Quality Assurance Project Plan

State of California
California Monitoring and Assessment Program:

"CMAP"

prepared under contract by:

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for the:

California State Water Resources Control Board
Division of Water Quality
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SECTION A1. TITLE AND APPROVAL SHEET

Program Title	California Monitoring and Assessment Program ("CMAP")
Project Management	California State Water Resources Control Board (SWRCB) Division of Water Quality, TMDL Section, Assessment and TMDL Support Unit 1001 "I" St, 15th Floor Sacramento, CA 95814
Primary Contractor	California Department of Fish and Game Office of Spill Prevention and Response Aquatic Bioassessment Laboratory Rancho Cordova, Ca 95670
Secondary Contractor(s)	San Jose State University Foundation Moss Landing Marine Laboratory Studies 7544 Sandholdt Rd. Moss Landing, CA 95039
Secondary Contractor(s)	Chico State University Research Foundation CSU-Chico Building 25 Chico, CA 95929-0870
Primary Contact	Val Connor, SWAMP Program Manager, (916) 341-5573
Effective Date	This Quality Assurance Project Plan (QAPP) is effective from July 1, 2004 through March 31, 2006, unless otherwise revised, approved, and distributed accordingly to an earlier date.

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Approvals:

Val Connor, SWRCB, SWAMP Program Manager Assessment and TMDL Support Unit, TMDL Section, Division of Water Quality

_____Date _____

Margie Lopez Read, SWRCB, CMAP Contract Manager, Division of Water Quality

_____Date_____

William Ray, SWRCB, Quality Assurance Officer for all SWRCB Programs, Division of Water Quality

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James Harrington, CDFG, Aquatic Bioassessment Laboratory Program Manager and CMAP Project Director

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Shawn McBride, CDFG, CMAP Project Manager

_____Date_____

Michael Dawson, CDFG, CMAP Quality Assurance Manager

_____Date_____

Approvals continued.

San Jose State University Foundation, Quality Assurance Manager

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Chico State University Research Foundation, Quality Assurance Manager

_____Date_____

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SECTION A3. DISTRIBUTION LIST

Table 1. Contact Information for the Primary* CMAP Personnel for Each Participating Organization

Name	Agency, Company, or Organization
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ORGANIZATIONS WITHIN MASTER CONTRACT TO CA DEPT FISH & GAME	
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Max Puckett*	**California Department of Fish and Game** Marine Pollution Studies Laboratory/Granite Canyon c/o 4580 Blufftop Lane; Hydesville, CA 95547 Phone: (707)-768-1999; Email: granite@redshift.com
Dave Crane*, Abdu Mekebri, Kathleen Regelado, Bob Todd, Martice Vasquez	**California Department of Fish and Game** Fish & Wildlife Water Pollution Control Lab. 2005 Nimbus Road; Rancho Cordova, CA 95670 Phone: (916)-358-2859; Email: dcrane@ospr.dfg.ca.gov

Table 1. Contact Information for the Primary* CMAP Personnel for Each Participating Organization

Name	Agency, Company, or Organization
ORGANIZATIONS WITHIN MASTER CONTRACT TO CA DEPT FISH & GAME Continued	
Jim Harrington*, Peter Ode, Shawn McBride, Michael Dawson Andy Rehn, Jennifer York	**Calif. Dept. Fish and Game;** Aquatic Bioassessment Lab 2005 Nimbus Road; Sacramento, CA 95670 Phone: (916)-358-2862; Email: harringj@ospr.dfg.ca.gov
Russell Fairey*, Cassandra Roberts, Marco Sigala,	**San Jose State University Foundation** Moss Landing Marine Lab./Marine Pollution Studies Lab 7711 Sandholdt Road, Moss Landing, CA 95039 Phone: (831)-771-4161; Email: fairey@mlml.calstate.edu
Ron Tjeerdema, John Hunt*, Brian Anderson, Bryn Phillips Patricia Nicely	**Univ. of California, Davis Granite Canyon Marine Lab.** Environmental Toxicology Department 34500 Coast Highway One, Monterey, CA 95540 Phone: (831)-624-0947; Email: jwhunt@ucdavis.edu
Jennifer Rotnam, Norma Myers Daniel Pickard	**California State University Chico ResearchFoundation** Bidwell Environmental Institute; Chico, CA 95929-0555 Phone: (530) 898-5205; Email: jrotnem@csuchico.edu
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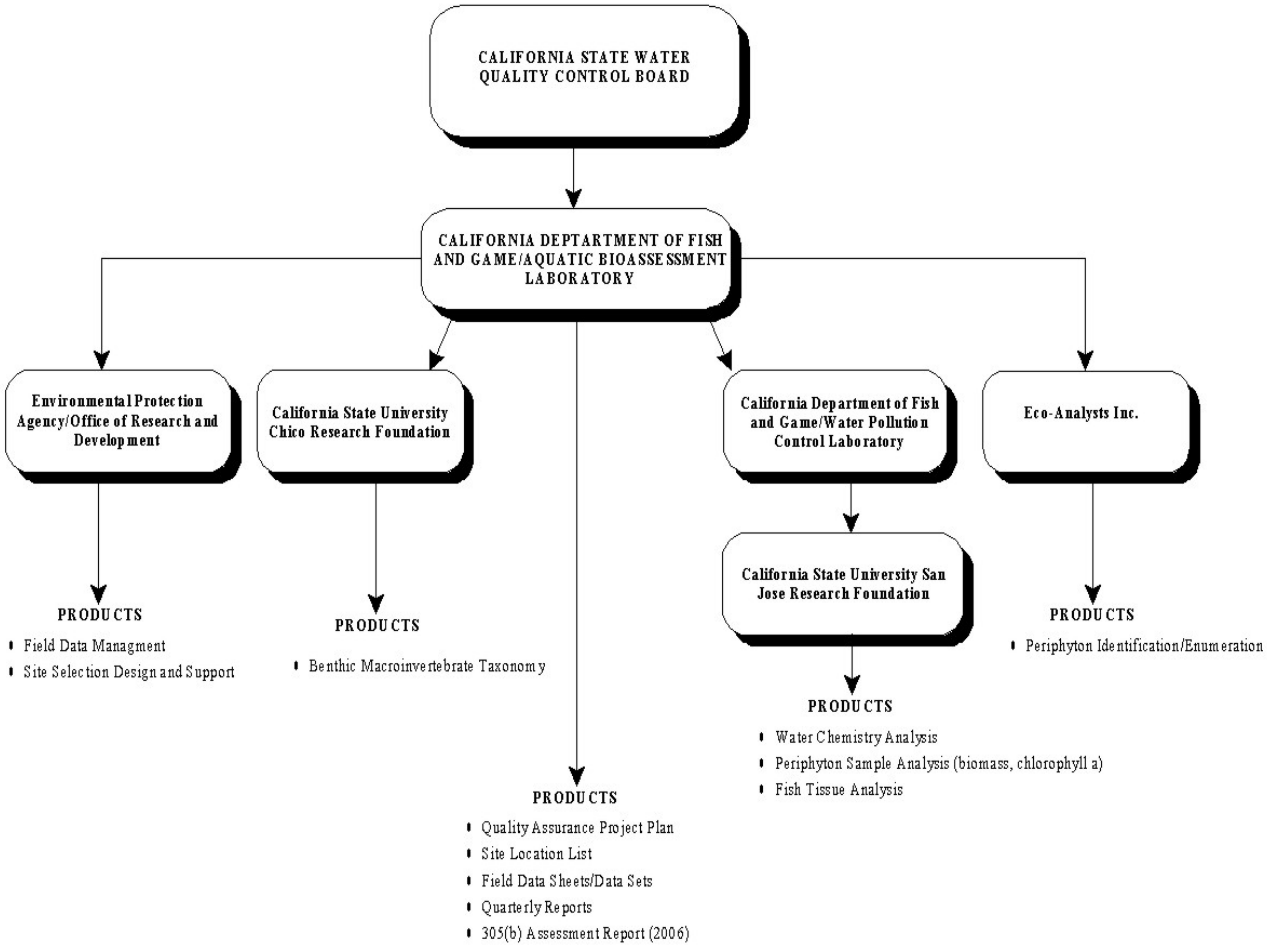
SECTION A4. CMAP PROJECT ORGANIZATION



SECTION A5. PROBLEM DEFINITION AND BACKGROUND

Introduction to the California Monitoring and Assessment Program (CMAP).

California's streams and lakes provide essential habitat for freshwater plants and animals and provide important recreation opportunities. Identifying unique aquatic habitats, recognizing endemic species of plants and animals and assessing whether streams and lakes are healthy or impaired is an important part of water resource management. Bioassessment can be used to measure water and habitat quality based on the kinds of organisms living there, and has recently been implemented in California with the goal of incorporating biological criteria into water quality standards. However, California has no currently accepted set of quantitative biological criteria that allows for prioritization of restoration and conservation efforts. Such criteria can be used to protect biological resources, report on the condition of water bodies, identify impaired water bodies and set restoration goals for impaired sites. In fact, the Clean Water Act mandates that "States shall adopt [water quality] criteria based on biological monitoring or assessment methods" [Section 303(c)(2)(B)], and that "States shall develop and publish criteria for water quality accurately reflecting the latest scientific knowledge... on the effects of pollutants on biological community diversity, productivity and stability" [Section 304 (a)(1)].

In 1989, the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD), with the cooperation of other state and federal agencies implemented the Environmental Monitoring and Assessment Program (EMAP) to identify the extent, magnitude, and status, with regards to human-influence induced degradation, of ecological resources within the United States. The overall goal of EMAP is to develop a set of assessment tools, contribute to decisions on environmental protection and management and to aid in the monitoring and assessment of our nation's ecological resources.
In 1999 the EPA initiated a western pilot to develop assessment tools for 12 western states including California (Fig 1). With the cooperation of the California Department of Fish and Game (CDFG) Aquatic Bioassessment Laboratory (ABL), the assessment tools for California were evaluated and modified for 5 years through 2004. In 2004, the resulting EMAP protocol was adopted by the State Water Resources Control Board (SWRCB) as part of the Surface Water Ambient Monitoring Program (SWAMP), was put into practice as an official monitoring methodology for California, and was re-named the California Monitoring and Assessment Program (CMAP).
One of the goals of the Surface Water Ambient Monitoring Program (SWAMP) is to develop statewide and region wide information on the status and trends of the water quality condition of California's surface water resources. These concepts are essential to be able to make valid decisions relating to management of water resources.

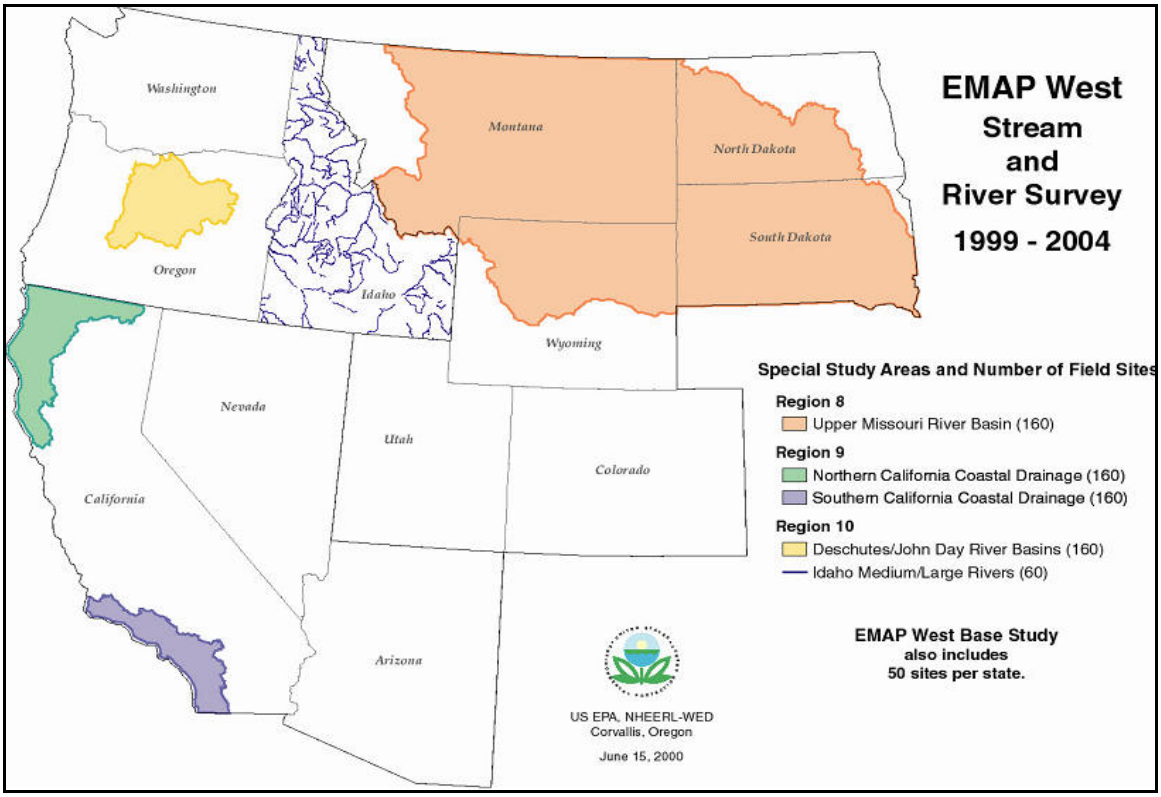


Figure 1. Map showing geographic extent of EMAP Western Pilot 1999-2004.

SECTION A6. PROGRAM DESCRIPTION AND GOALS

The SWRCB Clean Water Act (CWA) 319(h) Workplan for 2003-2004 describes the need for SWAMP to provide services in order to assist the California Nonpoint Source (NPS) Program in determining where water quality improvements have or have not occurred. The objective is to determine the status and trends of aquatic life in California's wadeable streams by using the California Monitoring and Assessment Program (CMAP) approach to evaluate biological and physical habitat integrity of California streams. This approach will provide information on the percentage of water bodies achieving different degrees of biological integrity, build upon the data collected during the 1999-2003 pilot for California and assist in developing associations with land uses.

The technical goal of CMAP is to assess aquatic life beneficial use protection in rivers and streams using a probabilistic design that incorporates a suite of core indicators. The objectives are to:

- Estimate the current status, extent and trends in indicators of the condition of surface water target population with a known confidence
- Evaluate the associations between observed biological effects and physical and chemical stressors (between-induced stresses and ecological condition)
- Prioritize stressors
- Provide periodic statistical summaries and interpretive reports on ecological status and trends relative to statewide conditions and land use reporting units
- Develop indices of biotic integrity
- Maintain a reference condition program to help develop regional indices of biotic integrity

The programmatic goal is to evaluate the technical data that is produced and to determine what answers it can help provide to the NPS Program, including an understanding of status and trends as it relates to NPS Pollution and Program Implementation. CMAP is intended to help SWAMP answer the following questions:

- What is the quality of water in California?
- What is the extent of impairments associated with nonpoint sources?
- What are the nonpoint sources that are threatening water quality?
- Is water quality getting better or worse?
- Is the California NPS Program investing resources consistent with water quality problems?
- Are NPS investments effective in protecting and restoring water quality?

Scope of Quality Assurance Project Plan (QAPP)

This QAPP addresses the data acquisition effort currently being conducted by the CDFG/ABL under contract with the SWRCB and its SWAMP program from 2004 through 2006.

Data Management, Evaluation, and Reporting

Currently, all data collected during the 2004 CMAP field season is being stored on the EPA Surface Water Information Management (SWIM) database. The ultimate goal is to have all data deposited in the California Ecological Data Application System (CalEDAS) database housed at the ABL. This database will eventually be linked to other compatible databases including the SWAMP database through a central hub.

SECTION A7. DATA QUALITY OBJECTIVES AND CRITERIA*

*The following are criteria and objectives proposed by the U.S. EPA for EMAP Surface Water Research Activities, CMAP plans to adhere to these criteria.

Target criteria established for CMAP for estimating status and trends in condition are as follows:

- Estimate the status of a population of resources (the proportion of the population that is at or below some value of concern for an indicator) with 95 percent confidence intervals that are within ±10 percent of the estimate.

- Determine an average change in condition of a resource population (estimated as the change in the proportion of the population that is at or below some value of concern for an indicator) of twenty percent over 10 years with 95 percent confidence and a statistical power of 0.8.

Progress towards full implementation of routine surface water monitoring activities requires data and other information needed to make decisions regarding the refinement of the overall sampling design and to evaluate proposed indicators of ecological condition. Estimates of the magnitude of various sources of natural and extraneous variation are needed to refine the basic sampling design with respect to the number of sampling sites required and the frequency and number of repeat sampling visits needed within or among years, regardless of the number or types of different indicators being used.

For many of the indicators, little information is available on the components of variability and their magnitude, especially as they might vary among geographic regions. As a first step in developing data quality objectives (DQOs), pilot and demonstration surveys are designed to provide information on the sources of variability and their relative magnitude. This is done through index and overall sampling designs, which include revisit and repeat sampling, multiple sampling locations within a site, sample compositing, use of performance evaluation (PE) samples, and other means of obtaining estimates of variability components. Within each indicator, performance objectives are established for all measurements based on the level of quality required by individual indicator leads to develop and evaluate indicator metrics (combinations of one or more measurements into a new variable). Initial performance objectives are set based on the

best estimate of the quality of individual measurements needed to produce rigorous regional population estimates and discern trends. These performance objectives are referred to as measurement quality objectives (MQOs). MQOs are expressed in terms of such data quality

attributes as precision, accuracy or bias, taxonomic accuracy, completeness, comparability, representativeness, and method detection limits, as applicable.

The indicator evaluation activities conducted in the pilot and demonstration surveys represent a compromise between providing information needed to refine the overall sampling design and that required to develop an indicator that meets the criteria for CMAP implementation. Table 2 presents the criteria against which all potential indicators are evaluated at each stage of their development and eventual implementation. The criteria are both qualitative and quantitative in nature, and the determination of attainment of each criterion is achieved by consensus of indicator leads, program management, and scientific peer reviewers. It is anticipated that some or all of these criteria will become more quantitative as input from potential clients is utilized, or until benchmarks can be developed based on existing indicators that have been implemented and found to be successful.

Once the sources of the greatest variability are identified, they may be minimized through index and overall sampling design changes, which include optimizing the frequency of sampling both within and among sampling locations, use of PE and other QA/QC samples, and implementation of QC procedures. Through these processes, the MQOs may also be refined.

Initial DQOs for the indicator or index level may be developed through error propagation techniques. The magnitude of errors propagated from measurements through metrics to an indicator cannot be understood or estimated until the data are available to develop potential metrics and subject them to sensitivity analyses. In addition, the error distributions of metrics and indicators may not be typical and thus subject to standard techniques for estimation and inference, much like diversity indices or indices of niche breadth and overlap that are utilized in community ecology. As the available data base increases through the full 3-year sampling cycle and additional regions are sampled, additional refinement of the DQOs is made possible. Ultimately, index or program level DQOs may be developed which may be comparable to the CMAP program-level DQOs.

TABLE 2 GENERAL CRITERIA FOR EVALUATING ECOLOGICAL INDICATORS (from Barber, 1994)

Candidate Indicators:

- Potential or demonstrated importance in assessing status and trends in the ecological conditions of a resource class.
- Provides conceptual linkage of environmental stressors to assessment endpoints or environmental values.
- Potentially capable of responding over gradients of stressor intensity.
- Potentially adaptable to index sampling approach and constraints.
- Sampling and analytical methodologies available and mostly standardized, or have the potential to be successfully adapted to index sampling approach.
- The potential to obtain valid measurements and samples from every resource site is high.
- Additional testing can be accomplished at reasonable cost.
- Information obtained from indicator is not redundant with other indicators.

Core Indicators:

- Demonstrated ability to be implemented on a regional scale as part of an integrated monitoring activity during the index period.
- New information is provided at a regional scale that is not available as part of other existing monitoring programs.
- The magnitude of spatial and temporal variation within each resource site during the index period is small relative to the variation among resource sites.

Methods for Meeting Data Quality Objectives

Quality Assurance (QA) within the CMAP program will be achieved by employing the following:

Field Collections -

- Utilizing a standard operating protocol (SOP) for field operations during the collection of all field data. This SOP is essentially the Field Operations Manual for Wadeable Streams developed by the EPA and modified for California by the CDFG/ABL (Appendix A).

- Performing internal and external QA checks such as field and laboratory audits.

- Frequent briefing and de-briefing of field crews to discuss data collection techniques to ensure consistency and comparability of data among and between multiple crews

- Use of temporal index periods for sample collections to ensure site conditions are at or near base-flow. This will facilitate more reproducible results during the collection phase.

Analytical Laboratories –

- Using approved standard methodologies for analysis of various sample types as set forth by U.S. EPA. Refer to (Appendix B) for methods used by the CDFG Water Pollution Control Laboratory (WPCL).

Taxonomic Laboratories –

- All taxonomy for benthic macroinvertebrates (BMI) will be performed according to the CDFG Aquatic Bioassessment Laboratory taxonomy protocols using prescribed taxonomic effort and nomenclature described in ABL QAPP (Appendix C).

Data quality will be attained by maximizing the accuracy and precision of methods used. In addition, any changes in procedures due to equipment or to improved precision and accuracy will be documented.

Comparability –All measurements are made according to standard procedures to ensure comparability. Common metric units will be used for all field data collections i.e. meters, meters/sec, mg/L, Celsius, etc. as described by the field operations manual. Any deviation due to equipment or other valid reasons will be documented.

Method Detection Limits (MDLs) - For chemical measurements, requirements for the method detection limit (MDL) are established. The MDL is defined as the lowest level of analyte that can be distinguished from zero with 99 percent confidence based on a single measurement (Glaser et al., 1981). The MDL for an individual analyte is calculated as:

$$MDL \quad t_{[\hat{a} \quad 0.01,\ i \quad n\ 1]} \times s$$

where *t* is a Students' *t* value at a significance level (á) of 0.01 and n-1 degrees of freedom (í), and *s* is the standard deviation of a set of *n* measurements of a standard solution. The standard contains analyte concentrations between two and three times the MDL objective, and is subjected to the entire analytical method (including any preparation or processing stages). At least seven nonconsecutive replicate measurements are required to calculate a valid estimate of the MDL. Replicate analyses of the standard should be conducted over a period of several days (or several different calibration curves) to obtain a long-term (among-batch) estimate of the MDL.

Precision, Bias and Accuracy – Precision and bias are estimates of random and systematic error in a measurement process (Kirchmer, 1983; Hunt and Wilson, 1986). Collectively, precision and bias provide an estimate of the total error or uncertainty associated with an individual measurement or set of measurements. Systematic errors are minimized by using validated methodologies and standardized procedures. Precision is estimated from repeated measurements of samples. Net bias is determined from repeated measurements of solutions of known composition, or from the analysis of samples that have been fortified by the addition of a known quantity of analyte. For analytes with large ranges of expected concentrations, objectives for precision and bias are established in both absolute and relative terms, following the approach outlined in Hunt and Wilson, 1983. At lower concentrations, objectives are specified in absolute terms. At higher concentrations, objectives are stated in relative terms. The point of transition between an absolute and relative objectives is calculated as the quotient of the absolute objective divided by the relative objective (expressed as a proportion, e.g., 0.10 rather than as a percentage, e.g., 10%). Precision in absolute terms is estimated as the sample standard deviation when the number of measurements is greater than two:

$$s = \sqrt{\frac{\sum (x_i - \bar{X})^2}{(n-1)}}$$

where x_i is an individual measurement, $\bar{X}$ is the mean of the set of measurements, and *n* is the number of measurements. Relative precision for such measurements is estimated as the relative standard deviation (RSD, or coefficient of variation, [CV]):

$$RSD = \frac{s}{\bar{X}} \times 100$$

where *s* is the sample standard deviation of the set of measurements, $\bar{X}$ and equals the mean value for the set of measurements. Precision based on duplicate measurements is estimated based on the range of measured values (which equals the difference for two measurements). At higher concentrations, the relative percent difference (RPD) is calculated as:

$$RPD \quad \frac{|x_1 \quad x_2|}{\bar{X}} \times 100$$

where x_1 is the first measured value, x_2 is the second measured value, $\bar{X}$ and is the mean value of the two sample measurements. Precision objectives based on the range of duplicate measurements can be calculated as:

$$Critical\ Range \quad s \times \sqrt{2}$$

where *s* represents the precision objective in terms of a standard deviation. Range-based objectives are calculated in relative terms as:

$$Critical\ RPD \quad RSD \times \sqrt{2}$$

where *RSD* represents the precision objectives in terms of a relative standard deviation.

For repeated measurements of samples of known composition, net bias (*B*) is estimated in absolute terms as:

$$B \quad \bar{X} \quad T$$

where $\bar{X}$ equals the mean value for the set of measurements, and *T* equals the theoretical or target value of a performance evaluation sample. Bias in relative terms (*B[%]*) is calculated as:

$$B(\%) \quad \frac{\bar{X} \quad T}{T} \times 100$$

where $\bar{X}$ equals the mean value for the set of measurements, and *T* equals the theoretical or target value of a performance evaluation sample.

Accuracy is estimated for some analytes from fortified or spiked samples as the percent recovery. Percent recovery is calculated as:

$$\%\ recovery \quad \frac{C_{i\ s} \quad C_i}{C_s} \times 100$$

where $C_{i\,s}$ is the measured concentration of the spiked sample, C_i is the concentration of the

unspiked sample, C_s and is the concentration of the spike.

Completeness – CMAP completeness requirements are evaluated from two perspectives. The first objective is to set the minimum number of sites to be evaluated of that will yield a specified level of confidence when making subpopulation estimates. This number for CMAP is 50.

Within each indicator, completeness objectives are also established for individual samples or individual measurement variables or analytes. These objectives are estimated as the percentage of valid data obtained versus the amount of data expected based on the number of samples collected or number of measurements conducted. When necessary, supplementary objectives for completeness are presented in the indicator-specific sections of this QAPP.

SECTION A8. SPECIAL TRAINING REQUIREMENTS , CERTIFICATION, AND SAFETY

Training Field Personnel –

Proper training of field personnel is a critical step to facilitate the quality of data collection and safety. All field crews will consist of at least one CDFG Biologist or Environmental Scientist who has been officially trained in the standard methods of the CMAP program for data acquisition. Support staff will be trained annually by the lead staff using a hands-on approach during actual site visits. Once trained, each staff member must demonstrate their proficiency in all sampling activities before becoming certified in data collection for CMAP. This certification will be documented by the Field Technician Certification Check Sheet (Figure 2) and renewed each season. In addition, field audits will be scheduled routinely throughout each sampling season to assess each crew as a whole. Training, certification and auditting will ensure staff members adhere to procedures outline by field operations manual and the proper use of the equipment.

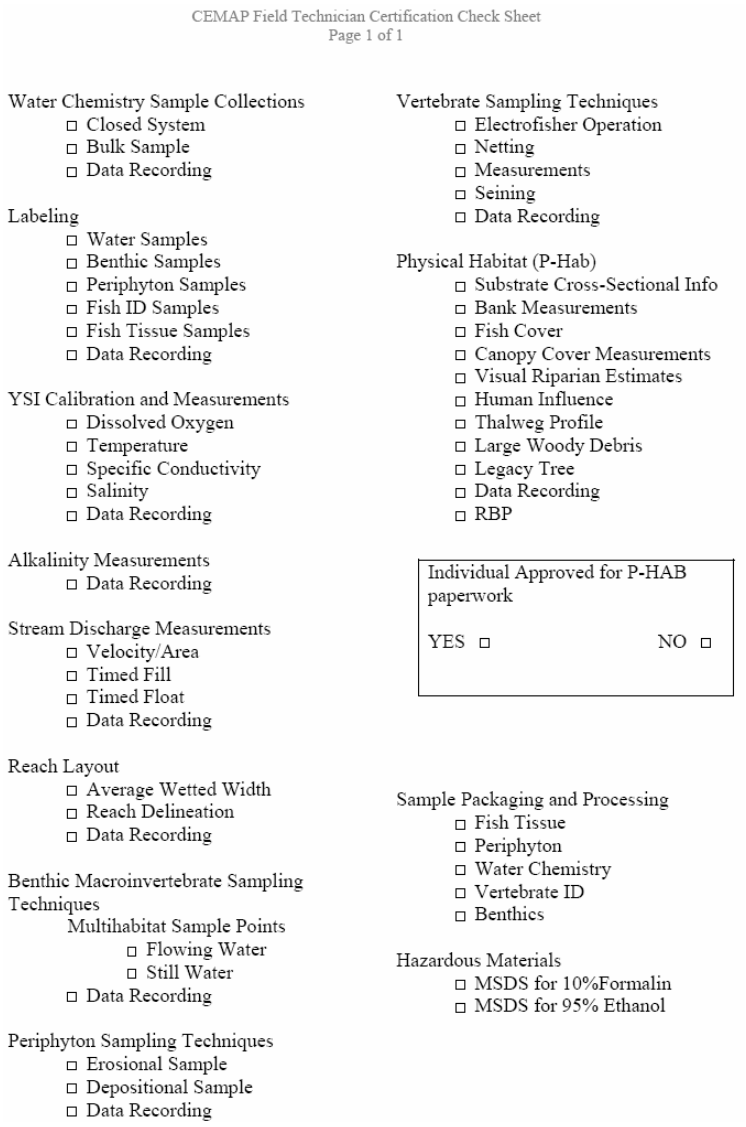
The CMAP program requires safety awareness/trainings prior to any field activities. This information is summarized in the CDFG Field Safety and Training Manual. It is the responsibility of the CMAP staff leads to ensure that field and safety training is completed by all field personnel. All safety and training requirements are listed in Field Safety and Training Manual (FSTM). Each CMAP crew member will read all safety and training documentation and sign off on all components of the manual prior to the start of work. Figure 3 is the checksheet for field safety training components described in the FSTM. CMAP staff leads are responsible for preparing and maintaining the FSTM in compliance with the Occupational Safety and Health Administration (OSHA), or equivalent state or local regulations. The FSTM will be readily available to field personnel with copies being kept in each project vehicle. CMAP sample collections require the use of a backpack-mounted electrofisher. This piece of equipment has the potential to electrocute and is operated only after operators have been certified in its operation using proper safety equipment and precautions. In addition, operators will also follow methods established by the National Marine Fisheries Service for fishing streams containing salmonids to promote fishing efficiency and reduce injury to fish (Appendix D1).

Driving tests for certain vehicles, as required by CDFG, will be administered to any crew member who might be responsible for its operation including the use of 4-wheel drive techniques, if equipped. This step is not included in the staff certification process. In addition,

all CDFG employees are required to take an agency-sponsored defensive driver course prior to State vehicle operation.

Hazardous Materials –

CMAP field operations require the use of certain chemicals used in the preservation of collected samples. Material Safety Data Sheets (MSDS) will be provided and readily available for all chemicals used by CMAP. Crew members will be advised on the safe handling of all chemicals and are required to review all MSDS for applicable chemicals to be certified CMAP field technicians.



CEMAP Field Technician Certification Check Sheet
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Water Chemistry Sample Collections
- □ Closed System
- □ Bulk Sample
- □ Data Recording

Labeling
- □ Water Samples
- □ Benthic Samples
- □ Periphyton Samples
- □ Fish ID Samples
- □ Fish Tissue Samples
- □ Data Recording

YSI Calibration and Measurements
- □ Dissolved Oxygen
- □ Temperature
- □ Specific Conductivity
- □ Salinity
- □ Data Recording

Alkalinity Measurements
- □ Data Recording

Stream Discharge Measurements
- □ Velocity/Area
- □ Timed Fill
- □ Timed Float
- □ Data Recording

Reach Layout
- □ Average Wetted Width
- □ Reach Delineation
- □ Data Recording

Benthic Macroinvertebrate Sampling Techniques
- Multihabitat Sample Points
  - □ Flowing Water
  - □ Still Water
- □ Data Recording

Periphyton Sampling Techniques
- □ Erosional Sample
- □ Depositional Sample
- □ Data Recording

Vertebrate Sampling Techniques
- □ Electrofisher Operation
- □ Netting
- □ Measurements
- □ Seining
- □ Data Recording

Physical Habitat (P-Hab)
- □ Substrate Cross-Sectional Info
- □ Bank Measurements
- □ Fish Cover
- □ Canopy Cover Measurements
- □ Visual Riparian Estimates
- □ Human Influence
- □ Thalweg Profile
- □ Large Woody Debris
- □ Legacy Tree
- □ Data Recording
- □ RBP

Individual Approved for P-HAB paperwork

YES □ NO □

Sample Packaging and Processing
- □ Fish Tissue
- □ Periphyton
- □ Water Chemistry
- □ Vertebrate ID
- □ Benthics

Hazardous Materials
- □ MSDS for 10%Formalin
- □ MSDS for 95% Ethanol

Figure 2. Field Technician Certification Check Sheet used for evaluation of field personnel.

CMAP Field Safety and Training Documentation

DOCUMENTS

- ☐ CMAP Orientation
- ☐ Department of Fish and Game Health and Safety Policies and Procedures for Daily Operations
- ☐ Department of Fish and Game Health and Safety Policies and Procedures for Emergency Operations
- ☐ Safety Rules
- ☐ Orientation-Backpack Electrofishing
- ☐ DFG Operation Manual sections 12850 and 12864 about electrofishing safety
- ☐ Smith-Root battery powered backpack shocker operators manual
- ☐ "Some Shocking Facts About Electrofishing" by Coffelt Electronics
- ☐ Chapter 8, Electrofishing (from Fisheries Techniques by Nielson and Johnson 1983)
- ☐ Non-Routine Tasks-Electrofishing Safety
- ☐ Warn Winch operations
- ☐ 4-Wheel Drive Operations
- ☐ Mountain Lions and Bears

TRAINING

- ☐ Driving Test
- ☐ Field Technician Certification Check Sheet
  - ☐ Follow-up QA

Figure 3. Field safety check sheet to be completed by all field staff prior to field activities.

Permits –
All necessary CMAP collection permits will be obtained by CDFG staff prior to any sample collections. All vertebrate sampling permits will be acquired using the procedures outlined by the SOP for Acquiring Vertebrate Sampling Permits for EMAP (Appendix D2). Table 3 summarizes the typical permits to obtain for CMAP sampling.

Table 3. Typical permits required for CMAP sampling.

Permit Group	Source of Permit
Macroinvertebrates	DFG scientific collection permit (not needed if DFG employee)
Anadromous salmonids	NOAA fisheries/NMFS
Non anadromous fish and amphibians (Threatened and Endangered)	US Fish and Wildlife Service

SECTION A9. DOCUMENTATION AND RECORDS

All data collected by CMAP personnel are recorded on standardized field data entry forms and are stored in clearly marked files at the ABL indefinitely. Electronic versions of the data are stored in CalEDAS, an Access© database which functions as the central repository for all data collected by the ABL.

SECTION B1. SAMPLING PROCESS / EXPERIMENTAL DESIGN
Sampling Site Acquision/Organization….McBride, RECON SOP.

Water Chemistry Indicator

The reach layout design for stream sampling is shown in Figure 4. Sampling for the water chemistry indicator occurs at the midpoint, or index site, of this designated reach as described by Kaufman et al. 1988. At the index site, a single water sample is taken along with a single set of field measurements to represent the stream's chemical condition.

Benthic Macroinvertebrate Indicator

Benthic macroinvertebrate (BMI) samples are collected using two independent protocols: Targetted Riffle Benthos (TRB) and Reach-Wide Benthos (RWB). The TRB sample involves randomly sampling 8 ft^2 of substrate from 4 "fast water" habitat units within the established reach. All 8 samples are used to create a TRB composite sample for the site. The RWB sample is taken from randomly selected locations one meter downstream of eleven cross-sectional transects which are systematically established along the stream reach. All eleven samples are used to create a reachwide composite. Figure 5 illustrates BMI sampling locations along a defined reach. Refer to the field operations manual (Appendix A) for more detailed procedures for BMI sampling.

Periphyton Indicator

Periphyton samples are collected from all eleven cross-sectional transects of the established reach. Each sample is taken from the dominant substrate type at each transect and is composited to produce a single reach-wide periphyton sample. Figure 6 illustrates the sampling design for the periphyton indicator.

AquaticVertebrate Indicator

Aquatic vertebrates are collected within the boundaries of the established reach to obtain a representative sample of relative abundance and species assemblage. A series of samples are collected from all available habitat types within the designated stream reach. Sampling effort will vary depending on a number of variables, mainly the diversity of available habitat types, the size of the water body being processed and the methods used. The two main methods to collect the aquatic vertebrate indicator are seining and electroshocking. Figure 7 provides an illustration of sampling design for the aquatic vertebrate indicator.

Physical Habitat Indicator

The physical habitat indicator is based on field measurements and observations, therefore, no sample collections are associated with this indicator. All physical habitat measurements and observations are taken based on the systematic spacing of cross-sectional transects and the uniform area between transects. In addition, a "rapid" assessment of habitat quality for the entire reach is conducted using the Rapid Bioassessment Protocol developed by Plafkin et al, 1989.

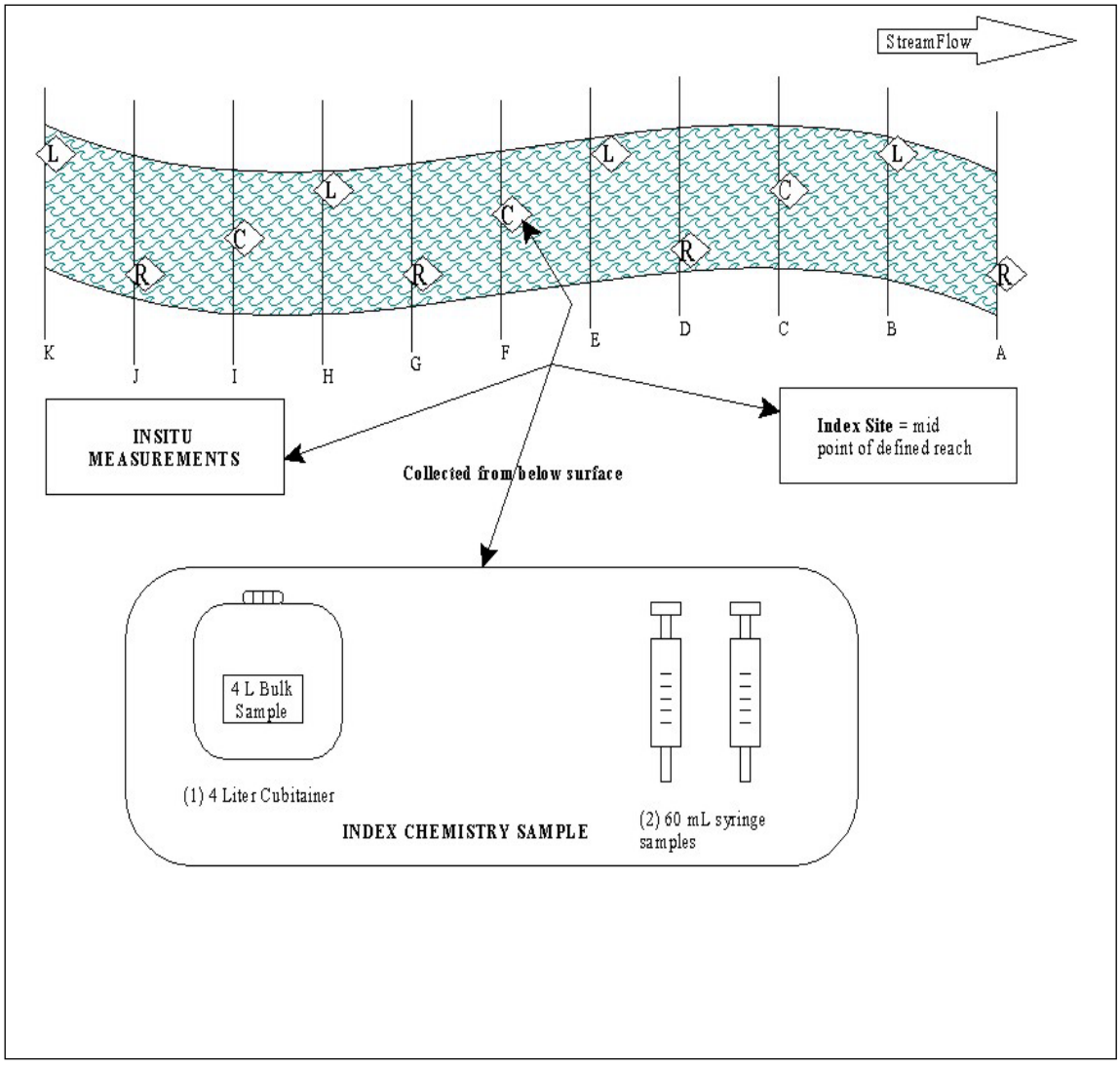


Figure 4. Index sampling design for the water chemistry indicator.

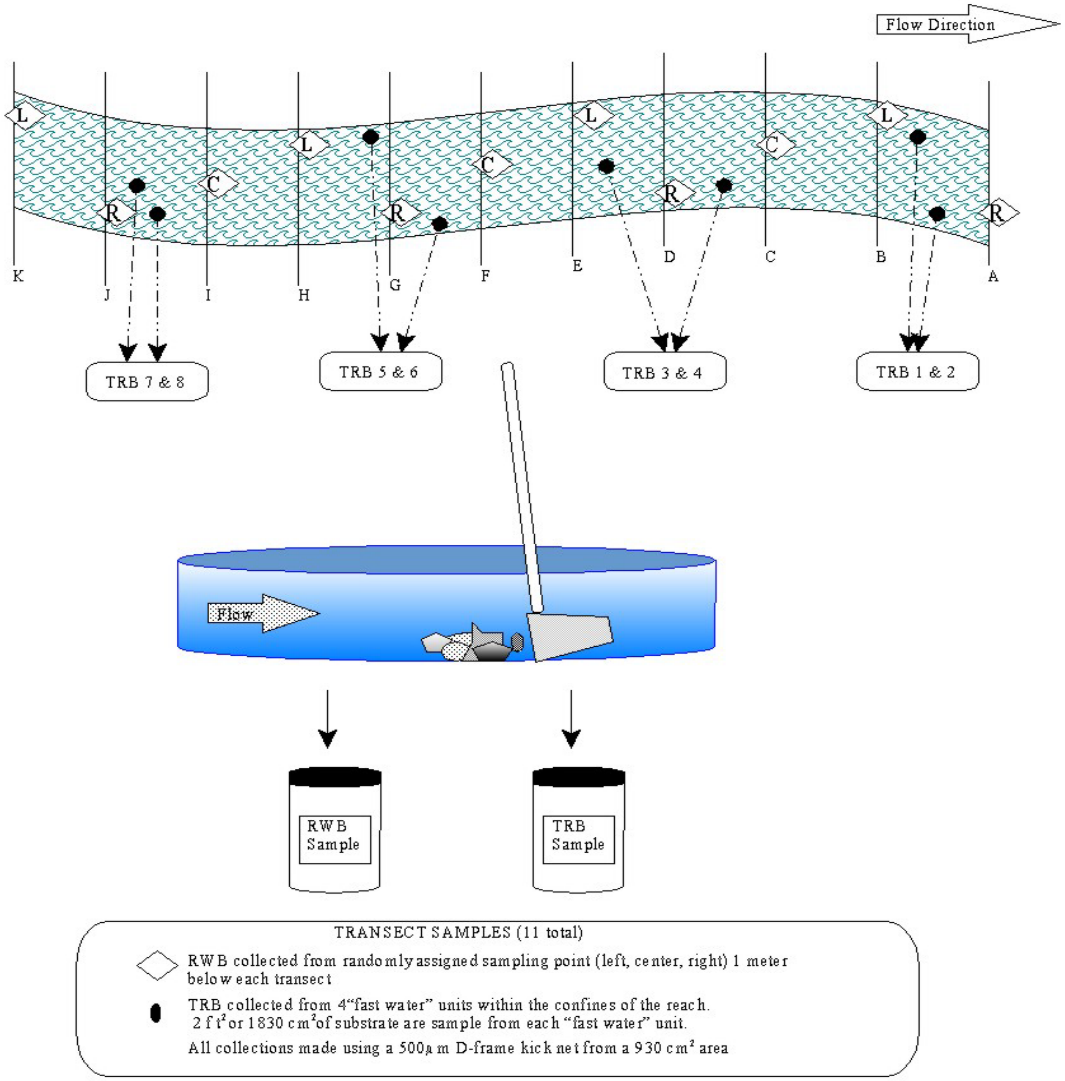


Figure 5. Index sampling design for benthic macroinvertebrate indicator.

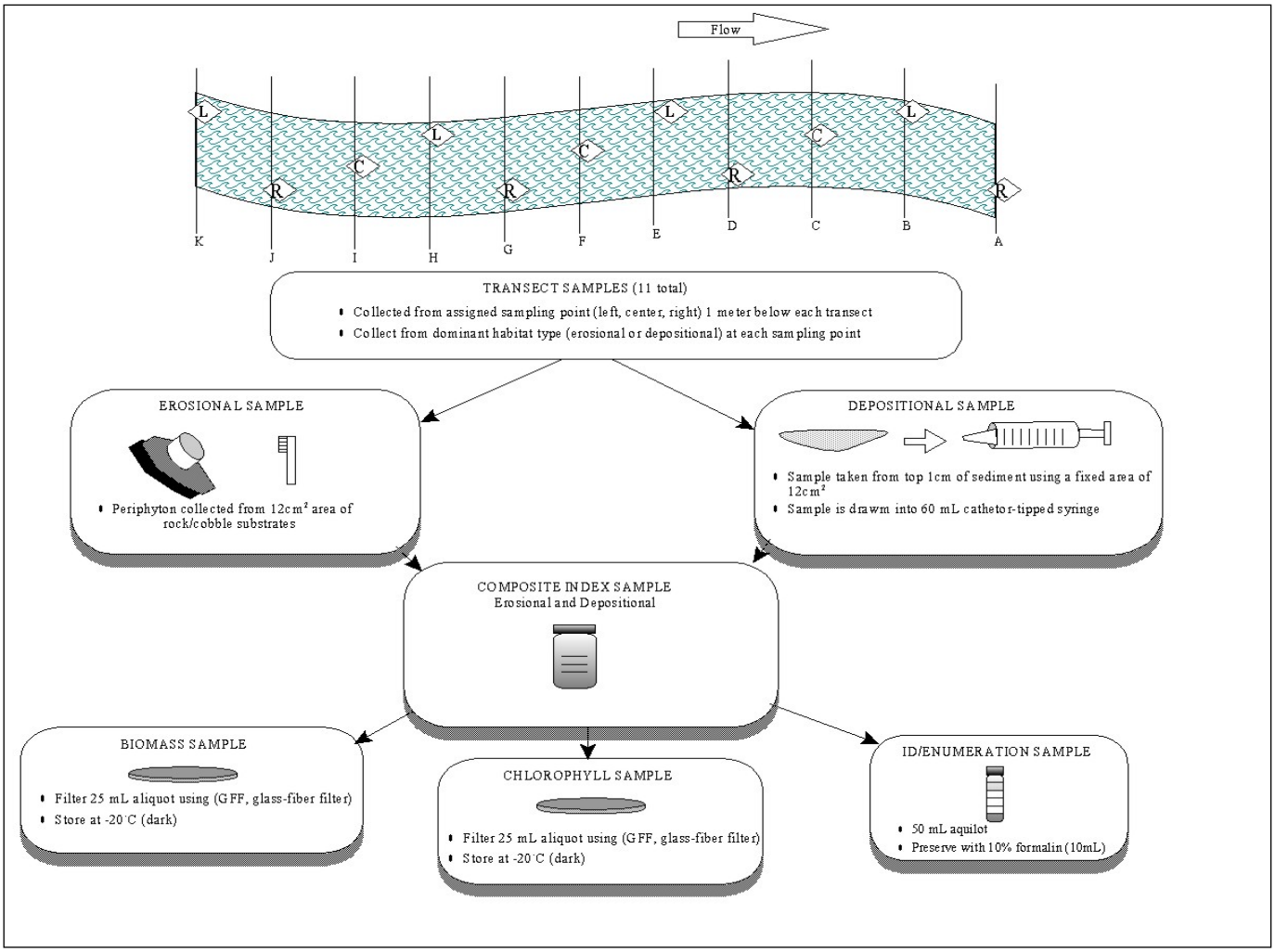


Figure 6. Index sampling design for the stream periphyton indicator.

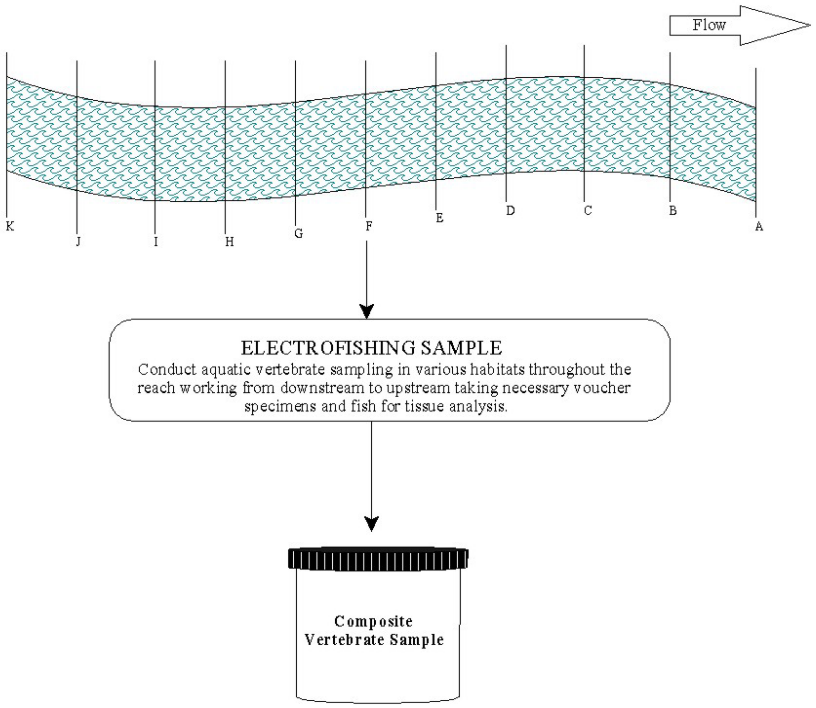


Figure 7. Index sampling design for the aquatic vertebrate indicator.

SECTION B2. SAMPLING METHODS REQUIREMENT

Water Chemistry Indicator

There are two components to collecting water chemistry information at each CMAP site: collecting samples of stream water for controlled environment analysis, and the on site or in situ measurements taken using a handheld meter for temperature, specific conductance, dissolved oxygen, and salinity. In addition, in situ total alkalinity is collected using a standard acid titration. In situ measurements are recorded on standardized field data forms. At each site, field personnel fill one 4-L pre-washed and rinsed cubitainer and two 60 mL Luer-lok syringes with stream water. These samples are packed in a cooler of bagged ice and shipped to the analytical lab within 24 hour of collection. Bulk water samples are taken using a series of grab samples from the upper portion of the water column using clean sampling techniques. These grabs are composited into a single 4-L cubitainer. Two syringe samples are filled by submerging each syringe and drawing water from under the surface without exposure to the atmosphere. More detailed procedures for this sampling method are described in the field operations manual.
Field Measurements- Refer to the field operations manual for detailed procedures for conducting in situ water chemistry measurements. Table 4 summarizes methods for on site water chemistry measurements.

Table 4. Summary of field measurements for water chemistry indicator.

Variable or Measurement	Expected Range	Methods Summary	References
Temperature, in situ	4 to 30 ˚C	Measured at mid-channel deploying temperature probe of YSI model 85 multi-function meter.	YSI Incorporated, 1986.
Dissolved Oxygen, in situ	0 to 14 mg/L	Measured at mid-channel deploying temperature probe of YSI model 85 multi-function meter.	YSI Incorporated, 1986.
Specific Conductivity, in situ	10 to1000 µS/cm	Measured at mid-channel deploying temperature probe of YSI model 85 multi-function meter.	YSI Incorporated, 1986.
Salinity, in situ	0 to 0.5 parts/1000	Measured at mid-channel deploying temperature probe of YSI model 85 multi-function meter.	YSI Incorporated, 1986.
$Alkalinity_{total}$, in situ	5 to 400 mg/L $CaCO_3$	Measured from sample taken at mid-channel, and titrated using drop-count sulfuric acid method.	Hach Company, 1997.

Benthic Macroinvertebrate Indicator

BMI samples are collected from a 1 ft^2 or ~ 930 cm^2 area of substrate, randomly located, below 11 cross-sectional transects. All samples are taken using a 500 µm mesh D-frame kick net and are combined to make one composite reach-wide sample. Composite samples are preserved in 70% ethanol for transport to the taxonomic processing lab. See Section 11 of the field operations manual (Appendix A) for further details on BMI sampling techniques.

Periphyton Indicator

Periphyton samples are collected at each of the 11 cross-sectional transects from the dominant substrate at each sampling point. One of two collection methods is used depending on the dominant substrate size at the established sampling point. Detailed procedures for obtaining periphyton sample are described in Section 8 of the field operations manual located in (Appendix A).

AquaticVertebrates Indicator

Aquatic vertebrate samples are collected using electric current from as many possible micro-habitats (Figure 8) as possible throughout the entire reach. Samples are taken from the 10 sub-reach areas or the areas between the 11 cross-sectional transects. Each aquatic vertebrate is tallied by species type and its relative collection location within the reach is noted. Total length measurements are taken in order to establish a maximum and minimum size for each species type. In addition, the first 30 fish of each species are measured to aid in determining the presence of fish reproduction at the site. Refer to Section 12 of the field operations manual, located in (Appendix A), for specific collection methodologies for aquatic vertebrates.

Physical Habitat Indicator

Physical habitat measurements are taken throughout the designated reach and up to 50 meters into the riparian corridor on either side of the stream. There are 7 major components to the physical habitat measurements:

Substrate Cross-Sectional Information
Bank Measurements
Fish Cover
Canopy Cover Measurements
Visual Riparian Estimates
Thalweg Profile
Large Woody Debris Tally

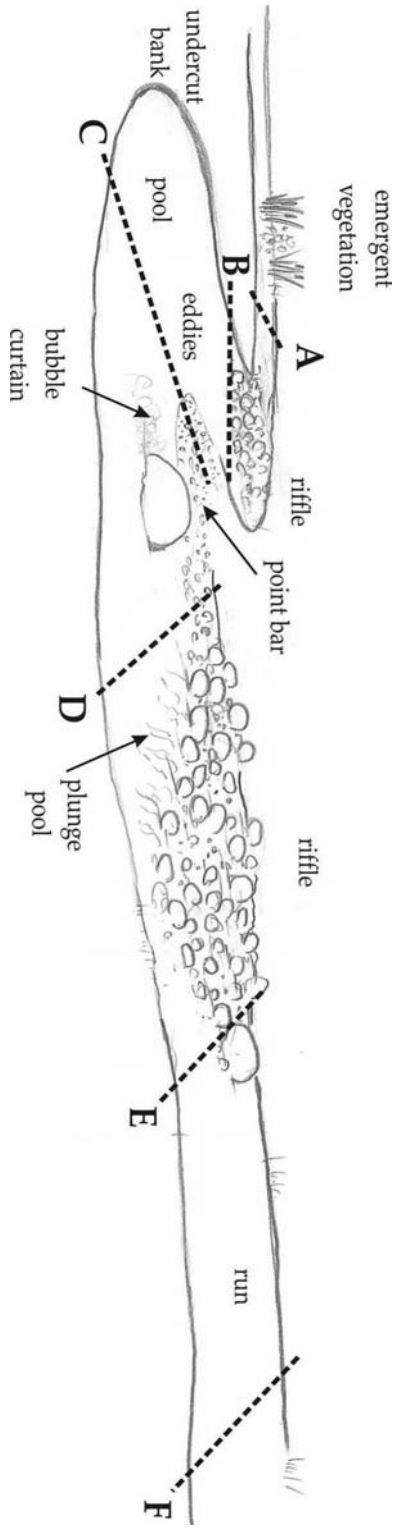


Figure 8. Partial stream reach diagram showing cross-sectional transects and various micro-habitats targeted during vertebrate sampling.

All data taken from measurements and observations of these components are recorded on standardized field forms for entry into the central data management system housed at the Aquatic Bioassessment Laboratory. Detailed information regarding the specific methodologies used to obtain the physical habitat data are described Section 7 of the field operations manual (Appendix A).

SECTION B3. SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Sample Log-in Procedures:
Each set of samples submitted to the ABL is logged into the electronic ABL Database (Cal EDAS). The information entered into this database is essential in data management and reporting and must be complete and consistent. The sample database contains the following information for each site:

1. The project name and the watershed name.

2. Complete locality information for each sample, including Latitude/Longitude, County, locality description (e.g., Pine Creek at Centerville Road), replicate number (if appropriate), sampling date and name of collector.

3. Date and time samples arrived at the ABL.

4. Total number of samples (and total number of jars if different from total samples due to single samples occupying more than one jar).

5. Sample ID numbers ("ML numbers"). These are assigned to each sample during the log in procedure.
6. All samples will be labeled with the appropriate CalWater Identification number for the waterbody from which the sample was taken.

7. (**Optional**) Site codes for each sample: the site code is an abbreviation for the sampling location, for example Santa Margarita River at Camp Pendleton = SMR-CP.

All samples from a given project are logged in simultaneously so that the ABL numbers generated for that project are consecutive. When more than one watershed is sampled in a project, all samples from each watershed should be grouped so that ABL numbers are consecutive within watersheds. It is desirable to have samples within a watershed logged in according to elevation so that upstream sites receive the lowest numbers in a series.

Once all samples have been logged into the ABL Sample Inventory Database, the sample information is printed as a Chain of Custody (COC) using the Access report function. The COC

is signed by one of the ABL staff members. Following completion of the COC form, the appropriate ML number is affixed to each sample container.

Samples collected by other agencies

Samples delivered from other agencies must be accompanied by a COC form at the time of delivery (**note**: a page of instructions for agencies that want to submit samples is attached at the end of this document), and must contain the following information in addition to that listed above:

1. The name of the agency that completed the original sampling, the name of that agency's project advisor, the name of at least one crew member that participated in sampling, and address/telephone numbers for both.

2. Complete locality information for each sample (see above).

Upon transfer of samples, the presence of each sample listed on the COC form is verified by ABL staff. After verification the relinquisher signs and dates that portion of the COC form titled "Relinquished by" and ABL staff signs and dates the section titled "Received by" to complete this stage of the COC procedure.

SECTION B4. ANALYTICAL METHODS REQUIREMENT

Water Chemistry Indicator

All water samples collected are tested based on the standard EPA methods for the following analytes summarized in Table 5 below.

Appendix B2 contains specific methods of analysis for the various analytes referred to in Table 5.

Benthic Macroinvertebrate Indicator

There are 3 stages to process BMI samples once collected. First, the samples are "picked" or subsampled, which involves randomly removing and enumerating organisms from the rest of the sample. The next stage is "sorting." In this stage, the picked organisms are sorted into like groupings based on certain levels of taxonomy, usually Order. The final stage of the process is the taxonomic phase where sorted groups of organisms are identified to a standardized taxonomic level, in most cases, species. For more detail, refer to the CDFG/ABL QAPP (Appendix C).

Table 5. Summary of analytical methodologies for water chemistry indicator.

Analyte	QA Class	Expected Range	Summary of Method	References
pH, closed system	C	3 to 9 pH units	Sample collected and analyzed without exposure to atmosphere; electrometric determination (pH meter and glass combination electrode)	EPA 150.6 (modified); U.S. EPA (1987)
pH, equilibrated	N	3 to 9 pH units	Equilibration with 300 ppm CO_2 for 1 hr prior to analysis; Electrometric determination (pH meter and glass combination electrode)	EPA 150.6 (modified); U.S. EPA (1987)
Acid Neutralizing Capacity (ANC)	C	-100 to 5,000 µeq/L	Acidimetric titration to pH ≤ 3.5, with modified Gran plot analysis	EPA 310.1 (modified); U.S. EPA (1987)
Carbon, dissolved[a] inorganic (DIC), closed system	N	0.1 to 50 mg C/L	Sample collected and analyzed without exposure to atmosphere; acid-promoted oxidation to CO_2, with detection by infrared spectrophotometry	U.S. EPA (1987)
Carbon, dissolved organic (DOC)	C	0.1 to 30 mg C/L	UV-promoted persulfate oxidation, detection by infrared spectrophotometry.	EPA 415.2, U.S. EPA (1987)
Conductivity	C	1 to 500 µS/cm	Electrolytic (conductance cell and meter)	EPA 120.6, U.S. EPA (1987)
Aluminum, total dissolved	C	10 to 1,000 µg/L	Atomic absorption spectroscopy (graphite furnace)	EPA 202.2; U.S. EPA (1987)
Aluminum, monomeric and organic monomeric	N	0 to 500 µg/L	Collection and analysis without exposure to atmosphere. Portion of sample passed through a cation exchange column before analysis to obtain estimate of organic-bound fraction. Colorimetric analysis (automated pyrocatechol violet).	APHA 3000-Al E.; APHA (1989), U.S. EPA (1987)

(continued)

C = critical, N = non-critical quality assurance classification.
[a] For DIC, "dissolved" is defined as that portion passing through a 0.45 µm nominal pore size filter. For other analytes, "dissolved" is defined as that portion passing through a 0.4 µm pore size filter (Nucleopore or equivalent).

Table 5. (continued)

Analyte	QA Class	Expected Range	Summary of Method	References
Major Cations (dissolved)				
Calcium	C	0.02 to 76 mg/L (1 to 3,800 µeq/L)	Atomic absorption spectroscopy (flame)	EPA 200.6, U.S. EPA (1987)
Magnesium	C	0.01 to 25 mg/L (1 to 2,000 µeq/L)		
Sodium	C	0.01 to 75 mg/L (0.4 to 3.3 µeq/L)		
Potassium	C	0.01 to 10 mg/L (0.3 to 250 µeq/L)		
Ammonium	N	0.01 to 5 mg/L (0.5 to 300 µeq/L)	Colorimetric (automated phenate)	EPA 350.7; U.S. EPA (1987)
Major Anions, dissolved				
Chloride	C	0.03 to 100 mg/L (1 to 2,800 µeq/L)	Ion chromatography	EPA 300.6; U.S. EPA (1987)
Nitrate	C	0.06 to 20 mg/L (0.5 to 350 µeq/L)		
Sulfate	C	0.05 to 25 mg/L (1 to 500 µeq/L)		
Silica, dissolved	N	0.05 to 15 mg/L	Automated colorimetric (molybdate blue)	EPA 370.1 (modified), U.S. EPA (1987)
Phosphorus, total	C	0 to 1000 µg/L	Acid-persulfate digestion with automated colorimetric determination (molybdate blue)	USGS I-4600-78; Skougstad et al. (1979), U.S. EPA (1987)

(continued)

C = critical, N = non-critical quality assurance classification.

[a] For DIC, "dissolved" is defined as that portion passing through a 0.45 µm nominal pore size filter. For other analytes, "dissolved" is defined as that portion passing through a 0.4 µm pore size filter (Nucleopore or equivalent).

Table 5. (continued)

Analyte	QA Class	Expected Range	Summary of Method	References
Nitrogen, total	N	0 to 25,000 µg/L	Alkaline persulfate digestion with determination of nitrate by cadmium reduction and determination of nitrite by automated colorimetry (EDTA/sulfanilimide).	EPA 353.2 (modified); U.S. EPA (1987)
True Color	N	0 to 300 Platinum Cobalt Units (PCU)	Visual comparison to calibrated glass color disks	EPA 100.2 (modified), APHA 204 A.; U.S. EPA (1987)
Turbidity	N	1 to 100 Nephelometric Turbidity Units (NTU)	Nephelometric	APHA 214 A., EPA 180.1; U.S. EPA (1987)
Total Suspended Solids (TSS)	N	1 to 200 mg/L	Gravimetric	EPA 160.3; APHA (1989)

C = critical, N = non-critical quality assurance classification.
[a] For DIC, "dissolved" is defined as that portion passing through a 0.45 µm nominal pore size filter. For other analytes, "dissolved" is defined as that portion passing through a 0.4 µm pore size filter (Nucleopore or equivalent).

Periphyton Indicator

All periphyton samples are prepped in the field for the analysis phase. The composite periphyton samples are measured for volume and the subsampled for the various analyses:

Chlorophyll *a*

Chlorophyll-containing phytoplankton, in a measured volume of sample water, are concentrated by filtering at low vacuum through a glass microfibre filter under low light conditions. The filter is then placed into a labeled centrifuge tube and frozen at -20°C. The pigments are extracted from the phytoplankton in 90% acetone with the aid of a mechanical tissue grinder. The filter slurry is allowed to steep for a minimum of 2 hours to ensure thorough extraction of the chlorophyll *a*. The sample is centrifuged for 15 minutes at 675g. An aliquot of the supernatant is transferred to a glass cuvette and fluorescence is measured on the Turner Fluorometer. The concentration of chlorophyll *a* in samples is determined by calculations based on a

predetermined calibration curve. The concentration of chlorophyll *a* in the natural water sample is reported in µg/L.

Biomass (Ash-free Dry Mass)

Controlled heating in a drying oven is used to evaporate all weight from water in the sample. The dry filter is weighed and the measurement recorded. The sample filters are then combusted (ashed) using a blast furnace to decompose the organic matter. The filters are saturated with water to rehydrate the clays, and placed back in the drying oven. Dry filters are weighed and that measurement is recorded. Ash free dry mass is then calculated using weight measurements and field data (area scraped, number of transects, volume of sample collected and volume of sample filtered).

Taxonomic Identification

Sample Preparation for Analysis: Each periphyton sample jar will be shaken thoroughly to dislodge epiphytes from filamentous algae and to randomly mix the periphyton sample (Stevenson and Bahls 1999). A tissue homogenizer will be used to aid this process, especially when filamentous algae are abundant in the sample. After homogenization is complete, each sample will be divided into three parts: one for diatom analysis, one for soft-bodied algae analysis, and one for archiving.

Diatom Identification and Enumeration: Approximately, 10-20 mL of periphyton solution will be processed with concentrated sulfuric acid and potassium dichromate for diatom analysis (Patrick and Reimer 1966). After rinsing numerous times with distilled water, cleared diatom frustules will be permanently slide mounted using NAPHRAX® mounting medium.
A total of 600 diatom valves or 300 diatom frustules/cells will be enumerated and identified to the species level whenever possible, using current taxonomic references by Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) and others (e.g., Patrick and Reimer 1966, 1975). Diatom valves will be identified and enumerated at 1000X magnification under the microscope.

Soft-bodied Algae Identification and Enumeration: A total of 300 algal counting units will be identified and enumerated at 400X magnification under the microscope. For colonial algae, each colony will be counted as one algal unit for purposes of tallying 300 counting units in a count. Cell numbers in each colony will be estimated and recorded in a separate column. For thin filamentous bluegreen algae (e.g., *Schizothrix*) in which cross-walls are often difficult to detect, a 10 µm length of trichomes will be counted as one algal unit. Individual diatom cells will be counted as one counting unit. This procedure enables unbiased characterization of algal assemblages which are dominated by colonial or filamentous algae. Non-diatom algae will be identified to the genus level or species level if possible and diatoms with protoplasm will be counted but not identified.
Major taxonomic references include Dillard (1999), Palmer (1977), Prescott (1978), Smith (1950), and Whitford and Schumacher (1984).

Sample Archiving: Remaining original sample and permanent slides from each sample processed will be archived until data are verified and validated.

Aquatic Vertebrates:

Aquatic Vertebrate Assemblage Indicator:

Aquatic vertebrate samples are prepared for taxonomic confirmation in the field during post site sampling activities. Voucher specimens of each vertebrate type are labeled and preserved in 10% formalin for transport to the laboratory. Detailed procedures for fish collection and preparing voucher specimens are found in section 12 of the field operations manual (Appendix A). Each specimen is then identified to species using standardized taxonomic references by well trained staff. There is no further analysis associated with the aquatic vertebrate assemblage indicator.

**Fish Tissue Contaminants Indicator:*

Selected target species of fish are collected during the sampling phase to provide a sufficient tissue amount for analysis. In general, 3-5 large individuals (>120mm) or 20-200 small fish of similar species will yield an adequate tissue sample. Detailed procedures for preparing fish tissue samples are located in Appendix A, Section 12 of the field operations manual.

** Specific analytes of fish tissue are currently being negotiated.*

SECTION B5. QUALITY CONTROL REQUIREMENTS

QA/QC for Site Acquision/Organization

The CMAP probabilistic sample design was created by the US EPA's Western Ecology division in Corvallis, Oregon. The target population for CMAP is all California wadeable streams and rivers with flowing water. The sampling framework is designed to take the target population and use RF3 files to further restrict streams and rivers that are coded as perennial and Strahler orders 1-5. A side goal is to make sites compatible with those of California's Western Pilot EMAP project so that data may be used interchangeably. The significant difference between the EMAP and CMAP datasets are the multi-density categories that have been created within the CMAP design. The multi-density categories are based on four California vegetation GIS coverages (Agriculture, Forest, Urban, and Other). The goal is to have equal distribution of all four land use categories in the final sample size for CMAP. When one site for a particular category is removed it is replaced with a new site from the same category; this process should yield an equal

sample size from each category. A master site list is generated by the US EPA containing all potential 2400 sites for four years. Set within the master site list are equal representations of the four landuse categories. Fifty sites are to be sampled each year with equal representation from each landuse category. Detailed procedures for paring down the site list to 50 sampled sites are explained in (Appendix E). All data collected during this site reconnaissance and access phase of the project are stored in the CMAP Site Recon data base at the ABL. The data base is an Access design developed specifically to track all site information gathered on every site prior to sampling. In addition, the data base is updated regularly during the sampling season using data entry forms (Figure 9) to reflect any site status changes that occur.

QA/QC for Biological Sample Collections

The CMAP sampling design is constructed to produce random samples of BMI's, aquatic vertebrates, and periphyton. It is important to strictly adhere to the protocol when establishing the experimental reach to prevent biasing transect locations and/or sampling points. The following procedures will help field crews obtain consistent and unbiased samples:

All field crews are trained by experienced DFG biologists to use the CMAP protocol for biological sample collections.

All procedures for sample collections are reviewed annually prior to the initiation of the field season.

In addition, the following QC procedures will be adhered to as outlined by Stevenson and Bahls, 1999:

1. All sample labels must be accurately and thoroughly completed, including the sample identification code, date, stream name, sampling location, and collector's name. The outside and any inside labels of the container should contain the same information. Chain of custody and sample log forms must include the same information as the sample container labels.
2. After sampling has been completed at a given site, all nets, brushes, suction and scraping devices that have come in contact with the sample should be rubbed clean and rinsed thoroughly in distilled water. The equipment should be examined again prior to use at the next sampling site, and rinsed again if necessary.
3. After sampling, review the recorded information on all labels and forms for accuracy and completeness.
4. Collect and analyze one replicate sample from 10% of the sites to evaluate precision or repeatability of sampling technique, collection team, sample analysis, and taxonomy.

Sampling effort must be kept consistent throughout the life of the project in order for results to be comparable. It is not necessary to time the effort because it will vary will substrate/channel conditions. The overall goal is to obtain the consistent representation of the BMI, aquatic vertebrate, and periphyton communities that is present at the site of interest. For example, BMI sampling will take more time to complete at a site dominated by large cobble and boulder substrates than at a site with a sandy bottom in order to obtain proper representation in the sample.

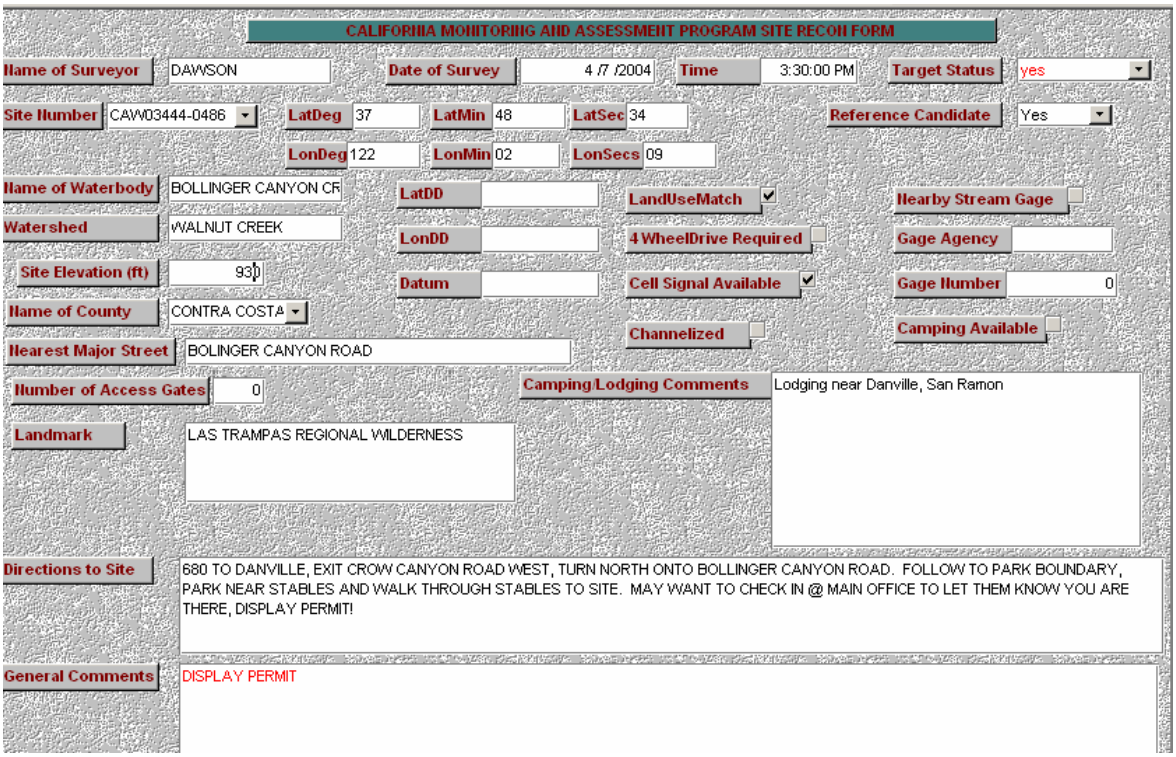


Figure 9. Sample reconnaissance form used to track site information for CMAP.

QA/QC for Water Chemistry Sample Collections
Water chemistry samples are collected at each site within the designated reach. It is important to use clean and consistent methods when collecting samples for water chemistry analysis. The following steps will ensure samples are consistent:

All field crews are trained by experienced DFG biologists to use the CMAP protocol for water chemistry sample collections including sampling techniques, labeling, and packaging.

All water samples are collected into EPA approved vessels by procedures described in Section 5 of the field operations manual, located in Appendix A of this document.

Water samples may be kept in a cooler on ice for up to 72 hrs prior to analysis. Any samples that depart from these conditions will be documented.

QA/QC for Measuring Physical Habitat
A comprehensive suite of stream physical habitat data is collected at each site. A consistent understanding of all elements of this suite is imperative to insure data comparability. The following steps will ensure this consistency:

All field crews are trained by experienced DFG biologists to use the CMAP protocol for physical habitat measurements.

During the sampling season, field personnel assessing physical habitat will be re-assigned to different crews and/or responsibilities. All questionable results for each site will be discussed at the end of each sampling day to address and resolve discrepancies and inconsistencies.

QA/QC for Field Data Forms
All data collected during the field season are recorded on standardized forms for entry into a Data Management System (DMS). Prior to entry into the DMS, all submitted paperwork for each site is reviewed by a data QA officer at the ABL. This review takes place at the end of each sampling week as is aimed at confirming proper the of data entries.

Analytical Quality Control

Benthic Macroinvertebrate Sample Processing
Internal QC is conducted by ABL taxonomists on samples that have been processed by the ABL itself. Internal QC procedures target two specific stages of sample processing: the subsampling ("picking") stage and the identification stage.

Subsampling QA (Remnant Evaluation): All remnant samples from every project are examined by a QC taxonomist at the time subsampling is completed. These samples are examined for organisms that may have been overlooked during subsampling. The number of unpicked BMI's (if any) and their identity is recorded in the ABL Quality Control Worksheet. For subsamples containing 300 or more organisms, the remnant sample should contain fewer than 10% of the total organisms subsampled. The remnant should contain fewer than 30 organisms for samples containing fewer than 300 organisms. IF these criteria are not met, then corrective action is initiated. For example, student pickers are currently paid on a per sample basis, which means that they earn more per hour if they process samples quickly. Error rates greater than 10% result in a student earning minimum wage for the time spent processing that sample (or samples).

Internal Taxonomic Identification QA: Taxonomic identifications are evaluated by the ABL's QC taxonomist with the goal of checking the accuracy and consistency of individual taxonomists. Ten percent of the samples from any given project are randomly selected and then checked for taxonomic accuracy. All taxa from each of the randomly selected samples are re-identified by the QC taxonomist, and the number of specimens in each vial is re-checked. Any errors in taxonomy, including misidentification, multiple taxa per vial, counting error and deviation from standard taxonomic effort are recorded in spreadsheet form, and then are analyzed with QC MANAGER, an ACCESS© program that summarizes the types of discrepancy and their frequencies. If a taxonomist is discovered to consistently misidentify a particular taxon, that person will receive instruction from the QC taxonomist about how to properly identify specimens in that group, and all future ID's involving that taxon will be checked until the problem is resolved.

External Quality Control

The ABL has the option of sending all processed samples to an independently contracted lab for external QA/QC of identified specimens. When external QC is performed, 10 percent of all samples are evaluated for taxonomic accuracy and accuracy of specimen counts.

Aquatic Vertebrate Sample Processing

All vertebrates are identified and enumerated in the field at each site. Voucher specimens are captured and retained for further QA/QC to determine/confirm taxonomic identification in the lab at a later date. At least three specimens of each species are retained. Species are organized by site and held in 1000 ml plastic jars preserved in a10% formalin solution. All jars holding vertebrate samples have a unique site code and ABL unit code affixed to the outer container and is logged into the CalEDAS database. Vertebrates are identified using Inland Fishes of California (Moyle, 2002) taxonomic key. All vertebrate vouchers are corroborated or corrected from the original field data sheet to the laboratory worksheet **CMAP vertebrate QA/QC Form**,

(Figure 10). Corrections are then made to the CalEDAS database. An additional hardcopy of the **CMAP vertebrate QA/QC Form** is delivered to each unique site file stored at the ABL.

Periphyton Sample Processing

All periphyton samples processed will be handled in the following manner based on quality control procedures outlined by the following from (Stevenson and Bahls, 1999):

1. Upon delivery of samples to the laboratory, periphyton samples will be logged into sample inventory of the processing lab.

2. Voucher collections of all samples and diatom slides will be maintained. They should be accurately and completely labeled, preserved, and stored in the laboratory for future reference. Specimens on diatom slides should be clearly circled with a diamond or ink marker to facilitate location. A record of the voucher specimens should be maintained. Photographs of specimens improve "in-house" QA.

3. For every QA/QC sample (replicate sample in every 10th stream), assess relative abundances and taxa richness in replicate wet mounts and a replicate diatom slide to assess variation in metrics due to variability in sampling within reaches (habitats), sample preparation, and analytical variability.

4. QA/QC samples should be counted by another taxonomist to assess taxonomic precision and bias, if possible.

5. Common algal taxa should be the same for the two wet mount replicates. The percent community similarity index (Whittaker 1952) calculated from proportional counts of the two replicate diatom slides should exceed 75%.

6. If it is not possible to get another taxonomist in the lab to QA/QC samples, an outside taxonomist should be consulted on a periodic basis to spot-check and verify taxonomic identifications in wet mounts and diatom slides. All common genera in the wet mount and all major species on the diatom slide (>3% relative abundance) should be identified similarly by both analysts (synonyms are acceptable). Any differences in identification should be reconciled and bench sheets should be corrected.

7. A library of basic taxonomic literature is an essential aid in the identification of algae and should be maintained and updated as needed in the laboratory. Taxonomists should participate in periodic training to ensure accurate identifications.

CMAP Vertebrate QA/QC form

Site ID # _____ Date_____

ABL Lab # _____

	Vert sample #1	Vert sample #2	Vert sample #3
Original field ID			
Confirmed Lab ID			

	Vert sample #4	Vert sample #5	Vert sample #6
Original field ID			
Confirmed Lab ID			

	Vert sample #7	Vert sample #8	Vert sample #9
Original field ID			
Confirmed Lab ID			

	Vert sample #10	Vert sample #11	Vert sample #12
Original field ID			
Confirmed Lab ID			

Identifying taxonomist_____

Figure 10. CMAP Vertebrate QA/QC form used during laboratory ID phase of vertebrate analysis.

Water Sample Processing

All water samples collected for CMAP will be processed and handled by the CDFG Water Pollution Control Laboratory (WPCL) using standardized methods described in the CDFG/OSPR/WPCL Quality Assurance Program Plan and SOP's located in (Appendix B1-B2) of this document and based on the following requirements as mandated by the Surface Water Ambient Monitoring Program (SWAMP):

1. Strict adherence to common QA/QC procedures.
2. Routine analysis of certified reference materials.
3. Regular participation in an ongoing series of inter-laboratory comparison exercises.
4. A program of scheduled maintenance of analytical balances, microscopes, and other laboratory equipment and instrumentation.
5. Routine checking of analytical balances using a set of standard reference weights (American Society of Testing and Materials (ASTM) Class 3, NIST Class S-1, or equivalents).
6. Checking and recording the composition of fresh calibration standards against the previous lot. Acceptable comparisons are <5 percent difference from previous value.
7. Recording all analytical data in bound (where possible) logbooks, with all entries in ink, or electronic format.
8. Monitoring and documenting the temperatures of cold storage areas and freezer units once per week.
9. Verifying the efficiency of fume hoods.
10. Having a source of reagent water meeting ASTM Type I specifications (ASTM, 1984) available in sufficient quantity to support analytical operations. The resistivity of the reagent water will not exceed 18 megaohm at 25°C. Alternately, the conductivity of the reagent water will exceed 10 μmhos/cm.
11. Labeling all containers used in the laboratory with date prepared, contents, initials of the individual who prepared the contents, and other information as appropriate.
12. Dating and safely storing all chemicals upon receipt. Proper disposal of chemicals when the expiration date has passed.
13. Having QAPP, SOPs, analytical methods manuals, and safety plans readily available to staff.
14. Having raw analytical data, such as chromatograms, accessible so that they are available upon request.

SECTION B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE REQUIREMENTS

All field and sampling equipment will be maintained in good working order. During each field/sampling season, backup equipment and spare parts will be made available for in-field

repairs in order to minimize the costs and inconveniences associated with unnecessary return trips to sampling sites.

Field Equipment:
All field equipment will be maintained according to manufacturer's recommended maintenance schedule if available. Other equipment will be checked for proper operation prior to use for data collection. All Backpack-mounted electrofishers will be returned to manufacturer on an annual basis for calibration and routine maintenance. At the end of each sampling effort, all used equipment will be re-checked for any necessary repairs.

Laboratory Equipment:
At minimum, all lab equipment will be maintained according to manufacturer's prescribed maintenance schedules. Commonly replaced parts will be kept on hand to minimized downtime. Any additional calibrations and testing will be performed according to individual lab QAPPs. Equipment manuals containing trouble-shooting SOPs will be kept either with the instrument or in the possession of in-house maintenance personnel. Instrument operators are responsible for daily maintenance and for maintaining instrument logs. These logs will contain the date and description of routine maintenance procedures.

SECTION B7. INSTRUMENT CALIBRATION AND FREQUENCY

All lab instruments will be calibrated by the means and frequency prescribed by manufacturer outlined in the analytical methods section of this QAPP. Field instruments will be calibrated according to procedures and frequency outlined in the field operations manual (Appendix A).

SECTION B8. INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

The procurement of supplies, equipment, and services must be controlled to ensure that specifications are met for the high quality and reliability required for each field and laboratory function. All equipment and material specifications used by ABL and WPCL personnel in surface water quality monitoring are outlined in the respective laboratories operating procedures and policies. It is the responsibility of staff person procuring the equipment to inspect it and materials for quality. Upon receipt of materials or equipment, a designated employee receives and signs for the materials. The items are reviewed to ensure the shipment is complete and they are then delivered to the proper storage location. All chemicals are dated upon receipt. All supplies are stored appropriately and are discarded upon expiration date.

SECTION B9. DATA MANAGEMENT

Currently, at the time of this draft, all data collected for this project are being stored on the EPA Surface Water Information Management (SWIM) database. Details of this management system can be found in the Environmental Monitoring and Assessment Program: Integrated QAPP for Surface Waters Research Activities (Appendix F). The ultimate goal is to have all data deposited in the California Ecological Data Application System (CalEDAS) database housed at the ABL.

This database will eventually be linked to other compatible databases including the SWAMP database through a central hub and follow the standardized data transfer protocols (SDTPs) described in the SWAMP QAMP.

SECTION C1. ASSESSMENTS AND RESPONSE ACTIONS

The CDFG/ABL and the WPCL are committed to providing the highest quality data in the industry. In order to accomplish this, performance evaluations/audits are required to ensure this data quality. Internal and external audits are scheduled regularly for laboratory and field activities. Refer to individual sections of this document and their references for methods of performance evaluations and necessary corrective actions taken.

SECTION C2. REPORTS TO MANAGEMENT

As required by contract with the SWRCB, technical reports will be provided in a timely manner to management as described under Task 9: (Draft and Final Project Reports) section of the finalized CMAP master contract. The schedule of delivery for these reports and other products are summarized in Table 6 below.

Table 6. Contract deliverables and due dates as described in CMAP contract.

TASK AND DELIVERABLES		DUE DATE
Task 1	**Project Administration**	
	1.2 Quarterly Progress Reports	July 10, 2004 and quarterly
	1.5 Contract Summary Form	July 10, 2004
	1.6 MBE/WBE Documentation	Ongoing
	1.7 Subcontractor Documentation	Ongoing
	1.8 Project Survey Form	February 15, 2006
		March 1, 2006
Task 2	**Quality Assurance Project Plan (QAPP) and Monitoring Plan**	
	2.1 QAPP	July 31, 2004
	2.2 Monitoring Plan	July 31, 2004
Task 3	**Analysis of Historic EMAP Data**	
	3.1 Technical Report #1	July 31, 2004
	3.2 Technical Report #2	December 1, 2004
	3.3 Technical Report #3	January 2, 2005
Task 4	**Preliminary Site Selection**	
	List of Preliminary Site Locations	April 15, 2004, January 15, 2005, January 15, 2006
Task 5	**Site Access/Reconnaissance/Ground-Truthing**	
	List of 50 to 60 Sampling Sites	April 30, 2004, April 15, 2005

Task 6	**Field Sampling**	
	Field Data Sheets	October 15, 2004, October 15, 2005
Task 7	**Laboratory Analysis**	
	7.1 Completed Laboratory Reports	
	BMI Analysis	April 15, 2005, January 15, 2006
	Periphyton Analysis	April 15, 2005, January 15, 2006
	Water Sample analysis	January 15, 2005, January 15, 2006
Task 8	**Data Analysis**	
	8.4Technical Report #4	March 31, 2005
Task 9	**Draft and Final Project Reports**	
	9.2Draft Project Report	January 15, 2006
	9.3Final Project Report	March 1, 2006

SECTION D1. DATA REVIEW, VALIDATION AND VERIFICATION REQUIREMENTS

Data verification and data validation are key steps in the transition from the implementation (sampling and analysis) phase to the assessment phase. EPA has provided a comprehensive guidance document (EPA 2001), entitled "*Guidance on Environmental Data Verification and Data Validation (EPA QA/G-8)".* The purpose of this guidance is to explain how to implement data verification and data validation, and to provide practical advice and references. This guidance describes an array of data verification and data validation practices in order to promote common understanding and effective communication among environmental laboratories, field samplers, data validators, and data users.

Although data verification and data validation are commonly-used terms, they are defined and applied differently in various organizations and quality systems. Without attempting to preempt other meanings or approaches, the CMAP Program will generally follow EPA's informal guidance on this topic, as provided in EPA 2001, and incorporates the following definitions:

Data Verification is confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. Data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements.

Data Validation is confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Data validation is an analyte-and sample-specific process that extends the evaluation of data beyond method, procedural, or

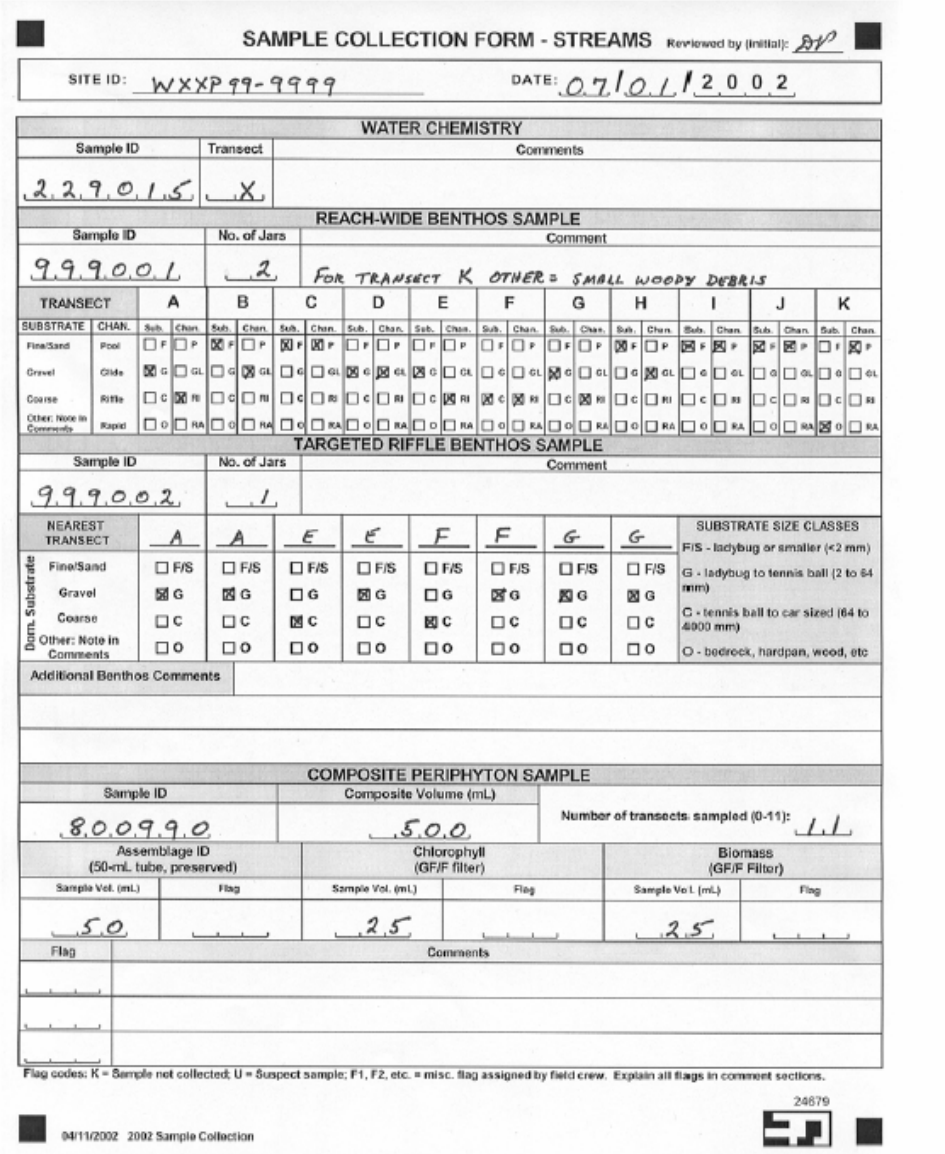
contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set.

Data meeting applicable Data Acceptability Criteria are accepted for inclusion in the SWIM and CalEDAS data bases. Data which do not meet these requirements are excluded from being entered into these data bases.

SECTION D2. VALIDATION AND VERIFICATION METHODS

All data reported by the CMAP program are subject to error checks for transcription, calculation and computer input. Currently, all data collected are thoroughly reviewed and electronically scanned into the SWIM database using specifically designed field forms (Figure 11), to minimize transcription and data input errors. In addition, several features have been designed into the design of the data base itself to control such errors. All data are subjected to various data validation activities depending on the type of data being analyzed. These methods are summarized by indicator in the 1997 draft of the Environmental Monitoring and Assessment Program: Integrated Quality Assurance Project Plan for Surface Water Research Activities (Appendix F). An example of these procedures for the physical habitat indicator can be found in appendix B of the following EPA document:

Kaufmann, P.R, P. Levine, E.G. Robison, C. Seeliger, and D.V. Peck. 1999. Quantifying Physical Habitat in Wadeable Streams. U.S. Environmental Protection Agency. Washington, D.C. EPA/620/R-99/003



SAMPLE COLLECTION FORM - STREAMS Reviewed by (initial): DVP

SITE ID: WXXP99-9999 DATE: 07/01/2002

WATER CHEMISTRY

Sample ID	Transect	Comments
229015	X	

REACH-WIDE BENTHOS SAMPLE

Sample ID	No. of Jars	Comment
999001	2	FOR TRANSECT K OTHER = SMALL WOODY DEBRIS

TRANSECT	A		B		C		D		E		F		G		H		I		J		K	
SUBSTRATE / CHAN.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.	Sub.	Chan.
Fine/Sand / Pool	☐ F	☐ P	☒ F	☐ P	☒ F	☒ P	☐ F	☐ P	☐ F	☐ P	☐ F	☐ P	☐ F	☐ P	☒ F	☐ P	☒ F	☒ P	☒ F	☒ P	☐ F	☒ P
Gravel / Glide	☒ G	☐ GL	☐ G	☒ GL	☐ G	☐ GL	☒ G	☒ GL	☒ G	☐ GL	☐ G	☐ GL	☒ G	☐ GL	☐ G	☒ GL	☐ G	☐ GL	☐ G	☐ GL	☐ G	☐ GL
Coarse / Riffle	☐ C	☒ RI	☐ C	☐ RI	☐ C	☐ RI	☐ C	☐ RI	☐ C	☒ RI	☒ C	☒ RI	☐ C	☒ RI	☐ C	☐ RI	☐ C	☐ RI	☐ C	☐ RI	☐ C	☐ RI
Other: Note in Comments / Rapid	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☐ O	☐ RA	☒ O	☐ RA

TARGETED RIFFLE BENTHOS SAMPLE

Sample ID	No. of Jars	Comment
999002	1	

NEAREST TRANSECT	A	A	E	E	F	F	G	G
Dom. Substrate: Fine/Sand	☐ F/S	☐ F/S	☐ F/S	☐ F/S	☐ F/S	☐ F/S	☐ F/S	☐ F/S
Gravel	☒ G	☒ G	☐ G	☒ G	☐ G	☒ G	☒ G	☒ G
Coarse	☐ C	☐ C	☒ C	☐ C	☒ C	☐ C	☐ C	☐ C
Other: Note in Comments	☐ O	☐ O	☐ O	☐ O	☐ O	☐ O	☐ O	☐ O

SUBSTRATE SIZE CLASSES
F/S - ladybug or smaller (<2 mm)
G - ladybug to tennis ball (2 to 64 mm)
C - tennis ball to car sized (64 to 4000 mm)
O - bedrock, hardpan, wood, etc

Additional Benthos Comments

COMPOSITE PERIPHYTON SAMPLE

Sample ID	Composite Volume (mL)	Number of transects sampled (0-11):
809990	500	11

Assemblage ID (50-mL tube, preserved)		Chlorophyll (GF/F filter)		Biomass (GF/F Filter)	
Sample Vol. (mL)	Flag	Sample Vol. (mL)	Flag	Sample Vol. (mL)	Flag
5.0		2.5		2.5	

Flag	Comments

Flag codes: K = Sample not collected; U = Suspect sample; F1, F2, etc. = misc. flag assigned by field crew. Explain all flags in comment sections.

24679

04/11/2002 2002 Sample Collection

Figure 11. Example of a scannable Sample Collection Form, showing data recorded for water chemistry, BMIs, and periphyton.

SECTION D3. RECONCILIATION WITH USER REQUIREMENTS

There is not a specific decision which is solely made as a result of the data collected under this project. These data, will be subsequently analyzed and used by the CDFG, SWRCB and RWQCB's for water quality assessments, IBI development, stream standards modifications, 305(b) reporting, permit decisions, and to help answer numerous other NPS questions.

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APPENDIX A

EMAP Field Operations Manual for Wadeable Streams

APPENDIX B1

State of California Department of Fish and Game/OSPR/WPCL Quality Assurance Project Plan

APPENDIX B2

WPCL Standard Operating Procedures for CMAP water chemistry analytes

APPENDIX C

Quality Assurance Project Plan for the California Stream Bioassessment Procedure

APPENDIX D1

Guidelines for Electrofishing Waters Containing Salmonids listed under the Endangered Species Act (June 2000)

APPENDIX D2

SOP for Acquiring Vertebratre Sampling Permits for EMAP

APPENDIX E

Standard Operating Procedures for Site Evaluation and Reconnaissance, Wadeable Streams, CA. CMAP

APPENDIX F

Environmental Monitoring and Assessment Program: Integrated Quality Assurance Project Plan for Surface Waters Research Activities