STREAM TEAM
MALIBU CREEK • HEAL THE BAY

The Malibu Creek Watershed Stream Team Pilot Project

Shattering the Myths of Volunteer Monitoring

The Stream Team is generously funded by:
The California State Coastal Conservancy, Environment Now, Environmental Systems Research Institute and Public Involvement and Education Fund of the Santa Monica Bay Restoration Project

Heal the Bay

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I. Executive Summary

World famous Malibu Surfrider Beach is one of southern California's most heavily used recreational assets. Well over 1.5 million people visit this beach annually to surf, fish, swim and recreate. Unfortunately, Surfrider Beach is also one of southern California's most polluted beaches. Surfrider Beach scored the dubious honor of being the tenth worst polluted beach in southern California in 1999-2000. Surfrider Beach receives water and pollutants from the Malibu Creek Watershed, the second largest watershed draining into the Santa Monica Bay. The Malibu Creek Watershed is also home to three federally listed endangered aquatic species: the tidewater goby, steelhead trout and red-legged frog.

Heal the Bay had encouraged monitoring groups throughout the watershed to expand the scope of their monitoring in an effort to identify the sources of the poor downstream water quality. Heal the Bay grew frustrated with the slow pace of development and implementation of a watershed scale comprehensive monitoring program. Finally, in August of 1997, a team of four graduate students from the Department of Landscape Architecture at California State Polytechnic University, Pomona were contracted by Heal the Bay to conduct a watershed assessment and design a watershed scale citizen volunteer monitoring program. The Stream Team program was designed to evaluate the overall ecological health of the Malibu Creek Watershed and to serve as a model that can be implemented in other watersheds. Finally, the Stream Team program was designed to collect high quality data that is useable by resource agencies, municipalities, and organizations to assess the state of the resources and develop restoration efforts throughout the Malibu Creek Watershed.

During the course of their research, the Cal Poly students identified imported water (water quantity), impervious surfaces, erosion and sedimentation, nutrient loading, and pollutants associated with urban runoff as the primary issues that should be addressed by any monitoring effort. The Cal Poly Team also researched existing volunteer monitoring programs to determine which monitoring protocols best address these issues. Finally in August of 1998, Cal Poly produced two documents, *The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action* and *The Malibu Creek Watershed Stream Team Field Guide. The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action* assesses the major issues within the Malibu Creek Watershed, evaluates and recommends specific monitoring protocols that can be accurately and reliably performed by volunteers, and identifies likely sources of pollution in order to prioritize monitoring locations. This document serves as a case study for other groups interested in creating a comprehensive watershed monitoring program for their own unique watersheds. *The Malibu Creek Watershed Stream Team Field Guide* provides educational background about the watershed and detailed step-by-step procedures to allow volunteers to collect information on the environmental changes that contribute to watershed impairment. The field guide was designed to be easily adaptable for use by other monitoring groups.

The pilot phase of the Stream Team monitoring program was composed of two distinct activities: water quality analysis and stream walk survey. Water chemistry has been analyzed the first Saturday of every month since November of 1998. The Stream Team uses chemical testing to examine the water quality at seven fixed locations throughout the Malibu Creek Watershed. Tests include pH, temperature, stream flow, dissolved oxygen, conductivity, turbidity, nitrates, ammonia, phosphates and enterococcus bacteria. The Stream Team program combines high quality testing equipment, intense field training and old-fashioned hard work. The Water chemistry testing program was designed to determine how much each subwatershed is contributing to downstream flows and water quality problems. Water chemistry data is compiled and analyzed by Heal the Bay staff and distributed to the Los Angeles Regional Water Quality Control Board (LARWQCB).

The Stream Walk Survey has volunteers walking the various creeks and streams and precisely mapping pollution sources and areas of environmental degradation. Stream walkers locate all discharges that flow into the stream, disturbed areas affected by erosion and exotic/invasive plants, barriers to fish passage, dump sites and streambank alterations. Whenever one of the parameters is identified its precise location is mapped using a Global Positioning System (GPS), information about that parameter is recorded on the field sheet and an image of the parameter is taken using a digital camera. All the information collected by volunteers is entered into a Geographic Information System (GIS), a computer mapping and database program, which is maintained by Heal the Bay. Stream Team GIS data is distributed to numerous stakeholders and resource agencies throughout the region.

Since November of 1998, Heal the Bay has conducted extensive testing to determine if the Stream Team Monitoring Program and Stream Team Field Kit provide accurate, reliable and precise water quality data that can be used for watershed assessment and subsequent resource management decisions. Heal the Bay's monitoring program has provided high quality data, as demonstrated by the results of our QA/QC program. Also, after extensive research and field testing of analytical techniques and methods, Heal the Bay has developed a water quality monitoring and stream walk program that is relatively easy for volunteers to implement, yet still provides high quality data. Heal the Bay is confident that the Stream Team Field Kit and monitoring protocols, if followed, yield accurate, precise, reliable and comparable water chemistry results. The Stream Team volunteer monitoring provided significant cost savings, $12, 035.76 over a 12-month monitoring period, compared to using a State-certified laboratory to process samples. Heal the Bay's Malibu Creek Stream Team has trained and certified 64 volunteers to collect water quality data over the past 15 months.

Heal the Bay strongly believes that the stream walk component is essential to any monitoring effort interested in identifying and addressing pollution sources. The stream walk precisely locates and documents likely sources of pollution and environmental degradation. The parameters located in the field are mapped to within one-meter accuracy so they can be easily relocated, targeted for removal and/or restoration. The stream walk component provides data that can be used to develop watershed scale restoration plans and is crucial to prioritizing restoration efforts, as well as setting funding priorities. The stream walk component is incredibly labor intensive and would be cost prohibitive for a public agency to implement. The Stream Team has trained and certified 45 volunteers to help conduct Stream Walk surveys over the past 15 months. The Stream Walk Teams have mapped over 15 miles of creeks throughout the watershed.

As further testament to the quality and usability of Stream Team data, the Los Angeles RWQCB is using this data to help develop TMDLs for the Malibu Creek Watershed. The Stream Team, along with the Santa Monica BayKeeper, (with approval from the California Coastal Commission) conducted a compliance monitoring program for the Army Corps of Engineers contaminated sediment dredging project in Marina del Rey. The monitoring project involved measuring for turbidity in the Marina during dredging operations. This project offered substantial cost savings and greatly increased the frequency and number of samples collected. In addition, Stream Team data is being used by the National Park Service to conduct a massive invasive vegetation removal project in Malibu Creek. Also, Stream Team data will be used by the Army Corps of Engineers for a feasibility study investigating the restoration possibilities around Rindge Dam to enhance endangered steelhead habitat. This monitoring data, valued at $45,000 by the Corps, will be used as in-kind funding towards the cost of the feasibility study. Finally, the Stream Team has been approached by other public agencies to assist and partner in data collection and research projects. For example the Resource Conservation District of the Santa Monica Mountains (RCDSMM), is conducting a study to determine the distribution of non-native invasive aquatic species and their impacts on the endangered tidewater goby. The RCD has requested that the Stream Team map and measure pool habitat for this study.

Heal the Bay believes that LARWQCB, the State Water Resources Control Board, counties, cities and public agencies mandated to conduct water chemistry monitoring and identify pollution sources should financially support volunteer monitoring efforts modeled after the Stream Team. These programs are cost effective and provide high quality data that fulfills these mandates. In addition, volunteer monitoring has the added benefit of community outreach and public education. Over 500 people have been educated about the issues concerning the future water quality and ecological health of the Malibu Creek Watershed. These volunteers witness first hand the affects of impervious surfaces, nutrient loading, sediment loading and urban runoff on stream ecology. Volunteers, who attend Stream Team trainings, leave with the knowledge of what they can do to protect this precious resource. Heal the Bay has witnessed our volunteers take ownership of the Malibu Creek Watershed and truly become stewards of the environment.

II. Introduction

Water quality monitoring will become increasingly more important in the next decade as the United States Environmental Protection Agency (USEPA) and other regulatory agencies set Total Maximum Daily Loads (TMDLs) and load allocations for various pollutants that enter America's already polluted waterways. Effective monitoring is severely hindered under the current regulatory system given the numerous waterways that require monitoring and the tight budgets faced by monitoring agencies and non-profit organizations. One unique solution to this daunting problem is to train concerned citizens as volunteers to monitor water quality in their local waterways, thereby increasing the number of monitors available and dramatically reducing costs. In order to demonstrate the feasibility of this type of volunteer program, Heal the Bay established "Stream Team," a volunteer water quality monitoring program in the Malibu Creek Watershed.

The Stream Team Pilot Program objectives were to: 1) identify sources of pollution in the watershed; 2) demonstrate effective methods for recruiting and training volunteers; 3) confirm that trained volunteers could collect accurate, reliable data for use in regulation and decision-making; 4) determine cost/benefits of using volunteers instead of paid staff and/or State-certified laboratories; and 5) create a model program that would allow other monitoring groups and agencies to benefit from the lessons Heal the Bay learned in establishing this program.

Based on one year of extensive testing efforts and volunteer feedback/observations, Heal the Bay determined that Stream Team volunteers could provide accurate and reliable water chemistry data. These data are of the quality to be integrated into the process to determine TMDLs and to ensure that these waste load allocations are being met. Moreover, it is our belief that without the use of volunteer monitoring, the efforts required to establish and verify TMDLs would be too expensive. Heal the Bay strongly believes that the stream walk component is essential to any monitoring effort interested in addressing the sources of problems. The stream walk component could not be efficiently implemented by anyone other than a volunteer monitoring organization. Finally, the Stream Team program, through the use of volunteers, provides the added benefit of public education and stewardship for community members. This will help change the actions of the public at large and create a team of spokespersons with first hand knowledge of the issues affecting water quality.

This report is intended to provide a model format for non-profit environmental organizations, government agencies, and municipalities to design and manage a volunteer program for monitoring in their local watershed. Heal the Bay believes that the Stream Team Program is a useable model for the collection of high quality, accurate, and reliable data that is applicable to all watersheds. The model program provides specific information regarding volunteer selection, effective training methods, monitoring techniques for different pollutants and impairments to a stream, equipment recommendations and associated costs, and data collection and management. In addition, a list of resources is provided to aid new and existing volunteer programs in enhancing the quality and accuracy of their data. Although the information presented herein is specific to the Malibu Creek Watershed, many of the methods and techniques are applicable to any volunteer monitoring program. General recommendations are provided to assist other organizations in setting up monitoring programs and to avoid the difficulties encountered in establishing and maintaining the Malibu Creek program.

Heal the Bay is impressed with the quality of the data that has been and can be collected using well-trained motivated volunteers. More impressive is the use of Stream Team data by stakeholders and resource agencies to protect and enhance the environment. Water Chemistry data is being utilized by the Los Angeles Regional Water Quality Control Board (LARWQCB) to help establish waste load allocations for the Malibu Creek Watershed. It is a testament to the program design that the monitoring locations selected and the equipment and protocols used provide data to fill this role. The Stream Team and the Santa Monica BayKeeper partnered to conduct compliance monitoring for the Army Corps of Engineers contaminated sediment dredging project in Marina Del Rey. The two groups monitored the turbidity in the Marina during dredging operations. This project offered substantial cost savings and greatly increased the frequency and number of samples. The information collected during this project will likely result in changes to future dredging projects that afford superior protection to the environment. In addition, Stream Team data is being used by the National Park Service to conduct a massive invasive vegetation removal project in Malibu Creek. Stream Team data will also be utilized by the Army Corps of Engineers for restoration planning around Rindge Dam for a feasibility study to enhance endangered steelhead habitat. The data provided by the Stream Team was valued at $45,000 and will be used as in-kind funding towards the cost of the feasibility study. The Stream Team has also been approached by other agencies to assist in data collection and to partner on research projects. For example, the Resource Conservation District of the Santa Monica Mountains (RCDSMM) is conducting a study to determine the distribution of non-native invasive aquatic species in lower Malibu Creek and the affect of these species on the endangered tidewater goby. The Stream Team was asked to map and measure pool habitat for this study and to assist with fish seines (Figure 1) to count the non-native aquatic species.


Figure 1. RCDSMM and Stream Team using the seine to rescue trapped fish

Heal the Bay's Stream Team has been recognized by numerous groups and agencies as a model that should be emulated to enhance the value and comparability of data collected by volunteer monitoring programs throughout the region. Heal the Bay currently sits on the technical advisory committee (TAC) for the Topanga Stream Team and the SWRCB Volunteer Monitoring TAC. These TAC’s review quality assurance protection plans (QAPP’s), recommend monitoring techniques and procedures and review data collected in the field. The Stream Team has worked closely with the Santa Monica BayKeeper, the Resource Conservation District of the Santa Monica

Mountains (RCDSMM), the Santa Barbara ChannelKeeper, Friends of the Los Angeles River (FOLAR), and the City of Calabasas providing advice on their monitoring programs to enhance data quality and to assist with data transfers to resource agencies.

Heal the Bay reviewed the monitoring plans and QAPP's for the Santa Monica BayKeeper, the RCDSMM and the City of Calabasas. Heal the Bay has also collected and processed field data with our Global Positioning System (GPS) to locate water chemistry monitoring sites for the City of Calabasas, RCDSMM and the Tapia Water Reclamation Facility. This data has been presented to the Los Angeles Regional Water Quality Control Board (LARWQCB) and the respective monitoring group to enhance data analysis and presentation. The Stream Team has also participated in four regional snap shot events. The snap shots consist of several monitoring groups that collect and analyze water samples on the same day. Numerous samples were taken from the San Gabriel River, Los Angeles River, Malibu Creek Watershed, Topanga Watershed and numerous storm drain outfalls throughout the Santa Monica Bay. In addition, FOLAR, the LARWQB, Cabrillo Marine Aquarium and the Southern California Marine Institute (SCMI) have attended a water chemistry training event and were certified to conduct Stream Team water quality analysis. Representatives from the Santa Monica BayKeeper and the LARWQCB have attended stream walk trainings. The Stream Team has consulted with the Santa Barbara ChannelKeeper and the Ventura County Chapter of the Surfrider Foundation about implementing the Stream Team program for the Ventura River Watershed. Heal the Bay has also provided detailed cost and time estimates and information about how to acquire funding to begin monitoring in the Ventura River Watershed.

Heal the Bay has provided recommendations and extensive training to the Santa Monica BayKeeper to aid the redesign of their volunteer monitoring program. In addition, to reviewing their monitoring protocols and quality control procedures, advice was offered to improve the organization of the program, the quality of training and training materials, field data sheets, field equipment and communication with volunteers. In addition, Heal the Bay provided intensive GPS computer and field training, created a special BeachKeeper program for the GPS and lent the unit to the Santa Monica BayKeeper to map storm drain outfalls throughout Los Angeles County. This data was post processed and put into Heal the Bay's Geographic Information System (GIS) computer mapping and database program for use by the BayKeeper and other interested agencies.

Acknowledgements

Heal the Bay would like to acknowledge our partners in the Stream Team project. The initial watershed assessment, program design, and production of the *Malibu Creek Watershed Stream Team Field Guide* and *The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action* were funded by the California State Coastal Conservancy. Environment Now provided the funds required to acquire the meters for the Stream Team Field Kit, Global Positioning System, Enterococcus analytical equipment, Geographic Information System workstation and software. The Santa Monica Bay Restoration Project provided funding to produce the Stream Team educational and recruitment brochures to be handed out in the community events. Finally, Environmental Systems Research Institute Conservation Program provided the Stream Team with GIS software and training. The combined efforts and funding of these generous groups has allowed Heal the Bay to create a viable high quality volunteer monitoring program.

Preceding this report, four students from the Graduate Department of Landscape Architecture at California State Polytechnic University, Pomona created two other publications regarding volunteer monitoring: *The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action* and *The Malibu Creek Watershed Stream Team Field Guide. The Malibu Creek Watershed: A Framework for Monitoring, Enhancement and Action* assesses the major issues of the Malibu Creek Watershed, evaluates and recommends specific monitoring protocols that can be accurately and reliably performed by volunteers, and identifies likely sources of pollution in order to prioritize monitoring locations. This document serves as a case study for other groups interested in creating a comprehensive watershed monitoring program for their own unique watersheds. *The Malibu Creek Watershed Stream Team Field Guide* provides educational background about the watershed and detailed step-by-step procedures to allow volunteers to collect information on the environmental changes that contribute to watershed impairment. The field guide was designed to be easily adaptable for use by other monitoring groups. Numerous Stream Team F0ield Guides have been purchased by schools, municipalities and other groups interested in conducting monitoring in southern California. Other references and resources are provided in Appendices A and B, respectively.

III. The Malibu Creek Watershed

Malibu Creek is identified as an impaired waterway as defined by Section 303(d) of the Federal Clean Water Act. The Malibu Creek Watershed is composed of seven sub watersheds, each of which is drained by a major tributary that eventually converges into Malibu Creek. Malibu Creek drains into Malibu Lagoon, which ultimately empties into Santa Monica Bay at Malibu Surfrider Beach (Figure 2). Within the watershed boundaries are the cities of Agoura Hills, Westlake Village, and portions of Malibu, Calabasas, Thousand Oaks, Hidden Hills, and Simi Valley.

Heal the Bay performed an initial study to determine the types of disturbances or pollution that adversely impacted the watershed. Six major areas of concern/impairment were identified: imported water (water quantity), pollutants associated with urban runoff, impervious surfaces, erosion and sedimentation, nutrient loading, and alteration of vegetative communities. In order to better understand how the volunteer monitoring program was constructed to meet the challenges of the Malibu Creek Watershed, each of these impairments is briefly discussed below.

Imported Water and Pollution from Urban Runoff

Approximately 20,000 acre-feet or 6.5 billion gallons of water are imported annually into the Malibu Creek Watershed for use by residents and businesses for drinking, cleaning, irrigation (landscape and agricultural), and sewage disposal. This enormous volume of water eventually enters the watershed's network of streams and aquifers in one of three ways: discharge from the Tapia Water Reclamation Facility, surface runoff via the storm drain network, and groundwater recharge.

The Tapia Water Reclamation Facility, located five miles north from Malibu Lagoon, discharges approximately 5,000 acre-feet or 1.63 billion gallons of treated wastewater annually into Malibu Creek. The wastewater discharge contains significant levels of nutrients, specifically nitrogen and phosphorous, which enhance creek nutrient loading.

The storm drain network collects surface runoff water from rainfall, irrigation, automobile and sidewalk washing, commercial facilities, and other sources. The runoff transports such pollutants as fertilizers (nutrients), herbicides, pesticides, heavy metals, oil, grease, antifreeze, pet fecal matter, sediments, yard wastes, and trash directly into the streams of the watershed. This is referred to as urban runoff and is identified as the most significant source of pollution to Santa Monica Bay. (Santa Monica Bay Restoration Plan, April, 1994, p.3.1).

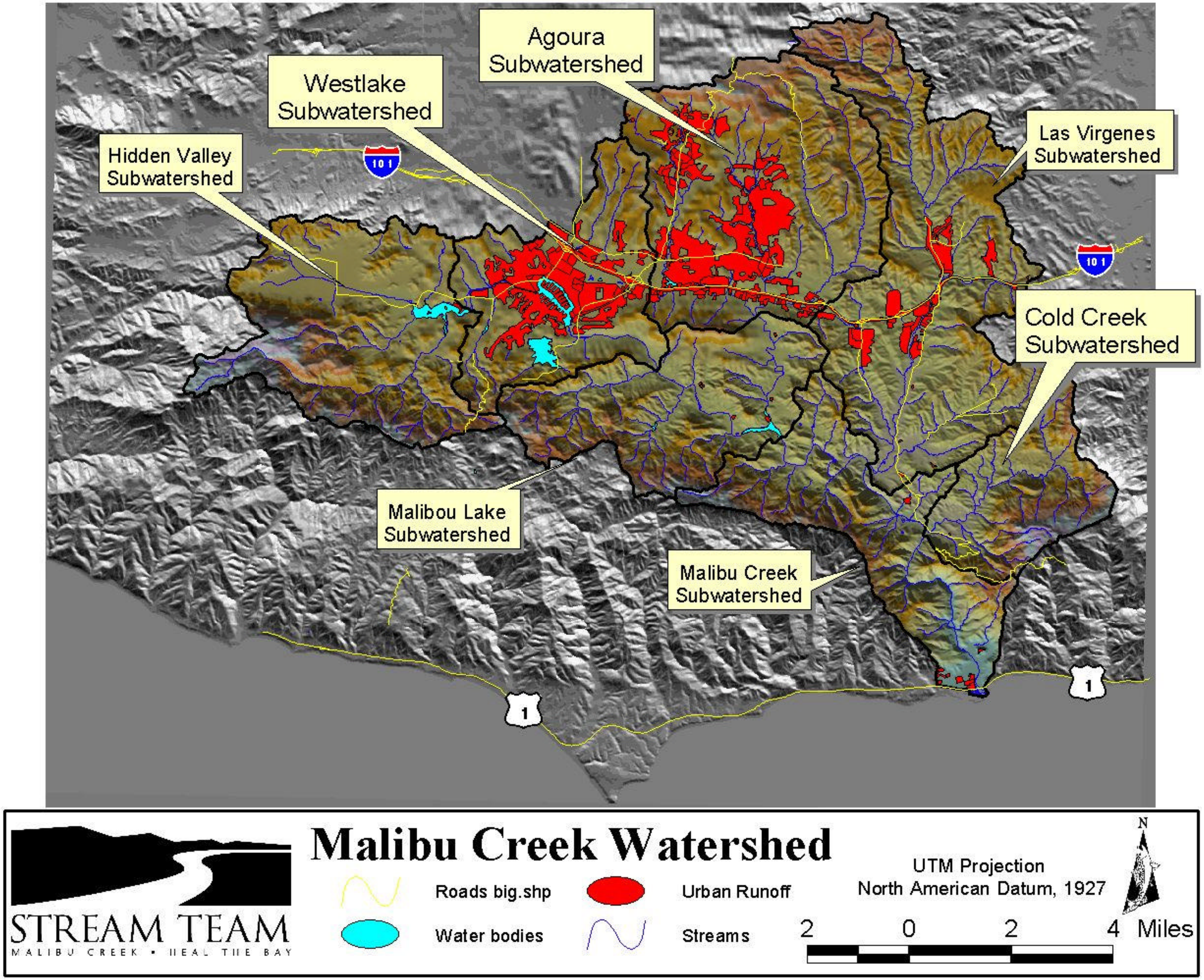

Figure 2. The Malibu Creek Watershed and Subwatersheds

Imported water infiltrates the soil through irrigation and septic systems and recharges groundwater. This groundwater recharge can carry pollutants from lawn fertilizers, horse paddocks, agricultural runoff, and improperly functioning septic systems. The Malibu Creek Watershed has an estimated 2,300 septic tanks (USDA NRCS MCWNRP 1995, p.16).

Impervious Surfaces

Impervious surfaces, such as rooftops, paved areas, and compacted soils, decrease water infiltration into the soil, and therefore increase the water volume delivered to watershed streams. In addition, the runoff travels at a higher velocity, causing increased streambank and bed erosion. The combination of these factors can change stream temperature, water chemistry, riparian habitat, and floral and faunal assemblages. Impervious surfaces also accumulate chemical pollutants, litter, and animal waste that wash into the storm drain network and then into Malibu Creek and its tributaries. A direct correlation has been established between the amount of pollution in a riparian system and the percentage of impervious surfaces in a watershed (Schueler 1995, p. 24).

Erosion and Sedimentation

Over 90% of the soil types in the Malibu Creek Watershed are classified as erodible to severely erodible (USDA, 1967). Erosion is a natural process in the watershed that adds sediments and nutrients to streams. Several factors have caused an increase in stream sedimentation: 1) soil disturbance due to construction and agriculture; 2) deposition of wind-born dust on impervious surfaces; 3) removal of native vegetation from steep slopes for fire protection; and 4) erosion from improperly designed drainage outlets. Sedimentation can change stream character by changing stream depth, flow, course, and bed composition. Sediment particles also act as transports for pollutants, trapping pollution in the streambed when sediment particles fall out of the water column.

Nutrient Loading

Nitrate and phosphate levels in Malibu Creek have increased due to runoff from agricultural areas, poorly designed horse facilities, leaking or improperly maintained septic systems, discharges from the Tapia Water Reclamation Facility, detergents and commercial cleaning preparations, soil erosion, and fertilizers (Behar, Dates, and Byrne 1996, p. 130). Areas of standing or slowly moving water are especially impacted, since they flush less often and provide good conditions for algae, plant, and aquatic organism growth. Excessive algal and plant growth causes a build-up of detritus and the bacteria that decompose it. This build-up depletes the oxygen concentration in the water, and can cause fish kills and odor problems.

Alteration of Vegetative Communities

Invasive, non-native vegetation has taken over many disturbed areas of the watershed and colonized riparian areas of Malibu Creek. The change in vegetation is especially important in the riparian areas because native vegetation influences water temperature and chemistry, provides resources for aquatic life, stabilizes streambanks, and prevents sediments from washing into the streams. However, non-native, invasive plants often provide little wildlife habitat for native birds and animals, can increase fire intensity, and often do a poor job of stabilizing streambanks, which contributes to sediment loading.

IV. Stream Team Program Overview

The Stream Team is a comprehensive effort to conduct reliable, accurate volunteer monitoring model program designed to collect quality data useable by resource agencies, municipalities, and organizations. The model program was created by Heal the Bay using the Malibu Creek Watershed as the case study area. An extensive analysis of the environmental issues affecting the Malibu Creek Watershed was performed prior to program implementation. In addition, regulatory agencies and other stakeholders were consulted to obtain information that would enhance decision-making to protect these resources. A monitoring program was created to address the specific issues affecting the Malibu Creek Watershed. The pilot phase of the Stream Team monitoring program was composed of two distinct activities: water quality analysis and stream walk survey. Each activity is discussed below.

Water Quality Analysis

The Stream Team water quality analysis program was designed to achieve the following objectives:

- Establish current baseline conditions within the various subwatersheds of the Malibu Creek Watershed.
- Determine how much each subwatershed is contributing to poor downstream water quality.
- Evaluate the quality of the stream habitat to support native plants and aquatic wildlife such as steelhead trout.

Heal the Bay determined the specific parameters to be monitored based on an extensive analysis of the environmental issues affecting the Malibu Creek Watershed and in consultation with regulatory agencies and other stakeholders. The parameters listed below have been monitored by Heal the Bay's Stream Team on a monthly basis since November 1998. In December 1999, the Stream Team added Enterococcus testing to the list of water chemistry parameters. Enterococcus is a bacteriological indicator of waste from warm-blooded animals.

Physical Parameters	Chemical Parameters
Site Conditions	Dissolved Oxygen
Stream Flow	pH
Air Temperature	Turbidity
Water Temperature	Conductivity
	Nutrients

Site Conditions
Site conditions of the monitoring location assist in future data analysis. These parameters include *Weather* conditions, presence of *Debris*, and stream *Properties* such as, the presence of algae and water color, appearance, and odor.

Stream Flow
Stream flow is the volume of water that moves past a fixed point in a specific interval of time. The amount of water (volume) and how fast it is traveling (velocity) determine the flow of a stream. Stream flow is an important indicator of water quality. It affects the available oxygen level in water that fish and other aquatic wildlife depend on to live. In general, streams with higher natural flows have more oxygen available for aquatic wildlife. Stream flow also controls the amount of sediment that is transported in a stream. Streams with higher velocities and larger volumes transport greater amounts of sediments than streams with lower flows. In addition, stream flow determines how pollution is transported downstream and influences the ability of a stream to dilute pollution. Large, swift rivers have a greater ability to dilute and degrade runoff pollutants, unlike smaller slower velocity streams.

Air Temperature
Air temperature is an important determinant of water temperature. Air temperature is measured at the beginning and end of the monitoring event.

Water Temperature
Water temperature directly affects biological and chemical processes. Some fish species like steelhead trout, prefer cooler waters than other species. Benthic macroinvertebrates (insects) will move in the stream in order to find their optimal temperature. Water temperature is measured at the beginning and end of the monitoring event.

Dissolved Oxygen
Aquatic organisms rely on the presence of dissolved oxygen (DO) in streams. Water temperature, altitude, time of day, and seasons can all affect the amount of DO in the stream. Oxygen is both produced and consumed in a stream because of the constant churning of running water, especially in riffles, which dissolve more oxygen than the still water of a lake or stream pool (US EPA 841-B-97-003 1997, p.139). The presence of aquatic plants also affects DO concentrations. Green plants release oxygen underwater during photosynthesis. Maximum amounts of DO are produced via photosynthesis with the energy of the late afternoon sun. By early morning, the same plants may have taken up the oxygen through respiration, making levels of DO lowest at this time. Because DO is lowest in the morning hours, it is one of the first tests performed at the sampling station.

pH
pH is a measure of acidity or alkalinity. The pH of a stream affects the ability of plants and wildlife to survive and reproduce. pH is measured on a scale from 1.0 to 14.0. Neutral pH is 7.0; acidic pH is less than 7.0; and alkaline is greater than 7.0. Most aquatic animals prefer a range of 6.5-9.0 pH.

Turbidity
Turbidity is a measure of water clarity. Insoluble solids or suspended particles such as clay, silt, sand, algae, plankton, and other substances can affect the clarity of water. High levels of turbidity adversely impact the ability of steelhead trout and other aquatic organisms to survive. Water temperature is increased, because suspended particles absorb more heat. Also, when turbidity is high, photosynthesis is reduced due to the decreased amount of light traveling through the water. Sources of turbidity include soil erosion, waste discharge, urban runoff, large numbers of bottom feeders that stir up sediments, and excessive algal growth.

Conductivity
Conductivity (indicator of Total Dissolved Solids) measures the ability of water to conduct an electric current and is an indicator of the concentration of dissolved solids or salinity. The conductivity of streams is directly affected by the substrate or stream bottom material. In general, conductivity is higher in areas with clay soils, because these soils tend to dissolve in water. Conductivity indirectly measures the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron, and aluminum (Murdoch, Cheo, and O'Laughin. 1996, p. 181). These substances and seawater enhance the ability of water to conduct electricity. Failing septic tanks, sewage spills, and agricultural runoff containing phosphates and nitrates are indicated by high conductivity measurements. Conversely, organic substances like oil, alcohol, and grease are poor conductors of electricity and will yield low conductivity measurements. Excessive amounts of dissolved solids lead to poor tasting drinking water with laxative effects (Murdoch, Cheo, and O'Laughin. 1996, p. 181).

Nutrients
Phosphorus and nitrogen are naturally occurring nutrients in streams and are essential for plant and animal survival. Naturally occurring sources of nitrogen and phosphorus include soil decomposition, rock erosion, and animal and plant waste. Sources of nutrients from human development include treated wastewater, runoff from fertilized agricultural lands, lawns and golf courses, manure laden runoff from horses and grazing animals, aerial deposition, fire fighting waste and commercial cleaning activities. Problems occur when large amounts of phosphorous and nitrogen are introduced into the stream ecosystem. As a result, there can be excessive algal growth depleting the available oxygen in the stream for fish and other aquatic organisms.

Phosphorous is a useful indicator of potential problems associated with excessive plant growth. High amounts of dissolved phosphorous may indicate a pollution source such as chemical fertilizers or septic system leachate. Insoluble phosphorous can be due to excessive erosion, animal waste, or sewage (Murdoch, Cheo, and O'Laughin 1996, p.180).

Two field tests are used to measure the nitrogen content in streams; nitrate-nitrogen (N_2 + $N0_3$-N), and ammonia-nitrogen (NH_3-N). Nitrogen gas (N_2) composes 80% of the air we breathe, but most plants cannot use nitrogen in this form. N_2 is converted into nitrates, which is usable by plants. In streams with low DO concentrations, nitrogen is found in the form of ammonia. Ammonia is extremely toxic to aquatic life as compared to nitrates. Sources of nitrates include wastewater treatment plants, runoff from animal manure storage areas, runoff from fertilized lawns and croplands, failing or improperly maintained septic systems, and industrial discharges containing corrosion inhibitors.

Stream Walking

Stream Walkers are the investigative sleuths of the Malibu Creek Watershed. This activity was created to help locate both point and non-point sources of pollution contributing to the poor downstream water quality and environmental degradation. The goal of Stream Walking is to characterize the stream reaches within the watershed. This task involves visually surveying the various stream reaches with the following objectives:

- Provide an overall view of the watershed
- Identify problem areas and pollution sources contributing to degraded water quality
- Target locations for future monitoring and restoration efforts
- Identify barriers that can prevent the upstream migration of the endangered steelhead trout.

Heal the Bay believes that the stream walk component is an essential element to having a comprehensive watershed scale monitoring program. Moreover, the information gleaned from the stream walk will help locate the sources and causes of degraded water quality and ecological function. The data collected in the stream walk is applicable to numerous agencies in the region and is collected so as to enhance restoration-planning efforts. In conjunction with the water quality analysis component of the program, the stream walk provides information that can be used for habitat and water quality assessments by regulatory agencies. The stream walk is also a unique educational opportunity providing volunteers with first hand experience on how urban streams are being irreparably damaged by poor development and planning practices.

Stream Walk information can be used by the various agencies in charge of protecting the numerous species of plants and wildlife, and by those concerned with making the area safe for recreational users. This information will be beneficial for Heal the Bay and other groups that are interested in monitoring the Malibu Creek Watershed to help locate areas that are in need of immediate restoration or further study. Stream Team members are asked to record information about each of the following physical parameters:

-- Discharge Points and Outfalls
-- Unstable Bank Conditions
-- Artificial Streambank Modifications
-- Adverse Land Uses
-- Large Patches of Exotic and/or Invasive Vegetation
-- Possible Barriers to Fish Passage
-- Illegal Dump Sites.

Identification of these adverse parameters should help chart a course of action geared toward improving the ecological function and water quality within the watershed. When one of the above parameters is identified, a field sheet is filled out for that specific item. The item location is mapped within one meter using the GPS unit and a digital photograph is taken. Each of the seven parameters has a unique field sheet that provides detailed information and clues to aid Heal the Bay and local stakeholders in identifying the source of the problem. Stream walk field sheets can be seen in Appendix D.

Locating Discharge Points and Outfalls

One of the main tasks of the stream walk is to identify, locate, and investigate the various discharge points flowing into the watershed. Discharge points include pipes, open channels, drainage ditches, and storm drains installed by municipalities, developers, and individuals. Discharge points transport pollutants, excess water quantity and may be a source of streambank collapse (Figure 3).

a. Pipes

The most obvious discharge points will be in the form of pipes draining directly into the stream. These can be of various sizes and condition, ranging from large corrugated steel and concrete reinforced pipes to small, white or black plastic (PVC) pipes or hoses. Homes and businesses commonly install drains to prevent pooling and to avoid lawns and planted areas from becoming muddy. In some rural areas in the watershed, pipes transporting water from washing machines directly to the creek have been identified. It is believed that this eases the burden on older septic systems.

b. Storm Drain Outlet

Storm drains are generally concrete pipes with diameters greater than 24 inches and metal grates. Storm drain outfalls are used to convey water carried from the streets through a network of underground pipes and eventually into the creeks, lakes, lagoon, and ocean. These are not connected to a sewage treatment plant. Any water, trash, or other substances they receive goes directly into the water body without filtration. Storm drains are designed for rainwater, however they frequently collect water from other sources such as improperly installed irrigation devices, car washing activities, and runoff caused by homeowners who hose down the sidewalks and driveways instead of sweeping.

Figure 3. Discharge points and outfalls identified during stream walks

c. Open Channel/Drainage Ditch

Open channels are used throughout the watershed to intercept and redirect stormwater runoff. They are constructed to reduce erosion, flooding or landslides near the numerous hillside homes in the area. Open channels can be constructed from concrete, corrugated metal pipes, or natural materials like earth and dirt. Drainage ditches are often associated with agricultural and rural areas and consists of exposed dirt or grass. They are U-shaped or V-shaped channels of excavated earth used to capture the excess water draining from roads or the overflow of agricultural irrigation.

Unstable Bank Conditions

Another aspect of Stream Walking is to identify areas with degraded streambanks. Collapsing and unstable streambanks are a significant source of sediment loading to streams. In the past, areas of persistent streambank erosion have been channelized to reduce the potential of flooding caused by stream blockage. By identifying these areas, alternative streambank stabilization measures, such as bioengineering, can be employed. Pinpointing the location of unstable streambanks will provide Heal the Bay and other agencies with the necessary information to devise a restoration strategy to minimize the flow of sediments into the stream (Figure 4). The following section describes the visual clues used to identify unstable streambanks.

Figure 4. Unstable streambanks identified during stream walks

a. Streambanks Eroding and Collapsing

Eroding and collapsing streambanks that are washed away or worn down by surface runoff must be noted. Visual indicators of erosion include large patches of bare or exposed soil, excessively exposed roots of vegetation, and trenches or gullies that have cut into the streambank.

b. Loss of Natural Vegetative Cover
Areas where the natural vegetation is conspicuously absent, with exposed bare soil, are likely sources of sediment inputs to the stream. Signs of the vegetation being trampled or pulled out may indicate unstable bank conditions. Vegetation is an important element in the stabilization of streambanks.

c. Collapsing Vegetation
Falling or collapsing streamside vegetation is an indicator of unstable streambanks. Falling and collapsing vegetation also is an indication that streambanks are being undercut and/or being subjected to above normal flows. Fallen trees and excessively exposed roots on the streambank are visual clues that the stream flow is too great or the streambank is moving.

Artificial Streambank Modifications

Another important element of Stream Walking is to identify and locate areas where there has been streambank modification. Streams within the watershed vary from natural to man-made channelization. As the level of modification increases, the beneficial qualities of the stream tend to decrease. Possible modifications include concrete lining and rip rap (a retaining wall made of concrete, large boulders, or sacked cement; Figure 5). Modifications can also include channelized sections of the stream with culverts, bridges, etc.

Figure 5. Streambank modifications identified during stream walks

The following categories are used to describe artificial streambank modifications:

NV = Natural Vegetation
CC = Concrete Channel
RR = Rip Rap
LB = Loose boulders stacked along streambank
CB = Boulders concreted together along streambank
WD = Wood retaining wall
GW = Gabion Walls (Rocks in wire mesh)
O = Other (describe).

Impacting Land Uses

Adjacent land uses that are obviously affecting the streamside environment or the stream itself can be significant non-point sources of pollution. Impacts that should be considered include landscaping adjacent to streams, horse corrals, pastures with grazing animals in the streamside environment, parking lots, and other land uses that are altering the natural vegetation in the riparian zone (Figure 6).

The following are categories used to describe land uses affecting the stream or streamside environment and are based on land use designations utilized by Los Angeles County Regional Planning Department.

SFR	= Single Family Residential (standard house)
MFR	= Multi-family Residential (apartments, condos)
AG	= Agriculture
VO	= Vineyards and Orchards (tree crops on hillsides)
AH	= Animal Husbandry (grazing livestock cattle,)
EQ	= Equestrian (horse owners)
IND	= Industrial (factories, manufacturing,)
COM	= Commercial (retail, shopping centers,)
V	= Vacant (undeveloped open space)
O	= Other.

Figure 6. Impacting Land uses identified during stream walks

Exotic and/or Invasive Vegetation

Exotic and/or invasive plants in both degraded and healthy-looking sections of the stream are a major problem throughout the Malibu Creek Watershed. Invasive plants provide little habitat value for native wildlife, poor stabilization of streambanks, and increase the risks and damage caused by fires. Increased fire damage in the riparian zone is caused by more frequent and hotter burning fires, and result in increased sediment loading to the streams. A significant patch is one where the non-native plants seem to be flourishing or are out-competing native plants (Figure 7). To assist the volunteer with identifying invasive vegetation, a plant identification guide was created by the Cal Poly team and is included in the *Malibu Creek Watershed Stream Team Field Guide* and is part of stream walk training materials. Also, the Stream Team contracted with a botanist, Marti Witter, who is well versed with the flora of the Santa Monica Mountains. A summary of Invasive Vegetation Information with helpful recommendations is included in Appendix E.

Figure 7. Invasive vegetation identified during a stream walk

Figure 8. Stream Crossing identified during a stream walk

Possible Barriers to Fish Passage

A key component of the Stream Walk is to identify and locate potential barriers to fish migration, particularly the steelhead trout. Stream Walkers record anything that would adversely impact the ability of fish to travel upstream or downstream in the watershed. Dams are obvious examples of migration barriers. Naturally occurring obstacles such as waterfalls taller than three feet, steep fast flowing cascades, and logjams can block movement. Artificial modifications such as check dams, culverts, water diversions, stream crossings, and channelized streams can also inhibit the movement of aquatic wildlife (Figure 8). Since there is a significant difference in the seasonal water flows in the watershed, obstacles may or may not be apparent. Consideration is given for fluctuating water levels.

Dumping Sites

Stream Walkers identify dumping; large piles of trash, abandoned cars, appliances, large quantities of yard waste, and/or miscellaneous pieces of junk (Figure 9). Volunteers also look for evidence of green-waste dumping, such as grass and yard clippings, piles of palm leaves, etc. These areas probably will be near roads. Observations concerning the type and abundance of wastes discovered are recorded on field sheet. Small amounts of litter are picked up and placed in the trash bags provided in the field kit. The concern here is to note the location of large quantities of trash or larger items that will require additional people or equipment to remove it at a later date.

Figure 9. Dumping sites identified during stream walks

Volunteer Program

Of critical importance to any monitoring effort is a program manger that is vested and passionate about the program. This person is responsible for day-to-day communications with volunteers, maintaining a database of trained volunteers, organizing and disseminating data, maintaining and purchasing necessary equipment, supervising monthly trainings and water chemistry testing events, conducting nutrient and bacteria testing, analyzing field data, and understanding GIS and GPS programs. Heal the Bay hired a full-time Stream Team manager to serve in this capacity. While this position substantially adds to the cost of conducting water quality analysis, it is critical to have a person responsible for program organization and quality of the data. This person also serves as a recruiter, spokesperson, and cheerleader for the program.

Volunteer Training and Motivation

Volunteers are the lifeblood of any monitoring program and will mean the difference between success and failure. Volunteers must feel comfortable in their ability to use the equipment and to follow established procedures. Heal the Bay conducts monthly six-hour training sessions for the water quality analysis volunteers. During the training session, volunteers are educated about the Malibu Creek Watershed and made aware of the issues of concern. Each of the issues is directly related to one or more of the testing procedures. For example, sediment loading is a major issue in the watershed. To examine the severity of the problem, the Stream Team monitors turbidity and conductivity. The ability of the volunteer to understand the linkage between the issue and the testing procedure is crucial to motivating volunteers. If they do not understand the purpose behind the testing, they will not be excited about the test or be motivated to perform the procedure correctly.

During training sessions, every volunteer uses each and every piece of equipment. The equipment is first demonstrated by the Stream Team Program Manager; each volunteer immediately follows the demonstration by using that piece of equipment to analyze water samples. Volunteers are also instructed on the proper method to complete Stream Team Field Sheets. The illustrated field sheets were created to provide the order of testing, to be easy to use in the field, and to provide a standardized system to record information collected in the field (Appendix C). After each volunteer has been given a chance to use each piece of equipment and perform the test procedures, volunteers are divided into teams and must demonstrate their ability to competently perform the entire array of water chemistry tests that they will be expected to perform in the field. Only after they have successfully demonstrated their abilities to follow protocol and use the equipment are volunteers eligible to participate in water chemistry events.

Training is limited to ten people or fewer to ensure that each volunteer is given ample time to get proficient with the testing equipment, and that enough one-on-one attention can be given to facilitate volunteer comfort and evaluate their competency. Heal the Bay recommends that training sessions be conducted in the field. It is impossible to simulate field conditions or give potential volunteers a true picture of what is expected of them without the field component. Finally, during the first two water chemistry events, newly certified volunteers are paired with experienced volunteers. This helps new Stream Team members build their confidence. It also provides a format for introducing changes in equipment and protocols to veteran volunteers without them having to attend additional training. Changes in protocol or equipment can be demonstrated and taught to new recruits who can then demonstrate these procedures to veteran volunteers. Volunteers are paired with the program manager or a highly trained college intern at least every six months. At this time their ability to follow protocols and use the equipment is reevaluated and the volunteer is re-certified.

Volunteers interested in becoming part of the stream walk activity are required to attend two four-hour training sessions. One training session is performed in a wide, more urbanized section of the watershed; a second session is conducted at a narrow stream with little or no surrounding development. This provides volunteers with a realistic picture of the physical requirements associated with the stream walk and allows volunteers to see all seven parameters that are to be located in the field including the various types of invasive vegetation. During the training sessions, volunteers are educated about the Malibu Creek Watershed. They are made aware of the issues of concern and how each of the parameters that will be identified during stream walks specifically relates to these issues

Training Materials

All people attending a training event receive an appropriate Heal the Bay Stream Team training packet. The water chemistry training packet is enclosed in Appendix C. Training materials provide general information about the Malibu Creek Watershed and step-by-step details on how to conduct water chemistry analysis. Included in the training packet is information about what levels are considered acceptable for each test. It is important that volunteers can assess if there is a problem. For example, is a turbidity reading of 1 NTU good or bad? The ability of a volunteer to generally understand the data they are collecting in the field is crucial. If a volunteer wakes up Saturday morning to brave the wet and cold to collect information that means nothing to them, rest assured they will be a short-term volunteer. On the other hand, if a volunteer understands a test reading, and can conclude that a stream is healthy or polluted and what the potential sources might be, then that volunteer feels an integral part of the process. Once a volunteer has demonstrated their commitment to the Stream Team by attending three water chemistry field events, they are awarded a Stream Team Field Guide. The 150-page field guide provides more detailed educational and background information about the Malibu Creek Watershed and is illustrated to better demonstrate procedures and equipment. The Stream Team Field Guides have proven to be an excellent incentive for motivating volunteers.

Stream Walk

For the Stream Team stream walking, each volunteer receives a stream walk training packet composed of educational information, illustrations about each of the seven parameters, and illustrated field sheets to be completed during the training. Volunteers are taught how to properly use a digital camera and then asked to demonstrate their ability. Each volunteer fills out the field sheet to simulate data collection in the field. The first training session emphasizes issues in the watershed, proper use of the digital camera, and accurately filling out field data sheets. The second session is conducted like an event. Volunteers identify and locate parameters to be mapped in the field, fill out data sheets, and take digital images. In addition, volunteers are introduced to the GPS unit and each volunteer maps a location and enters the data using the handheld controller. The second training reinforces the issues of concern in the Malibu Creek Watershed. Volunteers are asked to explain and summarize the issues and how the seven parameters relate to these issues. By conducting the second training to simulate an actual event, the volunteer is realistically prepared for the intensity and time it takes to conduct the stream walk survey. When a volunteer completes the training, he or she is acutely aware that they will get wet, that boulder hopping and bushwhacking are a must, and that at times stream walking can alternately be strenuous or tedious.

Once a volunteer has completed the two stream walk training sessions and is certified, they are eligible to join one of four stream walk teams. Stream walk teams meet on Saturdays and Sundays, and therefore, provide volunteers with the flexibility to participate on a team that best fits their personal schedule. Stream walk teams consist of a minimum of five people and may contain up to eight volunteers. The Stream Team program manager and/or a highly trained intern always accompany teams during an event. Much of the data collected during the stream walk is subjective and requires the volunteer to determine the likeliness that things located in the field will impact the stream or the environment. The program manager ensures the consistency of the data and helps volunteers feel more comfortable in identifying problems.

The stream walk continually moves and surveys new sections of the watershed. It is crucial that meeting locations be selected ahead of time by the program manger. Explicit directions to meeting locations are published on the website and in the volunteer newsletter providing two months advanced notice. To the maximum extent possible, meeting locations are selected that can be used over a two month period to provide some stability to the program.

The two-day training schedule is burdensome on the volunteer. Because it takes place over a period of two months, several volunteers have not completed the training. Volunteers have suggested condensing the training into a single, six-hour event, with more emphasis on the use of equipment and simulating an actual field event.

Volunteer Incentives

After completing a water chemistry or stream walk training, volunteers are awarded a certificate stating that they have successfully completed the Stream Team training . The certificate can be used by the volunteer in their resume, college application, or hung on the office wall. Certificates are tools to acknowledge the volunteer's effort and also serve as an advertisement for the Stream Team program. Volunteers that attend three stream team events are awarded a *Malibu Creek Watershed Stream Team Field Guide.* In addition, the Stream Team holds quarterly update meetings. Volunteers from stream walk and water chemistry groups have an opportunity to get together and socialize. Heal the Bay provides food and refreshments for the volunteers. The atmosphere is informal and volunteers are encouraged to participate. Social interaction is a critical element to keeping volunteers motivated and was identified by the Cal Poly team from interviews conducted with actual volunteers. At the quarterly meetings, the data collected in the field is interpreted and discussed. A high-ranking person from Heal the Bay, generally the Director of Programs or the Executive Director gives an informative talk regarding the importance and the successes of the program. Significant accomplishments and data uses are also highlighted at these meetings. Most importantly, the efforts and hard work of volunteers are recognized and truly appreciated. Crucial to the success of any volunteer monitoring program is to collect data that is used to improve the environment. There is no better motivation than seeing one's hard work and donated hours spent in the field make a difference in the environment.

Types of Volunteers

From more than 15 years of experience as an organization that is heavily dependent upon volunteer participation, Heal the Bay has identified four categories of volunteers:

Hard Core Volunteer -These are people who have a strong need to actively participate and feel they are making a real difference for the environment. These volunteers always attend events and can be relied upon to handle additional responsibilities such as becoming team captains. In an emergency, they are the first people you call. The hard-core volunteer generally participates for more than one year.

Ace Volunteer – This category of volunteer also has a need to participate and feel as if they are making a difference. However, they do not attend every event. They usually participate between 6 and 9 months. Many Aces' have selected Heal the Bay as a long-term commitment for community service requirements or are trying to gain some practical field experience and are interested in an environmental career.

College Intern – College interns are heavily motivated to build an impressive resume and gain practical experience with an environmental organization. Many interns earn college credits for working on a specific research project. The college intern has a strong need to actively participate and make a difference and generally participate for more than six months. Many interns are looking for a career working in the environmental arena. Interns help in the office and in the field, and because they commit more time, receive additional training and experience they are given greater responsibility. Interns are often paired with new volunteers in the field so they can provide a review of monitoring protocols and proper use of equipment. Interns are heavily depended upon by Heal the Bay and the Stream Team.

Summer Break Volunteer – This category of volunteer has an overall environmental ethic, but in general has specific requirements or goals that need to be fulfilled in a limited time frame. The Summer Breaker generally participates for less than six months. They need to accomplish a certain number of community service hours to meet graduation requirements or have short-term goals to boost their extracurricular activities or practical experience.

All four of these volunteer categories have proven to be invaluable to the Stream Team program. The fourth category, which is often ignored by volunteer efforts, has provided a talented pool of summer break volunteers that bring with them knowledge from many disciplines. They have greatly added to the satisfaction of all volunteers. Many programs make the mistake of holding training sessions quarterly or biannually. This does not account for the seasonality of volunteers. By conducting trainings monthly, anyone interested can get involved quickly for short-or long-term. When a person decides to invest their time and energy, it is imperative that this enthusiasm be quickly put to work. Long waiting periods between trainings will not fulfill their need to get involved. Monthly trainings greatly enhance the educational opportunities by accommodating the highest number of volunteers, expanding the pool of trained volunteers, providing fresh opportunities for social interaction, and reducing the need for every volunteer to attend every event. This added flexibility allows for vacations, emergencies, and weekend work making it less daunting to commit to the program. Finally, this approach makes the program less dependant on hard-core long-term volunteers, which are few and far between.

Certification

Since the first Stream Team water chemistry training in September of 1998, a total of 64 volunteers have been educated about the issues and resources of the Malibu Creek Watershed and received water chemistry monitoring certification. Today the water chemistry team has 25 active volunteers. Stream Team has trained and certified 45 stream walk volunteers. Currently, 23 volunteers have completed half of the training requirements. Stream Team volunteers range in age from 16-70 and travel up to 60 miles to attend Stream Team events.

Educational Opportunities

Volunteer monitoring programs offer a unique educational experience for students by combining discussions with fun, hands-on activities such as water quality analysis and stream walking. The students not only get to hear about storm water pollution, nutrient loading, sediment loading, and problems associated with impervious surfaces, they can also witness the consequences of these problems. This strongly reinforces the concept of watershed stewardship in the minds of the volunteers. Moreover, volunteers physically enter the stream and use meters, tape measures, leveling rods, and digital cameras to measure water quality, stream flow, and help map problem areas in the stream and surrounding area. This helps reinforce what they have learned and provides a fun activity.

The stream walk is a unique educational opportunity in the sense that volunteers directly witness to the effects of impervious surfaces and encroachment into the riparian buffer zone on the stream. It also makes clear how land uses even those as seemingly harmless as a single-family house can dramatically impact the stream. Stream walkers see countless animals and vegetation occupying the riparian zone and seem to grasp the critical importance of the stream and streamside environment on the ecosystem. It is not by accident that our most active volunteers are associated with the stream walk. This activity truly seems to inspire stewardship and ownership of the watershed.

Heal the Bay actively targeted local high schools to participate in the Stream Team program. We ran advertisements in school newspapers and posted flyers at three local high schools. Currently, one stream walk team is composed of high school students from Malibu High School, Pacific Palisades High School, and Santa Monica High School. Over the course of the pilot year, 24 students from five different schools have been educated about the issues of concern in the Malibu Creek Watershed and have participated in water quality analysis and/or stream walk activities.

Heal the Bay participates in a program called Eco Heroes that pairs high school science classes with environmental groups to conduct educational outings. Heal the Bay adapted the Stream Team program to enhance these educational outings. Eco Heroes students come on three field trips per semester. During these field visits students were educated about the issues of the Malibu Creek Watershed and participate in a beach cleanup, stream walk and water chemistry activities. Heal the Bay was pleasantly surprised about the reception these field trips received from the students. Students enjoyed the activities and learned a great deal about how each of our actions can and do affect the environment. Over the course of the pilot year, Heal the Bay educated 104 students. 70 were from Garfield High School located in East Los Angeles and 34 were students at Sylmar High School in the North San Fernando Valley.

A Typical Day of Water Chemistry

Water chemistry events are scheduled to occur the first Saturday of every month, rain or shine, with the exception of holidays. Stream Teamers meet at Malibu Lagoon State Park, which is centrally located to the monitoring sites. A consistent regular schedule and meeting place ensures that volunteers can plan their schedule around it, minimizes accidental scheduling conflicts and removes any confusion about the meeting place. Moreover, Heal the Bay volunteers are mailed a monthly newsletter. The newsletter includes a calendar of events, trainings for the following two months, and highlights the latest Stream Team accomplishments. The event calendar and exciting developments are also posted on Heal the Bay's website to help recruit new volunteers that are not on the mailing list. The website provides for up to the minute plan changes and shares motivational stories and Stream Team accomplishments.

Typical Saturday Event Day – Water Chemistry Testing

9:15 a.m.

- Water Chemistry volunteers assemble and sign in at the Malibu Lagoon.
- New members are introduced and placed on a team with more experienced volunteers. At least one member is assigned to each team who has previously visited and sampled the monitoring locations to ensure consistency and timeliness. Volunteers are provided opportunities to experience locations that they have not previously monitored. Opportunities for volunteers to interact with new people are provided by creating teams that have not sampled together.
- The program manger provides a brief update about the latest and greatest happenings surrounding the Stream Team and, if necessary, reviews new equipment and testing protocols.
- Field Kits, ice chests, field data sheets, analysis instruction sheets, gate keys and combinations, and detailed driving directions are distributed to the teams.

9:30 – 9:45 a.m.

- Teams depart from the lagoon and drive to their respective monitoring locations. Each team will visit two or three sites.

10:15 a.m. – 12:30 p.m.

- Teams conduct sampling, including flow measurements, at the assigned monitoring locations. Sampling takes approximately 20-30 minutes and flow measurements take an additional 25-35 minutes.
- Before driving to the next sampling site, teams collect water samples to be placed on ice for nutrient and bacteria testing at the Heal the Bay office.

12:30-1:00 p.m.

- Teams return to Malibu Lagoon and drop off field kits, ice chests with samples from each monitoring location, and field data sheets.
- The program manager checks in the equipment, reviews the field data sheets, answers any volunteer questions, and asks about any interesting or unusual occurrences.
- Volunteers sign out.

1:45 – 2:15 p.m.

- The Stream Team manager returns to Heal the Bay accompanied by at least one intern and any volunteers interested in participating or witnessing laboratory procedures for testing Enterococcus, Nitrate-Nitrogen (NO_3+NO_2-N), Orthophosphate (PO_4), and Ammonia-Nitrogen (NH_3-N).

2:30 – 3:30 p.m.

- Enterococcus samples are prepared and placed in the incubator.

3:45 – 7:00 p.m.

- Standards are tested and results are recorded to ensure equipment is functioning properly and reagents are good.
- Samples are tested and results are recorded for Nitrate-Nitrogen (NO_3+NO_2-N), Orthophosphate (PO_4), and Ammonia-Nitrogen (NH_3-N).

7:00 – 8:00pm

- Cleanup

Sunday after Event Day
3:30 p.m. (24 hours after Enterococcus samples were placed in the incubator)

- Enterococcus samples are read and recorded.

V. Water Quality Analysis Model Program

Program Mission and Objectives

At the onset of the Stream Team program, the Cal Poly team and the program manager were charged with the following tasks:

- Design a water quality monitoring program that collects accurate, reliable, and useable data.
- Determine if volunteers can provide data of high enough quality so that it can be utilized by stakeholders in determining the appropriate load allocations for TMDLs, and if volunteers can monitor those same water bodies to determine if those load allocations are being met.
- Determine the cost benefit of using volunteers to conduct monitoring.

The following pages will address each of these tasks and describe what Heal the Bay believes is a useable model to collect high quality, accurate, and reliable water quality data that is applicable to all watersheds.

Testing and Field Kit Selection

The Cal Poly team spent considerable time reviewing water quality analysis procedures and equipment and solicited the observations and feedback from volunteers who used the equipment in the field. The results of the data collected from 30 separate face-to-face interviews with trained and active volunteers yielded the following information:

- Volunteers felt that instrument calibration in the field was very time consuming and tedious and preferred the tests that did not involve calibration.
- Finding the necessary items to perform each water chemistry test was difficult because of how many things were contained in the water chemistry field kit.
- Volunteers found it difficult to determine the test results using LaMotte's color comparators for nutrient testing. Two volunteers looking at the same test results would frequently get different readings.
- Volunteers grew impatient waiting for 10 – 15 minutes before they could read the results of the DO test using the titration method and time delay between adding different chemicals for nutrient samples.

The Cal Poly team also tested the field kit and sampling protocols on a group of 20 high school students from three different schools. High schools were a specific group that Heal the Bay planned to target for the Stream Team program. Students were separated into three groups to minimize peer pressure and bias. In summary, the high school students hated the test kit and the protocols. They said it was boring, and the consensus was that they would not participate in this type of program even to fulfill mandatory community service hours for school.

Finally, Cal Poly team members evaluated the testing methods, results, and the expected accuracy of the pre-packaged Lamotte field kit at two inter-calibration sessions attended by the program managers of several volunteer monitoring groups throughout the southern California region. This calibration effort was designed to determine if the testing protocols were being properly followed and if equipment and reagents were accurate. The results from two sessions were as follows:

- The results of nutrient testing using LaMotte's color comparator and reagent systems were hard to replicate between program managers using the same equipment.
- Reagents used to test dissolved oxygen using the Winkler titration method frequently go bad or produced unreliable results. These results occurred on several occasions. Reagents were all within specified shelf life time limits and expiration dates. The Winkler method proved very accurate and reliable when reagents were determined to be good.
- The conductivity meters included with the field kit were too fragile for volunteers to use in the field. Two meters were ruined from being submerged too deeply in the sample solution.

Based on the results, Cal Poly recommended against purchasing the pre-packaged Lamotte test kit. Instead they recommended that Heal the Bay purchase the best available equipment and create a hybrid custom field kit that would best fit the testing needs of the program. To the maximum extent practicable, equipment purchases should minimize the need to calibrate in the field and eliminate the need for numerous small measuring devices used in the existing field kit. In addition, the Stream Team should use DO meters as opposed to the Winkler titration method. Meters eliminate the use of potentially harmful chemicals and dramatically reduce the test time. An electronic colorimeter should be used to conduct nutrient testing. To conserve money on this expensive piece of equipment, volunteers should collect and transport samples to a central location for analysis by the program manager. The carrying case for storing and transporting water chemistry equipment should be designed to make equipment easy to find and transport. Specifically, a backpack unit was recommended; all Stream Team equipment should be rugged and waterproof.

Heal the Bay implemented all of the above listed recommendations during the pilot year of the Stream Team program. The water chemistry equipment and monitoring protocols were rigorously tested for accuracy, reliability, repeatability, and endurance throughout the pilot phase of the project. The three field kits were tested at three inter-calibration events against standard solutions. The Southern California Marine Institute (SCMI) conducted and supervised the calibration events. In addition, side-by-side samples were conducted using known reliable and accurate methods and compared against the results of the Stream Team equipment.

Overall, Heal the Bay is very pleased with accuracy of data and speed that data can be collected using the Stream Team field kit (Figure 10.) Volunteers are never burdened with calibrating instruments in the field. The program manager or other qualified individual calibrates all instruments prior to each event. The Stream Team field kit requires no chemicals to be used in the field and eliminates the risk of accidental spills and inputs of hazardous chemicals into receiving waters. By enhancing the speed at which data can be collected, volunteers are able to sample two or three sites within a four-hour period, including driving time. Most importantly, volunteers like the field kit and monitoring protocols and are excited about helping Heal the Bay collect information about the water quality in the Malibu Creek Watershed.

Figure 10. Stream Team Field Kit

Water Quality Testing Equipment and Procedures

The following section describes all of the equipment necessary to do the field procedures outlined in the Stream Team monitoring program. Recommendations on equipment usage and maintenance also are provided. Step-by-step instructions on how to take measurements using this equipment can be found in *The Malibu Creek Watershed Stream Team Field Guide.*

DISSOLVED OXYGEN

Equipment

The Stream Team uses three YSI Model 55 Meters for DO analysis. Meters measure between 0 to 20 milligrams per liter (mg/L) or 0-200 percent saturation. In mg/l mode, the meter reads in increments of 0.01mg/l. In the percent saturation mode and when recording temperature, the meter has a resolution of 0.1% and 0.1 degrees Celsius. This unit was selected because of YSI's reputation for reliability, ease of use, and because the unit is equipped with a built in calibration chamber. Field calibration requires the volunteer to only enter the altitude and salinity. This is the only piece of equipment in the Stream Team field kit that requires any field calibration. The display is large and easy to read and the 12 foot cable provides enough length to enable one volunteer to stand on the streambank with the meter while a second enters the stream and moves the probe through the water at approximately one foot per second. This protects the meter from being accidentally dropped and submerged in the stream. The meter is rated safe for wind driven rain but should not be completely submerged.

To accommodate testing of DO meters at the inter-calibration events, water samples were placed into a three-gallon container with an automatic magnetic stirrer to completely saturate the water with 100% dissolved oxygen. Test results were very consistent between the three meters and were well below the $\pm$ 10% threshold described in the EPA certified quality assurance plan. Meters also underwent field verification on six separate occasions. Temperature readings and DO levels were measured using the meters; meters gave consistent results and never varied more than ± 3% when reading DO in mg/l or % Saturation mode. Temperature readings between the meters did not vary more than ± .02 degrees Celsius.

Maintenance
Meters should be rinsed with distilled water after each use and the probe should always be stored in the calibration chamber when not in use. The unit requires 6AA batteries, which last approximately 6 months. The probe membranes and electrolyte solution should be replaced monthly. A single replacement kit lasted 8 months for all three meters. None of the three units needed cathode cleaning during their 16 months of use.

Recommendations
Heal the Bay is satisfied with the performance of the DO meters and believes that when used properly, the results are accurate and reliable enough for use in water quality assessments and for subsequent resource management decisions. Meters must be turned on for 15 minutes prior to calibration for acclimation to environmental conditions. To eliminate this wait time, Stream Team volunteers leave the meters on when they are transported between monitoring sites. If a volunteer removes the probe from the calibration chamber before entering the altitude and salinity, the 15 minute acclimation period starts over. Heal the Bay would like to see a ready light that tells the user when the meter is ready for calibration and a message or indicator that the meter is calibrated. Meters should indicate when readings have stabilized, i.e. a ready indicator light. Finally, Heal the Bay recommends that probes be self-stirring. Volunteers have complained that if they are not consistent when moving the probe through the water it takes a while for readings to stabilize. Currently, new YSI meters can be purchased with replaceable self-stirring probes, but not with a ready indicator light.

TURBIDITY

Equipment
The Stream Team uses the LaMotte 2020 Turbidimeter for turbidity measurements. The turbidity test is the most difficult water chemistry test. The meter is easy to use and reads in either EPA mode, which automatically rounds the result, or regular mode with no rounding. Meters can detect turbidity from 0.01- 1100 NTUs. The turbidimeter is the most sensitive piece of equipment in the field kit. This meter should never get wet, and no dust should be introduced into the light chamber.

Turbidimeters were not tested at the inter-calibration events, but were tested 10 times over the pilot year of the program by using calibration standards of 1, 10 and 30 NTUs. Meters were calibrated 24 hours prior to testing by the program manager until they successfully read at both 1 and 10 NTUs to simulate normal field conditions. Each turbidity tube was measured three times and results were averaged. A minimum of two tubes were measured for each of the three calibration solutions and averaged together as stated in the protocol. All three meters were consistent with one another and did not vary more than ± 5%. When the averaged results were compared to the value of calibration solutions, nine of the ten tests fell within ± 5% of the known value in the 1 NTU range and one of the tests was ± 10% a difference of 0.10 NTU. In the two upper ranges, averaged results were always within a range of ± 3%.

Maintenance
Meters must be kept dry and free of dust. Turbidity sample tubes must be cleaned prior to each event. Turbidity tubes should be replaced every year or when scratched. Meters operate on a single 9-volt battery that lasts approximately six months.

Recommendations
Heal the Bay is satisfied with the performance of the turbidity meter and believes that when used properly, the results are accurate and reliable enough for use in decision-making. The sample tube should be gently inverted in a manner that does not induce air bubbles into the sample just prior to taking a measurement. Results should be the average of three readings for each tube with a minimum of two tubes for each location. The program manager or qualified person should calibrate meters before an event. Use calibration solutions with strengths similar to the value of samples measured in the field. Calibrate the meters until they properly read two different strength calibration solutions. During rain events volunteers should leave meters inside a vehicle to prevent meters from getting wet. Keep an absorbent towel to dry the turbidity tubes and Kimwipes® to keep the tubes lint free and free of smudges from fingerprints.

CONDUCTIVITY

Equipment
The Stream Team uses the 19830-00 Cole-Parmer waterproof conductivity meter. The meter is easy to read and use; it reads and stores calibrations for five different ranges including salt-water ranges. The meter has a thermometer and automatic temperature compensation. Conductivity ranges can be entered automatically or manually. Volunteers test and record the temperature and conductivity twice at each monitoring location. Meters will accurately hold their calibrations for a week.

The meter was tested at two inter-calibration events against calibration solutions. In addition, Heal the Bay conducted its own tests using solutions in each of the three highest ranges. Meters were calibrated 24 hours in advance to simulate field conditions. Meters read very consistently with one another in all three ranges and never varied more than ± 2% for both temperature and conductivity. Averaged results from two measurements in each of the three solutions were always within a range of ± 3% of the solutions known value.

Maintenance
The conductivity probe should be rinsed with distilled water after every use. Heal the Bay recommends rinsing the probe in a mild detergent bath, warm water, and liquid detergent every three months. Conductivity probes should be soaked for 10 - 15 minutes in distilled water prior to calibration. The meter takes 4 AAA batteries, which last approximately 1 year.

Recommendations
Heal the Bay is satisfied with the performance of the conductivity meter and believes that when used properly the results are accurate and reliable enough for use in water quality assessments and for subsequent resource management decisions. The unit has proved to be rugged and easy to use. Heal the Bay has modified the plastic cases for the turbidity meter so that it can also accommodate the conductivity meter. Heal the Bay placed the thermometer into a temperature bath for calibration every six months to ensure accurate results. Conductivity probes can be purchased and replaced separately. Volunteers should use the manual range function, **not** the automatic range finder function. The Cole-Parmer meters have a three-year warranty.

pH

Equipment
The Cole-Parmer pH Testr 2 was selected based on its compact, waterproof, and accurate design with a replaceable electrode. The range on this meter is -1.0 to 15.0 pH with a resolution of 0.1 pH. The pH Testr 2 can be calibrated in three pH ranges 4.0, 7.0, and 10.0. This provides the program with increased flexibility allowing for monitoring sites with varying ranges of pH. This also increases the accuracy of the unit.

The meters were tested at three inter-calibration events and in the field by volunteers with standards. The meters were calibrated at pH levels of 7.0 and 10.0 the morning of the event or at least 5 hours prior to an inter-calibration event to simulate field conditions. All solutions were measured twice and the results were averaged together to replicate methods used by volunteers in the field. Heal the Bay chose pre-mixed liquid calibration standards as opposed to tablets that have to be crushed and dissolved in water. The pH Testr 2 read consistently with one another and has never varied from the standards by more than ± 2%. Results from two of the three inter-calibration events demonstrated that the meters are within ± 0.2 pH units from the standards. At the other calibration event, meters were only calibrated at the 7.0 pH range and recorded results of ± 0.4 pH units. This single result was larger than the acceptable limits stated in the EPA certified quality assurance plan used during the pilot year. On four occasions, two standard samples were analyzed by volunteers in the field, and the results were averaged at the end of the sampling day. The four results were within the range of ± 0.2 pH units.

Maintenance
Rinse pH meters after each use in distilled water being sure to thoroughly shake the distilled water off the electrode before replacing the cap. Cut a piece of sponge to be placed in the cap to keep the electrode moist when not in use. The electrode should be replaced annually. The pH Testr 2 is powered by three 1.5-volt calculator batteries, which lasts for approximately 1 year.

Recommendations
Heal the Bay is satisfied with the performance of the pH Testr 2 and believes that when used properly, the results are accurate and reliable enough for use in water quality assessments and for subsequent resource management decisions. The units have proven to be rugged and easy to use. The meters should be calibrated at a minimum of two ranges using a calibration solution that is similar to the pH of the sampling location.

STREAM FLOW

Equipment
The Stream Team monitors flow at five of the seven water sampling sites; the Malibu Creek Outlet (Site 1) and Malibou Lake Outlet (Site 4) were eliminated due to safety concerns. Volunteers calculate the average cross sectional area of the stream using a tape measure and leveling rod (Figure 11.) Volunteers then calculate the velocity of the water by floating an orange peel 20 feet (Appendix C). Equipment consists of an orange, fiberglass stadia rods, tape measure, solar pocket calculator, stop watch, dead blow hammer, wooden stakes, and survey twine.

Stream Flow was not covered at any of the calibration events. Heal the Bay was able to calculate flow at one monitoring site using a borrowed velocity meter. The velocity calculated using the orange peel method as compared to the meter was ± 10%. We are currently investigating the possibility of purchasing a flow meter.

Figure 11. Volunteers measuring the cross sectional area of Las Virgenes Creek.

Maintenance
Make sure all the equipment is free of dirt and returned to the backpack. The waterproof LCD stopwatch is powered by a single 1.5-volt calculator battery that should last one year or longer.

Recommendations
Volunteers like measuring flow. It gives them the opportunity to wade through the creek and conduct hands on testing. Determining flow involves the ability to calculate simple formulas and strongly encourages the team to work together.

AIR AND WATER TEMPERATURE

Equipment

Thermometers were purchased to measure both air temperature and water temperature. Heal the Bay selected the armored-protected, mercury-based thermometers with a temperature range between –35 to 50 degrees Celsius. Thermometers marked in 1-degree increments are easy for volunteers to read. The monitoring protocol was changed from an in-stream measurement to the measurement of water temperature in a bottle containing a stream sample.

Water temperature was measured in two ways throughout the pilot year of the project: First as described above in a sample bottle and second by using the built in thermometer on the DO meters. Water temperature is taken twice at each sampling location unless it takes less than 15 minutes between the start and end of testing. Temperature readings have been consistent at $\pm$ 0.04 degrees Celsius between the thermometers and the DO readings.

Maintenance

Wipe dirt and water off the unit after use and store upright in a protective case. Heal the Bay constructed protective cases out of half inch rigid PVC with padded screw caps.

Recommendations

Heal the Bay is satisfied with the performance of the thermometer and believes that the data provided are both accurate and reliable enough to be used for water quality assessments and subsequent resource management decisions.

NUTRIENT AND BACTERIA TESTING

Collecting Water Samples

The last thing volunteers do before leaving a monitoring site is collect two water samples from the stream. Stream samples are taken in the thalweg, area of greatest flow, in a steady moving section of stream with no turbulence. Each team is given a 500-ml or larger sample container. This container is submerged below the top of the stream. The volunteer fills the container until no air bubbles are visible. The cap is removed and replaced while the container is still submerged to prevent the introduction of air bubbles and debris in the stream. Volunteers take the large container and use it to fill two smaller 250-ml containers. One container is used for ammonia as nitrogen analysis and contains sulfuric acid to prevent sample decay; the second container is used for the remaining analyses (i.e., enterococcus, orthophosphate and nitrate + nitrite as nitrogen). This technique was selected to minimize the introduction of sulfuric acid into receiving waters and to assure the samples being analyzed are homogenous. Water samples are taken to Heal the Bay's office for analysis, which eliminates volunteer contact with hazardous chemicals and accidentally introducing these chemicals into receiving waters.

Equipment

The LaMotte SMART Colorimeter and reagents are used to test nutrients and the IDEXX Quanti-tray 2 sealer and reagent system is used to test for enterococcus. The SMART Colorimeter is used to conduct the three nutrient tests used by the Stream Team. Samples are taken by volunteers and placed on ice. These samples are transported back to Heal the Bay's office and tested the same day they were taken. The Stream Team selected colorimetric analysis because it is a proven, easy to use method that yields accurate results. Colorimetric analysis is a test, which forms a color and then measures the amount of that color. The SMART Colorimeter can test for 35 constituents and therefore affords the opportunity to expand the monitoring program by testing additional constituents in the future.

Heal the Bay rigorously tested the colorimeter and reagent systems for analyzing nutrients over the course of the pilot year. The Stream Team held four split-sampling events over the course of the pilot year. Three sets of samples were taken at each of the seven monitoring sites. One set of samples was taken to Heal the Bay for analysis and the two remaining sample sets were analyzed by two separate state certified laboratories. In addition, standard solutions were placed in the same type of sample container and sent with the other samples to all three labs. Finally, at three of the four split sampling events, a duplicate sample was analyzed by dividing one of the standard solutions into two separate sample containers. This additional measure was implemented to help determine the repeatability of the testing. In addition, Heal the Bay conducted a split sample with Tapia. Tapia monitors nutrients in the lower watershed, which is required by their discharge permit. The accuracy and reliability of nutrient tests were also measured at the three inter-calibration events mentioned previously.

The two state certified labs were the Southern California Marine Institute (SCMI) and Associated Laboratories. In addition SCMI was contracted by Heal the Bay to create the standards and duplicates that would be distributed to Associated Laboratories and tested by both Heal the Bay and SCMI. SCMI was specially selected because they use the SMART Colorimeter and would provide an additional data set in order to review the use of the colorimeter by volunteer monitors. Standards were varied in strength to analyze the accuracy and reliability of the colorimeter at different concentrations. In addition, Heal the Bay ordered standards in three strengths, 1-ppm, 5-ppm and 10-ppm for each of the nutrient tests. On three separate occasions, ten tests were conducted on the standards at each concentration in an effort to determine the reliability and repeatability of testing. Further, the concentrations of the standards were selected to approximate the human error that can be expected when diluting samples of different strengths.

Heal the Bay also brought the colorimeter into the field to test nutrients. Samples were collected as usual and then two tests were run for each nutrient. Sample bottles were then closed and put on ice within 5 minutes of the time they were collected. The samples were then transported back to the office and measured under normal Stream Team testing conditions. This procedure was done to determine if any decay was occurring between the time that the sample was taken and the time that the testing was performed.

AMMONIA AS NITROGEN

The Stream Team uses the Nesslerization test method. This method is considered more accurate for measuring ammonia as nitrogen (NH_3-N) in fresh water and was recommended by our technical advisors. Unfortunately, the reagent contains mercury and must be disposed of at a hazardous waste facility. The colorimeter detects ammonia as nitrogen in a range of 0.01- 3.0-ppm and has a resolution of 0.01-ppm. Concentrations greater than 3.0-ppm are diluted with distilled water.

At the beginning of the program, Heal the Bay received conflicting reports about whether or not to preserve the samples for NH_3-N analysis. To resolve this issue, the colorimeter was taken into the field for on-site NH_3-N measurements. These results were compared to samples analyzed with and without preservation five hours later at Heal the Bay's office. The samples that were not preserved experienced decay of up to 50%. The comparison of results from **preserved** samples and field test were ± 4%. In addition, at the first three way split sample event, Heal the Bay tested NH_3-N standards preserved and not preserved. Six NH_3-N tests were run on the standard that was not preserved every two hours over a 12-hour period. The results showed that the largest decay occurred in the first two hours with a drop in standard strength of 31%.

The February 26, 1999 split sample results were not used in the QA/QC analysis, because the samples were not preserved. At all other split sampling and inter-calibration events Heal the Bay was within ± 10% of standards created at a strength of 1.0-ppm or greater. Testing standards with a concentration of 0.50-ppm or lower, Heal the Bay's results never exceeded ± 20%, or a maximum difference of 0.10-ppm. Results from Heal the Bay, SCMI, and Associated Laboratory were similar when comparing the three groups despite the fact that methods differ between the colorimeter and measuring ammonia-nitrogen using distillation the method used by Associated Labs. Twenty-one distinct samples were compared between the three groups. 12 were in agreement below 0.10-ppm, constituting 57% of all samples (0.10 is the minimum detection limit for Associated Labs). The remaining 9 samples had an average difference of 0.19-ppm and a maximum difference 0.31-ppm between the three groups. The raw data of the split sampling is in Appendix F.

The table below summarizes the accuracy and repeatability using the LaMotte SMART colorimeter to test NH_3-N. Tests were conducted on certified standards at concentrations of 1.0-ppm, 5.0-ppm and 10.0-ppm. These results demonstrate that the colorimeter yields accurate and precise measurements.

NH_3-N DIFFERENCES FROM KNOWN STANDARDS ON 1-PPM, 5-PPM, AND 10-PPM CONCENTRATIONS

# of Samples	Concentration of Standard	Largest Difference ppm percentage	Average Difference ppm percentage	Max Recommended Allowable Difference %
30	< 0.50-ppm	± 0.10-ppm ± 20%	± 0.09-ppm ± 18%	±25%
30	1.0-ppm	± 0.08-ppm ± 8 %	± 0.07-ppm ± 7%	±10%
30	5.0-ppm	± 0.45-ppm ± 9 %	± 0.35-ppm ± 7%	±10%
30	10.0-ppm	± 0.85-ppm ± 8.5%	± 0.65-ppm ± 6.5%.	±10%

NITRATE AND NITRITE AS NITROGEN

Equipment

The Stream Team measures NO_3+NO_2-N using the cadmium reduction method. This method is more accurate and reliable than the zinc method, however, it does produce hazardous waste. The colorimeter detects NO_3+NO_2-N in a range of 0.01- 3.0-ppm and has a resolution of 0.01-ppm. Concentrations greater than 3.0-ppm must be diluted using distilled water.

The same QA/QC testing was done on the NO_3+NO_2-N as was mentioned for NH_3-N with the addition of a split-sampling event conducted with Tapia. When standards were successfully run prior to an event, the results from Heal the Bay, SCMI, and Associated Laboratory were similar despite the fact that methods differ (i.e., colorimeter versus the specific ion electrode utilized by Associated Labs). A total of 28 discrete samples were compared; thirteen samples, which constitute 46%, were in agreement below the 0.10-ppm detection limit of Associated Labs. The remaining 15 samples were further evaluated and had a mean precision of 22.6% and a standard deviation of 23.2%.

The Tapia split sample proved extremely valuable in comparing data in the watershed. Heal the Bay was given a split sample by Tapia from four of their monitoring stations. Heal the Bay tested standards for PO_4 and NO_3+NO_2-N and tested each sample twice for both constituents. Ammonia-Nitrogen was not tested because the samples were not preserved. The largest difference recorded between results of the two groups was 0.07-ppm for NO_3+NO_2-N. The largest result difference from averaged duplicate samples was 0.045-ppm or a difference of 4%. Clearly, the methodology used by Heal the Bay gave comparable results to those methods used by Tapia.

The Stream Team internal analyses using the standards at 1.0 ppm, 5.0 ppm and 10.0 ppm proved to be accurate and repeatable. The table below summarizes the accuracy and repeatability using the LaMotte SMART colorimeter to test NO_3+NO_2-N.

NO_3+NO_2-N DIFFERENCES FROM KNOWN STANDARDS ON 1-PPM, 5-PPM, AND 10-PPM CONCENTRATIONS

# of Samples	Concentration of Standard	Largest Difference ppm percentage	Average Difference ppm percentage	Max Recommended Allowable Difference %
30	< 0.50-ppm	$\pm$ 0.09-ppm $\pm$ 18%	$\pm$ 0.08-ppm $\pm$ 16%	$\pm$25%
30	1.0-ppm	$\pm$ 0.08-ppm $\pm$ 8 %	$\pm$ 0.065-ppm $\pm$ 6.5%	$\pm$10%
30	5.0-ppm	$\pm$ 0.50-ppm $\pm$ 10 %	$\pm$ 0.39-ppm $\pm$ 7.8%	$\pm$10%
30	10.0-ppm	$\pm$ 0.85-ppm $\pm$ 8.5%	$\pm$ 0.65-ppm $\pm$ 6.5%.	$\pm$10%

These results demonstrate that the colorimeter provides accurate and precise measurements.

ORTHOPHOSPHATE

Equipment

Heal the Bay analyzes PO_4 samples using the Ascorbic acid reduction method. The colorimeter detects PO_4 in a range of 0.01- 3.0-ppm and has a resolution of 0.01-ppm. Concentrations greater than 3.0-ppm must be diluted using distilled water.

The same QA/QC testing was done on Orthophosphate as was conducted on Nitrate–Nitrogen including the Tapia split sampling event. When standards were successfully run prior to an event, the results from Heal the Bay, SCMI, and Associated Laboratory were similar. The results of 21 samples from three split sampling events were compared from each of the three testing groups. The data from the December 20, 1999 split was discarded because neither Heal the Bay or SCMI were able to successfully test the standard solution. From the 21 samples, five were in agreement below 0.04 ppm, which is Associated Labs minimum detection limit. The remaining 16 samples were further evaluated and had a mean precision value of 18.9% with a standard deviation of 21%. The split sampling event conducted with Tapia recorded the largest difference between the two groups was ± 0.04-ppm or ± 20% for Orthophosphate. The largest difference in results when duplicate samples were averaged was ± 0.025-ppm or ± 12.5%. Clearly, the methodology used by Heal the Bay gave comparable results to those methods used by Tapia.

Heal the Bay tested Orthophosphate for accuracy and repeatability by testing standards at concentrations of 1.0 ppm, 5.0 ppm and 10.0 ppm. Orthophosphate testing proved to be accurate and repeatable the results are summarized in the table below.

PO_4 DIFFERENCES FROM KNOWN STANDARDS ON 1-PPM, 5-PPM, AND 10-PPM CONCENTRATIONS

# of Samples	Concentration of Standard	Largest Difference ppm percentage	Average Difference ppm percentage	Max Recommended Allowable Difference %
30	< 0.50-ppm	± 0.07-ppm ± 14%	± 0.05-ppm ± 10%	±25%
30	1.0-ppm	± 0.07-ppm ± 7 %	± 0.06-ppm ± 6%	±10%
30	5.0-ppm	± 0.42-ppm ± 8.4 %	± 0.29-ppm ± 5.8%	±10%
30	10.0-ppm	± 0.76-ppm ± 7.6%	± 0.59-ppm ± 5.9%.	±10%

These results demonstrate that the colorimeter provides accurate and precise measurements.

Recommendations for Nutrient Testing

All field samples taken for NH_3-N must be preserved with sulfuric acid (H_2SO_4) until the pH is reduced to 2.0 pH. The Stream Team uses 2-ml of 1 normal strength sulfuric acid per 250-ml sample container. Samples are restored using 1 normal strength sodium hydroxide until the pH is above 7.0 pH. As a result of Heal the Bay's rigorous QA/QC testing it was determined that LaMotte reagents for PO_4 and NO_3+NO_2-N were unreliable. Since November of 1998 two distinct batches of reagents for both PO_4 and NO_3+NO_2-N provided results that were markedly different from the known value of the standard. Heal the Bay strongly recommends that a standard should be run prior to every sampling event to ensure that the equipment and reagents are working properly. In addition, reagents should be used within a six-month period and detailed records of reagent lot numbers and the date the reagent was first opened should be recorded with nutrient test results for each water chemistry event. Heal the Bay plans to evaluate colorimeters and reagent systems from alternative manufacturers.

Quality Assurance/Quality Control

To ensure the quality of data Heal the Bay recommends the following actions:

- Each parameter tested in the field should be done twice. If the results of the two tests are significantly different a third test should be conducted.
- Nutrients and enterococcus samples should immediately be placed on ice after the sample is collected.
- Standards should be tested for each nutrient at every event to ensure reagents and equipment are properly functioning.
- Reagent blanks should be tested as if it were a sample collected in the field for each nutrient. The results of the reagent blank will be subtracted from sample results.
- One duplicate sample should be tested for every five field samples. The sample location should be random.
- One replicate sample should be taken at every event. This will ensure that samples collected in the field are representative. Replicate samples are samples taken at the same monitoring site in a separate sample container.
- Split-sampling events should occur at least every six months.
- Water samples should be collected in a section of the stream with steady flow that has no turbulence. Sample containers should be opened and sealed below the water surface to avoid interference from floating particles.
- Ammonia-Nitrogen samples should be preserved with sulfuric acid to bring the pH level down to 2.0 pH.
- Ammonia-Nitrogen samples must be restored to a pH of 7.0 pH with sodium hydroxide. The test should be run immediately after the pH is restored.
- Enterococcus samples must have reagents added and be run through the IDEXX sealer and placed into the incubator at 41 degrees Celsius within six hours of the time the sample was taken.
- When diluting enterococcus samples add reagents into the buffer solution or distilled water before adding sample water.
- Sterile pipettes should be used to accurately measure nutrient and enterococcus samples and to perform any dilutions.

Savings and Benefits of Volunteer Monitoring

Once you have purchased the Stream Team field kit, colorimeter, and IDEXX system, what are the real costs of accurately measuring the water chemistry, and how do these costs compare to using State-Certified laboratories and agency personnel? Heal the Bay carefully scrutinized costs over the pilot year of this program. Costs were broken down by materials, labor, and mileage. Detailed summaries of Stream Team costs are provided in Appendix G.

The total cost per analysis and for each sampling event is summarized in the table below.

TOTAL COST PER RESULT STREAM TEAM

Lab Test	Method	# of samples analyzed	Average Price Per Test	Total Price Per event
Turbidity	Meter	7	$4.06	$28.42
Conductivity	Meter	7	$3.47	$24.29
Ammonia-N	Colorimeter	9	$3.32	$29.88
Nitrate+Nitrite-N	Colorimeter	9	$3.83	$34.47
Orthophosphate	Colorimeter	9	$3.26	$29.34
Enterococcus	IDEXX	8	$7.39	$59.12
Labor			Included	Included
Mileage				$19.20
Total		**49**		$ **224.72**

For comparison purposes, Heal the Bay proposed two monitoring scenarios that agencies and/or municipalities would implement to conduct the required analogous sampling. The first scenario (i.e., Scenario No. 1) utilizes paid staff members to collect samples in the field for ultimate analysis by a State-Certified laboratory. Scenario No. 2 uses paid staff to collect and analyze samples with a laboratory set up for nutrient and enterococcus analyses. The baseline costs for the Stream Team field kit (includes DO and pH meters), colorimeter, and IDEXX system would be the same for both the Stream Team and Scenario No. 2. Therefore they have not been included herein; these costs are summarized in Appendix G. These cost comparisons will assist agencies and/or municipalities in decision-making efforts concerning upcoming TMDL work.

Scenario No. 1

Heal the Bay evaluated a range of salaries based on employment announcements from several municipalities and agencies who were considered candidates for in-house monitoring programs. Heal the Bay believes these salary estimates are conservative. Hourly wages were estimated at $ 18.00 per hour including insurance and payroll taxes for employees who would go into the field to collect water samples, make physical observations, and perform pH and DO level measurements. In addition, eight hours were included to verify and enter data in report form. Heal the Bay utilizes college interns for data entry and verification and incurs no labor charge for this item. Mileage estimates were limited to thirty miles based on the assumption that cities would monitor within their own jurisdiction. It is assumed that both pH and dissolved oxygen would be measured in the field because of the time sensitive nature of the tests. Estimates are based on seven sampling sites and two duplicate samples for each nutrient being analyzed and eight enterococcus tests from seven monitoring sites with one duplicate sample. Due to the six-hour hold times of enterococcus, it was assumed that two people would conduct the sample collection. Each staff person was allotted four hours to perform the fieldwork.

Heal the Bay obtained price quotes from three State-Certified laboratories to perform water quality analyses equivalent to the Stream Team program. The three bids were averaged to provide a realistic picture of the cost of laboratory testing; excessive bids were eliminated from the averaging exercise. Included in the estimate is the cost of two DO and pH meters for field analyses.

TOTAL COST FOR SCENARIO NO. 1

Lab Test	Method	# of samples analyzed	Average Price per Test	Total Price
Turbidity	EPA 180.1	7	$20.00	$140.00
Conductivity	EPA 120.1	7	$10.00	$70.00
Ammonia-N	EPA 350.2	9	$20.00	$180.00
Nitrate+Nitrite-N	EPA 300.0	9	$20.00	$180.00
Orthophosphate	EPA 300.0	9	$22.50	$202.50
Enterococcus		8	$18.50	$148.00
Labor				$288.00
Mileage				$19.20
Total		**49**		$ **1227.70**

Overall, the cost savings is $1,002.98 per sampling event upon comparison of the Stream Team and Scenario No. 1. Over the course of one year, this adds up to $12,035.76. This represents a significant savings for a comprehensive monitoring program.

Scenario No. 2

Scenario 2 requires paid staff to go into the field to conduct water quality and flow measurements at seven water chemistry monitoring locations. This scenario will require three teams to accomplish field-testing and to return samples for in house laboratory analysis within the six-hour hold time for enterococcus testing. Conducting stream flow measurements will require an additional staff person in the field to assist the main technician. This person does not need the same training, and therefore, the salary is estimated at $13.00 per hour including payroll taxes and insurance. In addition, teams will collect samples and bring them back for analysis in the lab. It was assumed that testing frequency, equipment, costs and protocols were similar to those used by the Stream Team. Lab equipment for nutrient and enterococcus testing will also be assumed to require the same initial investments and maintenance costs. Laboratory personnel require greater education; a higher salary of $26.00 including payroll taxes and insurance was used. Additional time will be needed to include cleaning of glassware and sample containers for the laboratory. For purposes of this comparison, a wage of $13.00 per hour was assigned to the person conducting maintenance and cleaning of laboratory equipment and data entry. Heal the Bay utilizes dedicated college interns to conduct regular cleaning and maintenance of equipment, and for data verification and entry. All time estimates are based on the personal experience of the Stream Team.

Three teams of two staff will conduct field measurements. Teams consist of a highly trained field technician and a field assistant. Field measurements require four hours per team including driving time. Laboratory analysis will be assumed to take four hours and ten minutes utilizing both the lab technician and lab assistant. In addition, eight hours is required by the lab assistant to clean glassware and sample collection containers, to calibrate instruments prior to being sent in the field and to perform routine maintenance. Six hours additional time will be required of the lab assistant to verify results and enter data for monthly report submission. Heal the Bay's laboratory analysis is conducted by the program manager with the assistance of a volunteer college intern.

COST COMPARISON STREAM TEAM VS. SCENARIO 2

Monitoring Group	Labor Cost	Mileage	Total Price Per Event	Cost per Year
Scenario No. 2	$716.50	$34.56	$751.06	$9012.72
Heal the Bay	$189.76	$19.20	$208.96	$2507.52
Total Savings			**$542.10**	**$6505.20**

The costs of conducting a monitoring program, using either of the two scenarios, clearly demonstrates the benefits of using volunteer monitors. In addition, as the number of monitoring sites and frequency of sampling events increase, the cost benefits dramatically increase. It is the opinion of Heal the Bay that unless an agency or municipality has other monitoring needs, Scenario No. 1 the alternative that most agencies utilize.

Volunteer monitoring offers the additional benefits of public outreach and education that will not be realized from Scenario Nos. 1 and 2. This gives municipalities and other groups the platform to educate people about impacts on water quality and the environment and provides a hands-on opportunity for individuals to get involved and make a difference in their community.

VI. Stream Walking Model Program

Program Mission and Objectives

At the onset of the Stream Team program, the Cal Poly team and the program manager were charged with the following tasks:

- Design a monitoring protocol that helps locate the sources of problems and collects accurate, useable data for implementing solutions.
- Collect data in a manner that is useable by resource agencies and stakeholders charged with protecting the environment.
- Create a protocol that locates and identifies illegal/illicit storm drain connections.
- Document impacts related to impervious surfaces and encroachment into the riparian buffer zone.
- Map areas that are contributing to sediment loading in the watershed.
- Identify and map land uses that are contributing to nutrient, sediment and/or water quantity issues in the watershed.
- Map large patches of invasive vegetation so that a comprehensive removal strategy can be initiated.
- Map barriers preventing the upstream or downstream migration of aquatic species.
- Determine if quality steelhead habitat exists above Rindge Dam.

Stream Walking Equipment and Procedures

The Stream Team identifies and maps the following parameters in the field:

1. Discharge Points and Outfalls
2. Unstable Bank Conditions
3. Artificial Streambank Modifications
4. Adverse Land Uses
5. Large Patches of Exotic and/or Invasive Vegetation
6. Possible Barriers to Fish Passage
7. Illegal Dump Sites

These seven parameters are directly related to the major issues of concern in the watershed and/or supply needed data to decision-makers. The intent behind the stream walk data collection is to provide detailed information that can be used to enhance water quality and the environment. Precisely locating and documenting these seven items informs decision-makers of likely sources of environmental degradation and provides enough information to lead to thorough habitat assessments, Best Management Practice implementation and restoration of degraded habitats.

The most critical aspect of the stream walk activity is the ability to collect field data that is accurate enough for parameters to be readily relocated. Cal Poly recommended that the Stream Team map items located in the field using a Global Positioning System (GPS) and document those items with a photograph. GPS technology uses satellites to precisely triangulate and locate a position on the face of the earth. The GPS unit must receive a clear unobstructed satellite signal in order to accurately triangulate a position. GPS data can be integrated into a Geographic Information System (GIS), a computer mapping and database program that allow data to be displayed visually in a map format. Moreover, all the resource agencies and most of the city and county governments use GIS to map data for planning purposes. Collecting accurate data and making it available in GIS makes the information collected useable by the most groups and allows each agency or municipality to isolate data that is of particular interest. Heal the Bay believes that dissemination of GIS data will enhance research throughout the watershed by making the data easy to acquire and immediately useable.

GIS technology presents data visually making it easy to understand by the widest number of people. A specific objective of the Stream Team is to simply demonstrate the impacts associated with impervious surfaces and riparian buffer zone encroachment. The target audience for this data is decision makers such as members of city councils, members of the planning board, and politicians who may or may not understand ecological relationships and the impacts of poorly planned development on creeks and streams. Data displayed via GIS helps reinforce these relationships and is easy to comprehend.

GIS Software

In an effort to implement the recommendations of the Cal Poly team, Heal the Bay applied for a grant from Environment Now to secure funding for a high-powered computer workstation and Arc View GIS software. The Stream Team received the funding and then tried to leverage the money for software by applying for software and training grant from Environmental Systems Research Institute, the largest GIS software manufacturer. The ESRI Conservation Program is the non-profit support arm of the Environmental Systems Research Institute (ESRI). They have helped to create and develop spatial analysis, computer mapping and geographic information systems (GIS) capability among thousands of non-profit organizations and individual projects of all sizes and types worldwide. Heal the Bay was able to secure free software and training valued at $20,000.

GPS Unit

Heal the Bay opened a dialogue with the resource agencies in the region who had experience using GPS units to collect data. Accuracy of 30 meters or less was determined to be the minimum necessary to relocate items mapped by the Stream Team in the field. In order to achieve accuracy of less than 100 meters, you have to differentially correct for the intentional distortion being broadcast by the satellites for military security reasons. Differential correction requires a base station to be located at a known latitude longitude position. The base station then calculates the errors being broadcast by the satellites and then corrects the data.

Originally, we thought that an inexpensive high-end handheld GPS unit capable of differential correction would satisfy this requirement. Heal the Bay field-tested two Magellan and one Garmin handheld unit. These units were ineffective under light tree canopy and in canyons at tracking satellites. When data could be collected, the units tested were unable to provide accuracy less than 100 meters, even with differential correction. Finally, none of the units tested could interface with Arc View, the GIS program being used by Heal the Bay.

Heal the Bay was then forced to consider and test more sophisticated and expensive handheld models. We tested Ashtech's Pro Mark X, a 10-channel handheld model with a price tag of approximately $1,400, and Trimble's GeoExplorer 3, with a price tag of approximately $3,500. The Pro Mark X also performed poorly under tree canopy and in canyon areas and 90% of the time did not track enough satellites to collect data in our accuracy range. The GeoExplorer tracked satellites slightly better than the Pro Mark X but still proved inadequate under tree canopy and in canyons. Both units could interface with Arc View and would greatly simplify the data entry process.

The next step was backpack style units that carry a price tag starting at $6,500 going up to $11,000 dollars. These units are completely integrated to seamlessly export data into Arc View format and nearly eliminate data entry. Backpack units allow the user to create custom data entry menus to suit their specific needs. Heal the Bay tested Ashtech's Reliance sub-meter system and Trimble's Pathfinder unit. Both units performed well even in the most severe terrain and consistently provided accuracy of less than one meter. The Ashtech Reliance unit was better at tracking satellites under canopy and in canyon areas. The software and packaging of the Trimble unit was more intuitive and easier to use. The Ashtech unit was less expensive and ultimately won out.

GPS and Mapping

The Ashtech Reliance system offers the ability to locate a position as a point, a line, or an area. Points are used to denote discharges and outfalls, illegal dumpsites, and smaller patches of exotic invasive vegetation. Points are appropriate for noting small-condensed areas and problems. Lines are used to map impacting land uses that likely drain into the stream. Areas such as circles or polygons are used to map unstable bank conditions, large patches of invasive vegetation, artificial streambank modifications, and barriers to fish passage. Area mapping is appropriate when further calculations are required, such as determining how much sediment an unstable streambank contributes to the creek (Figure 12).

Mapping and Data Entry

Whenever one of the aforementioned parameters is identified in the field, the GPS or rover unit is used to precisely locate its position. This requires a person holding the GPS unit to either to walk the line or area stand still at the precise point they wish to map. In addition, a field data sheet (Appendix C) is recorded and a digital photograph is taken for the specific parameter identified in the field. Each of the seven parameters has its own field data sheet that provides detailed information about the nature of the problem. The Ashtech Reliance software allows the user to pre-program menus into the hand-held unit to enhance data collection in the field. The Stream Team has created menu choices for each of the seven parameters identified in the field. For example, the Stream Team locates a patch of invasive vegetation. The person operating the GPS unit has the option to record this as a point, if the patch is relatively condensed, or as an area if it is large. Once the operator selects invasive vegetation a menu selection appears asking them to choose the type of vegetation, which side of the stream the vegetation is located and any notes that may be pertinent. When the location of this invasive vegetation is exported to Arc View, the data entered becomes part of the table attached to the map. The ability for the data to be connected to the location in the field greatly reduces the time required for data entry.

Stream Team members take a digital photograph of each parameter identified and mapped in the field. We use a process known as hot linking to connect that digital image to the precise location and information recorded about the problem (Figure 12). Data submitted by the Stream Team has the location within one-meter, detailed information about the problem and an exact image of the problem. By simply clicking on a point that was mapped the viewer can see an exact image of what was identified in the field, view information designed to help locate the source, and determine the extent of damage the parameter is causing. The digital cameras work beautifully, pictures are high quality and the playback feature allows the operator to view the image in the field, and determine if it provides enough context to demonstrate the problem. Displaying the data in this way simplifies the problem of relocating the item in the field and provides an easy to understand visual display of the issue.

Processing Stream Walk Field Data

The next issue facing the Stream Team was correcting the data to achieve the accuracy criteria. In order to correct the data to an accuracy of within 100 meters, a base station at a known position must be used to calculate and correct for the intentional errors being broadcast by the satellites.

Solution 1- Ashtech offers a solution called DGPS, which uses additional Coast Guard satellites to correct the data in real time. Real-time differential GPS requires a radio link between the rover receiver (i.e., your handheld unit) and a base receiver (i.e., the GPS receiver located at a known point). Corrections are made via this radio link before the point position is computed. The DGPS is capable of sub-meter accuracy but usually corrects data within nine meters. The DGPS solution could be acquired for approximately $3500 and requires that two satellite signals be strong enough to collect and then correct the data. In the unfavorable terrain conditions occupied by the Stream Team this option was expensive and considered less reliable than post processing.

Solution 2- Download free information from the Internet to correct data (known as post-processing, as it is not done in the field). Two major GPS networks provide their data free over the internet: The Southern California Integrated GPS Network (SCIGN)

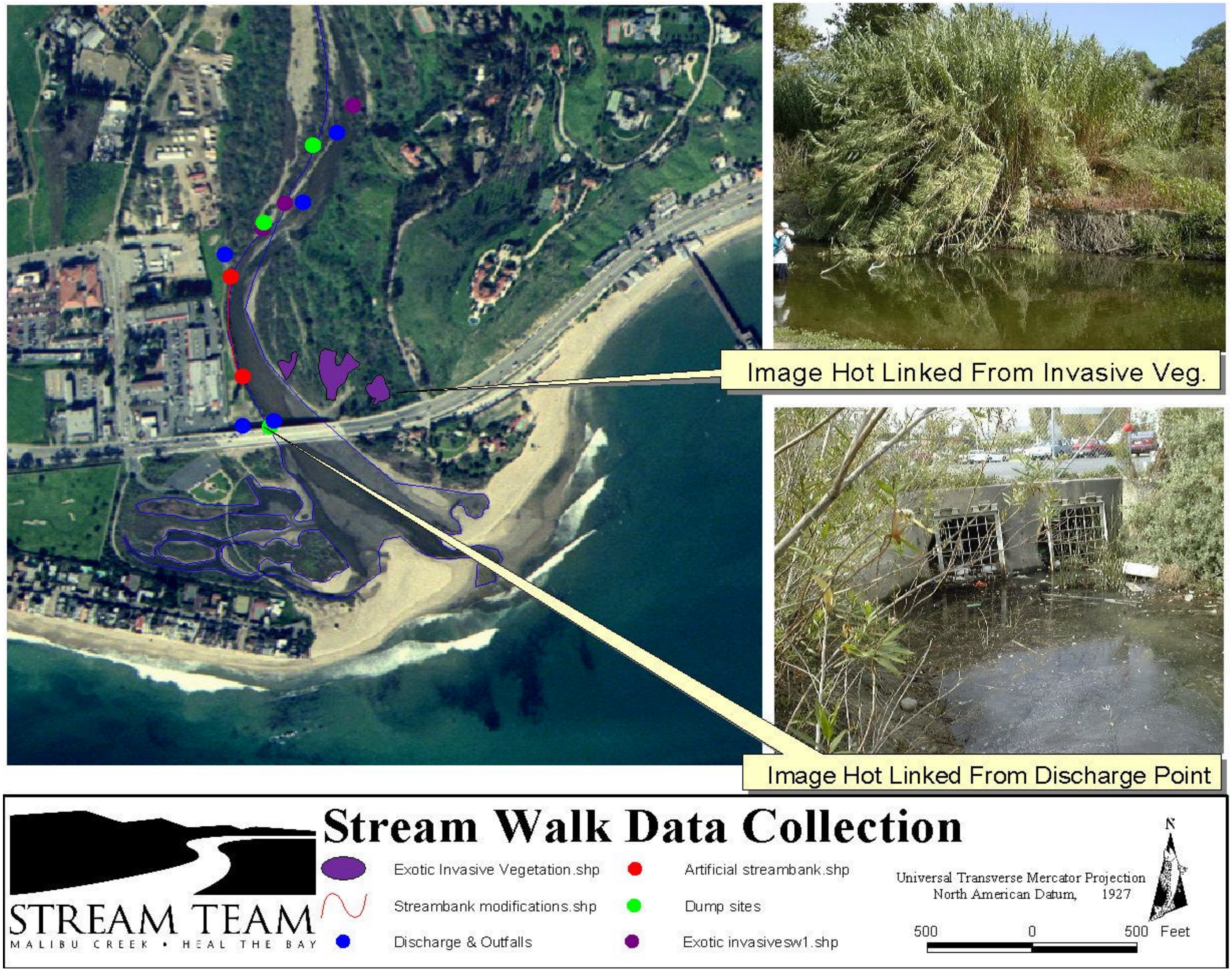

Figure 12. Map of data collected during stream walks with hot links of the exact item located

which provides regional coverage for monitoring earth movement and estimating earthquake potential in Southern California and the U.S. Continuously Operating Reference Stations (CORS).

In order to utilize the free internet data a base station must be located within 100 kilometers of where the rover data is collected. Base stations outside of this range would degrade the accuracy. Each website provides a detailed map of available base stations the SCIGN website address is http://lox.ucsd.edu/ and the CORS website address is http://www.ngs.noaa.gov/CORS/. Heal the Bay consulted maps of base station positions at both websites. Three SCIGN stations were within the 100-kilometer range.

After the necessary data has been downloaded, field data can be post processed, or corrected. Data collected by the base station is taken every 30-seconds, while field data from the rover unit records a position every two seconds. To enhance the accuracy an interpolation function that comes with Ashtech's reliance software package is used. It interpolates the single 30-second positions of the base station into 15 two-second positions.

The data collected from the base station is in a universal format known as RINEX 2 "Receiver Independent Exchange Format" which was developed by the astronomical Institute of the University of Berne for the easy exchange of the GPS data. This data needs to be converted into Ashtech format using the RINEX conversion tool supplied with the software. Once the data is in Ashtech format the user inputs the precise latitude and longitude of the base station and tells the software in what map coordinate system to display the results. The processed data can then be exported into the users specific GIS software program for display and or further analysis.

The process of downloading base station data off the web is extremely labor intensive and takes approximately the same amount of time to reconcile and correct data as it does to collect the data. In addition, this process robs resources and consumes valuable storage space on the GIS workstation. Data downloaded from the web is for a 24-hour period while field data is collected for approximately four-hours. This method requires 16-20 hours additional unneeded data storage for each event. The Stream Team has acquired a base station as previously discussed.

Savings and Benefits of Volunteer Monitoring

The total cost for a Stream Walk Field kit is summarized in the table below.

COST OF A STREAM WALK FIELD KIT

Description and Model	Cost
Digital Camera PDR M-1	$ 523.93
AC Adapter PDR M-1 (for uploading pictures to workstation)	$ 54.12
Battery Chargers with 4 AA High Capacity Nickel Cadmium Batteries	$ 36.78
8MB Smart Media Cards	$ 75.77
Ashtech Reliance Sub-meter 12 Channel GPS w/ shipping Case and 10m antenna	$ 6,481.47
Fiberglass Stadia Rods 25ft w/prism adapter for GPS antenna	$ 187.27
Total cost	**$ 7,359.34**

Other costs include labor and mileage. On the day of an event the program manger spends six-hours driving to and from the event and conducting the Stream Walk. Four events occur each month totaling 24-hours of labor. In addition, data entry takes approximately six-hours for each event or 24-hours a month and is entered by the program manager. Average mileage traveled is 30 miles per event. Finally, six-hours is attributed once a month for stream walk training including driving time and an additional 30 miles traveled.

STREAM TEAM PROGRAM MANAGER LABOR AND MILEAGE

Type of work	Labor Cost	Total Hours Per Event	Events per month	Hours per month	Labor Costs Per Month
Event	$19.63	6 hours	4	24 hours	$471.12
Training	$19.63	6 hours	1	6 hours	$117.78
Data entry	$19.63	6 hours	4	24 hours	$471.12
Total Labor			**9**	**54 hours**	**$1060.02**

Heal the Bay estimates the same program conducted by an agency or municipality would require three staff members for efficiency and safety reasons. One staff member must be trained to run the GPS unit and the two others to assist in data collection and surveying. Salaries based on people trained to operate and collect data with a GPS unit will be estimated at $18.00 per hour. The two assistants would make an estimated $15.00 per hour. Field assistants were valued higher than field assistants used for water quality analysis due to the increased hazards associated with the stream walk. In addition, a GIS technician is required to enter and reconcile field data. Hourly wage of the GIS technician has been conservatively estimated at $ 24.00 per hour. All labor cost include payroll taxes and insurance costs. Salary estimates are based on the salary range of people performing similar functions for other agencies.

Agency or MunicipalityStream Walk Labor Costs

Position	Labor Cost	Total Hours Per Event	Events per month	Hours per month	Labor Costs Per Month
GPS Operator	$18.00	6 hours	4	24 hours	$432.00
2 Field Assistants	$15.00	12 hours	4	48 hours	$720.00
GIS Technician	$24.00	6 hours	4	24 hours	$576.00
Total Labor			**12**	**96 hours**	**$1,728.00**

Using volunteers to conduct the stream walk will yield cost savings per month of $667.98 and a yearly cost benefit of $8,015.76 per GPS unit. Heal the Bay currently operates two GPS units simultaneously, which provides a yearly cost benefit of $16,031.52. This represents significant savings, while maintaining a high level of performance.

Lessons Learned and Recommendations

The stream walk is an intensive survey requiring approximately four-hours to map a half-mile of terrain. It is extremely labor intensive and requires a minimum of three people for efficiency and safety reasons. Heal the Bay is concerned about the length of time it takes to survey stream sections. The Malibu Creek Watershed has over 75 miles of major tributaries that need to be surveyed and the Stream Team is currently averaging only 12 miles a year. Heal the Bay believes that the distance covered during a stream walk must be enhanced.

The primary concern is mapping exotic invasive vegetation, which is the most significant parameter in the lower watershed. Vegetation is constantly changing within the watershed. Riparian vegetation is occasionally washed away or is temporarily displaced by fire and flood. Invasive vegetation commingles with the native plants making it difficult to efficiently map and isolate. Invasive vegetation also negatively impacts the riparian zone. It is critical to any effective native vegetation restoration effort that all exotics are removed starting from the top of the drainage and working down, and it is therefore critical to locate these non-native plants.

In an attempt to expedite data collection concerning vegetation, the Stream Team maps the center point of large patches of vegetation and then measures the length width or diameter using a tape measure. To the maximum extent possible the area function on the GPS unit should be used to highlight problem areas of invasive vegetation. In areas where invasive vegetation is interspersed with native vegetation, a polygon should be drawn around the entire area and an estimate made about the type and percentage of invasive vegetation. Finally, Heal the Bay requests guidance from our contract botanist and noted experts in the region about the plants we are mapping and the continued benefit of mapping all these species.

Based on literature and advice from the GPS manufacturer the Stream Team should occupy or record satellite data at the location being mapped as a point, or walk a line or an area for one-minute intervals to get an accurate location reading. Unfortunately, this proved to be an insufficient amount of occupation time to record accurate results. In addition, numerous points that were mapped in the field could not be corrected due to the lack of overlapping data points between the base station and rover unit. Heal the Bay hypothesizes that the problem is due to the difficult conditions in which Stream Team data is collected. Four to six miles of data collected by the Stream Team proved to be unusable due to the occupation time problem. The data appeared to process accurately until it was compared to a reference location on an accurate base map. Extensive research was conducted to find the appropriate occupation time, taking into consideration the difficult terrain and conditions under which the Stream Team collects their data. It was determined that three minutes is the minimum occupation time required to record locations in the field, and provides adequate overlapping base station and rover data to accurately correct field data. This increases the time it takes to collect data in the field.

To increase the efficiency of field data collection, the Stream Team has purchased a second GPS rover/base unit. This will provide the flexibility of either running two units in the field simultaneously, which doubles the distance that can be surveyed in a four-hour period, or using one as a base station. Currently, the additional unit is being used at the same time and location as the initial GPS unit. Three members of the team will use one unit to map a parameter while three other team members walk ahead to map the next parameter. This has doubled the distance that can be surveyed during a single event. In addition, the second GPS unit serves as a backup in the event that one of the units has to be sent in for service.

Using the second GPS unit as a base station will also increase the distance that can be surveyed in a four-hour period. The base station will collect data in the same location and at the same time interval as the rover unit, and will eliminate the problem of insufficient overlap between the two units. The addition of a base station that can be positioned close to the location being surveyed should cut the time needed to occupy a location in half. However, many of the parameters located in the field require measurements and/or data input that takes the full three minutes. The increase in distance will be less than double using the second unit as a base station. In addition, using the second unit, as a base station will eliminate the need to download data from the web, interpolate and convert the data. Download, interpolation and conversion are extremely time consuming and by eliminating that procedure would make the overall Stream Walk process more efficient, but the distance covered would still be less than using both units in the field. Finally, a base station will reduce the amount of computer storage space needed to hold base station data retrieved off the web. The data that is downloaded from the SCIGN Network is for a 24-hour period, while field data is collected for only four hours. A base station would save a minimum of 12-hours of data storage per event.

Digital photographs have to be linked to a file on the computer. Image numbers are recorded on the field data sheet and entered by hand in the office. The precise path to where that image file is located must be manually entered. This is time consuming and labor intensive. The Stream Team has experimented with entering image names directly into the handheld device. This did not work because often times several images are taken of one location and staff does not decide which image to use until viewing them on the computer workstation. Uploading images from the camera to the workstation is extremely slow. The Stream Team should acquire a smart card reader to increase the efficiency of upload.

The Stream Team spends all their time in the riparian zone in and along streams and creeks, in the worst possible conditions for collecting GPS data. Often, the Stream Team needs to locate positions under tree canopy or in canyons making unobstructed satellite coverage challenging. To minimize obstructions the Stream Team utilizes a collapsible 1-25 ft. pole to raise the GPS antenna above trees or higher in canyons to enhance the satellite signal (Figure 13). In addition, the GPS unit is not waterproof and cannot be submerged in water. Heal the Bay ordered an extra long cable that would allow for elevating the antenna above obstructions and provide an added measure of protection to the GPS unit. The longer cable enables one person to place the antenna on the item being mapped while another person carrying the GPS unit waits on safer ground.

Figure 13. Stream Team volunteers extending the antenna for the GPS

Recommendations

Heal the Bay should utilize the second GPS unit as a rover when six people or greater attend an event. In situations where less than six team members attend an event the second unit should be utilized as a base station. To accommodate the second GPS unit as a base station several secure locations throughout the watershed will need to be surveyed for their precise longitude latitude and height. It is critical that these locations are sheltered from the elements and have the ability to be locked. The GPS unit will have to remain at the location unattended while field data is being collected. In addition, Heal the Bay should recruit interns who are familiar with GIS and GPS to help post process and reconcile data in the office. Several universities offer classes and majors in geographic information systems and should be targeted for Stream Team interns. Heal the Bay will have to acquire an additional GIS workstation and network that station to the existing computer in order to accommodate GIS interns. GIS interns could also be used to collect data during the week. The Stream Team should also acquire funds to hire an intern. The paid intern will be responsible for data entry, monthly trainings and weekday data collection. Finally, the Stream Team should acquire a laser range finder (LRF). A laser range finder will allow the GPS operator to stand at one position and shoot the laser at the exact item to be mapped. The LRF has a range of 1000 feet and can map multiple locations during a single occupation time. The LRF calculates the distance, bearing (azimuth), and the slope (inclination) of the parameter being mapped. The LRF will allow the GPS operator to establish an accurate position without having to physically occupy that location. This will eliminate the need to climb treacherous steep slopes, reduce the time spent waiting for an adequate satellite signal, improve accuracy, minimize impacts on riparian habitat and locate parameters in ecologically sensitive habitats without causing any disturbance. If the LRF is utilized it would free up the second GPS unit so that it can be used as a portable base station.

Overall Program Recommendations

The Stream Team model is easily adapted to other watersheds. Heal the Bay believes that exporting this model to other watersheds will lead to high quality, comparable data throughout the region. Heal the Bay has already received requests from environmental organizations and public agencies to help implement the Stream Team model in their watersheds. The program requires a staff person to have basic GIS knowledge, extensive knowledge of the GPS and associated software, familiarity with water chemistry equipment and the maintenance of that equipment. Heal the Bay could offer on-site training for interested groups at minimal cost. Training should include the following items:

1. Assistance in the design of monitoring protocols and equipment purchases to address the issues of concern in the specific watershed.
2. Training of the recipient group's program coordinator.
    - Stream walk and water chemistry training methods.
    - Water chemistry equipment use and maintenance procedures.
    - Proper QA/QC protocol (field and lab).
3. Volunteer training materials, and scheduling.
4. Stream Team Field Guides.
5. Heal the Bay will provide easy to use documentation and teach the group how to collect and process Stream Walk data.
    - GPS collection in the field.
    - Custom programming for the hand held to ease data collection in the field.
    - GPS post processing.
    - GIS training
6. Heal the Bay would hold two equipment calibration sessions in year one and organize one split sampling session to validate water chemistry data quality.
7. Create a Quality Assurance Project Plan (QAPP) for the group.
8. GPS locations of H_20 monitoring sites for use on a website or with GIS.
9. Provide a volunteer component that includes how to recruit volunteers, how to communicate and organize volunteers, and incentives to keep volunteers motivated.

On-site training will ensure that new monitoring programs get up and running more quickly and will provide the tools necessary to rapidly begin collecting high quality data. Organizations that go through the on-site training program will realize substantial time and cost savings over the long run.

VII. Conclusions

As the TMDL development process moves ahead, water quality assessments and monitoring programs throughout California will become increasingly more important. Monitoring programs will have to increase both the geographic area of the receiving waters sampled and the number of samples and constituents analyzed. TMDLs may mandate for counties, cities and public agencies to monitor 303(d) listed receiving waters within their jurisdiction. Heal the Bay believes these entities could heavily utilize and fund volunteer monitoring efforts to supplement their own monitoring programs. By incorporating volunteer monitoring programs, counties, cities and public agencies will realize substantial cost savings, while extending their geographic coverage. Volunteers should be used to collect and perform the aforementioned water chemistry tests, with more complex measurements being sent to State-certified laboratories.

Heal the Bay believes that the Stream Team model is applicable and adaptable to all watersheds, urban and rural, throughout southern California. As demonstrated by the rigorous testing and equipment verification procedures described in this report, volunteers can collect high quality water chemistry data that is useable for water quality assessments and subsequent resource management decisions. Heal the Bay believes that the Stream Team Field Kit and monitoring protocols, if followed, yield accurate, precise, reliable and comparable water chemistry results. Moreover, data collected in accordance with the Stream Team guidelines could be integrated into the process to complete water quality assessments, develop TMDLs and to ensure that waste load allocations are met. The Stream Team volunteer monitoring program provided significant cost savings, $12, 035.76 over a 12-month monitoring period, compared to using a State-certified laboratory to process samples. Cost/benefits will increase as more monitoring sites are added or monitoring frequency is increased.

Heal the Bay strongly believes that the stream walk component is essential to any monitoring effort designed to identify and assess pollution sources. The stream walk precisely locates and documents likely sources of pollution and environmental degradation. The parameters located in the field are mapped to within one-meter accuracy so they can be easily relocated, targeted for removal and/or restoration. Stream walk data is placed into GIS to make it most useful to counties, cities and public agencies in the region. The stream walk component provides data that can be used to develop watershed scale restoration plans and prioritize restoration efforts, as well as funding priorities. The stream walk component is incredibly labor intensive and probably could not be effectively implemented by a public agency other than a volunteer monitoring organization. Public agencies, such as the State Water Resources Control Board and Regional Water Quality Control Boards(RWQCB), are well suited to fund stream walk efforts to identify illegal/illicit connections and likely sources of both point and non-point pollution. In addition, stream walk data can be used to accurately quantify algae and sediment impairments, as well as the actual location of these impairments. Finally, public agencies and foundations that invest financial efforts for habitat restoration will greatly benefit from the data collected during stream walks.

In conclusion, volunteer monitoring has the added benefit of community outreach and public education. Over 500 people have been educated about the issues concerning the future water quality and ecological health of the Malibu Creek Watershed. These volunteers witness first hand the affects of impervious surfaces, nutrient loading, sediment loading and urban runoff on stream ecology. Volunteers who attend Stream Team trainings, leave with the knowledge of what they can do to protect this precious resource. Heal the Bay has witnessed our volunteers take ownership of the Malibu Creek Watershed and truly become stewards of the environment.

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APPENDIX A
VOLUNTEER MONITORING RESOURCES

Scientific Supply Companies

Cole-Parmer Instrument Company 625 East Bunker Court, Vernon Hills, IL 60061-1844 • (800) 323-4340 • www.coleparmer.com

Fisher Scientific, 711 Forbes Ave., Pittsburgh, PA 15219 • www3.fishersci.com

HACH Company, P.O. Box 389, Loveland, CO 80539 • (800) 525-5940 • www.hach.com

Hydrolab Corporation, P.O. Box 50116, Austin, TX 78763 • (512) 255-8841 • www.hydrolab.com

LaMotte Company, P.O. Box 329, Chestertown, MD 21620 • (800) 344-3100 • www.lamotte.com

Microtech Scientific, 4729 E. Bond Avenue, Orange, CA 92869 • (714) 744-3974

Millipore Corporation, 80 Ashby Road, Bedford, MA 01730 • (800) 255-1380 • www.millipore.com

Thomas Scientific, 99 High Hill Road at I-295, P.O. Box 99, Swedesboro, NJ 08085 • (609) 467-2000 • www.thomassci.com

VWR Scientific, 200 Center Square Road, Bridgeport, NJ 08014 • (800) 234-9300
P.O. Box 66929, O'Hare AMF, Chicago, IL 60666 • (800) 932-5000
P.O. Box 7900, San Francisco, CA 94120 • (415) 467-6202 • www.vwrsp.com

Wildlife Supply Company, 301 Cass Street, Saginaw, MI 48602 • (517) 799-8100 • www.wildco.com

YSI Incorporated, 1725 Brannum Lane, Yellow Springs, OH 45387 • (513) 767-7241 • www.ysi.com

National Volunteer Monitoring Newsletters

River Network
P.O. Box 8787
Portland, OR 97207
(503) 241-3506
Call 1 (800) 42-DORIS for more information or for publications list.

The Volunteer Monitor
1318 Masonic Avenue
San Francisco, CA 94117

Federal Agencies

Environmental Protection Agency
Assessment & Watershed Protection Division, 401 M Street SW, Washington, DC 20460
Office of Wetlands, Oceans, and Watersheds, 401 M Street SW, Washington, DC 20460
(202) 260-7166

National Park Service
US Department of the Interior, 1849 C St., NW, Washington, DC 20240 • (202) 208-4621
Water Resources Division, 1201 Oak Ridge Drive, Ste 250, Fort Collins, CO 80525
(970) 225-3501

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Malibu Creek Watershed Stream Team

Water Chemistry Testing

SITE CONDITIONS FIELD SHEET

Date:____________ **Stream Name:**______________________

Time:____________ **Recorder:**________________________

Weather Conditions

Clear ☐ Overcast ☐ Showers ☐ Rain ☐

Air Temperature/Time: _____/_______ (@ start of testing)

Air Temperature/Time: _____/_______ (@ end of testing)

Type of Flow:

none ☐ intermittent ☐ trickle ☐ steady ☐ heavy ☐

PROPERTIES OF STREAM

Water Clarity:

clear ☐ cloudy ☐ milky ☐ muddy ☐ other:__________

Water Color: clear ☐ red ☐ yellow ☐

brown ☐ green ☐ gray ☐ other:________________

Odors: none ☐ rotten eggs ☐ sewage ☐ chlorine ☐

musty ☐ ammonia ☐ other:_____________________

Floatables: none ☐ oily sheen(rainbow colored) ☐

garbage ☐ sewage ☐ other:_____________________

Biological Floatables: mosquito larvae ☐

algae ☐ % coverage in stream _______

foam ☐ color________ height_______ %coverage_____

DEBRIS

Density of Trash: None ☐ Light ☐ Moderate ☐ High ☐ Appr. # of Items__________

Type of Trash: (% type of item)

_____% Organic (food items) ______% Plastics

_____% Recyclables-not plastic ______% Large items(cars, appliances etc.)

Field Notes: use back of this sheet

(Adapted from the "Standard Field Observation Sheet, RWQCB)

Malibu Creek Watershed Stream Team

Water Chemistry Testing

CHEMICAL PARAMITERS FIELD SHEET

5. Dissolved Oxygen

Mg/L	**% Saturation**	**Water Temp.**	**Time**
a._______	a._______	a._______	a._______
b._______	b._______	b._______	b._______
* _______	* _______		
** _______	** _______		

Average of two readings**

6. pH

______ (1st reading)

______ (2nd reading)

______ (3rd reading*)

______ Average of 2 reading**

7. Turbidity - Measured

a._____ NTU

b._____ NTU

c._____ NTU*

______ NTU - mean**

8. Conductivity (TDS)

		Water Temp.	**Time**
a._____ µS	a._____ mS	a._______	a._______
b._____ µS	b._____ mS	b._______	b._______
c._____ µS*	c._____ mS*		

______ µS / mS - mean**

9, 10, 11: Nutrient Testing

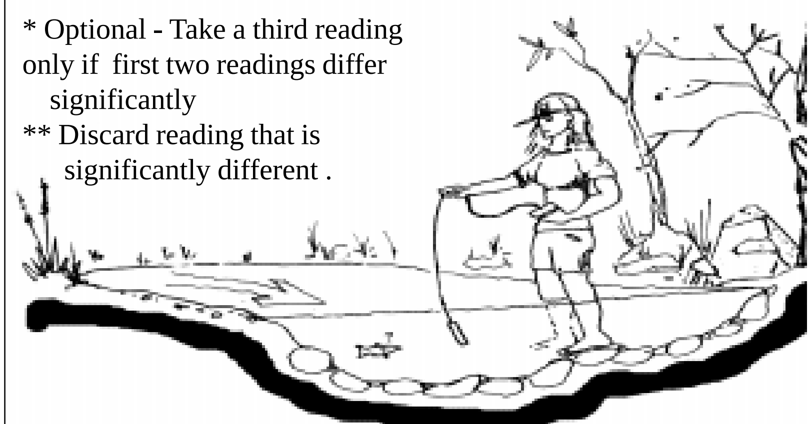
Sample bottle # _______

Time of Sample _______

Time put on Ice

* Optional - Take a third reading only if first two readings differ significantly

** Discard reading that is significantly different .



Malibu Creek Watershed Stream Team

Chemical Testing
Stream Flow

Use this form to calculate stream flow. Velocity and cross sectional area of the stream need to be determined. The result will be stream flow in CFS (cubic feet per second). The information you gather will be helpful in understanding the relationship between stream flow, sedimentation, dissolved oxygen, and concentration of pollutants.

Date: ____________ **Stream Name:** ____________________
Time: ____________ **Recorder:** ____________________

Velocity Float Trials:

Trial #	Time
1	
2	
3	
4	
5	
Total	

Distance [ ]

[/] = [ ]

total time / # of trials = average time

Cross Sectional Area:

Record depths at 1-foot intervals. Depth in inches = D

wetted width____________ **wetted width** ____________

Cross Section 1

#	D	#	D
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

sum of section 1= [ ]

Cross Section 2

#	D	#	D
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

sum of section 2= [ ]

Convert inches to decimal feet

section 1: ( )/12 = ________ **ft^2**

section 2: ( )/12 = ________ **ft^2**

Average Cross Sectional Area = (sum 1)+(sum 2) /2 [( ) +( ) / 2] [**ft^2**]

Average Surface Velocity = [/] = [ ] **X (0.8) =** [ft/sec.]

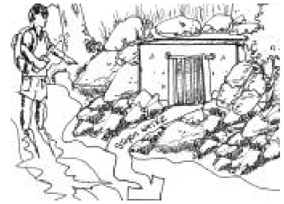
distance/ avg. time — feet/sec. — **Avg. Corrected Velocity**

Stream Flow = [ ] ft./sec. **X** [ ] **ft^2=** [ ] **CFS**

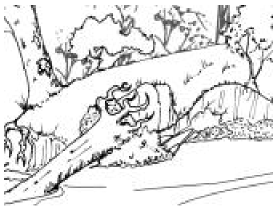
avg. corrected velocity — avg. cross sectional area — (cubic ft/second)

Appendix-C

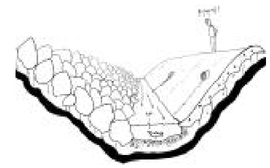
Stream Walkers must cover ground and make good observations of the stream conditions around them. Each walk can take three to four hours, and cover approximately a half-mile stretch. The walking can involve wading into the various streams and creeks, wading through dense vegetation, and climbing over rocks and large boulders. Besides covering ground, the other important task for a Stream Walker is to make good observations using the Field Sheets.



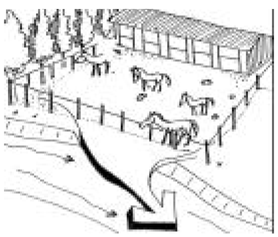
1. Discharge Points and Outfalls are pipes and culverts that carry stormwater runoff into a stream at a single point. As a result, water quality and stream morphology may be impacted, especially at the point of discharge into the creek. Not all discharges are legal. Current information regarding the location of all outfalls to the creeks is limited. Your information will help Heal the Bay update available mapped information.



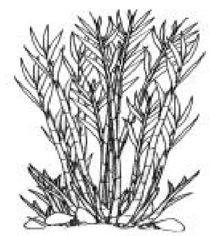
2. Unstable Bank Conditions is a common problem along local streams, particularly ones that are subject to upstream development. Banks that are eroding or collapsing into the stream do not have stable soils for vegetation to establish. Eroding banks contribute sediments that can impact the habitat of steelhead trout and macroinvertebrates, and collapsing banks can block stream flows, causing flooding and damage to nearby property.



3. Artificial Streambank Modifications often are used in urbanized or developing watersheds to prevent flooding. This method of streambank stabilization and flood control eliminates the natural vegetation. Vegetation provides food and habitat for aquatic and land based birds and wildlife, slows the flow of surface runoff, and balances the nutrient levels of streams. This alteration is often necessary when private property backs up to a stream and allows structures to be built close to the stream's edge. While artificial bank modification may solve the problem of one property owner, the results are a funneling of problems further downstream to the next property owner, and beyond.



4. Impacting Land Uses that are adjacent to streams can potentially affect the stream environment. The land uses of interest are those that have replaced riparian vegetation. For example, some places in the watershed have horses or other animals that graze right at the edge of the streambank. In other locations shopping centers or houses may be located on the streambank edge. While these land uses may not have a discharge directly to the stream, runoff from these areas could have an impact on stream health.



5. Large Patches of Exotic and/or Invasive Vegetation are plants introduced from other parts of the country or other regions in the world. Many of these plants are well adapted to local climate and soil conditions. Some are aggressive and may out-compete and displace native vegetation. Problems arise when these plants do not provide the food and habitat required by the native species of birds and wildlife.

6. Possible Barriers to Fish Passage potentially affect the passage of steelhead trout and other fish to protective spawning grounds within the upper watershed. Currently, the annual steelhead run is restricted to the lowest 2.5-mile stretch of Malibu Creek, below Rindge Dam. Healthy fish habitat is usually productive habitat for many other aquatic species.

7. Illegal Dump Sites exist partially because dumping is cheaper than legal disposal of waste. Frequently dumped wastes include hazardous chemicals, or large items like appliances. The problem is compounded when certain areas become recognized as places to dispose of waste. Areas in and around streams are frequently used as dump sites because they are off the beaten track, lessening the likelihood of being caught in the act. These areas will likely be near roads.

Malibu Creek Watershed Stream Team

Stream Walking Cover Sheet

Date: _________ Time Started_____ Time Finished__________

Stream Name: ______________________________

Name of Investigators

Stream Reach Location

Description of Starting Point

Description of End Point

Weather Conditions

Clear Overcast Drizzle Foggy Rain

Overview of Stream Walk (fill this out at end of walk)

# of discharge points recorded:

# of unstable stream banks recorded:

# of artificial stream bank modifications recorded:

# of patches of exotic invasive vegetation:

# of possible fish migration barriers:

# of dump sites recorded:

# of impacting land uses recorded:

# of pools recorded:

Comments on the Experience

Was the Stream reach degraded due to algae?

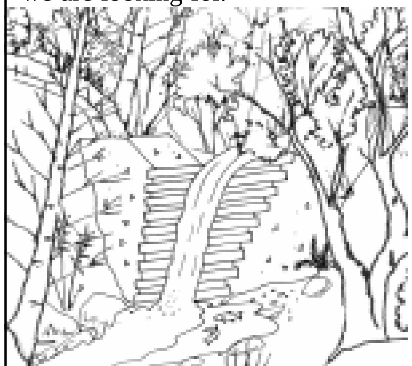
Was the Stream Reach degraded due to sediment?

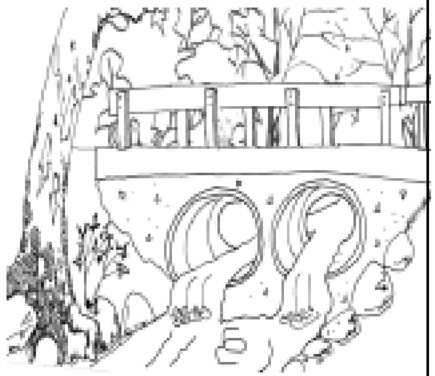
Malibu Creek Watershed Stream Team

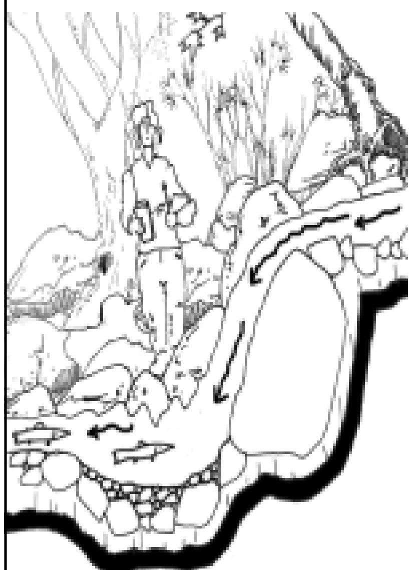
Stream Walking

Possible Barriers to Fish Passage

Use this form to describe possible migration barriers you encounter along your stream walk. Remember, a barrier is anything that may inhibit upstream fish movement. Below are a few examples of possible barriers. Barriers are not limited to just these and will take many forms. Review the section on identifying barriers in the field guide to get a better idea of what we are looking for.


Artificial Waterfall/Check Dams


Culverts/Stream Crossings


3’ or Higher Waterfalls


Long Steep Cascades

Date: **Stream Name:**
Time: **Recorder:**

Type Of Barrier:_______________________________
(GPS) Location:latitude_________ **longitude** _________
Photo #(s):________ **Event #:** ________
Notes:

Type Of Barrier:_______________________________
(GPS) Location:latitude_________ **longitude** _________
Photo #(s):________ **Event #:** ________
Notes:

Type Of Barrier:_______________________________
(GPS) Location:latitude_________ **longitude** _________
Photo #(s): ________ **Event #:** ________
Notes:

Type Of Barrier:_______________________________
(GPS) Location:latitude_________ **longitude** _________
Photo #(s): ________ **Event #:** ________
Notes:

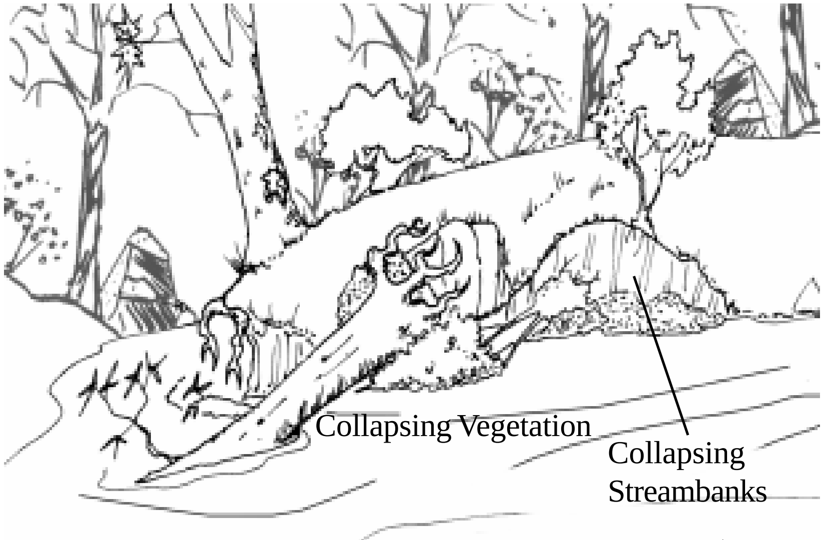
Type Of Barrier:_______________________________
(GPS) Location:latitude_________ **longitude** _________
Photo #(s): ________ **Event #:** ________
Notes:

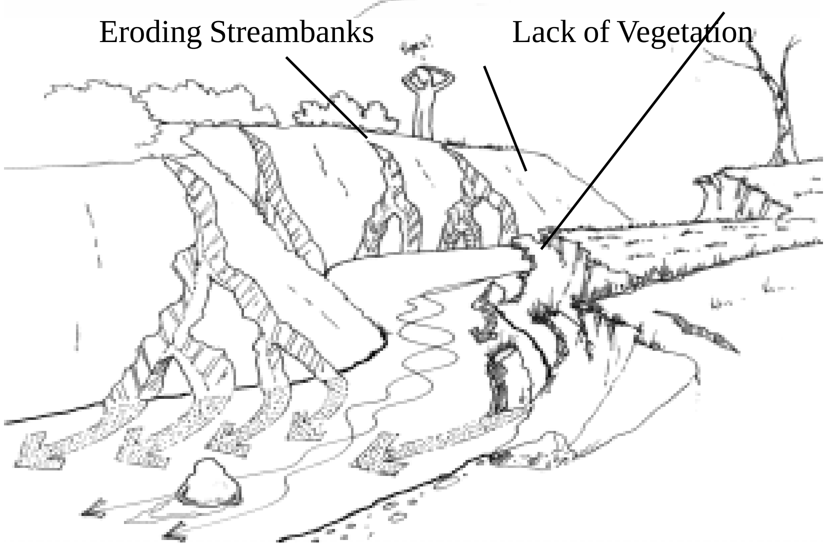
Type Of Barrier:_______________________________
(GPS) Location:latitude_________ **longitude** _________
Photo #(s): ________ **Event #:** ________
Notes:

Malibu Creek Watershed Stream Team

Stream Walking
Unstable Streambanks

Use this form to record information about areas with unstable bank conditions. The images below are to remind you about the various elements to look for when identifying unstable streambanks. Information gathered will help target areas in need of attention and restoration projects in the future.





Date: ____________ **Stream Name:** ____________________

Time: ____________ **Recorder:** ____________________

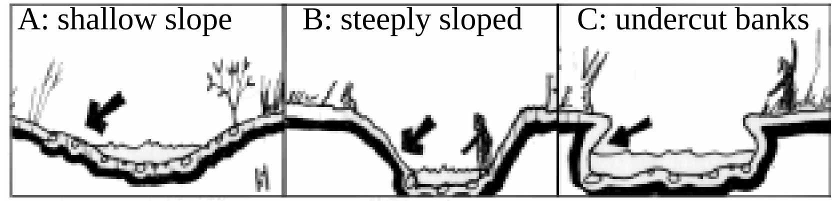
(GPS) Location Latitude: ___________ Longitude: ___________

Side of Stream (left or right looking downstream) Lt ☐ Rt ☐

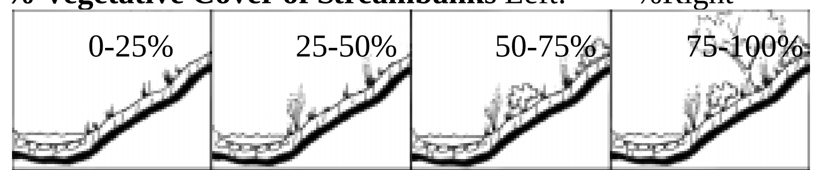
Photo #(s) ___________ **Event #** ___________ Both ☐

Streambank Description

Streambank Type Left: _______ Right: _______



% Vegetative Cover of Streambanks Left: %Right %



Landuse Associated with Unstable Bank (if identifiable):

SFR ☐ MFR ☐ AG ☐ OV ☐ AH ☐ EQ ☐ IND ☐ COM ☐ V ☐ DGL ☐

SFR = houses MFR = condos, apartments, townhouses
AG = agriculture OV orchards/vineyards AH = livestock
EQ = horses IND = manufacturing COM = retail/shopping
V = undeveloped open space DGL= disturbed grass land

Conditions of Streambank (circle A if apparent, B if severe)

loss of vegetative cover	Left Bank A B	Right Bank A B
collapsing vegetation	Left Bank A B	Right Bank A B
stream banks collapsed	Left Bank A B	Right Bank A B
stream banks eroding	Left Bank A B	Right Bank A B

Stream Conditions (circle A if apparent, B if severe)

mud/silt/sand entering the stream	Left Bank A B	Right Bank A B
vegetation collapsing into stream	Left Bank A B	Right Bank A B
slope collasping into stream	Left Bank A B	Right Bank A B

Describe Area on Backside of this Field Sheet

Malibu Creek Watershed Stream Team

Stream Walking
Identifying Discharge Points

Date: ____________ **Stream Name:** ____________________

Time: ____________ **Recorder:** _______________________

Photo #(s): ________ **Event #:** ________

Weather Conditions

Clear ☐ Overcast ☐ Showers ☐ Rain ☐

Type of Discharge

pipe ☐ storm drains ☐ open channels ☐ drainage ditch ☐

other: ____

(GPS) Location Lat. ____________ Long. ________________

Side of Stream (left or right looking downstream) Lt ☐ Rt ☐

Location in Relationship to Stream

in stream ☐ in streambank ☐ near stream ☐

Distance From Stream (approximate)**:** ___________ **Feet**

Diameter of Discharge point

< 12" ☐ 12" ☐ 18" ☐ 24" ☐ 36" ☐ > 36" ☐ other: ____________

Condition of Outfall: normal ☐ concrete cracking ☐

metal corrosion ☐ other: ______________________________

Streamside Environment

Landuse Associated with Outfall (if identifiable):

SFR ☐ MFR ☐ AG ☐ OV ☐ AH ☐ EQ ☐ IND ☐ COM ☐ V ☐

SFR = houses MFR = condos, apartments, townhouses

AG = agriculture OV orchards/vineyards

AH = livestock EQ = horses IND = manufacturing

COM = retail/shopping V = undeveloped open space

Streambank Conditions

NV ☐ CC ☐ RR ☐ LB ☐ CB ☐ WRW ☐

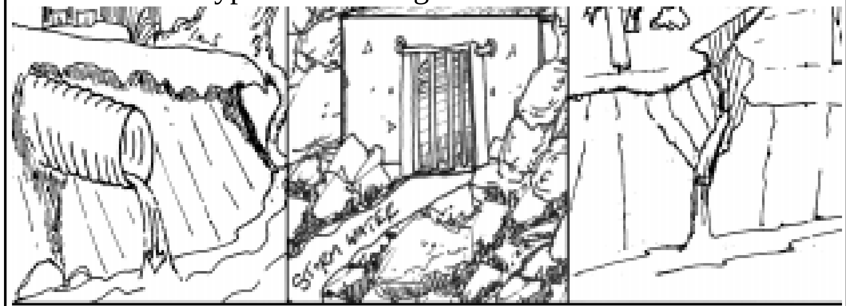
other: ____

NV = natural vegetation CC = concrete channel

RR = rip rap(stacked concrete bags) LB = loose piled boulders

CB = concreted boulders WRW = wooden retaining wall

Possible Types of Discharge Points



Pipes Storm Drains Ditches

Staining (in artificially modified areas):

none ☐ sediments ☐ oil/grease ☐ other: ____________

Vegetative Cover on Streambanks:

Lt bank: none ☐ sparse ☐ normal ☐ abundant ☐ eroded ☐

Rt bank: none ☐ sparse ☐ normal ☐ abundant ☐ eroded ☐

Discharge Information

Rate of Discharge:

none ☐ intermittent ☐ trickle ☐ steady ☐ heavy ☐

Water Clarity at Discharge Point:

clear ☐ cloudy ☐ milky ☐ muddy ☐ other: ____________

Color of Discharge: clear ☐ red ☐ yellow ☐

brown ☐ green ☐ gray ☐ other: ______________

Odors: none ☐ rotten eggs ☐ sewage ☐ chlorine ☐

musty ☐ ammonia ☐ other: ________________

Floatables: none ☐ oily sheen(rainbow colored) ☐

garbage ☐ sewage ☐ other: ________________

Biological Floatables: mosquito larvae ☐

algae ☐ % coverage in stream ______________

(include algae on bottom)

foam ☐ color ________ height _______ %coverage _______

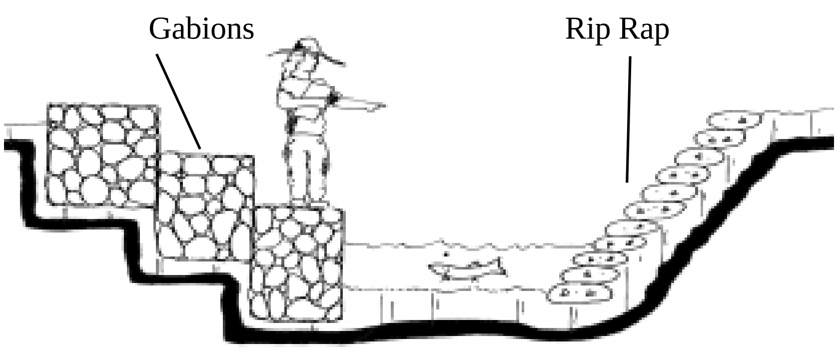
Field Notes:

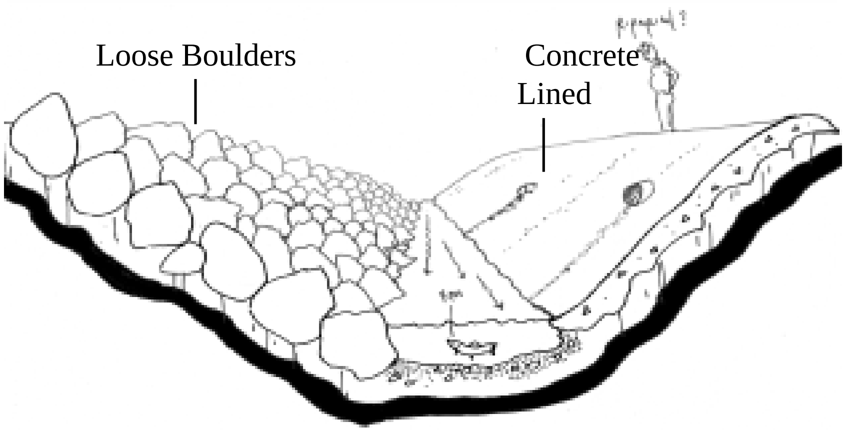
Malibu Creek Watershed Stream Team

Stream Walking
Streambank Alterations

Use this form to describe sections of streambank that have been artifically modified. Use the images below as a guide. Modifications will vary and not all types are represented here. Use the notes space provided to make descriptive comments.

NV = Natural Vegetation
CC = Concrete Channel
RR = Rip Rap (walls constructed of sacks filled with concrete looks like stacked pillows)
LB = Loose boulders stacked along streambank
CB = Boulders concreted together along streambank
WD = Wood retaining wall
GW= Gabion Walls (Rocks in wire mesh)





Date: ____________ **Stream Name:** ________________________
Time: ____________ **Recorder:** __________________________

Type of Streambank Alteration: **NV** ☐ **CC** ☐ **RR** ☐ **LB** ☐
CB ☐ **WD** ☐ **GB** ☐ **Other:** ____________________________
(GPS) Location: latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:** ______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Streambank Alteration: **NV** ☐ **CC** ☐ **RR** ☐ **LB** ☐
CB ☐ **WD** ☐ **GB** ☐ **Other:** ____________________________
(GPS) Location: latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:** ______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Streambank Alteration: **NV** ☐ **CC** ☐ **RR** ☐ **LB** ☐
CB ☐ **WD** ☐ **GB** ☐ **Other:** ____________________________
(GPS) Location: latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:** ______________
Photo #(s): ________ **Event #:** ________
Notes:

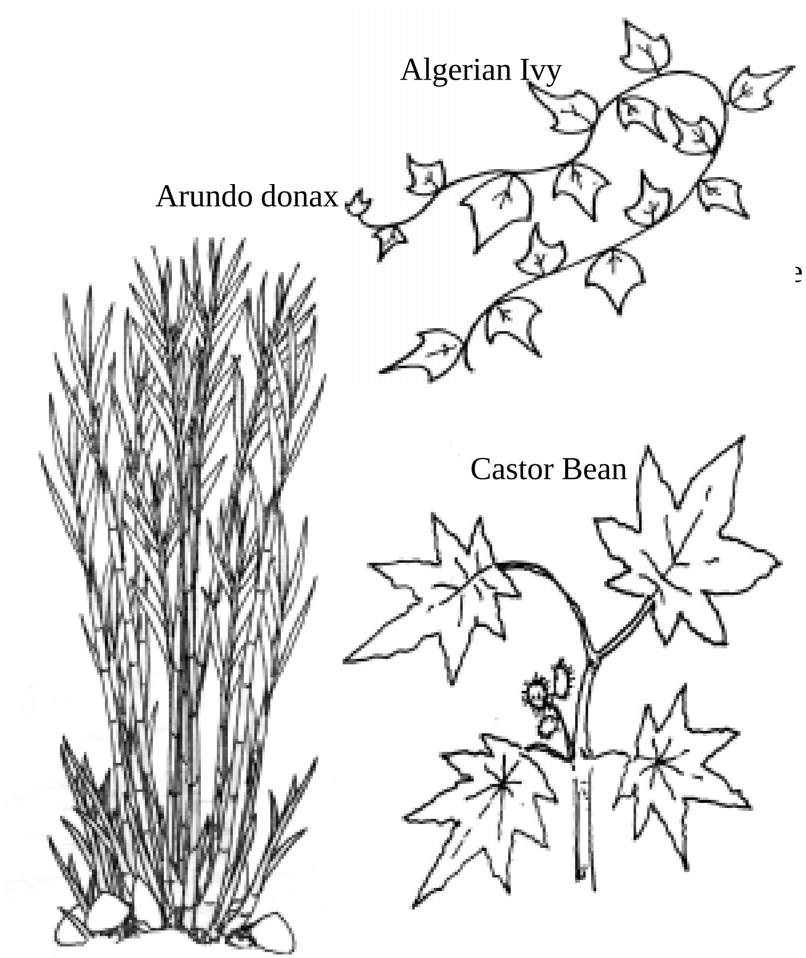
Type of Streambank Alteration: **NV** ☐ **CC** ☐ **RR** ☐ **LB** ☐
CB ☐ **WD** ☐ **GB** ☐ **Other:** ____________________________
(GPS) Location: latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:** ______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Streambank Alteration: **NV** ☐ **CC** ☐ **RR** ☐ **LB** ☐
CB ☐ **WD** ☐ **GB** ☐ **Other:** ____________________________
(GPS) Location: latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:** ______________
Photo #(s): ________ **Event #:** ________
Notes:

Malibu Creek Watershed Stream Team

Stream Walking
Invasive Vegetation

Use this form to target and describe significant patches of non-native/ invasive vegetation. Refer to the plant section (appendix A) in this field guide for descriptions of the target plants. We are looking for areas in which non-native/invasive vegetation has formed a stronghold and is out competing the native vegetation. The images below are sketches of some of the most prominent target plants. Refer to the section on Invasive Vegetation in appendix A of this field guide for descriptive information.



Date: ____________ **Stream Name:**____________________
Time: ____________ **Recorder:**________________________

Type of Non-Native/Invasive Vegetation:________________
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Non-Native/Invasive Vegetation:________________
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Non-Native/Invasive Vegetation:________________
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Non-Native/Invasive Vegetation:________________
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Non-Native/Invasive Vegetation:________________
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Malibu Creek Watershed Stream Team

Stream Walking
Impacting Land Uses

Use this form to describe land uses that seem to be having an impact on the stream side environment. We are looking for areas where the land use butts directly up against riparian areas. Of particular importance is identifying land uses associated with equestrian and grazing livestock. The images below will help you identify areas of concern.

SFR = houses   MFR = condos, apartments, townhouses
AG = agriculture   OV orchards/vineyards
AH = livestock   EQ = horses   IND = manufacturing
COM = retail/shopping   V = undeveloped open space

Date: ____________ **Stream Name:** ______________________
Time: ____________ **Recorder:** ________________________

Type of Impacting Land Use
SFR☐ MFR☐ AG ☐OV ☐ AH ☐EQ ☐IND ☐COM ☐V ☐
(GPS) Location: latitude____________ longitude____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Impacting Land Use
SFR☐ MFR☐ AG ☐OV ☐ AH ☐EQ ☐IND ☐COM ☐V ☐
(GPS) Location: latitude____________ longitude____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Impacting Land Use
SFR☐ MFR☐ AG ☐OV ☐ AH ☐EQ ☐IND ☐COM ☐V ☐
(GPS) Location: latitude____________ longitude____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

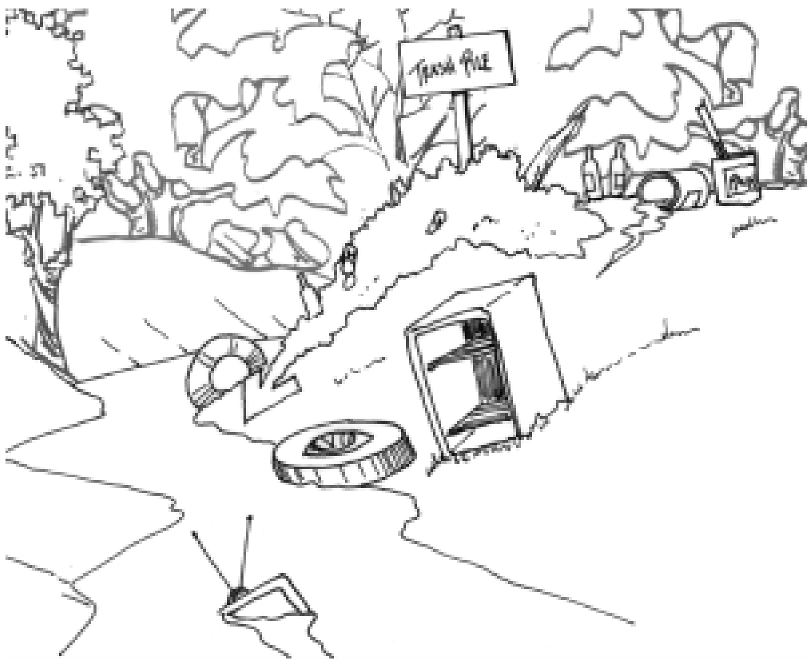
Type of Impacting Land Use
SFR☐ MFR☐ AG ☐OV ☐ AH ☐EQ ☐IND ☐COM ☐V ☐
(GPS) Location: latitude____________ longitude____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Type of Impacting Land Use
SFR☐ MFR☐ AG ☐OV ☐ AH ☐EQ ☐IND ☐COM ☐V ☐
(GPS) Location: latitude____________ longitude____________
Side of Stream: lt☐ rt☐ both☐ **Extent:**______________
Photo #(s): ________ **Event #:** ________
Notes:

Malibu Creek Watershed Stream Team

Stream Walking
Dump Sites

Use this form to describe sites used for dumping. We are looking for areas with significant piles of trash and junk. The information you gather will help target areas as trouble spots in need of clean up. Trash piles, and particularly hazardous wastes such as paints and oil are a serious danger to the watershed. Used the image below to give you a visual idea of target areas. Dump sites will vary in amounts and types of trash, use your best judgement.



Date: ____________ **Stream Name:**_____________________
Time: ____________ **Recorder:**________________________

Dump Sites:
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:**_____________
Photo #(s): ________ **Event #:** ________
Notes:

Dump Sites:
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:**_____________
Photo #(s): ________ **Event #:** ________
Notes:

Dump Sites:
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt ☐ rt ☐ both ☐ **Extent:**_____________
Photo #(s): ________ **Event #:** ________
Notes:

Dump Sites:
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt ☐rt ☐ both ☐ **Extent:**_____________
Photo #(s): ________ **Event #:** ________
Notes:

Dump Sites:
(GPS) Location:latitude____________ longitude ____________
Side of Stream: lt ☐rt ☐ both ☐ **Extent:**_____________
Photo #(s): ________ **Event #:** ________
Notes:

APPENDIX D
RECCOMENDATIONS FROM FIELD BOTANIST FOR INVASIVE VEGETATION DATA

Marti Witter

Riparian communities make up less than 1% of the land area of the Santa Monica Mountains but are primary habitat for approximately 20% of the native flora (Rundel, 1998). At the same time, riparian communities are highly impacted by exotic species and include more invasive alien species that any other community type in the Santa Monica Mountains with approximately half of the total exotic flora found in riparian areas (Rundel, In Press). The abundance of weed species in riparian areas can be attributed to a number of factors: the open nature of stream habitats, the natural disturbance cycle of flooding and sediment deposition, anthropogenic disturbances, and the availability of water in an arid climate zone.

Stream Walk Inventory

The stream walk inventory for invasive vegetation pre-selected 7 exotic species with the objective of mapping their location and the amount of coverage for all large patches of these species. The species selected were giant reed (*Arundo donax*), Algerian ivy (*Hedera canariensis*), tree tobacco (*Nicotiana glauca*), yellow pond lily (*Nuphar luteum*), castor bean (*Ricinis communis*), watercress (*Rorippa nasturtium-aquaticum*) and periwinkle (*Vinca major*). These species are all quite distinctive and are easily learned by volunteers, even those unfamiliar with the vegetation of the Santa Monica Mountains.

Of the seven target species, giant reed (*Arundo donax*) is widely acknowledged to have the greatest impact on riparian habitat in the Malibu Creek watershed because of its ability to form dense stands that displace native species and to intensify fire effects in riparian areas. In a recent study of lower Malibu Creek, *Arundo* was found in virtually every transect between Malibu Lagoon and the Salvation Army Camp (Ambrose, Richard F., P.W. Rundel, and M.I. Venkatesan. February 1999). Because of the seriousness of the problem with this species, the National Park Service has been awarded $100,000 to begin an eradication program within the Santa Monica Mountains National Recreation Area. The Stream Team data will be invaluable to the National Park Service to plan the organization and cost estimates for this program in Malibu Creek. It will also allow Heal the Bay and other organizations involved in *Arundo* eradication to determine what additional long-term efforts it will take to eliminate this species from the watershed.

Periwinkle occurs in shaded areas on streambanks, frequently beneath oak trees in scattered locations throughout the watershed. Where Periwinkle occurs it forms a continuous groundcover that eliminates habitat for native forest under story species and inhibits regeneration of oak or other canopy tree seedlings.

Algerian ivy can occur as a locally abundant species where it has escaped from residential development that is located close to the creek. It can smother both under story species and canopy trees.

Castor bean and tree tobacco are predominantly localized to the more disturbed sites within the riparian zone and are generally widely distributed throughout the watershed. Both species also occur on disturbed upland sites such as road cuts and landslides that may be a source of recolonization to riparian areas.

Watercress is both abundant and geographically widespread and occurs from the area north of Malibu Lagoon to the upper watershed, wherever there is relatively shallow, slow moving water. It is so common that without some understanding of the rate at which populations become established, spread, and die out, it is difficult to know how best to map the occurrences. More information is needed to understand the demographics and ecology of this species and the potential impact it has on the stream ecosystem. The Jepson Manual (1993) mistakenly notes it as a native species.

Yellow pond lily was not observed and is probably highly localized as it is reported from lakes such as Malibu Lake and Century Lake in Malibu Creek State Park.

Stream Walk Survey Effectiveness

The volunteer method is extremely effective in mapping a selected subset of the most common and morphologically distinctive invasive species of the Malibu Creek watershed. Data on the location and aerial extent of giant reed, periwinkle and Algerian ivy allow for the development of realistic eradication plans for these species that could potentially restore a significant amount of native riparian habitat. The data on castor bean and tree tobacco are also important, although plans to eradicate and control these species may be more difficult to develop because they spread by seed and have population sources outside of the riparian corridor itself. Information on the geographic distribution of watercress is important because it is such an abundant weed in the Malibu Creek watershed. However mapping it for potential eradication may be premature and a co-operative research project on its basic demography would be the most important information to collect in conjunction with its distribution. Finally, yellow pond lily appears to be a localized and should probably not be one of the target species for the Stream Teams.

Stream Walk Survey Method Limitations

The Stream Team method is limited by the number of species that can be reasonably recognized by volunteers and by the time required to log and map individual colonies of invasive plants. The target species set represents only a small fraction of the total invasive flora that occurs in the Malibu Creek watershed. Additionally, some species are so common that mapping the physical boundaries of their colonies is prohibitively time consuming. However, the recent data by Ambrose et al (1999) and Rundel (1998 and in press) show how serious the problem of invasive exotic vegetation is in riparian communities and how it is important to collect as much data as possible on species occurrences and distributions.

The target species list is missing abundant, ecologically significant invasive species. There are a number of species that occur in widespread patches throughout the watershed that are not identified as target species in the Stream Team field guide, for example, perennial peppergrass (*Lepidium latifolium*), rice grass (*Oryzopsis meliacea*), and rabbitsfoot grass (*Polypogon monspeliensis*). Perennial peppergrass, in particular, forms extensive stands on floodplain terraces that choke out all other species.

Occurrences of species that have the potential to spread explosively in the future may be missed. Species that have serious invasive potential such as tamarisk (*Tamarix ramosissima*), bluegum eucalyptus (*Eucalyptus globulus*), and Spanish broom (*Spartium junceum*) were all observed as highly localized occurrences that have the potential to spread in the future.

Significant or new weed species may not be recognized or incorrectly identified. Sixty percent of the weed species in the Santa Monica Mountains are dominated by species from five plant families – Poaceae (grass family), Asteraceae (sunflower family), Brassicaceae (mustard family), Chenopodiaceae (goosefoot family) and the Fabaceae (pea family) (Rundel, in press), all of which are have species which can be notoriously difficult to identify. There are a number of invasive species that have native species in the same genus and some exotic species that are vegetatively similar to native species.

Invasive species may not be identified because of cryptic seasonal/life cycle stages. In the native flora, woody species are the dominant aspect of the flora, but include only 11% of the species (ten riparian specialist trees and four characteristically riparian shrub species, *Cornus glabrata, Holodiscus discolor, Baccharis salicifolia*, and *Myrica* ***californica***, Rundel, 1998). Herbaceous perennials are the largest part of the riparian flora (58%), next are annuals (28%), and suffrutescent shrubs (3%). The distribution of life-forms in the exotic riparian flora have not been analyzed but exotic annuals and herbaceous perennials may not be easily detected at all seasons. Grasses may also be difficult to identify when in their vegetative state.

Habitat associations and species co-occurrences are not documented. Exotic species that occur in specialized habitats may eliminate native species that occur in specific microhabitats e.g. *Polypogon monspeliensis* at stream margins.

Potentially subtle impacts may occur between native and non-native species that share habitat preferences and general morphological and life history characteristics. For example non-native *Veronica anagalis-aquatica* (Scrophulariaceae) and the native *Epilobium ciliatum* (Onagraceae) are similar herbaceous perennials that co-occur at stream margins and on sand bars, but the ecological dynamics between the two species are unknown. Similarly on sandy floodplain terraces without an over story tree canopy, the native *Ambrosia psilostschy*a co-occurs with non-native *Meliolotus albus* and *M. indicus*. The impact of a species such as cocklebur (*Xanthium spinosum*), which does not obviously crowd out native species on sandbars or floodplain terraces, but does form one of the dominant species in these habitats is unclear.

Recommendations for Stream Walk Survey of Invasive Exotic Vegetation

1. Continue the Stream Team surveys with a revised set of target species (for example, delete yellow pond lily and add perennial peppergrass). The target species list should be reviewed by the Malibu Creek Watershed Council's Invasive Species Task Force to evaluate the species selections. Criteria to consider for target species include relative abundance, degree of ecological threat posed by the species, and the availability of feasible eradication methods. The list of target species and the field guide should be revised according to the Task Force's recommendations.

2. Measurements of the location and coverage data for mapped patches of invasive vegetation should be simplified to the greatest extent feasible to increase field efficiency. Patches of invasive vegetation should be located with a single GPS reading from the center of a patch and the amount of coverage approximated by estimating the radius or the length and width of the patch.

3. The habitat location of individual species should be noted. This can be done as a simple habitat checklist on the 'invasive vegetation' data sheet for: stream (S), sand bar (SB), channel slope/bank (B), high flow channel (HF), floodplain (FP), or upland terrace (UT). See attachment.

4. The Stream Team survey offers such a unique opportunity to inventory the distribution of invasive exotic vegetation in the Malibu Creek watershed that, if at all feasible, additional data should be collected in conjunction with mapping the main target species.

Because of the size of the exotic flora, its taxonomic complexity, and the abundance of exotic vegetation, it would be most effective if each Stream Team had one member with a knowledge of the flora, dedicated to recording survey data on invasive vegetation. These team members might be selected from interested Heal the Bay volunteers, California Native Plant Society members, National Park Service interns or college student interns.

It would be very useful if at specified intervals all observable invasive exotic species, their relative abundance and associated habitats could be recorded. A sample data collection sheet has been prepared (see Invasive Vegetation-Survey data sheet). These sheets could be filled out by the vegetation volunteer either at fixed intervals such as 100 meters or as a supplement to GPS field positions where other stream parameters were recorded.

5. In addition to Heal the Bay, four other groups have ongoing programs of research and/or eradication of invasive exotics in the Santa Monica Mountains. These are the California Native Plant Society, the National Park Service, the California State Department of Parks and Recreation, and the UCLA Stunt Ranch Natural Reserve. Representatives from these organizations all participate as members of the Malibu Creek Watershed Council's Invasive Species Task Force. The National Park Service will soon begin to develop a master plan for control of exotic invasive vegetation within the National Recreation Area (John

Tiszler, peers comm.). The Malibu Creek Watershed Council's Invasive Species Task Force is an existing forum that could be used to coordinate Heal the Bay's Stream Team program and ongoing or proposed programs by other agencies or organizations. Development of the following types of data would benefit all of these programs.

• Develop a comprehensive master list of invasive exotics and information of the type that was developed for the Channel Islands National Park including species descriptions, geographic distribution, ecological distribution, weed status, fungal and insect pathogens, and herbicide control (see attached).

• Establish permanent transects to study the demography of specific weed species where their general ecology and impact on the native flora is not well understood (e.g. watercress, great water speedwell, spiny cocklebur).

Recommendations for changes to the Field Guide Plant Section

1. Separate Appendix 1 into two parts – 1A Native plants and 1B Exotic and/or Invasive Plants.

2. At the beginning of each appendix list the native species (1A) and the non-native species (1B) followed by the photos or other figures of the selected species (natives for 1A and the target non-native species for 1B).

3. Add a third column to the species list in both 1A and 1B for a plant family's column and identify the family for each species. The species lists should be as comprehensive as possible and include notations for 1A on rarity or likelihood of occurrence (e.g. rare or outside of recorded range) and for 1B on whether there are native congeneric species.

4. Make the following corrections and additions to the existing Appendix 1 Riparian Plant Species List

Correct

*****Acer negundo (not native to SMM's)	
Anemopsis californica	~~lizardtail~~ **yerba mansa**
Cyperus species	umbrella sedge**s**
Lepid~~a~~**o**spartum squamatum	

Add:

*Ailanthus altissima	tree-of-heaven
* Conium maculatum	poison hemlock
* Eucalyptus globulus	bluegum eucalyptus
* Foeniculum vulgare	fennel
* Heliotropium curassavicum	wild heliotrope

* Hedera helix	English ivy
* Meliolotus indicus	yellow sweet clover
* Oryzopsis meliacea	rice grass, Smilo grass
* Rubus procerus	Himalayan blackberry
* Spartium junceum	Spanish broom
* Tamarix ramosissima	tamarisk
* Vitus girdiana	grape
* Xanthium spinosum	spiny cocklebur

5. For Appendix 1A have one sheet labeled as hazardous plants and show a photo/illustration of stinging nettles and poison oak.

6. It may be desirable to create a more comprehensive field guide with illustrations for native and non-native riparian plant species and to have this as a separate notebook for the designated vegetation team member. The native species might be grouped by life form - trees, shrubs, vines herbaceous perennials and annuals. Additionally, illustrations of all of the species in the riparian monocot genera such as Carex, Cyperus, and Juncus on one page rather than one species as an illustration for the entire genus would be useful. For the non-native species, illustrations of the species in groups such as the brooms, thistles, or genera with native and non-native species (e.g. Rubus procerus and Rubus ursinus) with notes on distinguishing characteristics would be useful.

Additional Recommendations for Field Guide Changes

1. Some sections of Malibu Creek have a complicated morphology where understanding the structure of the stream channel cross-section is important to understanding the forces that are contributing to stream impairment. Adding an introductory section to the unstable streambanks which describes and illustrates the development of historic and active stream features and a diagram of cross-sectional features (see attachments) would help Stream Team members to identify channel features e.g. active channel slopes, floodplain slopes, floodplain terrace, scarp slope, upland terrace, etc. Because the forces that affect stream slopes of different origin are not the same, the ‘ unstable streambanks’ data sheet should identify the slopes as channel slope (CS), floodplain slope (FS), or scarp slope (SS) (see attachment).

2. The upland fringe is the transitional zone between the floodplain and the surrounding landscape. This area is outside the active stream and floodplain zone and therefore has the greatest probability of being impacted by land use activities and to consequently have an impact on the stream corridor itself. In the Malibu Creek watershed, it is commonly observed that the land up to the creek margin has been cleared or otherwise degraded by poor land use practices. It is important to document where this has occurred, as it is one of the most significant factors contributing to reduced

habitat quality in the watershed. To quantify this impact, the ‘land use associated with unstable bank’ data sheet should subdivide the vacant land category to undeveloped open space with predominantly native habitat (V-N) and degraded/disturbed/unvegetated undeveloped open space (V-D) (see attached). The same categories should be added to the ‘impacting land uses’ data sheet – disturbed upland terraces where native vegetation has been removed is a significant source of sediment and degraded habitat quality.

Literature Cited

Ambrose, Richard F., P.W. Rundel, and M.I. Venkatesan. February, 1999. Vegetation Mapping. Chapter 4.1 In: Lower Malibu Creek and Barrier-Lagoon System resource Enhancement and Management. Draft Final Report to the California State Coastal Conservancy. Feddema, J., C. Gerba, P. Rundel, M. Suffet, M.I. Venkatesan, Principal Investigators. UCLA

Rundel, Philip W. In Press. Alien Species in the Flora and Vegetation of the Santa Monica Mountains, California: Patterns, Processes, and Management Implications. In: J. E. Keeley, M. Keeley and C.J. Fotheringham (eds.) *2nd Interface Between Ecology and Land Development in California*. U.S. Geological Survey.

Rundel, Philip W. and S. B. Sturmer. 1998. Native plant diversity in riparian communities of the Santa Monica Mountains, California. Madrono 45(2):93-100.

Stream Walking

Invasive Vegetation - Survey

Use this form to inventory the exotic vegetation that you can observe at this geographic location. Refer to the list in Appendix 2 for known exotic species. Estimate the relative abundance and associated habitats for each species in accordance with the following checklist.

Relative Cover

3. < 5% cover
4. 5-20% cover
5. 20-50% cover
6. > 50% cover

Habitat Descriptions

S	Stream
SB	Sand bar
HF	High flow channel
B	Channel bank/slope
FP	Floodplain
UT	Upland Terrace

Date:______________ Stream Name:_______________________

Time:____________ Recorder:________________________

GPS Location: latitude__________ longitude___________

Species	**%Cover**	**Habitat**
____________________________	_________	_________
____________________________	_________	_________
____________________________	_________	_________
____________________________	_________	_________

APPENDIX E
SPLIT SAMPLE DATA SUMMARY

Quality Assurance Report
Heal The Bay Malibu Creek Nutrient Monitoring
February 1999 – January 2000

Author: Dominic Gregorio, State Water Resources Control Board

Reviewed by: Bill Ray, State Water Resources Control Board

Submitted to: Jon Bishop, Los Angeles Regional Water Quality Control Board

Introduction

In 1998 Heal the Bay initiated a citizen monitoring program, christened the Malibu Creek Stream Team, which monitors seven sites monthly in the Malibu Creek watershed. The Heal the Bay Malibu Creek Stream Team is a member of the Los Angeles Volunteer Monitoring Steering Committee and operates under the Quality Assurance Project Plan (QAPP) of that group. The QAPP was approved in 1998 by staff of the U.S. EPA, the State Water Resources Control Board and the Los Angeles Regional Water Quality Control Board. The QAPP includes definitions, equations and objectives for accuracy, comparability, completeness, precision, representativeness, and sensitivity. In order to implement the QAPP Heal the Bay participated in inter-calibration sessions held for the members of the Los Angeles Volunteer Monitoring Steering Committee at the Southern California Marine Institute's Fish Harbor Laboratory on Terminal Island.

With regard to the nutrient parameters ammonia, nitrate, and orthophosphate, the QAPP was originally designed to address the use of visual comparators as the method to be employed by citizen monitors. These comparators and their associated wet chemistry reagent systems are packaged into relatively inexpensive kits for field monitoring purposes. Heal the Bay recognized the lack of sensitivity inherent in these kits and decided to use a more sophisticated electronic instrument (a LaMotte Smart Colorimeter) instead of the comparators. However, the use of a colorimeter and its associated reagent systems was not addressed in the QAPP. In order to account for this issue, Heal the Bay embarked on an additional quality assurance effort that was outside of the requirements of the QAPP, which is the subject of this report.

Between February 1999 and January 2000 Heal The Bay (HtB) performed five quality assurance (QA) exercises in conjunction with the Southern California Marine Institute (SCMI) and Associated Laboratories (AL). These QA exercises took place on February 6, 1999, March 25, 1999, September 4, 1999, December 20, 1999, and January 20, 2000. All of the QA exercises with the exception of

March 25 coincided with HtB 's regularly scheduled monthly field sampling events. Each of the seven HtB field samples were split and analyzed by each of these organizations. The split field samples were analyzed for ammonia nitrogen, nitrate nitrogen, and orthophosphate. In addition, SCMI produced laboratory spikes (standards) and distributed these to the other organizations for analysis.

Associated Labs and SCMI were both contracted by Heal the Bay to perform different components of this work, and their data was accordingly supplied to Heal the Bay. The raw data were verified and supplied to the author by Heal the Bay, and are located in the appendix.

While not included in this report, Heal the Bay participated in QA analyses for temperature, pH, conductivity, and dissolved oxygen during the inter-calibration sessions conducted at SCMI. The results from inter-calibration sessions conducted during the study period were tabulated by SCMI and distributed to the Los Angeles Volunteer Monitoring Committee.

Laboratory Methods

HtB and SCMI both used a LaMotte Smart Colorimeter and the same LaMotte reagent systems. These reagent systems are:

a) for ammonia nitrogen, a modified Nessler method, with pre-packaged reagents,
b) for nitrate nitrogen, a modified cadmium reduction method, with pre-packaged reagents and using powdered cadmium instead of cadmium beads, and
c) for orthophosphates, a modified ascorbic acid method, with pre-packaged reagents.

AL measured ammonia nitrogen via distillation and Nesslerization (or titration when values were above 1.0 mg/l), nitrate nitrogen via ion chromatography, and orthophosphate via the ascorbic acid method, all according to Standard Methods.

Terminology and Conditions

Comparability is the degree to which data from one monitoring program or laboratory can be compared directly to other programs/laboratories. This work was an attempt to establish comparability between the Heal the Bay, SCMI, and Associated Laboratories. Precision and accuracy are measures used in this study to evaluate comparability. **Precision** is the degree of agreement among different measurements of the same parameter on the same sample. **Accuracy** describes how close the measurement is to its true value. Accuracy is the measurement of a sample of known concentration and comparing the known value against the measured value. It should also be noted that high percent precision or accuracy values indicate lower precision or accuracy (e.g., a 90% precision or accuracy is less precise than 10% precision or accuracy). These definitions of comparability, precision, and accuracy are consistent with the QAPP.

An **intra-laboratory** quality assurance (QA) analysis may be conducted in review of the work performed by a single laboratory (laboratories, in this context, includes citizen monitoring groups). An inter-laboratory/intra-method QA analysis may be conducted in review of the work of two or more of related laboratories using the same methods. An **inter-laboratory/inter-method** QA analysis may be conducted in review of the work performed by two or more laboratories, when at least one laboratory uses different methods than the other lab(s). In this report an intra-laboratory analysis was performed in evaluating HtB's performance against split laboratory spiked samples (split standards) of known concentration (i.e., accuracy); in addition an inter-laboratory/inter-method analysis was performed on the comparison of results from HtB, SCMI, and AL on both split standards and split field samples. Each set of results from these labs, for each parameter, on a split sample is referred to herein as a data **series**.

For the split field samples some series contain data points which are all in agreement to the degree that the values are below or near detection limits, and that all of the data points are <0.10 mg/l. These are referred to herein as **first tier series** and were not subjected to quantified precision analysis. Series in which data points did not qualify in the previous definition were considered **second tier series**, and these were subjected to precision analysis.

For second tier series the occasional "<" qualifiers were removed prior to running precision analysis. For example, if the data point was "<0.01 mg/l" it was converted to "0.01 mg/l" and retained in the data series. Any data points associated with ">" qualifiers were removed from the data series as long as the data were in agreement. For example, if one data point was ">3.0 mg/l" and all the other data points in the series had discrete values larger than 3.0 mg/l, then these were considered to be in agreement, and the ">3.0 mg/l" data point was removed from the series.

During some of the split sample exercises the use of the LaMotte reagents resulted in obviously inaccurate values. Based on the experience of the split sample analyses, Heal the Bay began instituting a quality control procedure in which such data would not be included in their final Malibu Creek nutrient data set. Therefore, any data rejected by HtB is also not included in the accuracy and precision measures in this report. However, those relatively isolated cases and conditions in which LaMotte reagents gave less than adequate results are discussed under the "Reagent Shortcomings" section of this report.

Intra-laboratory and Inter-laboratory/Inter-method Split Standards

Heal the Bay's accuracy was determined by comparison against the split standards. Accuracy can be calculated for this data set since the standards represent known concentrations. Accuracy and precision were determined also for the split standards data series. It should be noted that this report does not characterize the intra-laboratory precision of the HtB program; precision is used herein only as a measure of the split sample inter-laboratory/inter-method results.

Ammonia Nitrogen - Split Standards

SCMI produced lab spiked samples (standards) on five different days during the study period, and sent them to the other two labs, for a split sample analysis. On the first day (February 6), at the request of HtB (so as to replicate their field practices at that time), the standard was not acidified. Therefore the February 6 series was not included in the following precision and accuracy results. The results from March 25, September 4, December 20, and January 20 are given in Table 1a. Heal the Bay's mean accuracy was 5.83%, with a standard deviation of 11.82. Table 2a depicts the mean inter-laboratory, inter-method precision and accuracy. The mean inter-laboratory, inter-method precision was 10.49% (standard deviation 8.18). The mean inter-laboratory, inter-method accuracy was -0.78% (standard deviation 5.99).

TABLE 1A

sample date	units	analyte	standard	AL result	AL%accuracy	SCMI result	SCMI%accuracy	HTB result	HTB%accuracy
25-Mar-99	mg/l	NH3N	0.50	0.34	-32.00	0.5	0.00	0.57	14.00
25-Mar-99	mg/l	NH3N	0.50	0.52	4.00				
04-Sep-99	mg/l	NH3N	0.50	0.44	-12.00	0.53	6.00	0.61	22.00
04-Sep-99	mg/l	NH3N	0.50	0.49	-2.00			0.58	16.00
18-Dec-99	mg/l	NH3N	1.00			1.01	1.00		
20-Dec-99	mg/l	NH3N	1.00	1.03	3.00	1.02	2.00	1.04	4.00
20-Dec-99	mg/l	NH3N	1.00					1.00	0.00
20-Jan-00	mg/l	NH3N	1.25	1.06	-15.20	1.25	0.00	1.18	-5.60
20-Jan-00	mg/l	NH3N	1.25					1.13	-9.60
			mean accuracy		-9.03		1.80		5.83
			standard deviation		13.70		2.49		11.82

TABLE 2A

sample date	analyte	mean	precision	accuracy
25-Mar-99	NH3N	0.48	20.61	-3.50
04-Sep-99	NH3N	0.53	12.87	6.00
20-Dec-99	NH3N	1.02	1.55	2.00
20-Jan-00	NH3N	1.16	6.94	-7.60
		mean	10.49	-0.78
		st.dev.	8.18	5.99

Nitrate Nitrogen - Split Standards

SCMI produced lab spiked samples (standards) on five different days during the study period for a three-way lab split sample analysis. On one day (Mar. 26) two different nitrate standards were produced, resulting in a total of six series. According to Mark Abramson, Malibu Creek Stream Team Coordinator for HtB, the nitrate nitrogen results from Sept. 4, 1999 were not included on their final data set since their results were more than 20% higher than the value of the standard. Therefore these data were removed from further consideration in the determination of accuracy and precision. All of the other results are given in Table 1b. Heal the Bay's mean accuracy was -4.71%, with a standard deviation of 10.84. Table 2b depicts the mean inter-laboratory, inter-method precision and accuracy. The mean inter-laboratory, inter-method precision was 7.88% (standard deviation 5.21). The mean inter-laboratory, inter-method accuracy was -3.53% (standard deviation 8.29).

TABLE 1B

sample date	units	analyte	standard	AL result	AL%accuracy	SCMI result	SCMI%accuracy	HTB result	HTB%accuracy
06-Feb-99	mg/l	NO3N	1.00	0.90	-10.00	1.09	9.00	1.13	13.00
25-Mar-99	mg/l	NO3N	0.30	0.22	-26.67	0.32	6.67	0.23	-23.33
25-Mar-99	mg/l	NO3N	0.30	0.22	-26.67	0.27	-10.00	0.22	-26.67
25-Mar-99	mg/l	NO3N	5.00	4.48	-10.40	4.36	-12.80	4.88	-2.40
04-Sep-99	mg/l	NO3N	5.00	5.35	7.00	5.06	1.20		
04-Sep-99	mg/l	NO3N	5.00	5.37	7.40	4.74	-5.20		
19-Dec-99	mg/l	NO3N	4.00			4.30	7.50		
20-Dec-99	mg/l	NO3N	4.00	4.00	0.00	4.04	1.00	4.04	1.00
20-Dec-99	mg/l	NO3N	4.00	3.90	-2.50			3.96	-1.00
20-Jan-00	mg/l	NO3N	5.00	4.70	-6.00	4.98	-0.40	4.98	-0.40
20-Jan-00	mg/l	NO3N	5.00	4.66	-6.80			5.06	1.20
			mean accuracy		-4.45		-2.67		-4.71
			standard deviation		10.90		7.07		10.84

TABLE 2B

sample date	analyte	mean	precision	accuracy
06-Feb-99	N03N	1.04	11.82	4.00
25-Mar-99	N03N	0.25	16.55	-17.78
25-Mar-99	N03N	4.57	5.95	-8.53
04-Sep-99	N03N	5.13	5.77	2.60
20-Dec-99	N03N	4.04	3.42	1.00
20-Jan-00	N03N	4.88	3.74	-2.48
		mean	7.88	-3.53
		st.dev.	5.21	8.29

Orthophosphate - Split Standards

SCMI produced lab spiked samples (standards) on four different days during the study period for a three-way lab split sample analysis. On one occasion (Dec.20) the LaMotte phosphate reagents were determined to be degraded and unsuitable for use. According to Mark Abramson, the HtB orthophosphate field sample results from Dec. 20 were not included on their final data set. Therefore these data were removed from further consideration in the determination of accuracy and precision. All of the other results are given in Table 1c. Heal the Bay's mean accuracy was -12.49%, with a standard deviation of 21.67.

In retrospect the September 4 HtB orthophosphate data resulted from faulty reagents (values were too low) but was incorporated at that time in the Malibu Creek data set. Therefore the September 4 HtB orthophosphate data was also included in the accuracy and precision analyses in this report. Heal the Bay did recognize a problem with that data, but was still in the process of developing the numerical limits for their quality control procedures relative to such instances. For a complete description of these quality control procedures and limits see the section on Reagent Shortcomings. By December 20 those limits were implemented and the faulty orthophosphate data from December 20 were rejected. If these limits had been implemented for the September 4 event, then the HtB mean accuracy would have been 1.33% with a standard deviation of 4.26. Table 2c depicts the mean inter-laboratory, inter-method precision and accuracy. The mean inter-laboratory, inter-method precision was 1.57% (standard deviation 1.16). The mean inter-laboratory, inter-method accuracy was -2.91% (standard deviation 6.76).

TABLE 1C

Sample date	units	analyte	standard	AL result	AL%accuracy	SCMI result	SCMI%accuracy	HTB result	HTB%accuracy
06-Feb-99	mg/l	PO4	1.00	0.96	-4.00	0.97	-3.00	0.97	-3.00
25-Mar-99	mg/l	PO4	1.00			0.98	-2.00	0.99	-1.00
04-Sep-99	mg/l	PO4	3.75	3.77	0.53	3.82	1.87	2.23	-40.53
04-Sep-99	mg/l	PO4	3.75	3.81	1.60	4.00	6.67	2.26	-39.73
20-Dec-99	mg/l	PO4	3.00	2.95	-1.67				
20-Jan-00	mg/l	PO4	3.00	3.08	2.67	3.18	6.00	3.20	6.67
20-Jan-00	mg/l	PO4	3.00			3.18	6.00	3.08	2.67
			mean accuracy		-0.17		1.91		-12.49
			standard deviation		2.67		4.31		21.67

TABLE 2C

sample date	analyte	mean	precision	accuracy
06-Feb-99	PO4	0.97	0.60	-3.33
25-Mar-99	PO4	0.99	0.72	-1.50
04-Sep-99	PO4	3.85	3.09	-11.60
20-Jan-00	PO4	3.14	1.88	4.80
		mean	1.57	-2.91
		st.dev.	1.16	6.76

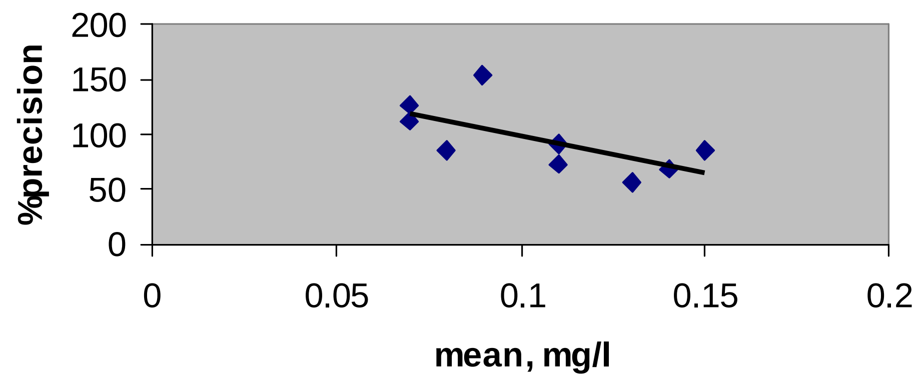
Inter-laboratory/Inter-method Split Field Samples

The split field samples were expected to have greater variability than the laboratory spiked samples (standards) discussed above. The split standards were composed primarily of distilled water with a known concentration of analyte. The split standards were therefore homogeneous and did not contain particulate matter or interferences. On the other hand, the field samples inherently contain particulate matter and potential interferences. In addition, sample transport, storage times and storage conditions may have varied slightly among the study participants. Accuracy cannot be calculated for this component of the study because there was no way to determine the absolute true value of a field sample. Precision was determined for the split sample results. It should be noted that this report does not characterize the intra-laboratory precision of the HtB program, but only uses precision as a measure of the split sample inter-laboratory/inter-method results.

Ammonia Nitrogen – Split Field Samples

Seven field samples were collected and split on each of four different days (Feb.6, Sept. 4, Dec. 20, and Jan.20). The samples on Feb. 6 were not preserved via acidification, and therefore these seven split field sample series were removed from further consideration. All subsequent field splits (representing 21 series) were acidified in the field and subjected to further analysis in this report. 57% (12 out of 21) of the three way series were in agreement at levels below 0.10 mg/l. These 12 first tier series were not subjected to further analysis. The other 43% (9 out of 21) of the series were considered second tier and were subjected to quantified precision analysis. The overall mean precision for these second tier series was 94.64%, with a standard deviation of 30.94. A general trend can be seen on Figure 1, which indicates an improvement in precision as the mean series value increases. However, since all of samples in these series had low concentrations of ammonia nitrogen, the calculated values for percent precision were high (i.e., precision was low). It should be noted that with these second tier series the maximum difference between results within a series was 0.31 mg/l, and the HtB results vary from the series mean by an average of only 0.06 mg/l.

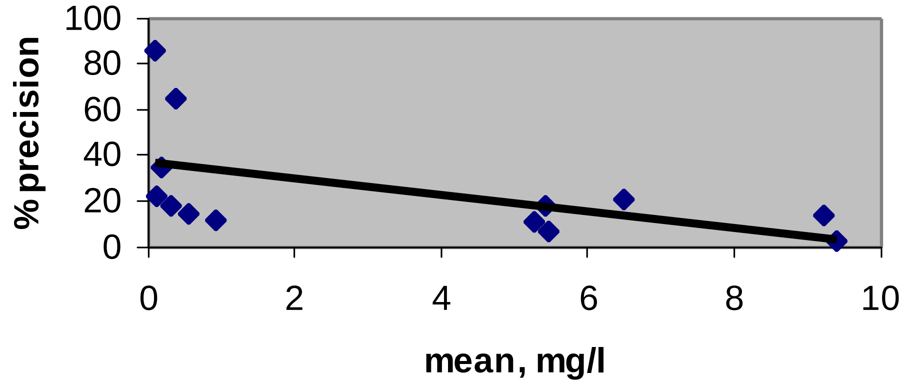
Figure 1
Ammonia N, Split Field Samples



Nitrate Nitrogen – Split Field Samples

Seven field samples were collected and split on each of four different days (Feb.6, Sept. 4, Dec. 20, and Jan.20). For the September 4 event Heal the Bay determined that the LaMotte nitrate reagents were not resulting in accurate values, and they did not include those results in their final data set. Therefore the Sept. 4 split field sample series were removed from further consideration. All other field splits (representing 21 series) were subjected to further analysis in this report. 38% (8 out of 21) of the three way series were all in agreement at levels below 0.10 mg/l. These eight first tier series were not subjected to further analysis. The other 62% (13 out of 21) of the series were in the second tier and were subjected to quantified precision analysis. The mean precision for these second tier series was 24.90 %, with a standard deviation of 24.11. A general trend can be seen on Figure 2, which indicates an improvement in precision as the mean series value increases. For series mean values <0.3 mg/l the precision was 47.54% with a standard deviation of 33.84. For series mean values >0.3 mg/l the precision improved to 18.11% with a standard deviation of 17.28. For series mean values >1.0 mg/l the precision further improved to 12.01% with a standard deviation of only 6.80.

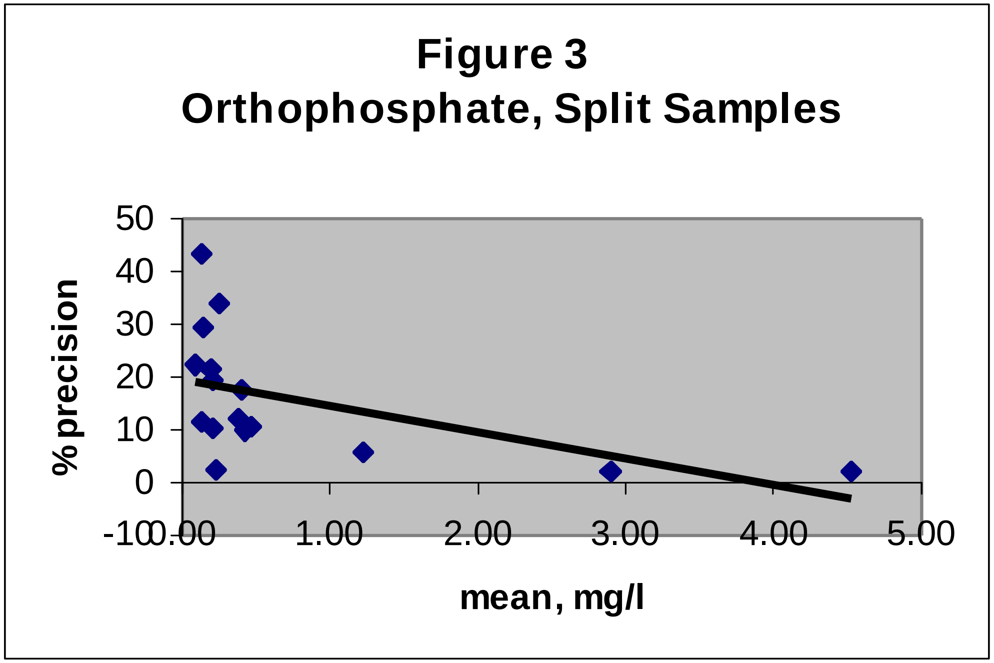
Figure 2
Nitrate N, Split Field Samples



Orthophosphate – Split Field Samples

Seven field samples were collected and split on each of four different days (Feb.6, Sept. 4, Dec. 20, and Jan.20). For the December 20 event Heal the Bay determined that their LaMotte reagents were degraded and unsuitable for use, and were not resulting in representative data. In addition, SCMI determined that the LaMotte reagents were similarly degraded for the December 20 event, and aborted further orthophosphate analysis for the field samples. Therefore the 7 data series from Dec. 20 were removed from further consideration. In retrospect the September 4 HtB orthophosphate data also resulted from faulty reagents (values were likely to be too low) but were incorporated at that time in the Malibu Creek data set. Therefore the September 4 HtB orthophosphate data were included in the precision analyses in this report.

24% (5 out of 21) of the data series were all in agreement at levels below 0.10 mg/l. These five first tier series were not subjected to further analysis. The other 76% (16 out of 21) of the series were in the second tier and were subjected to quantified precision analysis. The mean precision for these second tier series was 15.93%, with a standard deviation of 11.99. A general trend can be seen on Figure 3, which indicates an improvement in precision as the mean series value increases. For series mean values <0.3 mg/l the precision was 21.64%, with a standard deviation of 12.73. For series mean values >0.3 mg/l the precision improved to 7.80% with a standard deviation of 4.41. For series mean values >1.0 mg/l the precision further improved to 3.34% with a standard deviation of only 2.08; however, the sample size for the >1.0 mg/l group was small, being limited to only three series.



Reagent Shortcomings

The LaMotte orthophosphate reagents were shown to produce high quality results when first opened. However, these reagents seem to degrade over time, well in advance of their expiration date, giving results that were lower than the true value. This may possibly be due to reagent exposure to air, light or heat. This was first observed during the September exercise, with values reported by Heal the Bay being approximately 60% of the true value when compare against a standard (accuracy of approximately -40%). During the December exercise these reagents were again determined to have degraded over a relatively short period of about one month, giving results of approximately 50% of the standard. Possibly this degradation was a result of the oxidation of the phosphate reducing reagent. On one occasion (September 4) the LaMotte nitrate reagents used by HtB gave results that were approximately 20% higher than the standard. Both SCMI and HtB reported these problems to the LaMotte Company.

Based on the problems discussed above, procedures were instituted in the HtB program to include a positive standard (spiked sample) tested for each nutrient parameter prior to field sample analysis. This is in addition to the analysis of a reagent blank, which has always been, and continues to be, employed by HtB. Now, during each sampling event, prior to analyzing the field samples, Heal the Bay tests a spiked sample (i.e., a positive standard) for nitrate nitrogen, ammonia nitrogen, and orthophosphate. The following accuracy guidelines and limits are employed:

- analytical results of spiked samples with a concentration of 0.50 mg/l or lower must be within ±20% of the known value;

- analytical results of spiked samples with a concentration of between 0.50 and 1.00 mg/l must be within $\pm$15% of the known value; and

- analytical results of spiked samples with a concentration of 1.00 mg/l or greater must be within $\pm$10% of the known value.

If a result exceeds these accuracy limits, then the ambient data for that parameter do not qualify for inclusion in the final data set for that day. If on the same day another lab is used for split sampling, and that lab does not exceed these same accuracy limits, the results from that other lab are recorded in the final data set instead of the Heal the Bay results.

Acidification of Ammonia Samples

Ammonia is volatile in fresh water and at high pH levels. A standard method for preserving ammonia samples is to acidify with sulfuric acid. However, since the HtB program relies on volunteers for sample collection, acidification was initially avoided due to initial safety concerns. The original HtB sampling protocol therefore did not include a field acidification step. At the request of HtB the field samples and ammonia standards for the February 6 QA exercise were not acidified, so as to be consistent with the sampling protocol that was followed at that time.

Based on discrepancies observed in split sample analyses on February 6, an ammonia time series analysis was performed on March 26, and shown on Table 3. The results clearly show degradation of ammonia levels in an non-acidified sample over time. As a result of work done through this program HtB installed a procedure to acidify field samples using sulfuric acid at or near a pH of 2.0 upon collection.

Conclusions

It is the opinion of the author that the staff, procedures, reagents and instrument employed by Heal the Bay are being used to produce data of good quality to record and assess ambient nutrient conditions at sites monitored in the Malibu Creek watershed. Based on the results of the split standards, Heal the Bay's mean accuracy was at 5.8%, -4.7%, and -12.5% respectively for ammonia nitrogen, nitrate nitrogen, and orthophosphate. There was also good agreement between labs, with precision levels of 10.5%, 7.9%, and 1.6% respectively for ammonia nitrogen, nitrate nitrogen, and orthophosphate.

Even with the inherent variability of field samples, there was still fairly good agreement between labs. Many of the results were in agreement at or below 0.10 mg/l for nitrate nitrogen (38% of the samples) and orthophosphates (24% of the samples). For the remaining "second tier" field samples, the data series for nitrate nitrogen and orthophosphate had precision levels of 24.9% and 15.9% respectively. There was also an increased precision with slightly increased concentrations. Precision for these parameters at concentrations above 0.3 mg/l improves to 18.1% for nitrate nitrogen and 7.8%, for orthophosphate. In other words, as concentrations increased there was also increasing agreement in terms of percent precision between laboratories.

All of the field samples for ammonia nitrogen in this study resulted in concentrations at or below 0.31 mg/l. Most (57%) of the results were in agreement at or below 0.10 mg/l. While the precision for the second tier results was only 94.6%, the HtB results vary from the series mean by an average of only 0.06 mg/l. In this case the low precision is considered an artifact of low sample concentrations. However, the values and the differences between values were represented by very small concentration values, on the order of a tenth of a mg/l.

Based on the results of the split sampling exercises, additional procedures were instituted by Heal the Bay. During each water chemistry sampling event, prior to analyzing field samples, Heal the Bay tests a positive standard for nitrate nitrogen, ammonia nitrogen, and orthophosphate. If a result exceeds accuracy specific limits then the ambient data for that parameter do not qualify for inclusion in the final data set for that day. In addition, Heal the Bay now preserves all their ammonia samples with sulfuric acid to prevent degradation prior to analysis. With these procedures instituted, Heal the Bay is capable of producing high quality ammonia, nitrate and orthophosphate data representative of conditions in Malibu Creek.

APPENDIX F
COST ANALYSIS SUMMARIES

This section provides detailed cost figures for operating a volunteer monitoring program using Heal the Bay's Stream Team model. These figures were used for the cost analysis in sections IV and V of this document. The numbers below are the actual costs of operating the Heal the Bay's Stream Team program. Scenario one is based on price quotes from three state certified laboratories. Labor rates were estimated based on job announcements from agencies or municipalities for people performing similar functions. Heal the Bay believes the estimates used to compute costs under scenarios No. 1 and 2 are conservative.

STREAM TEAM FIELD KIT COSTS

Description	Unit Price
Do Meter with probe, 12ft cable, membranes and electrolyte fluid	$ 645.05
Beaker, Stackable 17oz 25/pk *	$ 13.77
pH Tester 2 Waterproof pocket tester w/ replaceable electrode	$ 80.75
2020 Turbidity Meter w/ 4 tubes, 2 standards and carrying case	$ 715.50
Cole-Parmer Waterproof Conductivity meter and probe	$ 445.50
Fiberglass Stadia Rods 13ft inches	$ 70.36
Fiberglass Tape Measure 100 ft inches	$ 21.59
Legend six pack Ice chest	$ 9.73
Pocket Calculator	$ 10.81
16 oz/500ml plastic bottle 12/pk *	$ 41.32
Thermometer Nickel-plated brass armor	$ 37.43
250 ml sample bottles plastic /12pk *	$ 29.92
LCD Stop Watch Waterproof	$ 14.04
Dead Blow Hammer	$ 33.55
Stuff Sack for D.O. meter	$ 24.89
Back Packs Day and 1.5 Day Tech Bags for H2O Chemistry Kits	$ 104.99
Wooden Stakes and survey twine	$ 1.50
Orange	$ .20
Total Cost of Stream Team Field Kit	**$2,300.90**

*500-ml/16 0z. bottles, 255-ml sample bottles and Stackable beakers are only a one-time purchase.

COLORIMETER

Description	Price
Smart Colorimeter w/ 4 tubes & A/C adapter	$ 805.50
Carrying case for Smart Colorimeter	$ 81.50
Total	**$ 887.00**

METER CALIBRATION

Test	1 Calibration Standards per ml	2 Calibration Standards per ml	Amount per test	Subtotal	Total cost
pH	$0.01 @ 7.0 pH	$0.01@ 10 pH	30-ml	$0.60	$0.60
Turbidity	$0.08 @ 1.0 NTU	$0.10 @ 10.0 NTU	15-ml	$2.70 / 3	$0.90
Conductivity	$0.02 @ 700 uS	$0.02 @ 7000 uS	15-ml	$0.60	$0.60

METER REPLACEMENT PARTS

Meter	Replacement Parts	Cost	Time	Cost per month	Subtotal	Cost per Test
pH	Electrode	$38.95	12 months	$3.25/ 2.33 tests/month	$1.39	$1.39
Dissolved Oxygen	Membranes, fluid, o-rings	$17.00	8 months	$2.13 / 3 # meters	$0.71/ 2.33 tests/month	$0.30

BATTERY REPLACEMENT

Test	Type of Battery	Cost	Time	Subtotal	Cost per Test
pH	(3) 1.5-volt	$6.45	12 months	$0.54/2.33 tests/month	$0.23
Turbidity	9-volt	$6.97	6 months	$1.16/2.33 tests/month	$0.50
Conductivity	4 AAA	$5.99	12 months	$0.50/2.33 tests/month	$0.21
Dissolved Oxygen	6 AA Batteries	$8.99	6 months	$1.50/2.33 tests/month	$0.64
Stop watch	1.5-volt	$2.15	18 months	$0.12/ 1.7 tests/month	$0.07

STREAM TEAM FIELD TESTING LABOR

Labor Cost	Number of Test Results	Total Labor Cost per Result
$107.97	47	$2.30

STREAM TEAM FIELD TESTING MILEAGE

Average # miles	Reimbursement Rate	Total Mileage Charge	Number of results	Cost per Result
60	$0.32	$19.20	74	$0 .26

TOTAL COST PER RESULT STREAM TEAM FIELD TESTING

Test	Calibration Standards	Labor Cost	Mileage	Misc. Cost	Battery Costs	Replacement Parts	Total cost Field Test
pH	$0.60	$2.30	$0.26	$0.10	$0.23	$1.39	$4.88
Dissolved Oxygen	$0.00	$2.30	$0.26	$0.10	$0.64	$0.30	$3.60
Turbidity	$0.90	$2.30	$0.26	$0.10	$0.50	$0.00	$4.06
Conductivity	$0.60	$2.30	$0.26	$0.10	$0.21	$0.00	$3.47
Air Temp	$0.00	$2.30	$0.26	$0.10	$0.00	$0.00	$2.66
Stream Flow	$0.00	$2.30	$0.26	$0.10	$0.07	$0.00	$2.73

NUTRIENT REAGENTS

Test	Reagent Cost	Number of Tests	Cost per test
NO_3+NO_2-N	$16.45	20 per kit	$0.83
NH_3-N	$14.85	50 per kit	$0.30
PO_4	$9.50	50 per kit	$0.19

STREAM TEAM NUTRIENT LABOR

Labor Cost per Minute	Time per Test	Total Labor Cost per Result
$0.327	7.7 minutes	$2.52

Laboratory and Accuracy

Item	Cost per unit	# of test results	Quantity used	Cost per result
10 ml pipettes	$0.31	35 (27 nutrient + 8 entero)	19	$0.17
PO_4 and NH_3 Standards 5-mg/l	$7.75 per 100-ml	200	.5 ml	$0.04
NO_3 + NO_2-N Standards 5-mg/l	$7.75 per 100-ml	400	.25 ml	$0.02
Sodium Hydroxide NH_3-N only	$0.01 per 1-ml	Not applicable	3-ml	$0.03
Sulfuric Acid NH_3-N only	$0.01 per 1-ml	Not applicable	2-ml	$0.02
Miscellaneous	$0.03	Not applicable	N/A	$0.03

Total Cost per result Stream Team Nutrient Testing

Test	Reagent Cost	Labor Cost	Mileage	Materials	Total cost
NO_3+NO_2-N	$0.83	$2.52	$0.26	$0.22	$3.83
NH_3-N	$0.30	$2.52	$0.26	$0.24	$3.32
PO_4	$0.19	$2.52	$0.26	$0.29	$3.26

Reagents

Test	Reagent Cost	Number of Tests	Cost per test
Enterococcus	$3.00	1 per kit	$3.00

Materials

Material	Cost	Number of Tests	Cost per test
135-ml sterile sample containers	$70.00	200	$0.35
Quanti-Tray 2000	$100.00	100	$1.00
10-ml pipettes	$0.17	1	$0.17
90-ml Butterfield's Buffer Solution	$69.50	72	$0.97
Total Material Costs			**$2.49**

Stream Team Enterococcus labor

Labor Cost per Minute	Time per Test	Total Labor Cost per Result
$0.327	5 minutes	$1.64

Total Cost per result Stream Team Enterococcus Testing

Test	Reagent Cost	Labor Cost	Mileage	Materials	Total cost
Enterococcus	$3.00	$1.64	$0.26	$2.49	$7.39

Total Cost per Result Stream Team

Lab Test	Method	Quantity	Average Price Per Test	Total Price Per event
Turbidity	Meter	7	$4.06	$28.42
Conductivity	Meter	7	$3.47	$24.29
Ammonia-N	Colorimeter	9	$3.32	$29.88
Nitrate+Nitrite-N	Colorimeter	9	$3.83	$34.47
Orthophosphate	Colorimeter	9	$3.26	$29.34
Enterococcus	IDEXX	8	$7.39	$59.12
Labor			Included	Included
Mileage				$19.20
Total		**49**		**$ 224.72**

Labor Scenario No. 1

Labor Cost	Number of Staff	Time per staff	Labor Cost for Physical Observation Sample collection & data entry
$18.00	2	4 hours	$144.00 field work
$18.00	1	8 hours	$144.00 data entry
Total			**$288.00**

Mileage Scenario No. 1

Average Miles Per Vehicle	Number of Vehicles	Total Miles	Reimbursement Rate	Total Mileage Charge
30	2	60	$0.32	$19.20

TOTAL COST PER RESULT STATE CERTIFIED LAB SCENARIO NO. 1

Lab Test	Method	Quantity	Average Price per Test	Total Price
Turbidity	EPA 180.1	7	$20.00	$140.00
Conductivity	EPA 120.1	7	$10.00	$70.00
Ammonia-N	EPA 350.2	9	$20.00	$180.00
Nitrate+Nitrite-N	EPA 300.0	9	$20.00	$180.00
Orthophosphate	EPA 300.0	9	$22.50	$202.50
Enterococcus		8	$18.50	$148.00
Labor				$288.00
Mileage				$19.20
Total		**49**		$ **1227.70**

COST COMPARISON STREAM TEAM VS. STATE CERTIFIED LAB

Stream Team Testing	Quantity	Average Price Per Test	Total Price Lab	Total Price Stream Team	Difference per Test Day
Turbidity	7	$4.06	$140.00	$28.42	$111.58
Conductivity	7	$3.47	$70.00	$24.29	$45.71
Ammonia-N	9	$3.32	$180.00	$29.88	$150.12
Nitrate+Nitrite-N	9	$3.83	$180.00	$34.47	$145.53
Orthophosphate	9	$3.26	$202.50	$29.34	$173.16
Enterococcus	8	$7.39	$148.00	$59.12	$88.88
Labor			$288.00	$0.00	$288.00
Mileage			$19.20	$19.20	$0.00
Total	**49**		$**1227.70**	**$224.72**	$**1002.98**

LABOR SCENARIO NO. 2

Staff type	Labor Cost	Number of Staff	Time per staff	Total Hours Per Event	Labor Costs Per Event
Field Technician	$18.00	3	4 hours	12 hours	$216.00
Field Assistant	$13.00	3	4 hours	12 hours	$156.00
Lab Assistant	$13.00	1	4 hrs 10 minutes + 8 hours maintenance 6 hours data entry	18 hours 10 minutes	$236.17
Lab Technician	$26.00	1	4 hours 10 minutes	4 hours 10 minutes	$108.33
Total Labor					**$716.50**

STREAM TEAM LABOR

Staff type	Labor Cost	Number of Staff	Time per staff	Total Hours Per Event	Labor Costs Per Event
Program Manager	$19.63	1	5 hours 30 min. Field work 4 hours 10 min lab work	9 hours 40 minutes	$189.76
College Intern	$0 .00	3	4 hours 50 min Field work 4 hrs 10 min Lab work 8 hours maintenance 6 hours data entry	23 hours	$0.00
Total Labor					**$189.76**

MILEAGE SCENARIO NO. 2

Group or Agency	Average Miles per Vehicle	Number of Vehicles	Total Miles Traveled	Reimbursement Rate	Total Mileage Charge
Scenario No. 2	36	3	108	$0.32	$34.56
Heal the Bay	60	1	60	$0.32	$19.20

COST COMPARISON STREAM TEAM VS. SCENARIO NO. 2

Monitoring Group or Agency	Labor Cost	Mileage	Total Price Per Event	Cost per Year
Scenario No. 2	$716.50	$34.56	$751.06	$9012.72
Heal the Bay	$189.76	$19.20	$208.96	$2507.52
Difference/ Savings	**$526.74**	**$15.36**	**$542.10**	**$6505.20**

Stream Walk Cost Analysis

STREAM TEAM PROGRAM MANAGER LABOR

Type of work	Labor Cost	Total Hours Per Event	Events per month	Hours per month	Labor Costs Per Month
Event	$19.63	6 hours	4	24 hours	$471.12
Training	$19.63	6 hours	1	6 hours	$117.78
Data entry	$19.63	6 hours	4	24 hours	$471.12
Total Labor				**52 hours**	**$1060.02**

STREAM TEAM MILEAGE COSTS

Type of work	Mileage Cost	Average Miles traveled Per Event	Events per month	Total miles traveled	Mileage Costs Per Month
Event	$0.32	30	4	120	$38.40
Training	$0.32	30	1	30	$9.60
Total				**150**	**$48.00**

AGENCY OR MUNICIPALITY STREAM WALK LABOR COSTS

Position	Labor Cost	Total Hours Per Event	Events per month	Hours per month	Labor Costs Per Month
GPS Operator	$18.00	6 hours	4	24 hours	$432.00
2 Field Assistants	$15.00	12 hours	4	48 hours	$720.00
GIS Technician	$24.00	6 hours	4	24 hours	$576.00
Total Labor				**96 hours**	**$1,728.00**

Credits

Production and Design: *Mark Abramson*

Report Research and Copy: *Mark Abramson, Dominic Gregorio, and Marti Witter*

Technical Editors: *Lisette Bauersachs, D.Env., Alix Gerosa, Mark Gold, D.Env., and Marti Witter*

Stream Team God: *Mark Abramson*

Stream Team Interns: *Damien Cowley, Mike Grimmer, Matt Horns, Ben Pitterle*