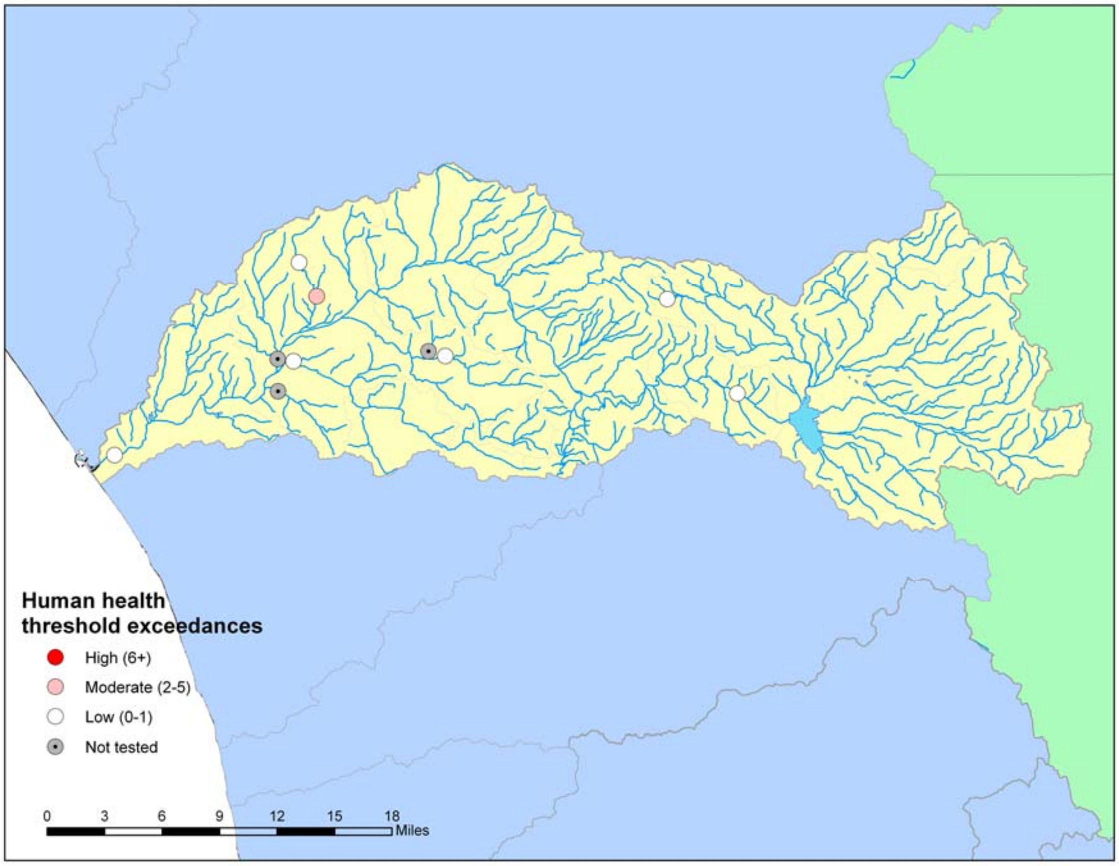


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances (this value did not occur in this watershed). At GRD2, KYS3, MSA2, and SLR8, 38 constituents were assessed. At GRD1, IRS2, and SLR2, 39 constituents were assessed.

All sites in San Luis Rey HU failed to achieve certain aquatic life and human health thresholds (Table 12). In general, the fewest aquatic life exceedances were observed at Iron Springs Creek (4) and the most at Keys Creek (10), followed closely by Moosa Creek and the lower San Luis Rey mainstem (9 each). This pattern suggested that tributaries draining the upper and northern portions of the watershed were in better condition than those in the lower and southern portions. A total of 11 constituents exceeded aquatic life thresholds throughout the watershed, and 4 exceeded human health thresholds on at least one sampling date (Table 12).

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

	Aquatic Life		Human Health	
Site	Exceedances	Constituents	Exceedances	Constituents
903SLGRD1	7	32	1	39
903SLGRD2	6	32	2	39
903SLIRS2	4	32	0	39
903SLKYS3	10	32	0	39
903SLMSA2	9	32	0	39
903SLSLR2	6	32	0	39
903SLSLR8	9	32	1	39
All sites in watershed	11	32	4	39

4.2 Toxicity

Toxicity was evident at all sites within the watershed, although results varied among sites and species (Table 13; Appendix III). Toxicity was most frequent at both sites on Gird Creek, where all samples resulted in chronic toxicity to all species tested. Toxicity was less frequent at Iron Springs Creek and Moosa Creek—no samples at these sites were toxic to *C. dubia* (Figure 8).

S. capricornutum and *H. azteca* were very sensitive indicators. Nearly all samples from all sites caused toxicity to these species. In contrast, toxicity to *C. dubia* had a more patchy distribution. For example, all samples from both sites on Gird Creek were toxic to *C. dubia,* but no samples from Iron Springs or Moosa Creek were. Only one sample from each of the mainstem sites was toxic to *C. dubia*. Acute toxicity to *C. dubia* was never observed. Across the entire watershed, 86% of samples resulted in chronic toxicity *H. azteca*, and 70% resulted in toxicity *S. capricornutum*.

Table 13. Frequency of toxicity detected for each endpoint and at each site. A sample was considered toxic if the response was less than 80% of control reference sample, 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	
	Sampling	Survival		Young / Female		Survival		Growth		Total cell count		indicators	
Site	events	n	Frequency	n	Frequency	n	Frequency	n	Frequency	n	Frequency	n	Frequency
903SLGRD1	3	3	--	3	1.00	1	--	1	1.00	3	1.00	7	1.00
903SLGRD2	1	1	--	1	1.00	1	--	1	1.00	1	1.00	3	1.00
903SLIRS2	4	4	--	4	--	2	--	2	0.50	4	1.00	10	0.50
903SLKYS3	5	5	--	5	0.60	3	--	3	0.67	5	0.80	13	0.69
903SLMSA2	4	4	--	4	--	3	--	3	1.00	4	1.00	11	0.64
903SLSLR2	4	4	--	4	0.25	2	--	2	1.00	4	1.00	10	0.70
903SLSLR8	4	4	--	4	0.25	2	--	2	1.00	4	1.00	10	0.70
All sites in watershed	25	25	--	25	0.36	14	--	14	0.86	25	0.96	64	0.70

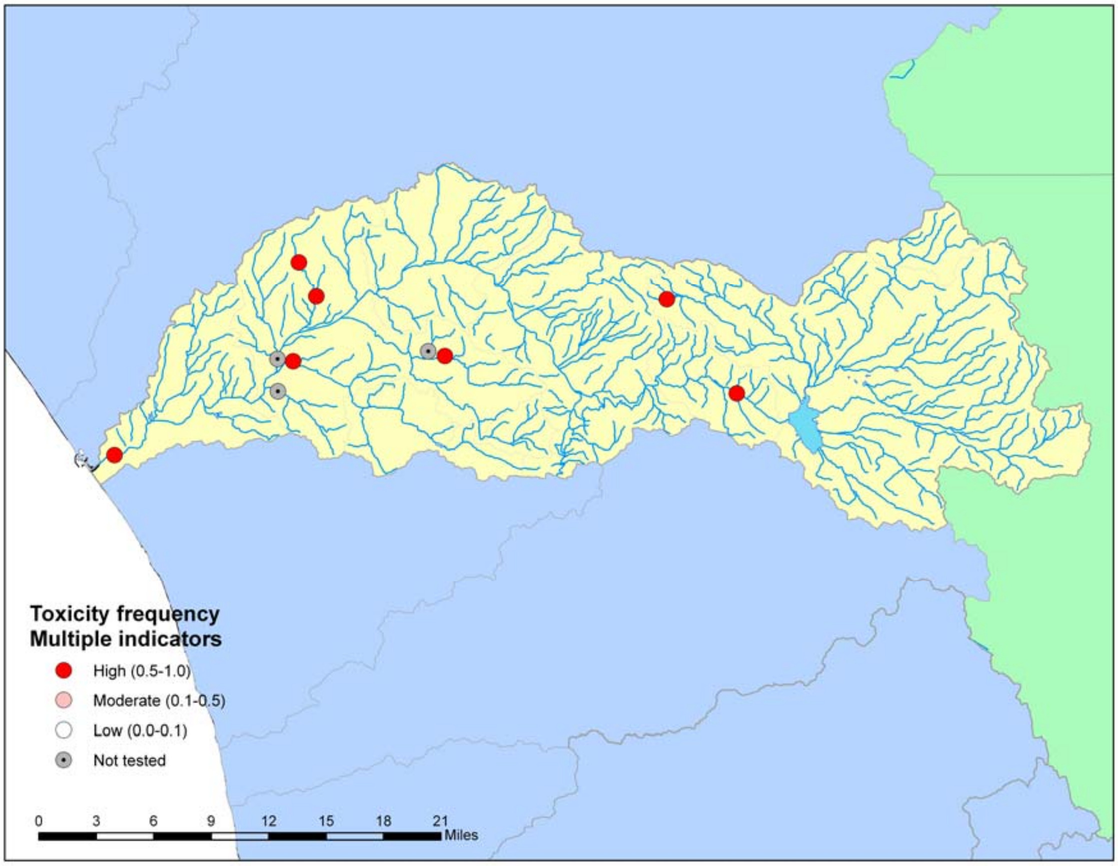


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity.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

4.3 Tissue

Analysis of fish tissues from Moosa Creek site showed little evidence of tissue contamination by PCBs and pesticides. Neither PCBs nor selenium was detected in quantities that exceeded thresholds. The majority of constituents did not occur at detectable concentrations (Table 14; Figure 9; Appendix IV). More than one-quarter of the 48 PCBs analyzed were detected in fish samples (Appendix IV). Despite this accumulation, PCBs were well below the OEHHA threshold of 20 ng/g. Of the ten metals analyzed, five were detected (i.e., chromium, copper, manganese, nickel, and zinc). However, human health thresholds have not been established for these constituents.

Table 14. Concentrations of contaminants in fish tissues, compared with OEHHA thresholds. A full list of analyzed constituents is presented in Appendix-IV. Bold face indicates constituents exceeding

Category	Constituent	Unit	Threshold	Detected in sample
Inorganics	Selenium	ppm	1.94	0.21
PCBs	PCBs	ng/g	20	3.05

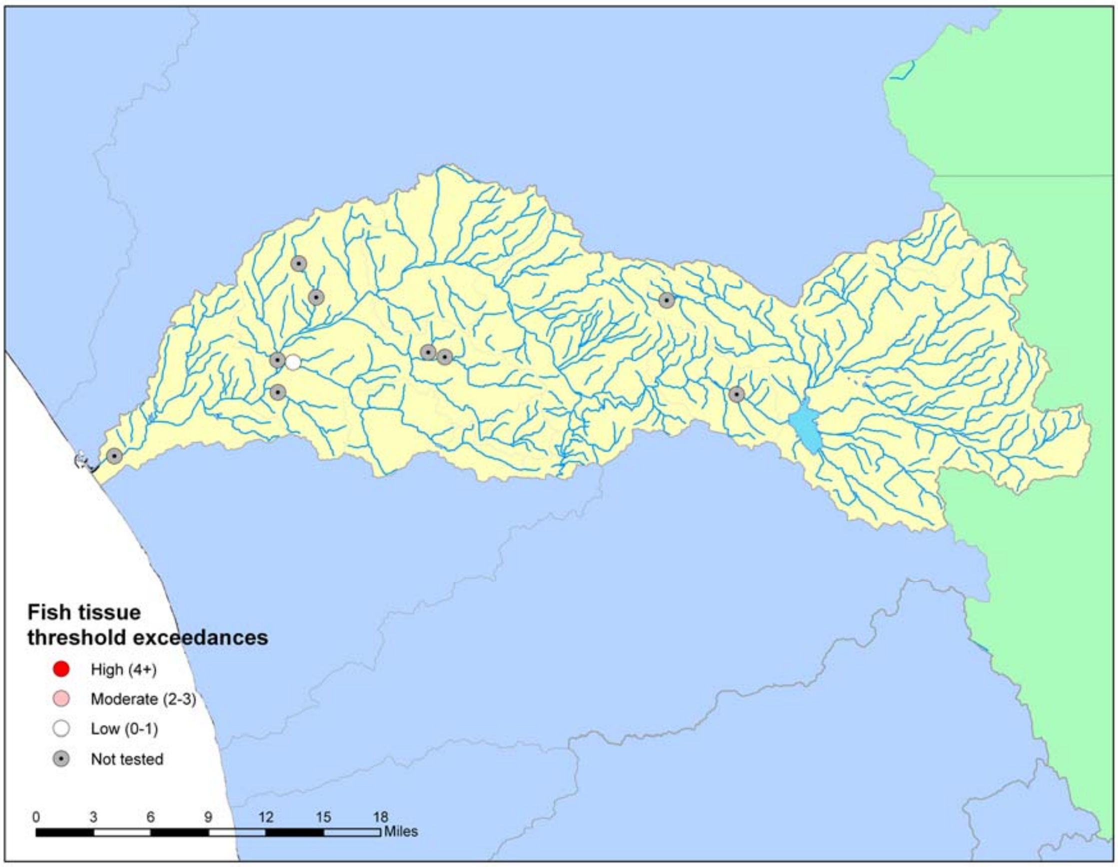


Figure 9. Fish tissue exceedances at SWAMP sites. White circles indicate 1 or fewer exceedances. Pink circles indicate 2 to 3 exceedances (this value did not occur in this watershed). Red circles indicate 4 to 5 exceedances (this value did not occur in this watershed).

4.4 Bioassessment

Biological health was poor or very poor for most sites and seasons in the San Luis Rey HU. Mean IBI scores ranged from 9.7 on the San Luis Rey mainstem near Bennet Road (site 10) to 85 at Doane Creek (site 9), a designated reference site (Table 15, Figure 10). Like Doane Creek, other creeks draining Palomar Mountain (i.e., Fry Creek (site 1) and Iron Springs Creek) were in fair or good condition. Weaver Creek, a tributary of Keys Creek, was also in fair condition and had a mean IBI of 43.9; however, poor conditions were sometimes observed at this site (i.e., in spring and fall of 1998, and fall of 2002). Furthermore, French Creek (site 2) and the West Fork of the San Luis Rey River (site 8) were both lower-elevation sites on Palomar Mountain, yet had poor ecological condition, with mean IBIs of 33.6 and 35.7, respectively. There was no consistent effect of season in IBI scores, and the differences between seasons were slight for most sites (Table 15; Figure 11). Therefore, poor biological condition persisted at some sites during both spring and fall.

Table 15. Mean and standard deviation of IBI scores at bioassessment sites within the San Luis Rey 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).

					IBI			
Site	Ecoregion	Season	n	Years	Mean	SD	Condition	Freq
SWAMP sites								
903SLGRD2	Chaparral	Spring	3	2003-2006	23.8	13.3	Poor	1.00
903SLIRS2	Mountains	Spring	1	2004	60.0		Good	0.00
903SLLGC2	Chaparral	Spring	2	2003-2006	24.3	6.1	Poor	1.00
903SLSLR2	Mountains	Average	12	1998-2006	28.8	2.4	Poor	0.92
	Mountains	Fall	3	1998-2000	27.1	8.7	Poor	1.00
	Mountains	Spring	9	1998-2006	30.5	10.9	Poor	0.89
903SLSLR6	Chaparral	Spring	1	2003	10.0		Very poor	1.00
903SLWVR1	Chaparral	Average	11	1998-2002	43.9	0.9	Fair	0.27
	Chaparral	Fall	4	1998-2002	43.2	17.0	Fair	0.50
	Chaparral	Spring	7	1998-2002	44.5	10.2	Fair	0.14
Non-SWAMP sites								
Site 1	Mountains	Spring	2	2001-2005	52.1	11.1	Fair	0.00
Site 2	Mountains	Average	4	2000-2005	33.6	7.1	Poor	0.75
	Mountains	Fall	1	2000	28.6		Poor	1.00
	Mountains	Spring	3	2001-2005	38.6	7.6	Poor	0.67
Site 4	Chaparral	Average	7	1998-2001	20.8	6.0	Poor	0.86
	Chaparral	Fall	2	1998-1999	25.0	11.1	Poor	1.00
	Chaparral	Spring	5	1998-2001	16.6	19.2	Very poor	0.80
Site 5	Chaparral	Average	5	1998-1999	17.5	6.6	Very poor	1.00
	Chaparral	Fall	2	1998-1999	22.1	13.1	Poor	1.00
	Chaparral	Spring	3	1998-1999	12.9	10.3	Very poor	1.00
Site 6	Chaparral	Average	15	1998-2005	15.8	0.8	Very poor	0.87
	Chaparral	Fall	6	1998-2004	16.4	14.2	Very poor	0.83
	Chaparral	Spring	9	1998-2005	15.2	12.3	Very poor	0.89
Site 8	Mountains	Spring	1	2005	35.7		Poor	1.00
Site 9	Chaparral	Average	3	2004-2005	85.0	1.0	Very good	0.00
	Chaparral	Fall	1	2004	84.3		Very good	0.00
	Chaparral	Spring	2	2004-2005	85.7	8.1	Very good	0.00
Site 10	Chaparral	Average	7	2002-2005	9.7	9.2	Very poor	1.00
	Chaparral	Fall	3	2002-2004	16.2	2.2	Very poor	1.00
	Chaparral	Spring	4	2002-2005	3.2	3.6	Very poor	1.00

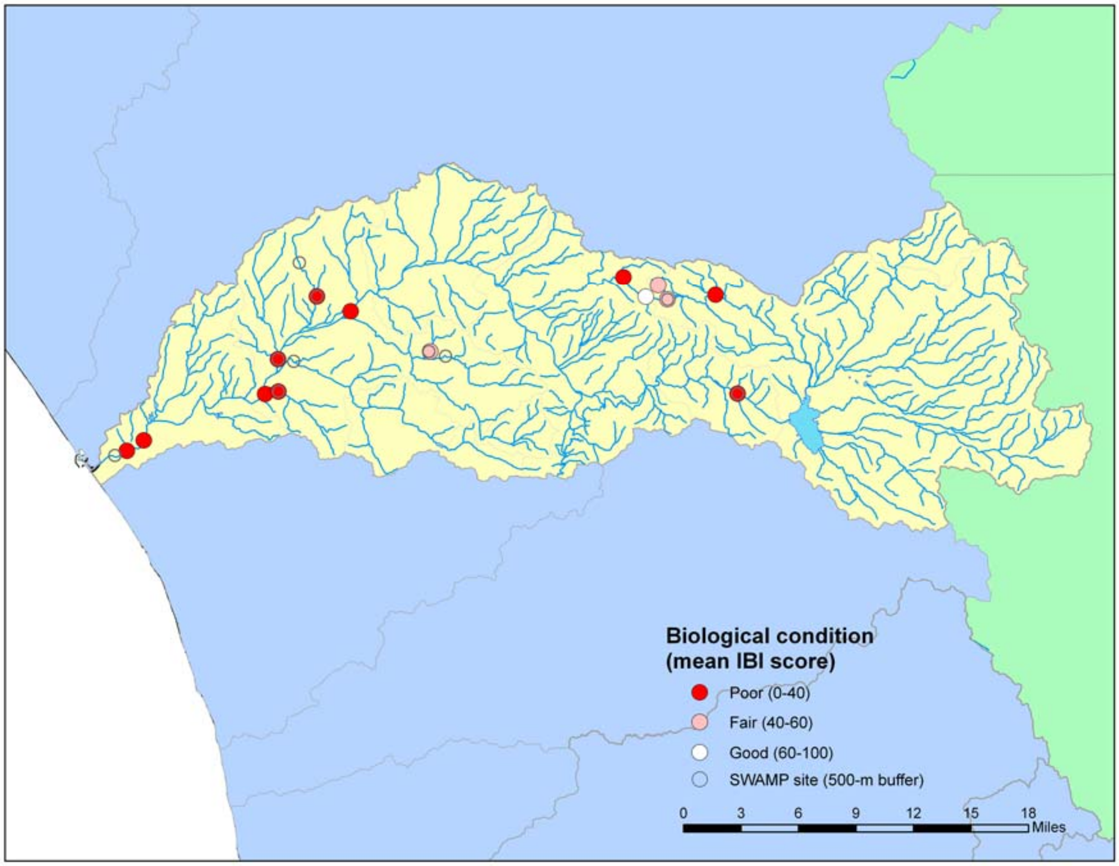


Figure 10. IBI scores at sites in the San Luis Rey HU. White circles indicate good or very good (60 to 100) IBI scores (this value did not occur in this watershed). Pink circles indicate fair (40 to 60) IBI scores (this value did not occur in this watershed). Red circles indicate poor (0 to 40) IBI scores.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

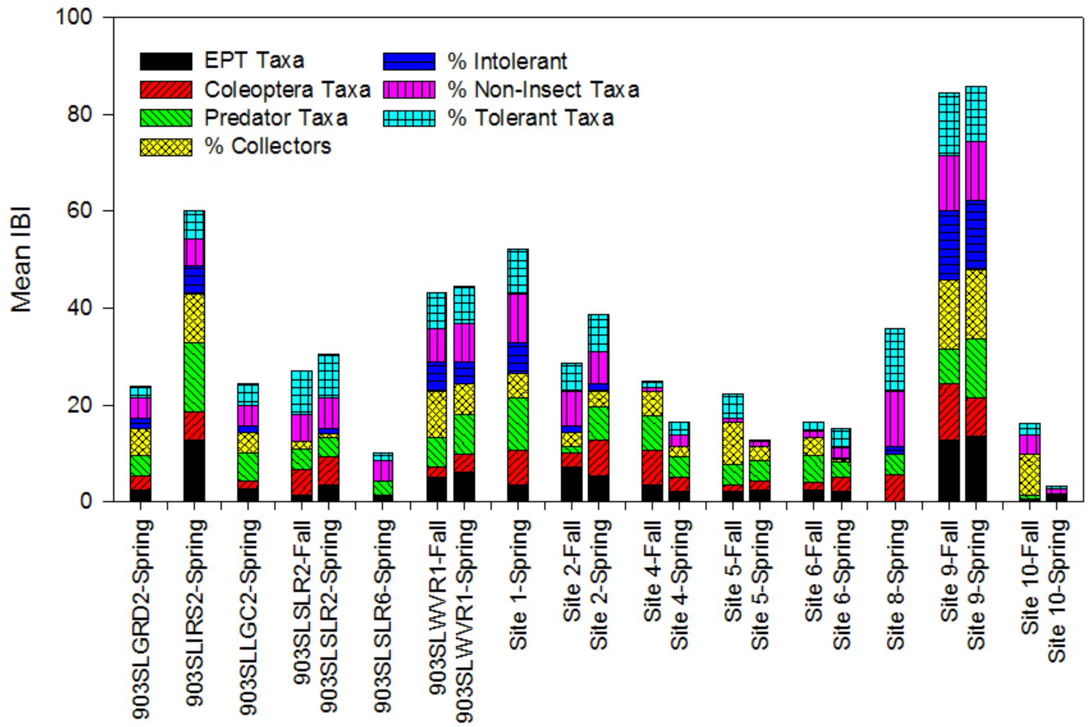


Figure 11. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI. Sites are split over two plots to improve clarity.

Mean values of the metrics that make up the IBI indicated very poor biological health. For example, pollution-sensitive taxa (used to calculate the % Intolerant metric) and beetles (used to calculate the Coleoptera Taxa metric) were nearly absent from all samples. The % Collectors, % Non-insect Taxa, and % Tolerant Taxa metrics also indicated impact, although to a lesser degree than the other metrics. (Appendix V; Figure 11).

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.

At some sites (e.g., site 10, the San Luis Rey River near Bennet Road), a clear seasonal pattern was evident, with samples collected in Fall having higher IBI scores than samples collected in Spring (Figure 12). However, seasonal patterns were not evident at most sites.

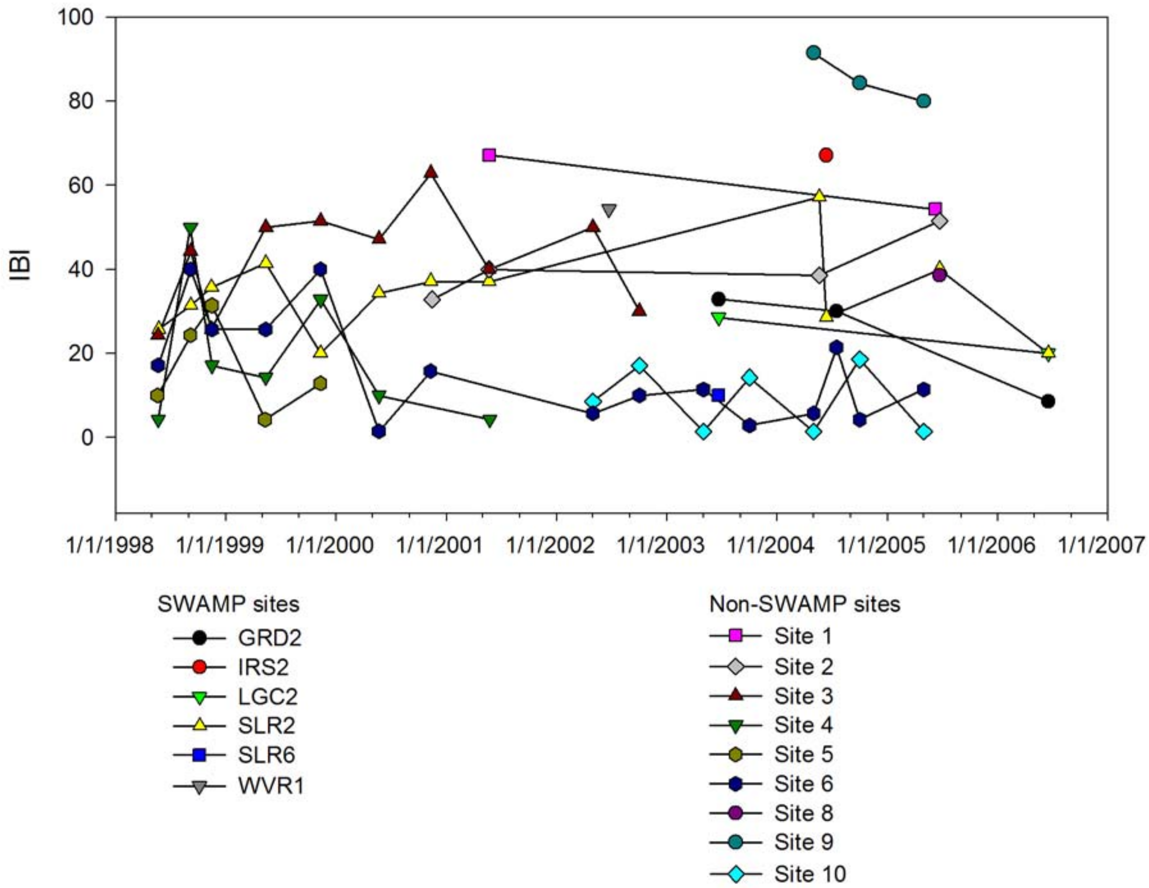


Figure 12. IBI values for each year and site. Each symbol represents a single site.

4.5 Physical Habitat

Physical habitat was moderately altered at most sites in the watershed. Good habitat (i.e., mean physical habitat score > 15) was found only at Iron Springs Creek. Moderately altered habitat (i.e., mean physical habitat score > 10) was found at all other sites throughout the watershed. Moosa Creek had the most altered habitat, with a mean score of 10.3 (Table 16; Figure 13). The upper mainstem site (SLR2) was assessed shortly after a major rainstorm, and several components of physical habitat could not be assessed (i.e., embeddedness, sediment deposition, and riffle frequency).

Some components of physical habitat suggested degradation in the watershed. For example embeddedness was observed at all sites in the San Luis Rey HU except for Iron Springs Creek. However, most components were in good condition at most sites. For example, sediment deposition, vegetation protection and epifaunal cover scored at least 10 at all sites, but embeddedness and riffle frequency did so at five of the six sites in the watershed.

Table 16. Score and mean for each component of physical habitat. Component range: 0 (heavily impacted habitat) to 20 (unimpacted habitat).

Site	Phab 1 Epifaunal cover	Phab 2 Embedded-ness	Phab 3 Velocity-depth regime	Phab 4 Sediment deposition	Phab 5 Channel flow	Phab 6 Channel alteration	Phab 7 Riffle frequency	Phab 8 Bank stability	Phab 9 Vegetation protection	Phab 10 Riparian zone	Mean score
903SLGRD2	16	7	11	16	18	9	16	18	20	16	14.7
903SLIRS2	18	16	11	16	16	15	17	12	12	20	15.3
903SLKYS3	10	5	10	15	8	15	9	15	17	15	11.9
903SLMSA2	10	0	8	13	16	15	6	13	13	9	10.3
903SLSLR2	13		10		19	15		14	14	18	14.7
903SLSLR8	13	0	10	16	15	15	13	15	16	14	12.7
All sites in watershed	13.3	5.5	10.0	15.2	15.3	14.0	12.2	14.5	15.3	15.3	13.1

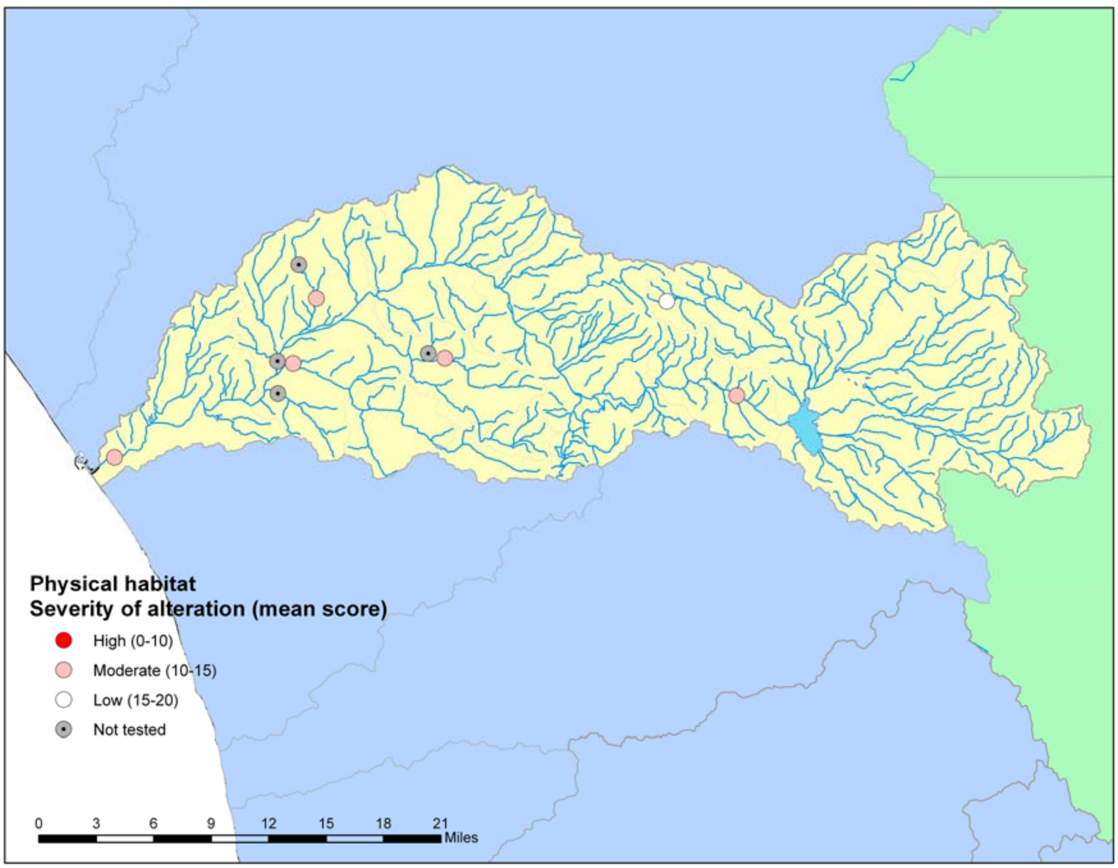


Figure 13. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

5. DISCUSSION

Every site sampled in the San Luis Rey HU showed some evidence of impact (Table 17; Figure 14). For example, exceedence of water quality thresholds, frequent toxicity, and low IBI scores were observed at the upper site on the San Luis Rey River (SLR2 and SLR3). However, severity of impacts varied among sites, suggesting that portions of the watershed are in better condition than others. The frequency of impact varied among indicators suggesting that certain aspects of stream health were more impacted than others. Despite this variability, and despite the limitations of this study (discussed below), data collected by SWAMP and other programs support the conclusion that much of the San Luis Rey watershed is in moderate to poor ecological health.

Some of the most severe impacts were observed near the mouth of the San Luis Rey River (at site SLR8). Water chemistry constituents exceeded nine aquatic life thresholds (for several nutrients, selenium, sulfate, manganese, dissolved oxygen, conductivity, and turbidity) and one human health threshold (nitrate and nitrite-N). Toxicity to all indicators was frequently observed. In fact, all water samples were toxic to *S. capricornutum*, and all sediment samples were toxic to *H. azteca*. Although most components of physical habitat were in moderate or good condition, a few (such as velocity-depth regime and riffle frequency) suggested moderate impairment. Embeddedness of streambed habitat was extreme, scoring 0 out of 20. Although bioassessment samples were not collected within 500 m of this site, samples collected short distances upstream on the mainstem (at Foussat, Mission, and Bennet Roads (sites 5, 6 and 10), as well as at SLR6) were in very poor condition, with IBI scores among the lowest in the entire watershed. No fish tissues were analyzed at this site.

Sites from tributaries in the middle portion of the watershed fared no better. For example, Moosa Creek (located just upstream of SLR6) had as many impacts to water chemistry as SLR8 (i.e., 9 aquatic life threshold exceedances). Furthermore, the constituents affected were nearly identical. Toxicity was similarly pervasive, with all water and sediment samples causing toxicity to *S. capricornutum* and *H. azteca*, respectively. Unlike SLR8, no water samples from Moosa Creek were toxic to *C. dubia*. Physical habitat was in worse condition, with the lowest mean physical habitat score observed in the watershed (10.3, compared to 12.7 at SLR8, and 13.1 at all sites in the watershed). All components scored lower at Moosa Creek than SLR8, except for embeddedness (which scored 0 at both sites) and channel alteration (which scored 15 at both sites). Fish tissue collected at Moosa Creek showed evidence of accumulation of PCBs and some metals (with 14 and 5 constituents detected, respectively).Of the two constituents with applicable health thresholds (i.e., PCBs and selenium), however, neither exceeded OEHHA thresholds.

Two sites on Gird Creek, another mid-watershed tributary, also showed signs of impacts, but generally less severe than those observed at Moosa Creek or SLR8. For example, water chemistry at the upstream site (GRD1) exceeded seven aquatic life thresholds, and the downstream site (GRD2) exceeded five. Like Moosa Creek at the lower mainstem site, nutrients, sulfate, manganese, dissolved oxygen, and conductivity were the source of most impacts. However, the upstream site was unique in the study as having no impacts to ammonia-N levels. Furthermore, selenium was below aquatic life thresholds at the downstream site. Toxicity was severe at both sites, with all water and sediment samples causing toxicity to all indicators. However, like all sites in the San Luis Rey watershed, no samples resulted in acute toxicity to *C. dubia* or *H. azteca.* Physical habitat (assessed only at the downstream site) was slightly degraded, with a mean physical habitat score of 14.7 out of 20. Most (i.e., 7) components of physical habitat were in good condition, with only three components (embeddedness, channel alteration, and velocity-depth regime) scoring below 15. The downstream site in Gird Creek was the only sampled site in the watershed to show evidence of major channel alteration. Biological integrity was poor (mean IBI 13.3) suggesting that despite the relative mildness of impacts suggested by some indicators (e.g., physical habitat), ecological integrity was poor.

Another tributary in this region, Little Gopher Creek (LGC2), was also in poor condition, as suggested by its low IBI scores (mean 24.3). No other indicators were measured at this site.

The most upstream sample on the mainstem (SLR2) was located a few miles below Lake Henshaw, and numerous impacts were observed at this site as well. Several nutrient-related water chemistry constituents exceeded aquatic life thresholds. Turbidity, and pH also exceeded thresholds. All of these constituents were sometimes observed below thresholds, suggesting that impacts did not persist for the entire study. However, toxicity was a more persistent problem: all water samples were toxic to *S. capricornutum,* and all sediment samples caused chronic toxicity to *H. azteca.* Furthermore, one sample caused chronic toxicity to *C. dubia* as well. Although the mean physical habitat score (14.7) suggested only moderate impact, several components were not assessed and were excluded from the mean score calculation. The exclusion of these components may have introduced a bias, because one component (embeddedness) was severely impacted at most sites. Biological integrity was poor, with a mean IBI score of 28.8. Releases of water from Lake Henshaw may have impacted this site by introducing an unnatural flow regime with frequent spates with little opportunity for recovery. Biological integrity, water chemistry, and other indicators are very sensitive to dam operation, and minimizing deviations from natural flow regimes can greatly improve the ecological health of a stream (Bednarek and Hart 2005).

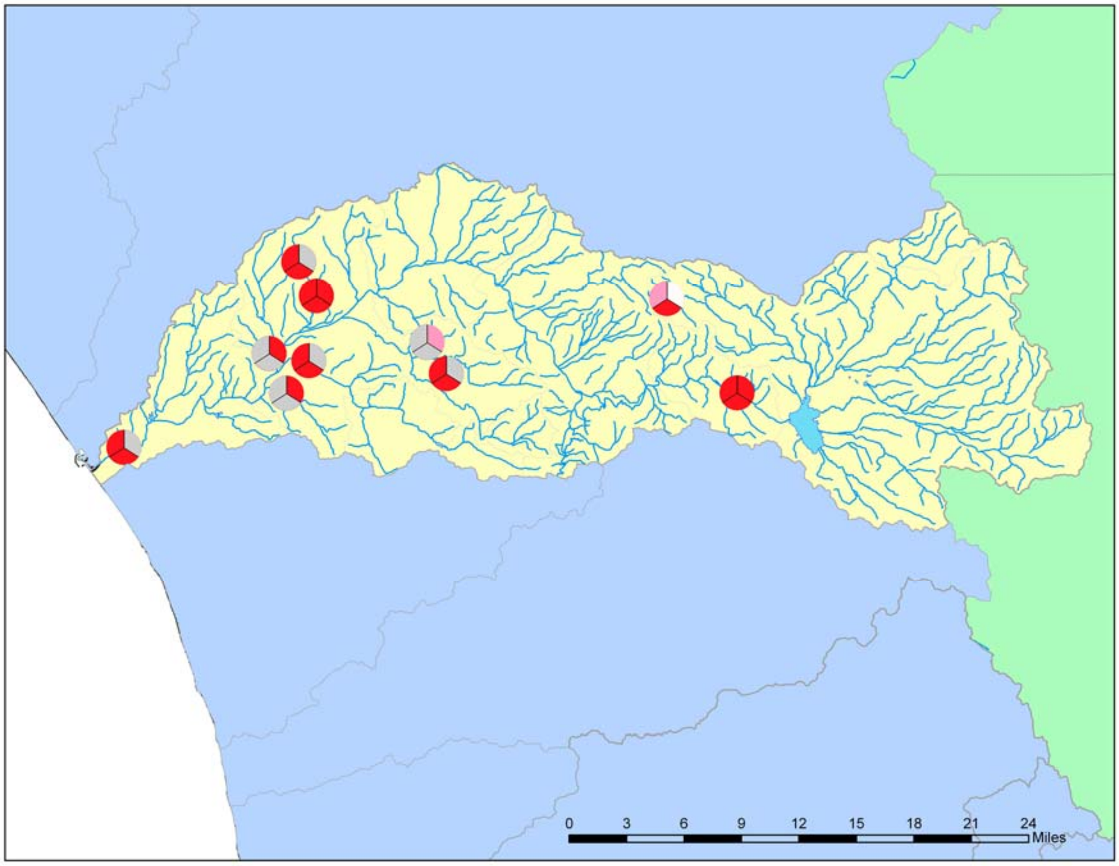
Iron Springs Creek was in better ecological condition than the other sites in the watershed by all indicators measured, although some impacts were observed. Only three nutrients exceeded aquatic life thresholds, and only on one sampling date. Unlike all other sites in the watershed, no physical measure of water quality (e.g., pH, turbidity, dissolved oxygen) exceeded aquatic life standards. Toxicity was also frequently observed, but less so than all other sites in the watershed. No sample was toxic to *C. dubia,* and one of two sediment samples resulted in chronic toxicity to *H. azteca*. All samples were toxic to *S. capricornutum.* Physical habitat at Iron Springs was good, with a mean score of

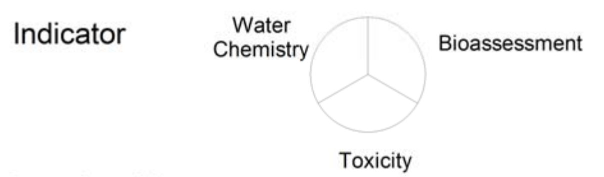
15.3, although a few components indicated moderate impacts (velocity-depth regime, bank stability, and vegetation protection). A high IBI score (60) suggested that the biological integrity of the stream was good. Bioassessment samples collected from other nearby drainages on the eastern side of Palomar Mountain (i.e., Fry Creek (site 1), Doane Creek (site 9)) were also in fair or better condition, suggesting that biological integrity was good in this region of the watershed. However, other sites on Palomar Mountain (i.e., further down the eastern slope at the West Fork of the San Luis Rey River (site 8), and French Creek (site 2) on the western slope) were in poor condition.

Table 17. Summary of the ecological health for ten SWAMP sites in San Luis Rey 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		Toxicity	Fish Tissue	IBI	Physical Habitat
	Description	# constituents Aquatic life	# constituents Human health	Frequency	# constituents	Frequency	Mean score
903SLGRD1	Gird Creek 1	7	1	1.00	n.t.	n.t.	n.t.
903SLGRD2	Gird Creek 2	5	2	1.00	n.t.	1.00	14.7
903SLIRS2	Iron Springs Creek 2	3	0	0.50	n.t.	0.00	15.3
903SLKYS3	Keys Creek 3	10	0	0.69	n.t.	n.t.	11.9
903SLMSA2	Moosa Creek 2	9	0	0.64	0	n.t.	10.3
903SLSLR2	San Luis Rey River 2	6	0	0.70	n.t.	0.92*	14.7
903SLSLR6	San Luis Rey River 6	n.t.	n.t.	n.t.	n.t.	1.00	n.t.
903SLSLR8	San Luis Rey River 8	9	1	0.70	n.t.	n.t.	12.7
903SLWVR1	Weaver Creek	n.t.	n.t.	n.t.	n.t.	0.27*	n.t.
903SLLGC2	Little Gopher Canyon Creek	n.t.	n.t.	n.t.	n.t.	1.00	n.t.

* = Includes data collected at nearby (within 500 meters) non-SWAMP sites





Severity of impact

Severity	Water chemistry (# aquatic life exceedences)	Toxicity (Frequency of toxicity)	Bioassessment (IBI Score)
Low	0-1	0.0-0.1	60-100
Moderate	2-5	0.1-0.5	40-60
High	6+	0.5-1.0	0-40
Not tested			

Figure 14. Summary of the ecological health of SWAMP sites in the San Luis Rey 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 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.

This study's assessment of the San Luis Rey HU suggested that parts of the watershed were in poor ecological health, although the condition is better on the eastern slope of Palomar Mountain. Multiple lines of evidence support this conclusion. For example, several water chemistry constituents exceeded aquatic life thresholds, toxicity was observed at every site, and bioassessment of macroinvertebrate communities were in poor or very poor condition at every sampling event.

Although these impacts were widespread, and in some cases severe, this study showed that, at least for water chemistry indicators, impacts were limited to certain constituents, such as nutrients and physical parameters. In contrast, all metals (except manganese and copper) were below applicable thresholds at every site, as were all pesticides. Furthermore, fish tissues did not exceed any thresholds.

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 fundamental finding that the San Luis Rey watershed is in poor health, as explained at the end of this section.

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 six years before 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).

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; therefore, tissue contamination may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the San Luis Rey 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 the San Luis Rey HU is 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 some of the likely causes of 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.

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7. APPENDICES

APPENDIX I

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

A. Beneficial uses of streams in the San Luis Rey HU.

San Luis Rey River	HUC	MUN	AGR	IND	FRSH	POW	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
San Luis Rey River	903.32	E	E	E	E	E	E	E	E	E	E		
Johnson Canyon	903.32	E	E	E	E	E	E	E	E	E	E		
San Luis Rey River	903.31	E	E	E	E	E	E	E	E	E	E		
Canada Aguanga	903.31	E	E	E	E	E	E	E	E	E	E		
Dark Canyon	903.31	E	E	E	E	E	E	E	E	E	E		
Bear Canyon	903.31	E	E	E	E	E	E	E	E	E	E		
Cow Canyon	903.31	E	E	E	E	E	E	E	E	E	E		
Blue Canyon	903.31	E	E	E	E	E	E	E	E	E	E		
Rock Canyon	903.31	E	E	E	E	E	E	E	E	E	E		
Agua Caliente Creek	903.31	E	E	E	E	E	E	E	E	E	E		
Unnamed tributary	903.31	E	E	E	E	E	E	E	E	E	E		E
Canada Agua Caliente	903.31	E	E	E	E	E	E	E	E	E	E		
Canada Verde	903.31	E	E	E	E	E	E	E	E	E	E		
Ward Canyon	903.31	E	E	E	E	E	E	E	E	E	E		
West Fork San Luis Rey River	903.31	E	E	E	E	E	E	E	E	E	E		E
Fry Creek	903.31	E	E	E	E	E	E	E	E	E	E		
Iron Springs Creek	903.31	E	E	E	E	E	E	E	E	E	E		E
Buena Vista Creek	903.31	E	E	E	E	E	E	E	E	E	E		
Cherry Canyon	903.31	E	E	E	E	E	E	E	E		E		
Bertha Canyon	903.31	E	E	E	E	E	E	E	E		E		
Hoover Canyon	903.31	E	E	E	E	E	E	E	E		E		
Buck Canyon	903.31	E	E	E	E	E	E	E	E		E		
Bergstrom Canyon	903.31	E	E	E	E	E	E	E	E		E		
San Ysidro Creek	903.31	E	E	E	E	E	E	E	E		E		
Matagual Creek	903.31	E	E	E	E	E	E	E	E	E	E		
Carrizo Creek	903.31	E	E	E	E	E	E	E	E	E	E		
Carrista Creek	903.31	E	E	E	E	E	E	E	E		E		
Kumpohui Creek	903.31	E	E	E	E	E	E	E	E		E		
San Luis Rey River	903.31	E	E	E	E	E	E	E	E	E	E		E
San Luis Rey River	903.23	E	E	E		E	E	E	E	E	E		
Wigham Creek	903.23	E	E	E		E	E	E	E	E	E		
Prisoner Creek	903.23	E	E	E		E	E	E	E	E	E		
Lusardi Creek	903.23	E	E	E		E	E	E	E	E	E		
Cedar Creek	903.23	E	E	E		E	E	E	E	E	E		
San Luis Rey River	903.22	E	E	E		E	E	E	E	E	E		
Bee Canyon	903.22	E	E	E		E	E	E	E	E	E		
Paradise Creek	903.22	E	E	E		E	E	E	E	E	E		
Hell Creek	903.22	E	E	E		E	E	E	E	E	E		
Horsethief Canyon	903.22	E	E	E		E	E	E	E	E	E		
Potrero Creek	903.22	E	E	E		E	E	E	E	E	E		
Plaisted Creek	903.22	E	E	E		E	E	E	E	E	E		
Yuima Creek	903.22	E	E	E		E	E	E	E	E	E		
Sycamore Creek	903.22	E	E	E		E	E	E	E	E	E		
Pauma Creek	903.22	E	E	E		E	E	E	E	E	E		E
Doane Creek	903.22	E	E	E		E	E	E	E	E	E		E
Chimney Creek	903.22	E	E	E		E	E	E	E	E	E		
French Creek	903.22	E	E	E		E	E	E	E	E	E		E
Lion Creek	903.22	E	E	E		E	E	E	E	E	E		E
Harrison Canyon	903.22	E	E	E		E	E	E	E	E	E		
Jaybird Creek	903.22	E	E	E		E	E	E	E	E	E		
Frey Creek	903.22	E	E	E		E	E	E	E	E	E		
Agua Tibia Creek	903.22	E	E	E		E	E	E	E	E	E		E

Appendix 1a, continued. Beneficial uses in the San Luis Rey HU.

San Luis Rey River	HUC	MUN	AGR	IND	FRSH	POW	REC1	REC2	WARM	COLD	WILD	RARE	SPWN
San Luis Rey River	903.21	E	E	E			E	E	E	E	E		
Marion Canyon	903.21	E	E	E			E	E	E	E	E		
Magee Creek	903.21	E	E	E			E	E	E	E	E		
Castro Canyon	903.21	E	E	E			E	E	E	E	E		
Trujillo Creek	903.21	E	E	E			E	E	E	E	E		
Pala Creek	903.21	E	E	E			E	E	E	E	E		E
Gomez Creek	903.21	E	E	E			E	E	E	E	E		
Couser Canyon	903.21	E	E	E			E	E	E	E	E		
Double Canyon	903.21	E	E	E			E	E	E	E	E		
Rice Canyon	903.21	E	E	E			E	E	E	E	E		
San Luis Rey River	903.12	X	E	E			E	E	E		E	E	
Keys Creek	903.12	X	E	E			E	E	E		E		
Moosa Canyon	903.15	X	E	E			E	E	E		E		
Unnamed tributary	903.16	X	E	E			E	E	E		E		
Moosa Canyon	903.14	X	E	E			E	E	E		E		
Moosa Canyon	903.13	X	E	E			E	E	E		E		
South Fork Moosa Canyon	903.13	X	E	E			E	E	E		E		
Moosa Canyon	903.12	X	E	E			E	E	E		E		
Gopher Canyon	903.12	X	E	E			E	E	E		E		
South Fork Gopher Canyon	903.12	X	E	E			E	E	E		E		
San Luis Rey River	903.11	X	E	E			E	E	E		E	E	
Pilgrim Creek	903.11	X	E	E			E	E	E	E	E	E	
Windmill Canyon	903.11	X	E	E			E	E	E	E	E		
Tuley Canyon	903.11	X	E	E			E	E	E		E		
Lawrence Canyon	903.11	X	E	E			E	E	E		E		

B. 303(d)-listed streams in the San Luis Rey HU.

Name	HUC	Stressor	Potential Source	Affected Length
San Luis Rey River	903.11	Chloride	Urban runoff/storm sewers	13 miles
			Unknown nonpoint source	19 miles
			Unknown point source	19 miles
		Total dissolved solid	Industrial point sources	19 miles
			Agriculture-storm runoff	19 miles
			Urban runoff/storm sewers	19 miles
			Surface mining	19 miles
			Flow regulation/modification	19 miles
			Natural sources	19 miles
			Golf course activities	19 miles
			Unknown nonpoint source	19 miles
			Unknown point source	19 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 2002. Non-SWAMP sites were monitored in Spring and Fall between 2002 and 2005.

A. SWAMP sites.

			903SLGRD1			903SLGRD2			903SLIRS2			903SLKYS3			903SLMSA2			903SLSLR2			903SLSLR8		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Bacteria	Enterococcus	MPN/100 ml			0			0			0	93		1			0			0			0
Bacteria	Fecal Coliform	MPN/100 ml			0			0			0	170		1			0			0			0
Bacteria	Total Coliform	MPN/100 ml			0			0			0	1600		1			0			0			0
Inorganics	Alkalinity as CaCO3	mg/L	252	7.57	3	218		1	46.8	21	4	241	16	5	223	35	4	146	26	4	277	64.5	4
Inorganics	Ammonia as N	mg/L	--	0	3	0.06		1	0.01	0	4	0.02	0	5	0.07	0.1	4	0.09	0.1	4	0.1	0.07	4
Inorganics	Chloride	mg/L	243		1			0	6.09		1			0			0	37		1			0
Inorganics	Nitrate as NO3	mg/L	15.9	1.8	3	7.05		1	0.03	0	4	9.05	2	5	4.83	2.4	4	0.22	0.2	4	1.8	2	4
Inorganics	Nitrite as N	mg/L	0.03	0.01	3	0.05		1	--	0	4	0.03	0	5	0.06	0	4	0.06	0.1	4	0.01	0.01	4
Inorganics	Nitrogen, Total Kjeldahl	mg/L	--	0	3	1.27		1	0.38	0.4	4	0.59	0.3	5	2	2.5	4	1.31	1.2	4	0.84	0.35	4
Inorganics	o-phosphate as P	mg/L			0			0			0	31		1			0			0			0
Inorganics	Phosphorus as P,Total	mg/L	0.14	0.07	3	0.23		1	0.07	0.1	4	0.08	0.1	5	0.52	0.4	4	0.17	0.1	4	0.31	0.15	4
Inorganics	Selenium,Dissolved	µg/L	6.37	4.48	3	2.38		1	0.82	0.6	4	7.9	7.1	4	5.32	4.7	4	2.48	1.5	4	7.31	5.97	4
Inorganics	Sulfate	mg/L	598	57.1	3	557		1	8.96	1.8	4	671	105	5	461	107	4	71.2	40	4	420	73	4
Metals	Aluminum,Dissolved	µg/L	2.23	1.48	3	0.64		1	13.3	9.8	4	3.96	3.4	5	5.13	3.2	4	10.8	6.1	4	1.42	1.31	4
Metals	Arsenic,Dissolved	µg/L	1.24	0.63	3	1.37		1	0.15	0.1	4	1.34	0.5	5	1.7	1.1	4	1.44	0.9	4	2.02	0.91	4
Metals	Cadmium,Dissolved	µg/L	0.03	0.01	3	0.05		1	0	0	4	0.03	0	5	0.05	0	4	0.04	0	4	0.04	0.01	4
Metals	Chromium,Dissolved	µg/L	0.41	0.09	3	0.11		1	0.11	0.1	4	0.42	0.4	5	0.42	0.3	4	0.39	0.5	4	0.29	0.17	4
Metals	Copper,Dissolved	µg/L	6.94	0.34	3	4.16		1	0.56	0.2	4	6.09	3.1	5	4.1	0.9	4	2.56	2.3	4	4.13	0.79	4
Metals	Lead,Dissolved	µg/L	0.08	0.06	3	0.02		1	0.08	0.1	4	0.03	0	5	0.07	0	4	0.05	0	4	0.05	0.02	4
Metals	Manganese,Dissolved	µg/L	44	26.7	3	37		1	27.3	13	4	30.5	34	5	37.9	26	4	82.3	60	4	605	472	4
Metals	Nickel,Dissolved	µg/L	0.93	1.62	3	--		1	0.31	0.2	4	2.75	4.2	5	0.18	0.3	4	0.82	1.6	4	0.62	1.24	4
Metals	Silver,Dissolved	µg/L	--	0	3	--		1	--	0	4	0.34	0.8	5	--	0	4	--	0	4	--	0	4
Metals	Zinc,Dissolved	µg/L	5.56	0.59	3	3.4		1	0.25	0.1	4	3.34	2.2	5	2.75	1.2	4	1.42	1.9	4	2.55	0.2	4
PAHs	Acenaphthene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Acenaphthylene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	alpha-BHC	µg/L			0			0			0	--		1			0			0			0
PAHs	Anthracene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Benz(a)anthracene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Benzo(a)pyrene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Benzo(b)fluoranthene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Benzo(e)pyrene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Benzo(g,h,i)perylene	µg/L	0	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Benzo(k)fluoranthene	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	beta-BHC	µg/L			0			0			0	--		1			0			0			0
PAHs	Biphenyl	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Chrysene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Chrysenes, C1 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Chrysenes, C2 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Chrysenes, C3 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	delta-BHC	µg/L			0			0			0	--		1			0			0			0
PAHs	Dibenz(a,h)anthracene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Dibenzothiophene	µg/L	--	0	3	--		1	0	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Dibenzothiophenes, C1 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Dibenzothiophenes, C2 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Dibenzothiophenes, C3 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Dichlofenthion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	0	0	4	--	0	4
PAHs	Dimethylphenanthrene, 3,6-	µg/L	--	0	3			0	--	0	3	--	0	3	--	0	3	--	0	3	--	0	3
PAHs	Fluoranthene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Fluorene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Fluorenes, C1 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Fluorenes, C2 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Fluorenes, C3 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	gamma-BHC (Lindane)	µg/L			0			0			0	--		1			0			0			0
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Methyldibenzothiophene, 4-	µg/L	--	0	3			0	--	0	3	--	0	3	--	0	3	--	0	3	--	0	3
PAHs	Methylfluoranthene, 2-	µg/L	--	0	3			0	--	0	3	--	0	3	--	0	3	--	0	3	--	0	3
PAHs	Methylfluorene, 1-	µg/L	--	0	3			0	--	0	3	--	0	3	--	0	3	--	0	3	--	0	3
PAHs	Methylnaphthalene, 1-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Methylnaphthalene, 2-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Methylphenanthrene, 1-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4

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

			903SLGRD1			903SLGRD2			903SLIRS2			903SLKYS3			903SLMSA2			903SLSLR2			903SLSLR8		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Naphthalene	µg/L	--	0	3	--		1	--	0	4	--	0	5	0	0	4	--	0	4	--	0	4
PAHs	Naphthalenes, C1 -	µg/L	--	0	3	0.01		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Naphthalenes, C2 -	µg/L	--	0	3	0.01		1	--	0	4	--	0	4	0	0	4	0	0	4	--	0	4
PAHs	Naphthalenes, C3 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Naphthalenes, C4 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Perylene	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Phenanthrene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PAHs	Pyrene	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 005	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 008	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 015	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 018	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 027	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 028	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 029	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 031	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 033	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 044	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 049	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 052	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 056	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 060	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 066	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 070	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 074	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 087	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 095	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 097	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 099	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 101	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 105	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 110	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 114	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 118	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 128	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 137	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 138	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 141	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 149	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 151	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 153	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 156	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 157	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 158	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 170	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 174	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 177	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 180	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 183	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 187	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 189	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 194	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 195	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 200	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 201	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 203	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 206	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB 209	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
PCBs	PCB-1016	µg/L			0			0			0	--		1			0			0			0
PCBs	PCB-1221	µg/L			0			0			0	--		1			0			0			0
PCBs	PCB-1232	µg/L			0			0			0	--		1			0			0			0
PCBs	PCB-1242	µg/L			0			0			0	--		1			0			0			0
PCBs	PCB-1248	µg/L			0			0			0	--		1			0			0			0
PCBs	PCB-1254	µg/L			0			0			0	--		1			0			0			0
PCBs	PCB-1260	µg/L			0			0			0	--		1			0			0			0

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

			903SLGRD1			903SLGRD2			903SLIRS2			903SLKYS3			903SLMSA2			903SLSLR2			903SLSLR8		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticide	Toxaphene	µg/L			0			0			0	--		1			0			0			0
Pesticides	Aldrin	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Ametryn	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Aspon	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Atraton	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Atrazine	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	0.05	0.1	4
Pesticides	Azinphos ethyl	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Azinphos methyl	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Bolstar	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Carbophenothion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Chlordane (tech)	µg/L			0			0			0	--		1			0			0			0
Pesticides	Chlordane, cis-	µg/L	--	0	3	0		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Chlordane, trans-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Chlordene, alpha-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Chlordene, gamma-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Chlorfenvinphos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Chlorpyrifos	µg/L	--	3	0	--		0	--	4	0	--	4	0	--	4	0	--	4	0	--	4	0
Pesticides	Chlorpyrifos methyl	µg/L	--	0	3			1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Ciodrin	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Coumaphos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Dacthal	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	DDD(o,p')	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	DDD(p,p')	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	DDE(o,p')	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	DDE(p,p')	µg/L	--	0	3	0		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	DDMU(p,p')	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	DDT(o,p')	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	DDT(p,p')	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Demeton-s	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Diazinon	µg/L	--	0	3	--		1	--	0	4	--	0	4	0	0	4	--	0	4	0	0.01	4
Pesticides	Dichlorvos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Dicrotophos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Dieldrin	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Dimethoate	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Dioxathion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Disulfoton	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Endosulfan I	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Endosulfan II	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Endosulfan sulfate	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Endrin Aldehyde	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Endrin Ketone	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Endrin	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Ethion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Ethoprop	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Famphur	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Fenchlorphos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Fenitrothion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Fensulfothion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Fenthion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Fonofos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	HCH, alpha	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	HCH, beta	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	HCH, delta	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	HCH, gamma	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Heptachlor epoxide	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Heptachlor	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Hexachlorobenzene	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Leptophos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Malathion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Merphos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Methidathion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Methoxychlor	µg/L	--	0	3	--		1	--	0	4	--	0	5	--	0	4	--	0	4	--	0	4
Pesticides	Mevinphos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Mirex	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Molinate	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Naled	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Nonachlor, cis-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Nonachlor, trans-	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4

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

			903SLGRD1			903SLGRD2			903SLIRS2			903SLKYS3			903SLMSA2			903SLSLR2			903SLSLR8		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Oxadiazon	µg/L	0.01	0.01	3	--		1	--	0	4	0	0	4	0	0	4	--	0	4	0.02	0.01	4
Pesticides	Oxychlordane	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Parathion, Ethyl	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Parathion, Methyl	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Phorate	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Phosmet	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Phosphamidon	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Prometon	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Prometryn	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Propazine	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Secbumeton	µg/L	--	0	3	--		1	0.01	0	4	0.01	0	4	--	0	4	0.01	0	4	--	0	4
Pesticides	Simazine	µg/L	--	0	3	--		1	--	0	4	0.01	0	4	--	0	4	--	0	4	0.1	0.13	4
Pesticides	Simetryn	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Sulfotep	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Tedion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Terbufos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Terbuthylazine	µg/L	--	0	3	0.03		1	0.01	0	4	--	0	4	0.01	0	4	0.01	0	4	0.01	0.02	4
Pesticides	Terbutryn	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Tetrachlorvinphos	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Thiobencarb	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Thionazin	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Tokuthion	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Trichlorfon	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Pesticides	Trichloronate	µg/L	--	0	3	--		1	--	0	4	--	0	4	--	0	4	--	0	4	--	0	4
Physical	Oxygen, Dissolved	mg/L	7.11	5.39	3	9.48		1	11.5	3.9	4	9.7	1.8	4	10.4	5	4	10.2	1.9	4	7.17	3.34	4
Physical	Oxygen, Saturation	%	70.8	53.2	3	109		1	108	36	4	103	24	4	113	63	4	108	25	4	74.1	34.2	4
Physical	pH	pH units	7.63	0.19	3	7.97		1	7.3	0.5	4	7.91	0.2	4	7.93	0.4	4	7.68	0.3	4	7.49	0.32	4
Physical	Salinity	ppt	1.07	0.02	3	1.12		1	0.05	0	4	1.42	0.2	4	1.07	0.2	4	0.29	0.1	4	1.08	0.25	4
Physical	Specific conductivity	µS/cm	1808	258	3	2184		1	87.8	69	4	2591	512	4	1930	604	4	561	191	4	2025	438	4
Physical	Suspended Solids,Total	mg/L	51.7	68.2	3	56.7		1	5.5	11	4	52.7	93	5	96	163	4	28.7	27	4	29.6	36.1	4
Physical	Temperature	ºC	16.1	2.69	3	21.4		1	13.3	6.3	4	18.1	4.4	4	19	4.8	4	17.4	5.7	4	17.4	1.9	4
Physical	Turbidity	NTU	8.77	7.63	3	2.9		1	3.29	1.5	4	24.1	39	4	7.53	7.4	4	9.67	14	4	20.2	22.5	4
Physical	Velocity	ft/sec	1.37		1			0	0.63	0.9	2	2.01		1	2.37		1	2.03	0.3	3	--		1

B. Non-SWAMP sites.

	Site 3 (REF-KC)			Site 6 (SLRR-MR)			Site 9 (REF-DC)			Site 10 (SLRR-BR)		
Constituent	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Dissolved Oxygen (mg/l)	9.5	1.3	2	9.2	0.9	7	10.4	0.5	3	7.0	2.4	7
pH	8.2	0.4	2	8.0	0.2	7	7.6	0.5	3	7.8	0.2	7
Specific Conductivity (mS/cm)	2.35	0.07	2	2.31	0.43	7	0.26	0.09	3	2.31	0.49	7
Turbidity (NTU)			0	18.4		1			0	13.5		1
Water Tempurature (ºC)	14.8	1.8	2	16.9	0.7	7	10.1	2.2	3	17.8	1.0	7

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*		
	Sampling	Survival			Young / Female			Survival			Growth			Total cell count		
Site	events	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
903SLGRD1	3	3	97	6	3	34	6	1	109		1	88		3	67	15
903SLGRD2	1	1	100		1	72		1	101		1	114		1	77	
903SLIRS2	4	4	98	10	4	92	11	2	99	9	2	80	1	4	113	37
903SLKYS3	5	5	98	4	5	69	25	3	110	5	3	102	12	5	81	60
903SLMSA2	4	4	98	5	4	85	3	3	106	3	3	101	35	4	87	37
903SLSLR2	4	4	100	9	4	95	16	2	107	5	2	99	4	4	99	61
903SLSLR8	4	4	100	0	4	90	25	2	108	3	2	94	12	4	54	47
All sites in watershed	25	25	98	6	25	79	25	14	106	5	14	97	18	25	80	41

APPENDIX IV

Concentrations of metals, PCBs, and pesticides in each replicate fish collected from two sites in the San Luis Rey HU. -- = Constituent not detected. Blank cells indicate that the constituent concentration was not analyzed. No constituent exceeded OEHHA standards.

Category	Constituent	Unit	Threshold	Detected in sample	Category	Constituent	Unit	Threshold	Detected in sample
Metals	Aluminum	ppm		--	PCBs	PCB 101	ng/g		0.300
Metals	Arsenic	ppm		--	PCBs	PCB 105	ng/g		0.120
Metals	Cadmium	ppm		--	PCBs	PCB 110	ng/g		0.340
Metals	Chromium	ppm		0.16	PCBs	PCB 114	ng/g		--
Metals	Copper	ppm		0.22	PCBs	PCB 118	ng/g		0.340
Metals	Lead	ppm		--	PCBs	PCB 128	ng/g		--
Metals	Manganese	ppm		1.3	PCBs	PCB 137	ng/g		--
Metals	Nickel	ppm		0.071	PCBs	PCB 138	ng/g		0.310
Metals	Silver	ppm		--	PCBs	PCB 141	ng/g		--
Metals	Zinc	ppm		7.2	PCBs	PCB 149	ng/g		0.120
Inorganics	Selenium	ppm	1.94	0.21	PCBs	PCB 151	ng/g		--
PCBs	PCB 008	ng/g		--	PCBs	PCB 153	ng/g		0.230
PCBs	PCB 018	ng/g		--	PCBs	PCB 156	ng/g		--
PCBs	PCB 027	ng/g		--	PCBs	PCB 157	ng/g		--
PCBs	PCB 028	ng/g		--	PCBs	PCB 158	ng/g		--
PCBs	PCB 029	ng/g		--	PCBs	PCB 170	ng/g		--
PCBs	PCB 031	ng/g		--	PCBs	PCB 174	ng/g		--
PCBs	PCB 033	ng/g		--	PCBs	PCB 177	ng/g		--
PCBs	PCB 044	ng/g		0.120	PCBs	PCB 180	ng/g		--
PCBs	PCB 049	ng/g		--	PCBs	PCB 183	ng/g		--
PCBs	PCB 052	ng/g		0.160	PCBs	PCB 187	ng/g		--
PCBs	PCB 056	ng/g		--	PCBs	PCB 189	ng/g		--
PCBs	PCB 060	ng/g		--	PCBs	PCB 194	ng/g		--
PCBs	PCB 066	ng/g		0.160	PCBs	PCB 195	ng/g		--
PCBs	PCB 070	ng/g		0.290	PCBs	PCB 200	ng/g		--
PCBs	PCB 074	ng/g		--	PCBs	PCB 201	ng/g		--
PCBs	PCB 087	ng/g		0.280	PCBs	PCB 203	ng/g		--
PCBs	PCB 095	ng/g		0.180	PCBs	PCB 206	ng/g		--
PCBs	PCB 097	ng/g		--	PCBs	PCB 209	ng/g		--
PCBs	PCB 099	ng/g		0.100	PCBs	PCBs	ng/g	20	3.05

APPENDIX V

Mean IBI and metric scores for bioassessment sites in the San Luis Rey 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. Ecor = Ecoregion used for calculation of the IBI. CH = Southern and Central California Chaparral and Oak Woodlands. MT = Southern California Mountains.

					IBI		EPT Taxa		Coleoptera Taxa		Predator Taxa		% Collectors		% Intolerant		% Non-insect Taxa		% Tolerant Taxa	
Site	Ecor.	Season	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SWAMP sites																				
903SLGRD2	CH	Spring	3	2003-2006	23.8	13.3	1.7	0.6	2.0	2.0	3.0	3.0	4.0	2.6	1.3	0.6	3.0	2.0	1.7	1.5
903SLIRS2	MT	Spring	1	2004	60.0		9.0		4.0		10.0		7.0		4.0		4.0		4.0	
903SLLGC2	CH	Spring	2	2003-2006	24.3	6.1	2.0	1.4	1.0	1.4	4.0	1.4	3.0	2.8	1.0	0.0	3.0	1.4	3.0	1.4
903SLSLR2	MT	Average	12	1998-2006	28.8	2.4	1.8	1.1	3.8	0.2	2.8	0.2	0.8	0.3	0.4	0.5	4.2	0.3	6.3	0.0
		Fall	3	1998-2000	27.1	8.7	1.0	0.0	3.7	1.5	3.0	2.0	1.0	1.0	0.0	0.0	4.0	1.0	6.3	2.1
		Spring	9	1998-2006	30.5	10.9	2.6	1.5	4.0	2.4	2.7	2.2	0.6	0.5	0.8	1.1	4.4	1.7	6.3	1.8
903SLSLR6	CH	Spring	1	2003	10.0		1.0		0.0		2.0		0.0		0.0		3.0		1.0	
903SLWVR1	CH	Average	11	1998-2002	43.9	0.9	3.9	0.6	2.1	0.9	4.9	0.9	5.6	1.6	3.8	0.7	5.1	0.5	5.3	0.1
		Fall	4	1998-2002	43.2	17.0	3.5	1.0	1.5	1.9	4.3	3.9	6.8	3.2	4.3	4.0	4.8	1.7	5.3	1.5
		Spring	7	1998-2002	44.5	10.2	4.3	1.3	2.7	1.7	5.6	1.5	4.4	1.7	3.3	1.5	5.4	1.8	5.4	1.9
Non-SWAMP sites																				
Site 1	MT	Spring	2	2001-2005	52.1	11.1	2.5	2.1	5.0	7.1	7.5	3.5	3.5	0.7	4.5	0.7	7.0	1.4	6.5	3.5
		Average	4	2000-2005	33.6	7.1	4.3	0.9	3.7	2.4	2.8	2.6	2.2	0.2	1.0	0.0	4.8	0.2	4.7	0.9
		Fall	1	2000	28.6		5.0		2.0		1.0		2.0		1.0		5.0		4.0	
Site 2	MT	Spring	3	2001-2005	38.6	7.6	3.7	1.2	5.3	1.5	4.7	1.5	2.3	0.6	1.0	1.0	4.7	3.1	5.3	2.3
Site 4	CH	Average	7	1998-2001	20.8	6.0	2.1	0.6	3.5	2.1	4.0	1.4	2.5	1.5	0.0	0.0	1.1	0.8	1.5	0.7
		Fall	2	1998-1999	25.0	11.1	2.5	0.7	5.0	4.2	5.0	2.8	3.5	0.7	0.0	0.0	0.5	0.7	1.0	1.4
		Spring	5	1998-2001	16.6	19.2	1.6	1.1	2.0	4.5	3.0	3.5	1.4	2.1	0.0	0.0	1.6	2.3	2.0	2.1
Site 5	CH	Average	5	1998-1999	17.5	6.6	1.6	0.1	1.2	0.2	3.0	0.0	4.0	2.8	0.0	0.0	0.6	0.1	1.9	2.2
		Fall	2	1998-1999	22.1	13.1	1.5	2.1	1.0	1.4	3.0	4.2	6.0	5.7	0.0	0.0	0.5	0.7	3.5	4.9
		Spring	3	1998-1999	12.9	10.3	1.7	0.6	1.3	2.3	3.0	2.6	2.0	1.7	0.0	0.0	0.7	0.6	0.3	0.6
Site 6	CH	Average	15	1998-2005	15.8	0.8	1.6	0.1	1.6	0.6	3.0	1.1	1.6	1.6	0.1	0.1	1.1	0.4	2.1	1.1
		Fall	6	1998-2004	16.4	14.2	1.7	1.0	1.2	2.0	3.8	4.1	2.7	2.7	0.0	0.0	0.8	1.6	1.3	1.5
		Spring	9	1998-2005	15.2	12.3	1.6	1.0	2.0	2.8	2.2	2.6	0.4	0.9	0.1	0.3	1.4	1.9	2.9	2.0
Site 8	MT	Spring	1	2005	35.7		0.0		4.0		3.0		0.0		1.0		8.0		9.0	
Site 9	CH	Average	3	2004-2005	85.0	1.0	9.3	0.4	6.8	1.8	6.8	2.5	10.0	0.0	10.0	0.0	8.3	0.4	8.5	0.7
		Fall	1	2004	84.3		9.0		8.0		5.0		10.0		10.0		8.0		9.0	
		Spring	2	2004-2005	85.7	8.1	9.5	0.7	5.5	2.1	8.5	2.1	10.0	0.0	10.0	0.0	8.5	0.7	8.0	0.0
Site 10	CH	Average	7	2002-2005	9.7	9.2	0.7	0.5	0.0	0.0	0.3	0.5	3.1	4.1	0.0	0.0	1.7	1.4	1.0	1.0
		Fall	3	2002-2004	16.2	2.2	0.3	0.6	0.0	0.0	0.7	1.2	6.0	4.0	0.0	0.0	2.7	1.5	1.7	2.9
		Spring	4	2002-2005	3.2	3.6	1.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.0	0.0	0.8	1.5	0.3	0.5