CHAPTER 6

MONITORING PROTOCOLS

This chapter is designed to provide specific monitoring resources for volunteer watershed monitoring. At present, there are almost as many different monitoring parameters and protocols available as there are watersheds. Based on present data needs on the Central Coast, this manual focuses on several diverse monitoring parameters, although it does not discuss water quality monitoring in detail. Water quality monitoring has been well-addressed by several different organizations (Save Our Streams, San Francisco Estuary Institute, U.S. Environmental Protection Agency); therefore, we do not detail those monitoring techniques in this document. We have included pertinent references for water quality monitoring at the end of the chapter.

As more emphasis is placed on volunteer monitoring by resource agencies, a stronger need to obtain consistent and reliable data has emerged. By coordinating with resource agency personnel and technical experts, the Monterey Bay Sanctuary Citizen Watershed Monitoring Network (Network) has spent a considerable amount of time researching and refining the most effective and sound protocols for citizen monitoring programs. Through our endeavors, the Network found that some of the resource agencies' key data needs were not being met, and that there was a lack of consistency in volunteer protocols and data collection. In an effort to bridge the gap, the Network chose to focus on five parameters for this manual:

Stream reconnaissance

I Benthic Macroinvertebrate Sampling and Habitat Bioassessment

II. Stormdrain Monitoring

III. Sedimentation Studies

IV. Low Flow Streamflow Monitoring

V. Marine Water Quality Monitoring Program

For each of these topics, we have compiled protocol information and resources to get volunteer groups started. Each section of this chapter provides: 1) background information on the monitoring topic; 2) the current protocol accepted by state and federal resource agencies and/or technical experts; and 3) a list of references and resources.

The protocols in this manual focus on nonpoint source problems. Nonpoint source pollution refers to pollution originating from diffuse sources and entering waterways by variable means. "Nonpoint source pollution has become the nation's largest water quality problem, causing many of our rivers, lakes, and beaches to be unsafe for swimming and fishing. In fact, more than half of the nation's 2,000 major watersheds are moderately to severely impaired due to nonpoint source pollution" (National Wildlife Federation 1998).

Nonpoint source monitoring provides a wonderful educational tool for both the monitoring groups and the general public and also allows citizen monitors to collect important data. To decrease the amount of nonpoint source pollution, we must first increase our communities' awareness of the types of activities that degrade our streams and rivers.

CHAPTER 6

MONITORING PROTOCOLS —STREAM BIOASSESSMENT

STREAM BIOASSESSMENT BACKGROUND INFORMATION

The California Stream Bioassessment is a procedure designed to conduct macroinvertebrate sampling and habitat assessment. This protocol, developed by Harrington and Born (1999), provides a consistent method of data collection for volunteer groups throughout California. The 1999 *Bioassessment for Citizen Monitors* manual and protocol are available through the Sustainable Land Stewardship Institute (www.slsii.org) and the Water Pollution Control Laboratory in Sacramento, California (916.358.2858, JHarring@OSPR.DFG.CA.GOV).

Why conduct stream biological monitoring? Aquatic insects, or benthic macroinvertebrates (BMIs), are the primary food sources for many fish, and are vital to a healthy watershed. Little information is known about benthic macroinvertebrate assemblages in our creeks and streams. What we do know is that many macroinvertebrates respond strongly to pollutants and other anthropogenic impacts and therefore their presence or absence in a stream can tell us a lot about the health of that system. The presence or absence of certain habitat parameters, such as instream cover (submerged logs, undercut banks, etc.), can also affect the stream's quality for fauna such as fish and macroinvertebrates.

Biocriteria obtains "reference" benthic macroinvertebrate assemblages and baseline data for preferred conditions in an area.

Biomonitoring inventories distribution and abundance of a single species or the entire assemblage of species in an area.

Bioassessment determines whether a body of water has been affected by a disturbance, often by point source pollution problems.

Benthic macroinvertebrate sampling

The following protocol in **Stream Bioassessment Protocols** was adapted from the comprehensive *California Bioassessment Manual for Citizen Monitors* (Harrington and Born 2000) which includes:

1 background stream information
2 citizen monitoring
3 laboratory procedures
4 quality assurance/quality control
5 taxonomic keys
6 data sheets

We highly recommend obtaining a copy and attending a training course offered by the Sustainable Land Stewardship International Institute (www.slsii.org). For this manual, we have chosen to focus on the nonpoint sampling design because it will best suit the needs of citizen monitoring groups on the Central Coast. The *California Bioassessment for Citizen Monitors* (Harrington and Born 2000) manual includes a protocol for point source sampling which will not be described here.

STREAM BIOASSESSMENT PROTOCOLS

Nonpoint Source Sampling Design

Adapted from Harrington and Born's
California Bioassessment for Citizen Monitors (2000).

These protocols are divided into 5 separate sections: 1) Site Selection; 2) BMI Collection; 3) Physical/Habitat Characteristics; 4) Assessing Physical/Habitat Quality of a Stream Reach; and 5) Laboratory Procedures for Analyzing BMI Samples.

SITE SELECTION - based on Available Access

This protocol is designed for areas where unlimited access to the stream is not possible due to private property and safety issues. The volunteer monitoring groups should only access portions of a stream or river where there is public access or consent from a landowner has been given. If you wish to access the stream on private property, property owners must be contacted in writing well in advance. Permission should be requested in writing also.

Step 1 Divide the watershed into tributary basins and then each basin into upper, middle and lower sections. Determine road access and property ownership for the watershed and designate the best possible access point in each of these sections.

Step 2 Access the stream at a road crossing or other available access point. Walk upstream and downstream until you reach a change in channel types or are stopped by private property. Identify the reach you will examine. A **reach** is defined as any specified length of stream or a relatively homogenous section of a stream having a repetitious sequence of physical characteristics and habitat types (e.g. riffle, pool, run) (Flosi, Downie, Hopelain, Bird, Coey and Collins 1998). If a bridge is present, try to stay upstream away from the influence of bridge abutments. Identify all the riffles within the reach of the stream. At least 3 riffles, but preferably 5, should be present within the reach you select.

Step 3 Randomly choose 3 riffles using a random numbers table. If you are limited to only three riffles in your reach, then you will take a sample from each.

Step 4 Collect one sample from the upstream third of each riffle. The step-by-step instructions to collect the samples are discussed in the following section.

When to Sample Benthic Macroinvertebrates (BMI)

Sampling should be done in the spring and fall, corresponding to the lifecycle of BMIs. The ideal situation would be to sample just prior to the hatch or when the immature BMIs are ready to leave the water and become adults. In salmonid streams, **care should be taken to avoid entering salmonid streams during the spawning season (winter and spring)**.

Preparation for Sampling

You will need to obtain a Scientific Collecting Permit through the California Department of Fish and Game. You can call the CDFG License and Revenue Branch in Sacramento, CA 916.227.2225 to obtain an application. On your application, it is important to indicate that you will be taking freshwater invertebrates (authorization 5), incidental fish (authorization 6), and amphibians (authorization 8). We also recommend that you contact your regional CDFG biologist to let them know about your plans to sample.

Arana Creek volunteers

PHOTO: BRUCE ASHLEY

Field Equipment and Supplies

Measuring Tape (300 ft or 100 meter)
D-shaped kick net (0.5 mm mesh)
Standard size 35 sieve (0.5 mm)* (we recommend 2 sieves if you can afford it)
Wide-mouth 500 ml jars
White enamel pan
Forceps (several pairs)
95% Ethanol
California Bioassessment Worksheet (CBW)
Physical/Habitat Quality Form
Chain of Custody Form
Random Number Table
pH, temp., DO, and conductivity monitoring equipment
Optional: Stadia rod and hand level or clinometer
Densiometer
Topographic map or GPS unit
2-3 Buckets
Heavy-duty rubber gloves (for collecting the samples)
Quart-sized squirt bottles
Note: These supplies can be ordered through the SLSII at www.slsii.org

Instructions for filling out sample labels

1 Develop a Sampling Identification Number system that indicates stream, reach and riffle. An example is illustrated below (GC for Gazos Creek), an abbreviation for the reach (UP for upper), and a number for the riffle (001).

2 Record the following information on the labels before going into the field: organization collecting the sample, Sampling Identification Number followed by 01, 02, etc. (to identify each transect sampled from a riffle or riffles in a reach), stream name, date and the samplers' initials. Always use a pencil and waterproof paper.

3 While in the field, other descriptive information about the sampling unit can be recorded on the back of the label.

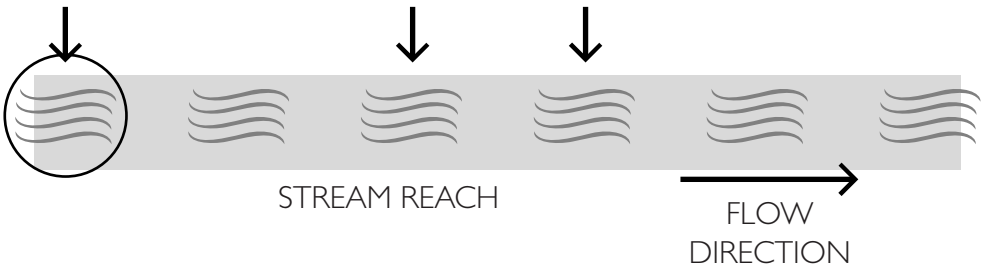
Bioassessment Sample Label

Organization:	Coastal Watershed Council
Sample ID Number:	GC-UP001-01
Stream Name:	Gazos Creek
Date:	09/09/99
Samples by:	MC, JP, SD, and DM

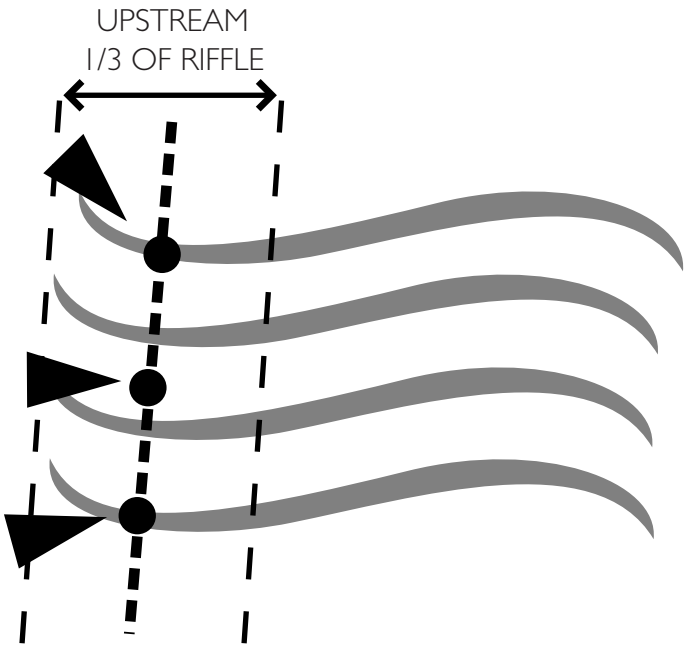
4 Place the label inside the jar after the sample material and 95% ethanol have been added.

Make sure you make labels before you go out into the field to prevent any confusion with the samples later. Bring enough data sheets into the filed with you for each sample. You can download up-to-date data sheets and protocols

1 Randomly, select a minimum of 3 riffles from the reach.



2 Randomly, select one transect within the top 1/3 of the riffle.



3 Collect and combine from both margins and the thalweg, to obtain a representation of the whole width of the riffle. Do this for each of the three randomly chosen riffles.

from the CDFG's Aquatic Bioassessment Lab website at: www.dfg.ca.gov/cabw/cabwhome.html.

BMI COLLECTION

Step 1 Randomly choose 3 of the 5 riffles within the stream reach using the random number table provided.

Step 2 Starting with the downstream riffle within the reach of the stream, place the measuring tape along the bank of the entire riffle. Avoid walking in the stream at this time. The upstream third of the riffle will be used for collecting the BMI sample. Determine which transect will be used by counting the number of meters or 3-foot marks, dividing by 3 and randomly choosing one from the upper third.

Step 3 Inspect the transect before collecting BMIs and imagine a line going from one bank to the other, perpendicular to the flow. Choose 3 locations along that line where you will place your net to collect the sample. If the substrate is fairly similar and there is no structure along the transect, the three locations will be on the left and right banks and the thalweg. When looking at the cross-section of the stream, the thalweg is the deepest part of the stream, and not necessarily the center of the stream. If there is substrate and structure complexity along the transect, then as much as possible, allow the 3 collections to reflect this complexity.

Step 4 After mentally locating the three areas, collect BMIs by placing the D-shaped kick net on the substrate, perpendicular to the flow, and disturbing a 1 x 2 foot portion of substrate upstream of the net to approximately 4-6 inches in depth. The 1-foot part of the 1 x 2 foot section corresponds to the width of your net. Pick up and scrub large rocks by hand underwater in front of the net. Be sure to pick up the substrate in front of the net and do not scoop it onto the net. Let the flow bring the materials into the net. Maintain a consistent sampling effort (approximately 1-3 minutes) at each site. Combine the 3 collections within the net to make one composite sample.

Using a bug net to search for macroinvertebrates in Soquel Creek.

PHOTO: BRUCE ASHLEY

Step 5 Place the contents of the net in a standard size 35 sieve (0.5 mm mesh) or white plastic or enamel tray. Remove the larger twigs, leaves and rocks by hand after carefully inspecting for clinging organisms. Also inspect your net and carefully remove all clinging organisms with a pair of for-

ceps. If a tray is used, place the material through the sieve to remove the water before placing the material in the jar. Place the sampled material and label in a jar and completely fill with 95% ethanol. Never fill a jar more than 2/3 full with sampled material and gently agitate jars that contain primarily mud or sand.

Step 6 Proceeding upstream, repeat steps 2 through 5 for the next 2 randomly chosen riffles within the stream reach.

Standard sieve with BMIs and debris

PHYSICAL/HABITAT CHARACTERISTICS

There are two distinct uses of physical/habitat measures; one to measure the physical condition or quality of a reach of stream and one to measure physical characteristics of the bioassessment sample site to assist the project advisor with data analysis.

The physical/habitat measurements should be conducted after the BMI samples have been collected. All measurements are of the riffle but weighed toward the transects. Always make note in the comment section of the CBW if the characteristics of the transects where the BMI sample was taken is considerably different than that of the riffle as a whole.

Step 1 Record the riffle length, and choose one transect within the top third riffle. Estimate the average riffle width by averaging several measurements along its length. Measure the riffle depth by placing a stadia rod or measuring stick at several places within the riffle and averaging the measurements. A stadia rod, which is simply a long (>8 ft) measuring stick, can be purchased or made.

Step 2 Estimate or measure the entire length of the reach with the three riffles.

Step 3 Estimate the riffle velocity by floating a twig, leaf or other organic object such as an orange, and timing its travel down the length of the riffle. Repeat this three times and divide the distance by time in seconds. Riffle velocity can also be more accurately measured with a flow meter. For more information, see Section IV Streamflow. Place the meter in front of the three locations along the transect(s) where you collected the BMI samples and average the readings.

Step 4 Estimate canopy cover by observing how much of the riffle surface is covered by shade from streamside vegetation. Canopy cover can be more accurately measured using a densiometer at several places along the riffle and averaging.

Step 5 Determine substrate complexity and embeddedness by applying

Parameters 1 and 2, respectively from the Physical/Habitat Quality Form to the riffle where the BMI sample was collected. Use the entire riffle to assess these parameters and make note if the area along the transect(s) is considerably different from the rest of the riffle.

Step 6 Visually estimate the percent of riffle in each of the following substrate categories: fines (<0.1"), gravel (0.1-2"), cobble (2-10"), boulder (>10"), and bedrock (solid). Use the entire riffle to assess this parameter and make note if the area along the transect(s) is considerably different from the rest of the riffle.

Step 7 Estimate substrate consolidation by kicking the substrate with the heel of your boots to note whether it is loosely, moderately or tightly cemented. The estimate should also take into consideration the hands-on experience obtained from collecting the BMI sample(s).

Step 8 Measure the gradient or slope of the riffle using a stadia rod and hand level. A hand-held level is a small telescope with a bubble level inside. First you measure the height of your eye on the stadia rod and then have someone take the rod to the top of the riffle while you make a level reading of the rod. The difference in height between your eye and the top of the riffle divided by the length of the riffle times 100% equals the percent gradient. It is important to measure gradient from the surface of the water and not the stream bottom.

Using the California Bioassessment Worksheet (CBW)

A California Bioassessment Worksheet (CBW) should be filled out for each reach. Use the following step-by-step procedures for filling out the CBW:

Step 1 Enter the watershed and stream name, date and time of sample collection, name of the monitoring or watershed group collecting the samples, sample identification number(s), and a short site description on the CBW.

Step 2 Enter the names of each crew member in the Crew Member Box.

Step 3 Determine the latitude and longitude coordinates and elevation from a GPS unit or watershed topographic map. Determine in which California ecoregion or sub-ecoregion the site is located by using the U.S. Forest Service map obtained by visiting the California Aquatic Bioassessment Web Site. Record this information and any other comments on the sampling site in the Site Location Box.

Step 4 Record the water temperature, specific conductance, pH and dissolved oxygen measurements in the Chemical Characteristics Box.

Step 5 Record the physical/habitat characteristics in the Riffle/Reach Characteristics Box. Record the reach length, the total score from the Physical/Habitat Quality Form and all the physical/habitat characteristics information on the lines below "riffle 1" through "riffle 3" columns.

Step 6 Record the location of the laboratory being used by your group to process the samples. If the group will be contracting out the laboratory work, then record the name and address of the bioassessment laboratory that received the samples along with the laboratory-issued sample numbers if they are different from the field sample identification numbers.

Sorting BMIs

ASSESSING PHYSICAL/ HABITAT QUALITY OF A STREAM REACH

The U.S. EPA's Physical/Habitat Quality procedure is designed to assess the entire reach where the BMI samples are collected as part of the nonpoint source sampling design. Since the bioassessment is for sampling riffles in wadeable streams, the high gradient procedure is the procedure to use for most of the Central Coast stream reaches. This procedure must be performed as part of the bioassessment procedure. Read the following instructions from the U.S. EPA's Rapid Bioassessment Procedures document before conducting the physical/habitat quality evaluation.

We also strongly recommend visiting the U.S. EPA's Rapid Bioassessment website at: www.epa.gov/owow/monitoring/rbp/download.html. At this site, you can view representative photos for each of the parameters and also get information on other aspects of the rapid bioassessment protocol.

HABITAT ASSESSMENT AND PHYSICOCHEMICAL PARAMETERS

Parameters to be evaluated in sampling reach:

1 EPIFAUNAL SUBSTRATE/AVAILABLE COVER

high and low gradient streams

Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna. A wide variety and/or abundance of submerged structures in the stream provides macroinvertebrates and fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, diversity decreases, and the potential for recovery following disturbance decreases. Riffles and runs are critical for maintaining a variety and abundance of insects in most high-gradient streams and serving as spawning and feeding refugia for certain fish. The extent and quality of the riffle is an important factor in the support of a healthy biological condition in high-gradient streams. Riffles and runs offer a diversity of habitat through variety of particle size, and, in many small high-gradient streams, will provide the most stable habitat. Snags and submerged logs are among the most productive habitat structure for macroinvertebrate colonization and fish refugia in low-gradient streams. However, "new fall" will not yet be suitable for colonization.

Selected References

Wesche et al.. 1985, Pearsons et al.. 1992, Gorman 1988, Rankin 1991, Barbour and Stribling 1991, Plafkin et al.. 1989, Platts et al.. 1983, Osborne et al.. 1991, Benke et al.. 1984, Wallace et al.. 1996, Ball 1982, MacDonald et al.. 1991, Reice 1980, Clements 1987, Hawkins et al.. 1982, Beechie and Sibley 1997.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Epifaunal Substrate/ Available Cover (high and low gradient)	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; 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.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

2A EMBEDDEDNESS

high gradient streams

Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish (shelter, spawning, and egg incubation) is decreased. Embeddedness is a result of large-scale sediment movement and deposition, and is a parameter evaluated in the riffles and runs of high-gradient streams. The rating of this parameter may be variable depending on where the observations are taken. To avoid confusion with sediment deposition (another habitat parameter), observations of embeddedness should be taken in the upstream and central portions of riffles and cobble substrate areas.

Selected References

Ball 1982, Osborne et al.. 1991, Barbour and Stribling 1991, Platts et al.. 1983, MacDonald et al.. 1991, Rankin 1991, Reice 1980, Clements 1987, Benke et al.. 1984, Hawkins et al.. 1982, Burton and Harvey 1990.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Embeddedness (high gradient)	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.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

2B POOL SUBSTRATE CHARACTERIZATION

low gradient streams

Evaluates the type and condition of bottom substrates found in pools. Firmer sediment types (e.g.,, gravel, sand) and rooted aquatic plants support a wider variety of organisms than a pool substrate dominated by mud or bedrock and no plants. In addition, a stream that has a uniform substrate in its pools will support far fewer types of organisms than a stream that has a variety of substrate types.

Selected References Beschta and Platts 1986, U.S. EPA 1983.

HABITAT PARAMETER	CONDITION CATEGORY: OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Pool Substrate Characterization (low gradient)	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or submerged vegetation.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

3A VELOCITY/DEPTH COMBINATIONS

high gradient streams

Patterns of velocity and depth are included for high-gradient streams under this parameter as an important feature of habitat diversity. The best streams in most high-gradient regions will have all 4 patterns present: (1) slow-deep, (2) slow-shallow, (3) fast-deep, and (4) fast-shallow. The general guidelines are 0.5 m depth to separate shallow from deep, and 0.3 m/sec to separate fast from slow. The occurrence of these 4 patterns relates to the stream's ability to provide and maintain a stable aquatic environment.

Selected References Ball 1982, Brown and Brussock 1991, Gore and Judy 1981, Oswood and Barber 1982.

HABITAT PARAMETER	CONDITION CATEGORY: OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Velocity/ Depth Regimes (high gradient)	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5 m).	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).
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

3B POOL VARIABILITY

low gradient streams

Rates the overall mixture of pool types found in streams, according to size and depth. The 4 basic types of pools are large-shallow, large-deep, small-shallow, and small-deep. A stream with many pool types will support a wide variety of aquatic species. Rivers with low sinuosity (few bends) and monotonous pool characteristics do not have sufficient quantities and types of habitat to support a diverse aquatic community. General guidelines are any pool dimension (i.e., length, width, oblique) greater than half the cross-section of the stream for separating large from small and 1 m depth separating shallow and deep.

Selected References Beschta and Platts 1986, USEPA 1983.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Pool Variability (low gradient)	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

4 SEDIMENT DEPOSITION

high and low gradient streams

Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Deposition occurs from large-scale movement of sediment. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of runs and pools. Usually deposition is evident in areas that are obstructed by natural or manmade debris and areas where the stream flow decreases, such as bends. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms.

Selected References

MacDonald et al.. 1991, Platts et al.. 1983, Ball 1982, Armour et al.. 1991, Barbour and Stribling 1991, Rosgen 1985.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Sediment Deposition (high and low gradient)	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.
SCORE	**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

high and low gradient streams

The degree to which the channel is filled with water. The flow status will change as the channel enlarges (e.g.,, aggrading stream beds with actively widening channels) or as flow decreases as a result of dams and other obstructions, diversions for irrigation, or drought. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. In high-gradient streams, riffles and cobble substrate are exposed; in low-gradient streams, the decrease in water level exposes logs and snags, thereby reducing the areas of good habitat. Channel flow is especially useful for interpreting biological condition under abnormal or lowered flow conditions. This parameter becomes important when more than one biological index period is used for surveys or the timing of sampling is inconsistent among sites or annual periodicity.

Selected References Selected References Rankin 1991, Rosgen 1985, Hupp and Simon 1986, MacDonald et al.. 1991, Ball 1982, Hicks et al.. 1991

HABITAT PARAMETER	CONDITION CATEGORY OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Channel Flow Status (high and low gradient)	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.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

Parameters to be evaluated broader than sampling reach:

6 CHANNEL ALTERATION

high and low gradient streams

Is a measure of large-scale changes in the shape of the stream channel. Many streams in urban and agricultural areas have been straightened, deepened, or diverted into concrete channels, often for flood control or irrigation purposes. Such streams have far fewer natural habitats for fish, macroinvertebrates, and plants than do naturally meandering streams. Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred. Scouring is often associated with channel alteration.

Selected References Barbour and Stribling 1991, Simon 1989a, b, Simon and Hupp 1987, Hupp and Simon 1986, Hupp 1992, Rosgen 1985, Rankin 1991, MacDonald et al.. 1991.

HABITAT PARAMETER	CONDITION CATEGORY OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Channel Alteration (high and low gradient)	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.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

7A FREQUENCY OF RIFFLES (OR BENDS)

high gradient streams

Is a way to measure the sequence of riffles and thus the heterogeneity occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna, therefore, an increased frequency of occurrence greatly enhances the diversity of the stream community. For high gradient streams where distinct riffles are uncommon, a run/bend ratio can be used as a measure of meandering or sinuosity (see 7b). A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refugia for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in some streams, a longer segment or reach than that designated for sampling should be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The "sequencing" pattern of the stream morphology is important in rating this parameter. In headwaters, riffles are usually continuous and the presence of cascades or boulders provides a form of sinuosity and enhances the structure of the stream. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al.. 1992).

Selected References Hupp and Simon 1991, Brussock and Brown 1991, Platts et al.. 1983, Rankin 1991, Rosgen 1985, 1994, 1996, Osborne and Hendricks 1983, Hughes and Omernik 1983, Cushman 1985, Bain and Boltz 1989, Gislason 1985, Hawkins et al.. 1982, Statzner et al.. 1988.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Frequency of Riffles (or bends) (high gradient)	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.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

7B CHANNEL SINUOSITY

low gradient streams

Evaluates the meandering or sinuosity of the stream. A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refugia for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in low gradient streams, a longer segment or reach than that designated for sampling may be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The "sequencing" pattern of the stream morphology is important in rating this parameter. In "oxbow" streams of coastal areas and deltas, meanders are highly exaggerated and transient. Natural conditions in these streams are shifting channels and bends, and alteration is usually in the form of flow regulation and diversion. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al.. 1992).

Selected References Hupp and Simon 1991, Brussock and Brown 1991, Platts et al.. 1983, Rankin 1991, Rosgen 1985, 1994, 1996, Osborne and Hendricks 1983, Hughes and Omernik 1983, Cushman 1985, Bain and Boltz 1989, Gislason 1985, Hawkins et al.. 1982, Statzner et al.. 1988.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Channel Sinuosity (low gradient)	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	**20 19 18 17 16**	**15 14 13 12 11**	**10 9 8 7 6**	**5 4 3 2 1 0**

8 BANK STABILITY (condition of banks)

high and low gradient streams

Measures whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. Eroded banks indicate a problem of sediment movement and deposition, and suggest a scarcity of cover and organic input to streams. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

Selected References Ball 1982, MacDonald et al.. 1991, Armour et al.. 1991, Barbour and Stribling 1991, Hupp and Simon 1986, 1991, Simon 1989a, Hupp 1992, Hicks et al.. 1991, Osborne et al.. 1991, Rosgen 1994, 1996.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Bank Stability (score each bank) Note: determine left or right side by facing downstream (high and low gradient)	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.
SCORE	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 BANK VEGETATIVE PROTECTION

high and low gradient streams

Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. This parameter is made more effective by defining the native vegetation for the region and stream type (i.e., shrubs, trees, etc.). In some regions, the introduction of exotics has virtually replaced all native vegetation. The value of exotic vegetation to the quality of the habitat structure and contribution to the stream ecosystem must be considered in this parameter. In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded and can extend to the bank vegetative protection zone. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

Selected References Platts et al.. 1983, Hupp and Simon 1986, 1991, Simon and Hupp 1987, Ball 1982, Osborne et al.. 1991, Rankin 1991, Barbour and Stribling 1991, MacDonald et al.. 1991, Armour et al.. 1991, Myers and Swanson 1991, Bauer and Burton 1993.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Vegetative Protection (score each bank) Note: determine left or right side by facing downstream (high and low gradient)	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.
SCORE	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

high and low gradient streams

Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic degradation of the riparian zone. Conversely, the presence of "old field" (i.e., a previously developed field not currently in use), paths, and walkways in an otherwise undisturbed riparian zone may be judged to be inconsequential to altering the riparian zone and may be given relatively high scores. For variable size streams, the specified width of a desirable riparian zone may also be variable and may be best determined by some multiple of stream width (e.g.,, 4 x wetted stream width). Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

Selected References Barton et al.. 1985, Naiman et al.. 1993, Hupp 1992, Gregory et al.. 1991, Platts et al.. 1983, Rankin 1991, Barbour and Stribling 1991, Bauer and Burton 1993.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
Riparian Vegetative Zone Width (score each bank riparian zone) (high and low gradient)	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 have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE	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**

ANALYZING BMI SAMPLES Laboratory Procedures

Once the BMI samples are collected, they will need to be processed in a laboratory and identified to a specific level of taxonomy. There are three levels of BMI identification:

Level 1 Taxonomic Effort- requires subsampling 100 BMIs from the sample, sorting those 100 BMIs into the major taxonomic groups and then separating the mayflies, stoneflies, and caddisflies into their different morphologic forms.

Level 2 Taxonomic Effort- requires subsampling 100 BMIs from the sample, sorting those 100 BMIs into major taxonomic groups and then identifying those groups to the family level of taxonomy.

Level 3 Taxonomic Effort (the professional level equivalent)- requires subsampling 300 BMIs into the major groups and then identifying those groups to the lowest possible taxon, usually to genera and/or species level.

We recommend that volunteer groups focus on the first two levels of effort. Level 1 does not require identification beyond the major groups, except for the important insects in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which are only separated by morphological differences. Level 1 is a faster, less technical analysis of the BMI sample and is ideal for citizen groups just getting started, or for high school projects stressing education as well as long term monitoring goals. Level 2 is the preferable taxonomic level for citizen groups.

We recommend sending your BMI samples to a professional BMI lab for Level 3 identification. A list of qualified BMI laboratories and taxonomists can be found on the CDFG's bioassessment website: (www.dfg.ca.gov/cabw/cabwhome.html). However, it is suggested that monitoring groups at least attempt to conduct the laboratory portion of the CSBP because it will help the educational process of your group. Again, we also strongly recommend attending a BMI training course offered by the Sustainable Land Stewardship Institute (www.slsii.org) to help with the learning curve of BMI identification.

In order to conduct laboratory identification, monitoring groups will need to obtain a copy of the Bioassessment for Citizen Monitors (Harrington and Born 1999). This manual contains detailed instruction for laboratory identification and also includes a taxonomic identification key complete with illustrations. Finding a high school or junior college laboratory with dissecting scopes that you can use would be very helpful. A list of supplies you will need follows. You can order these supplies through SLSI's website (www.slsii.org).

Laboratory Equipment and Supplies

Dissecting microscope
Gridded white enameled pan
Plastic petri dish
Taxonomic keys
Forceps
Waterproof paper and pencils
Random Number Table
Standard size 5 sieve (0.5 mm)
Wide-mouth glass jars
Vials
70% ethanol/5% glycerin solution
List of Standardized Taxonomic Levels
Laboratory benchsheets
Chain of Custody Form

Pescadero Creek, summer, 1999

STREAM BIOASSESSMENT REFERENCES & RESOURCES

Important Resources:

Jim Harrington, California Department of Fish & Game.
Water Pollution Control Laboratory
Oil Spill Prevention and Response Department,
2005 Nimbus Road
Rancho Cordova, CA 95670
Ph 916.358.2858
Email: jharrington@OSPR.DFG.CA.GOV
www.dfg.ca.gov/cabw/cabwhome.html

Sustainable Land Stewardship International Institute
Ph: 916.456.5696
Fax: 916.456.5616
Email: slsi@cwnet.com
www.slsii.org

EPA's Rapid Bioassessment Protocol:
www.epa.gov/owow/monitoring/rbp

References:

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1997. Revision to Rapid Bioassessment Protocols for Use in Streams and Rivers. Technical document no: EPA 841-D-97-002, Washington D.C. www.epa.gov/owow/monitoring/rbp

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey and B. Collins. 1998 California Salmonid Stream Habitat Restoration Manual, Third Edition. California Department of Fish and Game. Inland Fisheries Division. Sacramento, CA.

Harrington, Jim & Monique Born. 1999. Bioassessment for Citizen Monitors: A New Era for Water Quality. Sustainable Land Stewardship International Institute. Sacramento, CA.

Kellogg, L.L. 1994. Save Our Streams Monitor's Guide to Aquatic Macroinvertebrates. The Izaak Walton League of America, Gaithersburg, MD.

McCafferty, W. P. 1998. Aquatic Entomology. Jones & Bartlett Publishers, Sudbury Massachusetts.

Merritt, R.W. & K.W. Cummins. 1995. An Introduction to the Aquatic Insects of North America. Third Edition. Kendall/Hunt Publishing Co., Dubuque, IA.

U.S. Environmental Protection Agency. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Technical document no: EPA 440/4-89/001, Washington D.C.

CHAPTER 6

MONITORING PROTOCOLS —STORMDRAIN MONITORING

STORMDRAIN MONITORING BACKGROUND INFORMATION

Assessment of stormdrain outflow is an important way to quantify one type of nonpoint source pollution. Stormdrains, which channel urban pollutants, provide endpoints at which some parameters may be measured. Examples of urban runoff sources are:

Motor Oil
Antifreeze
Copper from brake pads
Paints
Soaps
Fertilizers
Trash

These sources can come from overland runoff from roads, permeation through agricultural lands, commercial sources, household sources, and improper or illegal connections to the stormdrain system. During dry periods, such as summers in Central California, stormdrain systems should contain little or no flow. Volunteer monitoring programs can be used to understand the types of discharges entering stormdrains during no flow periods.

A highly effective stormdrain monitoring program has been pioneered by Texas Watch, an environmental monitoring program developed by the Texas Natural Resource Conservation Commission. With the help of LaMotte Company, Texas Watch developed a stormdrain monitoring kit to be used in the field. Texas Watch protocols have been developed with the cooperation of the US Environmental Protection Agency, and are available through Texas Watch at the address below. The kit was developed according to National Pollutant Discharge Elimination System (NPDES) Phase I dry weather monitoring requirements and is designed

Santa Cruz water testers

Stormdrain sample collection

to detect illegal stormdrain connections and discharges. The Texas Watch stormdrain monitoring program focuses on dry weather monitoring, and attempts to pinpoint areas where illegal or illicit connections to stormdrains might have occurred.

The Coastal Watershed Council has been conducting the "Urban Watch" program with the City of Monterey for three years and with Pacific Grove for one year. The City of Monterey Urban Watch Monitoring Program was initiated in June 1997 and was a collaborative effort between the Coastal Watershed Council, the City of Monterey and the Water Quality Protection Program of the Monterey Bay National Marine National Marine Sanctuary. The purpose of this project is : (1) to use trained volunteers to monitor dry weather stormdrain summer activity in selected outflow areas during the summers; (2) to identify common pollutants/contaminants within the stormdrains in the study area; and (3) to provide data for public works personnel in order to pinpoint "hot spot areas." The program uses the "Urban Watch" monitoring kit manufactured by the LaMotte Company and designed in association with the City of Ft. Worth, Texas.

Following a one day training, volunteers are instructed to conduct sampling once to twice per month. Volunteers do not need a chemistry or biology background to get involved. Volunteers are divided into several teams with three to four members each. Volunteers conduct sampling twice within a 24-hour period with at least 4-hours between each sampling event. Parameters monitored include detergents, phenols, ammonia nitrogen, chlorine, turbidity, pH, water and air temperature, odor, and color. Volunteers also note if they observe oil sheen, sewage, trash, and surface scum present.

Data produced by such programs such as Texas Watch or CWC's Urban Watch is distributed to agencies and stakeholders within the urban watershed. For example, on the Central Coast, an important interested party is the Monterey Bay National Marine Sanctuary program. Pollution entering stormdrain systems in many of Central California's coastal cities ends up in the Sanctuary and contributes to degradation of marine water quality. The dissemination of analyzed data to agencies allows them to develop or improve management practices within the urban area, and potential problem points upstream. When the source of pollution is a commercial business, the agencies can use data supplied by the volunteer monitors to educate the business, helping it to improve its practices and reduce its impacts to receiving waters.

Types of urban pollutants in stormdrains:

Industrial
Freeways/roads
Residential/commercial
Agricultural

Typical pollutants of concern:

Solids
Trash & debris
Sediments
Bacteria & other pathogens
Nutrients (e.g., nitrogen, phosphorus)
Toxins
Petroleum hydrocarbons (e.g., grease, oil, solvents)
Heavy metals (e.g., lead, copper, cadmium)
Synthetic organics (e.g., pesticides, herbicides)
Chlorine
Detergents

The stormdrain monitoring kit (Stormdrain Kit # 7446) developed for this type of sampling is produced by LaMotte Company, 1.800.344.3100. The estimated cost of this kit is $500.00.

STORMDRAIN MONITORING PROTOCOLS AND OBJECTIVES

MONITORING PREPARATION

When planning your stormdrain monitoring program, obtain maps of your area and map out the location of all of the stormdrains. Work with your city's public works department to obtain maps and insight as to storm drains to focus on. Next, select stormdrains that are downstream of different land uses. For instance, in Coastal Watershed Council's Monterey Urban Watch Program, we monitor sites based on the City's Public Works Department recommendations. The sites monitored in the Monterey area include the following land uses: 1) residential, 2) golf courses, 3) commercial/ restaurants, and 4) highway runoff.

Before you go out to your monitoring site, make sure you have all of the necessary equipment:

Stormdrain monitoring kit

Required equipment for sampling

Data sheets/data binder	**Distilled/deionized water**
Thermometer	**Waste water container**
Whirl-Pak bags	**Stormdrain Monitoring Info. Display**
Permanent marker	**Paper towels**
Rubber gloves and eye protection	**Sponge**
LaMotte Stormdrain monitoring kit	**Trash bags**
Ruler (in centimeters)	**Cooler with ice**

The LaMotte stormdrain kit should contain all of the necessary supplies for stormdrain testing. Carefully follow the instructions for each chemical test as listed on the inside of the kit. We recommend conducting 1-2 training sessions to familiarize yourself with the testing procedures before you actually start collecting data.

Physical parameters, such as salinity, temperature, and dissolved oxygen, may also be important to incorporate into your monitoring design. Some chemicals that may be present are difficult to test for without the use of lab facilities: these include hydrocarbons, xenoestrogens, etc. You may want to contact a local lab to find out more details about testing parameters such as these.

MONITORING SITE TIPS

SAFETY FIRST!

Safety concerns are paramount in the use of the stormdrain monitoring kit. Many of the chemicals used in the tests are toxic or caustic. It is extremely important to consider safety for kit users whether in the field or in the lab. Keep safety in mind when parking vehicles near the sampling site and crossing traffic.

Other Safety and Equipment Considerations

- Avoid contact between reagent chemicals and skin, eyes, nose, and mouth.
- Safety glasses and gloves are necessary when handling kit chemicals or completing tests.
- When rinsing test tubes or mixing chemicals, cap the tubes with their covers, never with a gloved finger.
- When dispensing a reagent from a plastic squeeze bottle, hold the bottle vertically upside-down (not at an angle) and gently squeeze it (if a gentle squeeze does not suffice, the dispensing cap or plug may be

EQUIPMENT CHECKLIST

LaMotte stormdrain monitoring kit

IN STOCK?	EQUIPMENT	LIFE SPAN	REORDER
	pH meter pH calibrating buffer spare batteries	 2 yrs 	
	chlorine chlorine test tablets color slide phenols aminoantipyrine reagent ammonium hydroxide solution potassium ferricyanide solution spoon, 0.1 g pipet, plain glass, with cap pipet assembly, 1.0 ml plastic, with cap sample reaction tube color slide	 3 yrs 2 yrs 3 yrs 2 yrs	
	detergent reagent #1 reagent #2 reagent #3 pipet assembly, 0.5 ml, glass measuring spoon, 1.0 g test jar calibrated to 65 ml and 75 ml	 3 yrs 2 yrs 18 mos	
	copper reagent 2 years color slide ammonia nitrogen reagent #1 tablets reagent #2 tablets color card	 3 years 3 years	
	turbidity turbidity slide		
	color Borger Color System (booklet)		
	8 test tubes and 8 caps		

clogged). Holding the bottle at an angle results in differing sizes of drops, possibly changing your results and replicability.
- Wipe up any reagent spills**,** liquid or powder, as soon as they occur.
- Tightly close all reagent containers and return to kit immediately after use. Do not interchange caps from different containers.
- Avoid prolonged exposure of equipment and reagents to direct sunlight. Protect them from extremely high temperatures and freezing. Be sure to check expiration dates of the reagents, and replace those out-of-date.

Note taking

- Make sure you legibly record the data in the right place
  Take your time and fill out the data sheet completely
- Take notes on anything that could be affecting your data at that site.
  Note anything that may be directly affecting the data or conditions that have been affected by stormdrain flow.
  For example:
  land use changes - upstream or downstream
  vegetation changes (including algae)
  signs of recent higher flows coming out of the stormdrain
  signs of life in the water: fish, birds, tadpoles....
  possible discharge source
  information from passersby

Sample Collection

- Never try to take a sample if conditions are dangerous! This includes high water, high tide, obvious toxins (e.g., raw sewage), unstable or slippery slopes, biohazards (e.g., needles), etc.
- There should always be at least 2 people when you go out to monitor
- To collect the sample, use gloves and a Whirl-Pak bag. Make sure you write the sample location and date on the bag before it gets wet.
- Take the water from the mid-part of the flow without disturbing the bottom of the stormdrain.
- If the water is at a very low flow you may have to use another Whirl-Pak bag to create a ledge that allows you to direct the water into the first Whirl-Pak bag.
- After you are done with the sample collection look back over your data sheet to make sure that:
  - there are no blank spots where there should be information
  - all numbers are neat and in their correct place
  - all information is legibly written

If it has rained more than 1/10th of an inch in the last 48 hours
DO NOT SAMPLE!

Photo Documentation

Always record in the notes that you have taken a picture and what the picture shows. Be sure to make a note on the data sheet as to what number the photo is on the film roll.

Here are some considerations to make when you are taking a picture:

- Take a photo only if an occurrence or event would best be represented as a photo and not just in words or numbers.
- Pack as much information in the photo as possible.
- Include an object of known dimensions in the photo for scale.
- Examples of things to photograph are:
  - unusual water colors or flows
  - unusual amounts of trash
  - pollution sources

Analysis

- The pH meter must be calibrated within 24 hours of usage. See instruction sheet in the kit for this procedure.
- Follow the instructions provided on the kit for doing the test every time. Do not assume that you remember it from last time.

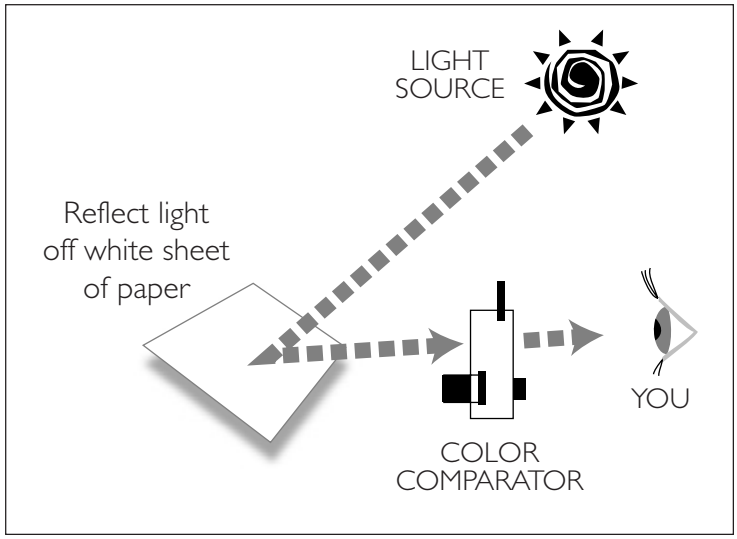
Rule 1 Always rinse the test tube you are using for your chemical reaction out three times with distilled water before putting the sample water into the tube. To rinse, put distilled water in the container, cap (not with your finger, gloved or otherwise!) shake, and empty the water into the wastewater receptacle provided.

Rule 2 Always use this method to judge color comparisons:

- One person does the detergent testing for all the sites. For each dropper-full of the detergent, make a tick mark on the data sheet. This allows the data manager to clearly see how much reagent has been used.
- One person will do the phenols testing.
- The remaining parameters can be split up among the other volunteers.

DO NOT SUBMERGE THE pH METER BELOW THE LINE ON THE METER.

- Note that there are set protocols for describing smells and colors.
  For smells: fan the air above your sample toward your nose.
  For colors: use the Borger Color System and compare the sample side by side to the color examples.



Cleaning the Kit

- Clean the kit immediately after use.
- It is important to rinse test tubes with deionized water, 3 times in succession, after each test procedure is completed.
- At the end of each day, all sampling and test glassware should be brushed with a test tube brush and rinsed 3 times in succession with deionized water.
- To avoid possible detergent test interference, do not use detergent (soap) to clean the Detergent Test Jar (0800). Rinse 3 times in succession with deionized water only.
- Be sure to note broken equipment or chemicals that need to be replaced

Important Phone Numbers

In the event of an accident or suspected poisoning, immediately call the Poison Control Center at 1-800-662-9886 or call your physician.

- Be prepared to give the name of the reagent in question and its LaMotte code number.

LaMotte reagents are registered with POISINDEX, a computerized poison control information system available to all local poison control centers. Keep hazardous material safety data sheets for each reagent and chemical (supplied by LaMotte with each reagent) in the kit at all times. These sheets provide important safety precautions and emergency first aid procedures.

STORMDRAIN RESOURCES AND REFERENCES

Important Resources:

LaMotte Company
P.O. Box 329, Chestertown, MD 21620
Ph: 1.800.344.3100

Texas Watch
MC 150, P.O. Box 13087, Austin, TX 78711-3087.
Ph: (512) 239.4720.
www.tnrcc.state.tx.us/txwatch/

Maris Sidenstecker, Monterey Bay National Marine Sanctuary.
299 Foam Street
Monterey, CA 93940
Ph: (831) 647-4216
www.mbnms.nos.noaa.gov

A Stormwater Resource Guide
of Public Outreach Materials in California
Contact: Joyce Neil
Stormwater Management Division
City of Los Angeles
650 S. Spring St., Suite 700
Los Angeles, CA 90014
(213) 847-4842
Fax: (213) 847-5443

To begin a city outreach program you *must obtain* a copy of the Model Urban Runoff Program Guide. This is the most comprehensive list of stormwater related outreach materials in California. Many stormwater programs actively share public information materials. Use this guide to utilize existing materials and share products that your program has developed with others.

To order:
Model Urban Runoff Program:
A How-To Guide for Developing Urban Runoff Programs for Small Municipalities:
Mail request to: Copy King—Attn: Chris
MURP Order
498 Calle Principal
Monterey, CA 93940
Cost of Manual: $165.96 plus $19.03 each for shipping and tax
Make checks payable to: Copy King
Allow 4-6 weeks for delivery

References:

California's Nonpoint Source Pollution Control Program Volumes 1 & 2, 1998-2013, SWRCB and California Coastal Commission, July 2, 1999.

Lehner et al.. 1999. Stormwater Strategies: Community Responses to Runoff Pollution. Natural Resources Defense Council, New York.

Texas Watch, Texas Watch Stormdrain Monitoring Manual. MC 150, P.O. Box 13087, Austin, TX 78711-3087 : (512) 239.4720. www.tnrcc.state.tx.us/txwatch/

Woodward-Clyde Consultants. 1998. Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. A guide developed for the following local governments: City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments and the Central Coast Regional Water Quality Control Board Monterey, CA.

CHAPTER 6

MONITORING PROTOCOLS —SEDIMENTATION STUDIES

SEDIMENTATION STUDIES BACKGROUND INFORMATION

Sediment monitoring is a new area volunteer monitoring groups have become involved with in the last few years. While sedimentation in Central California streams has been identified as a primary limiting factor for salmonid reproduction and rearing, management measures to reduce sediment are just beginning.

Sediment monitoring should be approached with the help of a qualified technical advisor such as a hydrologist or geomorphologist. The types of monitoring conducted to understand sediment delivery and processes within a watershed are extremely complex and require knowledge of geology, hydrology and geomorphology.

Strengths of Volunteers

One of the strengths in using volunteers to do sediment monitoring is that volunteers often stay committed for several years, and when sufficiently trained, can aid in the training of other volunteers. This is extremely valuable when working with resource management agencies that are implementing on-the-ground projects aimed at reducing or eliminating sediment sources. A volunteer group can grow to meet the needs of the project's monitoring goals as long as the volunteer group is managed effectively.

Summer channel monitoring

Winter monitoring

Water column sediment monitoring needs to occur in the winter months, during the rainy period, and often during heavy storms. Sediment monitoring conducted during the winter focuses on sampling bedload and suspended sediment, conducting stream discharge measurements, and creating rating curves to compute daily, monthly and annual sediment transport

through each monitoring station (Kittleson unpubl). Only professionals should conduct this type of sediment monitoring.

Summer monitoring

The most effective use of volunteers in conducting sediment monitoring is during low flow periods, generally corresponding to the summer and early fall months. Low flow sediment monitoring provides data that can help evaluate changes in bed conditions over time (Gary Kittleson, unpubl). This is valuable for providing information about how much and what type of sediment is entering a given stream. Low flow monitoring can also contribute to the understanding of how sediment may be impacting fisheries habitat.

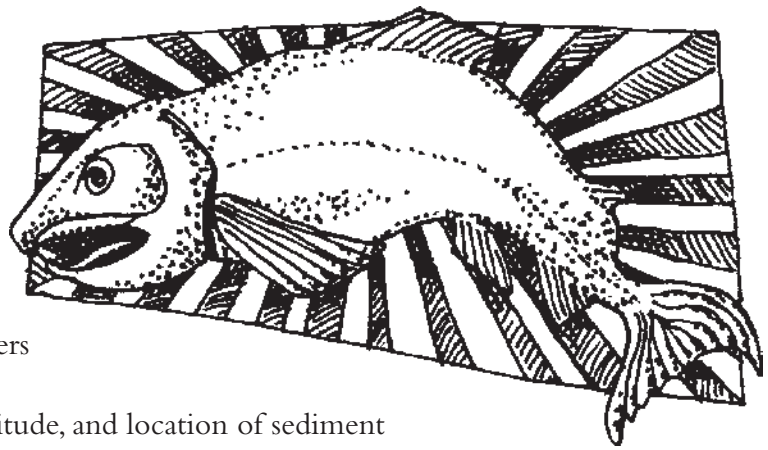
INFLUENCES ON THE NEED FOR SEDIMENT MONITORING

Sediment Total Maximum Daily Load Requirements (TMDLs)

Section 40CFR130.2 in the Clean Water Act, called the Total Maximum Daily Load (TMDL) provision, establishes the allowable amount for a pollutant (or other quantifiable parameters) for a water body (U.S. Environmental Protection Agency 1997). This provides the basis for states to establish water-quality based controls (example: sediment loads that allow for less than 25 percent embeddedness). TMDLs are required for water bodies listed as impaired or not meeting the standard for a particular constituent by the State Water Resources Control Board. Currently there are several watersheds on the Central Coast which have been listed as impaired for sedimentation, including Pajaro, Salinas, San Lorenzo, and Pescadero watersheds. Sediment TMDLs for these watersheds will be established over the next several years. The Environmental Protection Agency (EPA) is currently developing protocols for the development of TMDLs for pathogens, sediment, and nutrients. The TMDL process requires monitoring affected areas of the watershed over the long term. While professionals do most of the monitoring for TMDLs, there are some types of monitoring that can be conducted by volunteers, especially under the guidance of appropriate technical advisors. The long-term nature of TMDL monitoring is what makes this type of work a good match for volunteer groups.

Sedimentation and road failure during 1998 flooding, Gazos Creek

The TMDL development process includes:



- Problem identification for a listed water body that describes impairment
- Identification of water quality indicators and target values (target values could be set by parameters such as pebble counts)
- Source analysis to identify type, magnitude, and location of sediment
- Linkage between source analysis and indicators (cause and effect relationship)
- Allocation of sediment loads
- Assembling the TMDL
- Follow-up monitoring

Some categories of indicators for sediment TMDLs include:

- Water column sediment indicators
- Streambed sediment indicators
- Other channel conditions
- Biological indicators
- Riparian and hillslope indicators

Recovery Efforts for Salmonid Species

Other efforts that are occurring in many Central Coast streams focus on recovery of native salmonid species, which have been listed as endangered or threatened under the federal Endangered Species Act (ESA). One of the most important limiting factors identified for salmonid streams is sedimentation of spawning gravels and filling of pool and riffle areas. Agencies charged with developing recovery plans for these species are looking at ways to quantify baseline conditions in streams for instream habitat and ways to evaluate whether restoration efforts are effective at improving instream channel conditions. Sedimentation studies can serve as an excellent tool to monitor pre-and post restoration projects to see if the restoration project met its objectives.

There are many types of monitoring which are appropriate for volunteers to conduct with regards to fisheries habitat and sedimentation. Volunteer data can provide important information for resource managers working towards restoring fisheries. Groups interested in monitoring bed conditions for evaluating salmonid habitat should seek the assistance of a professional fisheries biologist, fluvial geomorphologist and/or hydrologist.

SEDIMENTATION STUDIES PROTOCOL AND OBJECTIVES

The main data collection tasks recommended for volunteer sediment monitoring focus on monitoring that can be done during summer or low flow periods. The recommended parameters include:

Bed condition survey (pebble counts)
Longitudinal/Thalweg profiles
Cross sections of stream channels
Road surveys

Each of these parameters is discussed below and protocols are provided. Sample data sheets can be found in the appendix of this manual.

CASE STUDY:
Coastal Watershed Council
Sediment Monitoring for San Lorenzo River Watershed

The Coastal Watershed Council (CWC) is currently working in partnership with the County of Santa Cruz and several private consultants on sediment monitoring for the San Lorenzo River in Santa Cruz County. This work, conducted under the guidance of the Regional Water Quality Control Board, is part of a TMDL study for this impaired watershed. CWC's role focuses on implementing the sediment parameters described above to complement professional surveys being conducted by consultants. CWC's sediment monitoring program has been designed for its repeatability over the long term and for its promotion of stewardship in the watershed. The program operates with 12 volunteers. The data has been provided to local, state and federal agencies.

CWC started cross section and thalweg profile fieldwork in the San Lorenzo study area during the fall of 1998. Volunteers were recruited and provided with an initial 25 hour training program. CWC then worked with the County of Santa Cruz and consultants to select appropriate monitoring sites. A CWC staffperson accompanied each monitoring team in the field during each monitoring event. The program focused first on completing longitudinal profiles and cross-sections at each site. Pebble counts and embeddedness surveys were completed during summer and fall.

Cross section locations were placed in order to "bracket" a reach of stream. For example, cross sections were placed near the beginning, middle and end of a long 'run' section of creek. This allowed us to see how the banks changed in response to different flows over time. Quality assurance of the project has been conducted with a professional hydrology consultant.

SAFETY FIRST

Most of these protocols require a fair amount of tromping around in the creek, so we recommend that at least one person invest in some hip or chest waders. Remember that these surveys are conducted during low flows therefore, volunteers should not be out in the creek or river during inclement weather or when flows are high. Since you may be out in the elements for long periods of time, we recommend bringing plenty of:

Sunscreen
Warm clothes
Insect repellent
Food
Water

Surveying Soquel Creek

Perhaps one of the most dangerous pieces of equipment is rebar. We strongly recommend that you cap all rebar with plastic caps to minimize the chances of injury.

Road surveys also require extra safety. Make sure you obey all traffic laws and exercise extreme caution when walking on or near roads.

SEDIMENTATION STUDIES PROTOCOLS

Bed condition surveys using pebble counts

Pebble counts assess particle size distribution within a reach, the extent fine particles may be degrading fisheries habitat, and types of sediment present within the streambed. For volunteers, there are two recommended types of monitoring that can be conducted: pebble counts and embeddedness surveys. Both of these types of monitoring are repeatable, require little equipment, and are enjoyable activities for a wide variety of groups. It should be kept in mind that these activities should avoid disturbing redds of spawning fish especially during the months of April through June. Volunteer groups should consult with a fisheries biologist or the Department of Fish and Game before conducting pebble counts.

A blank data sheet and an example of a completed data sheet used by the Coastal Watershed Council are included in the Appendix. The following procedure is an adaptation from Harrelson et al.'s *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (1994). Local hydrologist Gary Kittleson has also modified this procedure.

Equipment Needed:

- **100' tape measure**
- **Datasheet & pencil**
- **Several Metric Rulers**
- **Waders**

Number of Volunteers Needed:

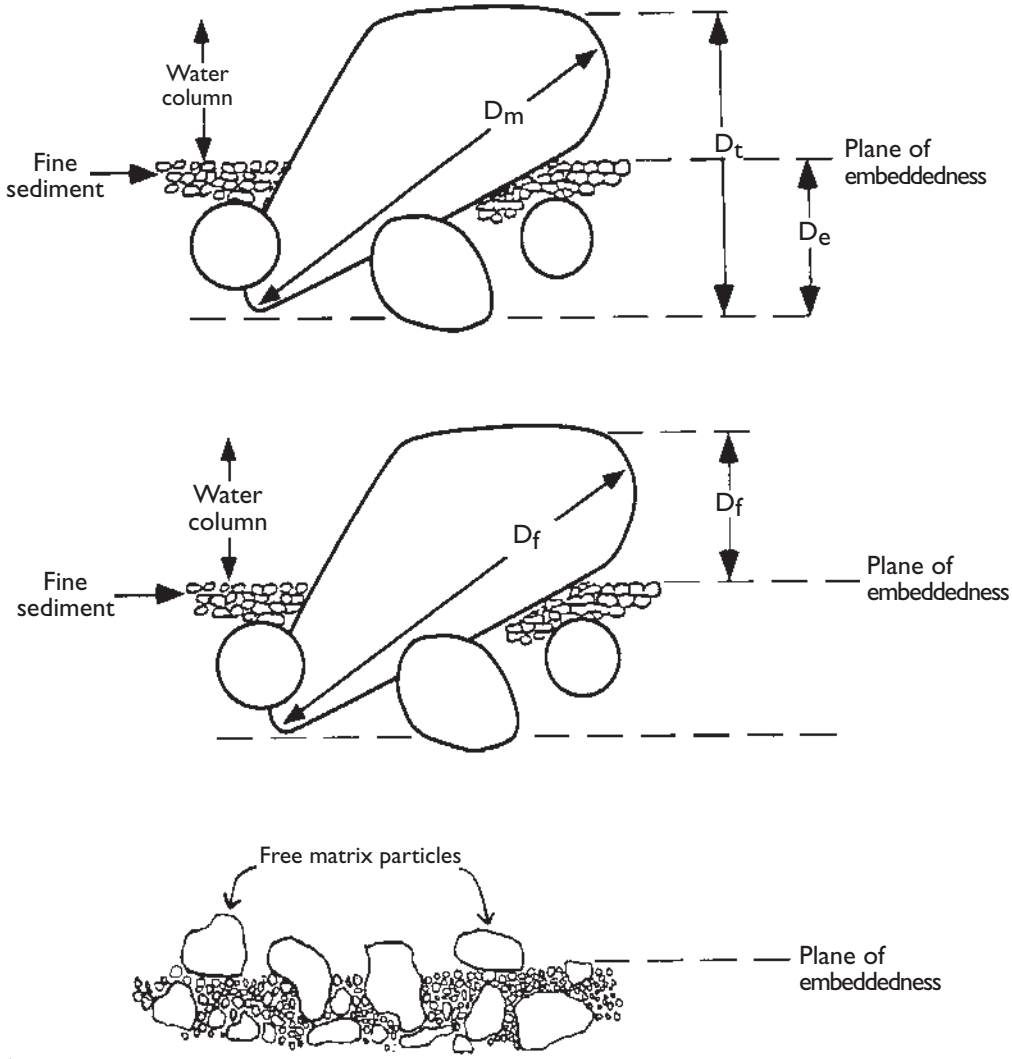
1 Notetaker
2 or more Pebble counters

Pebble Count Procedure

1 If you are also conducting cross-sections, select a reach on or near a cross-section and indicate it on your site map. Measure the bankfull width★ and then multiply this width by 10. For example, if the bankfull width is 15 feet, the total sampling distance along the reach would be 150 feet. Measure 150 feet of the reach with a tape measure and mark the upstream and downstream ends of the reach. Sample a sequence of at least one riffle, run, pool sequence evenly within a reach of 10 bankfull widths. A minimum of 100 samples is required.

2 Begin the sampling at a randomly selected point (perhaps by tossing a pebble) at one of the bankfull elevations. Sampling is done evenly within the channel in each of the channel forms. The sampling path is a diagonal path across the creek and includes presently dry portions of the channel including the banks up to the bankfull elevation and point bars.

To collect the pebbles, take a step (watch where you are going!) and reach down to the side of your foot without looking and pick up the first particle



Measuring Embeddedness

Representaion of the three main embeddedness measurements—embeddedness, free space and free matrix particles. D_m represents the length of the primary axis. Embeddedness for a single particle is equal to D_e/D_t

(US EPA Region 10 1200)

★ Bankfull width is defined for our purposes as the active channel from the left bank to right bank or what the perimeter of the stream would be during an average 1-2 year rise in water level.

touched by the tip of your index finger. This avoids the tendency to choose other stones that a person would subconsciously prefer to pick up.

3 Measure the intermediate axis (neither the longest nor the shortest of the three mutually perpendicular sides of each particle picked up). Measure embedded particles or those too large to be moved in place as best you can. Record sticks, leaves and other organic debris as "organic material."

Call out the measurement to a notetaker. The notetaker tallies it by size class and repeats it back for confirmation. Record the data on a data sheet or in a field notebook. See CWC's sample data sheets in the Appendix for an example. The notetaker keeps count of the particles. After counts and tallies are complete, plot the data by size class and frequency.

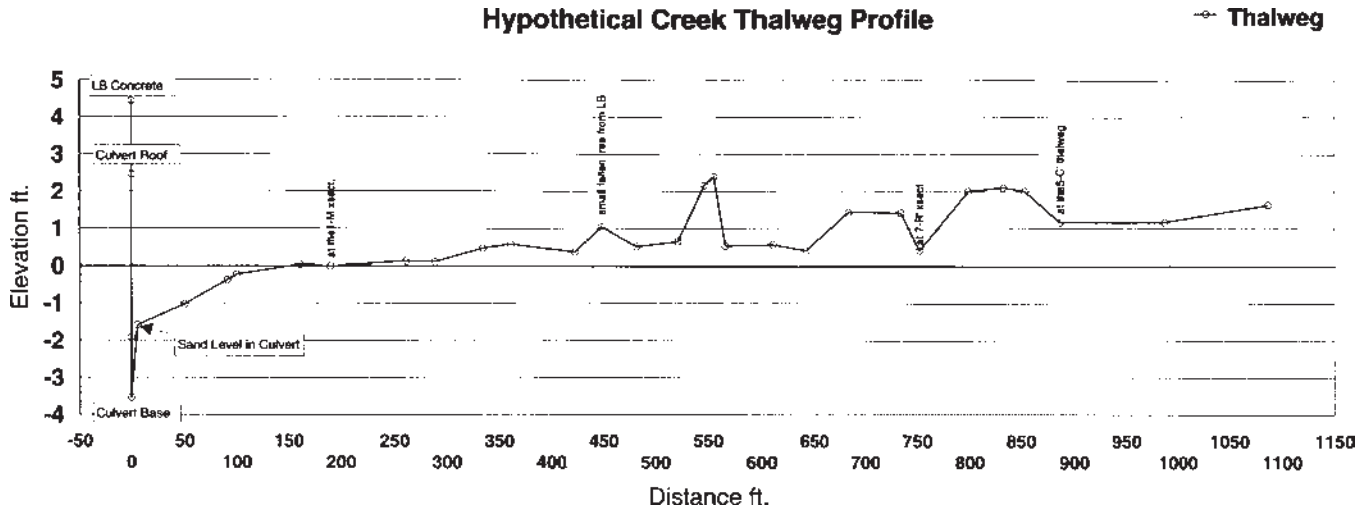
Longitudinal/Thalweg Profile

The longitudinal or thalweg profile provides a topographic "map" of the deepest part of the stream channel. The profile provides the means to determine changes in the vertical dimension or gradient of the stream channel. Thalweg profiles can also show the variation in streambed composition (e.g., pools, riffles, etc.) along the survey reach. Thalweg or longitudinal profiles are becoming increasingly important because of their ability to quantitatively and unambiguously assess changes in stream channel morphology (California Salmonid Stream Habitat Restoration Manual 1998).

Longitudinal profiles can be extremely useful for restoration projects so that you can see how the channel adjusts over time and if restoration goals are met.

The protocol adapted for conducting a thalweg or longitudinal profile is included in *Stream Channel Reference Sites: An Illustrated Guide to Field Techniques*, U.S. Forest Service.

Sampling pebbles within a reach; measuring pebble size and embeddedness



Longitudinal Profile Procedure

First, create a site map of the area with permanent points that can easily be found in the distant future. Develop a thorough description of the site and explanation with monitoring goals to accomplish at the site. Begin a field notebook to record all information and data. Make sure you also provide photo documentation of the reach.

Next, define the extent of your survey based on the monitoring needs within the watershed. Generally, the longitudinal profile extends approximately 300-500 feet along the channel (or approximately 20 times the channel width at bankfull) (Harrelson et al. 1994).

Establish a benchmark, an initial reference point (above the floodplain). either by utilizing a "permanent feature" (such as a large rock or a point on a bridge) or by creating one. You can also use 4' x 1/2" rebar to establish a benchmark. Make sure you describe the location and description of the benchmark in your notes so that it can be found in subsequent years. It's also helpful to measure and record distances of prominent features to the benchmark to help you remember where you put the benchmark. For long term projects, it's a good idea to establish two benchmarks in case one is lost or destroyed. It's best if the benchmarks are located in an unobtrusive place to minimize the possibility of vandalism.

The benchmark is important because it serves as an elevation and survey control point. If the benchmark elevation is not known, it is usually assumed to be 100' for ease of calculation.

Set up the level so that the benchmark and most of the site is visible. Find a good stable location where few obstructions (e.g., tree branches) will obscure the level person's view. The fewer set-ups, the better: having to move the level adds time and can also increase the likelihood of human error.

Measure elevations of important features based on your monitoring goals. For instance, we generally measure riffle-run-pool sequences that can be easily

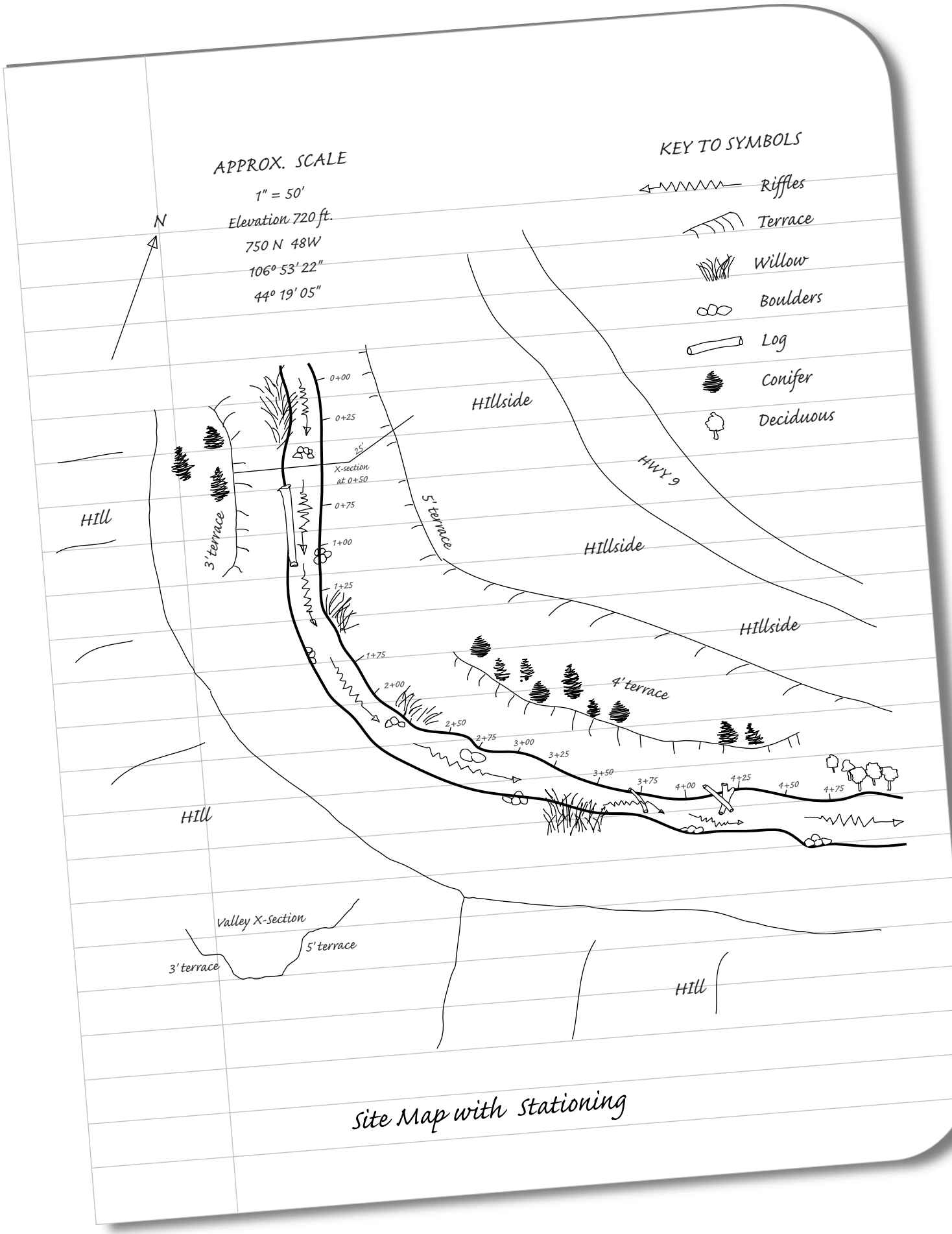
Equipment Needed:

- **25' Stadia fiberglass rod (oval shape is best)***
- **Survey level and tripod***
- **100' tape measure**
- **Field notebook & pencil**
- **3' &/or 4' x _" rebar**
- **rebar caps**
- **Flagging or stakes**
- **Waders**

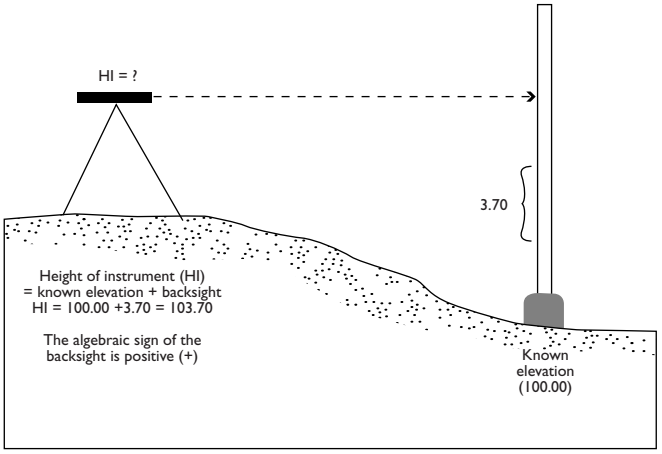
***Can be purchased from an engineering supply store**

Number of Volunteers Needed:

1 Rod person
1 Level person
1 Notetaker



Site Map with Stationing



identified in our graphs. Therefore, we take measurements at the beginning, middle and end of those features. This also allows us to track changes over time.

Measure or carefully estimate distances. Place the rod and shoot individual elevations of the channel bottom at the deepest part of the stream and record the distance and elevation in a field notebook. (See the example provided)

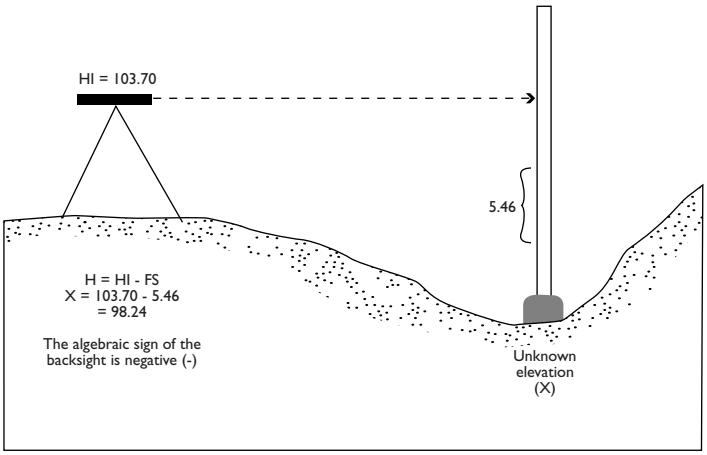
After you have surveyed all of the points in your monitoring reach, plot the longitudinal profile both by hand in your field notebook and on a computer using graphing software. We recommend that one of the surveyors do the actual plotting soon after surveying so that any errors can be tracked and resurveyed if necessary.

Cross-sections of stream channels

A channel cross-section is a topographic profile of the stream banks and streambed along a transect perpendicular to the direction of flow. Monitoring of changes in the channel cross-section can provide important insights into channel stability, bank stability, and the relative balance between sediment (particularly bedload) and discharge (Beschta et al. 1987).

Locations of each cross section should be justified with the study design. For example a reach of stream can be bracketed to look at how the channel within a run section of the stream changes with different flows. Cross sections can also be placed across points that will be obviously changing in the future (e.g.,: point bars) and the cross-section will show how much material has moved. Conversely, cross-sections can be important reference points for restoration projects to examine post-restoration adjustments.

The protocol CWC adapted for conducting cross-section surveys is from *Stream Channel Reference Sites: An Illustrated Guide to Field Techniques* (Harrelson et al. 1994).



Cross-section Surveying Procedure

1 Establish permanent markers for endpoints by driving 4' x 1/2" rebar into each bank to mark the endpoints. Make sure you cap the rebar with plastic caps to reduce the possibility of injury to someone walking by.

2 Establish a benchmark (above the floodplain) either by utilizing a "permanent feature" (such as a large rock or a point on a

bridge) or by creating one. You can also use 4' x ½" rebar to establish a benchmark. Make sure you describe the location and description of the benchmark in your notes so that it can be found in subsequent years. For long term projects, it's a good idea to establish two benchmarks in case one is lost or destroyed. It's best if the benchmarks are located in an unobtrusive place to minimize the possibility of vandalism.

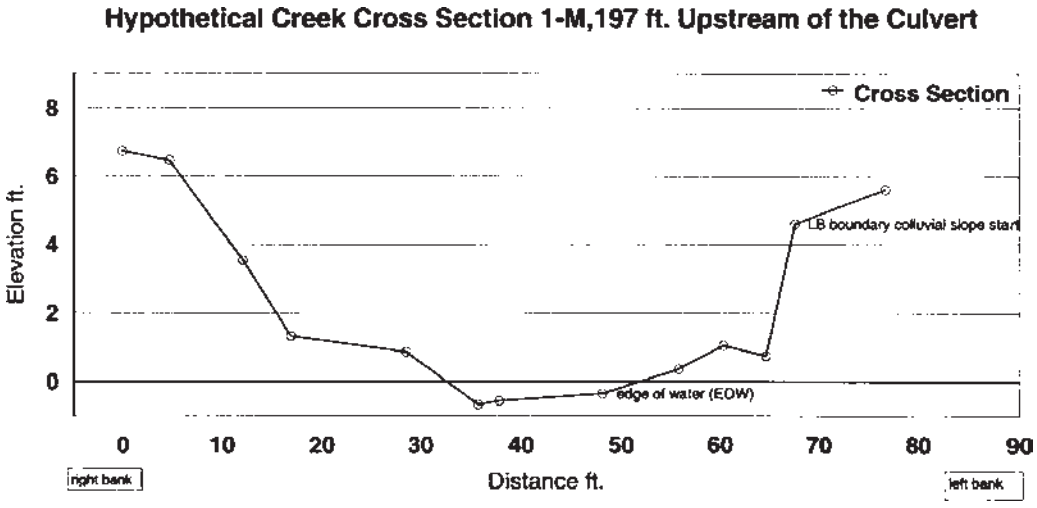
3 Measure and note endpoint locations in your field notebook. With the tape, triangulate between a benchmark, the nearest endpoint, and another permanent feature (an embedded boulder or healthy, long-lived tree away from the water's edge). Make a drawing in your field notebook so that you have a reference for future surveying.

4 Set up the tape measure. Attach the zero end of the tape to the left stake. *Denote left bank vs. right bank in your notes. (When looking downstream, left bank is on the left and right bank is on the right.) Stretch the tape tight and level above the water to the other endpoint. Record the total distance between the endpoints in the field notebook.

5 Measure elevations or foresights. There are two ways you can go about this depending on the width of the channel. If the channel is wide (>30 feet), begin at an endpoint and measure the distance to a significant elevation change. Use a piece of rebar or have one person mark the point the elevation was measured. Move to the next significant change in elevation and stretch the measuring tape from the last point to the next point and measure the elevation. Continue in this fashion until all significant elevations have been measured.

We always try to measure right- and left bank floodplain indicators, bankfull, and the edges of the wetted perimeter.

6 Plot your cross sections soon after surveying so you can catch any errors and resurvey if needed.



Equipment Needed:

- **25' Stadia fiberglass rod (oval shape is best)***
- **Survey level and tripod***
- **100' tape measure**
- **Field notebook & pencil**
- **3' &/or 4' x ½" rebar, rebar caps**
- **Flagging or stakes**
- **Waders**

***Can be purchased from an engineering supply store**

Number of Volunteers Needed:

1 Rod person
1 Level person
1 Notetaker

Equipment Needed:

- **Vehicle with odometer**
- **100 ft. tape measure**
- **camera**
- **hip chain (optional)**
- **clinometer (optional)**
- **stadia rod (optional)**

Number of Volunteers Needed:

1 Driver
1 Notetaker
1 Photo taker (optional)

Road Surveys

Roads are often the primary sources of sediment and erosion to a watercourse (Weaver and Hagens 1994). Due to their compacted surfaces and associated drainage ditches, roads can be considered drainage networks which contribute both water and sediment into the channel at an accelerated rate.

Road surveys provide an inventory for assessing sediment loads into a watercourse. The information can be used to reduce excessive sediment loading into a watercourse, minimize erosion potential and improve biological habitat, especially for fisheries.

A very useful project that can be done by volunteers is conducting road surveys in watersheds identified as impaired by sediment. By documenting the conditions of roads in the watershed, a map can be developed which identifies roads that are large sediment contributors to streams. We strongly recommend that volunteer groups work with their local public works and planning department staffs in selecting survey areas. Keep in mind that it is best to survey public roads only, unless your group has written permission to survey private roads.

The roads survey methods described in this manual were developed based on protocols implemented in the Tahoe Region. Please see the data sheet in the Appendix for an example of a field data collection form. Your group will have to solicit the assistance of a geomorphologist for training. On-going training of volunteers will be required to evaluate the conditions of roadways.

Road Survey Procedure

1 Familiarize your group or one person in your group with types of erosion and roads in your watershed. Working with a geomorphologist will be key so that your group can learn to identify both current problems and potential sediment problems. The Handbook for Forest and Ranch Roads (Weaver and Hagens 1994) provides a good starting point.

Determine how your data will be stored. Decide if the data will be stored in GIS, spreadsheet form or if it will simply be transcribed onto a map. This is important to determine what equipment and types of maps you will need.

2 Identify the watershed study area and the roads that will be surveyed on a topographic map. Document previous road or slope repair that may indicate chronic problems.

Santa Cruz Mountains rural road

3 Now you are ready to go out in the field. Generally, 2-3 people, including one leader, are needed. One person should be the designated notetaker; s/he should be good at taking notes quickly, writing legibly and paying attention to detail. The driver focuses on calling out pertinent features, dimensions and associated odometer reading. A third person, if present, calls out features, takes photos and reminds the driver to call out odometer readings. Zero out the odometer at a road intersection noting both cross streets or roads. Reference the odometer for accuracy against road mile markers which are at culverts.

Measure the average length, height and width of each road cut and any associated problems. If it is possible, pull over and measure some of the road cuts with a tape measure: this serves as an important quality assurance tool. Remember, safety first though!

For road cuts, estimate the amount of vegetation and the erosion potential of the material (e.g., loose sand stone, friable shale, loose decomposing granite, blocky sand stone, etc.).

Failing culverts can cause sedimentation and erosion problems

4 Estimate the percent of the road cut area that is actively eroding and if it is contributing low, medium or high amounts of erosion. If there is a spoils pile on the opposite side of the road, this is a sign of active erosion. Make a note of any spoils piles and whether or not vegetation is present or if there are signs of active erosion.

5 Record each culvert observed. If it's safe, stop and observe the condition of the culvert. Is the intake blocked or open? Is there erosion at the outfall? Is the culvert damaged in any way? Measure the circumference of the culvert and make a note of the material it is made of.

SEDIMENTATION STUDIES RESOURCES AND REFERENCES

Important Resources:

To order a copy of *Handbook of Forest and Ranch Roads* contact:
Mendocino County Resource Conservation District
405 Orchard Avenue, Ukiah, CA 95482
Ph: 707.468.9223

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CHAPTER 6

MONITORING PROTOCOLS —STREAMFLOW

BACKGROUND INFORMATION

During the dry season, substantial streamflow is essential for fish rearing and passage. Basically, the more water within the channel, the more biological habitat available. Streamflow monitoring allows us to:

1. Determine baseline flow
2. Better understand local geology
3. Determine whether or not streamflow is sufficient for fish
4. Analyze legal water diversions that may affect surface flow or subsurface flow
5. Determine whether illegal water diversions are present or are impacting flow

Monitoring streamflow during the dry season is a safe and relatively simple parameter for volunteer groups. The streamflow data can be extremely useful to water districts, the California Department of Fish and Game, fisheries biologists, and hydrologists.

Low flow monitoring generally means that streamflow levels are 10 cubic feet per second (cfs) or less. For this document, the low flow monitoring protocols will focus on surveying in areas with stream depths less than 2 feet. Although there are other streamflow monitoring techniques, we will only discuss the Six-tenth Monitoring Method because it is the appropriate method for stream depths less than 2 feet. The Six-tenths Method refers to where the reading is taken in the water column; six tenths from the surface, or four-tenths from the stream bottom.

Measuring streamflow on a wadeable stream

Generally, streamflow monitoring occurs during the summer and early fall when water levels are lowest. It should be noted that "low flow monitoring" should be conducted when the water levels are low enough to ensure not only accurate data, but more importantly, volunteer

Equipment Needed:

4' top setting rod
100' tape measure that reads in tenths
flow meter
data sheets
thermometer
2-3 people
watch w/second hand
flathead screwdriver
"D" size batteries
rubber boots or hip waders (if available)

Number of Volunteers Needed:

Top-setting rodperson
Timer
Data recorder

safety during monitoring. Abandon streamflow monitoring during stormy/rainy periods or when water levels exceed 2 feet.

Several meters are available for use and can be obtained through scientific supply companies. A popular, relatively inexpensive (~$1000.00) yet accurate meter available is the bucket wheel or "pygmy meter." Although this device provides accurate data, it requires a good deal of maintenance and can be more difficult for volunteers to use. Another type of meter that is easier for volunteer to use but more expensive (~$2000.00-$3000.00) and not necessarily more accurate is the current meter. Current meters allow easier data collection and some also come with data loggers so that data can be quickly downloaded directly onto your computer.

STREAMFLOW PROTOCOLS

0.6 Foot Streamflow Protocol

Current Meter

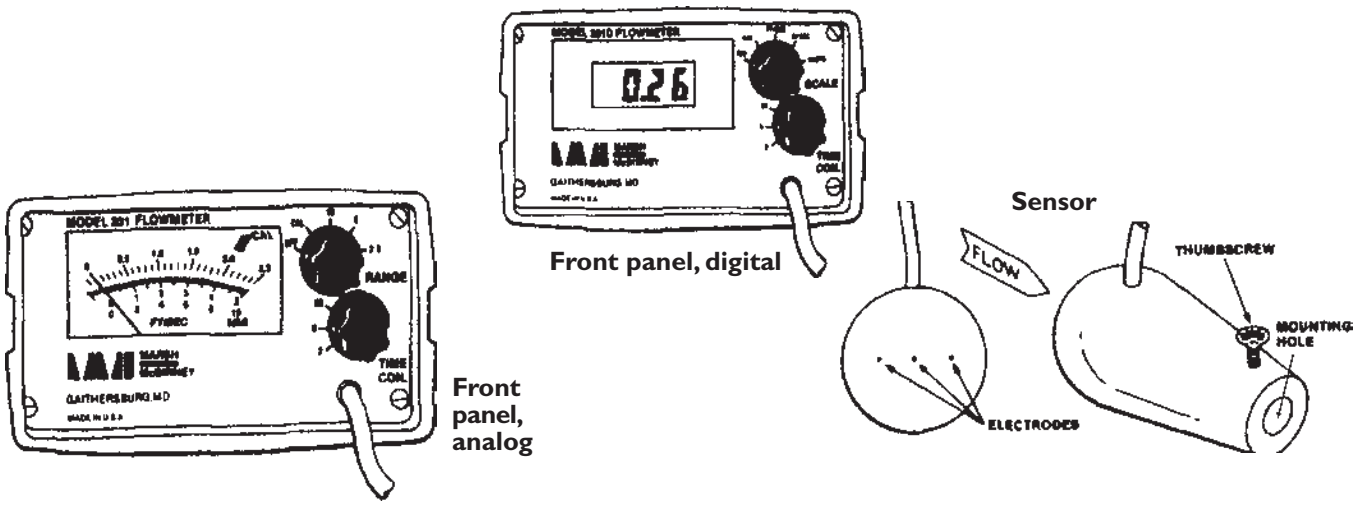
For use with a Marsh McBirney Portable Current Analog or Digital Meter (model 201) and a 4' topsetting wading rod.

1 Choose a point on the creek that is:

- wadable (less than 2 feet);
- lacks obstructions (such as logs, rocks, human structures or anything else that significantly affects the creek flow) within 15 feet up- or downstream of the site;
- at least 10 feet in width (if this isn't possible, take more readings);
- has a depth greater than 0.2 feet

2 Carefully **attach the flow meter to the topsetting rod**. Loosen the screw on the end of the meter and fit it onto the base of the rod. The meter should fit flush with the rod. Tighten the screw.

3 Extend the tape measure across the section of creek to be measured. Make sure you use the side of the tape that measures feet in tenths, not inches. The tape must be held in place firmly during all measurements and not



moved. Measure the total width of the creek. If the creek width is 20' or greater, take measurements at 1' intervals. If the creek is less than 20' wide, take measurements at 0.5' increments. Make sure to take at least 20 measurements.

4 Calibrate the meter by turning it from "Off" to "Cal. The meter needle should hit the black "Cal" box. If it does not, insert new 6 "D" batteries by unscrewing the back plate of the meter with a flathead screwdriver.

After calibrating, **switch the setting to "2.5" to read streamflow measurements**. "2.5" refers to 2.5 feet per second, indicating that you are estimating the flow within that range. If the meter is maxed out when you set it to the 2.5 setting you will have to change the setting to the 5 or 10 feet per second scale, depending on the streamflow. Read all measurements from the appropriate setting. The **Time Con. should be set at "2."**

5 Place the top-setting rod in the water so that the meter bulb faces upstream. Make sure the rod sits flat, stands upright, and there are no rocks, sticks, etc. obstructing the meter bulb. Hold the cord straight up from the meter bulb so that there is no slack in the cord.

Using the topsetting rod

6 Begin on the right bank (when facing downstream) of the creek and measure across to the left bank. You may be unable to obtain a reading at depths <0.2'.

At least 20 readings must be taken.

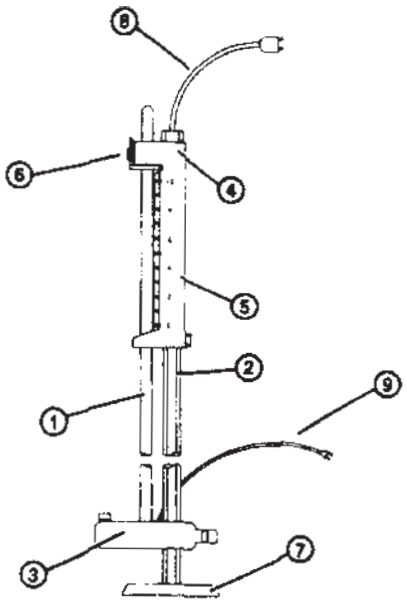
To set the top setting rod, visually measure the depth of the creek using the graduation lines on the hexagonal rod. One line = 0.1', Two lines = 0.5', Three lines = 1.0'.

Once you've determined the depth, set the rod to the 6/10 reading. To do this, press the trigger (see diagram) to slide the smaller rod up or down. This will change the setting within the "vernier" located at the top of the rod. The smaller rod has graduations marked in feet starting with "0" for depths less than 1 foot. For example, if the creek depth at a certain point is 1 foot, move the rod so that the 1 foot graduation lines up with the "0" on the vernier. If the creek depth is 1.4 feet, raise the rod to the 1 foot graduation and align it with the "4" on the vernier.

To measure the stream flow, have one person holding the rod. **This person should stand downstream and to the side of the top-setting rod**. Once the rod is set for the proper depth, let the flow meter **equilibrate for 20 seconds** in the creek. After 20 seconds, average the meter reading **for 40 seconds** and record on the data sheet provided. The data recorder should repeat the information back to the rod person to ensure correct data recording.

Repeat this process for all points.

Top Setting Wading Rod

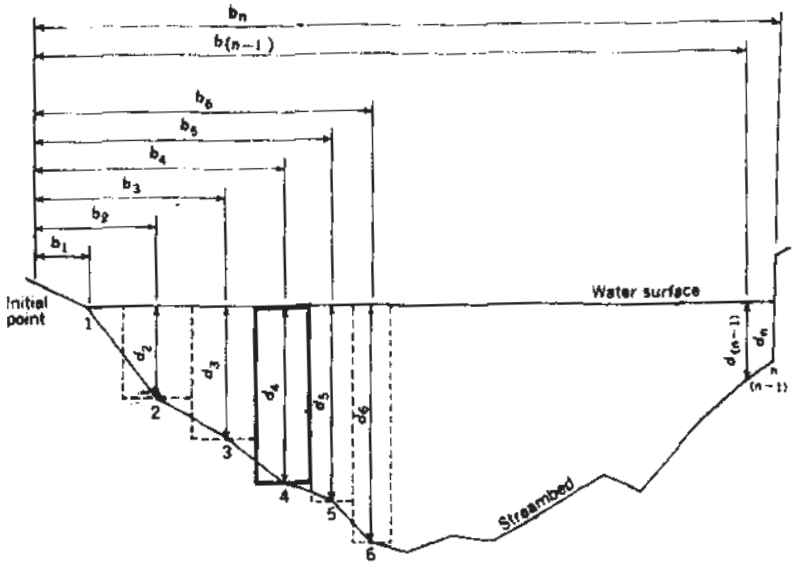


(1) The 3/8" diameter Aluminum rod.
(2) The 1/2" Hexagon Stainless Steel rod.
(3) The Sliding Support.
(4) The Handle.
(5) The Vernier.
(6) The Trigger.
(7) The Base.
(8) The Wire Assy. - Handle.
(9) The Wire Assy. - Meter.

The above numbers are used for purposes of description only, and do not reflect part numbers for ordering purposes.

*Wading Rods with an E suffix are designed for use with Direct Reading Current Meters and do not have items (8) and (9).

Example of streamflow mesurements across a channel



EXPLANATION

1, 2, 3, . . . n	Observation points
$b_1, b_2, b_3, \ldots b_n$	Distance, in feet, from the initial point to the observation point
$d_1, d_2, d_3, \ldots d_n$	Depth of water, in feet, at the observation point
Dashed lines	Boundary of partial sections; one heavily outlined discussed in text

0.6 Foot Streamflow Protocol

Bucket Wheel Meter

For use with a Scientific Instruments "mini" current meter (model 1205) and a topsetting wading rod.

1 Choose a point on the creek that is:

- wadable (less than 2 feet);
- lacks obstructions (such as logs, rocks, human structures or anything else that significantly affects the creek flow) within 15 feet up- or downstream of the site;
- at least 10 feet in width (if this isn't possible, take more readings)

2 Carefully attach the flow meter to the topsetting rod. Loosen the screw on the end of the meter and fit it onto the base of the rod. The meter should fit flush with the rod. Tighten the screw.

Attach the connecting wire from the top setting rod onto the meter by loosening the screw above the bucket wheel. Slide the connecting wire into the base of this screw and tighten.

Plug the headphones into the connection at the top of the top setting rod.

The meter is now ready to collect readings.

3 Extend the tape measure across the section of creek to be measured**. Make sure you use the side of the tape that measures feet in tenths not inches**. The tape must be held in place firmly during all measurements and not moved. Measure the total width of the creek. If the creek width is 20' or greater, take measurements at 1' intervals. If the creek is less than 20' wide, take measurements at 0.5' increments.

4 Begin on the right bank of the creek and measure across to the left bank (right and left banks when facing downstream). You may be unable to obtain a reading at depths <0.4'.

At least 20 readings should be taken.

To set the top setting rod, visually measure the depth of the creek using the graduation lines on the hexagonal rod. One line = 0.1', Two lines = 0.5', Three lines = 1.0'.

Once you've determined the depth, set the rod to the 6/10 reading. To do this, press the trigger on top of the rod to slide the smaller rod up or down. This will change the setting within the "vernier" located at the top of the rod. The smaller rod has graduations marked in feet starting with "0" for depths less than 1 foot. For example, if the creek depth at a certain point is 1 foot, move the rod so that the 1 foot graduation lines up with the "0" on the vernier. If the creek depth is 1.4 feet, raise the rod to the 1 foot graduation and align it with the "4" on the vernier.

5 To measure the stream flow, have one person holding the rod and wearing the headphones. Once the rod is set for the proper depth, let the flow meter

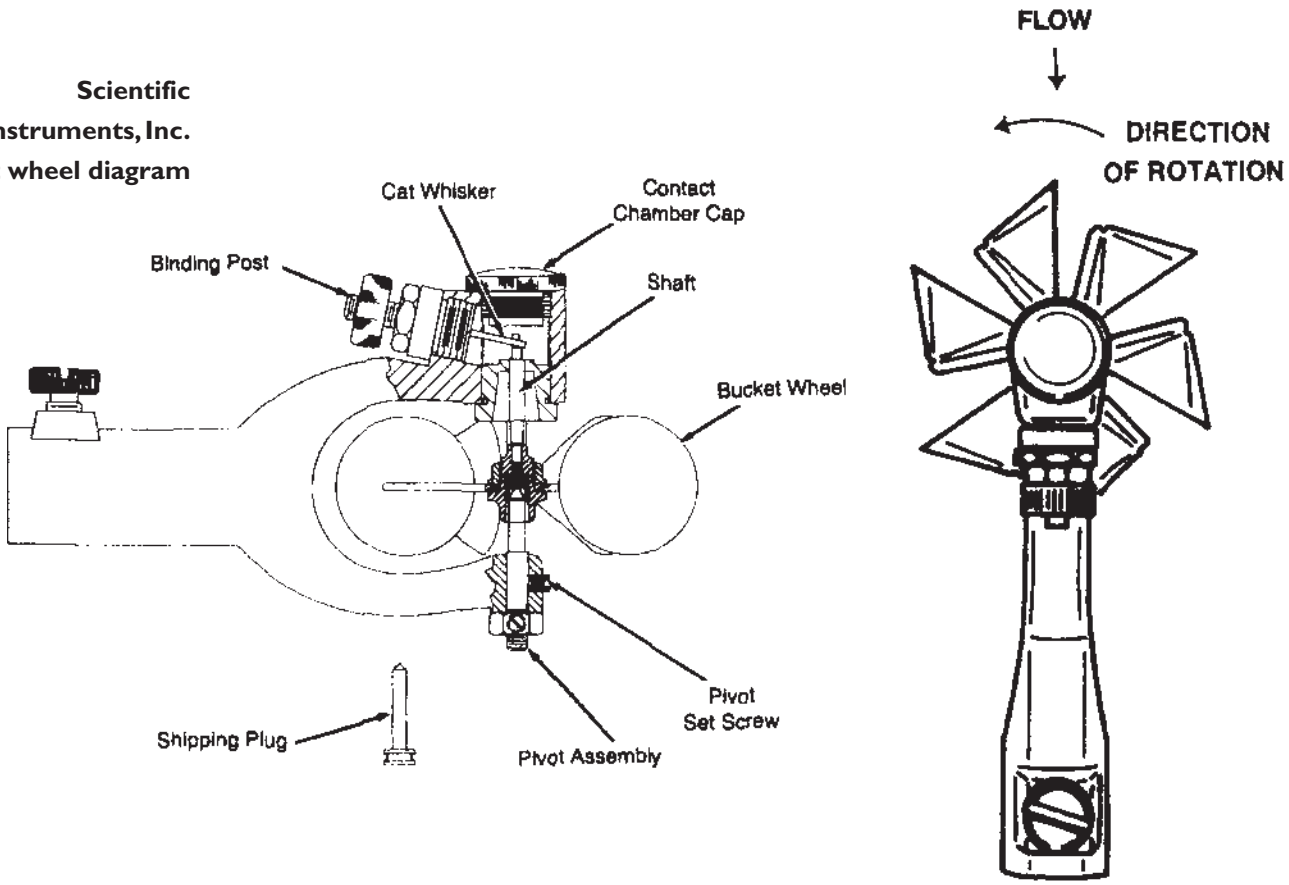
Equipment Needed:

4' top setting rod
100' tape measure that reads in tenths
flow meter
data sheets
headphones
calculator
thermometer
2-3 people
watch w/second hand
flathead screwdriver
"D" size batteries
rubber boots or hip waders (if available)

Number of Volunteers Needed:

Top-setting rodperson and "click" counter
Timer
Data recorder

Scientific Instruments, Inc. bucket wheel diagram



Velocity rating table

METRIC

RATING TABLE FOR MINI CURRENT METER

Actual Rating Limits: .075 to .914 meters per second

EQUATION: $V = \frac{REV}{TIME} \times .977 + .028 \times .3048$ Mini Standard Rating

Seconds	VELOCITY IN METERS PER SECOND — Revolutions													
	3	5	7	10	15	20	25	30	40	50	60	80	100	150	200
40	031	048	061	083	120	157	195	231	305	381	454	604	753	1.12	1.50
41	030	045	058	081	117	154	190	226	299	372	445	588	735	1.10	1.46
42	030	044	058	080	115	150	186	221	292	363	434	574	716	1.07	1.43
43	029	043	057	078	112	147	182	216	286	354	424	564	701	1.05	1.39
44	029	043	056	076	110	144	178	212	279	347	415	549	686	1.02	1.36
45	028	042	055	075	108	141	174	207	273	338	405	536	670	999	1.33
46	028	041	054	073	106	138	170	203	268	332	396	527	655	978	1.30
47	027	040	053	072	104	135	167	199	262	326	390	515	643	960	1.28
48	027	040	052	071	101	133	164	195	257	320	381	506	628	939	1.25
49	027	039	051	069	100	130	160	191	252	311	372	494	618	920	1.23
50	027	038	050	068	098	127	157	187	246	305	366	485	604	902	1.20
51	026	038	049	067	096	125	155	184	242	301	360	475	591	884	1.17
52	026	037	048	066	094	123	152	180	238	295	354	466	582	868	1.16
53	025	037	048	065	093	121	149	177	233	290	344	457	570	850	1.13
54	025	036	047	064	091	118	146	174	229	284	338	451	561	835	1.11
55	025	036	046	063	090	117	144	171	225	279	332	442	549	820	1.09
56	024	035	046	062	088	115	141	168	221	274	326	433	539	805	1.07
57	024	035	045	061	087	113	139	165	217	270	323	428	530	792	1.05
58	024	034	045	060	086	111	137	162	214	265	317	421	521	777	1.04
59	024	034	044	059	084	109	135	160	210	261	310	411	512	765	1.02
60	023	033	043	058	083	108	133	157	207	257	305	405	506	753	1.00
61	023	033	043	057	082	106	130	155	204	253	301	398	497	741	985
62	023	033	042	057	080	104	129	153	201	249	297	393	488	728	969
63	023	032	042	056	080	103	127	150	198	245	292	387	481	716	954
64	023	032	041	055	078	101	125	148	195	241	288	381	472	707	939
65	022	031	041	054	077	100	123	146	192	238	283	375	466	695	923
66	022	031	040	054	076	098	121	144	189	234	278	368	460	686	911
67	022	031	040	053	075	098	120	142	186	231	275	363	454	677	898
68	022	031	039	052	074	096	118	140	184	227	271	360	445	664	884
69	021	031	039	052	073	094	116	138	181	224	268	354	439	655	869
70	021	030	038	051	072	094	115	136	179	221	264	347	433	646	860
	3	5	7	10	15	20	25	30	40	50	60	80	100	150	200

Jan. 1990

ENGLISH

RATING TABLE FOR MINI CURRENT METER

Actual Rating Limits: 0.25 to 3.0 feet per second

EQUATION: $V = \frac{REV}{TIME} \times .977 + .028$ Mini Standard Rating

Seconds	VELOCITY IN FEET PER SECOND — Revolutions													
	3	5	7	10	15	20	25	30	40	50	60	80	100	150	200
40	101	150	199	272	394	516	639	761	1.00	1.25	1.49	1.98	2.47	3.69	4.91
41	099	147	195	266	385	505	624	743	981	1.22	1.46	1.93	2.41	3.60	4.79
42	098	144	191	261	377	493	610	726	958	1.19	1.42	1.89	2.35	3.52	4.68
43	096	142	187	255	369	482	596	710	937	1.16	1.38	1.85	2.30	3.44	4.57
44	095	139	183	250	361	472	583	694	916	1.14	1.36	1.80	2.25	3.36	4.47
45	093	137	180	245	354	462	571	679	896	1.11	1.33	1.76	2.20	3.28	4.37
46	092	134	177	240	347	453	559	665	878	1.09	1.30	1.73	2.15	3.21	4.28
47	090	132	174	236	340	444	548	652	859	1.07	1.28	1.69	2.11	3.15	4.19
48	089	130	170	232	333	435	537	639	842	1.05	1.25	1.66	2.06	3.08	4.10
49	088	128	168	227	327	427	528	626	826	1.02	1.22	1.62	2.02	3.02	4.02
50	087	126	165	223	321	419	516	614	810	1.00	1.20	1.59	1.98	2.96	3.94
51	085	124	162	220	315	411	507	603	794	986	1.18	1.56	1.94	2.90	3.85
52	084	122	160	216	310	404	498	592	780	967	1.16	1.53	1.91	2.85	3.79
53	083	120	157	212	305	397	489	581	765	950	1.13	1.50	1.87	2.79	3.71
54	082	118	155	209	299	390	480	571	752	933	1.11	1.48	1.84	2.74	3.65
55	081	117	152	206	294	383	472	561	739	916	1.09	1.45	1.80	2.69	3.58
56	080	115	150	202	290	377	464	551	726	900	1.07	1.42	1.77	2.64	3.52
57	079	114	148	199	285	371	457	542	714	885	1.06	1.40	1.74	2.60	3.45
58	079	112	145	196	281	365	449	533	702	870	1.04	1.38	1.71	2.55	3.40
59	078	111	144	194	276	359	442	525	690	856	1.02	1.35	1.68	2.51	3.34
60	077	109	142	191	272	354	435	516	679	842	1.00	1.33	1.65	2.47	3.28
61	076	108	140	188	268	348	428	508	669	829	989	1.31	1.63	2.43	3.23
62	075	107	138	186	264	343	422	501	658	816	973	1.29	1.60	2.39	3.18
63	075	106	137	183	261	338	416	493	648	803	958	1.27	1.58	2.35	3.13
64	074	104	135	181	257	333	410	486	639	791	944	1.25	1.55	2.32	3.08
65	073	103	133	178	253	329	404	479	629	780	930	1.23	1.53	2.28	3.03
66	072	102	132	176	250	324	398	472	620	768	916	1.21	1.51	2.26	2.99
67	072	101	130	174	247	320	393	466	611	757	903	1.19	1.49	2.22	2.94
68	071	100	129	172	244	315	387	458	603	746	890	1.18	1.46	2.18	2.90
69	070	099	127	170	240	311	382	453	594	736	878	1.16	1.44	2.15	2.85
70	070	098	126	168	237	307	377	447	586	726	866	1.14	1.42	2.12	2.82
	3	5	7	10	15	20	25	30	40	50	60	80	100	150	200

Jan. 1990

calibrate for 20 seconds in the creek. After 20 seconds, count the number of "clicks" or revolutions (these will sound like static blips in the headphones) **for 40 seconds** in the headphones and record on the data sheet provided. You can determine the velocity by consulting a rating table for your meter that determines velocity (one should be provided in your meter's manual).

Repeat this process for all points.

STREAMFLOW REFERENCES & RESOURCES

Important Resources

Harrelson, C.C., C.L. Rawlins, J.P. Potyondy. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* USDA Forest Service. General Technical Report RM-245. Pages 44-48 in this document discuss discharge/streamflow monitoring.

• http://ogee.do.usbr.gov/fmt/wmm/
An extremely useful website regarding streamflow. The 1997 Water Measurement Manual is also available here in an easy-to-access format.
• For historical information or assistance, contact your local California Department of Fish and Game fisheries biologist, water districts, and/or State Water Resources Control Board. Contacting a local hydrologist can also be extremely useful.

References

Bureau of Reclamation, U.S. Department of Interior. 1997.
The Water Measurement Manual.
To order this manual, contact the:
Government Printing Office
P.O. Box 371954
Pittsburg, PA 15250-7954
Ph: 202.512.1800 Fax 202.512.2250

CHAPTER 6

MONITORING PROTOCOLS —MARINE WATER QUALITY

IMPLEMENTING A MARINE WATER QUALITY MONITORING PROGRAM

by the Santa Cruz Chapter of the Surfrider Foundation

Goals of the Program

Surfrider's Blue Water Task Force (BWTF) Program, which also includes Stormdrain Stenciling, contains a marine water quality monitoring program. The BWTF is a national program that is implemented at the chapter level. Nationally, the BWTF was established with the following objectives:

To provide concerned citizens with the opportunity for hands-on involvement with an environmental problem solving effort.

To gather coastal water samples on a regular basis to determine pollution patterns in the near shore environment.

To raise public awareness regarding the extent and severity of coastal water pollution.

To use the data collected to bring polluters into compliance.

To develop a model program that could influence national legislation and enforcement of water quality monitoring.

History of the Program in Santa Cruz

From its humble beginnings in the garage of a chapter member in 1991, to our current "high-tech" lab in a local high school, Surfrider's BWTF has come a long way and learned a lot about coastal water quality monitoring. The program has become the backbone of Surfrider's educational and community involvement programs. It is a catalyst for achieving real changes in local coastal water problems, such as the diversion of polluted lagoon

water to the City of Santa Cruz's wastewater treatment plant, which now prevents polluted seasonal run-off from collecting in dirty pools at one of our main beaches.

Future of the Program

Our chapter's activism with regards to water quality has been instrumental in the passing of legislation such as AB 411 and SB 65. Volunteers from our chapter appeared before the California legislature on several occasions to impress upon our state leaders the importance of clean water. As of April 1999 new "draft" state rules resulting from AB 411 require California's 17 coastal counties to conduct weekly water testing April through October at beaches visited annually by more than 50,000 people, as well as sites where there is significant storm-drain discharge. The new rules also establish standards for the location of monitoring sites, frequency of monitoring, and mandate the posting of health warnings whenever state health standards are violated. The new state rules resulting from SB 65 require conspicuous posting of beaches in violation at primary access points to the beach in addition to the beach itself. Year-round standards for monitoring and posting, as well as a national standard are in the works.

With the newly drafted state rules for coastal water monitoring, and the fact that the County of Santa Cruz has had a water monitoring program in place since 1987, it was important for our chapter to step back and evaluate whether the water quality program was still relevant. Should it continue? Is it still furthering the original goals of the program? Is it benefiting beach and surf users and the community as a whole? The answer was yes, yes, and yes!

Marine water quality index published in Santa Cruz weekly newspaper, The *GoodTimes*

May 2000 Tide Chart

	AM	Ht.	PM	Ht.	AM	Ht.	PM	Ht.
25 Th	10:50	0.3	11:28	2.9	3:04	4.1	6:24	3.9
	Sunrise 5:42		PDT		Sunset 8:12			
26 F	11:39	0.4	---	---	4:18	3.8	6:57	4.2
27 Sa	12:39	2.5	12:24	0.6	5:39	3.6	7:25	4.5
28 Su	1:35	1.9	1:07	0.8	6:54	3.6	7:53	4.8
29 M	2:22	1.2	1:48	1.0	8:02	3.6	8:22	5.2
30 Tu	3:06	0.5	2:28	1.3	9:05	3.7	8:54	5.6
	Sunrise 5:40		PDT		Sunset 8:16			
31 W	3:51	-0.2	3:09	1.5	10:03	3.8	9:29	6.0

Marine Water Quality Index

Figures valid as of 5/14/00

Location	Approximate Bacteria Level*
Cowell's Outfall	10
Cowell's Stairs	<10
Cowell's Beach	<10
Neary Outflow	630
Seabright Beach	20
Harbor Beach	20
Black's Beach	<10
Twin Lakes	<10
Pleasure Point	<10
36th Ave. Beach	40
38th Ave. Beach	<10
The Hook	<10
Soquel Creek	<10
Capitola Beach	<10
Seacliff	90
Rio Del Mar	20
Aptos Creek	310
New Brighton	<10
La Selva Beach	<10
Manresa	<10
Sand Dollar	<10

Get Involved! Hotline: 476-7667

State standards specify levels of fecal coliform bacteria in swimming areas should not exceed 200 per 100 ml. water

*number of fecal coliform bacteria per 100 ml. water

www.surfridersantacruz.org

THIS WEEK'S TIDE CHART is sponsored by: GOOD TIMES O'NEILL Surf Shop

The Santa Cruz County Environmental Health Services (the County) oversees the water quality monitoring program of the County. They have a well-regarded program and staff, and test 12-15 key coastal sites weekly. The Santa Cruz Surfrider chapter monitors as many as 20 sites weekly, which include all of the County sites plus other out of the way and lesser-used sites. Surfrider is able to target special sites suspected of having high coliform counts. Additionally, results are published more visibly to the public; two local weekly newspapers, several local surf shops and other businesses receive weekly reports. These are the primary ways Surfrider raises public awareness, and gets the added benefit of the visibility associated with the water quality results.

The Santa Cruz chapter maintains a good relationship with the water quality staff at the County. There are links to the other's weekly water quality results on the individual websites, and the two groups share the same

lab methodology of membrane filtration. The County has advised Surfrider on technical and quality control issues in the lab. Surfrider has received positive comments from the County's staff that they appreciate having another entity testing the same waters. Surfrider's results have in the past alerted the County to re-test a site that counted high on Surfrider's reports but not the County's, and to test sites not routinely tested by the County but that showed up consistently high on Surfrider's reports.

Maintaining this relationship is a cornerstone for meeting Surfrider Foundation's 1999 strategic plan goals of "partnering with community efforts to develop solutions for water quality problems."

Surfrider is also meeting its goal of providing an outlet for community involvement. The majority of our chapter volunteers are in one way or another involved with the water testing program, and it is often the conduit for many first time volunteers to become involved in Surfrider. The water quality testing program is also an excellent tool to assist educational goals within the Respect the Beach Program. Finally, the lab itself is of great benefit to chapter members and any concerned citizen as a hub for informal gathering and discussions on sample nights.

Components of the Program

VOLUNTEER SAMPLERS:

The volunteers that gather the weekly water samples are really the core component of a successful water sampling program. Volunteer samplers come from all parts of the community: high school and college students to working adults. They are drawn to the program for various reasons and have varying degrees of enthusiasm. Typically they are motivated individuals and have many other activities and responsibilities going on in their lives. It is very important to remember that all volunteers must be understanding of each others commitments.

The Volunteer Coordinator plays a key role in keeping a high level of enthusiasm among the volunteers, in addition to organizing the volunteers to insure that the important test sites are covered weekly. If the Volunteer Coordinator can be at the lab when the volunteers bring in the samples, it goes a long way toward keeping them motivated. Together with the Lab Coordinator they should endeavor to keep the atmosphere in the lab upbeat and fun – a place where the volunteers look forward to coming.

The coordinators should take time to talk to the volunteers and ask them if they have any questions, concerns or new ideas. Demonstrating and explaining the testing process will give the volunteers a broader understanding of what's going on in the lab and increase their interest. Praise and thanks to the volunteers for their efforts will also keep them excited and coming back with more water samples.

The Santa Cruz chapter is fortunate to have a Coordinator that is highly motivated and keeps the volunteers interested and dedicated. This Coordinator calls the current volunteer samplers each week to remind them to take samples and confirm which sites they will be sampling. To achieve accurate test results it is important to keep the same volunteers sampling specific sites consistently over at least several months. Having volunteers come and go by the week leads to inconsistent sampling and coordination difficulties. The Coordinator also notifies samplers if the night to bring in samples must be changed due to a school holiday or other reason.

Publishing the test results in the local media not only informs the public but has the effect of motivating the volunteers. The volunteer samplers can see the published results and feel a sense of accomplishment and importance in the work they are doing.

LABORATORY

The second most important part of the BWTF water quality monitoring program is a laboratory complete with the necessary equipment and materials for processing the samples and scoring the water quality at the sampled sites.

Blue Water Task Force lab volunteer tests the water

Surfrider's lab is set up in a high school science classroom, providing the chapter with many benefits. It is the place where new volunteers are trained and prospective volunteers can observe the water testing process. The lab is also a great meeting place for chapter members and other interested parties to drop by and see what's going on or to discuss issues relevant to water quality. Being in a science classroom increases the visibility of Surfrider and the water quality program to the school's students. It has also helped keep the cost of running the program low, because there are no rent costs.

A Lab Coordinator carries out the water sample testing in the chapter. This person is also responsible for maintaining the equipment and ordering new materials required for the testing. There should also be at least one trainee as part of this program to serve as back-up and to be working toward moving into the Lab Coordinator position.

To add validity in the eyes of the public, state and local agencies, and maintain accurate results, it is critical to develop a Laboratory Procedure Manual. The Laboratory Procedure Manual for the Santa Cruz Chapter BWTF is included in this guidebook for a more detailed reference of the procedures involved. A list of equipment and estimated costs is included in this manual, along with several catalog resources that Surfrider uses.

WATER SAMPLING

To achieve successful results it is very important to establish a water sampling procedure for the volunteers to follow when gathering samples to be tested. This should be printed and given to all new volunteers at training. The Santa Cruz Chapter has an excellent water sampling instruction video that is used to train new volunteers. Copies of this video are available to other chapters starting a water quality monitoring program and may be obtained free of charge by contacting the Santa Cruz Chapter Hotline at 831/476-7667.

The sampling procedure should include instruction on the actual mechanics of drawing the sample and reporting the site environmental conditions on the sample log form. The procedure should also focus on standardization of test site names as well as the location at these sites from where the water sample should be drawn. Standardization will maintain consistency, lead to accurate results, and provide a basis for setting up a useful database of test site scores. If more than one name is used for a specific test site, the database will be less useful as a tool for running queries of past results. A copy of the sample data sheet is included in the data sheet section.

REPORTING TO THE PUBLIC AND RECORD KEEPING:

Surfrider endeavors to get the most current results to the public by sampling and processing water samples on Sunday nights, and scoring and distributing the results to the public on Monday nights in order to make the publishing deadline of Tuesday afternoon for the weekly papers.

The Santa Cruz Chapter publishes the water quality results in two local weekly newspapers with help from local businesses that underwrite the results with advertising. The results are also faxed and e-mailed out to local surf shops and other businesses for posting, and to local government officials and the County. Finally, they are also posted on the Chapter Website.

Finally, the Chapter has set up a database where the test results are entered for future reference. The data can then be used to generate reports, which enable Surfrider to identify trends in coliform levels. It is important to keep the database up to date at least monthly so that you don't get to the end of the year and find you have mountains of data to enter. The database can be as simple as entering date, site names, and scores or more complex with the addition of site environmental data; temperatures, weather, wind, etc. Surfrider's database includes entries for all the site observations shown on the Sample Data Sheet printed on the inside back cover of this guidebook.

BLUE WATER TASK FORCE-
MARINE WATER QUALITY MONITORING PROGRAM

LABORATORY PROCEDURE MANUAL

The Santa Cruz Chapter currently uses the Millipore Membrane Filtration method. The Membrane Filtration method requires a substantially higher equipment investment than other procedures, but the cost per test was lowered and accuracy was increased. The Membrane Filtration method allows for a more exact count of the bacteria.

The Membrane Filtration Method for Determining Total and Fecal Coliform levels in Marine Water Samples

Test Purpose and Summary

Typically the collection and filtration of samples and incubation take place on Sunday night, and the counting and scoring of the bacteria takes place on Monday night, as the filtered samples must incubate for 24 hours. Scores are entered into the database and results are distributed to the public by fax and e-mail on Monday nights as well.

We test for both Fecal and Total Coliform Indicator Bacteria but only report Fecal Coliform levels to the public because it is the most indicative of potential public health hazards. Fecal Coliform bacteria originate from the feces of warm-blooded animals: people, dogs, marine mammals, and shore birds. The Fecal count is an indicator for sewage contamination and for feces-borne organisms that can cause diseases including hepatitis A, bacterial meningitis, and encephalitis. *E. Coli* is the most abundant type of Fecal Coliform, and a high Fecal count may indicate high *E. Coli* levels. Past State Department of Health standards, based on health risk studies, dictate that Fecal counts above 200 per 100 mls may pose health risks for recreational activities in the ocean. New "draft" state rules require investigation and re-testing by counties at levels above 200, and immediate posting at levels above 400. Sites are also to be posted if the Fecal count is in excess of 200, based on the mean of the logarithms of at least 5 weekly samples during a 30-day period.

Total Coliform bacteria are naturally occurring and originate from decaying plant materials. They are not as dangerous, but it is instructive to track the ratio of Fecal to Total counts. Health risk studies suggest that the ratio should be less than 0.1 Fecal to Total. A Total Coliform count greater than 1000 is also indicative of a public health hazard, and the new state rules require investigative action by the counties at levels above 1000.

Lab Equipment and Materials List

Resources: Fisher Scientific @ 800-766-7000, Millipore @ 800-645-5476; both of these companies have catalogs available that can aid in the selection and purchasing of materials and equipment listed below. Also contact local scientific labs, schools, and universities for used equipment or donations.

Expendable Materials:	**Cost ***	**Frequency ofPurchase****
Sodium Hydroxide Solution	$21/ liter	1 year
Rosolic Acid Powder	$50/ 25 grams	1 yr
Ethyl Alcohol	$27/ liter	1 yr
M FC Agar Powder (Fecal Coliform Test)	$36/ 100 grams	6 mo.
M ENDO Agar LES Powder (Total Coliform Test)	$35/ 100 grams	6 mo.
Distilled or Deionized Water	$12/ 4x5 gal.	3 mo.
pH Buffered Dilution Water	$67/ Case	3 mo.
Millipore Microbiological Analysis Filter Membranes 47 mm, .45 micron pore size, sterile white with grid	$300/1000 count	1 yr
Petri Dishes, 47 mm, w/write-on labels	$90/ 500 count	6 mo.
Latex Gloves	$20/100 pair	1 Yr
Autoclave verifier tape (confirm sterilization completed)	$20/roll	1 yr
Autoclave bags (to sterilize used Petri dishes)	$96/ 200 count	2 yrs
Water sample bottles – 2 doz (or 4 oz whirl-pak bags, with write on labels – 500 count)	$50.00	6 mo.
Alconox disinfection soap powder (to clean glassware)	$16/ 4 lbs	6 mo.
Alconox disinfection soap tabs (to soak used pipettes)	$13/ 100 count	6 mo.
Total estimated materials cost:		**$818.00**

Lab Equipment:	**Cost****
Balance – standard pan type or dial type (for measuring reagents)	$150
Bunsen Burner (for heating growth medium), and Flask Stand Requires lab gas supply	$50
Glass microanalysis vacuum filter holders, – 47 mm, with glass base, req'd stainless mesh screen, glass funnel, and quick clamps	$124 x 3
Filter sterility test vacuum manifold – to fit #8 stoppers	$1,200
Length of 3/8" and _" tubing (to connect vacuum and filtering flask to manifold)	$5
Vacuum Pump – oiless diaphragm type Manufacturer: Gast, Fisher cat. no. 01-092-29	$320
Flask, Pyrex 250 ml (growth medium make-up)	$10 x 4 req'd
Filtering Flask, Pyrex 1000 ml, with stopper and filtrate spout	$35 x 2 req'd
Filter forceps (for handling filter membranes)	$10 x 2 req'd
Graduated cylinder, 100 ml	$10
Pipettes, glass, 10 ml, case of 12	$84 x 4 req'd
Pipette sterilizing containers	$55 x 3 req'd
Pipette pump	$15 x 2 req'd
Pipette jar, polyethylene (storage of used pipettes)	$80
Pipette washer/rinser, polyethylene (for washing pipettes)	$220
Pipette strainer baskets, polyethylene, for 16" pipettes	$90 x 2 req'd
Autoclave (for sterilization of pipettes and flasks)	$3,500
UV Sterilizer (for sterilization of glass vacuum filter holders) Millipore cat. no. XX637000, accommodates 3 filter holders	$2,000
Incubator (to maintain Fecal test dishes at 45 deg. C) Note: a second incubator is required if running both Fecal and Total Coliform tests (maintain Total test at 35 deg. C)	$850
Total estimated new equipment cost:	**$9,598.00**

Preparation for Filtration:

Most of the following procedures must be carried out using "sterile method techniques." This means that you should endeavor to avoid as much as possible the accidental introduction of any foreign microorganisms into the water samples or growth dishes.

During the procedure, if the tip of a sterile pipette touches an unsterilized surface, or any surface that could cause cross contamination, it should be discarded and new sterilized pipette used. Never leave caps off of dilution water bottles or lids off of growth dishes.

Spray and clean the workspace counter top areas with disinfectant, and always wash hands with anti-bacterial soap before and during the procedures to ensure that no foreign bacteria is introduced to the samples, sterilized lab apparatus, or growth dishes.

Once you begin work in the lab, never touch your hands to your face, body, eyes, nose, or mouth, as it is possible to transfer harmful bacteria into your body. Always use latex gloves if you have any cuts on your hands.

- Connect vacuum filter manifold to vacuum pump and filtrate collection flask.
- Make-up Fecal Coliform Bacteria growth medium;
- Measure out 2.6 grams of M FC Agar on the balance, pour into 250 ml flask
- Using a pipette, add 0.5 ml Rosolic acid solution to flask (see procedure for Rosolic Acid solution make-up)
- Use graduated cylinder to measure out 51 ml of distilled water, add to flask, and stir. This should be enough for 20 samples
- When required make-up Rosolic Acid solution: Mix 1gram Rosolic acid powder with 99 ml Sodium Hydroxide solution. Final mixture should be reddish-blue in color. Typically this amount of solution should last 3-4 months.
- Make-up Total Coliform bacteria growth medium;
- Measure out 2.6 grams of M ENDO Agar on the balance, pour into 250 ml flask
- Using a pipette, add 1 ml of ethyl alcohol to flask
- Use graduated cylinder to measure out 51 ml of distilled water, add to flask, and stir. This should be enough for 20 samples
- Heat Fecal Coliform growth medium on Bunsen burner until just boiling and all solids have dissolved. Watch for bubbles and remove before the solution comes to a rolling boil. If heated too much the solution will coagulate prematurely. If heated too little it will not solidify properly when coating the Petri dishes.
- Heat Total Coliform growth medium as indicated above in step 4.

- Enter water samples in logbook, assigning a number to each sample, and recording the name of sample taker and location of sample. Enter the log numbers on the sample scoring sheets.
- For each water sample label two Petri dishes with sample number using a Sharpie marker. Label one dish with a "T" to indicate Total Coliform test, and one dish with an "F" to indicate Fecal Coliform test.
- Coat the bottom of each Fecal Coliform test dish with approximately 2.5 ml of the heated Fecal growth medium using a pipette. Turn the dish while dispensing and use a back and forth motion to evenly coat. Work quickly and smoothly to get an even coating, and pull any bubbles back into the pipette. Place caps back on the dishes and stage for filtering. If medium solidifies prior to coating all the sample dishes, it may be reheated on the burner.
- Coat the bottom of each Total Coliform test dish with approximately 2.5 ml of the heated Total Coliform growth medium using the same procedure as described in step 8.
- Sterilize the vacuum filter holders, funnels, and mesh screens for 3 minutes in the UV sterilizer, and place on the vacuum manifold.

Filtration & Incubation:

- Using forceps place filter membranes in place over the mesh screens on the filter holders.
- Flame-sterilize the forceps with alcohol and burner flame for each filter. Clamp funnels in place on filter holders. Our manifold will accommodate 3 filters to allow filtration of 3 samples per filtration run.
- Stage 3 water sample bottles (or bags) in support cups in front of the vacuum filter manifold.
- Pour pH buffered dilution water into the funnels sufficient to cover the membranes; approximately 3 ml.
- Using a clean pipette, dispense 10 ml of water sample into the vacuum filter funnels. Use a single pipette for each water sample. Place used pipettes in strainer basket inside pipette jar.
- Turn on the vacuum pump to draw the water samples through the membrane and into the filtrate collection flask.
- With the pump still running, rinse each funnel and membrane with dilution water.
- Unclamp and remove funnels, place in sterilizer for holding while membranes are removed. Keep track of funnels to make certain that the same funnel is used to filter the sample for both the Fecal and Total tests.
- Using flame-sterilized forceps, remove the membranes and place in the appropriate Fecal Coliform growth dish. Make sure that the membrane is in full contact with the growth media without any air bubbles in between. Turn the vacuum pump off.

- Repeat steps 1 through 8 to filter the same 3 water samples for the Total Coliform test.
- Remove and sterilize the vacuum filter holders, mesh screens, and funnels in the UV sterilizer for 3 minutes, and place on the vacuum manifold.
- Repeat the above filtration procedure as necessary for all water samples.
- Wash and autoclave growth medium make-up flasks and sample bottles; wash with Alconox detergent, brush, rinse and place autoclave tape on flasks and bottles to verify that autoclave sterilization is complete.
- Preheat incubators to 45 deg. C for Fecal samples and 35 deg. C for Total samples.
- Place sample growth dishes in the appropriate incubators, with the media side up (sample number visible) to prevent condensation from dripping onto filter.
- Incubate for 23-24 hours.
- Clean area, store and lock up all apparatus securely.

Pipette Washing & Sterilization

- During the above procedures pipettes should be placed in the pipette jar with soaking solution immediately after use.
- Fill pipette soaking jar with an Alconox soap powder solution (approximately 1 tsp./gal. H20) to within 6 inches of top. The soaking jar holds 2-1/2 gallons of water. Replace with fresh solution every 3 months.
- To wash the used pipettes place 1 Alcotab in the wash/rinse cylinder then transfer the pipettes from the storage cylinder to the wash/rinse cylinder, using the pipette strainer basket.
- Connect the plastic hose from the wash/rinse cylinder input to a tap water faucet and direct the outflow tube into a sink.
- Turn on the water and monitor flow of water so that the cylinder fills up and drains without overflowing. After draining there should be a gurgling sound to indicate that the siphon has broken and then the cylinder will fill up again. This wash/rinse cycle should be done for 15 to 20 minutes.
- After the tap water rinse disconnect the input hose. Pour 2-1/2 gallons of deionized water into the wash/rinse cylinder until it starts to drain. Perform this step twice.
- After the pipettes have been rinsed, transfer them to the steel pipette storage and sterilization containers and place covers on. Wrap cover with strip of aluminum foil, affix 1 small piece of autoclave indication tape on the foil, and autoclave for 30 minutes.

Counting & Scoring Bacteria Levels

Total Coliforms:

- Locate the Petri dish with the corresponding log number as indicated on the Sample Scoring Sheet and followed by the letter "T", which indicates the Total Coliform media.
- Remove the cover of the dish, taking care not to smudge or touch the bacteria colonies.
- The Total Coliform colonies will have an apple-green sheen to them. Starting at the top of the gridded filter, count only the greenish colonies left to right, one row at a time, until the bottom of the grid is reached. If it appears green, count it, even if it looks too small to count. A colony that appears to be two colonies merged into one should be counted as one whole colony, not two. It will help to follow your count on the row with a pencil tip or other small pointer.
- Record the number of counted colonies on the Sample Scoring Sheet in the Coliform Count column in the Total box.
- Multiply the number entered above by the dilution factor, to obtain the number of organisms per 100 ml, which is value used to report the bacteria levels to the public. Example; If 10 ml of the sample was filtered, the dilution factor would be 10 and the number of organisms per 100 ml would be ten times the number of colonies counted on the filter. If 5 ml was filtered, the dilution factor would be 20 and the number to report would be twenty times the number of colonies counted on the filter.
- Record the number of organisms per 100 ml on the Sample Scoring Sheet in the Bacteria Level column.
- Repeat the above to obtain scores for each of the samples tested.

Fecal Coliforms:

- Locate the Petri dish with the corresponding log number as indicated on the Sample Scoring Sheet and followed by the letter "F", which indicates the Fecal Coliform media.
- Remove the cover of the dish, taking care not to smudge or touch the bacteria colonies.
- The Fecal Coliform colonies will have a blue color. Starting at the top of the gridded filter, count only the blue colonies left to right, one row at a time, until the bottom of the grid is reached. If it appears blue or slightly blue, count it, even if it looks too small to count. Note that the white colonies are a different type of bacteria and should not be counted.
- Record the number of counted colonies on the Sample Scoring Sheet in the Coliform Count column in the Fecal box.

- Multiply the number entered above by the dilution factor, to obtain the number of organisms per 100 ml, which is value used to report the bacteria levels to the public.
- Record the number of organisms per 100 ml on the Sample Scoring Sheet in the Bacteria Level column.
- Repeat the above to obtain scores for each of the samples tested.

Reporting & Data Entry

- Enter the Fecal counts for the corresponding test sites on the Excel reporting spreadsheet for distribution to the public. Sites with Fecal counts over 200 get a "thumbs down" icon and counts under 200 get a "thumbs up" icon next to them.
- Results are faxed or emailed using the reporting spreadsheet to all local surf shops, businesses, newspapers, politicians, website manager, and other interested parties on the distribution list.
- All environmental data from the sample collection sheets and both Fecal and Total Coliform scores are entered into the computer database. Make sure that site names correspond to the master site name list. This will insure accurate searching by site name later when queries are performed and the annual report is published.

Santa Cruz Chapter Surfrider Foundation

Marine Water Quality Monitoring Program

WATER SAMPLING PROCEDURE

Equipment Check List:

Container to keep samples cold – mini cooler, tupperware, etc.
Ice to keep container and contents cold
Cardboard Six-Pack Holder to keep samples organized in the mini-cooler
Permanent Marking Pen – waterproof Sharpie works well – for writing the site location name on the sample bottles
Tidebook**,** or other resource for determining the current tide condition
Sample Bottles – cleaned and sanitized
Sample Data Sheets
Pen or Pencil for filling out the sample data sheet

Procedure:

- Before approaching each site to take the sample, log the site location name along with temp, time, water depth, and environmental observations. Follow the key at the bottom of the data sheet. At the first site, enter sampler's name, date, and nearest tide condition.
- Use only site location names from the most current master list. This is very important for the record keeping in the lab and database queries.
- Mark the sample bottle with the site location name.
- Remove the sample bottle lid immediately before sample is taken to keep the bottle uncontaminated.
- Take the sample at least 6 inches below the surface of the water in knee deep water where waves are breaking or water is agitated. Try to avoid taking the sample from an area where the water is not moving.
- Do not fill to the top. An airspace should be left to allow the contents to be shaken in the lab.
- Close the bottle tightly and place in the cooler. Proceed to the next site.
- Take samples to the lab within 4 hours.
- Remember to always pick-up clean sample bottles at the lab for next week.