Final Technical Report	2008

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

January 2008

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

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Prepared for the California Regional Water Quality Control Board, San Diego Region (Region 9).

This project was funded by the Surface Water Ambient Monitoring Program.

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1. ABSTRACT

In order to assess the ecological health of the Sweetwater Hydrologic Unit (San Diego County, CA), water chemistry, water and sediment toxicity, and benthic macroinvertebrate communities were assessed at multiple sites. Water chemistry and toxicity were assessed under SWAMP in 2005 and 2006. Bioassessment samples were collected under other programs between 1998 and 2005. 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 the ecological indicators showed evidence of widespread impacts to the watershed. For example, all sites (n = 4) exceeded aquatic life thresholds for several water chemistry constituents (up to nine at one site). Toxicity was evident at all sites. Bioassessment samples collected at 10 sites were all in poor or very poor condition with mean annual IBIs ranging from 2.9 to 57.6, indicating that benthic assemblages were typical of impacted communities. However, some samples from three sites in the upper watershed were in fair, good, or very good condition. In general, sites in urban areas were in worse condition than those in the central or upper parts of the hydrologic unit. Multiple stressors, such as contaminated water and sediment, and alteration of physical habitat, are 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 the lower Sweetwater watershed is in poor ecological condition.

2. INTRODUCTION

The Sweetwater hydrologic unit (HU 909) is in San Diego County and is home to about 350,000 people and represents an important water resource in one of the most arid regions of the nation. Despite strong interest in the surface waters of the Sweetwater HU, a comprehensive assessment of the ecological health of these waters has not been conducted. The purpose of this study was to assess the health of the watershed using data collected in 2005 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 (Table 1). These programs collected data to describe water chemistry, water and sediment toxicity, physical habitat, and macroinvertebrate community structure. By examining data from multiple sources, this report provides a measure of the ecological integrity of the Sweetwater HU.

Table 1. Watersheds monitored under the SWAMP program.

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

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

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

2.1 Geographic Setting

The Sweetwater HU a major watersheds of San Diego Bay (Figure 1). Located entirely within San Diego County, the watershed covers 230 mi^2 and ranges from Cuyamaca Mountains in the interior to the Pacific Coast.

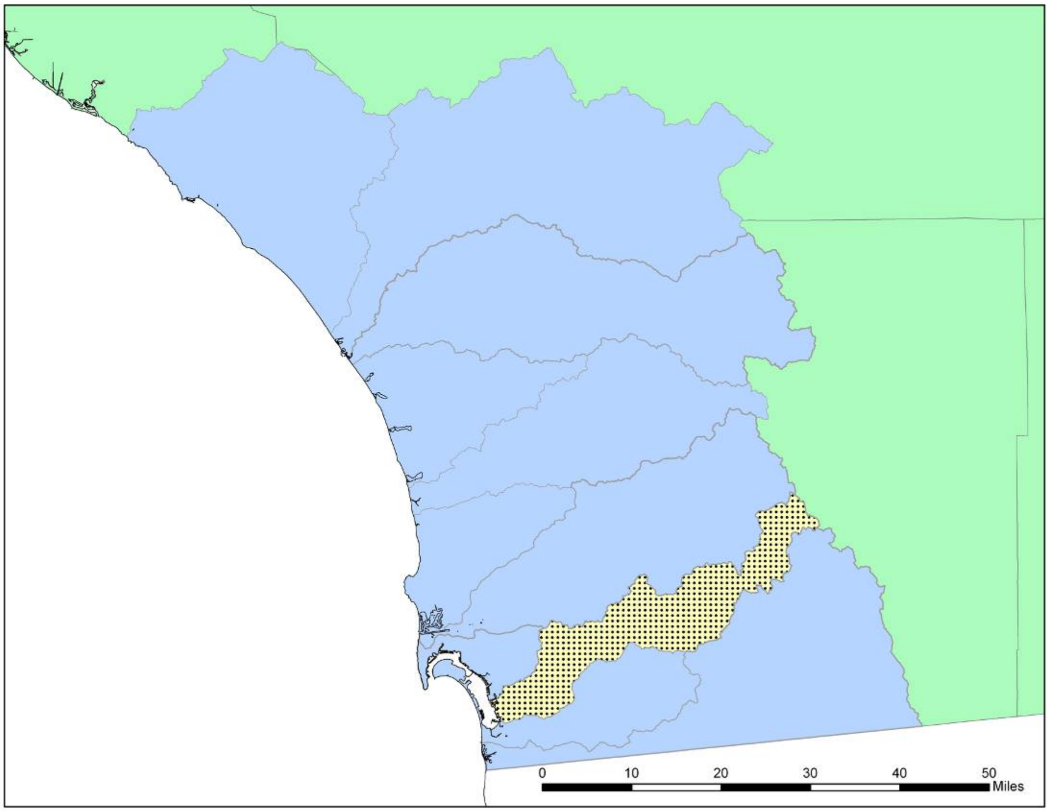


Figure 1. San Diego region (purple) includes portions of San Diego, Riverside, and Orange counties. The Sweetwater HU (tan, shaded) is located entirely within San Diego County.

2.1.1 Climate

The Sweetwater 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 Cuyamaca Rancho (near the inland end of the HU), La Mesa (in the central portion of the HU) and at Seaworld (near the coast outside the HU) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

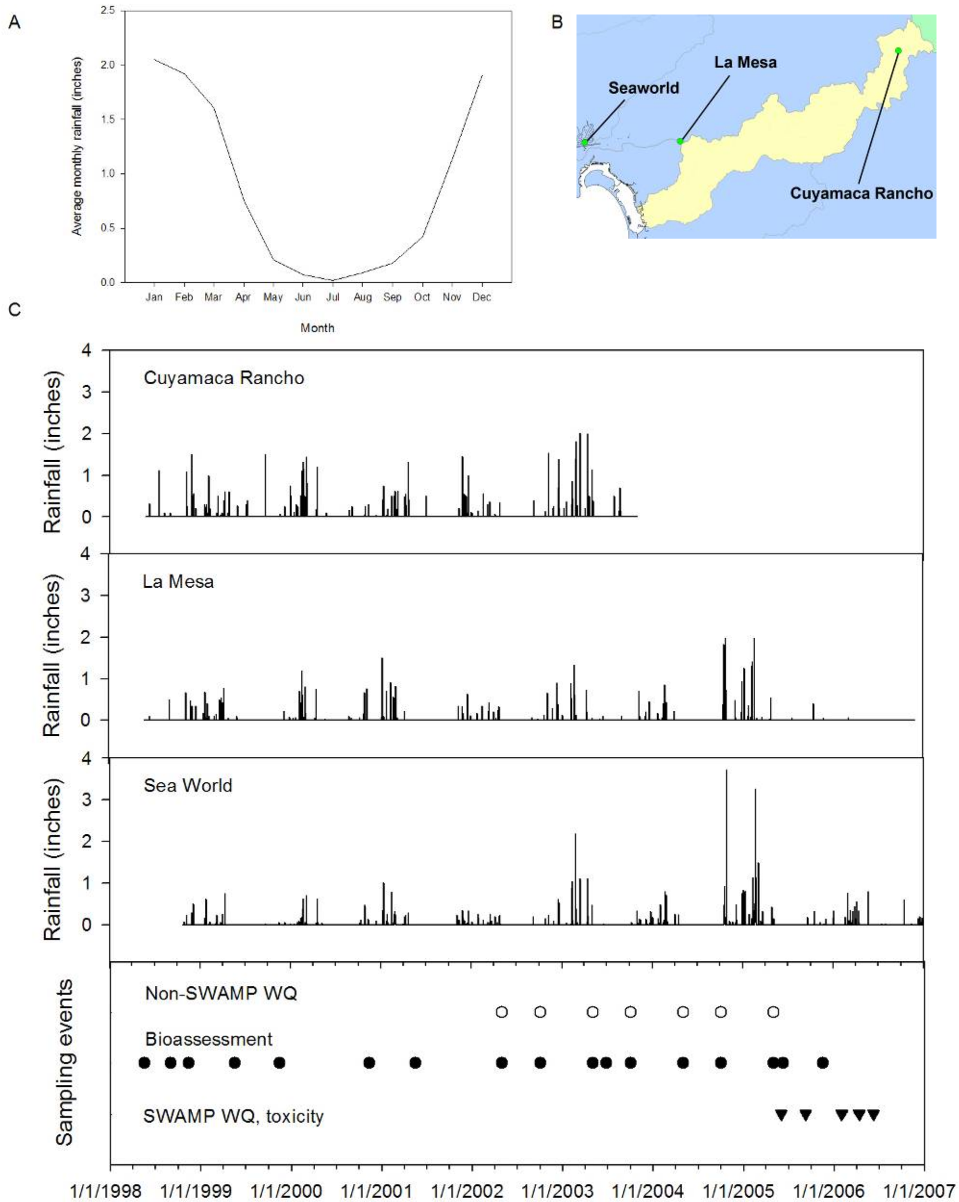


Figure 2. Rainfall and sampling events at stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Cuyamaca Rancho, La Mesa, and Seaworld gauges. C. Storm events and sampling events in the Sweetwater HU. The top three plots show daily precipitation between 1998 and 2006 at the two stations. The bottom plot shows the timing of sampling events. Non-SWAMP water chemistry is shown as white circles. Non-SWAMP bioassessment is shown as black circles. SWAMP water chemistry and toxicity is shown as black downward triangles.

2.1.2 Hydrology

The Sweetwater HU consists primarily of the Sweetwater watershed, plus the smaller Telegraph Creek. Both watersheds drain into the extensive wetlands of southern San Diego Bay (Figure 3). The mainstem of the Sweetwater River has two major dams, creating the lower Sweetwater Reservoir, as well as the upper Loveland Reservoir. Major tributaries include Long Canyon Creek (below the Sweetwater Reservoir), Harbinson Creek, Lawson Valley Creek (below Loveland Reservoir), Viejas Creek, Taylor Creek, and Japatul Creek (above the Loveland Reservoir).

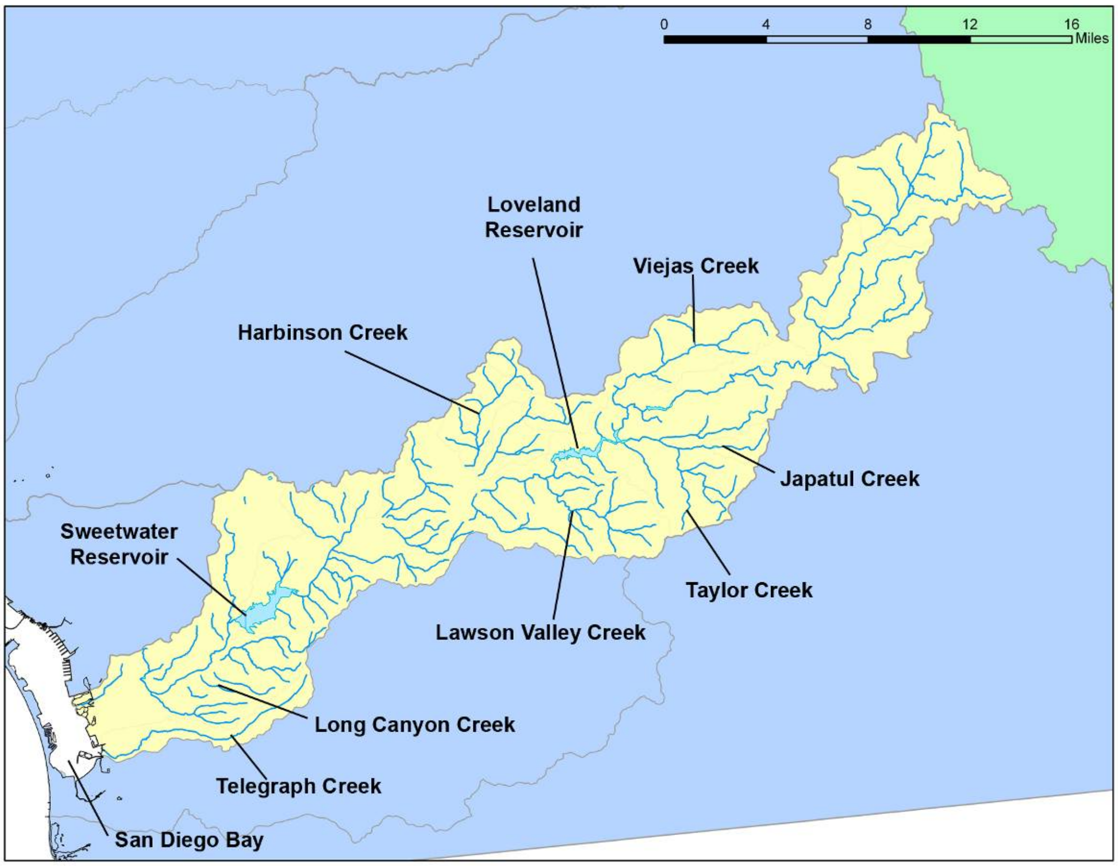


Figure 3. The Sweetwater watershed, including major waterways.

2.1.3 Land Use within the Watershed

Several municipalities have jurisdiction over portions of the watershed. The largest ownership is by the County of San Diego, which has jurisdiction over large unincorporated portions of the interior of the watershed. Other major jurisdictions include the cities of Chula Vista (9.4% of the watershed), San Diego

(1.4%), National City (1.4%), La Mesa (0.8%) and Lemon Grove (0.6%). All freeways are under the jurisdiction of Caltrans. Other major landowners include the Sycuan and Viejas Reservations. Much of the coastal portions of the HU are urbanized, with developed land uses occupying 29% of the area. Two-thirds of the watershed (67%) is undeveloped open space. Agriculture occurs only 4% of the watershed, and is scattered throughout the interior of the HU. Major protected areas include the Cleveland National Forest and Cuyamaca Rancho State Park. Portions of the estuary of the Sweetwater River is protected by the Sweetwater Marsh National Wildlife Refuge. (SANDAG 1998). Large portions of the upper watershed were severely burned in the 2003 Cedar Fire.

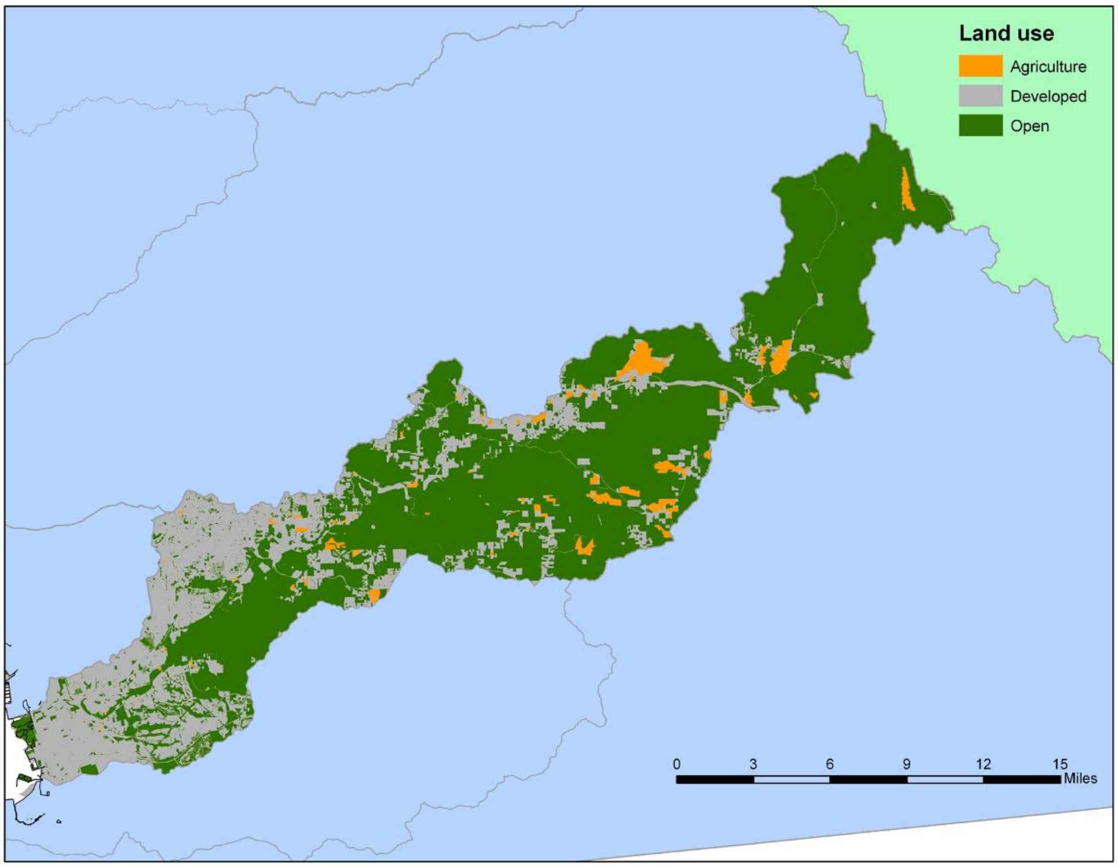


Figure 4. Land use within the Sweetwater HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

The Sweetwater HU is designated to support many beneficial uses. Beneficial uses in the watershed include municipal; agriculture; industry; power; recreation; biological habitats of special significance; warm and cold freshwater habitat; wildlife habitat; rare, threatened, or endangered species; and spawning habitat. Some streams in the Sweetwater HU have been exempted from municipal uses (Appendix I).

No streams in the Sweetwater HU are listed as impaired on the 303(d) list of water quality limited segments. However, the Loveland Reservoir is listed for dissolved oxygen, aluminum, and manganese. The Sweetwater Reservoir is also listed for dissolved oxygen.

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 Sweetwater HU in 2002 (Table 3; Figure 5). Water chemistry, and water and sediment toxicity were measured at each site. Physical habitat was assessed at one site (i.e., SWR03). Fish and invertebrate tissues were not assessed. Bioassessment was not included as part of SWAMP monitoring in the Sweetwater HU, but bioassessment data collected County of San Diego as part of its NPDES permit (from 2002 to 2005) was used in this report. In addition to bioassessment, conventional water chemistry (e.g., temperature, conductivity, dissolved oxygen) was also measured at sites sampled by San Diego County NPDES. Furthermore, the California Department of Fish and Game collected bioassessment samples as part of special studies commissioned by the San Diego Water Board. When two non-SWAMP sites were located within 500 meters of each other, they were treated as a single site. This distance was based on published measures of spatial correlation of benthic communities in streams (Gebler 2004). Non-SWAMP samples were collected between 1998 and 2005; in some cases, non-SWAMP sites were very close to SWAMP sites (Table 4; Figure 5).

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, physical habitat	2005-2006
CA Department of Fish and Game	Bioasssessment	1998-2005
San Diego County NPDES	Water chemistry, bioassessment	2002-2005

Table 3: SWAMP sampling site locations. W = water chemistry. T = toxicity. B = bioassessment (non-SWAMP sources). P = physical habitat.

Site		Description	Latitude (°N)	Longitude (°E)	W	T	B	P
1	908PTEL02*	Telegraph Canyon Creek 2	32.62853	-117.05751	X	X	X	
2	909SLAW02	Lawson Valley Creek 2	32.75409	-116.77885	X	X	X	
3	909SSWR03	Sweetwater River 3	32.83521	-116.62203	X	X	X	X
4	909SSWR08	Sweetwater River 8	32.65897	-117.04181	X	X	X	

*Although the site number for Telegraph Creek begins with the HUC for Pueblo San Diego (i.e., 908), it is located within the Sweetwater HU, and is therefore included in this analysis.

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

Site	SWAMP site within 500 m	Sources	W	B	Lattitude (N)	Longitude (E)
1 Cold Stream at Cuyamaca State Park	none	Regional Board (909CCCSPx)		X	32.9400	-116.5644
2 Lawson Creek at Lawson Valley Road	909SLAW02	Regional Board (909LSCLVR)		X	32.7542	-116.7786
3 Sweetwater River at Cuyamaca State Park (Hwy 79)	none	Regional Board (909SWCSPx, 909SWCSPD, 909SWCSPU)		X	32.9103	-116.5743
4 Sweetwater River at Hwy 94	none	Regional Board (909SWR94x)		X	32.7333	-116.9386
		NPDES (SR-94)	X	X		
5 Sweetwater River at Willow Street	909SSWR08	Regional Board (909SWRWSx)		X	32.6581	-117.0434
		NPDES (SR-WS)	X	X		
6 Sweetwater River at 79	none	Regional Board (909SWR79x)		X	32.8391	-116.6142
7 Telegraph Canyon Creek at Hilltop Park	908PTEL02	Regional Board (909TCCAHP)		X	32.6286	-117.0629
8 Sweetwater River at Glen Valley Campground	none	Regional Board (909WE0662)		X	32.8996	-116.5879
9 Sweetwater River at Acacia Drive	none	NPDES (SR-AD)	X	X	32.6566	-117.0133
10 Sweetwater River at Wildwood Glen Lane	909SSWR03	Regional Board (909SWRWWG)		X	32.8370	-116.6207

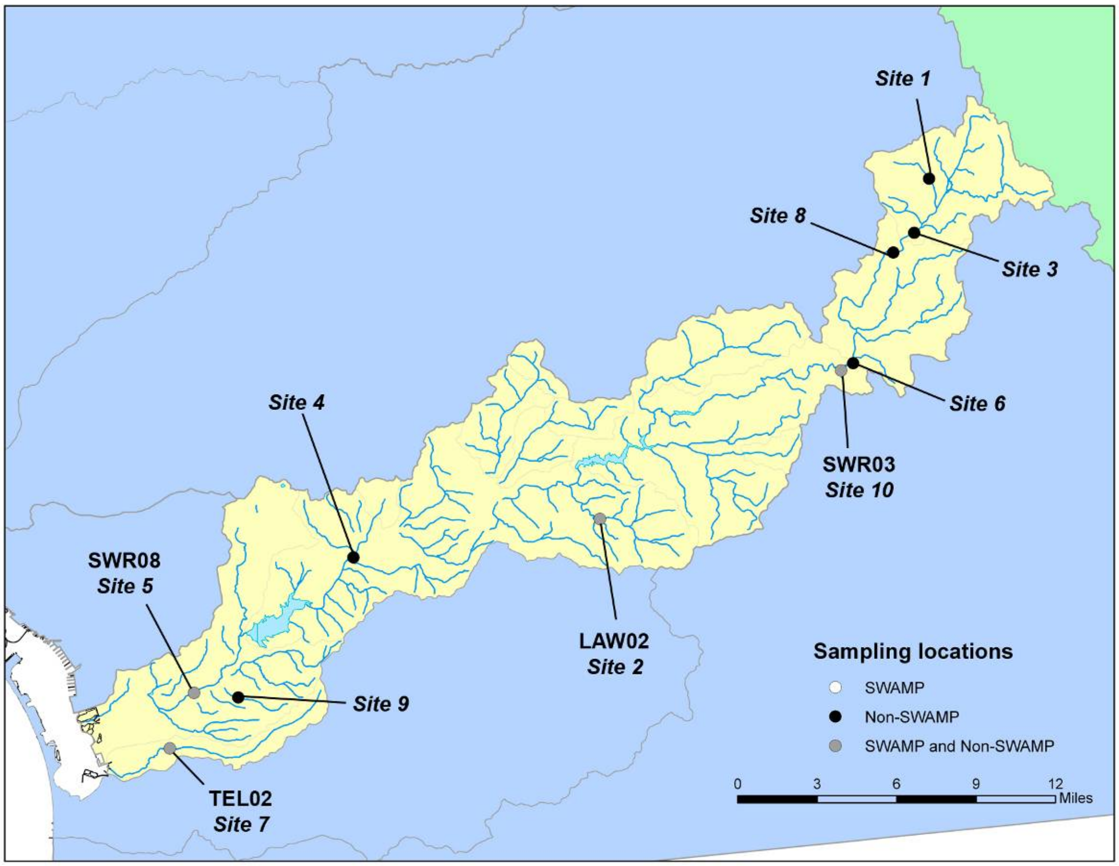


Figure 5. Sampling locations in the Sweetwater HU. White circles represent sites sampled under SWAMP. Black circles represent sites sampled under non-SWAMP programs. Gray circles represent sites sampled under both SWAMP and non-SWAMP programs. The SWAMP site prefix designating the hydrologic unit (i.e., 909SW-) has been dropped to improve clarity.

3.1 Indicators

Multiple indicators were used to assess the sites in the Sweetwater HU. Water chemistry, water and sediment toxicity, 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 Sweetwater 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

Fish and invertebrate tissues were not assessed in the Sweetwater HU.

3.1.4 Bioassessment

To assess the ecological health of the streams in Sweetwater HU, benthic macroinvertebrate samples were collected at 10 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. Physical habitat at one site (SWR03) was assessed on April 16, 2007.

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the Sweetwater 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. Physical habitat assessment was excluded due to lack of agreed-upon thresholds for evaluation of physical habitat scores, and the lack of data for most sites. 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 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, 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 Sweetwater HU. Therefore, the most stringent water quality objectives (e.g., municipal drinking water, aquatic life, etc.) for the measured constituents were used as thresholds points to evaluate the data.

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

Table 5. Threshold sources

Indicator	Source	Citation
Water chemistry	Water Quality Control Plan For the San Diego Basin (BP)	California Regional Water Quality Control Board, San Diego Region. 1994. Water quality control plan for the San Diego Region. San Diego, CA. http://www.waterboards.ca.gov/sandiego/programs/basinplan.html
	California Toxics Rule (CTR)	Environmental Protection Agency. 1997. Water quality standards: Establishment of numeric criteria for priority toxic pollutants for the state of California: Proposed Rule. *Federal Register* 62:42159-42208.
	EPA National Aquatic Life Criteria (EPA)	Environmental Protection Agency. 2002. National recommended water quality criteria. EPA-822-R-02-047. Office of Water. Washington, DC.
	National Academy of Sciences Health Advisory (NASHA)	National Academy of Sciences. 1977. Drinking Water and Health. Volume 1. Washington, DC.
	US Environmental Protection Agency Integrated Risk Information System (IRIS)	Environmental Protection Agency (EPA). 2007. Integrated Risk Information System. http://www.epa.gov/iris/index.html. Office of Research and Development. Washington, DC.
	California Code of Regulations §64449 (CCR)	California Code of Regulations. 2007. Secondary drinking water standards. Register 2007, No. 8. Title 22, division 4, article 16.

Table 5, continued. Threshold sources.

Indicator	Source	Citation
Bioassessment	Ode et al. 2005	Ode, P.R., A.C. Rehn and J.T. May. 2005. A quantitative tool for assessing the integrity of southern California coastal streams. *Environmental Management* 35:493-504.

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

Table 6. Water chemistry thresholds for aquatic life and human health standards. San Diego Basin Plan (BP); California Toxics Rule (CTR); Environmental Protection Agency National Aquatic Life Standards (EPA); National Academy of Science Health Advisory (NASHA); Environmental Protection Agency Integrated Risk Information System (IRIS); California Code of Regulations §64449 (CCR).

			Aquatic life			Human health		
Category	Constituent	Applicability	Threshold	Unit	Source	Threshold	Unit	Source
Inorganics	Alkalinity as CaCO3	All sites	20000	mg/l	EPA	none	mg/l	none
Inorganics	Ammonia as N	All sites	0.025	mg/l	BP	none	mg/l	none
Inorganics	Nitrate + Nitrite as N	All sites	10	mg/l	BP	none	mg/l	none
Inorganics	Nitrate as NO3	Designated MUN only	none	mg/l	none	45	mg/l	BP
Inorganics	Nitrite as N	All sites	none	mg/l	none	1	mg/l	EPA
Inorganics	Total N	All sites	10:1 (TN:TP) or 1	mg/l	BP	none	mg/l	none
Inorganics	Phosphorus as P,Total	All sites	0.1	mg/l	BP	none	mg/l	none
Inorganics	Selenium,Dissolved	All sites	5	µg/L	CTR	none	µg/L	none
Inorganics	Sulfate	HUC 909.1	500	mg/l	BP	none	mg/l	none
Inorganics	Sulfate	HUC 909.2, 909.3	250	mg/l	BP	none	mg/l	none
Inorganics	Chloride	HUC 909.1	500	mg/l	BP	230	mg/l	EPA
Inorganics	Chloride	HUC 909.2, 909.3	250	mg/l	BP	230	mg/l	EPA
Metals	Aluminum,Dissolved	All sites	1000	µg/L	BP	none	µg/L	none
Metals	Arsenic,Dissolved	All sites	50	µg/L	BP	150	µg/L	CTR
Metals	Cadmium,Dissolved	All sites	5	µg/L	BP	2.2	µg/L	CTR
Metals	Chromium,Dissolved	All sites	50	µg/L	BP	none	µg/L	none
Metals	Copper,Dissolved	All sites	9	µg/L	CTR	1300	µg/L	CTR
Metals	Lead,Dissolved	All sites	2.5	µg/L	CTR	none	µg/L	none
Metals	Manganese,Dissolved	All sites	0.05	mg/l	BP	none	mg/l	none
Metals	Nickel,Dissolved	All sites	52	µg/L	CTR	610	µg/L	CTR
Metals	Silver,Dissolved	All sites	3.4	µg/L	CTR	none	µg/L	none
Metals	Zinc,Dissolved	All sites	120	µg/L	CTR	none	µg/L	none
PAHs	Acenaphthene	All sites	none	µg/L	none	1200	µg/L	CTR
PAHs	Anthracene	All sites	none	µg/L	none	9600	µg/L	CTR
PAHs	Benz(a)anthracene	All sites	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(a)pyrene	All sites	0.0002	µg/L	BP	0.0044	µg/L	CTR
PAHs	Benzo(b)fluoranthene	All sites	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Benzo(k)fluoranthene	All sites	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Chrysene	All sites	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Dibenz(a,h)anthracene	All sites	none	µg/L	none	0.0044	µg/L	CTR

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

			Aquatic life			Human health		
Category	Constituent	Applicability	Threshold	Unit	Source	Threshold	Unit	Source
PAHs	Fluoranthene	All sites	none	µg/L	none	300	µg/L	CTR
PAHs	Indeno(1,2,3-c,d)pyrene	All sites	none	µg/L	none	0.0044	µg/L	CTR
PAHs	Pyrene	All sites	none	µg/L	none	960	µg/L	CTR
PCBs	PCBs	All sites	0.014	µg/L	CTR	0.00017	µg/L	CTR
Pesticides	Aldrin	All sites	3	µg/L	CTR	1.3E-07	µg/L	CTR
Pesticides	Alpha-BHC	All sites	none	µg/L	none	0.0039	µg/L	CTR
Pesticides	Beta-BHC	All sites	none	µg/L	none	0.014	µg/L	CTR
Pesticides	Gamma-BHC (Lindane)	All sites	0.95	µg/L	CTR	0.019	µg/L	CTR
Pesticides	Ametryn	All sites	none	µg/L	none	60	µg/L	EPA
Pesticides	Atrazine	All sites	3	µg/L	BP	0.2	µg/L	OEHHA
Pesticides	Azinphos ethyl	All sites	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	Azinphos methyl	All sites	none	µg/L	none	87.5	µg/L	NASHA
Pesticides	Chlordanes	All sites	0.0043	µg/L	CTR	0.00057	µg/L	CTR
Pesticides	DDD(p,p')	All sites	none	µg/L	none	0.00083	µg/L	CTR
Pesticides	DDE(p,p')	All sites	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	DDT(p,p')	All sites	none	µg/L	none	0.00059	µg/L	CTR
Pesticides	Dieldrin	All sites	none	µg/L	none	0.00014	µg/L	CTR
Pesticides	Dimethoate	All sites	none	µg/L	none	1.4	µg/L	IRIS
Pesticides	Endosulfan sulfate	All sites	none	µg/L	none	110	µg/L	CTR
Pesticides	Endrin	All sites	0.002	µg/L	BP	0.76	µg/L	CTR
Pesticides	Endrin Aldehyde	All sites	none	µg/L	none	0.76	µg/L	CTR
Pesticides	Endrin Ketone	All sites	none	µg/L	none	0.85	µg/L	CTR
Pesticides	Heptachlor	All sites	0.0038	µg/L	CTR	0.00021	µg/L	CTR
Pesticides	Heptachlor epoxide	All sites	0.0038	µg/L	CTR	0.0001	µg/L	CTR
Pesticides	Hexachlorobenzene	All sites	1	µg/L	BP	0.00075	µg/L	CTR
Pesticides	Methoxychlor	All sites	40	µg/L	BP	none	µg/L	none
Pesticides	Molinate	All sites	20	µg/L	BP	none	µg/L	none
Pesticides	Oxychlordane	All sites	none	µg/L	none	0.000023	µg/L	CTR
Pesticides	Simazine	All sites	4	µg/L	BP	none	µg/L	none
Pesticides	Toxaphene	All sites	0.0002	µg/L	CTR	0.0002	µg/L	CTR
Pesticides	Thiobencarb	All sites	70	µg/L	BP	none	µg/L	none
Physical	Oxygen, Dissolved	Designated WARM only	5	mg/L	BP	none	mg/L	none
Physical	Oxygen, Dissolved	Designated COLD only	6	mg/L	BP	none	mg/L	none
Physical	pH	All sites	>6 and <8	pH	BP	none	pH	none
Physical	Specific Conductivity	All sites	1600	µS/cm	CCR	none	mS/cm	none
Physical	Turbidity	All sites	20	NTU	BP	none	NTU	none

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

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

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

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

3.2.2 Quality Assurance and Quality Control (QA/QC)

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

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated widespread impact to water quality for multiple constituents. Across the entire watershed, 4 pesticides and 5 PAHs were detected (Table 7). At least one pesticide was detected at every site. Telegraph Creek (TEL02) had the highest numbers of pesticides (4). In contrast, only one pesticide and no PAHs were detected at Lawson Valley (LAW02). No PCBs were detected at any site. Means and standard deviations of all constituents are presented in Appendix II.

Table 7. Number of anthropogenic organic compounds detected at each site in Sweetwater HU.

	PAHs		PCBs		Pesticides	
	Tested	Detected	Tested	Detected	Tested	Detected
908PTEL02	48	2	50	0	79	4
909SLAW02	52	0	57	0	81	1
909SSWR03	48	1	50	0	79	2
909SSWR08	48	2	50	0	79	3
All sites	52	5	57	0	81	4

Several organic compounds were widespread throughout the watershed, although many were found at only one site (Table 8). For example, no PAH was detected at more than one site. Different phenanthrenes were found at Telegraph Canyon and the lower mainstem site on the Sweetwater River. In contrast, the pesticide diazinon was detected at every site. The pesticide dioxathion was detected at every site except Lawson Valley.

Table 8. Frequency of detection of anthropogenic organic compounds in the Sweetwater HU. Constituent not detected at any site (--).

Type	Constituent	Tested	Detected	Frequency
PAHs	Acenaphthene	4	0	--
PAHs	Acenaphthylene	4	0	--
PAHs	Anthracene	4	0	--
PAHs	Benz(a)anthracene	4	0	--
PAHs	Benzo(a)pyrene	4	0	--
PAHs	Benzo(b)fluoranthene	4	0	--
PAHs	Benzo(e)pyrene	4	0	--
PAHs	Benzo(g,h,i)perylene	4	0	--
PAHs	Benzo(k)fluoranthene	4	0	--
PAHs	Biphenyl	4	0	--
PAHs	Chrysene	4	0	--
PAHs	Chrysenes, C1 -	4	0	--
PAHs	Chrysenes, C2 -	4	0	--
PAHs	Chrysenes, C3 -	4	0	--

Table 8, continued. Frequency of detection of anthropogenic organic compounds.

Type	Constituent	Tested	Detected	Frequency
PAHs	Dibenz(a,h)anthracene	4	0	--
PAHs	Dibenzothiophene	4	0	--
PAHs	Dibenzothiophenes, C1 -	4	0	--
PAHs	Dibenzothiophenes, C2 -	4	0	--
PAHs	Dibenzothiophenes, C3 -	4	0	--
PAHs	Dichlofenthion	4	0	--
PAHs	Dimethylnaphthalene, 2,6-	4	0	--
PAHs	Dimethylphenanthrene, 3,6-	4	0	--
PAHs	Fluoranthene	4	1	0.25
PAHs	Fluoranthene/Pyrenes, C1 -	4	0	--
PAHs	Fluorene	4	0	--
PAHs	Fluorenes, C1 -	4	0	--
PAHs	Fluorenes, C2 -	4	0	--
PAHs	Fluorenes, C3 -	4	0	--
PAHs	Indeno(1,2,3-c,d)pyrene	4	0	--
PAHs	Methyldibenzothiophene, 4-	4	0	--
PAHs	Methylfluoranthene, 2-	4	0	--
PAHs	Methylfluorene, 1-	4	0	--
PAHs	Methylnaphthalene, 1-	4	0	--
PAHs	Methylnaphthalene, 2-	4	0	--
PAHs	Methylphenanthrene, 1-	4	0	--
PAHs	Naphthalene	4	1	0.25
PAHs	Naphthalenes, C1 -	4	0	--
PAHs	Naphthalenes, C2 -	4	0	--
PAHs	Naphthalenes, C3 -	4	0	--
PAHs	Naphthalenes, C4 -	4	0	--
PAHs	Perylene	4	0	--
PAHs	Phenanthrene	4	0	--
PAHs	Phenanthrene/Anthracene, C1 -	4	1	0.25
PAHs	Phenanthrene/Anthracene, C2 -	4	1	0.25
PAHs	Phenanthrene/Anthracene, C3 -	4	0	--
PAHs	Phenanthrene/Anthracene, C4 -	4	0	--
PAHs	Pyrene	4	1	0.25
PAHs	Trimethylnaphthalene, 2,3,5-	4	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	4	0	--
PCBs	PCB 008	4	0	--
PCBs	PCB 015	4	0	--
PCBs	PCB 018	4	0	--
PCBs	PCB 027	4	0	--
PCBs	PCB 028	4	0	--
PCBs	PCB 029	4	0	--
PCBs	PCB 031	4	0	--
PCBs	PCB 033	4	0	--
PCBs	PCB 044	4	0	--
PCBs	PCB 049	4	0	--

Table 8, continued. Frequency of detection of anthropogenic organic compounds.

Type	Constituent	Tested	Detected	Frequency
PCBs	PCB 052	4	0	--
PCBs	PCB 056	4	0	--
PCBs	PCB 060	4	0	--
PCBs	PCB 066	4	0	--
PCBs	PCB 070	4	0	--
PCBs	PCB 074	4	0	--
PCBs	PCB 087	4	0	--
PCBs	PCB 095	4	0	--
PCBs	PCB 097	4	0	--
PCBs	PCB 099	4	0	--
PCBs	PCB 101	4	0	--
PCBs	PCB 105	4	0	--
PCBs	PCB 110	4	0	--
PCBs	PCB 114	4	0	--
PCBs	PCB 118	4	0	--
PCBs	PCB 128	4	0	--
PCBs	PCB 137	4	0	--
PCBs	PCB 138	4	0	--
PCBs	PCB 141	4	0	--
PCBs	PCB 149	4	0	--
PCBs	PCB 151	4	0	--
PCBs	PCB 153	4	0	--
PCBs	PCB 156	4	0	--
PCBs	PCB 157	4	0	--
PCBs	PCB 158	4	0	--
PCBs	PCB 170	4	0	--
PCBs	PCB 174	4	0	--
PCBs	PCB 177	4	0	--
PCBs	PCB 180	4	0	--
PCBs	PCB 183	4	0	--
PCBs	PCB 187	4	0	--
PCBs	PCB 189	4	0	--
PCBs	PCB 194	4	0	--
PCBs	PCB 195	4	0	--
PCBs	PCB 200	4	0	--
PCBs	PCB 201	4	0	--
PCBs	PCB 203	4	0	--
PCBs	PCB 206	4	0	--
PCBs	PCB 209	4	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	--
Pesticide	Toxaphene	1	0	--
Pesticides	Aldrin	4	0	--
Pesticides	Aspon	4	0	--

Table 8, continued. Frequency of detection of anthropogenic organic compounds.

Type	Constituent	Tested	Detected	Frequency
Pesticides	Azinphos ethyl	4	0	--
Pesticides	Azinphos methyl	4	0	--
Pesticides	Bolstar	4	0	--
Pesticides	Carbophenothion	4	0	--
Pesticides	Chlordane, cis-	4	0	--
Pesticides	Chlordane, trans-	4	0	--
Pesticides	Chlordene, alpha-	4	0	--
Pesticides	Chlordene, gamma-	4	0	--
Pesticides	Chlorfenvinphos	4	0	--
Pesticides	Chlorpyrifos	4	0	--
Pesticides	Chlorpyrifos methyl	4	0	--
Pesticides	Ciodrin	4	0	--
Pesticides	Coumaphos	4	0	--
Pesticides	Dacthal	4	0	--
Pesticides	DDD(o,p')	4	0	--
Pesticides	DDD(p,p')	4	0	--
Pesticides	DDE(o,p')	4	0	--
Pesticides	DDE(p,p')	4	0	--
Pesticides	DDMU(p,p')	4	0	--
Pesticides	DDT(o,p')	4	0	--
Pesticides	DDT(p,p')	4	0	--
Pesticides	Demeton-s	4	0	--
Pesticides	Diazinon	4	4	1.00
Pesticides	Dichlorvos	4	0	--
Pesticides	Dicrotophos	4	0	--
Pesticides	Dieldrin	4	0	--
Pesticides	Dimethoate	4	0	--
Pesticides	Dioxathion	4	3	0.75
Pesticides	Disulfoton	4	1	0.25
Pesticides	Endosulfan I	4	0	--
Pesticides	Endosulfan II	4	0	--
Pesticides	Endosulfan sulfate	4	0	--
Pesticides	Endrin	4	0	--
Pesticides	Endrin Aldehyde	4	0	--
Pesticides	Endrin Ketone	4	0	--
Pesticides	Ethion	4	0	--
Pesticides	Ethoprop	4	0	--
Pesticides	Famphur	4	0	--
Pesticides	Fenchlorphos	4	0	--
Pesticides	Fenitrothion	4	0	--
Pesticides	Fensulfothion	4	0	--
Pesticides	Fenthion	4	0	--
Pesticides	Fonofos	4	0	--
Pesticides	HCH, alpha	4	0	--
Pesticides	HCH, beta	4	0	--
Pesticides	HCH, delta	4	0	--
Pesticides	HCH, gamma	4	0	--
Pesticides	Heptachlor	4	0	--
Pesticides	Heptachlor epoxide	4	0	--

Table 8, continued. Frequency of detection of anthropogenic organic compounds.

Type	Constituent	Tested	Detected	Frequency
Pesticides	Hexachlorobenzene	4	0	--
Pesticides	Leptophos	4	0	--
Pesticides	Malathion	4	0	--
Pesticides	Merphos	4	0	--
Pesticides	Methidathion	4	0	--
Pesticides	Methoxychlor	4	0	--
Pesticides	Mevinphos	4	0	--
Pesticides	Mirex	4	0	--
Pesticides	Molinate	4	0	--
Pesticides	Naled	4	0	--
Pesticides	Nonachlor, cis-	4	0	--
Pesticides	Nonachlor, trans-	4	0	--
Pesticides	Oxadiazon	4	2	0.50
Pesticides	Oxychlordane	4	0	--
Pesticides	Parathion, Ethyl	4	0	--
Pesticides	Parathion, Methyl	4	0	--
Pesticides	Phorate	4	0	--
Pesticides	Phosmet	4	0	--
Pesticides	Phosphamidon	4	0	--
Pesticides	Sulfotep	4	0	--
Pesticides	Tedion	4	0	--
Pesticides	Terbufos	4	0	--
Pesticides	Tetrachlorvinphos	4	0	--
Pesticides	Thiobencarb	4	0	--
Pesticides	Thionazin	4	0	--
Pesticides	Tokuthion	4	0	--
Pesticides	Trichlorfon	4	0	--
Pesticides	Trichloronate	4	0	--
Pesticides	Chlordane (tech)	1	0	--

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted by several constituents (Table 9). Most sites showed similar results, suggesting that impacts were not restricted to specific regions within the watershed (Figure 6, 7). For example, ammonia-N, total N, and selenium exceeded aquatic life thresholds at every site in the watershed. (Table 10). Although nitrogen exceeded thresholds at all sites, total phosphorous was below threshold at every site except for the lower mainstem site on the Sweetwater River (SWR08). Several constituents (i.e., copper, pH, and conductivity) exceeded thresholds at the two urban sites (i.e., TEL08 and SWR08).

All sites in Sweetwater HU failed to achieve certain aquatic life thresholds (Table 11). The lower mainstem site had the highest number of exceedances of aquatic life thresholds (9), followed by Telegraph Canyon Creek (7). In contrast, the two sites in less urban areas (i.e., LAW02 and SWR03) exceeded only 4 thresholds. One constituent (i.e., chloride) exceeded human health thresholds at Telegraph Canyon Creek and the lower mainstem site on the Sweetwater River.

Results from NPDES water chemistry monitoring at 3 sites were similar to results from SWAMP (Table 9C). For example, specific conductivity exceeded aquatic life thresholds at all sites and at almost every sampling date. Site 5, which was located near the lower mainstem site, exceeded the dissolved oxygen threshold on one sampling date and never exceeded the pH threshold suggesting that these constituents infrequently impacted water quality. The other NPDES sites were not located near sites sampled under SWAMP. However, resuts at these NPDES sites also suggested frequent impacts to conductivity and infrequent impacts to pH.

Table 9. 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. AL = Aquatic life. HH = Human health. -- = 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.

		908PTEL02		909SLAW02		909SSWR03		909SSWR08	
Category	Constituent	Frequency	n	Frequency	n	Frequency	n	Frequency	n
Inorganics	Alkalinity as CaCO3	--	4	--	3	--	4	--	4
Inorganics	Ammonia as N	1.00	4	0.33	3	0.75	4	1.00	4
Inorganics	Chloride	1.00	1	nt	0	nt	0	1.00	1
Inorganics	Phosphorus as P,Total	--	4	--	3	--	4	0.75	4
Inorganics	Selenium,Dissolved	1.00	4	0.50	2	0.25	4	1.00	4
Inorganics	Sulfate	--	4	--	3	--	4	--	4
Inorganics	Total N	1.00	4	0.67	3	0.50	4	0.25	4
Metals	Aluminum,Dissolved	--	4	--	3	--	4	--	4
Metals	Arsenic,Dissolved	--	4	--	3	--	4	--	4
Metals	Cadmium,Dissolved	--	4	--	3	--	4	--	4
Metals	Chromium,Dissolved	--	4	--	3	--	4	--	4
Metals	Copper,Dissolved	0.25	4	--	3	--	4	0.25	4
Metals	Lead,Dissolved	--	4	--	3	--	4	--	4
Metals	Manganese,Dissolved	--	4	--	3	0.25	4	1.00	4
Metals	Nickel,Dissolved	--	4	--	3	--	4	--	4
Metals	Silver,Dissolved	--	4	--	3	--	4	--	4
Metals	Zinc,Dissolved	--	4	--	3	--	4	--	4
PAHs	Benzo(a)pyrene	--	4	--	3	--	4	--	4
PCBs	PCBs	--	4	--	3	--	4	--	4
Pesticides	Chlordanes	--	4	--	3	--	4	--	4
Pesticides	Endrin	--	4	--	3	--	4	--	4
Pesticides	gamma-BHC (Lindane)	nt	0	--	1	nt	0	nt	0
Pesticides	Heptachlor	--	4	--	3	--	4	--	4
Pesticides	Heptachlor epoxide	--	4	--	3	--	4	--	4
Pesticides	Hexachlorobenzene	--	4	--	2	--	4	--	4
Pesticides	Methoxychlor	--	4	--	3	--	4	--	4
Pesticides	Molinate	--	4	--	2	--	4	--	4
Pesticides	Thiobencarb	--	4	--	2	--	4	--	4
Pesticide	Toxaphene	nt	0	--	1	nt	0	nt	0

Table 9, continued. Frequency of water chemistry threshold exceedances.
A, continued. Aquatic life thresholds at SWAMP sites.

		908PTEL02		909SLAW02		909SSWR03		909SSWR08	
Category	Constituent	Frequency	n	Frequency	n	Frequency	n	Frequency	n
Physical	Oxygen, Dissolved	--	4	--	2	--	4	--	4
Physical	pH	1.00	4	--	2	--	4	0.25	4
Physical	Specific conductivity	1.00	4	--	2	--	4	1.00	4
Physical	Turbidity	--	4	--	2	--	4	--	4

Table 9, continued. Frequency of water chemistry threshold exceedances.
B. Human health thresholds at SWAMP sites

		908PTEL02		909SLAW02		909SSWR03		909SSWR08	
Category	Constituent	Frequency	n	Frequency	n	Frequency	n	Frequency	n
Inorganics	Chloride	1.00	1	nt	0	nt	0	1.00	1
Inorganics	Nitrate + Nitrite as N	--	4	--	3	--	4	--	4
Inorganics	Nitrate as NO3 (either)	--	4	--	3	--	4	--	4
Inorganics	Nitrite as N	--	4	--	3	--	4	--	4
Metals	Arsenic,Dissolved	--	4	--	3	--	4	--	4
Metals	Cadmium,Dissolved	--	4	--	3	--	4	--	4
Metals	Copper,Dissolved	--	4	--	3	--	4	--	4
Metals	Nickel,Dissolved	--	4	--	3	--	4	--	4
PAHs	Acenaphthene	--	4	--	3	--	4	--	4
PAHs	Anthracene	--	4	--	3	--	4	--	4
PAHs	Benz(a)anthracene	--	4	--	3	--	4	--	4
PAHs	Benzo(a)pyrene	--	4	--	3	--	4	--	4
PAHs	Benzo(b)fluoranthene	--	4	--	3	--	4	--	4
PAHs	Benzo(k)fluoranthene	--	4	--	2	--	4	--	4
PAHs	Chrysene	--	4	--	3	--	4	--	4
PAHs	Dibenz(a,h)anthracene	--	4	--	3	--	4	--	4
PAHs	Fluoranthene	--	4	--	3	--	4	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	--	4	--	3	--	4	--	4
PAHs	Pyrene	--	4	--	3	--	4	--	4
PCBs	PCBs	--	4	--	3	--	4	--	4
Pesticides	Aldrin	--	4	--	3	--	4	--	4
Pesticides	alpha-BHC	nt	0	--	1	nt	0	nt	0
Pesticides	Azinphos ethyl	--	4	--	2	--	4	--	4
Pesticides	Azinphos methyl	--	4	--	2	--	4	--	4
Pesticides	beta-BHC	nt	0	--	1	nt	0	nt	0
Pesticides	Chlordanes	--	4	--	3	--	4	--	4
Pesticides	DDD(p,p')	--	4	--	3	--	4	--	4
Pesticides	DDE(p,p')	--	4	--	3	--	4	--	4
Pesticides	DDT(p,p')	--	4	--	3	--	4	--	4
Pesticides	Dieldrin	--	4	--	3	--	4	--	4
Pesticides	Dimethoate	--	4	--	2	--	4	--	4
Pesticides	Endosulfan sulfate	--	4	--	3	--	4	--	4
Pesticides	Endrin	--	4	--	3	--	4	--	4
Pesticides	Endrin Aldehyde	--	4	--	3	--	4	--	4
Pesticides	Endrin Ketone	--	4	--	2	--	4	--	4
Pesticides	gamma-BHC (Lindane)	nt	0	--	1	nt	0	nt	0

Table 9, continued. Frequency of water chemistry threshold exceedances.
B, continued. Human health thresholds at SWAMP sites.

		908PTEL02		909SLAW02		909SSWR03		909SSWR08	
Category	Constituent	Frequency	n	Frequency	n	Frequency	n	Frequency	n
Pesticides	Heptachlor	--	4	--	3	--	4	--	4
Pesticides	Heptachlor epoxide	--	4	--	3	--	4	--	4
Pesticides	Hexachlorobenzene	--	4	--	2	--	4	--	4
Pesticides	Oxychlordane	--	4	--	2	--	4	--	4
Pesticide	Toxaphene	nt	0	--	1	nt	0	nt	0

Table 9, continued. Frequency of water chemistry threshold exceedances.
C. Aquatic life thresholds at non-SWAMP sites.

	Site 4 (SR-94)		Site 5 (SR-WS)		Site 9 (SR-AD)	
Constituent	Frequency	n	Frequency	n	Frequency	n
Dissolved oxygen	--	4	0.17	6	--	1
pH	0.25	4	--	6	1.00	1
Specific conductivity	0.75	4	1.00	6	1.00	1
Turbidity	nt	0	--	1	nt	0

Table 10. 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	--	--	4
Inorganics	Ammonia as N	1.00	--	4
Inorganics	Chloride	1.00	1.00	2
Inorganics	Nitrate + Nitrite as N	--	--	4
Inorganics	Nitrate as NO3 (either)	--	--	4
Inorganics	Nitrite as N	--	--	4
Inorganics	Phosphorus as P,Total	0.25	--	4
Inorganics	Selenium,Dissolved	1.00	--	4
Inorganics	Sulfate	--	--	4
Inorganics	Total N	1.00	--	4
Metals	Aluminum,Dissolved	--	--	4
Metals	Arsenic,Dissolved	--	--	4
Metals	Cadmium,Dissolved	--	--	4
Metals	Chromium,Dissolved	--	--	4
Metals	Copper,Dissolved	0.50	--	4
Metals	Lead,Dissolved	--	--	4
Metals	Manganese,Dissolved	0.50	--	4
Metals	Nickel,Dissolved	--	--	4
Metals	Silver,Dissolved	--	--	4
Metals	Zinc,Dissolved	--	--	4
PAHs	Acenaphthene	--	--	4
PAHs	Anthracene	--	--	4
PAHs	Benz(a)anthracene	--	--	4
PAHs	Benzo(a)pyrene	--	--	4
PAHs	Benzo(b)fluoranthene	--	--	4
PAHs	Benzo(k)fluoranthene	--	--	4
PAHs	Chrysene	--	--	4

Table 10, continued. Frequency of SWAMP sites with aquatic life and human health threshold exceedances for each constituent.

Category	Constituent	Aquatic life	Human health	n
PAHs	Dibenz(a,h)anthracene	--	--	4
PAHs	Fluoranthene	--	--	4
PAHs	Indeno(1,2,3-c,d)pyrene	--	--	4
PAHs	Pyrene	--	--	4
PCBs	PCBs	--	--	4
Pesticide	Toxaphene	--	--	1
Pesticides	Aldrin	--	--	4
Pesticides	alpha-BHC	--	--	1
Pesticides	Azinphos ethyl	--	--	4
Pesticides	Azinphos methyl	--	--	4
Pesticides	beta-BHC	--	--	1
Pesticides	Chlordanes	--	--	4
Pesticides	DDD(p,p')	--	--	4
Pesticides	DDE(p,p')	--	--	4
Pesticides	DDT(p,p')	--	--	4
Pesticides	Dieldrin	--	--	4
Pesticides	Dimethoate	--	--	4
Pesticides	Endosulfan sulfate	--	--	4
Pesticides	Endrin	--	--	4
Pesticides	Endrin Aldehyde	--	--	4
Pesticides	Endrin Ketone	--	--	4
Pesticides	gamma-BHC (Lindane)	--	--	1
Pesticides	Heptachlor	--	--	4
Pesticides	Heptachlor epoxide	--	--	4
Pesticides	Hexachlorobenzene	--	--	4
Pesticides	Methoxychlor	--	--	4
Pesticides	Molinate	--	--	4
Pesticides	Oxychlordane	--	--	4
Pesticides	Thiobencarb	--	--	4
Physical	Oxygen, Dissolved	--	--	4
Physical	pH	0.50	--	4
Physical	Specific conductivity	0.50	--	4
Physical	Turbidity	--	--	4

Table 11. Number of constituents exceeding thresholds at each SWAMP site.

	Aquatic life		Human health	
Site	Exceedances	Tested	Exceedances	Tested
908PTEL02	7	30	1	36
909SLAW02	3	32	0	40
909SSWR03	4	30	0	36
909SSWR08	9	31	1	37

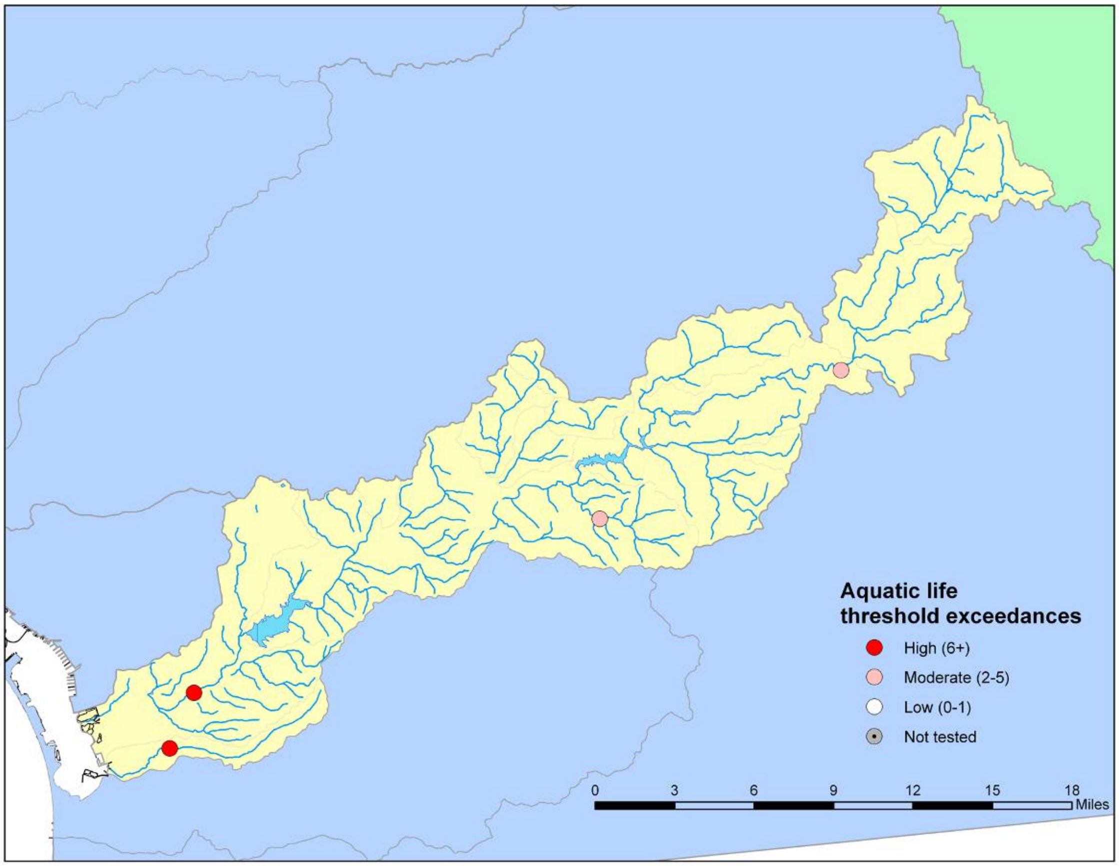


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances (this value did not occur in this watershed). Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. 30 constituents were assessed at TEL02 and SWR03; 31 constituents were assessed at SWR08; 32 constituents were assessed at LAW02.

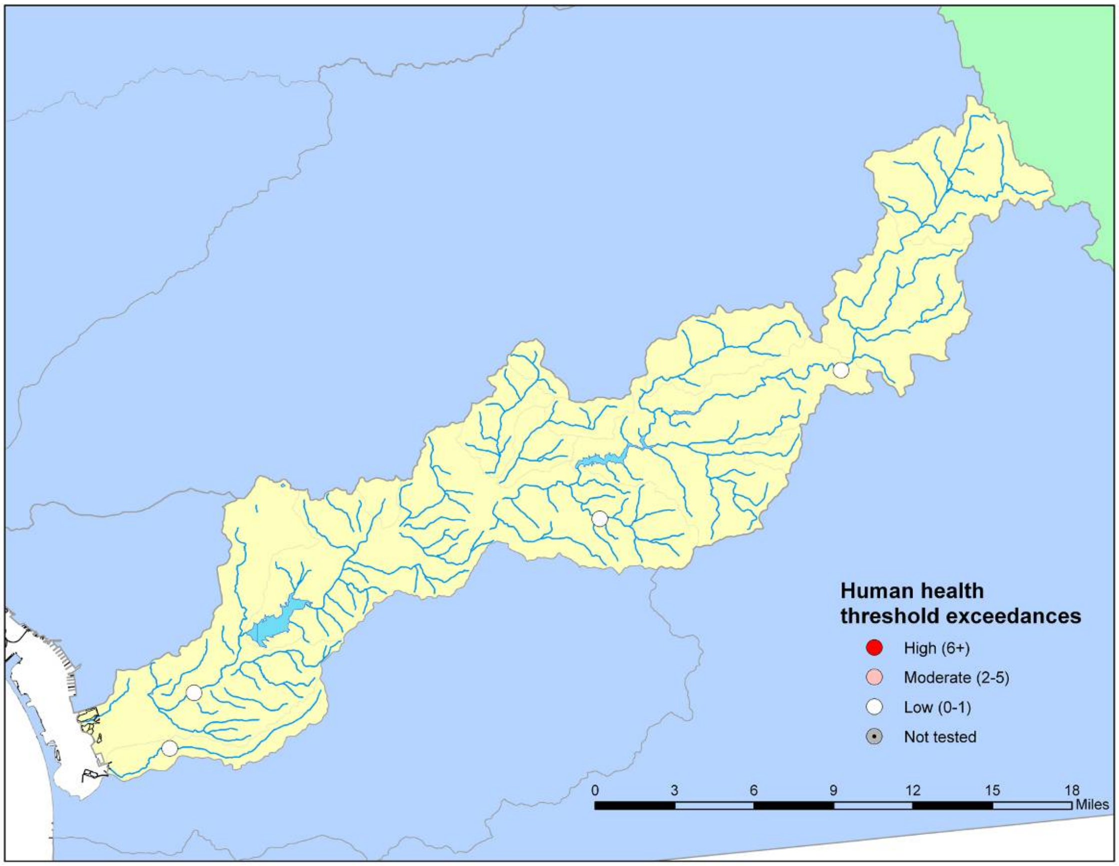


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances (this value did not occur in this watershed). Red circles indicate sites with 6 to 9 exceedances (this value did not occur in this watershed). 36 constituents were assessed at TEL02 and SWR03. 37 constituents were assessed at SWR08. 40 constituents were assessed at LAW02.

4.2 Toxicity

Toxicity was evident at all sites within the watershed, although results varied among sites and species (Table 12; Appendix III). For example every chronic endpoint indicated toxicity at the lower mainstem site (SWR08). In contrast, only one of four chronic assays indicated toxicity at Lawson Valley (LAW02) and at the upper mainstem site (SWR03) (Figure 8).

S. capricornutum was the most sensitive species tested at all sites except Lawson Valley. Similarly, sediment samples were toxic to *H. azteca* at all sites except the upper mainstem. However, repeated sampling of sediments indicated that toxicity was not persistent at most sites; only 40% of samples resulted in chronic toxicity to *H. azteca*.

Table 12. Frequency of toxicity detected for each endpoint and at each site. A sample was considered toxic if the response was less than 80% of the control sample, and the difference was considered statistically 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
908PTEL02	2	0	nt	0	nt	2	0.50	1	--	1	1.00	2	0.50
909SLAW02	1	1	--	1	--	2	--	2	0.50	1	--	4	0.25
909SSWR03	2	1	--	1	--	1	--	1	--	1	1.00	3	0.33
909SSWR08	2	0	nt	0	nt	2	--	1	1.00	1	1.00	2	1.00
All sites in watershed	7	2	--	2	--	7	0.14	5	0.40	4	0.75	11	0.45

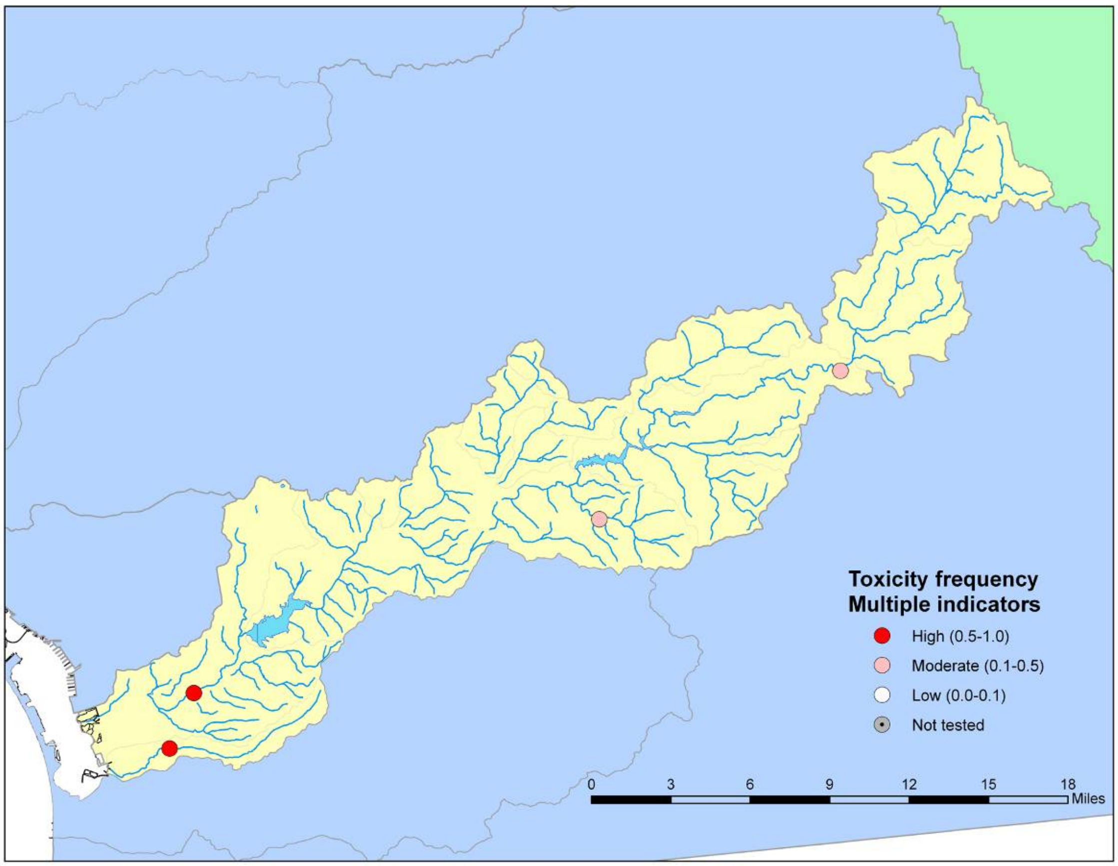


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity.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

4.3 Tissue

Fish tissues were not assessed in the Sweetwater HU.

4.4 Bioassessment

Biological health was poor or very poor for most sites and seasons in the Sweetwater HU. Mean IBI scores ranged from 2.9 at Telegraph Canyon Creek (Tel08) to a high of 53.6 at site 6 (Sweetwater River near in Cuyamaca Rancho State Park). However, samples in poor or very poor condition were collected at every site in the watershed. Two sites in fair condition (site 6, mentioned above, and site 3, located 9 km downstream on the mainstem) were both located in the upper reaches of the Sweetwater River near Cuyamaca Rancho State Park (Table 13A; Figure 9). However, site 8 (Sweetwater River at the Glen Valley Campground) was located between these two sites and was in very poor condition (mean IBI 17.9). Therefore, biological condition appeared to have great spatial as well as temporal variability.

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) were nearly absent from all samples, except for site 6. Some metrics such as Coleoptera taxa were very sensitive to biological integrity. These metrics made large contributions to high-scoring sites and small contributions to low-scoring sites. In contrast, other metrics such as % Collectors and % Non-insect taxa contributed to IBI scores at all sites. (Appendix IV; Figure 10).

Examination of IBI scores over time indicated an initial increase in biological condition between 1998 and 2000, followed by a decline. This increase may be related to large, late-season rains related to the 1997 El Niño weather patterns. The Cedar Fire of October 2003 may have also caused declines at sites in the upper watershed. Four sites in the burned area with pre- and post-fire data (i.e., SWR08, Site 1, Site 3, and Site 4) all showed declines in the IBI (Table 13B). These declines may have been exacerbated by low flows caused by dry weather in 2003 (Figure 2). No seasonal trends were evident at any site (Figure 11).

Variability among years was high, which may obscure temporal 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. None of these sites were monitored under SWAMP, and all bioassessment data came from monitoring efforts by NPDES permittees or the California Department of Fish and Game.

Table 13. A. Mean and standard deviation of IBI scores at bioassessment sites within the Sweetwater 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). B. IBIs at sites in the upper watershed, before and after the 2003 Cedar Fire.

A	Site	Season	n	Years	Mean	SD	Condition	Freq
	908PTEL02	Fall	1	2005	2.9		Very poor	1.00
	909SLAW02	Fall	1	2005	18.6		Very poor	1.00
	909SSWR03	Spring	2	2004-2005	24.3	4.0	Poor	1.00
	909SSWR08	Average	12	1998-2005	12.9	1.3	Very poor	1.00
		Fall	5	1998-2005	12.0	10.6	Very poor	1.00
		Spring	7	1998-2005	13.9	10.4	Very poor	1.00
	Site 1	Average	5	2001-2005	34.8	6.8	Poor	0.60
		Fall	1	2005	30.0		Poor	1.00
		Spring	4	2001-2005	39.6	22.0	Poor	0.50
	Site 3	Spring	5	2001-2005	41.7	9.6	Fair	0.20
	Site 4	Average	10	1998-2005	22.4	9.2	Poor	0.80
		Fall	4	1998-2003	28.9	14.2	Poor	0.75
		Spring	6	1998-2005	16.0	14.8	Very poor	0.83
	Site 6	Average	7	1998-2005	53.6	5.6	Fair	0.43
		Fall	3	1998-2005	57.6	25.2	Fair	0.33
		Spring	4	1998-2001	49.6	23.5	Fair	0.50
	Site 8	Spring	2	2004-2005	17.9	1.0	Very poor	1.00
	Site 9	Fall	1	2002	27.1		Poor	1.00

B	Site	Fire		Years	Mean	SD	Condition
	909SSWR08	Pre-Fire	7	1998-2003	17.1	11.1	Very poor
		Post-Fire	4	2003-2005	6.1	3.6	Very poor
	Site 1	Pre-Fire	2	2001-2003	57.9	5.1	Fair
		Post-Fire	3	2003-2005	24.3	8.7	Poor
	Site 3	Pre-Fire	2	2001-2003	48.2	6.6	Fair
		Post-Fire	2	2003-2005	34.3	10.1	Poor
	Site 4	Pre-Fire	7	1998-2003	25.5	16.5	Poor
		Post-Fire	2	2003-2005	10.0	2.0	Very poor

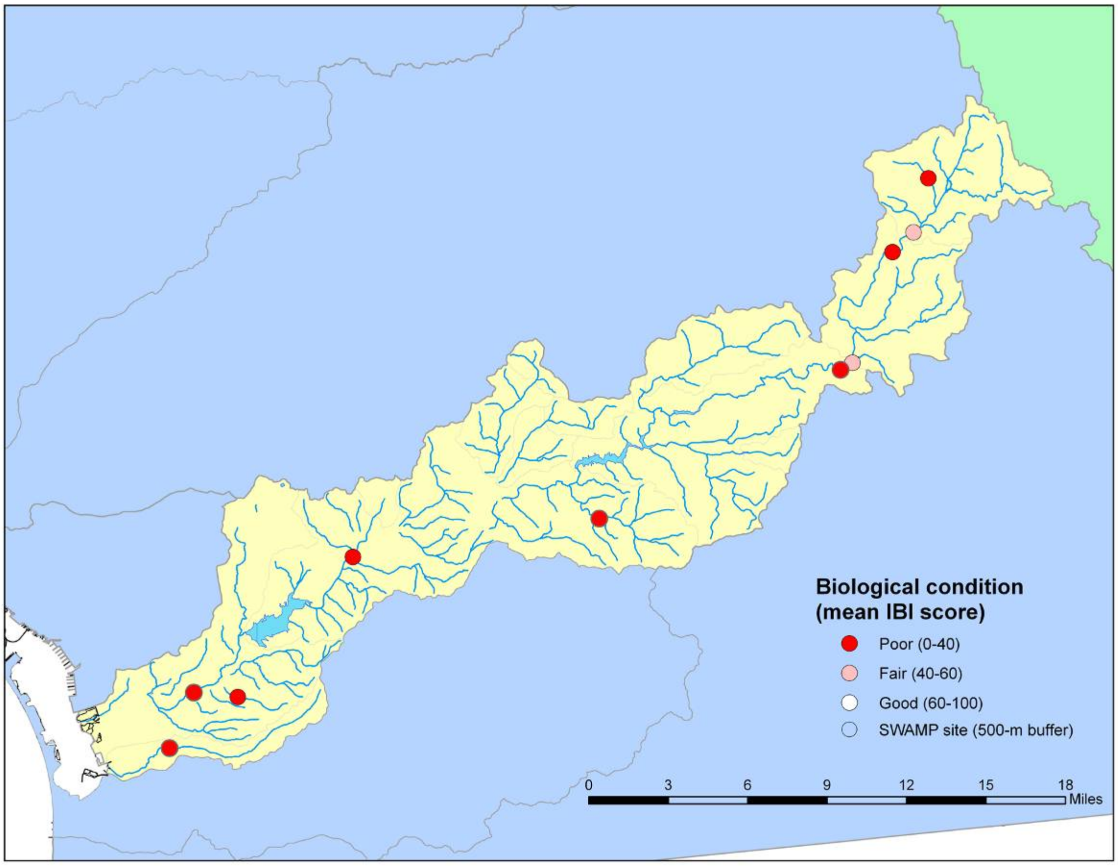


Figure 9. IBI scores at sites in the Sweetwater HU. White circles indicate good or very good (60 to 100) IBI scores (this value did not occur in this watershed). Pink circles indicate fair (40 to 60) IBI scores (this value did not occur in this watershed). Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites. Bioassessment data were available for every site sampled under SWAMP.

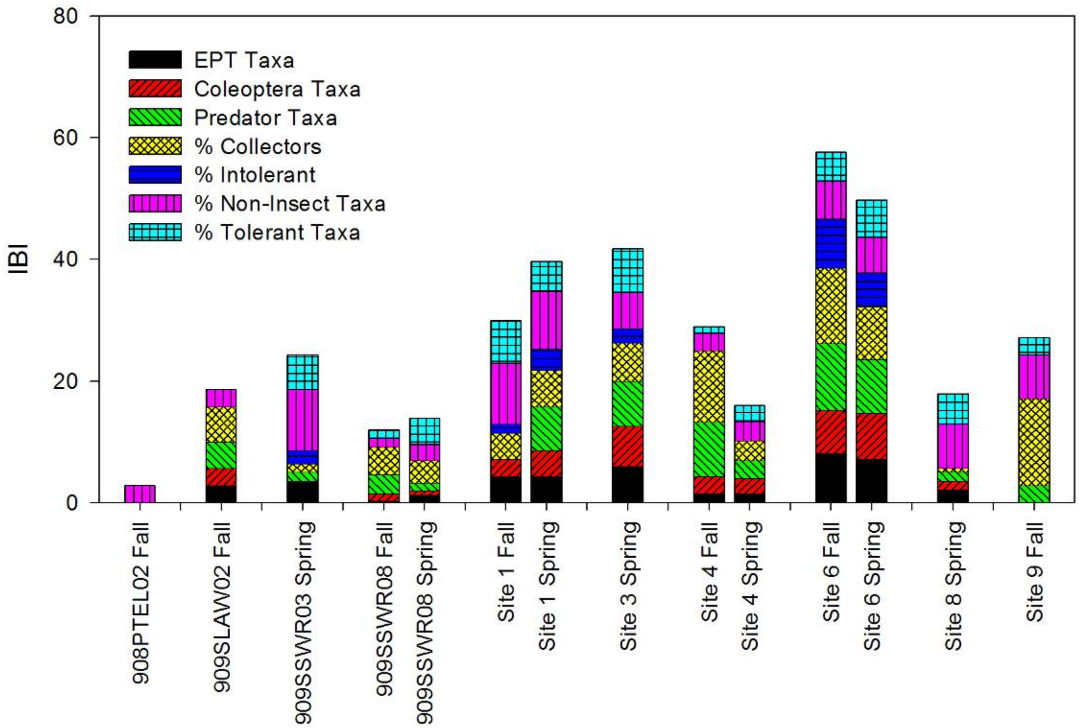


Figure 10. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI.

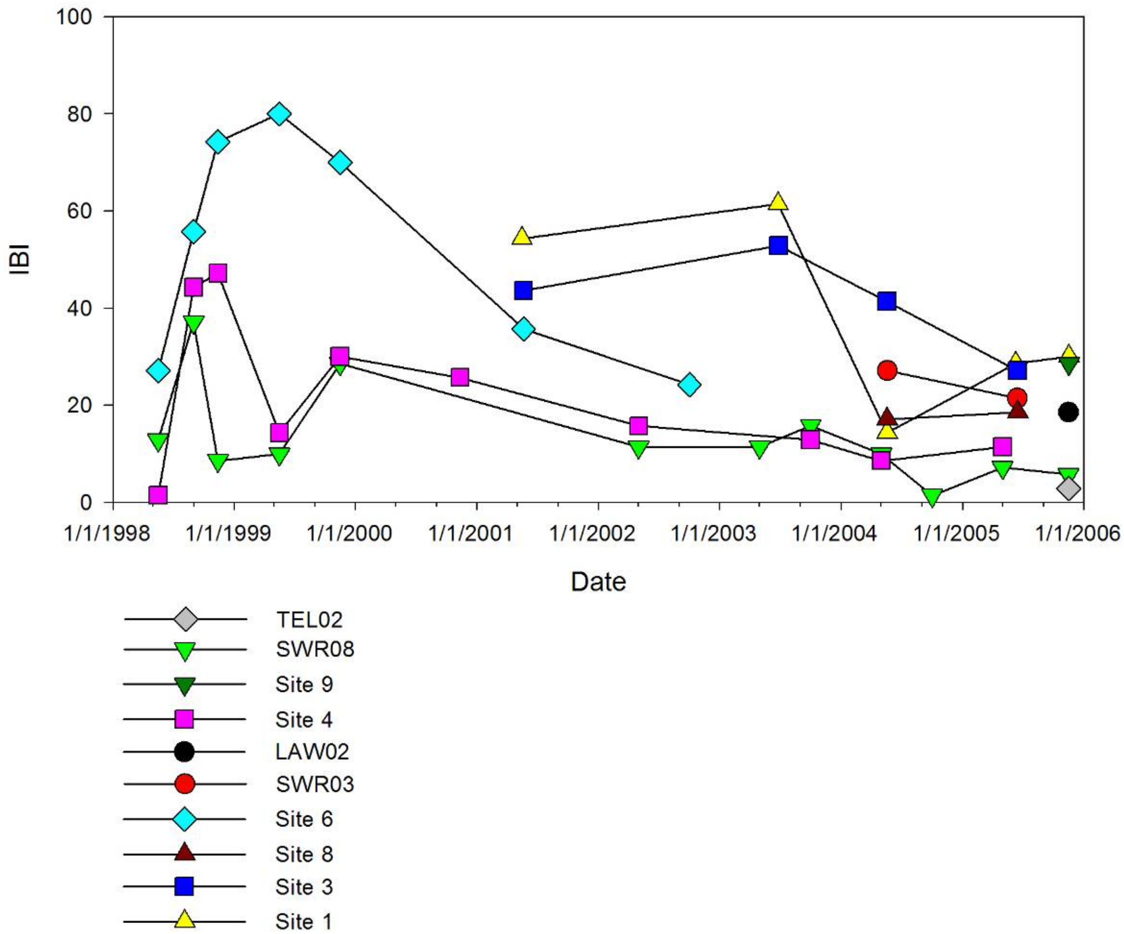


Figure 11. IBI values for each year and site. Each symbol represents a single sample. Sites are listed in order of increasing distance from the coast.

4.5 Physical Habitat

Physical habitat at the upstream mainstem site (SWR03) was moderately degraded. The mean physical habitat score was 14.5, just below the threshold for undegraded sites (i.e., 15). Only one component (i.e., velocity-depth regime) received a score below 10, suggesting that impacts are restricted to the uniform flow regime observed at the study site. Five components received scores of 13, indicating moderate degradation. Four components received scores of 18, indicating minimal degradation (Table 14; Figure 12).

Table 14. Score and mean for each component of physical habitat at SWR03. Component range: 0 (heavily impacted habitat) to 20 (unimpacted habitat).

Component	Score
Epifaunal cover	13
Embeddedness	13
Velocity-depth regime	8
Sediment deposition	13
Channel flow	13
Channel alteration	18
Riffle fequency	13
Bank stability	18
Vegetation protection	18
Riparian zone	18
Mean score	14.5

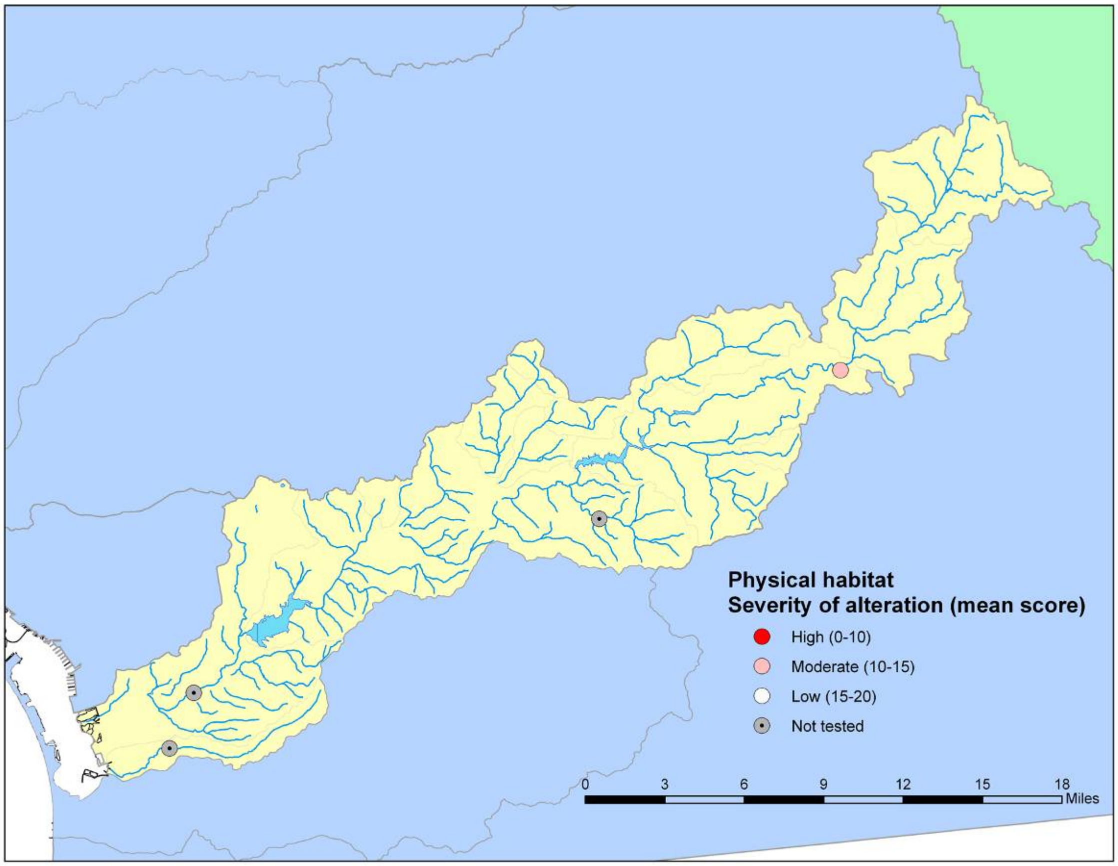


Figure 12. Assessment of physical habitat at SWAMP sites. White circles indicate sites with a mean physical habitat scores between 15 and 20. Pink circles indicate mean scores between 10 and 15. Red circles indicate mean scores between 0 and 10.

5. DISCUSSION

Every site sampled in the Sweetwater HU showed evidence of impact from multiple indicators (Table 15; Figure 13). Water chemistry, toxicity, and biological condition were degraded at every site assessed under SWAMP. In general, ecological condition was worst near San Diego Bay and better towards the interior. However, poor ecological health was evident throughout the watershed and multiple indicators indicated impacts at all sites in the HU. For example, the pesticide diazinon was detected at every site. Similarly, many water chemistry constituents, like ammonia-N, selenium, and total nitrogen, exceeded aquatic life thresholds at every site. Moreover, water and sediment samples from all sites caused toxicity to indicator species, and bioassessment samples in poor or very poor condition were collected at all sites in the watershed.

The downstream site on the Sweetwater River (SWR08) had the most severe degradation as determined by multiple indicators. For example, more water chemistry constituents exceeded aquatic life thresholds at this site than any other in the HU. These exceedences were most frequently associated with nutrients. However, selenium chloride, manganese, copper, pH, and conductivity exceeded water quality thresholds as well. Several organic constituents were detected, including the PAHs fluoranthene and pyrene, as well as the anthropogenic pesticides diazinon, dioxathion, and oxadiazon. Sediment and water samples were toxic to indicator species. Bioassessment samples collected by the regional board and by San Diego County were in very poor condition, with a mean IBI of 12.9. Furthermore, although bioassessment samples collected in the late 1990s were in poor condition, samples collected more recently were worse, suggesting a decline.

Telegraph Canyon Creek (TEL02) drains a small, but very urban part of the HU. Likewise, this site showed similar, but slightly less severe impacts than SWR08. Apart from total phosphorus, which was present at lower concentrations, the same suite of water chemistry constituents exceeded aquatic life thresholds at both sites. Additionally, the pesticides diazinon and dioxathion were detected at both sites. In addition, disulfoton and two phenanthrenes were detected at Telegraph Canyon Creek. Toxicity to both *S. capricornutum* and *H. azteca* was measured. However, only Telegraph Canyon Creek produced sediments that resulted in acute mortality of *H. azteca.* Although only one bioassessment sample was collected at this site, it had the lowest IBI score of any sample in the HU.

Lawson Valley Creek (LAW02) drains a watershed with less development than the downstream site (SW08) or Telegraph Canyon Creek (TEL02), and all indicators suggested that it is in better ecological condition. For example, only 4 water chemistry constituents exceeded aquatic life thresholds (i.e., ammonia-N, selenium, and total nitrogen). Furthermore, some samples were below thresholds on certain dates, suggesting that impacts were not persistent. Only one anthropogenic constituent (i.e., the pesticide diazinon) was detected. Toxicity was less frequent, affecting only one sample and one indicator species (i.e., *H. azteca*). Only one bioassessment sample was collected from Lawson Valley Creek, but it was in very poor condition (IBI 18.6). Although this value is higher than IBIs observed at the more urban sites (2.9 and 12.9 at Telegraph Canyon and the lower Sweetwater sites, respectively), it is unclear if the differences were significant.

The upstream site on the Sweetwater River (SWR03), like Lawson Valley Creek, was in poor ecological health, but in better condition than the urban sites further downstream. For example, the upper Sweetwater and Lawson Valley sites were impacted for the same constituents (i.e., ammonia-N, selenium, and total nitrogen), and exceedances were observed with similar frequencies. Only 3 organic constituents were detected (i.e., the PAH naphthalene, and the anthropogenic pesticides diazinon and dioxathion). Toxicity to *S. capricornutum* was observed, but not to *H. azteca.* Bioassessment samples from the upper Sweetwater were in better, but still poor condition (mean IBI 24.3). It is unclear if the differences between upper Sweetwater and the downstream urban sites were significant. Physical habitat, which was only assessed at this site, was moderately degraded. Only one component of physical habitat (i.e., velocity-depth regime) suggesting severe impacts.

This study's assessment of the Sweetwater HU suggested that the watershed is in poor ecological health. 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 during most sampling events.

Although these impacts were widespread, and in some cases severe, this study showed that impacts to water quality 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. Only one water chemistry constituent (chloride) exceeded human health thresholds. Furthermore, acute toxicity to indicator species was rarely observed. Lastly, bioassessment samples were frequently in poor or very poor condition, but samples in fair or good condition were sometimes observed, especially in the upper parts of the watershed.

Despite the strength of the evidence, limitations of this study affect the assessment. These limitations include difficulties integrating data from SWAMP and non-SWAMP sources, the non-randomization of sample sites, small sample size, and the lack of applicable thresholds for several indicators. Although these limitations require that results be interpreted with caution, it is unlikely that they would alter the fundamental finding that the Sweetwater HU 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 7 years before water chemistry and toxicity 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, physical habitat was assessed at only one site; therefore, habitat degradation may have gone undetected in unsampled regions of the watershed. Although SWAMP has produced a wealth of data about the Sweetwater watershed using limited resources, some indicators (especially those with high variability) may require more extensive sampling to produce more precise and accurate assessments.

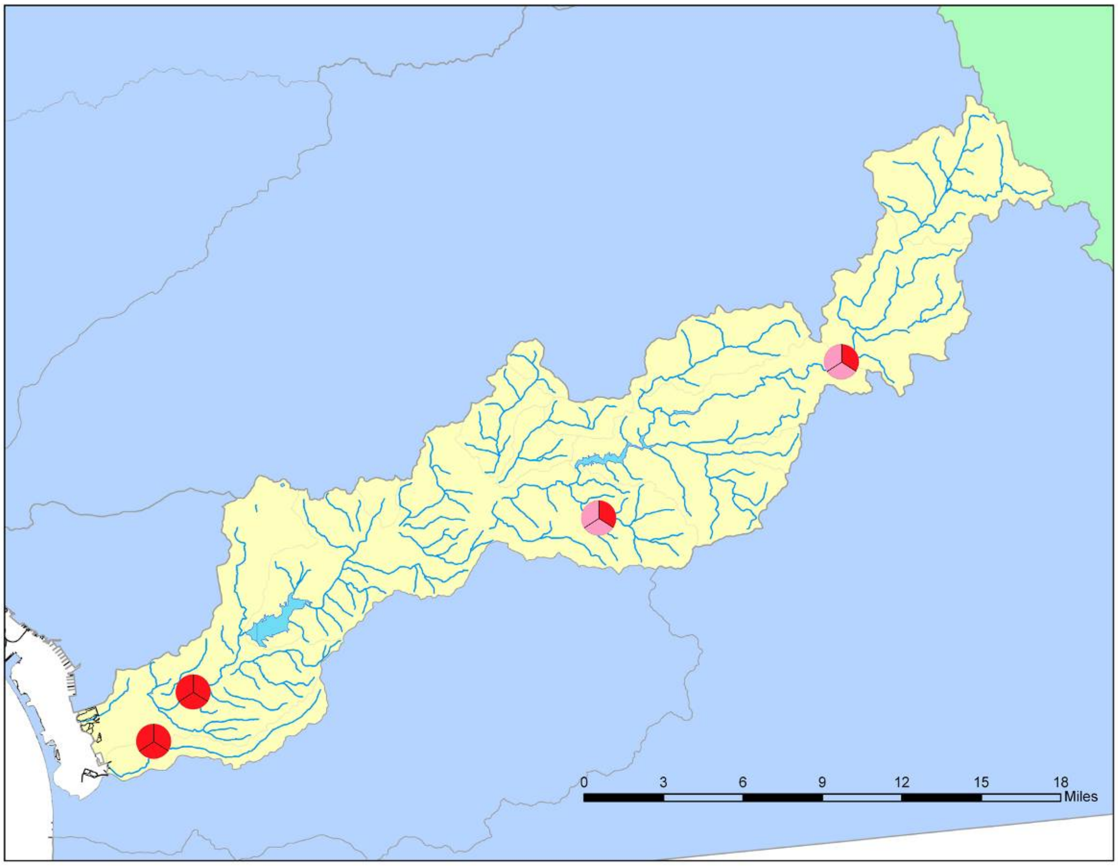
Thresholds are an essential tool for assessing water quality and ecological health. However, their use is limited to indicators that have been well studied, and they cannot provide a holistic view of watershed health. This limitation is exacerbated by the fact that many constituents and indicators lack 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).

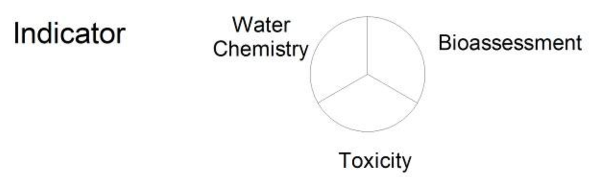
Despite these limitations, the data gathered under SWAMP and other programs strongly support the conclusion that the Sweetwater HU is in poor ecological health. Some of these limitations (such as the lack of applicable thresholds and the small sample size) may in fact have caused this assessment to underestimate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

Table 15. Summary of the ecological health for five SWAMP sites in Sweetwater HU. 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.

		Water chemistry		Toxicity	Biology*
Site		Aquatic life # constituents	Human health # constituents	Frequency	Frequency
908PTEL02	Telegraph Canyon Creek 2	7	0	0.50	1.00
909SLAW02	Lawson Valley Creek 2	4	0	0.25	1.00
909SSWR03	Sweetwater River 3	4	0	0.33	1.00
909SSWR08	Sweetwater River 8	9	0	1.00	1.00

* = Estimated from 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 13. Summary of the ecological health of SWAMP sites in the Sweetwater HU, as determined by water chemistry, toxicity, and bioassessment indicators. Each pie slice corresponds to a specific indicator, as described in the inset, with darker colors corresponding to more degraded conditions (unmeasured indicators are shown in cross-hatched gray). The top-left slice corresponds to the number of water chemistry constituents exceeding aquatic life thresholds. The bottom slice corresponds to the frequency of toxicity among three endpoints: *C. dubia* (fecundity), *H. azteca* (growth), and *S. capricornutum* (total cell count). The top-right slice corresponds to the IBI of bioassessment samples.

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7. APPENDICES

APPENDIX I

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

Beneficial uses of streams in the Sweetwater HU.

Sweetwater River	HUC	MUN	AGR	IND	PROC	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN
Sweetwater River	909.35	E	E	E	E	E	E		E	E	E		E
Stonewall Creek	909.35	E	E	E	E	E	E		E	E	E		E
Harper Creek	909.35	E	E	E	E	E	E		E	E	E		E
Cold Stream	909.35	E	E	E	E	E	E		E	E	E		E
Japacha Creek	909.35	E	E	E	E	E	E		E	E	E		E
Juaquapin Creek	909.35	E	E	E	E	E	E		E	E	E		E
Arroyo Seco	909.35	E	E	E	E	E	E		E	E	E		
Sweetwater River	909.34	E	E	E	E	E	E		E	E	E		E
Descanso Creek	909.34	E	E	E	E	E	E		E	E	E		
Samagatuma Creek	909.34	E	E	E	E	E	E		E	E	E		
Sweetwater River	909.31	E	E	E	E	E	E		E	E	E		E
Viejas Creek	909.33	E	E	E	E	E	E		E	E	E		
Viejas Creek	909.31	E	E	E	E	E	E		E	E	E		
Taylor Creek	909.31	E	E	E	E	E	E		E		E		
Japatul Valley	909.32	E	E	E	E	E	E		E		E		
Sweetwater River	909.21	E	E	E	E	E	E	E	E		E	E	
Unnamed tributary	909.21	E	E	E	E	E	E	E	E		E	E	
Lawson Creek	909.21	E	E	E	E	E	E		E		E		
Beaver Canyon	909.21	E	E	E	E	E	E		E		E		
Wood Valley	909.21	E	E	E	E	E	E		E		E		
Sycuan Creek	909.25	E	E	E	E	E	E		E		E		
North Fork Sycuan Creek	909.26	E	E	E	E	E	E		E		E		
North Fork Sycuan Creek	909.25	E	E	E	E	E	E		E		E		
Denesa Valley	909.23	E	E	E	E	E	E		E		E		
Harbinson Canyon	909.23	E	E	E	E	E	E		E		E		
Galloway Valley	909.24	E	E	E	E	E	E		E		E		
Mexican Canyon	909.21	E	E	E	E	E	E		E		E		
Unnamed tributary	909.22	E	E	E	E	E	E		E		E		
Steel Canyon	909.21	E	E	E	E	E	E		E		E		
Coon Canyon	909.21	E	E	E	E	E	E		E		E		
Sweetwater River	909.12	X		E		P	E		E		E		
Spring Valley	909.12	X		E		P	E		E		E		
Wild Mans Canyon	909.12	X		E		P	E		E		E		
Long Canyon	909.12	X		E		P	E		E		E		
Rice Canyon	909.12	X		E		P	E		E		E		
Telegraph Canyon	909.11	X		E		P			E				

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.

			908PTEL02			909SLAW02			909SSWR03			909SSWR08		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Bacteria	Enterococcus	MPN/100 mL			0	2400		1			0			0
Bacteria	Fecal Coliform	MPN/100 mL			0	900		1			0			0
Bacteria	Total Coliform	MPN/100 mL			0	1600		1			0			0
Inorganics	Alkalinity as CaCO3	mg/L	174	56	4	149	1	3	108	10	4	322	48	4
Inorganics	Ammonia as	mg/L	0.09	0.04	4	0.02	0.03	3	0.04	0.03	4	0.09	0.05	4
Inorganics	Chloride	mg/L	2180		1			0			0	1300		1
Inorganics	Nitrate as NO3	mg/L	17.93	1.94	4	0.24	0.29	3	0.29	0.33	4	1.06	0.62	4
Inorganics	Nitrite as N	mg/L	0.066	0.030	4	0.003	0.003	3	0.001	0.002	4	0.011	0.003	4
Inorganics	Nitrogen, Total Kjeldahl	mg/L	1.11	0.16	4	0.47	0.08	3	0.35	0.13	4	0.90	0.16	4
Inorganics	o-phosphate as P	mg/L			0	0.015		1			0			0
Inorganics	Phosphorus as P,Total	mg/L	0.05	0.02	4	0.02	0.02	3	0.04	0.02	4	0.11	0.01	4
Inorganics	Selenium,Dissolved	µg/L	49	37	4	5	4	2	6	9	4	35	15	4
Inorganics	Sulfate	mg/L	453	14	4	101	12	3	70	15	4	436	75	4
Metals	Aluminum,Dissolved	µg/L	0.508	0.799	4	14.167	13.411	3	7.813	7.282	4	1.638	2.242	4
Metals	Arsenic,Dissolved	µg/L	37.9	5.6	4	0.6	0.1	3	0.6	0.2	4	4.1	0.1	4
Metals	Cadmium,Dissolved	µg/L	0.03	0.03	4	0.02	0.02	3	0.01	0.01	4	0.02	0.01	4
Metals	Chromium,Dissolved	µg/L	0.76	0.86	4	0.76	0.63	3	0.39	0.23	4	1.88	1.60	4
Metals	Copper,Dissolved	µg/L	6.02	3.06	4	2.03	1.20	3	1.43	0.43	4	6.98	1.84	4
Metals	Lead,Dissolved	µg/L	0.04	0.06	4	0.14	0.24	3	0.09	0.15	4	0.04	0.03	4
Metals	Manganese,Dissolved	µg/L	6.4	6.3	4	21.6	22.1	3	37.5	29.4	4	143.1	84.1	4
Metals	Nickel,Dissolved	µg/L	1.6	0.8	4	0.9	1.3	3	0.1	0.2	4	0.5	0.8	4
Metals	Silver,Dissolved	µg/L	0.003	0.005	4	0.000	0.000	3	0.000	0.000	4	0.000	0.000	4
Metals	Zinc,Dissolved	µg/L	4.5	1.4	4	2.0	0.7	3	0.6	0.2	4	4.3	0.8	4
PAHs	Acenaphthene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Acenaphthylene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	alpha-BHC	µg/L			0	0		1			0			0
PAHs	Anthracene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Benz(a)anthracene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Benzo(a)pyrene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Benzo(b)fluoranthene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Benzo(e)pyrene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Benzo(g,h,i)perylene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Benzo(k)fluoranthene	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	beta-BHC	µg/L			0	0		1			0			0
PAHs	Biphenyl	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Chrysene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Chrysenes, C1 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Chrysenes, C2 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Chrysenes, C3 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	delta-BHC	µg/L			0	0		1			0			0
PAHs	Dibenz(a,h)anthracene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Dibenzothiophene	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Dibenzothiophenes, C1 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Dibenzothiophenes, C2 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Dibenzothiophenes, C3 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Dichlofenthion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Dimethylnaphthalene, 2,6-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Dimethylphenanthrene, 3,6-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4

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

			908PTEL02			909SLAW02			909SSWR03			909SSWR08		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PAHs	Fluoranthene	µg/L	0	0	4	0	0	3	0	0	4	0.002	0.004	4
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Fluorene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Fluorenes, C1 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Fluorenes, C2 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Fluorenes, C3 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	gamma-BHC (Lindane)	µg/L			0	0		1			0			0
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Methyldibenzothiophene, 4-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Methylfluoranthene, 2-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Methylfluorene, 1-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Methylnaphthalene, 1-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Methylnaphthalene, 2-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Methylphenanthrene, 1-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Naphthalene	µg/L	0	0	4	0	0	3	0.0018	0.0035	4	0	0	4
PAHs	Naphthalenes, C1 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Naphthalenes, C2 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Naphthalenes, C3 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Naphthalenes, C4 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Perylene	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Phenanthrene	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	0.0013	0.0025	4	0	0	2	0	0	4	0	0	4
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	0.0014	0.0029	4	0	0	2	0	0	4	0	0	4
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PAHs	Pyrene	µg/L	0	0	4	0	0	3	0	0	4	0.0016	0.0033	4
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 005	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 008	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 015	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 018	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 027	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 028	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 029	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 031	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 033	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 044	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 049	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 052	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 056	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 060	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 066	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 070	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 074	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 087	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 095	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 097	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 099	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 101	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 105	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 110	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 114	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 118	µg/L	0	0	4	0	0	2	0	0	4	0	0	4

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

			908PTEL02			909SLAW02			909SSWR03			909SSWR08		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
PCBs	PCB 128	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 137	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 138	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 141	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 149	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 151	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 153	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 156	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 157	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 158	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 170	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 174	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 177	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 180	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 183	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 187	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 189	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 194	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 195	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 200	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 201	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 203	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 206	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB 209	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
PCBs	PCB-1016	µg/L			0	0		1			0			0
PCBs	PCB-1221	µg/L			0	0		1			0			0
PCBs	PCB-1232	µg/L			0	0		1			0			0
PCBs	PCB-1242	µg/L			0	0		1			0			0
PCBs	PCB-1248	µg/L			0	0		1			0			0
PCBs	PCB-1254	µg/L			0	0		1			0			0
PCBs	PCB-1260	µg/L			0	0		1			0			0
Pesticide	Toxaphene	µg/L			0	0		1			0			0
Pesticides	Aldrin	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Aspon	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Azinphos ethyl	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Azinphos methyl	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Bolstar	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Carbophenothion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Chlordane (tech)	µg/L			0	0		1			0			0
Pesticides	Chlordane, cis-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Chlordane, trans-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Chlordene, alpha-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Chlordene, gamma-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Chlorfenvinphos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Chlorpyrifos	µg/L	0	4	0	0	2	0	0	4	0	0	4	0
Pesticides	Chlorpyrifos methyl	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Ciodrin	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Coumaphos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Dacthal	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	DDD(o,p')	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	DDD(p,p')	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	DDE(o,p')	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	DDE(p,p')	µg/L	0	0	4	0	0	3	0	0	4	0	0	4

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

			908PTEL02			909SLAW02			909SSWR03			909SSWR08		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	DDMU(p,p')	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	DDT(o,p')	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	DDT(p,p')	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Demeton-s	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Diazinon	µg/L	0.0255	0.0073	4	0.0050	0.0071	2	0.0058	0.0067	4	0.0060	0.0073	4
Pesticides	Dichlorvos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Dicrotophos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Dieldrin	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Dimethoate	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Dioxathion	µg/L	0.0518	0.0628	4	0	0	2	0.0113	0.0225	4	0.0575	0.0708	4
Pesticides	Disulfoton	µg/L	0.0145	0.0290	4	0	0	2	0	0	4	0	0	4
Pesticides	Endosulfan I	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Endosulfan II	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Endosulfan sulfate	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Endrin Aldehyde	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Endrin Ketone	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Endrin	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Ethion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Ethoprop	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Famphur	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Fenchlorphos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Fenitrothion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Fensulfothion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Fenthion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Fonofos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	HCH, alpha	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	HCH, beta	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	HCH, delta	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	HCH, gamma	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Heptachlor epoxide	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Heptachlor	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Hexachlorobenzene	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Leptophos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Malathion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Merphos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Methidathion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Methoxychlor	µg/L	0	0	4	0	0	3	0	0	4	0	0	4
Pesticides	Mevinphos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Mirex	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Molinate	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Naled	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Nonachlor, cis-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Nonachlor, trans-	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Oxadiazon	µg/L	0.0303	0.0113	4	0	0	2	0	0	4	0.0088	0.0070	4
Pesticides	Oxychlordane	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Parathion, Ethyl	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Parathion, Methyl	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Phorate	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Phosmet	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Phosphamidon	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Sulfotep	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Tedion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Terbufos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4

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

			904CBESC8			904CBLAC3			904CBSAM3			904CBSAM6			Entire watershed		
Category	Constituent	Units	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Inorganics	Alkalinity as CaCO3	mg/l	265	18	4	309	15	4	246	26	4	225	16	4	252	42	10
Inorganics	Ammonia as N	mg/l	0.07	0	4	0.16	0.15	4	0.12	0.1	4	0.14	0.07	4	0.13	0.04	10
Inorganics	Nitrate + Nitrite as N	mg/l	1.96	0.86	4	0.13	0.04	4	0.5	0.37	4	0.27	0.04	4	6.41	11.96	10
Inorganics	Nitrogen, Total Kjeldahl	mg/l	0.45	0.09	4	0.43	0.07	4	0.43	0.12	4	0.69	0.09	4	0.49	0.11	10
Inorganics	OrthoPhosphate as P	mg/l	0.11	0.02	4	0.03	0.01	4	0.14	0.05	4	0.2	0.02	4	0.12	0.06	10
Inorganics	Phosphorus as P,Total	mg/l	0.14	0.02	4	0.03	0.02	4	0.19	0.13	4	0.26	0.02	4	0.14	0.08	10
Inorganics	Selenium,Dissolved	µg/L	5.5	0.3	4	12.2	1.8	4	14.3	16.5	4	24.2	22.8	4	10.6	6.6	10
Inorganics	Sulfate	mg/l	433	73	4	221	28	4	312	70	4	941	517	4	470	243	10
Metals	Aluminum,Dissolved	µg/L	12	14	4	2	2.6	4	6.6	6.3	4	4.5	4.9	4	3.6	3.5	10
Metals	Arsenic,Dissolved	µg/L	2.1	0.1	4	5.4	0.7	4	5.4	4.7	4	7.4	4.7	4	4.7	1.8	10
Metals	Cadmium,Dissolved	µg/L	0.05	0.01	4	0.01	0.01	4	0.05	0.02	4	0.05	0.05	4	0.04	0.02	10
Metals	Chromium,Dissolved	µg/L	1.48	1.58	4	0.75	0.65	4	0.82	0.71	4	1.17	0.71	4	1.07	0.48	10
Metals	Copper,Dissolved	µg/L	3	0.42	4	2.12	0.39	4	3.17	0.19	4	5.31	2.54	4	3.54	1.21	10
Metals	Lead,Dissolved	µg/L	0.01	0.02	4	0	0.01	4	0.03	0.03	4	0.14	0.24	4	0.03	0.04	10
Metals	Manganese,Dissolved	µg/L	137	37	4	120	63	4	175	221	4	381	238	4	125	119	10
Metals	Nickel,Dissolved	µg/L	1.4	0.6	4	2.5	1.5	4	2	0.7	4	2.6	1.3	4	2.1	0.9	10
Metals	Silver,Dissolved	µg/L	--	--	4	--	--	4	0	0.01	4	0.01	0.01	4	0	0	10
Metals	Zinc,Dissolved	µg/L	2.8	0.4	4	1.2	0.8	4	7.7	4.8	4	16.1	12.5	4	6.5	5.2	10
PAHs	Acenaphthene	µg/L	--	--	4	--	--	4	--	--	4	0.009	0.018	4	0.001	0.003	10
PAHs	Acenaphthylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Anthracene	µg/L	--	--	4	--	--	4	--	--	4	0.02	0.04	4	0.004	0.007	10
PAHs	Benz(a)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(a)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(b)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(e)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(g,h,i)perylene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Benzo(k)fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Biphenyl	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Chrysene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Chrysenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Chrysenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Chrysenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenz(a,h)anthracene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Dibenzothiophene	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenzothiophenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenzothiophenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dibenzothiophenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Dimethylnaphthalene, 2,6-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Fluoranthene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Fluorene	µg/L	--	--	4	--	--	4	--	--	4	0.006	0.013	4	0.001	0.002	10
PAHs	Fluorenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Fluorenes, C2 -	µg/L	0.044	--	1	0.026	--	1	0.028	--	1	0.026	--	1	0.029	0.005	10
PAHs	Fluorenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Methylnaphthalene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Methylnaphthalene, 2-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Methylphenanthrene, 1-	µg/L	--	--	4	--	--	4	--	--	4	--	--	4	--	--	10
PAHs	Naphthalene	µg/L	--	--	4	--	--	4	--	--	4	0.018	0.02	4	0.004	0.006	10
PAHs	Naphthalenes, C1 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Naphthalenes, C2 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Naphthalenes, C3 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10
PAHs	Naphthalenes, C4 -	µg/L	--	--	1	--	--	1	--	--	1	--	--	1	--	--	10

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

			908PTEL02			909SLAW02			909SSWR03			909SSWR08		
Type	Constituent	Unit	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Pesticides	Tetrachlorvinphos	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Thiobencarb	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Thionazin	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Tokuthion	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Trichlorfon	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Pesticides	Trichloronate	µg/L	0	0	4	0	0	2	0	0	4	0	0	4
Physical	Oxygen, Dissolved	mg/L	11.0	1.6	4	7.7	0.7	2	10.0	1.5	4	7.5	1.3	4
Physical	Oxygen, Saturation	%	130	28	4	86	15	2	90	5	4	84	10	4
Physical	pH	pH units	8.5	0.2	4	7.5	0.0	2	7.8	0.2	4	7.8	0.4	4
Physical	Salinity	ppt	3.86	0.11	4	0.48	0.03	2	0.22	0.03	4	2.15	0.63	4
Physical	Specific conductivity	µS/cm	7112	27	4	958	65	2	435	71	4	5730	4206	4
Physical	Suspended Solids,Total	mg/L	9.2	4.9	4	0.0	0.0	3	5.5	5.5	4	12.6	0.8	3
Physical	Temperature	ºC	22.3	7.1	4	20.8	4.0	2	10.5	4.1	4	19.3	3.9	4
Physical	Turbidity	NTU	2.35	2.00	4	0.40		1	4.19	3.91	3	8.83	6.75	4
Physical	Velocity	ft/sec	2.0	0.4	3	1.3		1	2.2	0.8	3			0

B. Non-SWAMP sites.

	Site 4 (SR-94)			Site 9 (SR-AD)			Site 5 (SR-WS)		
Constituent	Mean	SD	n	Mean	SD	n	Mean	SD	n
Dissolved oxygen (mg/L)	10.7	6.5	4	14.3		1	7.4	1.5	6
pH	7.8	0.2	4	8.9		1	7.7	0.2	6
Specific conductivity (mS/cm)	1.96	0.89	4	3.6		1	4.1	0.4	6
Turbidity (NTU)			0			0	18.4		1
Water temperature (ºC)	20.4	1.8	4	16.4		1	19.3	1.6	6

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
908PTEL02	2	0	nt		0	nt		2	89	14	1	77		1	80	
909SLAW02	1	1	111		1	136		1	106	20	1	102	3	1	262	
909SSWR03	2	1	105		1	111		1	114		1	78		1	111	
909SSWR08	2	0	nt		0	nt		2	104	5	1	70		1	31	
All sites in watershed	7	2	108	4	2	123	17	6	103	10	4	82	14	4	121	100

APPENDIX IV

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

				IBI		EPT Taxa		Coleoptera Taxa		Predator Taxa		% Collectors		% Intolerant		% Non-insect Taxa		% Tolerant Taxa	
Site	Season	n	Years	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
908PTEL02	Fall	1	2005	2.9		0.0		0.0		0.0		0.0		0.0		2.0		0.0	
909SLAW02	Fall	1	2005	18.6		2.0		2.0		3.0		4.0		0.0		2.0		0.0	
909SSWR03	Spring	2	2004-2005	24.3	4.0	2.5	2.1	0.0	0.0	1.0	1.4	1.0	0.0	1.5	0.7	7.0	1.4	4.0	0.0
909SSWR08	Average	12	1998-2005	12.9	1.3	0.5	0.5	0.7	0.2	1.5	0.9	2.9	0.4	0.0	0.0	1.4	0.6	2.0	1.4
	Fall	5	1998-2005	12.0	10.6	0.2	0.4	0.8	1.1	2.2	3.9	3.2	3.1	0.0	0.0	1.0	1.7	1.0	1.0
	Spring	7	1998-2005	13.9	10.4	0.9	0.4	0.6	1.5	0.9	2.3	2.6	3.6	0.0	0.0	1.9	0.9	3.0	1.5
Site 1	Average	5	2001-2005	34.8	6.8	3.0	0.0	2.5	0.7	2.5	3.5	3.6	0.9	1.8	1.1	6.8	0.4	4.3	1.1
	Fall	1	2005	30.0		3.0		2.0		0.0		3.0		1.0		7.0		5.0	
	Spring	4	2001-2005	39.6	22.0	3.0	1.8	3.0	2.4	5.0	4.4	4.3	4.3	2.5	3.1	6.5	1.9	3.5	2.4
Site 3	Spring	5	2001-2005	41.7	9.6	4.2	1.9	4.6	3.1	5.2	2.7	4.4	3.6	1.6	0.5	4.2	1.6	5.0	1.9
Site 4	Average	10	1998-2005	22.4	9.2	1.0	0.0	1.9	0.1	4.1	3.0	5.3	4.2	0.0	0.0	2.1	0.1	1.3	0.8
	Fall	4	1998-2003	28.9	14.2	1.0	0.8	2.0	1.6	6.3	3.8	8.3	2.4	0.0	0.0	2.0	1.6	0.8	1.5
	Spring	6	1998-2005	16.0	14.8	1.0	0.6	1.8	2.2	2.0	2.8	2.3	3.9	0.0	0.0	2.2	1.5	1.8	2.0
Site 6	Average	7	1998-2005	53.6	5.6	5.3	0.5	5.1	0.2	7.0	1.0	7.3	1.9	4.8	1.2	4.2	0.2	3.8	0.6
	Fall	3	1998-2005	57.6	25.2	5.7	2.5	5.0	3.0	7.7	4.0	8.7	1.5	5.7	4.5	4.3	0.6	3.3	3.1
	Spring	4	1998-2001	49.6	23.5	5.0	2.9	5.3	2.8	6.3	3.8	6.0	3.8	4.0	4.1	4.0	1.6	4.3	1.3
Site 8	Spring	2	2004-2005	17.9	1.0	1.5	0.7	1.0	1.4	1.0	1.4	0.5	0.7	0.0	0.0	5.0	0.0	3.5	4.9
Site 9	Fall	1	2002	27.1		0.0		0.0		2.0		10.0		0.0		5.0		2.0	