Contra Costa Monitoring and Assessment Program

Summary of Benthic Macroinvertebrate Bioassessment Results (2007)

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Preface and Acknowledgements

Many volunteers assisted the Contra Costa Clean Water Program agency staff in collecting the bioassessment data described in this report. Volunteers from the Friends of Pinole, Alhambra, Marsh, and Mt. Diablo Creek Watersheds, Aqua Team, Friends of Five Creeks, Friends of Lafayette Creeks, Friends of Orinda Creeks, students from Los Medanos College, and the San Pablo Watershed Neighbors Education and Restoration Society, as well numerous other volunteers have put in countless hours in the field. Additionally, the Program's Watershed Assessment and Monitoring (WAM) Subcommittee members have provided guidance to Program staff.

This report is based on the "Preliminary Assessment of Aquatic Life Use Condition in Contra Costa Creeks; Summary of Benthic Macroinvertebrate Bioassessment Results (2001-2006)", June 22, 2007, prepared for the Contra Costa Clean Water Program by Chris Sommers and others at Eisenberg, Olivieri, and Associates (EOA) of Oakland, CA. Some of the content of that report, including background and information related to the development of the preliminary Contra Costa IBI, are included herein.

The assessments described and results presented in this report should be considered preliminary and non-regulatory in nature. Results are based on limited data analyses and may be revised in the future as new analytical tools are developed.

Executive Summary

Since 2001, the Contra Costa Monitoring and Assessment Program (CCMAP) has monitored fresh water benthic macroinvertebrate (BMI) communities as the lead indicator of the condition of aquatic life uses in Contra Costa County water bodies. Volunteer monitors began to assist the Contra Costa Clean Water Program (Program) in conducting bioassessments in 2005, and took over primary responsibility for the bioassessment monitoring in 2007.

BMIs are composed primarily of insect larvae, mollusks, and worms. They are an essential link in the aquatic food web, providing food for fish and consuming algae and aquatic vegetation. These organisms are also sensitive to disturbances in water and sediment chemistry and physical habitat, both in the stream channel and along the riparian zone. They are considered to be useful as integrative indicators of in-stream biotic health.

In 2007 the Contra Costa Volunteer Creek Monitoring Program conducted bioassessments at 61 creek sampling stations, within 14 of the 29 major watersheds in Contra Costa County. BMI samples and associated habitat quality data were collected using the new (2007) California Surface Water Ambient Monitoring Program (SWAMP) protocols. To provide a measurement of Aquatic Life Use condition at these stations, a preliminary Benthic Index of Biotic Integrity (B-IBI) score was calculated from the BMI identification results for each station, using a method developed previously for creeks in Contra Costa County. Ranges of B-IBI scores were then assigned to poor, marginal, fair, good and very good categories.

Results from 2007 indicate that roughly 70% of all creek stations sampled in Contra Costa County scored in the very good, good or fair categories. Individual stations in Las Trampas and San Ramon Creeks (in the Walnut Creek Watershed), Arroyo Del Hambre (Alhambra Watershed), and Upper Marsh Creek scored the highest of all stations sampled, with B-IBI scores in the "very good" category (equal to or above 43). The lowest IBI scores (10 or lower) were calculated for stations in Rheem Creek and Cerrito Creek.

Watershed-wide average B-IBI scores were calculated from the 2007 data to allow for broad, inter-watershed comparisons. Among the 14 monitored watersheds there is a wide range in average scores, from Marsh Creek watershed, ranked first with an average B-IBI score in the "good" category, to Cerrito Creek watershed, ranked last and in the "poor" category. Most watersheds had average scores in the "fair" category, while several were in the "marginal" category.

For many of the watersheds monitored, B-IBI scores tend to be lower in the lower reaches, and improve with distance upstream. Physical habitat quality score (based on a semi-quantitative scoring system) was positively, though weakly, correlated with the 2007 B-IBI scores.

For stations sampled in both 2006 and 2007, B-IBI scores tended to be higher in 2007. This may be related to the change in sample collection protocols, but if so, the direction of change (improved scores) is counter-intuitive. Therefore other factors related to seasonal conditions may be operative. One such factor is likely to be seasonal rainfall, which was much higher in the months preceding the 2006 BMI sample collection than prior to the 2007 sampling. The higher resulting creek flows may have prevented establishment of diverse BMI communities in 2006. Additional analysis should be performed to evaluate potential trends based on data from subsequent years.

A site on West Antioch Creek was impacted by the documented presence of the New Zealand mud snail. Identification of this invasive species was independently confirmed by several scientists. Assessment of the presence of this ecologically harmful invasive should be continued, and careful attention should be given to decontamination of sampling equipment to prevent cross-contamination of monitoring sites.

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1.0 INTRODUCTION

Bioassessment monitoring has been performed in Contra Costa County creeks under the Contra Costa Monitoring and Assessment Program (CCMAP) since 2001. CCMAP is the principal monitoring vehicle for the Contra Costa Clean Water Program (Program)[1], serving to fulfill monitoring requirements in the Joint Municipal NPDES Permits (Permits) issued by the San Francisco Bay and Central Valley Regional Water Quality Control Boards (Water Boards). Beginning in 2007, all bioassessment data were collected through the efforts of the Contra Costa Volunteer Creek Monitoring Program. This report summarizes the methods and results of bioassessment data collection in 2007 under the CCMAP.

1.1 OVERVIEW OF MONITORING PROGRAM

1.1.1 Contra Costa Monitoring and Assessment Program

The CCMAP was created to provide the Program with a strategy to assess the condition of beneficial uses in individual creeks in Contra Costa County and identify likely stressors and associated sources. The CCMAP entails a tiered monitoring approach designed to help the Program answer core management questions (shown in Table 1), and to reach the overall goal of protecting beneficial uses in Contra Costa creeks by reducing or eliminating pollutants in urban runoff.

Table 1. Five core management questions that guide the implementation of the Contra Costa Monitoring and Assessment Program (CCMAP).

1.	What is the condition/status of beneficial uses in Contra Costa receiving waters?
2.	What is the extent and magnitude of current or potential receiving water problems?
3.	What is the relative stormwater contribution to the receiving water problem(s)?
4.	What are the sources to stormwater that contribute to receiving water problem(s)?
5.	Are conditions in receiving waters getting better or worse?

The first phase of the CCMAP was initiated in 2001 in the Program's pilot watershed, Alhambra Creek. Lessons learned from this pilot effort were used to refine CCMAP in subsequent years. To assess the condition of aquatic life uses, the Program developed a watershed-based sampling design, where creeks within particular watersheds are monitored for (at least) two consecutive years before Program monitoring resources are moved to another watershed.

1.1.2 Contra Costa Volunteer Creek Monitoring Program

In 2003, the Program submitted a grant application to the State Water Resources Control Board in collaboration with the Contra Costa Watershed Forum[2] to create a citizen-based watershed monitoring and assessment program (i.e., Volunteer Creek Monitoring Program). Among the variety of tasks described in the grant was the expansion of the CCMAP's bioassessment monitoring using citizen-monitors. The overall goal of the Volunteer Creek Monitoring Program is to aid in protecting and restoring the San Francisco Estuary and its tributaries by reducing/eliminating pollutants and impacts to water bodies in Contra Costa County. The Volunteer Creek Monitoring Program is jointly managed by the Contra Costa County Department of Conservation and Development, the Contra Costa Clean Water Program, and the Contra Costa Watershed Forum.

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[1]The Contra Costa Clean Water Program is comprised of Contra Costa County, all nineteen of its incorporated cities and the Contra Costa County Flood Control & Water Conservation District (i.e., Co-permittees).

[2] The Contra Costa Watershed Forum is an open committee of private individuals and public agency staff that seeks to identify common principles among parties involved in creek and watershed issues, and promotes actions that promote the transformation of local water resources into healthy, functional, attractive, and safe community assets.

1.0 INTRODUCTION

Beginning in 2007, all CCMAP bioassessment sample collection and field observations were performed by the Volunteer Creek monitoring Program. The spring 2007 field data collection effort involved 67 volunteers and approximately 1006 volunteer hours, county-wide.

1.2 BENTHIC MACROINVERTEBRATES AS INDICATORS OF AQUATIC LIFE USE CONDITION

From among the various options available, the Program selected fresh water benthic macroinvertebrate (BMI) communities as the lead indicator of aquatic life use condition for Contra Costa water bodies.

BMIs are composed primarily of insect larvae (as illustrated in Figure 1), plus mollusks and worms. They are an essential link in the aquatic food web, providing food for fish and consuming algae and aquatic vegetation (Karr and Chu, 1999).

The presence and distribution of BMIs can vary across geographic locations based on elevation, creek gradient, and substrate (Barbour et al., 1999). These organisms are sensitive to disturbances in water and sediment chemistry, and physical habitat, both in the stream channel and along the riparian zone.

Because of their relatively long life cycles (approximately one year) and limited migration, BMIs are particularly susceptible to site-specific stressors (Barbour et al., 1999). They are therefore considered to be useful as integrative indicators of in-stream biotic health.

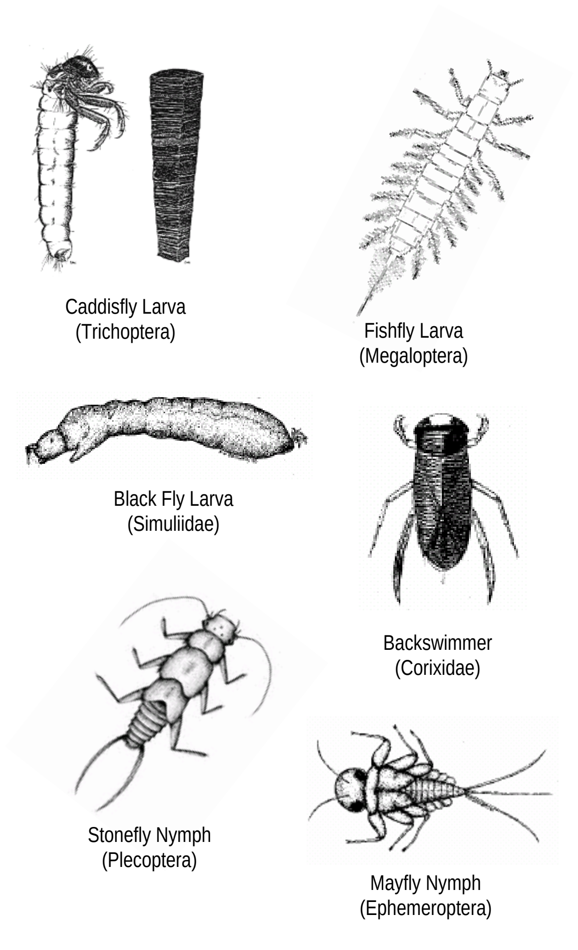


Figure 1. Examples of benthic macroinvertebrates (BMIs) used by the Contra Costa Clean Water Program as indicators of aquatic life use condition.

2.0 METHODS AND APPROACH

2.1 CONTRA COSTA WATERSHEDS AND SAMPLING STATIONS

Contra Costa County is divided into 29 major watersheds with approximately 1,295 miles of creeks flowing through them (Contra Costa CDD, 2003). Some watersheds have no creeks or only small creeks with ephemeral water flow. Other larger watersheds have been broken into smaller sub-watersheds for planning purposes. Additionally, a few of the watersheds in the southern portion of the County make up the headwaters of major watersheds in Alameda County. Major watersheds, their respective land areas, and miles of creeks (including tributaries) within each watershed are presented in Table 2.

Table 2. Watershed areas and lineal creek distances within the major watersheds of Contra Costa County

Watershed Name	Watershed Area (mi^2)	Creek Length (mi)
1. Alamo Creek/Tassajara Creek (Upper Alameda Creek Watershed)	41.2	101
2. Alhambra Creek	16.7	48.1
3. Baxter Creek	8.64	14.44
4. Cerrito Drainages	2.07	5.82
5. Brushy Creek	37.1	45.9
6. Carquinez Area Drainages	10.3	27
7. Cayetano Creek (Upper Alameda Creek Watershed)	6.9	14.1
8. Concord	8.7	0
9. East Antioch	11.4	8.7
10. Garrity Creek	6.2	4.1
11. Grayson Creek (Walnut Creek Watershed)	24	25.4
12. Kellogg Creek	32.6	67.6
13. Kirker Creek	17.4	43.7
14. Las Trampas Creek (Walnut Creek Watershed)	26.9	64.1
15. Marsh Creek	93.8	167.2
16. Mt. Diablo Creek	38.2	80
17. Peyton Slough (Alhambra Creek Watershed)	6.4	8.1
18. Pine Creek/Galindo Creek (Walnut Creek Watershed)	31.5	60
19. Pinole Creek	15.2	46.6
20. Refugio Creek	4.9	9.2
21. Rheem Creek	2.8	3.4
22. Rodeo Creek	10.4	31.6
23. San Leandro Creek/Moraga Creek	20.6	53.8
24. San Pablo Creek	43.6	108.6
25. San Ramon Creek (Walnut Creek Watershed)	54	136.7
26. South San Ramon Creek (Upper Alameda Creek Watershed)	13.1	26.2
27. West Antioch Creek	12.8	26.5
28. Wildcat Creek	11	22.2
29. Willow Creek and Coastal Drainages	23.6	44.8
Total	632.0	1294.9

Note: watersheds where bioassessments were conducted in 2007 are shaded.

In the presentation of results that follows, the Lower and Upper Marsh Creek watersheds are combined into a single March Creek watershed.

2.0 METHODS AND APPROACH

The locations of creek stations sampled during 2007 are presented graphically in Figure 2. Additional information on the locations of the 2007 CCMAP sampling stations is presented in Table 3.

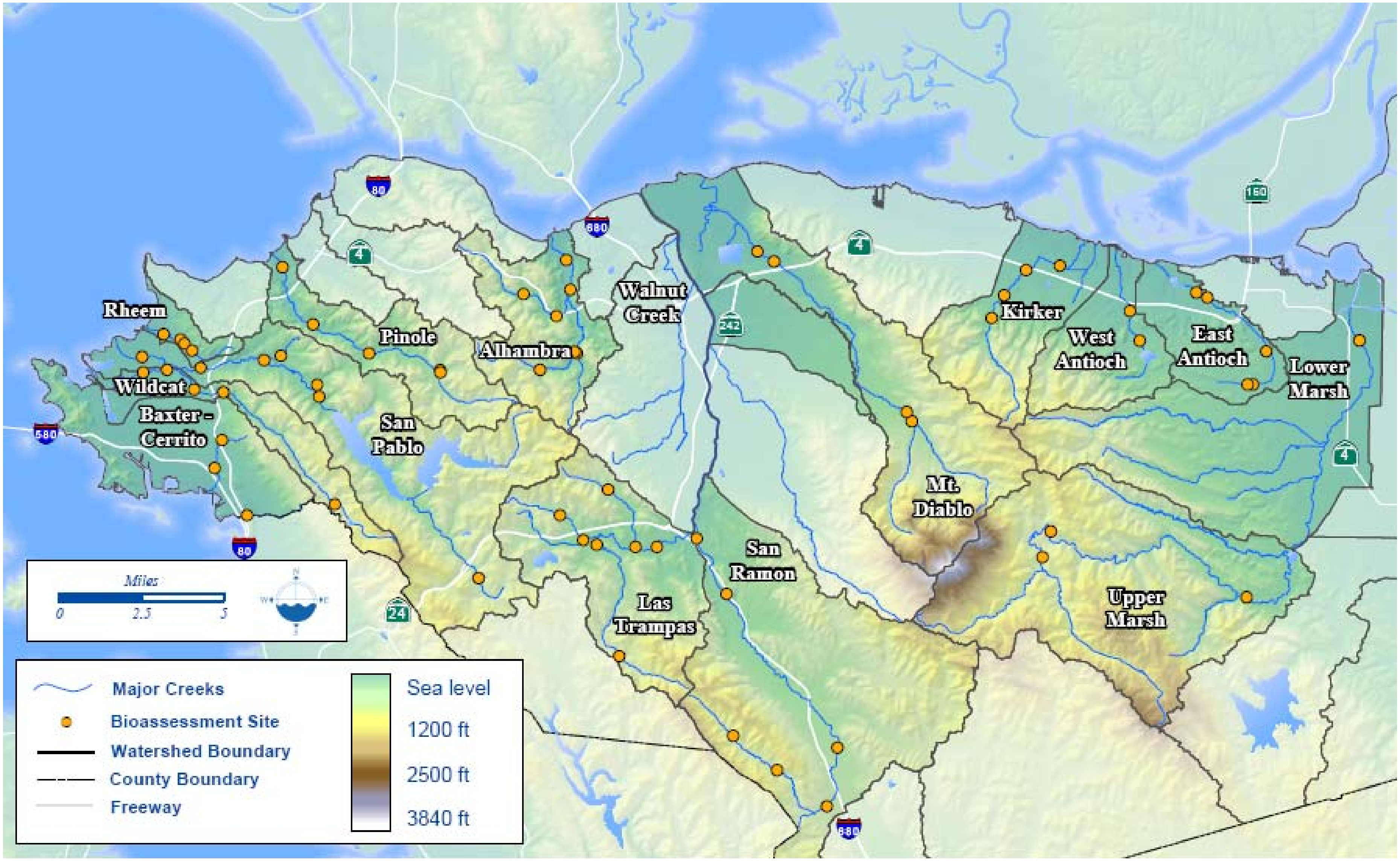


Figure 2. Benthic Macroinvertebrate (BMI) bioassessment stations sampled under the Contra Costa Monitoring and Assessment Program (CCCMAP) in 2007.

Table 3. Benthic Macroinvertebrate (BMI) bioassessment stations sampled under the Contra Costa Monitoring and Assessment Program (CCMAP) in 2007.				
Station Code	Waterbody	Location	Latitude	Longitude
Alhambra Creek Watershed				
ALH020	Alhambra Creek	Alhambra Cr. above Susana St.	38.01373	-122.13277
ALH050	Alhambra Creek	Alhambra Creek AT Martinez Adult School	38.00050	-122.12978
ALH080	Franklin Creek	Franklin Cr. At 1530 Franklin Canyon Road	37.98828	-122.13784
ALH140	Arroyo del Hambre	Arroyo del Hambre above Alhambra Cr.	37.97287	-122.12693
ALH160	Arroyo del Hambre	Arroyo del Hambre above Vaca Creek Rd	37.96481	-122.14620
ALH170	Alhambra Creek	Alhambra Cr. above Arroyo del Hambre	37.97212	-122.12568
Baxter Creek Watershed				
BAX030	Baxter Creek	Booker T. Anderson Park	37.91898	-122.32610
BAX045	Baxter Creek	At Gateway restoration Site	37.93121	-122.32229
Cerrito Creek Watershed				
CER010	Cerrito Creek	Pacific East Mall	37.89807	-122.30696
East Antioch Creek Watershed				
EAN020	East Antioch Creek	Upstream of 18th St., below trib.; Access from Trembath Lane	38.00374	-121.78160
EAN030	East Antioch Creek	Below Viera Ave off of Oakley Avenue	37.99666	-121.76952
EAN052	East Antioch Creek	Highway 4 bypass	37.97783	-121.74174
EAN065	East Antioch Creek	Downstream of Fairside Way culvert behind shopping mall	37.96405	-121.75243
EAN066	East Antioch Creek	Upstream of Fairside Way culvert	37.96283	-121.74957

Table 3. Benthic Macroinvertebrate (BMI) bioassessment stations sampled under the Contra Costa Monitoring and Assessment Program (CCMAP) in 2007.

Station Code	Waterbody	Location	Latitude	Longitude
Kirker Creek Watershed				
KIR040	Kirker Creek	Below Loveridge Rd, next to Auto Public Auction	38.01514	-121.85959
KIR085	Kirker Creek	Downstream of Garcia	38.01178	-121.87692
KIR110	Kirker Creek	At Buchanan Park	38.00088	-121.87997
KIR115	Kirker Creek	Kirker Creek Apartments, above culvert	37.99067	-121.89485
Marsh Creek Watershed				
MSH010	Lower Marsh Creek	Marsh Creek above Laurel Road	37.98320	-121.69004
MSH090	Upper Marsh Creek	Marsh Creek at Round Valley Park	37.86859	-121.75152
MSH130	Upper Marsh Creek	Marsh Creek at Detention Center	37.89722	-121.86031
MSH140	Upper Marsh Creek	Marsh Cr. below Curry Cr. at Tumbleweed Ct.	37.88522	-121.86527
Mt. Diablo Creek Watershed				
MTD020	Mt. Diablo Creek	In Diablo Creek Golf Course (hole 10)	38.01362	-122.01487
MTD050	Mt. Diablo Creek	Near North Mitchell Canyon Rd.	37.94937	-121.94407
MTD060	Mt. Diablo Creek	Near George Cardinet Path	37.94405	-121.93749
Pinole Creek Watershed				
PNL010	Pinole Creek	Pinole Creek at Senior Center	38.00722	-122.29030
PNL040	Pinole Creek	Pinole Creek at Amber Swartz Park	37.98295	-122.27256
PNL070	Pinole Creek	Pinole Creek above Simas Creek	37.97028	-122.24040
PNL100	Periera Creek	Periera Creek 200 feet above Pinole Creek	37.96392	-122.20161
PNL110	Pinole Creek	Pinole Creek along Bear Creek Road	37.96249	-122.20126

Table 3. Benthic Macroinvertebrate (BMI) bioassessment stations sampled under the Contra Costa Monitoring and Assessment Program (CCMAP) in 2007.

Station Code	Waterbody	Location	Latitude	Longitude
Rheem Creek Watershed				
RHM005	Rheem Creek	Giant Road	37.97737	-122.35593
RHM010	Rheem Creek	Bayview School	37.97524	-122.34653
RHM020	Rheem Creek	Wanlass Street (Rivers/San Pablo)	37.97340	-122.34417
RHM030	Rheem Creek	Contra Costa Community College	37.97044	-122.33987
San Pablo Creek Watershed				
SPA020	San Pablo Creek	At 3rd Ave Bridge	37.96750	-122.36583
SPA070	San Pablo Creek	El Portal Rd at St. Josephs Cemetary Bridge	37.96278	-122.33278
SPA110	Wilkie Creek	Santa Rita Road	37.96887	-122.29047
SPA124	San Pablo Creek	San Pablo Creek at Laurel Ln, EcoFarm	37.96654	-122.29930
SPA130	Castro Creek	Above Olinda Road	37.95592	-122.26992
SPA134	San Pablo Creek	San Pablo Creek at Stanley Ln	37.95232	-122.26844
SPA240	San Pablo Creek	Below Camino Encinas Road	37.87250	-122.17861
Las Trampas Creek (Walnut Creek Watershed)				
WAL300	Las Trampas Creek	Las Trampas Cr. below Boulevard Way bridge	37.88816	-122.07809
WAL330	Reliez Creek	Reliez Cr. at 3400 Springhill Road	37.91234	-122.10740
WAL340	Las Trampas Creek	Las Trampas Cr. above Reliez Creek	37.88729	-122.09118
WAL350	Happy Valley Creek	Happy Valley Cr. upstream of Rose Lane	37.90105	-122.13420
WAL360	Lafayette Creek	Lafayette Cr. above Fiesta Square	37.88941	-122.12011
WAL380	Las Trampas Creek	Las Trampas Cr. above Lafayette Creek	37.88757	-122.11107
WAL420	Las Trampas Creek	Las Trampas Cr. below Valley Hill Road	37.83922	-122.09908

Table 3. Benthic Macroinvertebrate (BMI) bioassessment stations sampled under the Contra Costa Monitoring and Assessment Program (CCMAP) in 2007.

Station Code	Waterbody	Location	Latitude	Longitude
San Ramon Creek (Walnut Creek Watershed)				
WAL500	San Ramon Creek	Creekside Street	37.89151	-122.05717
WAL520	San Ramon Creek	Paseo Nogales	37.86708	-122.04015
WAL670	San Ramon Creek	Zephyr Circle	37.80003	-121.97701
WAL700	San Ramon Creek	Playa Court	37.77406	-121.98235
WAL730	Bollinger Creek	Chen's property off Bollinger Canyon Road	37.78976	-122.01042
WAL750	Bollinger Creek	Bollinger Estates off Bollinger Canyon Road	37.80458	-122.03511
West Antioch Creek Watershed				
WAN060	West Antioch Creek	Upstream of Putnam St. below drop structure	37.99487	-121.81796
WAN080	West Antioch Creek	Downstream of James Donlon Blvd	37.98186	-121.81227
Wildcat Creek Watershed				
WIL030	Wildcat Creek	3rd Street bridge	37.96042	-122.36682
WIL050	Wildcat Creek	at Davis park	37.96177	-122.35330
WIL060	Wildcat Creek	at Vale Road	37.95631	-122.35000
WIL070	Wildcat Creek	Alvarado Park at Buckeye Picnic Area	37.95225	-122.32200
WIL130	Wildcat Creek	1/4 mile up Lone Oak Picnic Area trail	37.90367	-122.25885

2.2 BIOASSESSMENT METHODS

From 2001 to 2006, the California Stream Bioassessment Procedure (CSBP) for wadable streams (CDFG 1999 and 2003) was consistently utilized by the Program and volunteer monitors in Contra Costa County. Beginning in 2007, the CSBP was replaced by the new SWAMP Bioassessment Procedures, established in February 2007 (Ode, 2007). The principal change in protocols concerns the switch from a targeted-riffle composite (TRC) sampling method to a reach-wide benthos (RWB) method of sampling. The RWB procedure is an objective method of selecting sub-sampling locations because it does not target specific habitats.

2.2.1 Field Procedures

The 2007 SWAMP protocols were used by citizen monitors to collect BMI samples during 2007.

In accord with the SWAMP protocols, the standard sampling layout consists of a 150-m reach (length measured along the bank) divided into 11 equidistant transects.

Ambient water chemistry measurements are first taken at the downstream end of the reach. These measurements include temperature, pH, electrical conductivity, dissolved oxygen and alkalinity. Next, the "bug team" proceeds upstream, collecting BMI samples at every transect, using the method described below.

The bug team is followed by the physical habitat ("PHAB") team, who record observations regarding physical characteristics of the stream reach, as well as biological habitat characteristics. The dominant land use and land cover in the area surrounding the reach are recorded, along with evidence of recent flooding, fire, or other disturbances that might influence bioassessment samples. See the sample field data sheet (Appendix E) for details on the observations recorded by the PHAB team. See Appendix F for completed field sheets used during actual sampling.

Photographs of the reach are also taken at downstream, mid-reach, and upstream locations, and the reach slope is "shot" (measured) using surveying techniques from the upstream location, looking downstream.

The BMI samples are collected using a 500-µ mesh D-frame "kick-net" for "kick-sampling". Taking a "kick" sample consists of placing the net on the stream bottom; placing any heavy organisms in the sampling area in the net; rubbing stones within the sample area in front of the net to remove all attached animals; kicking and dislodging substrate under large, heavy rocks to displace BMIs into the net; and finally, digging fingers 10 cm into the substrate in the sampling area to gather any other organisms. If current is slow, the sampling procedure for "slack water" habitats is used, which involves more vigorous kicking during which the net is swept over the disturbed substrate for 30 seconds to collect all organisms. At each transect a one-square-foot area of stream bed is sampled.

The RWB method requires taking 11 samples with the D-net, one at each transect. The bug team alternates the horizontal location of the BMI sample within the transects as they move upstream, starting at 25% of the wetted width from the right bank for the first transect, then at mid-stream for the next, then at 25% of the wetted width from the left bank, and so on. The BMI samples are composited within the kick-net as the team moves upstream to form a spatial composite for the whole reach. After the upstream sample has been collected from the 11th transect, the contents of the net are transferred into a 500-mL or 1000-mL wide-mouth plastic sample jar with 95% ethanol and sent to the laboratory for analysis.

2.2.2 Laboratory Procedures

Bioassessment Services, Inc. (BSI) was contracted to perform the biological identifications and related analysis. BSI hired a subcontractor to first "pick" (or remove) BMIs from the contents in the sample jars. This entailed rinsing the sample bottle contents through a No. 35 standard testing sieve (0.5 mm brass mesh), and transferring the sieved sample into a tray marked with twenty 25 cm^2 grids. Then, all material was removed from one randomly-selected grid at a time and placed into a Petri dish for inspection under a stereomicroscope (10x). All macroinvertebrates from the grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 2% glycerin. This process was continued until 500 organisms were removed from each station's composited sample. The picked samples were then delivered to trained aquatic entomologists.

The bioassessment entomologist responsible for identifying the organisms from the picked samples and analyzing the results (enumeration and grouping according to taxa, and developing the associated metrics) was Tom King of BSI. Mr. King participates in the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) organization (formerly the California Bioassessment Laboratories Network) and is approved for BMI sample analysis by the California Department of Fish and Game (CFDG) Aquatic Bioassessment Laboratory. BMIs were identified to standard taxonomic levels as established by the CDFG (typically genus for insects and order or class for non-insects), using standard taxonomic references.

Bioassessment results (i.e., taxa lists) were provided to Program and Volunteer Creek Monitoring Program staff in Excel spreadsheets, and the five relevant metrics were then used to compute the IBI scores for each site, according to the preliminary Contra Costa IBI methodology described above.

2.3 PHYSICAL HABITAT ASSESSMENT METHODS

As part of the revised SWAMP bioassessment protocols published in Feb., 2007, physical habitat assessment methods and field forms were provided by SWAMP. The format of the field forms was modified slightly by SWAMP in response to requests by the Volunteer Creek Monitoring Program, and the resulting modified SWAMP forms were used by volunteer personnel in the field. The field form is shown in Appendix E.

As indicated in the SWAMP protocols, measurements of in-stream and riparian habitat and ambient water chemistry always accompany bioassessment samples. Physical habitat measurements were made relative to the main cross-sectional stream transects. For each transect the wetted stream width, bankfull width and height, and depth were measured, along with various other parameters. Additional inter-transect measurements also were made. These include stream discharge (flow) measurements and gradient. The various items are compiled and given a reach-wide score Scores can range from 1 to 200 (higher scores = higher quality habitat). A summary of physical habitat scores for all bioassessment stations is provided in Appendix A.

2.4 DATA QUALITY ASSESSMENT

The CCMAP and Volunteer Creek Monitoring Program comply with quality control and assurance procedures described in the Quality Assurance Project Plan (QAPP) developed for the Volunteer Creek Monitoring Program, which in turn is comparable with data quality assessment procedures implemented by the State of California's Surface Water Ambient Monitoring Program (SWAMP). The QAPP identifies data quality acceptance criteria (i.e., data quality objectives) related to the accuracy, precision, completeness, comparability, sensitivity and representativeness of data collected. Based on these criteria, duplicate samples are collected and analyzed annually for 10% of stations sampled, and the results are assessed for precision. Precision is assessed by calculating the percent of species similarity between original and duplicate samples. Additionally, accuracy is measured by annually re-analyzing 10-20% of samples by an independent taxonomist. The independent taxonomy QA/QC analysis was conducted by the Aquatic Bioassessment Laboratory at California State University, Chico. Results of the 2007 data quality assessments are summarized in Appendix B.

2.5 ANALYSIS AND INTERPRETATION METHODS

2.5.1 Benthic Macroinvertebrate Metrics

According to Barbour *et al*. (1999), a metric is "a measure of the biota that changes in a predictable way with increased human influence". For the CCMAP, a variety of metrics are calculated for each sample to allow interpretation of BMI taxonomic data received from the entomologist. Metrics can be categorized into five main types:

- Richness Measures (total number of distinct taxa);
- Composition Measures (distribution of individuals among taxonomic groups, which includes measures of diversity);
- Tolerance/Intolerance Measures (reflects the relative sensitivity of the assemblage to disturbance);
- Functional Feeding Groups (shows the balance of feeding strategies in the aquatic assemblage);
- Abundance (estimates total number of organisms in sample based on a nine sq. ft. sampling area).

2.5.2 Benthic Indices of Biotic Integrity

An Index of Biotic Integrity (IBI) is an index that reduces complex information about biological community structure into a simple numerical value based on measures of taxonomic richness (number of taxa); taxonomic composition (e.g., insects vs. non-insects); taxonomic diversity; feeding groups (e.g., shredders, scrapers, or predators); habits (e.g., burrowing, clinging, or climbing taxa); and tolerance to stressors. Typically, separate metrics are used from each of these categories to develop a multi-metric index (IBI) for a particular region of interest (e.g., Western U.S., California or Contra Costa County) to assess the biological condition in creeks.

Table 4. Six general steps typically used to develop an Index of Biotic Integrity (IBI)

1.	Classify stream types into classes and select reference sites
2.	Select potential metrics
3.	Evaluate metrics to select most robust ones
4.	Score metrics and combine scores into IBI
5.	Assign rating categories to IBI score ranges
6.	Evaluate IBI and refine

Barbour *et al*. (1999) identify six general steps involved in the development of an IBI (Table 4); each step can be modified based on the needs of the region or availability of research tools. Benthic macroinvertebrate IBIs (B-IBI) recently developed for Southern and Northern California wadable streams and the status of the San Francisco Bay B-IBI are discussed here, along with steps used to develop a preliminary B-IBI for Contra Costa creeks.

Northern and Southern California B-IBIs

Benthic Indices of Biotic Integrity (B-IBIs) were recently developed for coastal Northern California (Oregon border to Marin County) and Southern California (Mexico Border to Monterey County) using the steps presented in Table 4 (Ode et al., 2005; Rhen and Ode, 2006). Of 71 possible metrics, eight were selected for the Northern California B-IBI and seven for the Southern California B-IBI (Table 5). Four metrics were selected in common for the Northern and Southern California B-IBIs.

Table 5. Metrics selected for development of the Southern and Northern California B-IBIs.

B-IBI Metric	Southern California	Northern California
Coleoptera Richness	x	x
EPT Richness (Ephemeroptera + Plecoptera + Trichoptera)	x	x
Predator Richness	x	
Diptera Richness		x
% Collector individuals	x	
% Noninsect Taxa		x
% Tolerant	x	x
% Intolerant Taxa	x	x
% Non-Gastropoda Scraper Individuals		x
% Predator Taxa	x	
% Shredder Taxa		x

San Francisco Bay Area B-IBI

To better understand the biological integrity of Bay Area creeks, the Bay Area Macroinvertebrate Bioassessment Information (BAMBI) network[3] has begun to develop a provisional B-IBI for San Francisco Bay Area Creeks. The Bay Area B-IBI is being developed using data collected from Contra Costa, Alameda, Santa Clara, San Mateo, Napa, Marin, Sonoma and Solano counties, and will fill a geographical data gap created by the Northern and Southern California B-IBIs. The Bay Area B-IBI was originally scheduled to be completed in 2007; the actual completion date is unknown.

Contra Costa B-IBI

As a preliminary step in developing the B-IBI for San Francisco Bay Area creeks, data from Contra Costa County were used to test metrics used in Southern and/or Northern California B-IBIs for applicability in the Bay Area. As a result, a preliminary B-IBI for Contra Costa was developed. To determine which metrics are applicable, IBI development steps 1-5 were followed (see Table 4). The following paragraphs briefly describe this process.

[3] BAMBI is a network of scientists, watershed managers, regulators and community members interested in using biological communities as indicators of stream health in the San Francisco Bay Area.

Reference Station Selection

Reference stations are sections of creeks that have "reference conditions" representing the desired state of stream health for a region of interest. There are many definitions of the term "reference condition" ranging from the pristine, undisturbed state of a stream, to merely the "best available" or "best attainable" conditions in a region. Because practical considerations limit our ability to find minimally disturbed sites, most reference condition approaches seek to identify a compromise, the "least disturbed condition" in region. In regions like the San Francisco Bay Area, it is necessary to select sites that represent the "best attainable" condition given application of best management practices in a heavily human-impacted ecosystem. Once candidate reference stations have been identified, these are used to characterize the range of biotic conditions expected for minimally disturbed sites. Deviation from this range can then be used as an indication that non-reference stations may be impacted.

The bioassessment programs in Contra Costa County have attempted to include information about minimally impacted conditions at selected "reference" stations to supplement data collected at BMI monitoring sites. Using "best professional judgment" and qualitative physical habitat scores, a pool of potential reference stations (~30) was initially selected. From those, the 11 stations listed in Table 6 were selected to represent reference conditions in Contra Costa County.

Table 6. Reference stations selected during the development of the preliminary B-IBI for Contra Costa County.

Water Body	Station Code	Location
Upper Marsh	543MSH170	Upper Marsh Creek 4.8 miles above Curry Creek
Upper Marsh	543MSH160	Upper Marsh Creek 3.8 miles above Curry Creek
Upper Marsh	543MSH150	Curry Creek between 1st and 3rd bridges near mouth
Upper Marsh	543MSH140	Marsh Cr. below Curry Cr. at Tumbleweed Ct.
Upper Marsh	543MSH130	Marsh Creek at Detention Center
Kellogg	543KEL040	Kellogg Creek at 0.3 miles above Mallory Creek
Mallory	543KEL030	Mallory Creek 0.25 mile above road, upper site
Mallory	543KEL020	Mallory Creek 900 feet above road, lower site
Kellogg	543KEL010	Kellogg Creek just above Los Vaqueros Reservoir
Las Trampas	207WAL420	Las Trampas Creek below Valley Hill Road
Mitchell	207MTD100	Mitchell Creek at Oak Street

Variation in BMI assemblages due to natural factors (such as elevation) can affect the development and interpretation of IBI scores. These factors were not fully evaluated during the development of the Preliminary B-IBI for Contra Costa County. Ideally, reference conditions would represent each set of sampling sites with significantly different BMI assemblages due to natural conditions. The process of identifying these reference conditions is currently underway in the development of the B-IBI for San Francisco Bay Area creeks.

Metrics Screening and Selection for Use in IBI

Selection of the most appropriate bioassessment metrics for an IBI is a critical phase in the creation of an IBI and typically undergoes the most revision in subsequent refinement of an index. Ideal metrics differ from region to region (hence the need for regional IBIs), but share common characteristics. Most critically, "core" metrics should be able to discriminate between known reference stations and stations with known impacts.

A series of techniques was used to select appropriate metrics in the development of the preliminary Contra Costa B-IBI, following United States Environmental Protection Agency recommendations (Barbour *et al*. 1999, Hughes *et al*. 1998, McCormick *et al*. 2001). However, since similar techniques were used in the development of the Northern and Southern California B-IBIs, the 11 metrics selected in these indices were used as the starting point for the Contra Costa B-IBI, instead of testing all possible metrics (~71). Each of the 11 metrics was tested for its power to discriminate between reference and test stations. Based on the results of this screening process, the following five "core" metrics used in the Northern and/or Southern California B-IBIs were selected for inclusion in the preliminary Contra Costa B-IBI:

1. EPT Richness (Ephemeroptera + Plecoptera + Trichoptera)
2. Diptera Richness
3. Predator Richness
4. Percent Collector Individuals
5. Percent Noninsect Taxa

Defining Scoring Ranges of Core Metrics

Metric scoring ranges were defined using techniques described in Hughes *et al*. (1998) and McCormick *et al*. (2001). Statistical properties of the distribution of metric scores for both reference and test stations were used to define cutoffs for each of the 5 metrics selected using the following criteria: 1) any station with a metric value of less than the 5th percentile of the test stations was assigned a "0" score, and 2) any site with a metric value of greater than the 25th percentile of the reference stations was assigned a "10" score. The range between these values was divided into 9 equal portions and assigned values between 1 and 9. Table 7 presents the scoring ranges for the five metrics included in the preliminary Contra Costa County B-IBI.

Table 7. Scoring ranges for the five metrics included in the preliminary Contra Costa County Benthic-IBI and scoring categories that define biotic condition.

IBI Score	Cumulative EPT Taxa	% Non-Insecta Taxa	Diptera Taxa	Predator Taxa	% Collectors
10	>9	0-17	> 5	> 9	0-78
9	9	18-22		9	79-80
8	8	23-28	5	8	81-82
7	7	29-33		7	83-85
6	6	34-39	4	6	86-87
5	5	40-44		5	88-89
4	4	45-50	3	4	90-91
3	3	51-55		3	92-94
2	2	56-61	2	2	95-96
1	1	62-66		1	97-99
0	0	>66	< 2	0	100

B-IBI Scoring Categories				
Very Good	Good	Fair	Marginal	Poor
50-43	42-35	34-23	22-11	10-0

Calculation of the B-IBI

For each monitoring event, the five selected core metrics are assigned scores for each site, using the scoring categories defined in Table 7, and the B-IBI score for each site is calculated by simply summing the component metric scores. The resulting B-IBI scores are then divided into scoring categories that define thresholds of biotic condition as shown at the bottom of Table 7. For the preliminary Contra Costa B-IBI the scoring categories were established by first using the 25th percentile of reference stations to set the boundary between the "Good" and "Fair" scoring ranges. Then the top end of the scale was divided into two equal sections ("Good" and "Very Good") and the bottom end of the scale was divided into three equal sections ("Fair", "Marginal" and "Poor").

3.0 RESULTS

3.1 COUNTY-WIDE OVERVIEW - BMI RESULTS

During 2007, over 30,000 individual macroinvertebrate organisms were taxonomically identified from the 61 sampling stations in the 14 Contra Costa County watersheds monitored. These organisms were made up of 133 distinct BMI taxa, present in varying degrees. Table 8 provides an overview of distribution by major taxonomic grouping, county-wide. A complete list of taxa identified in Contra Costa County samples in 2007 is included in Appendix D.

Table 8. Percentages of all organisms identified within various BMI groups (2007).

GROUPS OF BENTHIC MACROINVERTEBRATES IDENTIFIED	% OF ALL ORGANISMS
Aquatic Insects/Spiders/Crustaceans (Arthropoda)	72.9%
Aquatic Insects:	
True Flies (Diptera)	41.6%
Mayflies (Ephemeroptera)	5.8%
Stoneflies (Plecoptera)	0.2%
Caddisflies (Trichoptera)	5.7%
Beetles (Coleoptera)	1.3%
Dragonflies and Damselflies (Odonata)	1.0%
Acari	1.4%
Amphipoda	5.8%
Ostracoda	10.0%
Alderflies and Dobsonflies (Megaloptera)	0.1%
Segmented Worms (Annelida)	16.9%
Oligochaetes	16.7%
Snails and Clams (Mollusca)	9.8%
Flat Worms (Platyhelminthes)	0.4%
Other (Cnidaria and Nemertea)	0.1%

3.1.1 Most Dominant Taxa

Nearly 60% of the organisms identified in 2007 belonged to one of five distinct taxa (Table 9). Moderately pollution-tolerant, non-biting midges (*Tanytarsini* in the Chironomidae family) and segmented worms (Oligocheates) were the most frequent taxa identified. Chironomids are closely related to mosquitoes (Culicidae) and biting midges (Ceratopogonidae), and are usually the most abundant macroinvertebrate group in freshwater habitats (Epler, 2001). Oligochaetes are aquatic segmented worms common in most freshwater habitats. Many aquatic worms can tolerate low dissolved oxygen and may be found in large numbers in organically polluted habitats.

Table 9. Five most frequently identified benthic macroinvertebrate taxa identified in samples collected in 2007.

TAXON	TAXONOMIC GROUP	COMMON NAME	TOLERANCE VALUE (0-10)*	% OF ALL ORGANISMS
Oligochaeta	Oligochaeta	Segmented worms	5	16.7%
Tanytarsini	Diptera	Non-biting midges	6	13.1%
Ostracoda	Ostracoda	Mussel shrimp	8	10.0%
Chironomini	Diptera		6	9.7%
Orthocladiinae	Diptera		5	9.6%
			Total	59.0%

*Tolerance values range from 0-10, 0 = the least tolerant and 10 = the most tolerant to stress (e.g., pollution).

3.1.2 Functional Feed Groups (FFGs)

Without a relatively stable source and variety of food types (e.g., fine and coarse particulate organic material, algae and other BMIs), an imbalance in BMI community structure will occur, reflecting stressed conditions. To assess if conditions are likely stressed in a creek, BMI taxa are classified into functional feeding groups (FFGs) based on their feeding mechanisms. FFGs include collector-gatherers, collector-filterers, scrapers, shredders and predators.

Collector-filterers and collector-gatherers depend upon fine particulate organic matter (FPOM) for their primary food resource. Filterers obtain fine suspended material from the water column, while collector-gatherers, also called deposit-feeders, generally gather fine materials, including plant, animal, and fungal detritus, from the surfaces of substrates. Scrapers (grazers) depend upon attached periphyton (i.e., algae and associated flora and fauna) that develops on submerged substrates for their primary food resource. Shredders depend upon coarse particulate organic matter (CPOM) for their primary food resource. CPOM is any material greater than about 1 mm in diameter; examples include twigs, leaves, fruits and flowers of terrestrial or aquatic vegetation. Lastly, predators attack living prey organisms.

Generalists, such as collector-gatherers and collector-filterers, have a broader range of acceptable food materials than specialists (Cummins and Klug 1979), and thus are more tolerant to stressors that might alter availability of certain food. BMI communities at sampling stations in Contra Costa County are dominated by these FFGs (Figure 3). Specialized feeders, such as scrapers, shredders and predators are typically considered the more sensitive types of BMIs and thought to be well represented in healthy streams. Organisms from these FFGs have been identified in Contra Costa creeks, but to a lesser degree than collector-gatherers and collector-filterers.

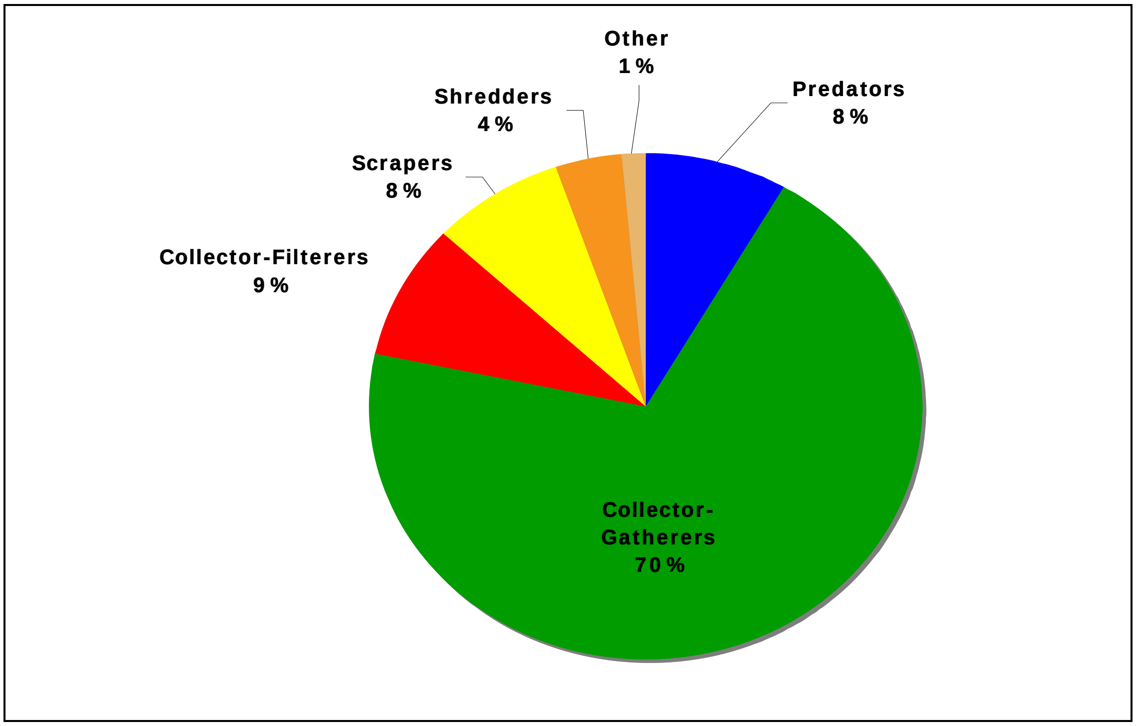


Figure 3. Percentages of organisms identified in functional feeding groups in 2007.

3.2 CONDITION OF BENTHIC AQUATIC LIFE IN CONTRA COSTA COUNTY CREEKS

Using the preliminary B-IBI scoring ranges developed for Contra Costa County, B-IBI scores were calculated for each creek sampling station and event. B-IBI scores presented in this report represent the most up-to-date evaluation of bioassessment data on a "county-wide" basis.

Results from 2007 indicate that roughly 70% of creek stations sampled in Contra Costa County scored in the very good, good or fair categories (Figure 4). Stations in Las Trampas and San Ramon Creeks (Walnut Creek Watershed), Arroyo Del Hambre (Alhambra Watershed), and Upper Marsh Creeks scored the highest of all stations sampled (B-IBI scores equal to or above 43). The lowest IBI scores (10 or lower) were calculated for stations in Rheem Creek and Cerrito Creek.

To assess the general condition of aquatic life uses on a watershed scale, average B-IBI scores were calculated for the 14 Contra Costa watersheds monitored during 2007, using the average score of all stations within the watershed boundaries (Figure 5, Table 10).

The individual metrics and scores used to calculate the B-IBI scores are presented in Appendix C.

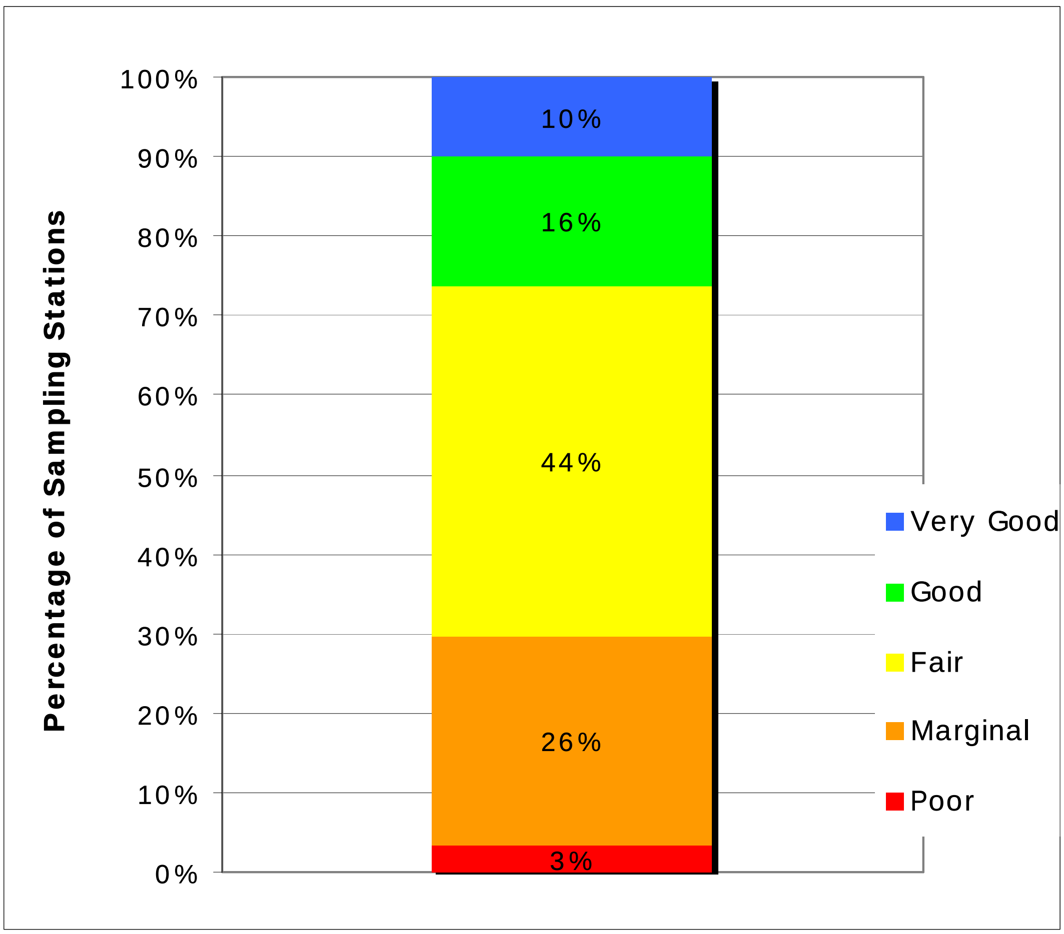


Figure 4. Percentage of Contra Costa County creek stations in each B-IBI scoring category, based on 2007 data.

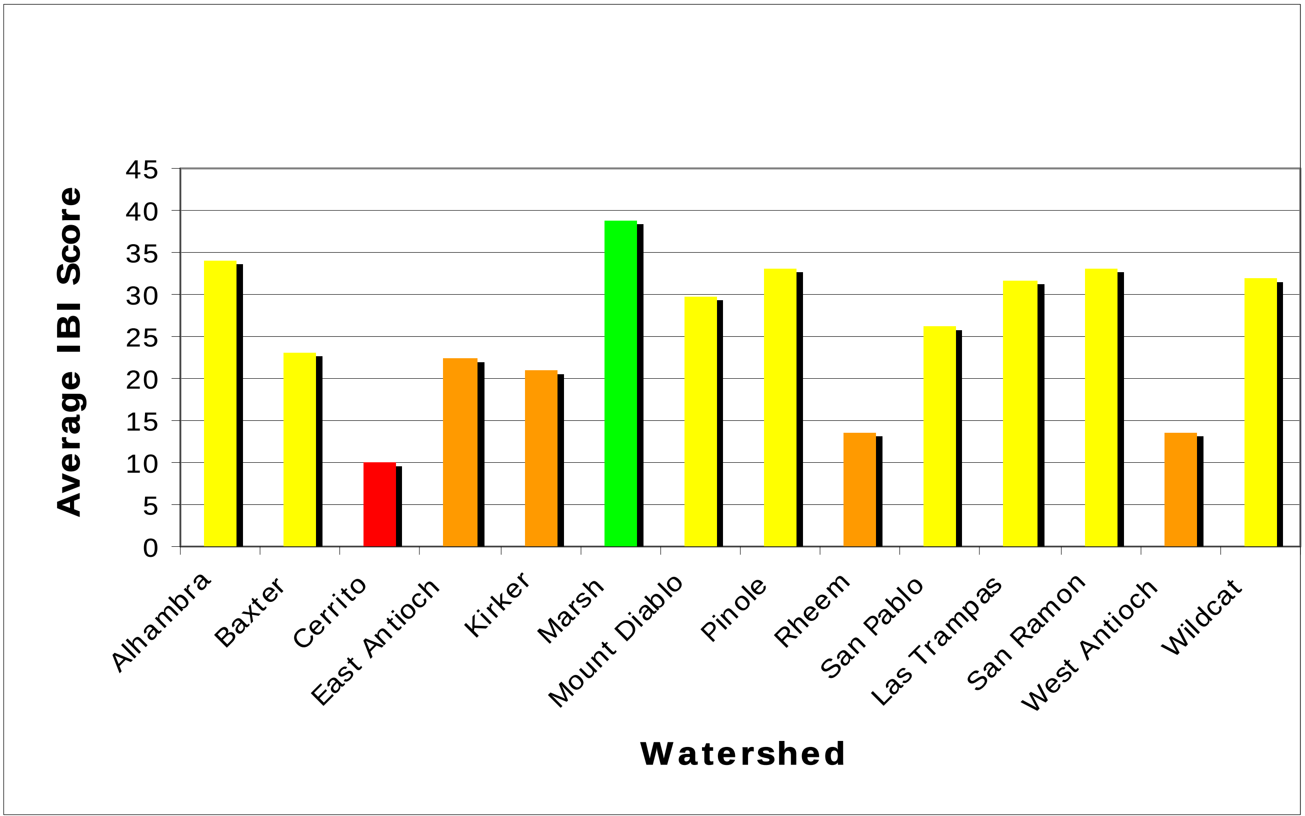


Figure 5. Average 2007 B-IBI Score on a watershed scale

Note: the Las Trampas and San Ramon Creek sites are located within the Walnut Creek watershed.

Table 10. Average B-IBI Watershed Score and Ranking, 2007 Data

1	Marsh	39
2	Alhambra	34
3	Pinole	33
4	San Ramon	33
5	Wildcat	32
6	Las Trampas	32
7	Mt. Diablo	30
8	San Pablo	26
9	Baxter	23
10	East Antioch	22
11	Kirker	21
12	Rheem	13.5
13	West Antioch	13.5
14	Cerrito	10

3.3 ANNUAL VARIABILITY IN B-IBI SCORES

BMI communities naturally vary spatially and temporally. The CCMAP standardizes the monitoring approach to attempt to minimize the variability due to the sampling regime, by consistently collecting samples from the same stream reaches on a recurring basis, and by collecting during the same time of year in each annual cycle.

In Contra Costa County, bioassessments are conducted once annually during the late spring or early summer. Sampling occurs during this "index period" because benthic communities are typically at their most diverse and are highly abundant prior to emergence (i.e., adult flight). Because samples are collected only during this one period annually, intra-annual (within year) variation is not addressed. However, the considerable degree of inter-annual (between years) variability confounds attempts to assess changes in the condition of aquatic life use indicators over time. An analysis of annual variation in B-IBI scores from 2001-2006 in the 2007 CCMAP BMI Summary report (EOA, 2007) revealed that it was not possible to discern any notable or consistent temporal trends in the BMI monitoring data. A longer time frame is often needed to illustrate temporal trends, as sufficient data must be accumulated to discern a cause and effect above the inherent noise (innate variation) in the data.

The change in BMI data collection protocols implemented in 2007 may have an effect on the resulting B-IBI scores; this possibility is discussed below.

3.3.1 Change in Sample Collection Approach

In February, 2007 the Surface Water Ambient Monitoring Program issued new protocols for benthic bioassessment for use throughout the state of California. As described in Section 2.2.1, the new protocols required use of a reach-wide benthos (RWB) technique, rather than the targeted-riffle composite (TRC) method used previously.

To provide an initial assessment of the effect of the change in protocols, B-IBI scores were compared for sites that were sampled both in 2006 and 2007 (see Appendix H). The results of those comparisons support the idea that the change in protocols may have affected sample results, but the direction of the change is counterintuitive. Of 47 data pairs available for comparison, the 2007 B-IBI scores were *higher* than the 2006 scores in most cases. The ten exceptions included all sites monitored in both years in Rheem and West Antioch Creeks. Average B-IBI score for the paired sites was 19.6 in 2006 and 27.0 in 2007. This difference was statistically significant at $p<0.0001$.

We would expect that the RWB technique would result in increased sample collection in less-rich habitat, and lower B-IBI scores, as the riffle sites targeted in the TRC technique are considered to generally be the most desirable habitat type for benthic organisms. The 2006/2007 comparison supports the opposite conclusion.

This phenomenon was further tested by comparisons of the average annual scores for the five individual metrics that comprise the IBI composite score for all sites monitored in both 2006 and 2007. The results of the paired t-tests are shown in Table 11. In this table, the higher of the average for the two years is highlighted for each metric tested, and the t-test probability ("P") is shown bolded in Table 11 when the difference between the 2006 and 2007 averages is statistically significant ($P \leq 0.05$).

Three of the individual metrics produced statistically significant differences as defined by the t-tests between the 2006 and 2007 averages, and these three metrics support the higher average 2007 IBI scores. The Number of Diptera Taxa and the Number of Predator Taxa are both expected to track directly with IBI score; that is, those metrics should generally increase as IBI score increases, and that in fact is what happened, as the 2007 averages were higher than the 2006 averages for those metrics, at a statistically-significant level. The Percent Collectors metric should track inversely with IBI score; that is, lower proportions of collectors contribute to higher IBI scores, and that is borne out in the results, as the 2007 data showed lower % collectors than 2006 on average.

Two of the metrics (EPT Taxa and Percent Non-Insect Taxa) did not show statistically-significant differences between 2006 and 2007, and the mean values of both of those metrics tracked opposite to the trend in average annual B-IBI scores (EPT Taxa, a beneficial measure, was higher in 2006, and % Non-Insect Taxa, a detrimental measure, was higher in 2007). Typically a less-than-significant result in such cases indicates a relatively high degree of variability in the data. These results are therefore given less weight.

Overall, these test results indicate that the underlying metrics support the idea that benthic populations were on average healthier in 2007 compared to 2006, for those sites tested in both years.

Table 11. Comparisons of Average B-IBI Scores and Individual Metrics, 2006 vs. 2007

Metric	2006	2007	P
IBI	19.6	**27.0**	**0.000**
EPT Taxa	**2.9**	2.2	0.097
Number Diptera Taxa	3.5	**6.7**	**0.000**
Number Predator Taxa	2.9	**5.1**	**0.000**
Percent Collectors	**0.91**	0.76	**0.000**
Percent Non-Insecta Taxa	0.37	**0.42**	0.145

3.3.2 Climate

In addition to the change in protocols, it is also possible that differences in annual climate, particularly rainfall, could influence annual average B-IBI statistics. In fact, the 2005-06 and 2006-07 rainfall years were dramatically different (see Table 12). The 2006 BMI samples were collected following a year with over 27 inches of rainfall, more that three times the amount received in the following year, prior to the 2007 BMI sample collection. The critical spring period (March-May) of 2006 received ten times as much rainfall as the spring period of 2007. The flushing effect of the higher 2005-06 rainfall and resulting higher creek flows may have prevented establishment of diverse and populous benthic assemblages prior to the 2006 sampling period.

Table 12. Comparison of Incident Rainfall, 2005-06 vs. 2006-07

Month	2005-06	2006-07
July	0	0
Aug	0	0
Sept	0	0
Oct	0.09	0.1
Nov	1.2	1.45
Dec	11.79	2.39
Jan	2.2	0.43
Feb	1.8	3.58
mar	6.18	0.15
Apr	3.81	0.76
may	0.65	0.3
June	0	0
Year:	**27.72**	**9.16**
Spring:	**10.64**	**1.21**

Rainfall in inches at “Concord Wastewater Plant” station

One year of comparison data is not sufficient to conclusively determine whether the change in sample collection protocols produces a discernable signal in the BMI data. The comparisons between the pre- and post-2007 data should continue with the data produced during the 2008 and 2009 BMI monitoring.

3.4 POTENTIAL FACTORS AFFECTING AQUATIC LIFE USES

BMI communities can be affected by a variety of natural (e.g., elevation, hydrology, in-stream and riparian physical habitat quality, food availability and predation) and anthropogenic (e.g., urbanization, impoundments, water quality, and introduced invasive species) factors. Limited data are currently available on food availability, stream hydrology and water quality, and therefore no analyses were performed on these factors. The effects of watershed-scale urbanization (via elevation) and reach-scale physical habitat quality were examined using available data in the 2007 report (EOA, 2007).

3.4.1 Urbanization

Urbanization can affect the type and diversity of BMIs present at creek stations due to changes in hydrology, riparian vegetation, creek substrate and water quality. In previous studies, the effects of urbanization on BMIs have been evaluated using indicators such as percent impervious surfaces and percent urban area in upstream land areas. Although data were not available for these urbanization indicators, information on other indicator, elevation, was available to assess correlation between urbanization and IBI scores.

Due to historical development patterns, urbanization in Contra Costa County typically increases as elevation decreases. In the 2007 BMI report (EOA, 2007), elevation did not correlate well with B-IBI score. Additional analysis of the relationship should be performed, to assess whether other indicators of urbanization, such as population density, are correlated with BMI measurements.

For the 2007 BMI sample results, monitoring sites were characterized as being in “lower”, “middle”, or “higher” reach ranges, and the minimum, mean, and maximum B-IBI scores for each group were compared (see Figure 6). The results of these comparisons support the idea that upper regions of watersheds, which are generally less developed that lower regions, tend to have higher B-IBI scores. The minimum, mean, and maximum in each category consistently increased from lower to middle to upper ranges of the watersheds tested in 2007.

3.4.2 Reach-Scale Physical Habitat Quality

Physical habitat characteristics that may influence BMI assemblages include substrate composition and embeddedness, in-stream vegetation, channel alternation and canopy cover. These parameters were qualitatively assessed at each sampling station using the physical habitat assessment (PHAB) approach as provided in the 2007 SWAMP protocols, based substantially on procedures included in the U.S. Environmental Protection Agency’s (EPA) Rapid Bioassessment Protocol (Barbour et al., 1999).

For the 2007 data, the resulting PHAB scores were positively correlated with the B-IBI scores. The relationship was highly significant ($p = 0.0002$), but the correlation was not strong ($r^2 = 0.20$). Additional investigation should be done to further illuminate how physical habitat factors influence BMI populations.

3.4.3 Invasive Species

BMI assemblages also can be impacted by invasive species. This appears to have happened at the WAN080 site in West Antioch Creek. Whereas in 2006 the sample from this site was dominated by chironamids and planariads, in 2007 the sample was dominated by Hydrobiidae, the family to which the invasive New Zealand mudsnail belongs. Confirmation of the New Zealand mud snail identification was provided by scientists from several institutions. The B-IBI score for this site dropped from 15 in 2006 to 14 in 2007. The 2007 decrease was even more pronounced at site WAN060, downstream of the site impacted by the documented presence of the New Zealand mud snail, where the B-IBI score went from 18 in 2006 to 13 in 2007.

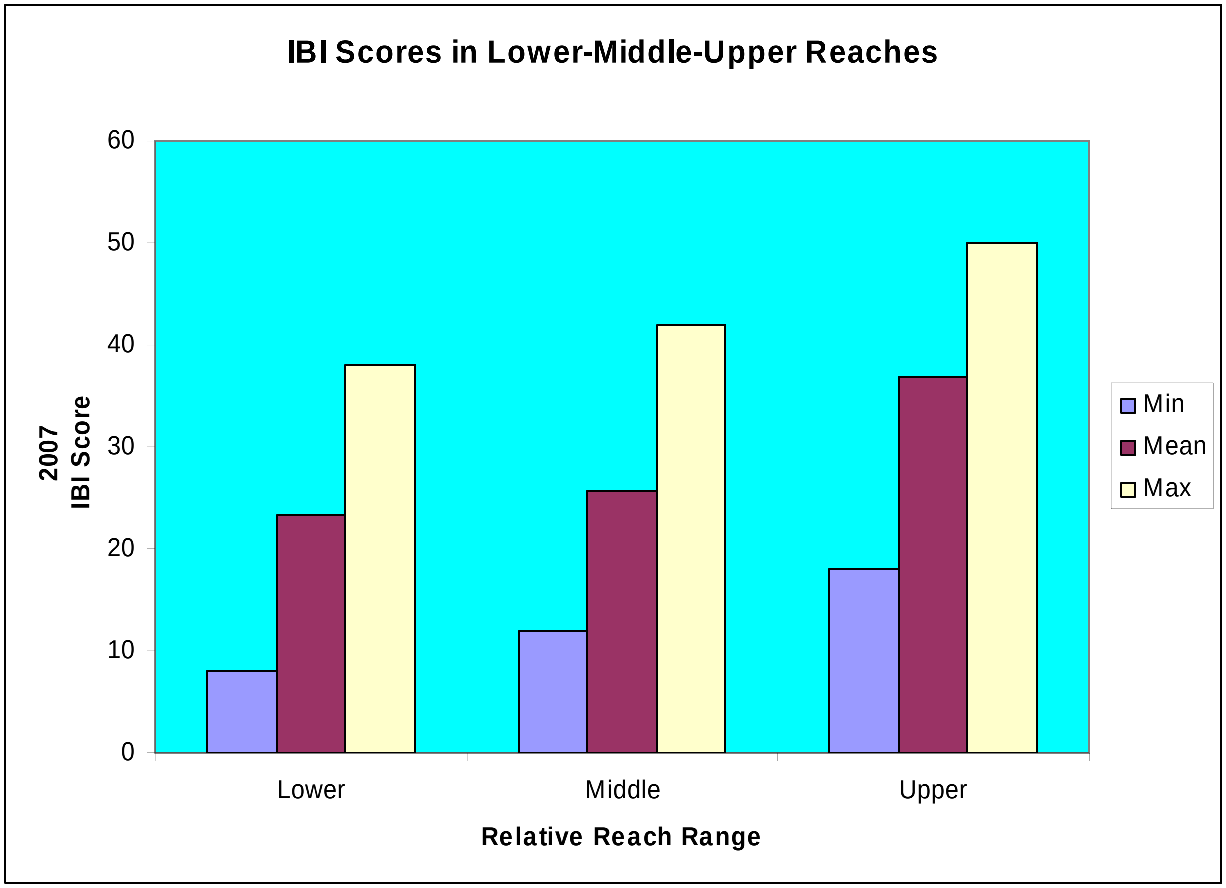


Figure 6. Comparisons of IBI Scores in Lower, Middle and Upper Creek Stations, 2007 Data

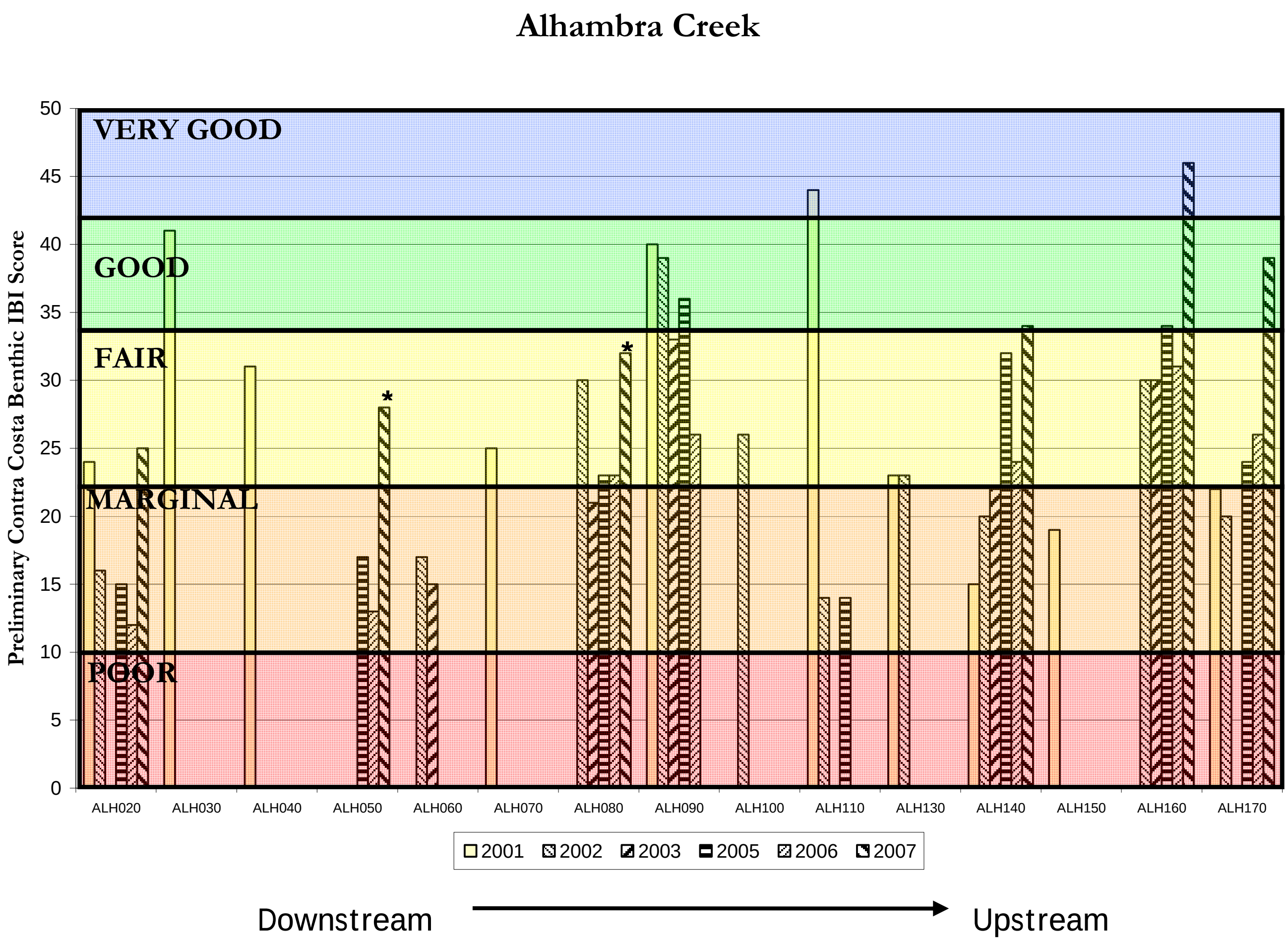
3.5 WATERSHED-SPECIFIC OBSERVATIONS

This section includes graphical presentations of all BMI monitoring results from 2001-07, to allow for assessments of both spatial and temporal variation. The charts are arranged by site within each watershed, proceeding from downstream on the left side to upstream on the right. This also follows the site numbering system, which runs from lower to higher numbers as one proceeds from downstream to upstream within each watershed.

Note: all samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*) in the following charts.

3.5.1 Alhambra Creek Watershed

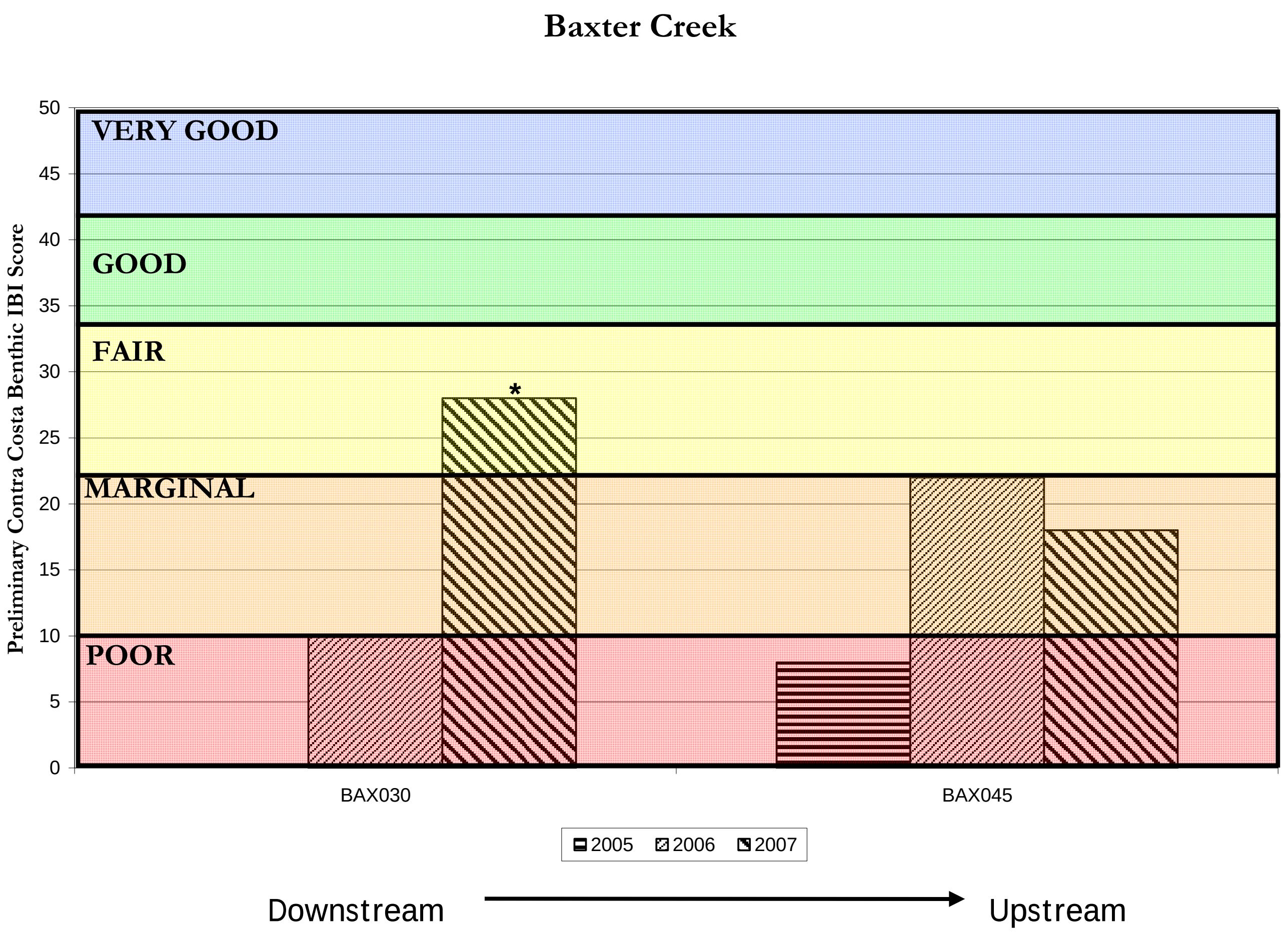
Within the Alhambra Creek watershed the general condition of aquatic life uses in creeks appears to be good, relative to other watersheds in Contra Costa County. Alhambra had the second-highest average B-IBI score for the 2007 data.



Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)

3.5.2 Baxter Creek Watershed

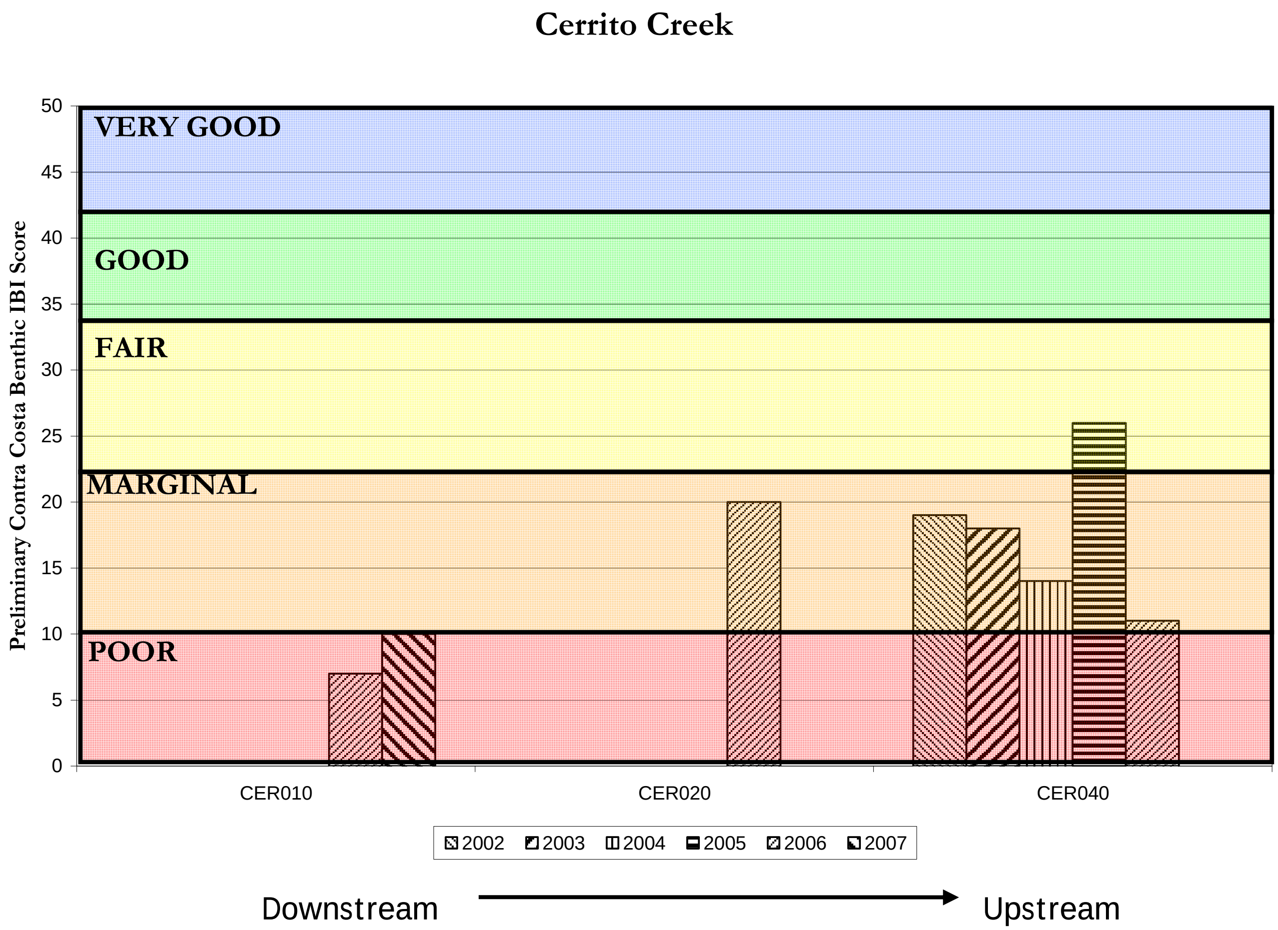
Baxter Creek watershed is made up of predominately urban land uses, and creek channels have been heavily altered due the historical effects of urbanization. Therefore, it is not unexpected that stations within this watershed would generally have B-IBI scores within the poor to marginal categories. These stations are dominated by short-lived, tolerant benthic macroinvertebrates that generally indicate stress on a system.



Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)

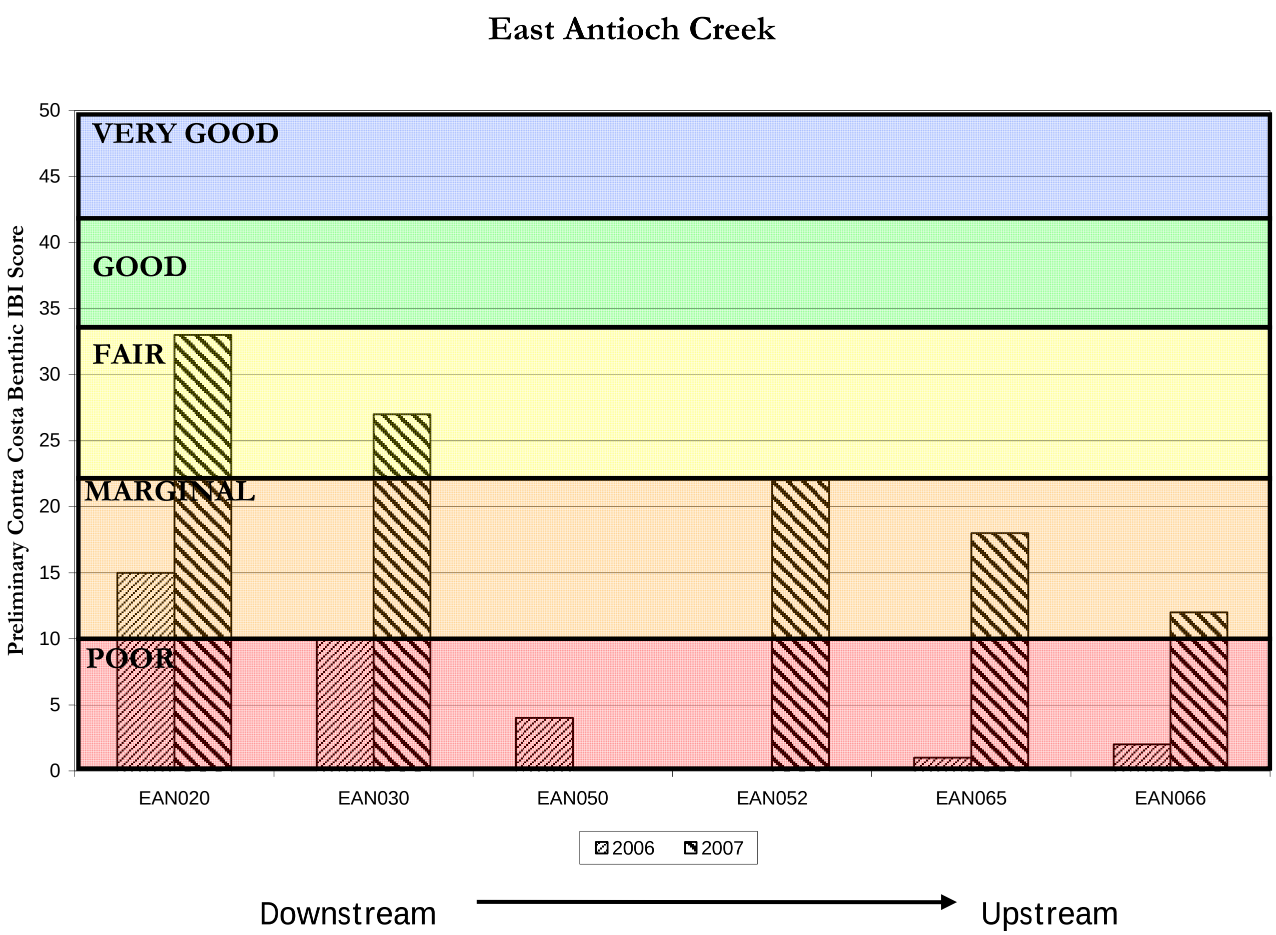
3.5.3 Cerrito Creek Watershed

Cerrito Creek watershed is also are made up of predominately urban land uses, and creek channels have been heavily altered due the historical effects of urbanization. Therefore, it is not unexpected that stations within this watershed would generally have B-IBI scores within the poor to marginal categories. These stations are dominated by short-lived, tolerant benthic macroinvertebrates that generally indicate stress on a system.



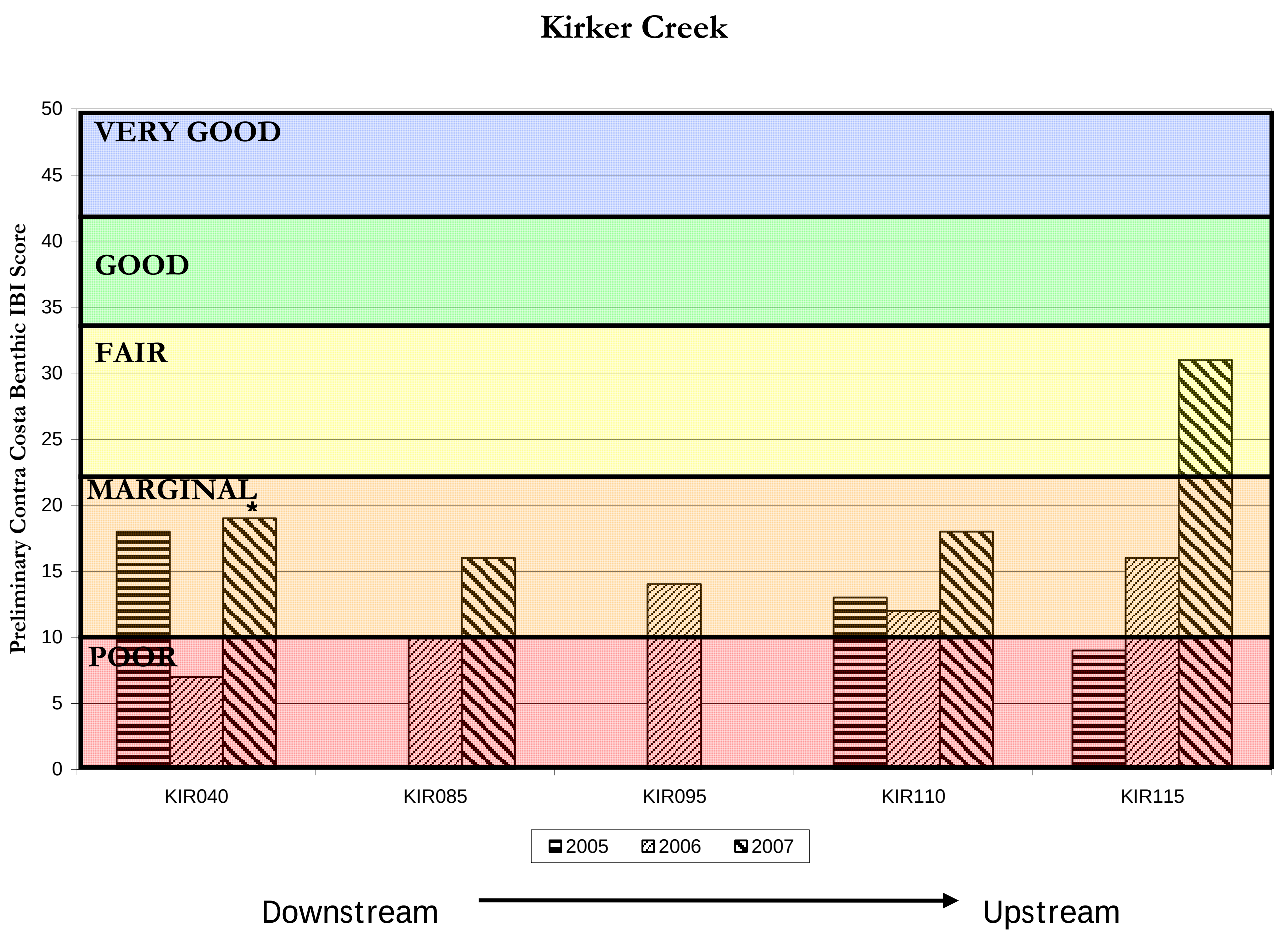
3.5.4 East Antioch Creek Watershed

All stations within East Antioch Creek scored in poor to fair B-IBI scoring categories and BMI assemblages were dominated by short-lived tolerant benthic macroinvertebrates that generally indicated stress on a system. The watersheds are made up of predominately urban land uses and creek channels have been heavily altered due the historical effects of urbanization, which likely affect aquatic life uses. For these relatively new sites, all B-IBI scores were substantially higher in 2007 than the corresponding scores in 2006. As discussed in 3.3.1, this is counter-intuitive since the change in sample collection protocols was expected to lead to lower numbers of taxa being collected.



3.5.5 Kirker Creek Watershed

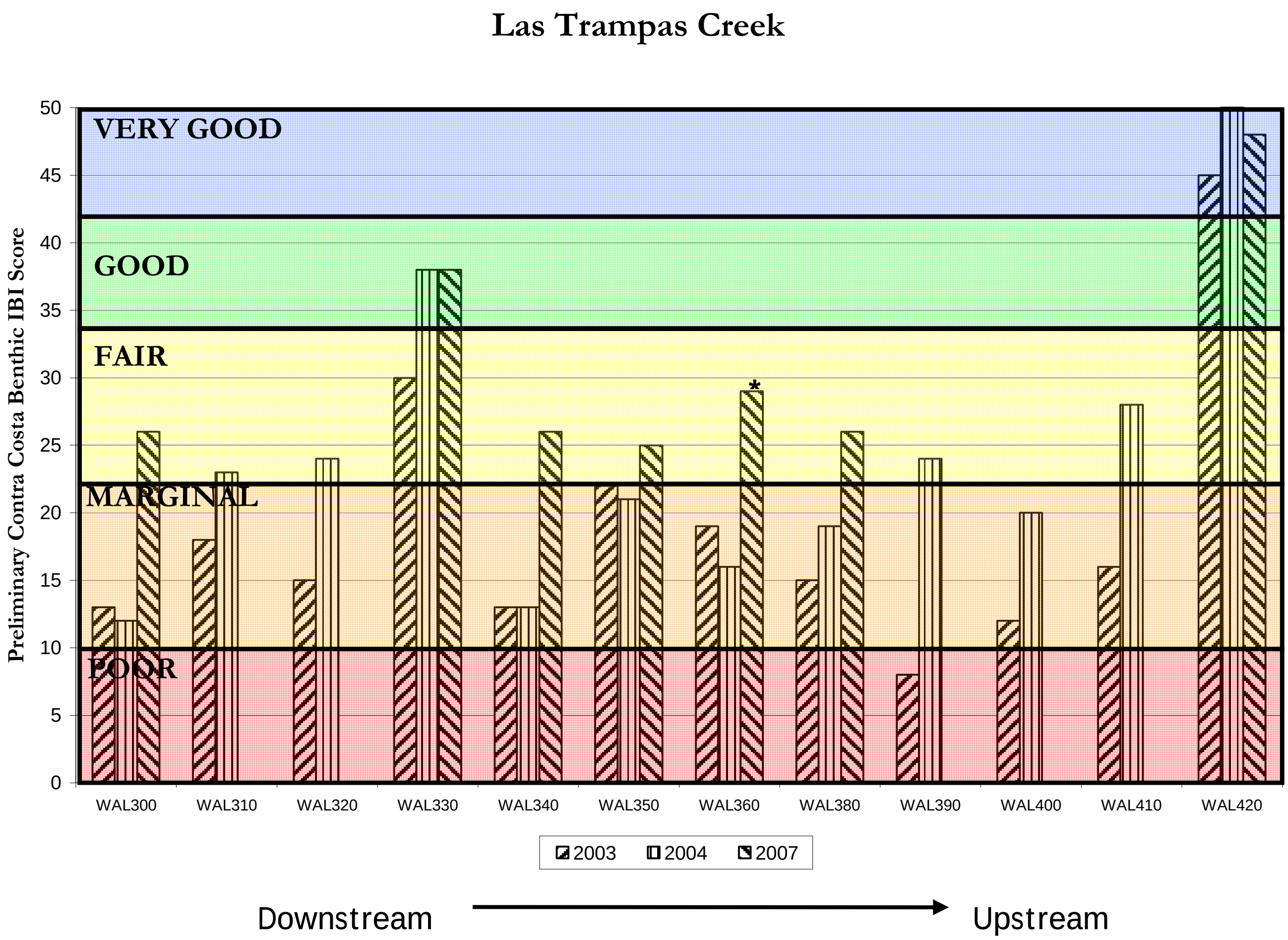
Benthic IBI scores for stations in the Kirker Creek watershed consistently scored in the poor to marginal categories, with the exception of the 2007 score for site KIR115, in the upper watershed, which was substantially higher than all other scores within this watershed. Kirker creek stations are dominated by short-lived tolerant benthic macroinvertebrates that generally indicate stress on a system.



Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)

3.5.6 Las Trampas Creek Watershed

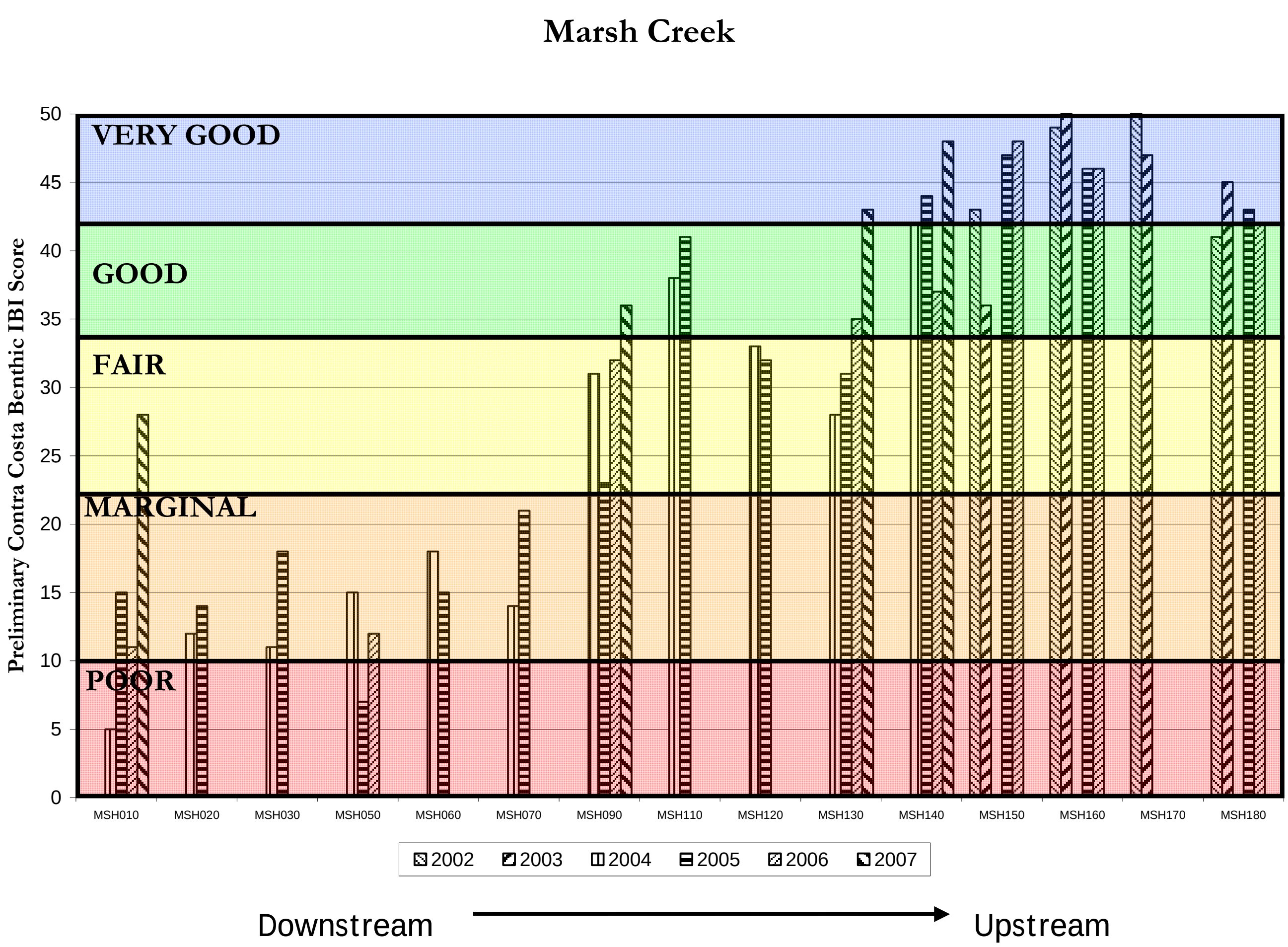
With the exception of stations WAL330 and WAL420, B-IBI scores for stations in the Las Trampas creek watershed were marginal. Stations WAL330 (Reliez Creek) and WAL420 (Las Trampas Creek) are located in the upper Walnut Creek watershed and predominately drain open space land uses and relatively large parcels of land. In contrast, other stations in the watershed are surrounded by residential and commercial development.



Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)
Note: the Las Trampas Creek sites are located within the Walnut Creek watershed.

3.5.7 Marsh Creek Watershed

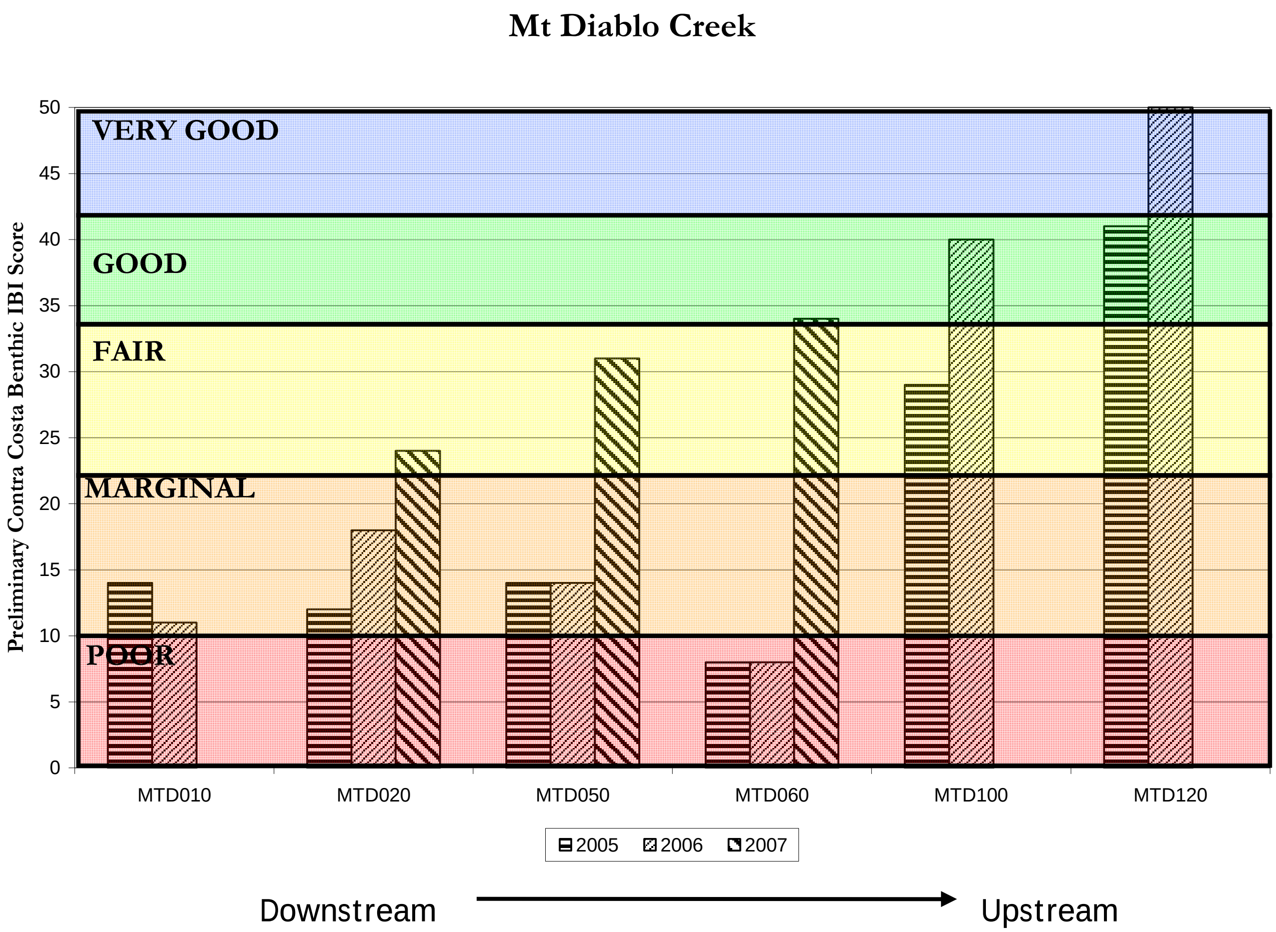
In contrast to the upper watershed, stations in the lower watershed consistently generally score in the poor to marginal categories, and are dominated by short-lived tolerant benthic macroinvertebrates that generally indicate stress on a system. The low scores at stations in the Lower March Creek watershed, located downstream of the Marsh Creek reservoir (below MSH090), are likely due to the reduced habitat complexity caused by the straightening of the channel and lack of riparian habitat. Additionally, the reservoir itself reduces the amount of large substrate (e.g., cobbles and boulders) that can be transported to the sections of the creek directly below the dam, and therefore likely reduces the diversity of BMI habitat available. However, the sites in the Upper Marsh Creek watershed, above the dam (MSH090 and above), range generally in the fair to very good categories; as a result, the March Creek watershed ranked highest in average B-IBI score for 2007.



Note: Marsh Creek Reservoir is located between sites MSH070 and MSH090

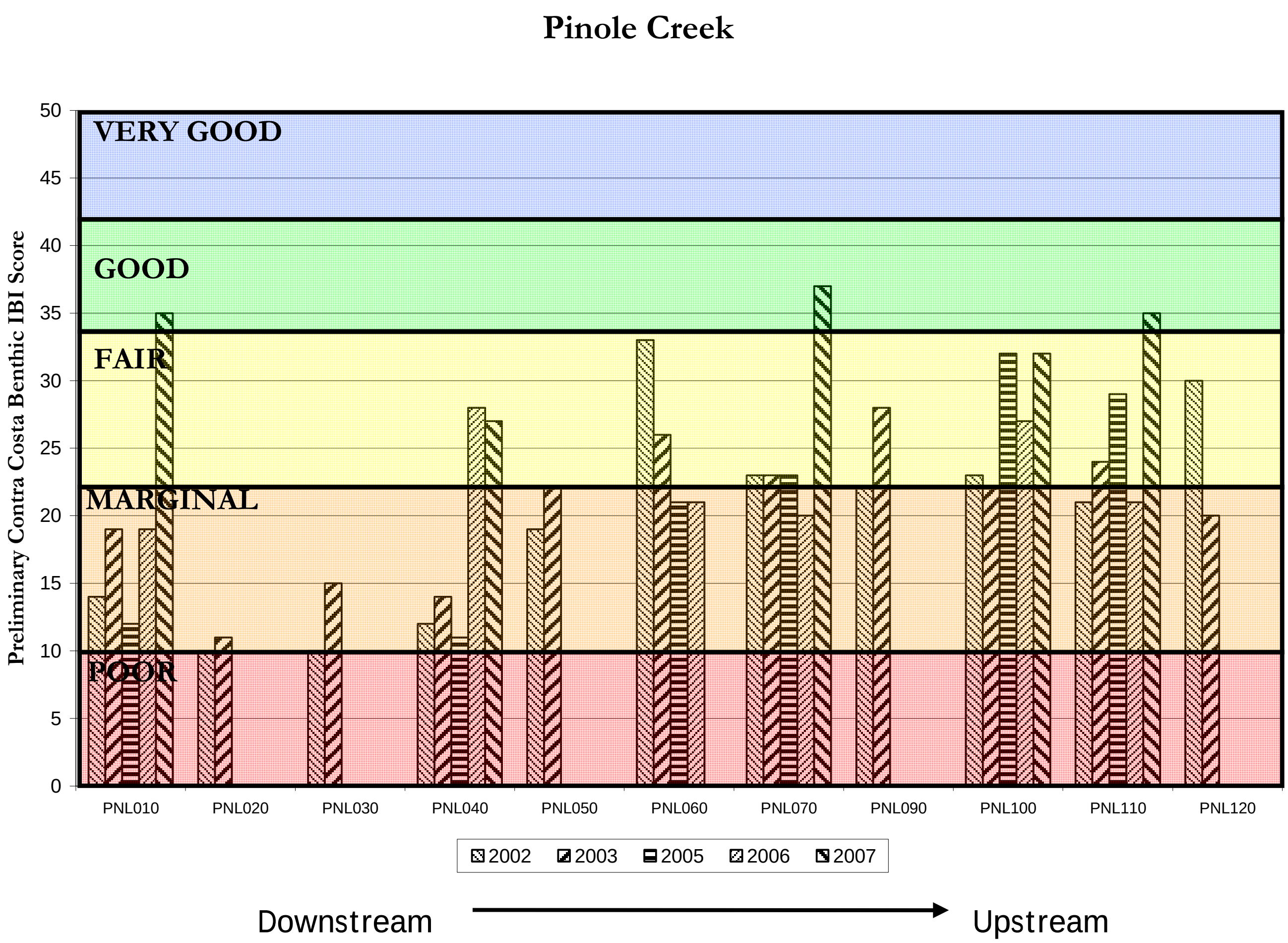
3.5.8 Mt. Diablo Creek Watershed

Based on median B-IBI scores, the Mt. Diablo Creek watershed ranked seventh among the 14 watersheds assessed in the county. In this watershed there is a fairly clear progression in B-IBI scores from lower to upper watershed. Stations in the upper watershed, particularly MTD120, had B-IBI scores in the good to very good categories. Scores in the mid to lower watershed stations (below MTD100) were much lower, falling into the marginal and poor categories. These lower watershed stations were generally dominated by short-lived tolerant BMIs that generally indicate stress on a system. Lower scores at these stations could indicate that degraded physical habitat and/or water quality may be impacting benthic communities. The three stations sampled in 2007 exhibited notably higher B-IBI scores than corresponding scores from previous years. As discussed in 3.3.1, this is counter-intuitive since the change in sample collection protocols was expected to lead to lower numbers of taxa being collected.



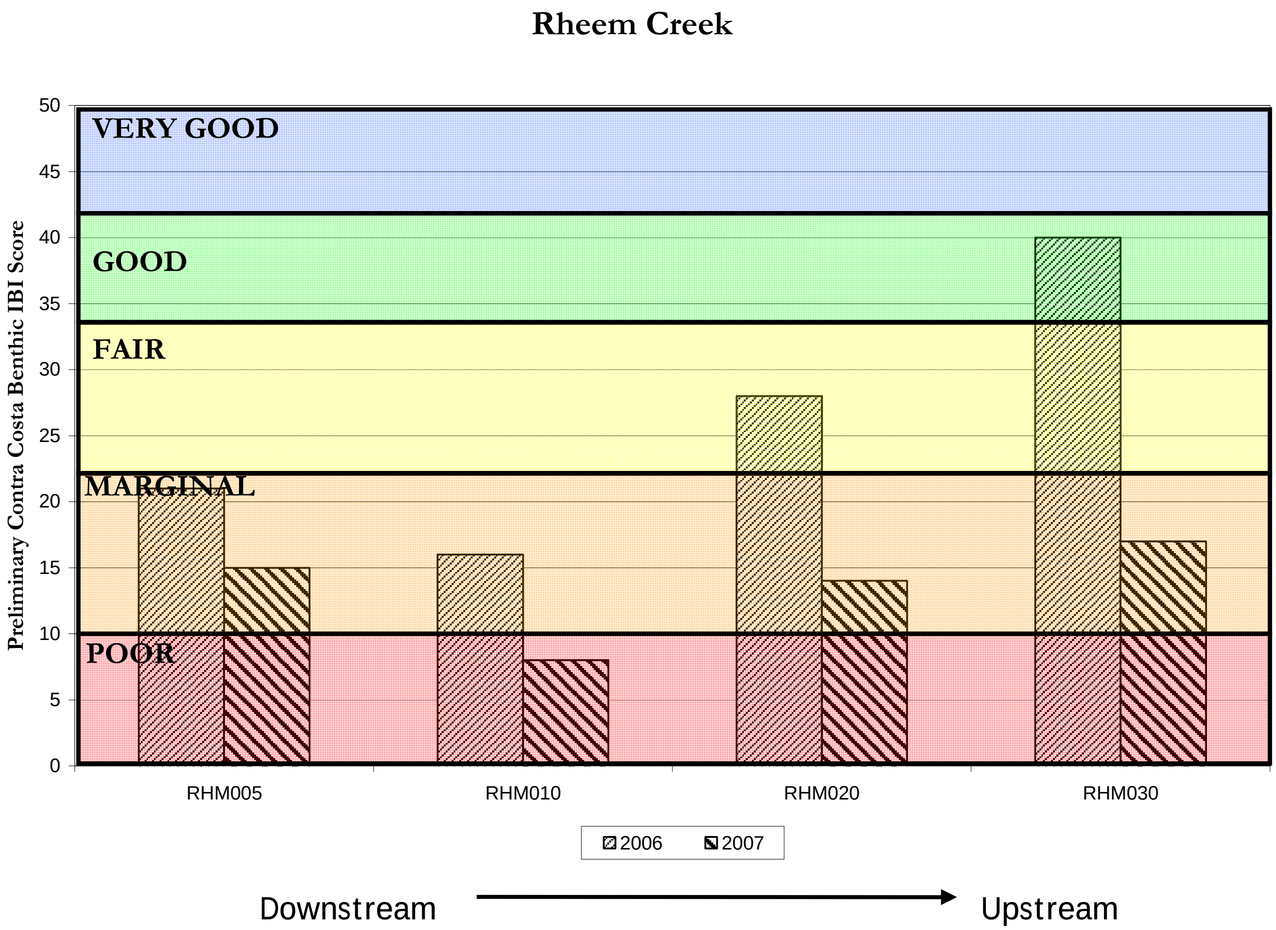
3.5.9 Pinole Creek Watershed

Aquatic life use conditions in creeks within the Pinole Creek watershed appear to be relatively good compared to other watersheds in the County. Throughout this watershed scores tend to range from marginal to fair. Overall, Pinole Creek watershed ranked third in average B-IBI score, based on 2007 data.



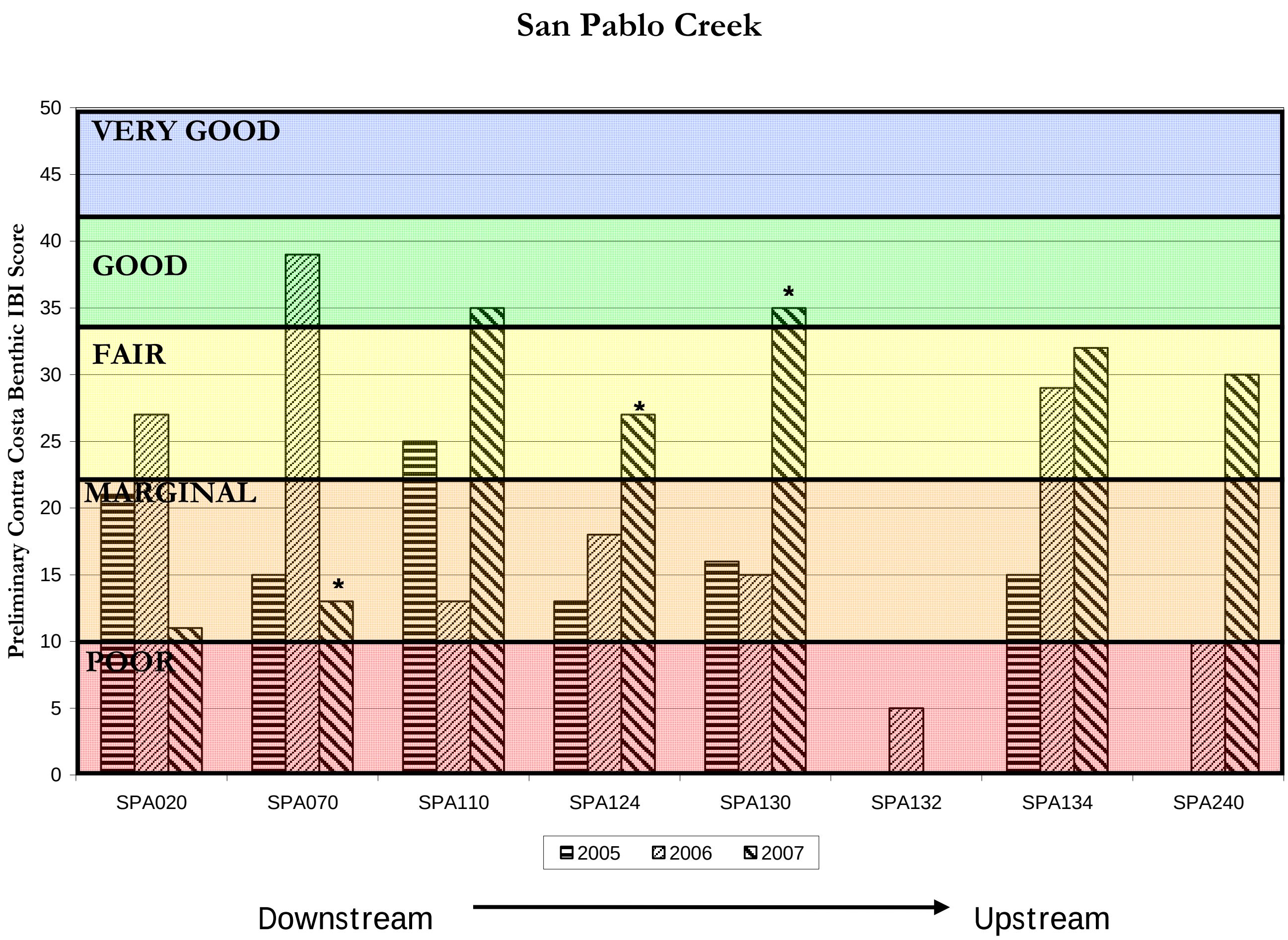
3.5.10 Rheem Creek Watershed

Stations within Rheem creek scored in marginal to good B-IBI scoring categories during the 2006 sample collection, but scores dropped into the poor category across the board with the 2007 sample results. Rheem Creek watershed ranked 12th out of 14 watersheds based on the 2007 B-IBI scores. Stations in the lower watershed are dominated by short-lived tolerant benthic macroinvertebrates that generally indicate stress on a system. Reduced physical habitat quality at these and all stations in the watershed may partially explain benthic community composition. The Rheem Creek 2007 B-IBI scores were consistently lower than the 2006 scores, contrary to most other Contra Costa watersheds.



3.5.11 San Pablo Creek Watershed

The condition of aquatic life uses in creek stations located in the San Pablo Creek watershed appears to be highly variable from site to site and year to year. The 2007 results ranged from poor to fair, placing San Pablo Creek mid-range in average B-IBI score compared to other Contra Costa County stations. For sites in the lower watershed 2007 scores were lower than in previous years; for stations in the mid- to upper watershed 2007 scores were higher than in previous years.

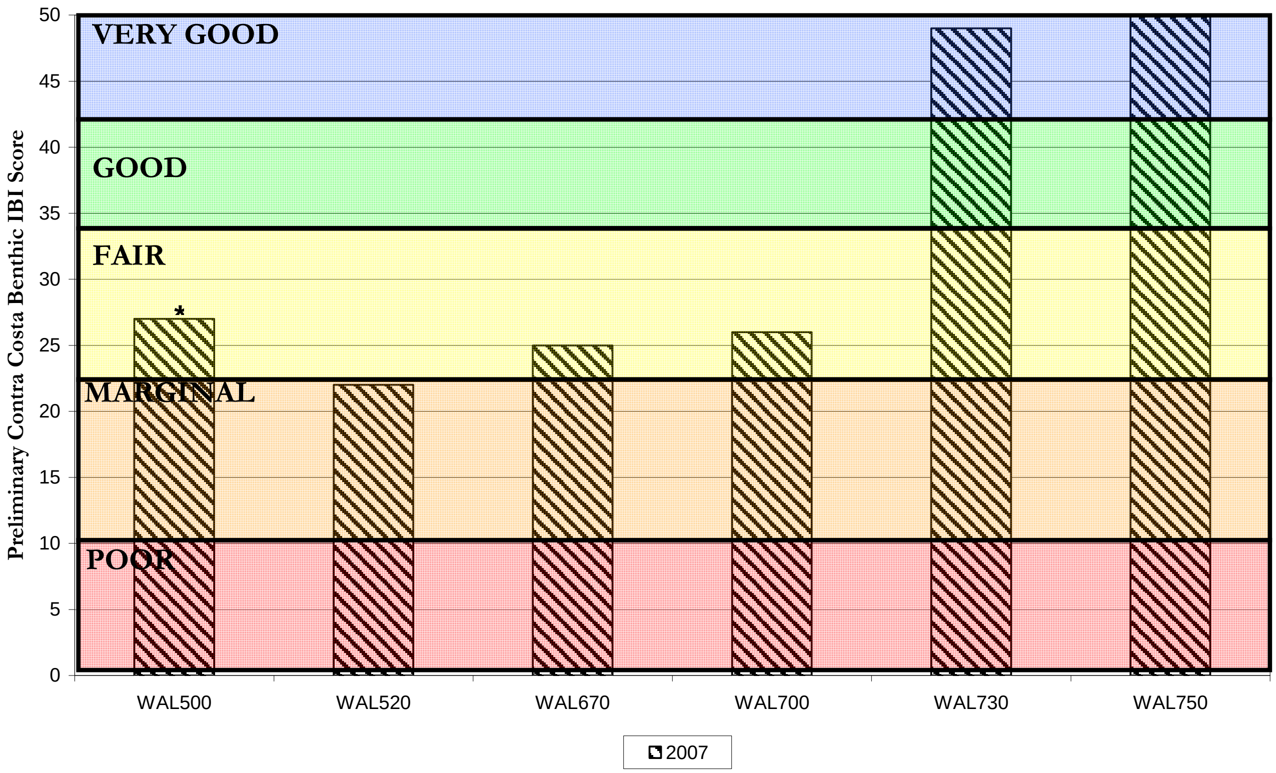


Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)

3.5.12 San Ramon Creek Watershed

The San Ramon Creek watershed was monitored for the first time in 2007. The condition of aquatic life uses in the creek stations located in the San Ramon Creek watershed appears to be marginal to very good, and the San Ramon watershed ranked fourth in average B-IBI score for 2007, compared to other Contra Costa County stations.

San Ramon Creek

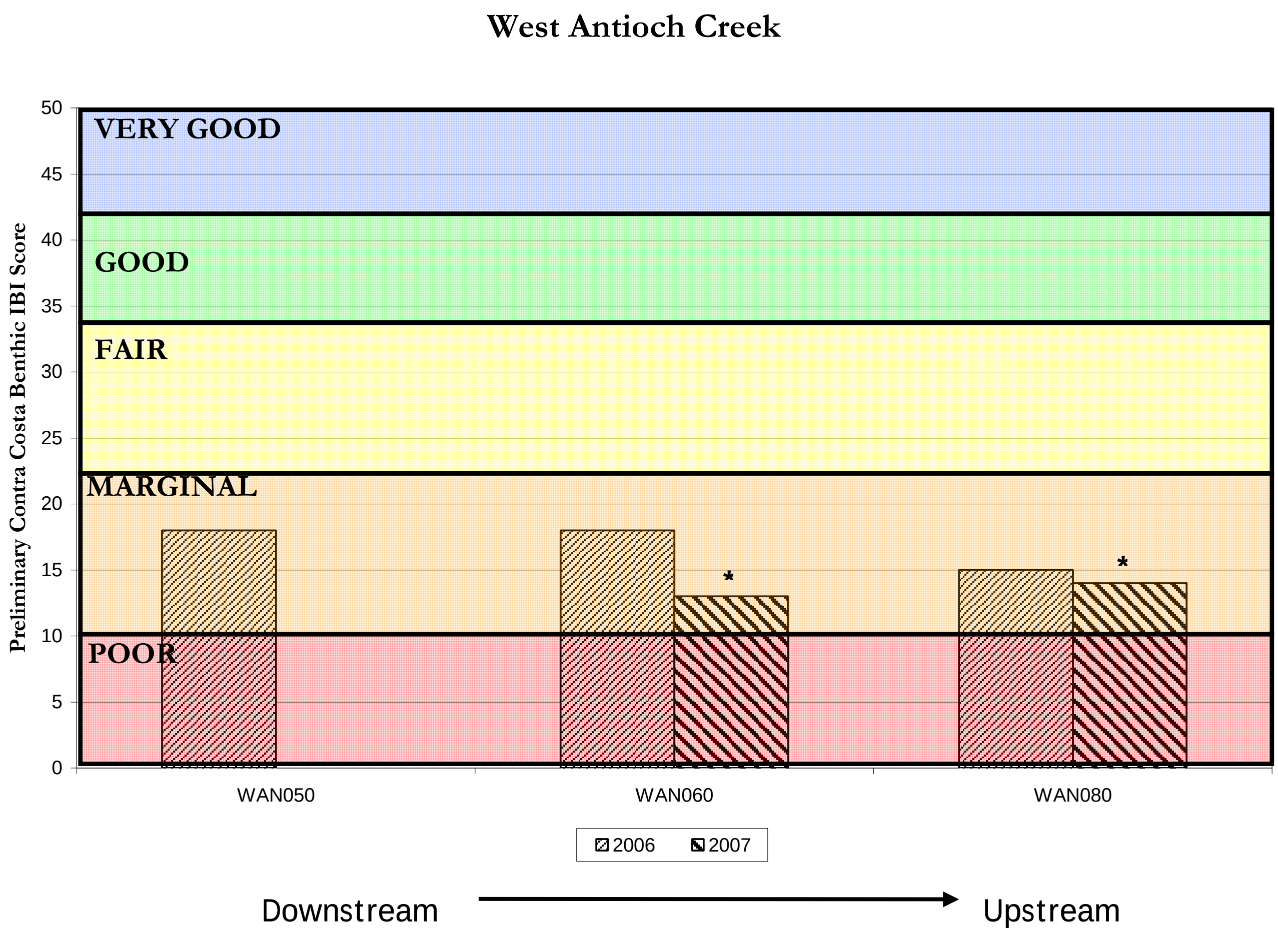


Downstream → Upstream

Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)
Note: the San Ramon Creek sites are located within the Walnut Creek watershed.

3.5.13 West Antioch Creek Watershed

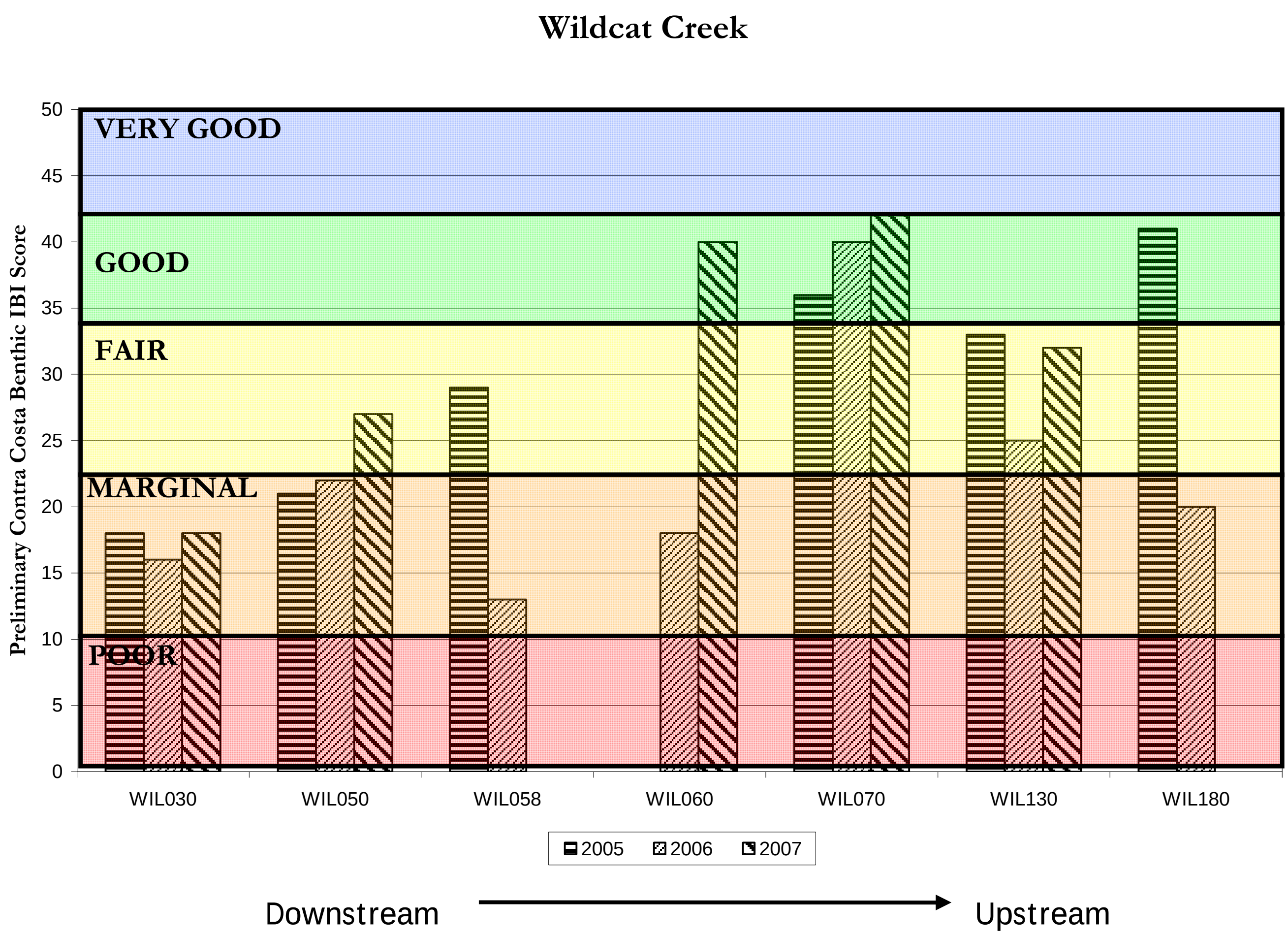
All stations within West Antioch Creek scored in poor to marginal B-IBI scoring categories, based on limited sampling in 2006 and 2007. BMI assemblages were dominated by short-lived tolerant benthic macroinvertebrates that generally indicated stress on a system. The watershed is comprised of predominately urban land uses, and creek channels have been heavily altered due the historical effects of urbanization, which likely affect aquatic life uses. As with Rheem Creek, the 2007 B-IBI scores were consistently lower than the 2006 scores, contrary to most other Contra Costa watersheds. The decrease was more pronounced at site WAN060, downstream of the site impacted by the documented presence of the New Zealand mud snail.



Note: all 2007 samples for which less than 500 organisms were collected and available for analysis are flagged with an asterisk (*)

3.5.14 Wildcat Creek Watershed

Stations in the Wildcat Creek watershed have marginal to good B-IBI scores, rating relatively good at 5th overall compared to other watersheds in the County, based on 2007 data. No clear trend was observable in 2007 vs. previous years.



4.0 CONCLUSIONS AND RECOMMENDATIONS

In 2007 the Contra Costa Volunteer Creek Monitoring Program conducted bioassessments at 61 sampling stations in creeks within 14 of the 30 major watersheds in Contra Costa County, using the new (2007) California Surface Water Ambient Monitoring Program (SWAMP) protocols. To provide a measurement of Aquatic Life Use condition at these stations, a preliminary Benthic Index of Biotic Integrity (B-IBI) was calculated for each station, using an approach developed previously for creeks in Contra Costa County. Ranges of B-IBI scores were then assigned to poor, marginal, fair, good and very good categories.

Results from 2007 indicate that roughly 70% of creek stations sampled in Contra Costa County scored in the very good, good or fair categories. Individual stations in Las Trampas and San Ramon Creeks (Walnut Creek Watershed), Arroyo Del Hambre (Alhambra Watershed), and Upper Marsh Creeks scored the highest of all stations sampled, with B-IBI scores in the "very good" category (equal to or above 43). The lowest IBI scores (10 or lower) were calculated for stations in Rheem Creek and Cerrito Creek.

Watershed-wide average B-IBI scores were calculated from the 2007 data to allow for broad inter-watershed comparisons. Among the 14 monitored watersheds there is a wide range in average scores, from Marsh Creek watershed, ranked first with an average B-IBI score in the "good" category, to Cerrito Creek watershed, ranked last and in the "poor" category. Most watersheds had average scores in the "fair" category, while several were in the "marginal" category.

For most of the watersheds monitored, B-IBI scores tend to be lower in the lower reaches, and improve with distance upstream. Physical habitat quality score (based on a semi-quantitative scoring system) was positively, though weakly, correlated with the 2007 B-IBI scores.

For stations sampled in both 2006 and 2007, B-IBI tended to be higher in 2007. This may be related to the change in sample collection protocols, but if so, the direction of change (improved scores) is counter-intuitive. Therefore other factors related to seasonal conditions may be operative. One such factor is likely to be seasonal rainfall, which was much higher in the months preceding the 2006 BMI sample collection than prior to the 2007 sampling. The higher resulting creek flows may have prevented establishment of diverse BMI communities prior to BMI sample collection in 2006. Additional analysis should be performed to evaluate potential trends based on data from subsequent years.

A site on West Antioch Creek was impacted by the documented presence of the New Zealand mud snail. Identification of this invasive species was independently confirmed by several scientists. Assessment of the presence of this ecologically harmful invasive should be continued, and careful attention should be given to decontamination of sampling equipment to prevent cross-contamination of monitoring sites.

Recommendations

The following recommendations are made for CCMAP monitoring and data analysis:

- Update the Quality Assurance Project Plan (QAPP) to reflect changes in program leadership, organization and sample methods.
- Continue to investigate the differences in results produced by the former TRC sample collection vs. the newly-adopted RWB technique. To determine whether the change in monitoring protocols (from TRC to RWB methods) produces a discernable signal in the BMI data, the comparisons between the pre- and post-2007 data should continue with the data produced during the 2008 and 2009 BMI monitoring.
- Continue analysis of the influence of climatic factors such as seasonal rainfall on annual average B-IBI scores.

4.0 CONCLUSIONS AND RECOMMENDATIONS

- Perform additional analysis regarding the influences of land use and physical habitat factors on benthic status, for example by analysis of population density, percentage watershed impervious surface, or type of channel construction vs. B-IBI score.
- Accommodate assessment of the presence of the New Zealand mud snail within the BMI identification process. Continue to pay careful attention to decontamination of sampling equipment to prevent cross-contamination of monitoring sites.

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SUMMARY OF FIELD MEASUREMENTS AND PHYSICAL HABITAT ASSESSMENT SCORES FOR SITES SAMPLED IN 2007

Site Code	Stream Name	Site Name	Date	Time	Temp. °C	DO	DO % Satur.	pH	Spec. Cond.	Alk.	PHAB Score
ALH020	Alhambra	Susana Park	5/3/2007	16:00	14.2	9.14	90%	6.95	1261	300	113
ALH050	Alhambra	Adult School	5/3/2007	10:00	13.13	7.55	71%	6.83	1101	300	113
ALH080	Franklin Canyon	1530 Franklin Cyn Rd.	6/4/2008	9:30	15.93	9.85	99%	7.80	1229	720	94
ALH140	Arroyo del Hambre	Alhambra Valley Rd. @Wanda	5/15/2007	11:30	14.65	8.53	84%	6.82	1202	320	100
ALH160	Arroyo del Hambre	Above Vaca Creek Rd.	5/11/2007	10:00	12.84	11.13		6.83	1437		127
ALH170	Alhambra	5103 Alhambra Valley Rd.	5/15/2007	9:30	12.88	17.96	169%	6.51	1529	300	103
BAX030	Baxter	Booker T. Anderson Park	12:45	12:45	16.31	8.30		7.97	667	300	135
BAX045	Baxter		5/8/2007	10:30	16.3	4.57		6.55	597	300	91
CER010	Cerrito	Pac East Mall	5/11/2007	13:15	15.24	12.81		8.41	792	180	91
EAN020	East Antioch	Meadowbrook Park	3/18/2007	15:45	20.99	14.66	154%	7.64	2377	300	94
EAN030	East Antioch	Viera Ave	3/13/2008	15:00	21.92	19.40		8.13	2149	180	82
EAN052	East Antioch	Hwy 4 Bypass	4/19/2007	13:50							71
EAN065	East Antioch		4/21/2007	10:40	16.2	1.26	12%	7.35	6835		74
EAN066	East Antioch		4/21/2007	16:00	18.11	1.28	14%	7.57	5818		88
KIR040	Kirker	Pittsburg/Antioch Hwy	4/29/2007	14:00	21.41	6.11	68%	7.94	690		80
KIR085	Kirker	Garcia Industrial Park	4/29/2007	9:30	16.26	6.32	65%	7.91	802		87
KIR110	Kirker	Buchanan Park	3/13/2007	11:00	13.93	2.05	20%	7.90	755	300	101
KIR115	Kirker	Kirker Cr. Apts.	5/11/2007	15:00	19.51	9.55	105%	7.46	2472	180	90
MSH010	Marsh		5/10/2007	10:00	21.01	10.83	122%	8.27	1590	180	124
MSH090	Marsh	Round Valley Park	5/10/2007	15:00	18.16	3.20	34%	7.19	1572	720	117
MSH130	Marsh	County Detention Center	4/20/2007	13:57	18.84	12.62		7.85	1097		130
MSH140	Marsh	Tumbleweed Court	4/20/2007	10:40	13.16	9.65	93%	8.09	974		142
MTD020	Mt. Diablo	Golf Course	5/25/2007	14:00	19.94			7.55	1090	720	97
MTD050	Mt. Diablo	Lydia Lane Park	5/25/2007	10:00	15.72			8.18	1242	300	94
MTD060	Mt. Diablo	Library	5/20/2007	12:30	18.35	12.63	135%	7.73	1146	720	116
PNL010	Pinole	Senior Center	5/26/2007		16.1			8.34		180	108
PNL040	Pinole		5/12/2007	11:00	3.27	9.79	94%	7.85	1300	300	133
PNL070	Pinole	Alhambra Valley Rd.	5/17/2007	10:00	13.84	10.16		6.65	1260	300	141
PNL100	Pereira		5/22/2007	9:30	12.82			7.96	726	180	100
PNL110	Pinole	Bear Cr. Rd.	5/22/2007	14:00	18.94			7.78	1814	300	115
RHM005	Rheem		5/26/2007	13:40	17.9	10.60		8.08	881	300	130

Site Code	Stream Name	Site Name	Date	Time	Temp. ˚C	DO	DO % Satur.	pH	Spec. Cond.	Alk.	PHAB Score
RHM010	Rheem	Bayview School	5/26/2007	10:00	14.39	7.65		7.92	785	180	75
RHM020	Rheem	Wanlass Park	5/24/2007	13:00	22.94	11.77		8.37	814	180	82
RHM030	Rheem	Contra Costa College	5/24/2007	10:00	15.49			8.01	1109	180	98
SPA020	San Pablo		4/27/2007	16:00	16.77	10.52		7.19	1506		100
SPA070	San Pablo	El Portal	4/27/2007	10:00	13.08	12.25		7.49	1663		123
SPA110	San Pablo	Santa Rita Rd.	6/1/2007	14:00	15.8	11.61	117%	7.86	1601		109
SPA124	San Pablo	EcoVillage Farm	6/1/2007	10:00	13	9.85	94%	7.76	1382	180	105
SPA130	Castro Creek		4/26/2007	10:00	10.75	9.70		8.07	2417		140
SPA134	San Pablo		4/26/2007	15:00	13.44	10.35		7.26	2807		104
SPA240	San Pablo	92 Camino Encinas	6/2/2007	9:30	12.61			8.36	658	180	119
WAL300	Las Trampas	Boulevard Way	6/3/2007	10:00	14.79			8.17	641	180	137
WAL340	Las Trampas	Kaiser Property	6/3/2007	15:00	18.63			7.86	699	300	103
WAL350	Las Trampas	Rose Lane	5/19/2007	10:00	12.67	18.50	174%	6.98	780	720	108
WAL360	Las Trampas	Fiesta Square/Lafayette	3/19/2007	13:30	15.01	12.20	121%	7.26	608	300	123
WAL380	Las Trampas		4/28/2007	10:30	15.86	9.73	99%	7.42	1371		131
WAL420	Las Trampas	Bollinger Canyon Rd	4/28/2007	15:00	17.87	9.36	99%	7.20	1249		146
WAL500	San Ramon	Creekside	4/24/2007	15:00	14.47	8.92		7.15	1182		97
WAL520	San Ramon		4/24/2007	10:00	14.71	12.21		7.56	1165		123
WAL670	San Ramon	Zephyr Cir.	5/23/2007	14:00	24.3			7.80	773	720	114
WAL700	San Ramon	Playa Ct.	5/23/2007	9:30	15.17			7.30	792	720	131
WAL730	Bollinger	Chen	5/1/2007	11:00	15.44	11.59		7.02	731		142
WAL750	Bollinger	Bollinger Estates	5/1/2007	15:00	15.62	8.80		7.64	640		122
WAN060	West Antioch	Putnam	5/9/2007	15:30	21.88			6.94	1118	180	118
WAN080	West Antioch	James Donlon Rd.	5/2/2007	15:30	17.29	8.60	90%	7.52	3031	300	112
WIL030	Wildcat	3rd St. Bridge	5/31/2007		13.36	4.76	45%	7.27	807	180	59
WIL050	Wildcat	Davis Park	5/19/2007	14:50	25.18	14.32		9.07	456	300	67
WIL060	Wildcat	Vale Rd	5/19/2007	10:00	14.18	9.02		8.17	617	120	88
WIL070	Wildcat	Alvarado Park Richmond	5/12/2007	10:15	11.91	12.32		8.32	603	180	122

Note: All information in this table is derived directly from the field data sheets.

Note: the Las Trampas and San Ramon Creek sites are located within the Walnut Creek watershed.

DATA QUALITY ASSESSMENT - OVERVIEW

During each year of data collection, the Contra Costa Clean Water Program and/or the Volunteer Creek Monitoring Program have conducted quality assurance procedures based on guidance from the California Department of Fish and Game and SWAMP.

To assess the accuracy of field data collection techniques, duplicate samples are collected annually in the field from at least 10% of the sites sampled during that year. Organisms identified in the original sample are compared with those identified in the duplicate sample using species similarity measurements. Past results of these comparisons consistently indicated that duplicate and original samples were at least 80% similar, suggesting that the accuracy of field measurements was high (Cressey and Sommers 2002, 2003, 2004, 2005, 2006).

In addition to field duplicate quality assurance measurements, each year at least 10% of the samples enumerated are analyzed a second time by an independent laboratory for discrepancies in taxonomic identification, and any such discrepancies are reviewed and resolved.

Procedures and results of these efforts are briefly summarized below for the 2007 data collection effort.

2007 QC SUMMARY – Completeness/Representativeness

All samples were collected as planned; however, 11 samples contained less than the target minimum 500 (±5%) organism sub-sample size, due to limited numbers of organisms collected. These samples were collected from the following sites:

- SPA070
- SPA124
- SPA130
- BAX030
- ALH050
- ALH080
- KIR040
- WAN060
- WAN080
- WAL360
- WAL500

The low abundance illustrated by these low sample counts could be due to inherently low abundance at the sites, or due to sampling in recently-wetted areas where there was insufficient time for invertebrate colonization.

2007 QC SUMMARY - Field Duplicates

Six field duplicate samples were submitted to the BSI lab and analyzed in 2007. For the various metrics associated with these six samples, relative percent difference (RPD) was calculated between the original and duplicate samples, as a means of assessing precision in the field collection and analytical processes. For the 2007 duplicates (non-zero pairs only), the average RPD was 70% for the standard set of BMI metrics.

2007 QC SUMMARY – Inter-lab Comparisons

For 2007, inter-lab analysis was performed by the Aquatic Bioassessment Laboratory (ABL) at California State University, Chico on five samples submitted by BSI from the Contra Costa County BMI project. This QC analysis was performed in accordance to the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT)'s Standard Taxonomic Effort Document (STE), 28 November 2006 version (Richards and Rogers, 2006).

The ABL reports that, based on their analysis, the overall taxonomy as reported by BSI was accurate and was performed in accordance with the SAFIT Level I standards, with the following few exceptions:

There were three instances of "tagalong" organisms. These are defined as specimens accidentally included in a vial of organisms of another taxon. These are marked as "Probable sorting error" in the Listing of Taxonomic Discrepancies file.

The only major count discrepancies involved Oligochaeta. The two labs have slightly different standard operating procedures in this regard. Fragments are placed in a separate vial for reference and only worms with heads were counted as per the ABL procedures.

The remaining taxonomic discrepancies involve Diptera. The QC determination for each relies on the keys in Courtney et al. (1996). A single Chironomini pupa (Dicrotendipes sp.) was misidentified as Orthocladiinae. The presence of a spine on the caudolateral angle of the eighth abdominal segment and absence of anal macrosetae will separate pupae of Chironomini from Orthocladiinae. As this was the only misidentified chironomid, this was likely actually a sorting error rather than a misidentification. An immature psychodid larva with tergal plates was originally identified as Pericoma/Telmatoscopus sp. According to the key in Courtney et al. (1996), the absence of a preanal plate will force specimens to Psychoda sp. even if there are up to 26 tergal plates. Finally, although the name Caloparyphus/Euparyphus is correct for all the specimens so labeled, there were a few final instar Euparyphus included.

The raw inter-laboratory QC data files are available through the CCMAP.

INDIVIDUAL METRICS AND CALCULATED B-IBI SCORES FOR SITES SAMPLED IN 2007

Waterbody Name	Site	Collection Date	EPT Taxa	Metric Score	Number Diptera Taxa	Metric Score	Number Predator Taxa	Metric Score	% Collectorers	Metric Score	% Non-Insecta Taxa	Metric Score	Total IBI
Alhambra Creek	ALH020	5/3/2007	2	2	6	10	7	7	0.93	3	0.55	3	25
Alhambra Creek	ALH050	5/3/2007	1	1	12	10	9	9	0.96	2	0.35	6	28
Franklin Creek	ALH080	6/4/2007	2	2	6	10	6	6	0.81	8	0.36	6	32
Arroyo del Hambre	ALH140	5/15/2007	3	3	10	10	10	10	0.91	4	0.3	7	34
Arroyo del Hambre	ALH160	5/11/2007	7	7	11	10	12	10	0.47	10	0.21	9	46
Alhambra Creek	ALH170	5/15/2007	4	4	9	10	12	10	0.81	8	0.33	7	39
Baxter Creek	BAX030	5/10/2007	1	1	6	10	4	4	0.61	10	0.53	3	28
Baxter Creek	BAX045	5/2/2007	0	0	3	4	2	2	0.32	10	0.6	2	18
Cerrito Creek	CER010	5/11/2007	0	0	4	6	3	3	0.98	1	0.67	0	10
E Antioch Creek	EAN020	5/18/2007	2	2	7	10	3	3	0.76	10	0.23	8	33
E Antioch Creek	EAN030	5/13/2007	2	2	8	10	2	2	0.88	5	0.27	8	27
E Antioch Creek	EAN052	4/19/2007	0	0	8	10	2	2	0.96	2	0.27	8	22
E Antioch Creek	EAN065	4/21/2007	0	0	8	10	1	1	0.98	1	0.36	6	18
E Antioch Creek	EAN066	4/21/2007	0	0	4	6	0	0	0.99	1	0.43	5	12
Kirker Creek	KIR040	4/29/2007	0	0	5	8	0	0	0.83	7	0.5	4	19
Kirker Creek	KIR085	4/29/2007	0	0	5	8	1	1	0.97	1	0.38	6	16
Kirker Creek	KIR110	5/13/2007	0	0	4	6	1	1	0.87	6	0.43	5	18
Kirker Creek	KIR115	5/11/2007	1	1	11	10	5	5	0.86	6	0.21	9	31
Lower Marsh Creek	MSH010	5/10/2007	4	4	4	6	3	3	0.69	10	0.44	5	28
Upper Marsh Creek	MSH090	5/10/2007	3	3	5	8	10	10	0.68	10	0.43	5	36
Upper Marsh Creek	MSH130	4/20/2007	3	3	11	10	11	10	0.51	10	0.17	10	43
Upper Marsh Creek	MSH140	4/20/2007	16	10	10	10	10	10	0.43	10	0.23	8	48
Mt. Diablo Creek	MTD020	5/25/2007	1	1	8	10	4	4	0.96	2	0.29	7	24

Waterbody Name	Site	Collection Date	EPT Taxa	Metric Score	Number Diptera Taxa	Metric Score	Number Predator Taxa	Metric Score	% Collectorers	Metric Score	% Non-Insecta Taxa	Metric Score	Total IBI
Mt. Diablo Creek	MTD050	5/25/2007	2	2	7	10	5	5	0.74	10	0.5	4	31
Mt. Diablo Creek	MTD060	5/20/2007	3	3	9	10	6	6	0.65	10	0.43	5	34
Pinole Creek	PNL010	5/26/2007	3	3	7	10	7	7	0.46	10	0.4	5	35
Pinole Creek	PNL040	5/12/2007	1	1	6	10	7	7	0.91	4	0.41	5	27
Pinole Creek	PNL070	5/17/2007	5	5	12	10	9	9	0.9	4	0.2	9	37
Periera Creek	PNL100	5/22/2007	1	1	7	10	10	10	0.89	5	0.35	6	32
Pinole Creek	PNL110	5/22/2007	2	2	7	10	5	5	0.69	10	0.25	8	35
Rheem Creek	RHM005	5/26/2007	1	1	5	8	1	1	0.94	3	0.56	2	15
Rheem Creek	RHM010	5/26/2007	0	0	3	4	3	3	0.97	1	0.7	0	8
Rheem Creek	RHM020	5/24/2007	2	2	4	6	2	2	0.95	2	0.57	2	14
Rheem Creek	RHM030	5/24/2007	1	1	5	8	3	3	0.92	3	0.57	2	17
San Pablo Creek	SPA020	4/27/2007	1	1	4	6	0	0	0.99	1	0.55	3	11
San Pablo Creek	SPA070	4/27/2007	1	1	5	8	2	2	0.97	1	0.64	1	13
Wilkie Creek	SPA110	5/1/2007	2	2	8	10	6	6	0.77	10	0.29	7	35
San Pablo Creek	SPA124	5/1/2007	0	0	6	10	4	4	0.7	10	0.54	3	27
Castro Creek	SPA130	4/26/2007	2	2	8	10	5	5	0.44	10	0.24	8	35
San Pablo Creek	SPA134	4/26/2007	1	1	10	10	9	9	0.94	3	0.22	9	32
San Pablo Creek	SPA240	6/2/2007	3	3	9	10	7	7	0.86	6	0.46	4	30
Las Trampas Creek	WAL300	6/3/2007	3	3	5	8	2	2	0.88	5	0.27	8	26
Reliez Creek	WAL330	6/5/2007	3	3	9	10	8	8	0.77	10	0.29	7	38
Las Trampas Creek	WAL340	6/3/2007	4	4	5	8	3	3	0.88	5	0.36	6	26
Happy Valley Creek	WAL350	5/19/2007	3	3	8	10	5	5	0.9	4	0.37	6	28
Lafayette Creek	WAL360	5/19/2007	3	3	7	10	3	3	0.9	4	0.21	9	29
Las Trampas Creek	WAL380	4/28/2007	3	3	8	10	5	5	0.93	3	0.42	5	26
Las Trampas Creek	WAL420	4/28/2007	12	10	11	10	8	8	0.36	10	0.16	10	48
San Ramon Creek	WAL500	5/1/2007	4	4	7	10	4	4	0.94	3	0.39	6	27

Waterbody Name	Site	Collection Date	EPT Taxa	Metric Score	Number Diptera Taxa	Metric Score	Number Predator Taxa	Metric Score	% Collectorers	Metric Score	% Non-Insecta Taxa	Metric Score	Total IBI
San Ramon Creek	WAL520	5/1/2007	3	3	6	10	3	3	0.97	1	0.44	5	22
San Ramon Creek	WAL670	5/23/2007	2	2	8	10	5	5	0.92	3	0.41	5	25
San Ramon Creek	WAL700	5/23/2007	4	4	6	10	3	3	0.94	3	0.35	6	26
San Ramon Creek	WAL730	4/24/2007	10	10	10	10	10	10	0.52	10	0.19	9	49
San Ramon Creek	WAL750	4/24/2007	16	10	10	10	12	10	0.56	10	0.14	10	50
W Antioch Creek	WAN060	5/9/2007	0	0	1	0	3	3	0.65	10	0.88	0	13
W Antioch Creek	WAN080	5/2/2007	0	0	3	4	0	0	0.14	10	0.67	0	14
Wildcat Creek	WIL030	5/31/2007	1	1	4	6	3	3	0.81	8	0.67	0	18
Wildcat Creek	WIL050	5/19/2007	1	1	4	6	6	6	0.61	10	0.5	4	27
Wildcat Creek	WIL060	5/19/2007	4	4	10	10	9	9	0.64	10	0.3	7	40
Wildcat Creek	WIL070	5/12/2007	7	7	8	10	7	7	0.17	10	0.26	8	42
Wildcat Creek	WIL130	5/27/2007	6	6	8	10	4	4	0.88	5	0.29	7	32

Taxonomic list of benthic macroinvertebrates identified in samples from Contra Costa County stream sites, spring 2007.

Phylum	Class	Order	Family	Final ID	CTV[1]	FFG[2]
Arthropoda						
	Insecta					
		Coleoptera				
			Dryopidae			
				Helichus	5	sh
				Postelichus	5	sh
			Dytiscidae			
				Agabus	8	p
				Dytiscidae	5	p
				Hygrotus	5	p
				Sanfillipodytes	5	p
				Stictotarsus	5	p
			Elmidae			
				Optioservus	4	sc
				Zaitzevia	4	sc
			Gyrinidae			
				Gyrinis	5	p
			Haliplidae			
				Peltodytes	5	mh
			Helophoridae			
				Helophorus	?	sh
			Hydrophilidae			
				Berosus	5	p
				Cymbiodyta	5	cg
				Enochrus	5	cg
				Hydrophilidae	5	p
				Tropisternus	5	p
		Diptera				
				Cyclorrhaphous/Brachycera	6	?
			Ceratopogonidae			
				Atrichopogon	6	cg
				Bezzia/ Palpomyia	6	p
				Ceratopogonidae	6	p
				Dasyhelea	6	cg
				Probezzia	6	p
			Chironomidae			
				Chironomini	6	cg
				Orthocladiinae	5	cg
				Pseudochironomini	5	cg
				Tanypodinae	7	p
				Tanytarsini	6	cg
			Dixidae			
				Dixella	2	cg
				Meringodixa chalonensis	2	cg

APPENDIX D - Benthic Macroinvertebrate Taxa Identified in Contra Costa County, 2007, cont'd

Phylum	Class	Order	Family	Final ID	CTV[1]	FFG[2]
			Dolichopodidae			
				Dolichopodidae	4	p
			Empididae			
				Empididae	6	p
				Hemerodromia	6	p
				Neoplasta	6	p
				Trichoclinocera	6	p
				Trichoclinocera/Clinocera	6	p
			Ephydridae			
				Ephydridae	6	?
			Muscidae			
				Muscidae	6	p
			Pelecorhynchidae			
				Glutops	3	p
			Psychodidae			
				Maruina lanceolata	2	sc
				Pericoma/ Telmatoscopus	4	cg
				Psychoda	10	cg
			Sciomyzidae			
				Sciomyzidae	6	p
			Simuliidae			
				Simulium	6	cf
			Stratiomyidae			
				Caloparyphus/Euparyphus	8	cg
				Euparyphus	8	cg
				Hedriodiscus/Odontomyia	8	cg
				Stratiomyidae	8	cg
			Tabanidae			
				Tabanidae	8	p
			Tipulidae			
				Cryptolabis	3	sh
				Dicranota	3	p
				Erioptera	3	cg
				Hexatoma	2	p
				Limonia	6	sh
				Rhabdomastix	3	p
				Tipula	4	om
				Tipulidae	3	?
		Ephemeroptera				
			Ameletidae			
				Ameletus	0	cg
			Baetidae			
				Baetis	5	cg
				Callibaetis	9	cg
				Centroptilum	2	cg
				Diphetor hageni	5	cg
				Fallceon quilleri	4	cg
			Caenidae			

Phylum	Class	Order	Family	Final ID	CTV[1]	FFG[2]
				Caenis	7	cg
			Ephemerellidae			
				Drunella flavilinea	0	cg
				Ephemerella	1	cg
			Heptageniidae			
				Ecdyonurus/Leucrocuta	4	sc
				Heptageniidae	4	sc
			Leptohyphidae			
				Tricorythodes	4	cg
			Leptophlebiidae			
				Paraleptophlebia	4	cg
		Lepidoptera				
				Lepidoptera	5	sh
		Megaloptera				
			Sialidae			
				Sialis	4	p
		Odonata				
			Aeshnidae			
				Anax	8	p
			Coenagrionidae			
				Argia	7	p
				Coenagrionidae	7	p
			Cordulegastridae			
				Cordulegaster dorsalis	3	p
			Libellulidae			
				Paltothemis lineatipes	9	p
		Plecoptera				
			Capniidae			
				Capniidae	1	sh
			Chloroperlidae			
				Sweltsa	1	p
			Nemouridae			
				Malenka	2	sh
				Nemouridae	2	sh
			Perlodidae			
				Isoperla	2	p
				Kogotus nomus	2	p
		Trichoptera				
			Brachycentridae			
				Micrasema	1	mh
			Glossosomatidae			
				Agapetus	0	sc
			Hydropsychidae			
				Cheumatopsyche	5	cf
				Hydropsyche	4	cf
			Hydroptilidae			
				Hydroptila	6	ph
				Oxyethira	3	ph

APPENDIX D - Benthic Macroinvertebrate Taxa Identified in Contra Costa County, 2007, cont'd

Phylum	Class	Order	Family	Final ID	CTV[1]	FFG[2]
			Lepidostomatidae			
				Lepidostoma	1	sh
			Leptoceridae			
				Mystacides	4	om
			Psychomyiidae			
				Tinodes	2	sc
			Rhyacophilidae			
				Rhyacophila	0	p
			Sericostomatidae			
				Gumaga	3	sh
			Uenoidae			
				Neophylax	3	sc
	Arachnoidea					
		Acari				
			Hygrobatidae			
				Atractides	8	p
				Corticacarus	8	p
				Hygrobates	8	p
			Lebertiidae			
				Lebertia	8	p
			Mideopsidae			
				Mideopsis	5	p
			Sperchontidae			
				Sperchon	8	p
			Unioncolidae			
				Neumania	5	p
				Unionicola	5	p
	Malacostraca					
		Amphipoda				
				Amphipoda	4	cg
			Anisogammaridae			
				Ramellogammarus	6	cg
			Corophiidae			
				Americorophium spinicorne	4	cf
			Crangonyctidae			
				Crangonyx	4	cg
				Stygobromus	4	cg
			Hyalellidae			
				Hyalella	8	cg
		Tanaidacea				
			Tanaidae			
				Sinelobus stanfordi		
	Ostracoda					
				Ostracoda	8	cg
Annelida						
	Hirudinea					
		Arhynchobdellida				

APPENDIX D - Benthic Macroinvertebrate Taxa Identified in Contra Costa County, 2007, cont'd

Phylum	Class	Order	Family	Final ID	CTV[1]	FFG[2]
			Erpobdellidae			
				Erpobdellidae	8	p
		Rhyncobdellida				
			Glossiphoniidae			
				Glossiphoniidae	8	pa
				Helobdella	6	pa
				Placobdella	6	pa
	Oligochaeta					
				Oligochaeta	5	cg
				Megadrili		cg
	Polychaeta					
				Polychaeta		cf
Cnidaria						
	Hydrozoa					
		Hydroida				
			Hydridae			
				Hydra	5	p
Mollusca						
	Bivalvia					
		Veneroida				
			Sphaeriidae			
				Pisidium	8	cf
				Sphaeriidae	8	cf
			Corbiculidae			
				Corbicula	10	cf
	Gastropoda					
		Basommatophora				
			Ancylidae			
				Ferrissia	6	sc
			Lymnaeidae			
				Lymnaeidae	6	sc
			Physidae			
				Physa	8	sc
			Planorbidae			
				Gyraulus	8	sc
				Menetus	7	sc
				Planorbella	6	sc
				Planorbidae	6	sc
		Hypsogastropoda				
			Hydrobiidae			
				Potamopyrgus antipodarum	8	sc
				Hydrobiidae	8	sc
Nemertea						
	Enopa					
			Tertastemmatidae			
				Prostoma	8	p
Platyhelminthes						

APPENDIX D - Benthic Macroinvertebrate Taxa Identified in Contra Costa County, 2007, cont'd

Phylum	Class	Order	Family	Final ID	CTV[1]	FFG[2]
	Turbellaria					
				Turbellaria	4	p

1) CTV based on a scale of 0 (highly intolerant) to 10 (highly tolerant)

2) Abbreviations used in denoting functional feeding group (FFG) are as follows:
- cf = collector filterer
- cg = collector-gatherer
- mh = macrophyte herbivore
- om = omnivore
- p = predator
- pa = parasite
- ph = piercer herbivore
- sc = scraper
- sh = shredder

APPENDIX E – SAMPLE PHYSICAL HABITAT (PHAB) FIELD DATA SHEET AND SWAMP STREAM CHARACTERIZATION FORM

CALIFORNIA DEPARTMENT OF FISH AND GAME
AQUATIC BIOASSESSMENT LABORATORY

WATER POLLUTION CONTROL LABORATORY
REVISION DATE-- MAY 1999

PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)

WATERSHED/ STREAM: ______________________ DATE/ TIME: ______________________

COMPANY/ AGENCY: ______________________ SAMPLE ID NUMBER: ______________________

SITE DESCRIPTION: ______________________

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

Parameters to be evaluated within the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes *(deep<0.5 m, slow<0.3 m/s)*	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

CALIFORNIA DEPARTMENT OF FISH AND GAME
AQUATIC BIOASSESSMENT LABORATORY

WATER POLLUTION CONTROL LABORATORY
REVISION DATE-- MAY 1999

Parameters to be evaluated in an area longer than the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities haveimpacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0

REACH DOCUMENTATION

Standard Reach Length (wetted width ≤ 10 m) = 150 m Distance between transects = 15 m
Alternate Reach Length (wetted width >10 m) = 250 m Distance between transects = 25 m

Project Name:	Date:	Time:
Stream Name:	Site Name/ Description:	
Site Code:	Crew Members:	
Latitude: °N	datum: NAD27 NAD83	
Longitude: °W		

AMBIENT WATER QUALITY MEASUREMENTS

Temperature (°C)		Dissolved O_2 (mg/L)		pH	
Specific Cond. (µs)		Dissolved O_2 Saturated		Alkalinity (mg/L)	

REACH LENGTH

150 m		Other	
Actual Length (m)			
Explanation:			

DISCHARGE MEASUREMENTS (first measurement = left bank)

Check if measurement not possible. ☐

VELOCITY AREA METHOD (preferred) | Transect Width:

	Distance from Bank (cm)	Depth (cm)	Velocity (m/sec)		Distance from Bank (cm)	Depth (cm)	Velocity (m/sec)
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

NOTABLE FIELD CONDITIONS (check one box per topic)

Evidence of recent rainfall (enough to increase surface runoff)	NO		minimal		>10% flow increase	
Evidence of fires in reach or immediately upstream (<500 m)	NO		< 1 year		< 5 years	
Dominant landuse/ landcover in area surrounding reach	Agriculture		Forest		Rangeland	
	Urban/ Indus		Suburb/ Town		Other	

Site Code:	Site Name:	Date:	
Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: A

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall		Center Upstream					
Rapid							
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool		Center Right					
Dry							
PHOTOGRAPHS:		A (up):			A (down):		

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: B

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall		Center Upstream					
Rapid							
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool		Center Right					
Dry							

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: C

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall		Center Upstream					
Rapid							
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool		Center Right					
Dry							

Site Code:	Site Name:	Date:

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: D

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: E

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: F

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

PHOTOGRAPHS:	F (up):	F (down):

Site Code:	Site Name:	Date:

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: G

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: H

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	Transect: I

FLOW HABITATS (% between transects, T=100%)		DENSIOMETER READINGS (0-17) *count covered dots*		BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	%	Center Left		Left Bank	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		Right Bank	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

APPENDIX E – SAMPLE PHYSICAL HABITAT (PHAB) FIELD DATA SHEET AND SWAMP STREAM CHARACTERIZATION FORM, cont'd

Site Code:	Site Name:	Date:

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	**Transect: J**

FLOW HABITATS (% between transects, T=100%)		**DENSIOMETER READINGS (0-17)** *count covered dots*		**BANK STABILITY** 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	**%**	Center Left		**Left Bank**	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		**Right Bank**	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	**Transect: K**

FLOW HABITATS (% between transects, T=100%)		**DENSIOMETER READINGS (0-17)** *count covered dots*		**BANK STABILITY** 5m up and 5m downstream of transect and from bankfull to wetted width			
Channel Type	**%**	Center Left		**Left Bank**	eroded	vulnerable	stable
Cascade/ Fall							
Rapid		Center Upstream					
Riffle							
Run		Center Down-stream		**Right Bank**	eroded	vulnerable	stable
Glide							
Pool							
Dry		Center Right					

PHOTOGRAPHS:	**K (up):**	**K (down):**

REACH SLOPE (BASIC PHAB, Reach Based use as many segments as needed)	**METHOD**	C L		H L		T R		H L	

SEGMENT 1		**SEGMENT 2**		**SEGMENT 3**		**SEGMENT 4**		**SEGMENT 5**		**SEGMENT 6**	
Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)	
	% cm		% cm		% cm		% cm		% cm		% cm
Segment Length		Segment Length		Segment Length		Segment Length		Segment Length		Segment Length	
Bearing		Bearing		Bearing		Bearing		Bearing		Bearing	
Propor-tion (%)		Propor-tion (%)		Propor-tion (%)		Propor-tion (%)		Proportion (%)		Proportion (%)	

APPENDIX F – COMPLETED PHYSICAL HABITAT (PHAB) FIELD DATA SHEETS AND SWAMP STREAM CHARACTERIZATION FORMS

Completed Physical Habitat field data sheets and SWAMP Stream Habitat Characterization Forms from all sites collected in 2007 (on CD-ROM).

APPENDIX G – 2007 MONITORING SITE PHOTOGRAPHS

Photos from all sites monitored in 2007 (on CD-ROM)

Appendix H - Comparison of B-IBI Scores for Sites Monitored in 2006 and 2007

Waterbody Name	Site Code	Total IBI 2006	Total IBI 2007
Alhambra Creek	ALH020	12	25
Alhambra Creek	ALH050	13	28
Franklin Creek	ALH080	23	32
Arroyo del Hambre	ALH140	24	34
Arroyo del Hambre	ALH160	31	46
Alhambra Creek	ALH170	26	39
Baxter Creek	BAX030	10	28
Baxter Creek	BAX045	22	18
Cerrito Creek	CER010	7	10
E Antioch Creek	EAN020	15	33
E Antioch Creek	EAN030	10	27
E Antioch Creek	EAN065	1	18
E Antioch Creek	EAN066	2	12
Kirker Creek	KIR040	7	19
Kirker Creek	KIR085	10	16
Kirker Creek	KIR110	12	18
Kirker Creek	KIR115	16	31
Lower Marsh Creek	MSH010	11	28
Upper Marsh Creek	MSH090	32	36
Upper Marsh Creek	MSH130	35	43
Upper Marsh Creek	MSH140	37	48
Mt. Diablo Creek	MTD020	18	24
Mt. Diablo Creek	MTD050	14	31
Mt. Diablo Creek	MTD060	8	34
Pinole Creek	PNL010	19	35
Pinole Creek	PNL040	28	27
Pinole Creek	PNL070	20	37
Periera Creek	PNL100	27	32
Pinole Creek	PNL110	21	35
Rheem Creek	RHM005	21	15
Rheem Creek	RHM010	16	8
Rheem Creek	RHM020	28	14

APPENDIX H - COMPARISON OF IBI SCORES FOR SITES MONITORED IN 2006 AND 2007, cont'd

Waterbody Name	Site Code	Total IBI 2006	Total IBI 2007
Rheem Creek	RHM030	40	17
San Pablo Creek	SPA020	27	11
San Pablo Creek	SPA070	39	13
Wilkie Creek	SPA110	13	35
San Pablo Creek	SPA124	18	27
Castro Creek	SPA130	15	35
San Pablo Creek	SPA134	29	32
San Pablo Creek	SPA240	10	30
W Antioch Creek	WAN060	18	13
W Antioch Creek	WAN080	15	14
Wildcat Creek	WIL030	16	18
Wildcat Creek	WIL050	22	27
Wildcat Creek	WIL060	18	40
Wildcat Creek	WIL070	40	42
Wildcat Creek	WIL130	25	32

Higher scores are shaded