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Surface Water Ambient Monitoring Program (SWAMP) Report on the Pueblo San Diego Hydrologic Unit

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SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP) REPORT ON THE PUEBLO SAN DIEGO HYDROLOGIC UNIT

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1. ABSTRACT

In order to assess the ecological health of the Pueblo San Diego Hydrologic Unit (San Diego County, CA), water chemistry, water and sediment toxicity, and benthic macroinvertebrate communities were assessed at multiple sites on Chollas and Paradise Creeks. Water chemistry, toxicity, and bioassessment samples were assessed under SWAMP between 2005 and 2006. Bioassessment samples were also collected under other programs between 2003 and 2005. Although impacts to human health were assessed, the 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, water chemistry constituents at both sites exceeded aquatic life thresholds. Toxicity was evident at both sites, with the alga *Selenastrum capricornutum* indicating toxicity at both Paradise and Chollas Creeks. Bioassessment samples collected at 2 sites on Chollas Creek were all in poor or very poor condition. Mean annual IBIs ranged from 10.0 at the downstream site to 19.5 at the upstream site, indicating that benthic assemblages were typical of impacted communities. Multiple stressors, including contaminated water, 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 these sites in the Pueblo San Diego HU are in poor ecological condition.

2. INTRODUCTION

The Pueblo San Diego hydrologic unit (HU 908) is in southern San Diego County and is home to about 500,000 people and represents an important water resource in one of the most arid regions of the nation (SANDAG 1998). Despite strong interest in the surface waters of the Pueblo San Diego 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 Water Ambient Monitoring Program (SWAMP), and data collected by other programs, such as monitoring by National Pollution Discharge Elimination System (NPDES) permittees and by the California Department of Fish and Game (DFG). 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, and macroinvertebrate community structure. By examining data from multiple sources, this report provides a measure of the ecological integrity of the Pueblo San Diego 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, and benthic macroinvertebrate communities.

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 Pueblo San Diego HU is a collection of coastal watersheds in southern San Diego County draining into San Diego Bay (Figure 1). Located entirely within San Diego County, the watershed covers 56 mi^2 and ranges from Paradise Mountains, in the interior, to the Pacific Coast.

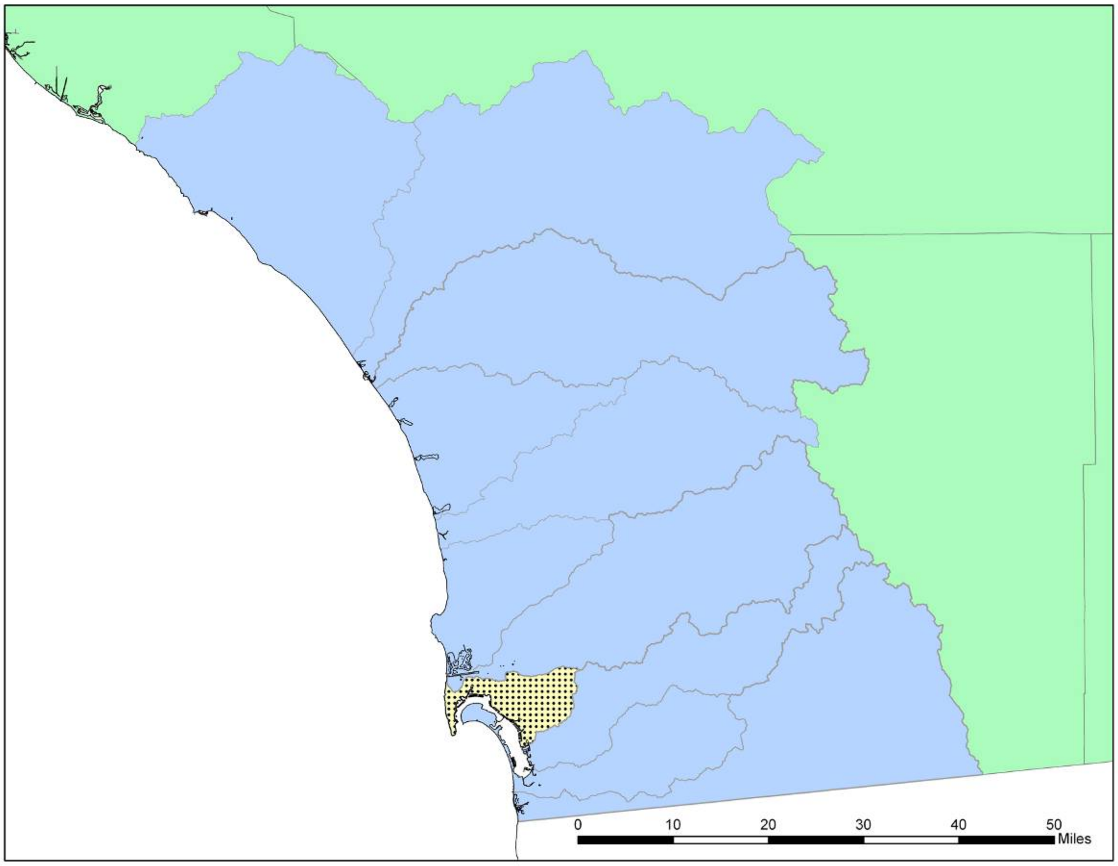


Figure 1. San Diego region (purple) includes portions of San Diego, Riverside, and Orange counties. The Pueblo San Diego HU (tan, shaded) is located entirely within San Diego County.

2.1.1 Climate

The Pueblo San Diego 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 Sea World (near the inland end of the HU) and at La Mesa (near the interior of the HU) shows considerable variability in rainfall throughout the HU (National Oceanic and Atmospheric Administration 2007) (Figure 2).

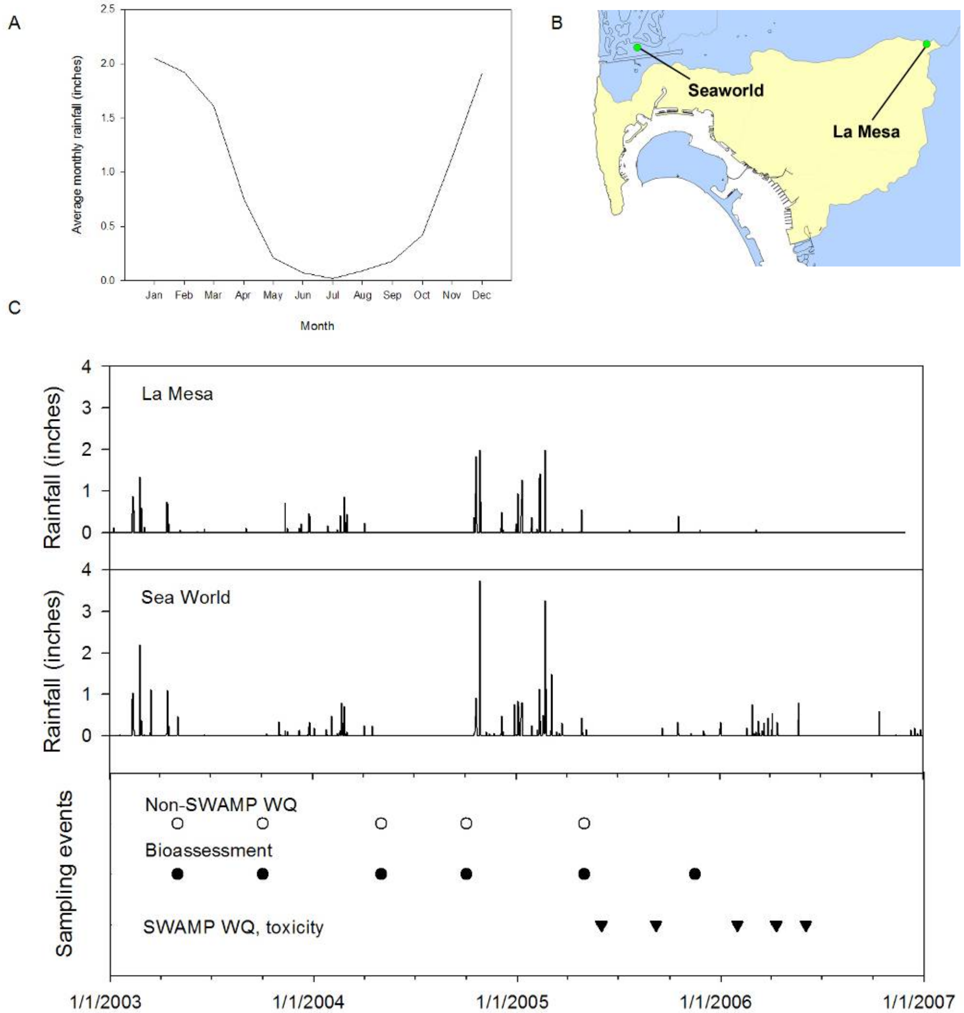


Figure 2. Rainfall and sampling events at stations in the San Diego region. A. Average precipitation for each month at the Lindberg Station (DWR station code SDG), based on data collected between January 1905 and November 2006. B. Location of the Seaworld and La Mesa gauges. C. Storm events and sampling events in the Pueblo San Diego HU. The top two plots show daily precipitation between 2003 and 2007 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 Pueblo San Diego HU consists of four major watersheds which drain to San Diego Bay: Chollas Creek, Paradise Creek, Powerhouse Creek, and Paleta Creek (Figure 3). The largest watershed is Chollas Creek, which consists of two major tributaries.

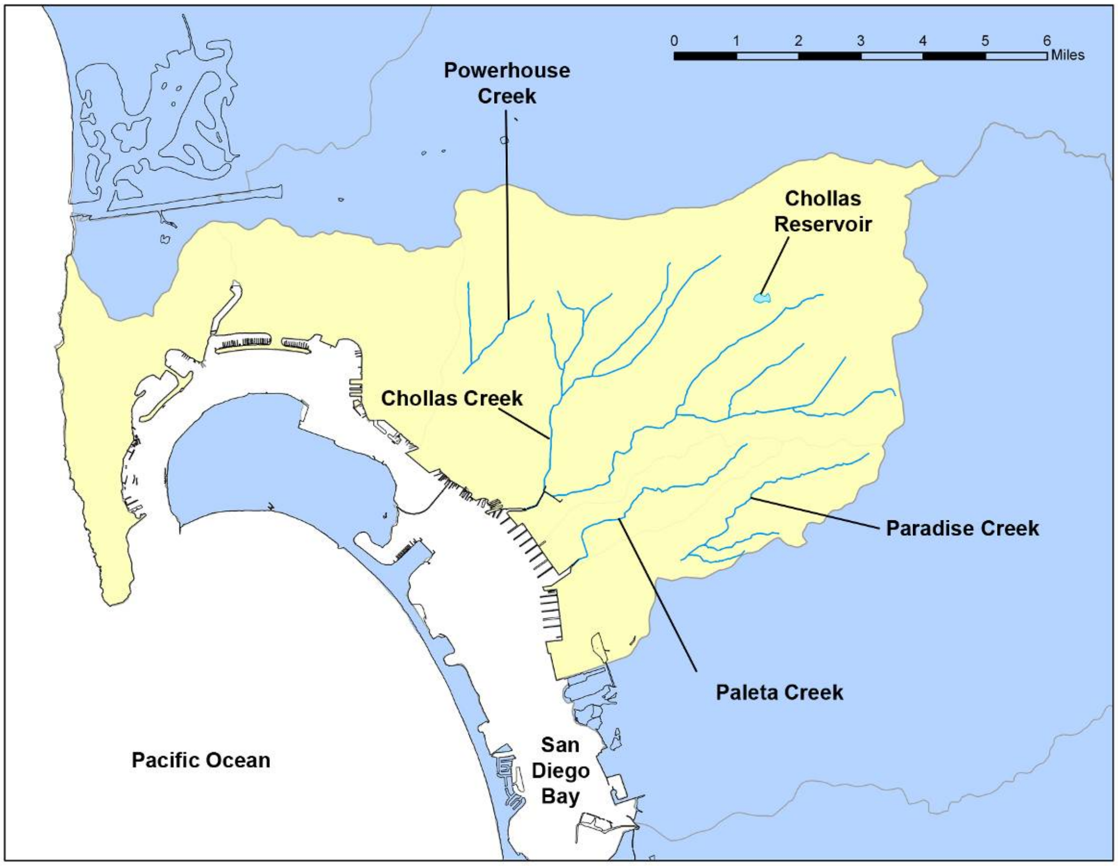


Figure 3. The Pueblo San Diego watershed, including major waterways.

2.1.3 Land Use within the Watershed

Several municipalities have jurisdiction over portions of the watershed. The City of San Diego occupies the largest portion of the watershed (83.6%), followed by National City (7.0%), Lemon Grove (4.6%), and La Mesa (4.5%). The watershed is extensively developed, with urban and industrial land uses covering 88% of the area. Open parklands occupy 12%; agricultural lands do not occupy a significant portion of the watershed. The largest protected area is Balboa Park (1.9 mi^2), which contains portions of Powerhouse Creek. Portions of Chollas Creek are protected by small riverside parks managed by the City of San Diego, such as Chollas Lake Park. Caltrans is a major landowner within the HU, and it has jurisdiction of all major freeways and highways (SANDAG 1998).

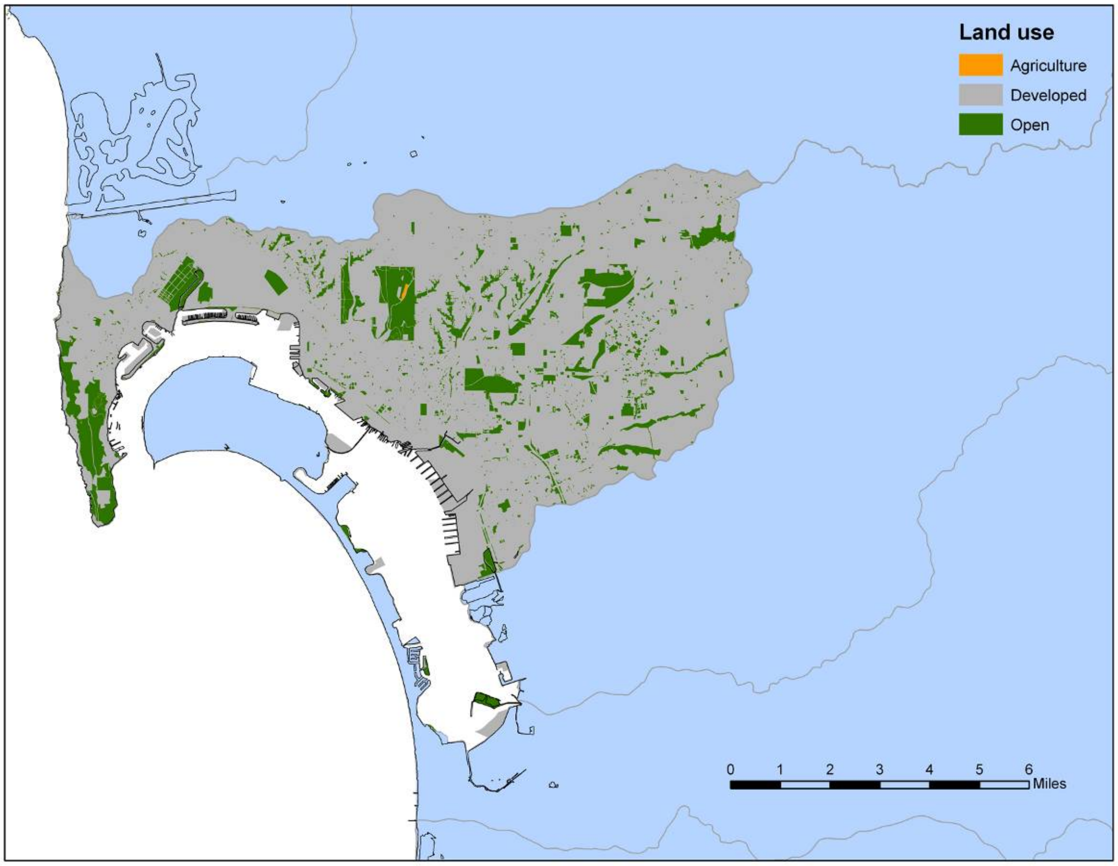


Figure 4. Land use within the Pueblo San Diego HU. Undeveloped open space is shown as green. Agricultural areas are shown as orange. Urban and developed lands are shown as dark gray.

2.1.4 Beneficial Uses and Known Impairments in the Watershed

The Pueblo San Diego HU is designated to support beneficial uses related to aquatic life and human health. Beneficial uses in the watershed include recreation; warm freshwater habitat; wildlife habitat. All streams in the Pueblo San Diego HU have been exempted from municipal uses (Appendix Ia).

Chollas Creek in the Pueblo San Diego HU is listed as impaired on the 303(d) list of water quality limited segments, affecting a total of 3.5 stream miles. Known stressors include copper, indicator bacteria, lead, zinc, and diazinon from nonpoint and point sources (Appendix Ib).

3. METHODS

This report combines data collected under SWAMP with data collected under other programs by the Regional Board, and under NPDES monitoring (Table 2). Two sites of interest were sampled under SWAMP in the Pueblo San Diego HU in 2005: Chollas Creek and Paradise Creek (Table 3; Figure 5). Water chemistry and water and sediment toxicity were measured at both sites.

Bioassessment samples were collected in 2005 and 2006 under SWAMP and other programs by the San Diego Water Board at Chollas Creek. Bioassessment samples and limited water chemistry (e.g., temperature, conductivity, dissolved oxygen) were collected at a second site on Chollas Creek by the Regional Board, and by the County of San Diego as part of its NPDES monitoring (Table 4; Figure 5). Physical habitat and fish tissues were not assessed in the Pueblo San Diego HU.

Table 2. Sources of data used in this report.

Project	Indicators	Years
SWAMP	Water chemistry, toxicity, bioassessment	2005-2006
Regional board monitoring	Bioassessment	2005
San Diego County NPDES	Water chemistry, bioassessment	2003-2005

Table 3. SWAMP sampling site locations. Bioassessment samples were collected at the locations marked with an asterisk (*).

Site		Description	Latitude (°N)	Longitude (°E)
1	908PPAR04	Paradise Creek 4	32.66943	-117.10279
2	CHL4*	Chollas Creek 4	32.69584	-117.12226

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	Chollas Creek tributary near Federal Avenue	None	Regional Board (908CCTNFA)		X	32.7273	-117.06977
			NPDES (CC-FB)	X	X		
2	Chollas Creek above National Boulevard	CHL4	Regional Board (908CLCANB)		X	32.69629	-117.12237

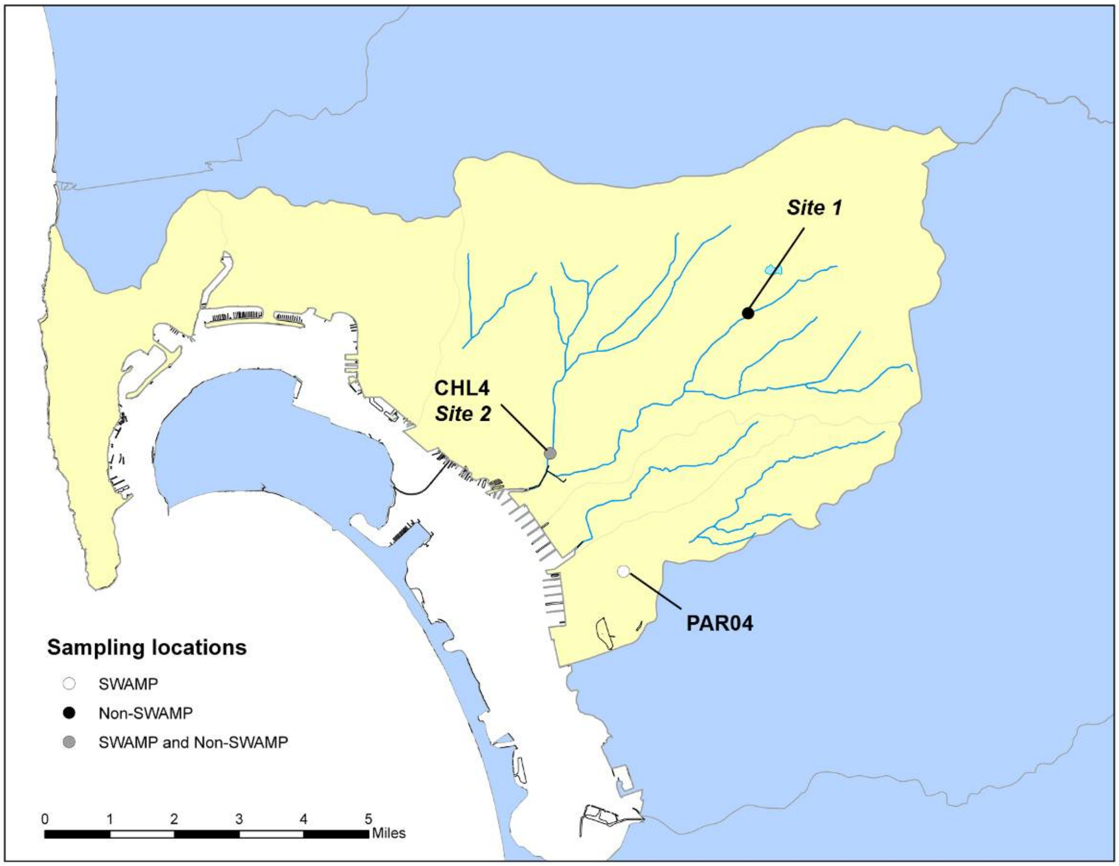


Figure 5. Sampling locations in the Pueblo San Diego HU. White circles represent sites sampled under SWAMP. Black circles represent sites sampled under non-SWAMP programs. Gray circles represent sites sampled under both SWAMP and non-SWAMP programs.

3.1 Indicators

Multiple indicators were used to assess the sites in the Pueblo San Diego HU. Water chemistry, water and sediment toxicity, and benthic macroinvertebrate communities.

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 the 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 Chollas and Paradise Creeks, 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.

All indicators were measured from one sample per site. All samples from Chollas Creek were collected on June 2, 2006. Water samples were collected at Paradise Creek on September 6, 2005. Sediment samples from Paradise Creek were collected on April 10, 2006.

3.1.3 Tissue

Fish tissues were not assessed in the Pueblo San Diego HU.

3.1.4 Bioassessment

To assess the ecological health of the streams in Pueblo San Diego HU, benthic macroinvertebrate samples were collected at 2 sites on Chollas Creek. 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 not assessed in the Pueblo San Diego HU.

3.2 Data Analysis

To evaluate the extent of human impacts to water chemistry in streams in the Pueblo San Diego 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) was 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. 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 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, and bioassessment. 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 Pueblo San Diego HU. Therefore, the most stringent water quality objectives (e.g., municipal drinking water, aquatic life, etc.) for the measured constituents were used as threshold 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), Total Maximum Daily Loads (TMDLs) for Chollas Creek, 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.
	Total Maximum Daily Loads (TMDL) for Chollas Creek	California Regional Water Quality Control Board, San Diego Region. 2007. Total Maximum Daily Loads for Dissolved Copper, Lead, and Zinc in Chollas Creel, Tributary to San Diego Bay. http://www.swrcb.ca.gov/rwqcb9/tmdls/
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 Pueblo San Diego 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). Total Maximum Daily Load for Copper, Lead and Zinc in Chollas Creek (TMDL)—applies only to Chollas Creek.

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
Inorganics	Alkalinity as CaCO3	20000	mg/l	EPA	none	mg/l	none
Inorganics	Ammonia as N	0.025	mg/l	BP	none	mg/l	none
Inorganics	Nitrate + Nitrite as N	10	mg/l	BP	none	mg/l	none
Inorganics	Phosphorus as P,Total	0.1	mg/l	BP	none	mg/l	none
Inorganics	Selenium,Dissolved	5	µg/L	CTR	none	µg/L	none
Inorganics	Chloride	none	mg/l	BP	230	mg/l	EPA
Metals	Aluminum,Dissolved	1000	µg/L	BP	none	µg/L	none
Metals	Arsenic,Dissolved	50	µg/L	BP	150	µg/L	CTR
Metals	Cadmium,Dissolved	5	µg/L	BP	2.2	µg/L	CTR
Metals	Chromium,Dissolved	50	µg/L	BP	none	µg/L	none
Metals	Copper,Dissolved	9	µg/L	CTR	1300	µg/L	CTR
Metals	Copper,Dissolved (CHL4 only)	8.8	µg/L	TMDL*	none	µg/L	none
Metals	Lead,Dissolved	2.5	µg/L	CTR	none	µg/L	none
Metals	Lead,Dissolved (CHL4 only)	2.2	µg/L	TMDL*	none	µg/L	none
Metals	Nickel,Dissolved	52	µg/L	CTR	610	µg/L	CTR
Metals	Silver,Dissolved	3.4	µg/L	CTR	none	µg/L	none
Metals	Zinc,Dissolved	120	µg/L	CTR	none	µg/L	none
Metals	Zinc,Dissolved (CHL4 only)	53	µg/L	TMDL*	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

* TMDL thresholds for copper, lead, and zinc apply to Chollas Creek, and assume a hardness of 100 mg/L $CaCO_3$.

Table 6, continued. Water chemistry thresholds.

		Aquatic life			Human health		
Category	Constituent	Threshold	Unit	Source	Threshold	Unit	Source
Pesticides	Heptachlor epoxide	0.0038	µg/L	CTR	0.0001	µg/L	CTR
Pesticides	Hexachlorobenzene	1	µg/L	BP	0.00075	µg/L	CTR
Pesticides	Methoxychlor	40	µg/L	BP	none	µg/L	none
Pesticides	Molinate	20	µg/L	BP	none	µg/L	none
Pesticides	Oxychlordane	none	µg/L	none	0.000023	µg/L	CTR
Pesticides	Simazine	4	µg/L	BP	none	µg/L	none
Pesticides	Thiobencarb	70	µg/L	BP	none	µg/L	none
Pesticides	Toxaphene	0.0002	µg/L	CTR	0.0002	µg/L	CTR
Physical	Oxygen, Dissolved	5	mg/L	BP	none	mg/L	none
Physical	pH	>6 and <8	pH	BP	none	pH	none
Physical	Specific Conductivity	1600	µS/cm	CCR	none	mS/cm	none
Physical	Turbidity (PAR04 only)	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.

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 water chemistry and toxicity. No chemistry, toxicity, or tissue data were excluded as a result of QA/QC violations.

QA/QC procedures for NPDES water chemistry data were similar to those used in SWAMP (Weston Solutions Inc. 2007) Non-SWAMP bioassessment samples were screened for samples containing fewer than 450 individuals. No bioassessment sample was excluded from this analysis.

4. RESULTS

4.1 Water Chemistry

Analysis of water chemistry at SWAMP sites indicated widespread impact to water quality for multiple constituents. Across the entire watershed, 4 pesticides and 25 PAHs were detected (Table 7). No anthropogenic constituents were detected in Chollas Creek, although a small number of constituents were assessed at that site. PCBs were never detected at either site. Means and standard deviations of all constituents are presented in Appendix II.

Several compounds were frequently detected at Paradise Creek. For example, diazinon was detected in 3 of 4 samples collected, and dioxathion was detected in half the samples at Paradise Creek. Similarly, dibenzothiophenes, fluoranthene, naphthalenes, and phenanthrenes were detected in half of the Paradise Creek samples. Twenty other PAHs were also detected (Table 8).

Comparison with applicable aquatic life and human health thresholds support the conclusion that water quality is impacted in the Pueblo San Diego watershed (Table 9). Both sites showed similar results, suggesting that impacts are not restricted to a single location within the watershed (Figure 6, 7).. Total phosphorus exceeded aquatic life thresholds in every sample. Furthermore, selenium, ammonia-N, benzo(a)pyrene, pH, and specific conductivity exceeded standards at Paradise Creek. Some of these constituents (selenium and total phosphorus) exceeded thresholds in every sample from Paradise Creek. Furthermore, several PAHs exceeded human health thresholds at Paradise Creek, but not Chollas Creek.

Results from NPDES water chemistry monitoring at Chollas Creek were similar to results from SWAMP (Table 9C). For example, specific conductivity exceeded aquatic life thresholds in every sample. In addition, pH exceeded aquatic life thresholds on one date. However, dissolved oxygen and turbidity were always within thresholds.

Table 7. Number of anthropogenic organic compounds detected at each site in Pueblo San Diego HU.

	PAHs		PCBs		Pesticides	
	Tested	Detected	Tested	Detected	Tested	Detected
CHL4	20	0	7	0	15	0
908PPAR04	48	25	50	0	79	4
Both sites	52	25	57	0	81	4

Table 8. Frequency of detection of anthropogenic organic compounds at Chollas and Paradise Creeks in the Pueblo San Diego HU. Constituent not detected in any sample (--).

		CHL4		908PPAR04	
Class	Constituent	Detected	Tested	Detected	Tested
PAHs	Acenaphthene	--	1	--	4
PAHs	Acenaphthylene	--	1	--	4
PAHs	Anthracene	--	1	--	4
PAHs	Benz(a)anthracene	--	1	0.25	4
PAHs	Benzo(a)pyrene	--	1	0.25	4
PAHs	Benzo(b)fluoranthene	--	1	0.25	4
PAHs	Benzo(e)pyrene	--	1	--	4
PAHs	Benzo(g,h,i)perylene	--	1	0.25	4
PAHs	Benzo(k)fluoranthene	nt	0	0.25	4
PAHs	Biphenyl	nt	0	--	4
PAHs	Chrysene	--	1	0.25	4
PAHs	Chrysenes, C1 -	nt	0	--	4
PAHs	Chrysenes, C2 -	nt	0	--	4
PAHs	Chrysenes, C3 -	nt	0	--	4
PAHs	Dibenz(a,h)anthracene	--	1	0.25	4
PAHs	Dibenzothiophene	nt	0	0.25	4
PAHs	Dibenzothiophenes, C1 -	nt	0	0.50	4
PAHs	Dibenzothiophenes, C2 -	nt	0	0.50	4
PAHs	Dibenzothiophenes, C3 -	nt	0	0.25	4
PAHs	Dichlofenthion	nt	0	--	4
PAHs	Dimethylnaphthalene, 2,6-	nt	0	0.25	4
PAHs	Dimethylphenanthrene, 3,6-	nt	0	--	4
PAHs	Fluoranthene	--	1	0.50	4
PAHs	Fluoranthene/Pyrenes, C1 -	nt	0	--	4
PAHs	Fluorene	--	1	--	4
PAHs	Fluorenes, C1 -	nt	0	--	4
PAHs	Fluorenes, C2 -	nt	0	--	4
PAHs	Fluorenes, C3 -	nt	0	0.25	4
PAHs	Indeno(1,2,3-c,d)pyrene	--	1	0.25	4
PAHs	Methyldibenzothiophene, 4-	nt	0	0.25	4
PAHs	Methylfluoranthene, 2-	nt	0	--	4
PAHs	Methylfluorene, 1-	nt	0	--	4
PAHs	Methylnaphthalene, 1-	nt	0	--	4
PAHs	Methylnaphthalene, 2-	nt	0	--	4
PAHs	Methylphenanthrene, 1-	nt	0	--	4
PAHs	Naphthalene	--	1	0.25	4
PAHs	Naphthalenes, C1 -	nt	0	--	4
PAHs	Naphthalenes, C2 -	nt	0	0.25	4

Table 8, continued. Frequency of detection of anthropogenic organic compounds at each site.

		CHL4		908PPAR04	
Class	Constituent	Detected	Tested	Detected	Tested
PAHs	Naphthalenes, C3 -	nt	0	0.50	4
PAHs	Naphthalenes, C4 -	nt	0	0.25	4
PAHs	Perylene	nt	0	--	4
PAHs	Phenanthrene	--	1	0.50	4
PAHs	Phenanthrene/Anthracene, C1 -	nt	0	0.50	4
PAHs	Phenanthrene/Anthracene, C2 -	nt	0	0.50	4
PAHs	Phenanthrene/Anthracene, C3 -	nt	0	0.25	4
PAHs	Phenanthrene/Anthracene, C4 -	nt	0	--	4
PAHs	Pyrene	--	1	0.25	4
PAHs	Trimethylnaphthalene, 2,3,5-	nt	0	--	4
Pesticide	alpha-BHC	--	1	nt	0
Pesticide	beta-BHC	--	1	nt	0
Pesticide	delta-BHC	--	1	nt	0
Pesticide	gamma-BHC (Lindane)	--	1	nt	0
PCBs	PCB 005	nt	0	--	4
PCBs	PCB 008	nt	0	--	4
PCBs	PCB 015	nt	0	--	4
PCBs	PCB 018	nt	0	--	4
PCBs	PCB 027	nt	0	--	4
PCBs	PCB 028	nt	0	--	4
PCBs	PCB 029	nt	0	--	4
PCBs	PCB 031	nt	0	--	4
PCBs	PCB 033	nt	0	--	4
PCBs	PCB 044	nt	0	--	4
PCBs	PCB 049	nt	0	--	4
PCBs	PCB 052	nt	0	--	4
PCBs	PCB 056	nt	0	--	4
PCBs	PCB 060	nt	0	--	4
PCBs	PCB 066	nt	0	--	4
PCBs	PCB 070	nt	0	--	4
PCBs	PCB 074	nt	0	--	4
PCBs	PCB 087	nt	0	--	4
PCBs	PCB 095	nt	0	--	4
PCBs	PCB 097	nt	0	--	4
PCBs	PCB 099	nt	0	--	4
PCBs	PCB 101	nt	0	--	4
PCBs	PCB 105	nt	0	--	4
PCBs	PCB 110	nt	0	--	4
PCBs	PCB 114	nt	0	--	4
PCBs	PCB 118	nt	0	--	4
PCBs	PCB 128	nt	0	--	4
PCBs	PCB 137	nt	0	--	4
PCBs	PCB 138	nt	0	--	4
PCBs	PCB 141	nt	0	--	4
PCBs	PCB 149	nt	0	--	4
PCBs	PCB 151	nt	0	--	4
PCBs	PCB 153	nt	0	--	4
PCBs	PCB 156	nt	0	--	4

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

		CHL4		908PPAR04	
Class	Constituent	Detected	Tested	Detected	Tested
PCBs	PCB 157	nt	0	--	4
PCBs	PCB 158	nt	0	--	4
PCBs	PCB 170	nt	0	--	4
PCBs	PCB 174	nt	0	--	4
PCBs	PCB 177	nt	0	--	4
PCBs	PCB 180	nt	0	--	4
PCBs	PCB 183	nt	0	--	4
PCBs	PCB 187	nt	0	--	4
PCBs	PCB 189	nt	0	--	4
PCBs	PCB 194	nt	0	--	4
PCBs	PCB 195	nt	0	--	4
PCBs	PCB 200	nt	0	--	4
PCBs	PCB 201	nt	0	--	4
PCBs	PCB 203	nt	0	--	4
PCBs	PCB 206	nt	0	--	4
PCBs	PCB 209	nt	0	--	4
PCBs	PCB-1016	--	1	nt	0
PCBs	PCB-1221	--	1	nt	0
PCBs	PCB-1232	--	1	nt	0
PCBs	PCB-1242	--	1	nt	0
PCBs	PCB-1248	--	1	nt	0
PCBs	PCB-1254	--	1	nt	0
PCBs	PCB-1260	--	1	nt	0
Pesticide	Toxaphene	--	1	nt	0
Pesticides	Aldrin	--	1	--	4
Pesticides	Aspon	nt	0	--	4
Pesticides	Azinphos ethyl	nt	0	--	4
Pesticides	Azinphos methyl	nt	0	--	4
Pesticides	Bolstar	nt	0	--	4
Pesticides	Carbophenothion	nt	0	--	4
Pesticides	Chlordane, cis-	nt	0	--	4
Pesticides	Chlordane, trans-	nt	0	--	4
Pesticides	Chlordene, alpha-	nt	0	--	4
Pesticides	Chlordene, gamma-	nt	0	--	4
Pesticides	Chlorfenvinphos	nt	0	--	4
Pesticides	Chlorpyrifos	nt	0	--	4
Pesticides	Chlorpyrifos methyl	nt	0	--	4
Pesticides	Ciodrin	nt	0	--	4
Pesticides	Coumaphos	nt	0	--	4
Pesticides	Dacthal	nt	0	--	4
Pesticides	DDD(o,p')	nt	0	--	4
Pesticides	DDD(p,p')	--	1	--	4
Pesticides	DDE(o,p')	nt	0	--	4
Pesticides	DDE(p,p')	--	1	--	4
Pesticides	DDMU(p,p')	nt	0	--	4
Pesticides	DDT(o,p')	nt	0	--	4
Pesticides	DDT(p,p')	--	1	--	4
Pesticides	Demeton-s	nt	0	--	4

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

		CHL4		908PPAR04	
Class	Constituent	Detected	Tested	Detected	Tested
Pesticides	Diazinon	nt	0	0.75	4
Pesticides	Dichlorvos	nt	0	--	4
Pesticides	Dicrotophos	nt	0	--	4
Pesticides	Dieldrin	--	1	--	4
Pesticides	Dimethoate	nt	0	--	4
Pesticides	Dioxathion	nt	0	0.50	4
Pesticides	Disulfoton	nt	0	0.25	4
Pesticides	Endosulfan I	--	1	--	4
Pesticides	Endosulfan II	--	1	--	4
Pesticides	Endosulfan sulfate	--	1	--	4
Pesticides	Endrin	--	1	--	4
Pesticides	Endrin Aldehyde	--	1	--	4
Pesticides	Endrin Ketone	nt	0	--	4
Pesticides	Ethion	nt	0	--	4
Pesticides	Ethoprop	nt	0	--	4
Pesticides	Famphur	nt	0	--	4
Pesticides	Fenchlorphos	nt	0	--	4
Pesticides	Fenitrothion	nt	0	--	4
Pesticides	Fensulfothion	nt	0	--	4
Pesticides	Fenthion	nt	0	--	4
Pesticides	Fonofos	nt	0	--	4
Pesticides	HCH, alpha	nt	0	--	4
Pesticides	HCH, beta	nt	0	--	4
Pesticides	HCH, delta	nt	0	--	4
Pesticides	HCH, gamma	nt	0	--	4
Pesticides	Heptachlor	--	1	--	4
Pesticides	Heptachlor epoxide	--	1	--	4
Pesticides	Hexachlorobenzene	nt	0	--	4
Pesticides	Leptophos	nt	0	--	4
Pesticides	Malathion	nt	0	--	4
Pesticides	Merphos	nt	0	--	4
Pesticides	Methidathion	nt	0	--	4
Pesticides	Methoxychlor	--	1	--	4
Pesticides	Mevinphos	nt	0	--	4
Pesticides	Mirex	nt	0	--	4
Pesticides	Molinate	nt	0	--	4
Pesticides	Naled	nt	0	--	4
Pesticides	Nonachlor, cis-	nt	0	--	4
Pesticides	Nonachlor, trans-	nt	0	--	4
Pesticides	Oxadiazon	nt	0	0.75	4
Pesticides	Oxychlordane	nt	0	--	4
Pesticides	Parathion, Ethyl	nt	0	--	4
Pesticides	Parathion, Methyl	nt	0	--	4
Pesticides	Phorate	nt	0	--	4
Pesticides	Phosmet	nt	0	--	4
Pesticides	Phosphamidon	nt	0	--	4
Pesticides	Sulfotep	nt	0	--	4
Pesticides	Tedion	nt	0	--	4
Pesticides	Terbufos	nt	0	--	4

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

		CHL4		908PPAR04	
Class	Constituent	Detected	Tested	Detected	Tested
Pesticides	Tetrachlorvinphos	nt	0	--	4
Pesticides	Thiobencarb	nt	0	--	4
Pesticides	Thionazin	nt	0	--	4
Pesticides	Tokuthion	nt	0	--	4
Pesticides	Trichlorfon	nt	0	--	4
Pesticides	Trichloronate	nt	0	--	4

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 and human health thresholds at SWAMP sites.

		908PPAR04			CHL4		
Class	Constituent	Aquatic life	Human health	n	Aquatic life	Human health	n
Inorganics	Alkalinity as CaCO3	--	NA	4	--	NA	1
Inorganics	Ammonia as N	0.75	NA	4	--	NA	1
Inorganics	Nitrate + Nitrite as N	NA	--	4	NA	--	1
Inorganics	Nitrate as NO3 (either)	NA	--	4	NA	--	1
Inorganics	Nitrite as N	NA	--	4	NA	--	1
Inorganics	Phosphorus as P,Total	1.00	NA	4	1.00	NA	1
Inorganics	Selenium,Dissolved	1.00	NA	4	nt	NA	0
Inorganics	Total N	--	NA	4	--	NA	1
Metals	Aluminum,Dissolved	--	NA	4	--	NA	1
Metals	Arsenic,Dissolved	--	--	4	--	--	1
Metals	Cadmium,Dissolved	--	--	4	--	--	1
Metals	Chromium,Dissolved	--	NA	4	--	NA	1
Metals	Copper,Dissolved	0.50	--	4	--	--	1
Metals	Lead,Dissolved	--	NA	4	--	NA	1
Metals	Nickel,Dissolved	--	--	4	--	--	1
Metals	Silver,Dissolved	--	NA	4	--	NA	1
Metals	Zinc,Dissolved	--	NA	4	--	NA	1
PAHs	Acenaphthene	NA	--	4	NA	--	1
PAHs	Anthracene	NA	--	4	NA	--	1
PAHs	Benz(a)anthracene	NA	0.25	4	NA	--	1
PAHs	Benzo(a)pyrene	0.25	0.25	4	--	--	1
PAHs	Benzo(b)fluoranthene	NA	0.25	4	NA	--	1
PAHs	Benzo(k)fluoranthene	NA	0.25	4	NA	nt	0
PAHs	Chrysene	NA	0.25	4	NA	--	1
PAHs	Dibenz(a,h)anthracene	NA	0.25	4	NA	--	1
PAHs	Fluoranthene	NA	--	4	NA	--	1
PAHs	Indeno(1,2,3-c,d)pyrene	NA	--	4	NA	--	1
PAHs	Pyrene	NA	--	4	NA	--	1
PCBs	PCBs	--	--	4	--	--	1
Pesticide	Toxaphene	nt	nt	0	--	--	1
Pesticides	Aldrin	NA	--	4	NA	--	1
Pesticides	alpha-BHC	NA	nt	0	NA	--	1
Pesticides	Azinphos ethyl	NA	--	4	NA	nt	0
Pesticides	Azinphos methyl	NA	--	4	NA	nt	0
Pesticides	beta-BHC	NA	nt	0	NA	--	1
Pesticides	Chlordanes	--	--	4	--	--	1

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

		908PPAR04			CHL4		
Class	Constituent	Aquatic life	Human health	n	Aquatic life	Human health	n
Pesticides	DDD(p,p')	NA	--	4	NA	--	1
Pesticides	DDE(p,p')	NA	--	4	NA	--	1
Pesticides	DDT(p,p')	NA	--	4	NA	--	1
Pesticides	Dieldrin	NA	--	4	NA	--	1
Pesticides	Dimethoate	NA	--	4	NA	nt	0
Pesticides	Endosulfan sulfate	NA	--	4	NA	--	1
Pesticides	Endrin	--	--	4	--	--	1
Pesticides	Endrin Aldehyde	NA	--	4	NA	--	1
Pesticides	Endrin Ketone	NA	--	4	NA	nt	0
Pesticides	gamma-BHC (Lindane)	nt	nt	0	NA	NA	1
Pesticides	Heptachlor	--	--	4	--	--	1
Pesticides	Heptachlor epoxide	--	--	4	--	--	1
Pesticides	Hexachlorobenzene	--	--	4	nt	nt	0
Pesticides	Methoxychlor	--	NA	4	--	NA	1
Pesticides	Molinate	--	NA	4	nt	NA	0
Pesticides	Oxychlordane	NA	--	4	NA	nt	0
Pesticides	Thiobencarb	--	NA	4	nt	NA	0
Physical	Oxygen, Dissolved	--	NA	4	nt	NA	0
Physical	pH	0.75	NA	4	nt	NA	0
Physical	Specific conductivity	0.50	NA	4	nt	NA	0
Physical	Turbidity	--	NA	4	nt	NA	0

C. Aquatic life thresholds at the non-SWAMP site (CC-FB).

Constituent	Frequency	n
Dissolved oxygen (mg/l)	0.0	5
pH	0.2	5
Specific conductivity (mS/cm)	1.0	5
Turbidity (NTU)	0.0	1

Table 10. Number of constituents exceeding thresholds at each SWAMP site.

	Aquatic life		Human health	
Site	# exceedances	# constituents	# exceedances	# constituents
908PPAR04	7	29	6	36
CHL4	2	23	0	33

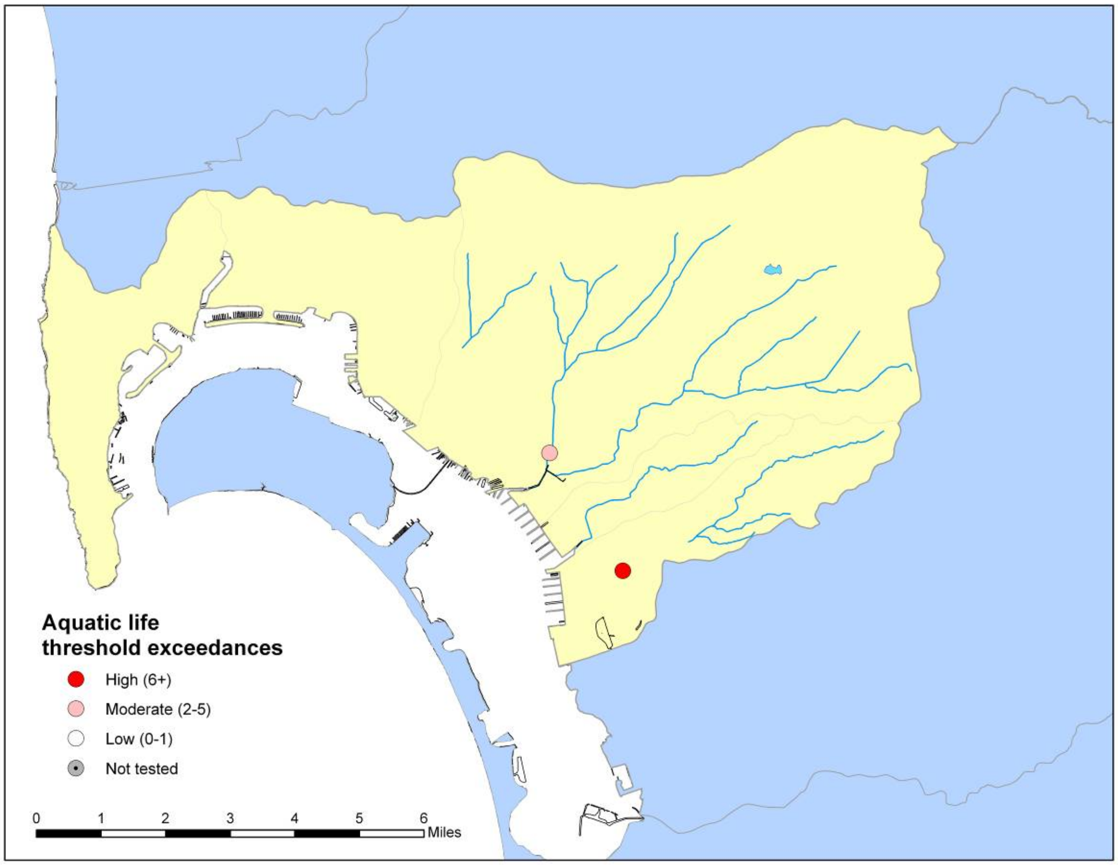


Figure 6. Map of aquatic life threshold exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances (this value did not occur in this watershed). Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances. At Paradise Creek, 29 constituents were assessed. At Chollas Creek, 23 constituents were assessed.

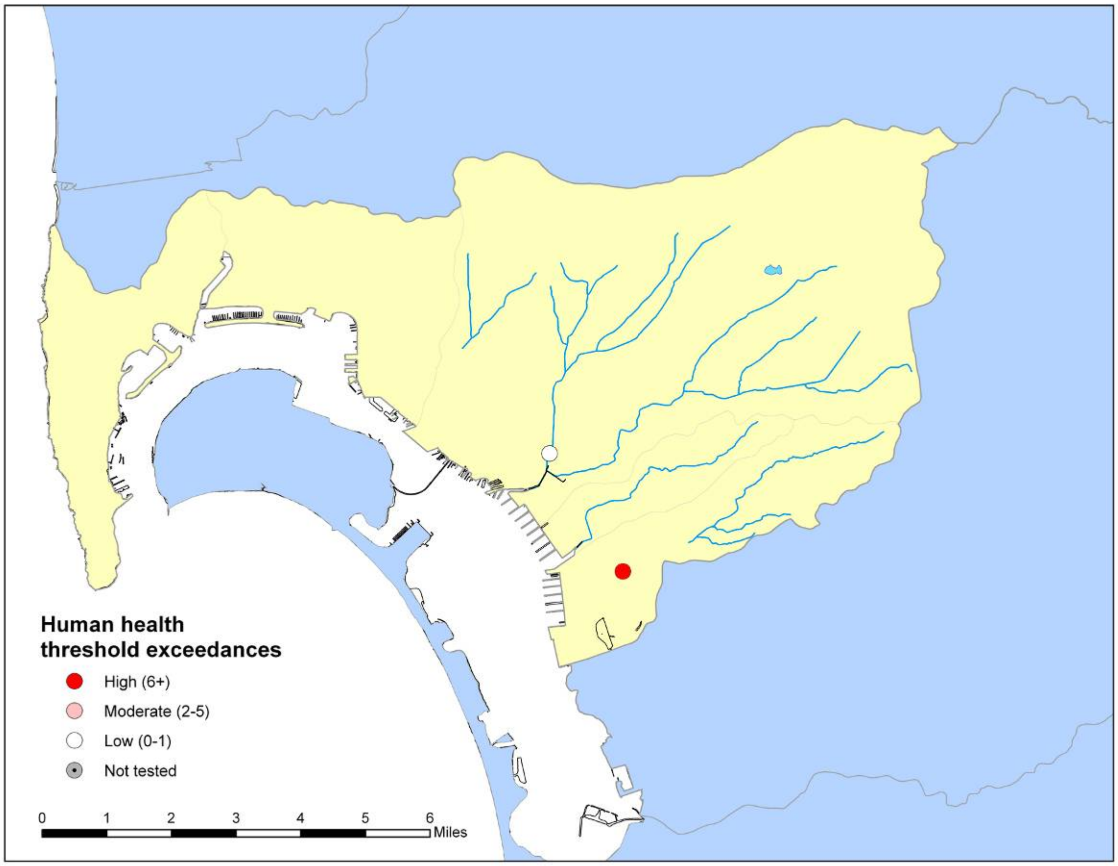


Figure 7. Map of human health exceedances for water chemistry at SWAMP sites. White circles indicate sites with one or fewer exceedances. Pink circles indicate sites with 2 to 5 exceedances. Red circles indicate sites with 6 to 9 exceedances (this value did not occur in this watershed). At Paradise Creek, 36 constituents were assessed. At Chollas Creek, 33 constituents were assessed.

4.2 Toxicity

Toxicity was evident at all sites within the watershed, although results varied among sites and indicators (Table 11). Water samples were toxic to two indicators at Chollas Creek: the alga *S. capricornutum* and the crustacean *C. dubia.* In contrast, water samples from Paradise Creek were only toxic to *S. capricornutum.* Sediment samples from both sites were not toxic to the crustacean *H. azteca.* (Figure 8).

Table 11. Frequency of toxicity detected for each endpoint and at each site. A sample was considered toxic if the percent control of the endpoint was less than 80% of reference samples, and the difference was considered significant at 0.05. One sample was assessed for each assay.

		908PPAR04						908PCHL4		
		9/6/2005			4/10/2006			6/2/2006		
Species	Endpoint	% Control	p	Toxicity	% Control	p	Toxicity	% Control	p	Toxicity
C. dubia	Survival	84.2	0.16	Not detected				0.0	<0.05	Detected
C. dubia	Young / Female	90.5	0.25	Not detected				No survival--not tested		
H. azteca	Survival				107.7	0.85	Not detected	110.0	>0.05	Not detected
H. azteca	Growth				82.65	0.15	Not detected	137.7	>0.05	Not detected
S. capricornutum	Total cell count	82.2	0.00	Detected				32.8	<0.05	Detected
Multiple indicators		Frequency = 0.33						Frequency = 0.66		

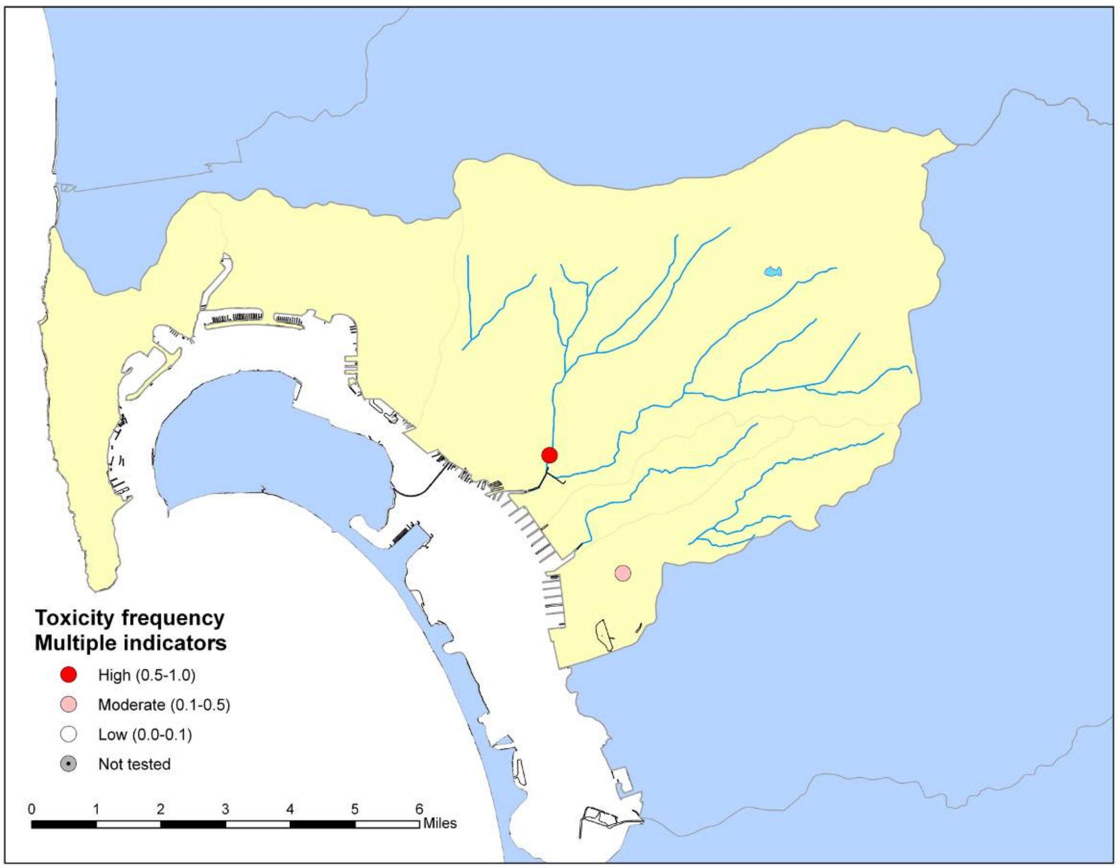


Figure 8. Frequency of toxicity (*C. dubia* fecundity, *H. azteca* growth, and *S. capricornutum* total cell count) at SWAMP sites. White circles indicate low frequency (0.0 to 0.1) of toxicity (this value did not occur in this watershed) . Pink circles indicate moderate frequency (0.1 to 0.5) of toxicity.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

4.3 Tissue

Fish tissues were not assessed in the Pueblo San Diego HU.

4.4 Bioassessment

Biological health was poor or very poor for all samples and all seasons in the Pueblo San Diego HU. Mean IBI scores were 19.5 at site 1 (the upstream site on Chollas Creek), and 10 at site 2 (CHL4) (Figure 9). Mean values for spring and fall samples were identical at site 1, suggesting that poor biological condition persisted during all seasons of the study (Table 12; Figure 10). No bioassessment samples were collected at Paradise Creek.

Table 12. Mean and standard deviation of IBI scores at bioassessment sites on Chollas Creek in the Pueblo San Diego 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	Season	n	Years	Mean	SD	Condition	Freq
Site 1	Average	6	2003-2005	19.5	0.0	Very poor	1.00
	Fall	3	2003-2005	19.5	5.9	Very poor	1.00
	Spring	3	2003-2005	19.5	6.8	Very poor	1.00
CHL4	Fall	1	2005	10.0		Very poor	1.00

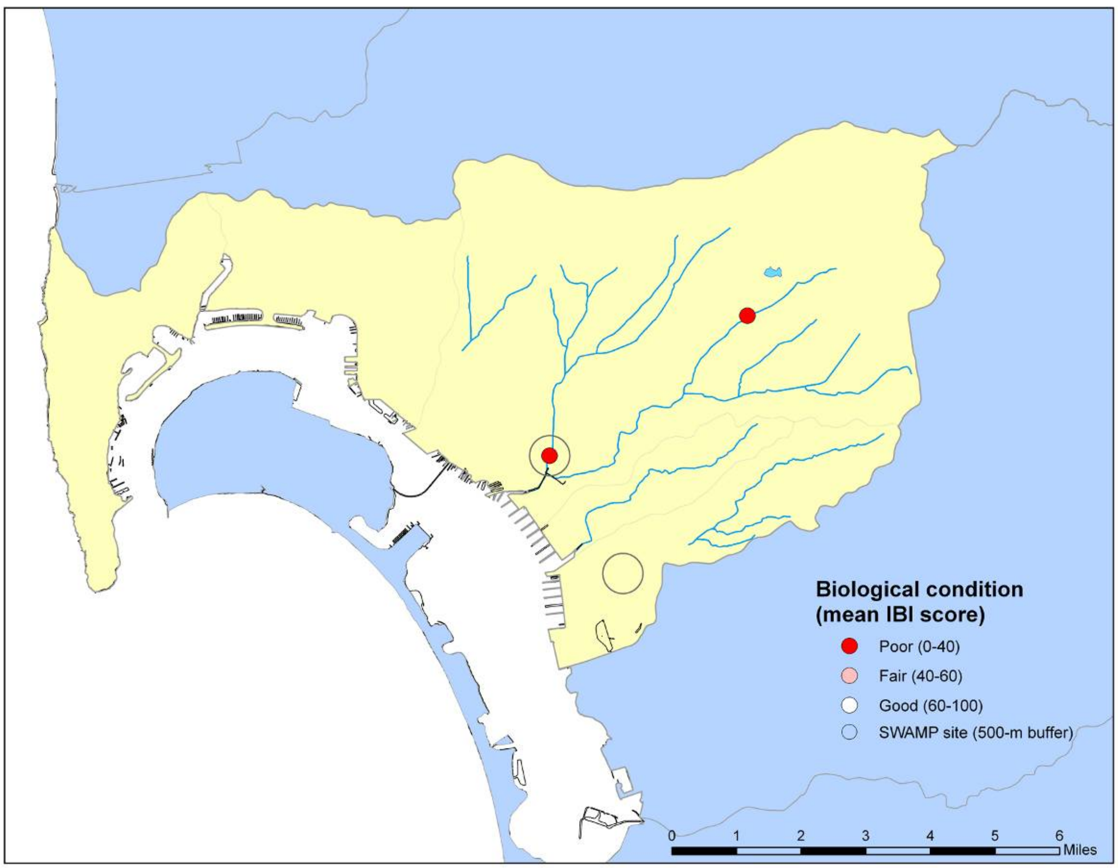


Figure 9. IBI scores at sites in the Pueblo San Diego HU. White circles indicate good or very good (60 to 100) IBI scores (this value did not occur in this watershed). Pink circles indicate fair (40 to 60) IBI scores (this value did not occur in this watershed). Red circles indicate poor (0 to 40) IBI scores. Open circles represent 500-m buffers around SWAMP sites; one of these buffers included bioassessment sites, and one did not.

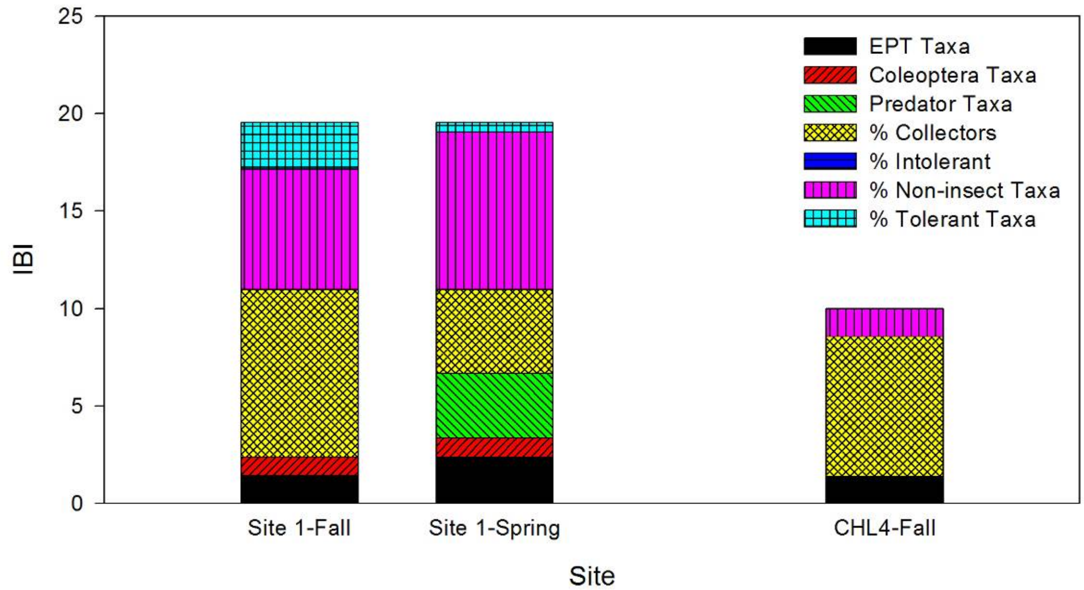


Figure 10. Mean IBI scores at each bioassessment site and each season. The height of the bar indicates the mean IBI score, and the size of each component of the bar represents the contribution of each metric to the IBI.

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. The % Collectors metric was the largest component of IBIs measured in the Fall at both sites, and % Non-insect Taxa was the largest component of IBIs measured in the Spring at site 1. (Appendix III; Figure 10).

Examination of IBI scores over time at site 1 indicated a very weak trend towards deteriorating biological condition (Figure 11). However, variability was too high for this trend to be statistically significant. IBI scores fluctuated above and below the threshold between poor and very poor condition. No seasonal trends were evident, as both samples collected in Spring or Fall had mean IBI scores of 19.5.

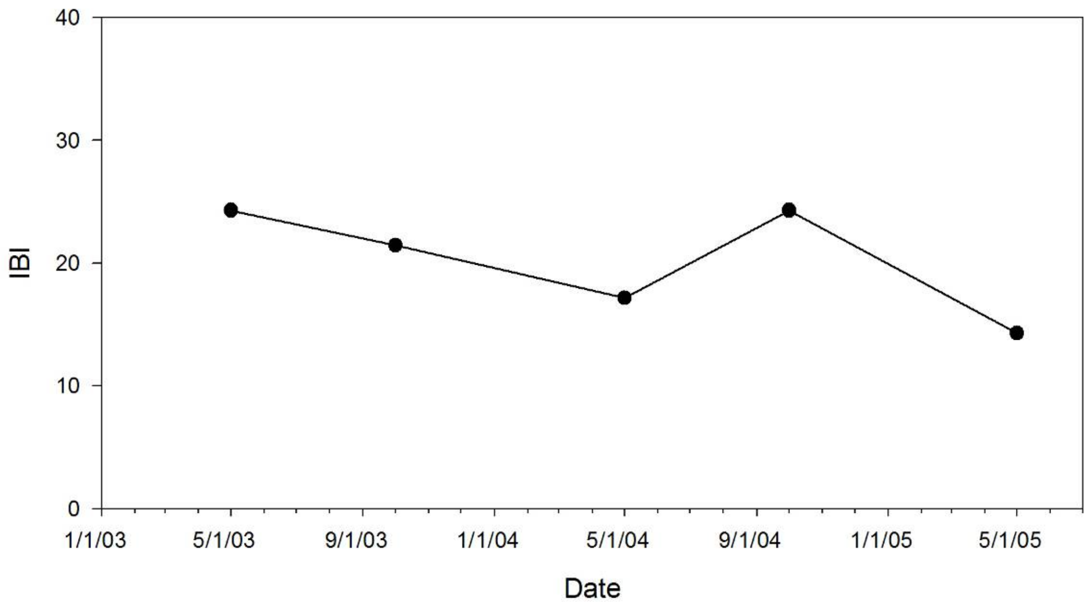


Figure 11. IBI values at Chollas Creek at Federal Boulevard (Site 1). Each symbol represents a single sample.

4.5 Physical Habitat

Physical habitat was not assessed in the Pueblo San Diego HU.

5. DISCUSSION

The data collected by this study cannot be used to evaluate the overall health of the Pueblo San Diego HU because only two sites in the watershed were sampled. Although the data were inadequate to confidently infer about the condition of the entire watershed, they were sufficient to evaluate the two sites selected for monitoring.

The two sites in the Pueblo San Diego HU showed evidence of impact from multiple indicators (Table 13, Figure 12). For example, both sites exceeded aquatic life thresholds for multiple water chemistry constituents. Toxicity was evident at both sites. Furthermore, bioassessment samples collected at one site (Chollas Creek) was in very poor biological condition. Therefore, the data collected under SWAMP support the conclusion that ecological health of Chollas and Paradise Creeks is poor.

Different indicators suggested different levels of impairment at the two creeks. For example, toxicity was more severe at Chollas Creek (toxicity to two indicator species) than at Paradise Creek (toxicity to one indicator species). However, more water chemistry constituents exceeded aquatic life thresholds at Paradise Creek (2) than at Chollas Creek. This discrepancy may be explained by the fact that fewer constituents were assessed at Chollas Creek (24 versus 30 at Paradise Creek), and water chemistry was assessed only once at Chollas Creek, versus four times at Paradise Creek. These differences may have caused the underestimation of water chemistry impacts at Chollas Creek. These differences, plus the fact that bioassessment samples were not collected at Paradise Creek, impede comparisons of the two sites.

Despite the fact that Chollas Creek is included on the 303(d) list of impaired waterbodies for lead, copper, and zinc, these constituents were not found in excess of the thresholds established by the TMDL. However, all SWAMP monitoring occurred during dry weather, and the peak concentrations of these constituents could not be estimated. Monitoring by NPDES permittees in wet weather showed that these metals regularly exceeded TMDL thresholds in Chollas Creek (Woodward-Clyde 1998).

This study's assessment of the Pueblo San Diego HU suggests that the two sites in the watershed were 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 both sites, and bioassessment of macroinvertebrate communities were in poor or very poor condition at every sampling event.

Although these impacts were 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 were below applicable thresholds at both sites, as were all pesticides. However, no water qualities were collected immediately after storm events, and peak concentrations of these constituents may have been inderestimated.

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 these sites in the Pueblo San Diego watershed are 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 2 years before water chemistry and toxicity 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 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).

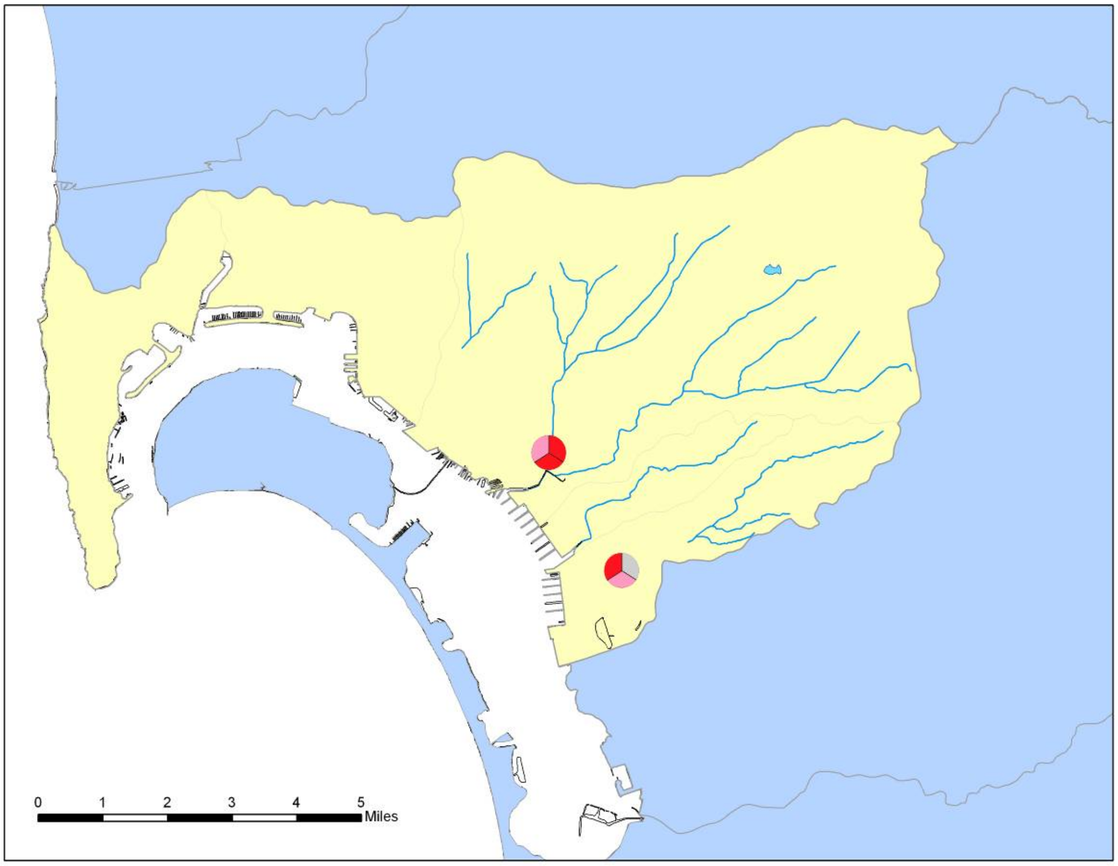
The small number of sites monitored under SWAMP also limits the certainty of this study's assessment. The low level of replication (i.e., 2) of sites in the Pueblo San Diego HU severely limits the ability to infer about the condition about the watershed as a whole. Although SWAMP has produced a wealth of data about the Pueblo San Diego HU using limited resources, some indicators (especially those with high variability) require more extensive sampling to produce more precise and accurate assessments. A larger number of sites will be necessary to evaluate the health of the Pueblo San Diego HU with greater certainty.

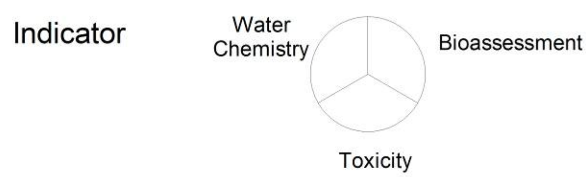
Thresholds are an essential tool for assessing water quality and ecological health. However, their use is limited to indicators that have been well studied, and they cannot provide a holistic view of watershed health. This limitation is exacerbated by the fact that many constituents and indicators lack applicable thresholds. For example, of the 165 water chemistry constituents, only 59 (36%) had applicable water quality objectives that could be used as thresholds for water quality. 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 Pueblo San Diego 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 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 13. Summary of the ecological health for five SWAMP sites in Pueblo San Diego 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.

Indicator	Measurement	Paradise Creek 4 908PPAR04	Chollas Creek 4 CHL4
Water chemistry	Aquatic life exceedances	7	2
	Human health exceedances	6	0
Fish tissue	OEHHA exceedances	n.t.	n.t.
Toxicity	Frequency	0.33	0.66
Biology	Frequency	n.t.	1.00
Physical habitat	Mean score	n.t.	n.t.





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 12. Summary of the ecological health of SWAMP sites in the Pueblo San Diego 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

A. Beneficial uses of streams in the Pueblo San Diego HU (California Regional Water Quality Control Board, San Diego Region 1994). B. Streams on the 303(d) list of impaired water bodies in the Pueblo San Diego HUC. HUC = Hydrologic Unit Code. MUN = Municipal and domestic supply. REC1 = Contact recreation. REC2 = Non-contact recreation. WARM = Warm freshwater habitat. WILD = Wildlife habitat. X = Exempted from municipal supply. E = Existing beneficial use. P = Potential beneficial use.

A. Beneficial uses of streams in the Pueblo San Diego HU.

Pueblo San Diego	HUC	MUN	REC1	REC2	WARM	WILD
San Diego County Coastal Streams						
Unnamed intermittent coastal streams	908.10	X	P	E	E	E
Powerhouse Canyon	908.21	X	P	E	E	E
Chollas Creek	908.22	X	P	E	E	E
South Chollas Valley	908.22	X	P	E	E	E
Unnamed intermittent streams	908.31	X	P	E	E	E
Paradise Creek	908.32	X	P	E	E	E
Paradise Vallley	908.32	X	P	E	E	E

B. 303(d)-listed streams in the Pueblo San Diego HU.

Name	HUC	Stressor	Potential source	Affected length
Chollas Creek	908.22	Copper	Nonpoint/point source	3.5 miles
		Indicator bacteria	Nonpoint/point source	3.5 miles
		Lead	Nonpoint/point source	3.5 miles
		Zinc	Nonpoint/point source	3.5 miles
		Diazinon	Nonpoint/point source	3.5 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.

			908PPAR04			CHL4		
Type	Constituent	Units	Mean	SD	n	Mean	SD	n
Bacteria	Enterococcus	MPN/100mL			0	11		1
Bacteria	Fecal Coliform	MPN/100mL			0	900		1
Bacteria	Total Coliform	MPN/100mL			0	1600		1
Inorganics	Alkalinity as CaCO3	mg/L	187	11.6	4	210		1
Inorganics	Ammonia as N	mg/L	0.06	0.051	4	--		1
Inorganics	Nitrate as N	mg/L	0.49	0.457	4	--		1
Inorganics	Nitrate as NO3	mg/L			0	--		1
Inorganics	Nitrite as N	mg/L	0.02	0.02	4	--		1
Inorganics	Nitrogen, Total Kjeldahl	mg/L	1.67	0.355	4	2.4		1
Inorganics	o-phosphate as P	mg/L			0	32		1
Inorganics	Phosphorus as P,Total	mg/L	0.25	0.076	4	0.22		1
Inorganics	Selenium,Dissolved	µg/L	77.5	115.8	4			0
Inorganics	Sulfate	mg/L	431	454.4	4	460		1
Metals	Aluminum,Dissolved	µg/L	3.21	1.527	4	24		1
Metals	Arsenic,Dissolved	µg/L	1.96	1.027	4	4.7		1
Metals	Cadmium,Dissolved	µg/L	0.1	0.024	4	--		1
Metals	Chromium,Dissolved	µg/L	1.47	0.656	4	0.24		1
Metals	Copper,Dissolved	µg/L	9.54	3.044	4	3		1
Metals	Lead,Dissolved	µg/L	0.39	0.059	4	1		1
Metals	Manganese,Dissolved	µg/L	43.6	63.66	4	130		1
Metals	Nickel,Dissolved	µg/L	2.81	1.134	4	8.7		1
Metals	Silver,Dissolved	µg/L	0.01	0.01	4	0.61		1
Metals	Zinc,Dissolved	µg/L	13.6	4.142	4	20		1
PAHs	Acenaphthene	µg/L	--	0	4	--		1
PAHs	Acenaphthylene	µg/L	--	0	4	--		1
PAHs	alpha-BHC	µg/L			0	--		1
PAHs	Anthracene	µg/L	--	0	4	--		1
PAHs	Benz(a)anthracene	µg/L	0	0.008	4	--		1
PAHs	Benzo(a)pyrene	µg/L	0.01	0.012	4	--		1
PAHs	Benzo(b)fluoranthene	µg/L	0.01	0.015	4	--		1
PAHs	Benzo(e)pyrene	µg/L	--	0	4	--		1
PAHs	Benzo(g,h,i)perylene	µg/L	0.01	0.015	4	--		1
PAHs	Benzo(k)fluoranthene	µg/L	0.01	0.015	4			0
PAHs	beta-BHC	µg/L			0	--		1
PAHs	Biphenyl	µg/L	--	0	4			0
PAHs	Chrysene	µg/L	0.01	0.011	4	--		1
PAHs	Chrysenes, C1 -	µg/L	--	0	4			0
PAHs	Chrysenes, C2 -	µg/L	--	0	4			0
PAHs	Chrysenes, C3 -	µg/L	--	0	4			0

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

			908PPAR04			CHL4		
Type	Constituent	Units	Mean	SD	n	Mean	SD	n
PAHs	delta-BHC	µg/L			0	--		1
PAHs	Dibenz(a,h)anthracene	µg/L	0.01	0.016	4	--		1
PAHs	Dibenzothiophene	µg/L	0	0.007	4			0
PAHs	Dibenzothiophenes, C1 -	µg/L	0.02	0.033	4			0
PAHs	Dibenzothiophenes, C2 -	µg/L	0.04	0.065	4			0
PAHs	Dibenzothiophenes, C3 -	µg/L	0	0.003	4			0
PAHs	Dichlofenthion	µg/L	--	0	4			0
PAHs	Dimethylnaphthalene, 2,6-	µg/L	0	0.007	4			0
PAHs	Dimethylphenanthrene, 3,6-	µg/L	--	0	4			0
PAHs	Fluoranthene	µg/L	0.01	0.007	4	--		1
PAHs	Fluoranthene/Pyrenes, C1 -	µg/L	--	0	4			0
PAHs	Fluorene	µg/L	--	0	4	--		1
PAHs	Fluorenes, C1 -	µg/L	--	0	4			0
PAHs	Fluorenes, C2 -	µg/L	--	0	4			0
PAHs	Fluorenes, C3 -	µg/L	0.02	0.035	4			0
PAHs	gamma-BHC (Lindane)	µg/L			0	--		1
PAHs	Indeno(1,2,3-c,d)pyrene	µg/L	0.01	0.018	4	--		1
PAHs	Methyldibenzothiophene, 4-	µg/L	0	0.005	4			0
PAHs	Methylfluoranthene, 2-	µg/L	--	0	4			0
PAHs	Methylfluorene, 1-	µg/L	--	0	4			0
PAHs	Methylnaphthalene, 1-	µg/L	--	0	4			0
PAHs	Methylnaphthalene, 2-	µg/L	--	0	4			0
PAHs	Methylphenanthrene, 1-	µg/L	--	0	4			0
PAHs	Naphthalene	µg/L	0	0.003	4	--		1
PAHs	Naphthalenes, C1 -	µg/L	--	0	4			0
PAHs	Naphthalenes, C2 -	µg/L	0	0.01	4			0
PAHs	Naphthalenes, C3 -	µg/L	0.01	0.009	4			0
PAHs	Naphthalenes, C4 -	µg/L	0	0.006	4			0
PAHs	Perylene	µg/L	--	0	4			0
PAHs	Phenanthrene	µg/L	0.01	0.007	4	--		1
PAHs	Phenanthrene/Anthracene, C1 -	µg/L	0.01	0.008	4			0
PAHs	Phenanthrene/Anthracene, C2 -	µg/L	0.01	0.014	4			0
PAHs	Phenanthrene/Anthracene, C3 -	µg/L	0	0.005	4			0
PAHs	Phenanthrene/Anthracene, C4 -	µg/L	--	0	4			0
PAHs	Pyrene	µg/L	0	0.004	4	--		1
PAHs	Trimethylnaphthalene, 2,3,5-	µg/L	--	0	4			0
PCBs	PCB 005	µg/L	--	0	4			0
PCBs	PCB 008	µg/L	--	0	4			0
PCBs	PCB 015	µg/L	--	0	4			0
PCBs	PCB 018	µg/L	--	0	4			0
PCBs	PCB 027	µg/L	--	0	4			0
PCBs	PCB 028	µg/L	--	0	4			0
PCBs	PCB 029	µg/L	--	0	4			0
PCBs	PCB 031	µg/L	--	0	4			0
PCBs	PCB 033	µg/L	--	0	4			0
PCBs	PCB 044	µg/L	--	0	4			0
PCBs	PCB 049	µg/L	--	0	4			0
PCBs	PCB 052	µg/L	--	0	4			0

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

			908PPAR04			CHL4		
Type	Constituent	Units	Mean	SD	n	Mean	SD	n
PCBs	PCB 056	µg/L	--	0	4			0
PCBs	PCB 060	µg/L	--	0	4			0
PCBs	PCB 066	µg/L	--	0	4			0
PCBs	PCB 070	µg/L	--	0	4			0
PCBs	PCB 074	µg/L	--	0	4			0
PCBs	PCB 087	µg/L	--	0	4			0
PCBs	PCB 095	µg/L	--	0	4			0
PCBs	PCB 097	µg/L	--	0	4			0
PCBs	PCB 099	µg/L	--	0	4			0
PCBs	PCB 101	µg/L	--	0	4			0
PCBs	PCB 105	µg/L	--	0	4			0
PCBs	PCB 110	µg/L	--	0	4			0
PCBs	PCB 114	µg/L	--	0	4			0
PCBs	PCB 118	µg/L	--	0	4			0
PCBs	PCB 128	µg/L	--	0	4			0
PCBs	PCB 137	µg/L	--	0	4			0
PCBs	PCB 138	µg/L	--	0	4			0
PCBs	PCB 141	µg/L	--	0	4			0
PCBs	PCB 149	µg/L	--	0	4			0
PCBs	PCB 151	µg/L	--	0	4			0
PCBs	PCB 153	µg/L	--	0	4			0
PCBs	PCB 156	µg/L	--	0	4			0
PCBs	PCB 157	µg/L	--	0	4			0
PCBs	PCB 158	µg/L	--	0	4			0
PCBs	PCB 170	µg/L	--	0	4			0
PCBs	PCB 174	µg/L	--	0	4			0
PCBs	PCB 177	µg/L	--	0	4			0
PCBs	PCB 180	µg/L	--	0	4			0
PCBs	PCB 183	µg/L	--	0	4			0
PCBs	PCB 187	µg/L	--	0	4			0
PCBs	PCB 189	µg/L	--	0	4			0
PCBs	PCB 194	µg/L	--	0	4			0
PCBs	PCB 195	µg/L	--	0	4			0
PCBs	PCB 200	µg/L	--	0	4			0
PCBs	PCB 201	µg/L	--	0	4			0
PCBs	PCB 203	µg/L	--	0	4			0
PCBs	PCB 206	µg/L	--	0	4			0
PCBs	PCB 209	µg/L	--	0	4			0
PCBs	PCB-1016	µg/L			0	--		1
PCBs	PCB-1221	µg/L			0	--		1
PCBs	PCB-1232	µg/L			0	--		1
PCBs	PCB-1242	µg/L			0	--		1
PCBs	PCB-1248	µg/L			0	--		1
PCBs	PCB-1254	µg/L			0	--		1
PCBs	PCB-1260	µg/L			0	--		1
Pesticide	Toxaphene	µg/L			0	--		1
Pesticides	Aldrin	µg/L	--	0	4	--		1

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

			908PPAR04			CHL4		
Type	Constituent	Units	Mean	SD	n	Mean	SD	n
Pesticides	Aspon	µg/L	--	0	4			0
Pesticides	Azinphos ethyl	µg/L	--	0	4			0
Pesticides	Azinphos methyl	µg/L	--	0	4			0
Pesticides	Bolstar	µg/L	--	0	4			0
Pesticides	Carbophenothion	µg/L	--	0	4			0
Pesticides	Chlordane (tech)	µg/L			0	--		1
Pesticides	Chlordane, cis-	µg/L	--	0	4			0
Pesticides	Chlordane, trans-	µg/L	--	0	4			0
Pesticides	Chlordene, alpha-	µg/L	--	0	4			0
Pesticides	Chlordene, gamma-	µg/L	--	0	4			0
Pesticides	Chlorfenvinphos	µg/L	--	0	4			0
Pesticides	Chlorpyrifos	µg/L	--	0	4			0
Pesticides	Chlorpyrifos methyl	µg/L	--	0	4			0
Pesticides	Ciodrin	µg/L	--	0	4			0
Pesticides	Coumaphos	µg/L	--	0	4			0
Pesticides	Dacthal	µg/L	--	0	4			0
Pesticides	DDD(o,p')	µg/L	--	0	4			0
Pesticides	DDD(p,p')	µg/L	--	0	4	--		1
Pesticides	DDE(o,p')	µg/L	--	0	4			0
Pesticides	DDE(p,p')	µg/L	--	0	4	--		1
Pesticides	DDMU(p,p')	µg/L	--	0	4			0
Pesticides	DDT(o,p')	µg/L	--	0	4			0
Pesticides	DDT(p,p')	µg/L	--	0	4	--		1
Pesticides	Demeton-s	µg/L	--	0	4			0
Pesticides	Diazinon	µg/L	0.03	0.029	4			0
Pesticides	Dichlorvos	µg/L	--	0	4			0
Pesticides	Dicrotophos	µg/L	--	0	4			0
Pesticides	Dieldrin	µg/L	--	0	4	--		1
Pesticides	Dimethoate	µg/L	--	0	4			0
Pesticides	Dioxathion	µg/L	0.07	0.094	4			0
Pesticides	Disulfoton	µg/L	0.01	0.027	4			0
Pesticides	Endosulfan I	µg/L	--	0	4	--		1
Pesticides	Endosulfan II	µg/L	--	0	4	--		1
Pesticides	Endosulfan sulfate	µg/L	--	0	4	--		1
Pesticides	Endrin Aldehyde	µg/L	--	0	4	--		1
Pesticides	Endrin Ketone	µg/L	--	0	4			0
Pesticides	Endrin	µg/L	--	0	4	--		1
Pesticides	Ethion	µg/L	--	0	4			0
Pesticides	Ethoprop	µg/L	--	0	4			0
Pesticides	Famphur	µg/L	--	0	4			0
Pesticides	Fenchlorphos	µg/L	--	0	4			0
Pesticides	Fenitrothion	µg/L	--	0	4			0
Pesticides	Fensulfothion	µg/L	--	0	4			0
Pesticides	Fenthion	µg/L	--	0	4			0
Pesticides	Fonofos	µg/L	--	0	4			0
Pesticides	HCH, alpha	µg/L	--	0	4			0
Pesticides	HCH, beta	µg/L	--	0	4			0
Pesticides	HCH, delta	µg/L	--	0	4			0
Pesticides	HCH, gamma	µg/L	--	0	4			0

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

			908PPAR04			CHL4		
Type	Constituent	Units	Mean	SD	n	Mean	SD	n
Pesticides	Heptachlor epoxide	µg/L	--	0	4	--		1
Pesticides	Heptachlor	µg/L	--	0	4	--		1
Pesticides	Hexachlorobenzene	µg/L	--	0	4			0
Pesticides	Leptophos	µg/L	--	0	4			0
Pesticides	Malathion	µg/L	--	0	4			0
Pesticides	Merphos	µg/L	--	0	4			0
Pesticides	Methidathion	µg/L	--	0	4			0
Pesticides	Methoxychlor	µg/L	--	0	4	--		1
Pesticides	Mevinphos	µg/L	--	0	4			0
Pesticides	Mirex	µg/L	--	0	4			0
Pesticides	Molinate	µg/L	--	0	4			0
Pesticides	Naled	µg/L	--	0	4			0
Pesticides	Nonachlor, cis-	µg/L	--	0	4			0
Pesticides	Nonachlor, trans-	µg/L	--	0	4			0
Pesticides	Oxadiazon	µg/L	0.02	0.016	4			0
Pesticides	Oxychlordane	µg/L	--	0	4			0
Pesticides	Parathion, Ethyl	µg/L	--	0	4			0
Pesticides	Parathion, Methyl	µg/L	--	0	4			0
Pesticides	Phorate	µg/L	--	0	4			0
Pesticides	Phosmet	µg/L	--	0	4			0
Pesticides	Phosphamidon	µg/L	--	0	4			0
Pesticides	Sulfotep	µg/L	--	0	4			0
Pesticides	Tedion	µg/L	--	0	4			0
Pesticides	Terbufos	µg/L	--	0	4			0
Pesticides	Tetrachlorvinphos	µg/L	--	0	4			0
Pesticides	Thiobencarb	µg/L	--	0	4			0
Pesticides	Thionazin	µg/L	--	0	4			0
Pesticides	Tokuthion	µg/L	--	0	4			0
Pesticides	Trichlorfon	µg/L	--	0	4			0
Pesticides	Trichloronate	µg/L	--	0	4			0
Physical	Oxygen, Dissolved	mg/L	113	198.9	4			0
Physical	Oxygen, Saturation	%	175	98.1	4			0
Physical	pH	pH units	8.78	0.754	4			0
Physical	Salinity	ppt	4.19	5.655	4			0
Physical	Specific conductivity	µS/cm	6925	9619	4			0
Physical	Suspended Solids,Total	mg/L	39.5	48.82	4	31		1
Physical	Temperature	ºC	25.7	5.42	4			0
Physical	Turbidity	NTU	8.32	7.491	3			0

Appendix II, continued. Means and standard deviations of water chemistry constituents.
B. Non-SWAMP sites.

	Site 1 (CC-FB)		
	Mean	SD	n
Dissolved oxygen (mg/l)	9.8	2.2	5
pH	7.7	0.3	5
Specific conductivity (mS/cm)	4.5	1.2	5
Turbidity (NTU)	8		1
Water Tempurature (ºC)	21.4	2.0	5

APPENDIX III

Mean IBI and metric scores for bioassessment sites in the Pueblo San Diego 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
Site 1	Average	6	2003-2005	19.5	0.0	1.3	0.5	0.7	0.0	1.2	1.6	4.5	2.1	0.0	0.0	5.0	0.9	1.0	0.9
	Fall	3	2003-2005	19.5	5.9	1.0	0.0	0.7	1.2	0.0	0.0	6.0	3.6	0.0	0.0	4.3	1.5	1.7	1.5
	Spring	3	2003-2005	19.5	6.8	1.7	0.6	0.7	1.2	2.3	0.6	3.0	3.5	0.0	0.0	5.7	1.5	0.3	0.6
CHL4	Fall	1	2005	10.0		1.0		0.0		0.0		5.0		0.0		1.0		0.0	