GROUP A ELEMENTS: PROJECT MANAGEMENT

1. TITLE AND APPROVAL SHEETS

Quality Assurance Project Plan For
Version 1

PROJECT NAME:
Identification of Sources of Fecal Pollution Impacting Pillar Point Harbor

Proposal Identification Number: 07-574-550-0

Date: 12/2007

NAME OF RESPONSIBLE ORGANIZATION : San Mateo County Resource Conservation District

APPROVAL SIGNATURES

GRANT ORGANIZATION – San Mateo County Resource Conservation District (SMCRCD):

Title:	Name:	Signature:	Date*:
Project Manager	Kellyx Nelson		
Resource Specialist/ QA Officer	Carolann Towe		

State Water Resources Control Board (SWRCB):

Title:	Name:	Signature:	Date*:
Contract Manager	Jennifer Toney		
QA Officer	Mina Danieli		

Balance Hydrologics:

Title:	Name:	Signature:	Date*:
Principal Hydrologist	Barry Hecht		
QA Officer	Shawn Chartrand		

San Mateo County Public Health Lab (SMCPHL):

Title:	Name:	Signature:	Date*:
Lab Director	Bruce Fujikawa		
QA Officer	Doug Coffman		

UC Davis – Civil and Environmental Engineering:

Title:	Name:	Signature:	Date*:
Professor	Stefan Wuertz		
QA Officer	Dan Wang		

* This is a contractual document. The signature dates indicate the earliest date when the project can start.

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3. DISTRIBUTION LIST

Title:	Name (Affiliation):	Tel. No.:	QAPP No*:
Contractor Project Manager	Kellyx Nelson, SMCRCD	650-712-7765	7
Contractor Resource Specialist/QA Officer	Carolann Towe, SMCRCD	650-712-7765	6
SWRC Board Contract Manager	Jennifer Toney, SWRCB	916-341-5375	1
SWRC Board QA Officer	William Ray	916-341-5583	2
San Mateo Public Health Laboratory Director	Bruce Fujikawa, SMCPHL	650-573-2500	4
Professor of Environmental Engineering at University of California, Davis	Stefan Wuertz, UC Davis	530-754-6407	3
Principal Hydrologist	Barry Hecht, Balance Hydrologics	510-704-1000	5

4. PROJECT/TASK ORGANIZATION

4.1 Involved parties and roles.

Table 1. (Element 4) Personnel responsibilities.

Name	Organizational Affiliation	Title	Contact Information (Telephone number, fax number, email address.)
Kellyx Nelson	SMCRCD	Project Manager	ph. 650-712-7765 Fax 650-726-0494 Email kellyx@sanmateorcd.org
Carolann Towe	SMCRCD	Resource Specialist/QA Officer	Ph. 650-712-7765 Fax. 650-726-0494 Email carolann@sanmateorcd.org
Jennifer Toney	SWRCB Board Contract Manager	Contract Manager	Ph. 916-341-5646 Fax. Email jtoney@waterboards.ca.gov
Stefan Wuertz	University of California, Davis	Professor of Environmental Engineering	Ph. 530-754-6407 Fax. 530-752-7872 Email swuertz@ucdavis.edu
Bruce Fujikawa	SMC Public Health Laboratory	Laboratory Director	Ph. 650-573-2500 Fax. 650-573-2147 Email bfujikawa@co.sanmateo.ca.us
Douglas Coffman	SMC Public Health Laboratory	Lead PH Lab Tech	Ph. 650-573-2456 Fax. 650-573-2147 Email dcoffman@co.sanmateo.ca.us
Barry Hecht	Balance Hydrologics	Principal Hydrologist	Ph. 510-704-1000 Fax. 510-704-1001 Email bhecht@balancehydro.com

4.2 Quality Assurance Officer role

The SMCRCD Resource Specialist, Carolann Towe is the Quality Assurance officer, and will be assisted by the appropriate involved parties. Duties will include managing and coordinating training sessions, preparing all necessary documents and arranging for technical assistance from labs, universities and local agencies. She will review copies of the field data sheets and chain of custody (COC) forms for accuracy and completeness. Review data for compliance with data quality objectives, and recommend corrective actions as necessary. She will also review laboratory reports to ensure the quality of the data is as specified in the QAPP and liaise with the Wuertz Laboratory at UC Davis, the San Mateo Public Health Laboratory, and Balance Hydrologics if questions arise about data quality. The Resource Specialist is responsible for overall Quality Assurance.

4.3 Persons responsible for QAPP update and maintenance.
The Resource Specialist, Carolann Towe, is responsible for maintaining and updating the official approved QAPP after a review of the evidence for change and with the concurrence of the Grant Manager. The Resource Specialist will make the changes, submit drafts for review, and submit the final document for signature. Only the Resource Specialist can make changes to the QAPP.

4.4 The project key staff and their responsibilities are as follows:

The Project Manager, Kellyx Nelson (SMCRCD) will be responsible for administration of the agreement and communications with the SWRCB as well as managing the Balance Hydrologics and University of California, Davis contracts with SMCRCD. She will be responsible for all project management tasks including the reporting and oversight of project progress. Invoices and reports will be sent to Jennifer Toney, Grant Manager with SWRQCB. Ms Nelson will work closely with the Quality Assurance (QA) Officer, receive reports, and ensure that any problems are solved promptly.

The SMCRCD Resource Specialist, Carolann Towe, will be responsible for preparing and updating the QAPP and MPP, coordinating sampling events and data distribution. As the Quality Assurance officer duties will include managing and coordinating training sessions, preparing all necessary documents and arranging for technical assistance from labs, universities and local agencies. She will review copies of the field data sheets and chain of custody (COC) forms for accuracy and completeness. Review data for compliance with data quality objectives, and recommend corrective actions as necessary. She will also review laboratory reports to ensure the quality of the data is as specified in the QAPP and liaise with the Wuertz Laboratory at UC Davis, the San Mateo Public Health Laboratory, and Balance Hydrologics if questions arise about data quality,

The Grant Manager, Jennifer Toney, will be responsible for reviewing the deliverables specified in Table of Items for Review within the Grant agreement, including monitoring results and receive the quarterly reports and invoices for the project.

The Primary Investigator, Dr. Stefan Wuertz (UC Davis) will develop and manage all technical activities associated with this project, prepare project reports, coordinate with the Project Representative to ensure communication and information transfer and direct activities of UC Davis and SMCRCD technical staff. In addition Dr Wuertz' will oversee the following Wuertz Laboratory activities:

- Train field technicians participating in sample collection
- Oversee sampling operations on the beach
- Review data sheets from field personnel
- Receive water and fecal samples from field personnel
- Train lab technicians on SOPs for general lab activity (see below)
- Supervise Fecal Indicator Bacteria (FIB) analyses
- Supervise Fecal Coliform growth and shipping to subcontractor
- Supervise salinity, turbidity and UV absorbance analyses
- Supervise DNA and RNA filtering activities
- Supervise DNA extraction processes
- Supervise TRFLP analyses
- Manage archival of sample filters and fecal samples
- Provide blind QA samples from feces for all source assay validation studies
- Review data sheets from laboratory technicians
- Conduct QA analyses of FIB samples
- Provide input on recommended actions
- Prepare data reports

SMC Public Health Laboratory Director, Dr Bruce Fujikawa will oversee all SMCPHL activities and act in an advisory capacity as a member of the Technical Advisory.

SMC Public Health Laboratory Lead PH Lab Tech, Doug Coffman will:

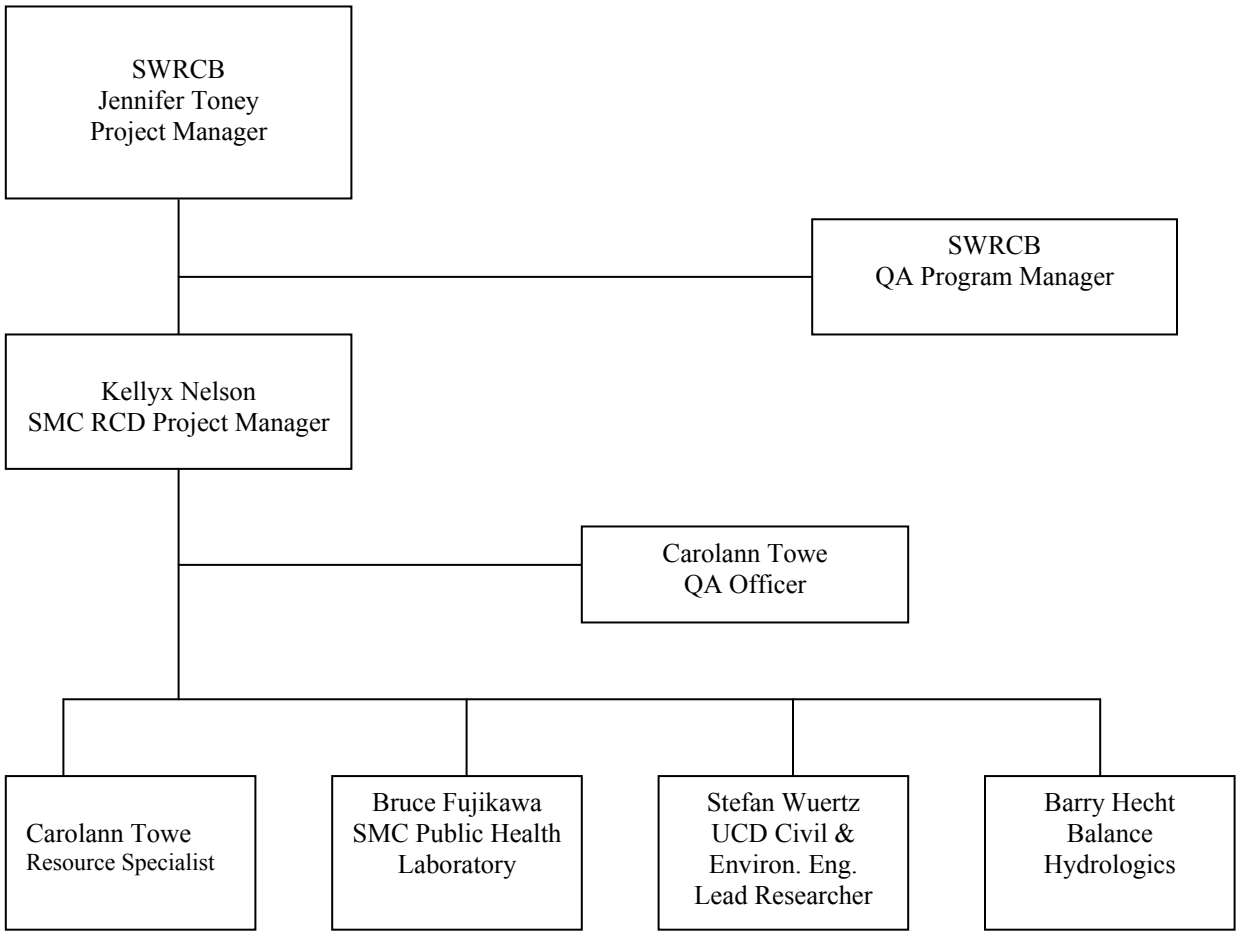
- Assist in sampling design and development of the work plan
- Train field technicians participating in sample collection
- Review data sheets from field personnel
- Receive water and fecal samples from field personnel
- Train lab technicians on SOPs for general lab activity (see below)
- Supervise Fecal Indicator Bacteria (FIB) analyses
- Review data sheets from laboratory technicians
- Conduct QA analyses of FIB samples
- Provide input on recommended actions
- Cross check calculations of FIB laboratory results and prepare data reports

Barry Hecht, Balance Hydrologics Principal Hydrologist, will:

- Oversee and conduct hydrologic studies in the harbor (including currents, flow, salinity, and residency time). Including a dye study using non-visual coloration and portable fluorometers, bench top fluorometers, or a sonde with an attached fluorometer.
- Characterize conditions in the harbor to the extent allowable in the remaining available budget for hydrologic investigations of the harbor.
- Conduct hydrologic studies of inflow sources, including the marsh, runoff, outflow from Denniston Creek and Deer Creek, storm drains, and storm sewers.
- Investigate the role of sediment as a potential source of elevated levels of fecal indicators.
- Provide input on recommended actions
- Assist in generation of final report

4.4 Organizational chart and responsibilities

Figure 1. Organizational chart.



5. PROBLEM DEFINITION/BACKGROUND

5.1 Problem statement.

Pillar Point Harbor water quality chronically is so poor that the State Water Resources Control Board recently listed the location as impaired by coliform bacteria on the 303(d) list submitted to the United States Environmental Protection Agency. Capistrano Beach has elevated levels of fecal indicator bacteria (FIB), such as *E.coli* and *Enterococcus* on over 95% of sampling events in wet and dry conditions. This beach has been ranked for several years by Heal the Bay's Report Card as a "Beach Bummer," meaning that it is in the top ten most polluted beaches in California in dry weather conditions. In 2005/2006, Capistrano Beach ranked sixth on the "Beach Bummer" list. It was the worst ranked beach in Northern California and is a Clean Beaches Task Force Priority Beach with regard to fecal pollution. Capistrano Beach is permanently posted by the San Mateo County Environmental Health Department as a potential health hazard.

The public health impact of the impaired waters may impact commercial ventures, harbor activities, tourism, recreation, ecological habitat, and sources of drinking water for municipal utilities in the watershed. The harbor area has approximately 100,000 visitors annually and is heavily used recreationally by boating enthusiasts, kayakers, windsurfers, campers, hikers, dog walkers, bird watchers, swimmers, waders, families, clam diggers, surfers, and thousands of spectators for the world famous Mavericks big wave surf break.

In 2005 and 2006, San Mateo County Department of Environmental Health repeatedly posted beaches in the Harbor as potential health hazards. Capistrano Beach was posted most frequently, approximately 50 weeks in each year. Marsh Beach was posted over 20 weeks in each year i.e. 42% to 51% of sampling events. Mavericks Beach was posted approximately 15 weeks each year, approximately 30% of sampling events. The county terminated sampling for Capistrano Beach and permanently posted the beach as a potential health hazard in March of 2006.

Within the local community there are numerous opinions as to the primary sources of fecal pollution impacting the harbor, including but not limited to human contamination from leaking sewer lines, avian contamination from resident and migratory bird populations including large flocks of gulls and other birds, and lack of flushing in the harbor due to the presence of two break walls. Although much effort has been expended on studying the locations of fecal pollution impacting the harbor, including water sampling and fecal indicator enumeration studies, data on identification of primary sources and their relative contributions to the overall magnitude of the pollution problem are lacking. There is an urgent need for a comprehensive study of all of the possible sources of pollution in this watershed and how these flows interact in the confines of the enclosed Pillar Point Harbor Bay.

A primary objective of the study is to determine which inlets constitute a significant source of pathogen indicators to Pillar Point Harbor, including the near shore area and adjacent beaches. A multi-tiered approach will be undertaken to identify sources and to quantify fecal loads. It is intended to go beyond the traditional methods of evaluating the receiving water based solely on fecal pathogen indicators. Fecal pathogen indicators are commonly used to indicate the presence of fecal pathogens due to the cost and numerous obstacles associated with the direct measurement of pathogens. Numerous investigators are expressing concern with regard to the ability of the traditional fecal pathogen indicators to accurately reflect the risks to human health. Studies have shown that the correlation between the pathogen indicators and human health risks may be poor primarily due to persistence of the indicators in the natural environment and the presence of indicators in feces from non-human sources. It should be noted, however, that fecal pathogen indicator data can provide valuable information in the analysis of the problem, and that non-human pathogen sources may also pose a human health risk.

5.2 Decisions or outcomes.

- Assessment and analysis of existing data.
- Creation of Technical Advisory Committee.
- Investigation of sources of fecal contamination.
- Recommend strategies to remediate fecal contamination.

5.3 Water quality or regulatory criteria

The project uses the AB411 maximum limit for *E. coli* of 200 MPN/100mL and *Enterococcus* of 35 MPN/100ml as defining the boundary of a bacterial "hot spot."

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6. PROJECT/TASK DESCRIPTION

The Source Identification Survey is divided into four tasks:

1) Assess and analyze existing data relevant to potential sources of fecal contamination impacting Pillar Point Harbor.
2) Investigate sources of fecal contamination impacting Pillar Point Harbor.
3) Conduct public outreach and community participation.
4) Develop implementation goals and strategies.

Numerous types of flows and drainages are to be investigated, including outflows from Denniston and Deer Creeks, outfall pipes, storm drains, runoff from blacktop and impervious surfaces, agricultural concerns and commercial operations; flows originating from wave action and/or wave generated surges broaching harbor walls, water circulation within the harbor, tidal surges, currents, other issues associated with enclosed beaches, and potential drainage from sewer lines. Effects of wet and dry weather upon these flows will be analyzed. Water flows draining into the harbor with well documented elevated levels of fecal indicators include Capistrano and Bathhouse outfall pipes and Denniston Creek, and these flows will be a primary focus of the project.

6.1 Assess and analyze existing data relevant to potential sources of fecal contamination impacting the Harbor.
The project team will perform a full search for all existing data, review and analyze with respect to the following:

- 6.1.1 Hydrology of contributing watersheds, marsh, and harbor
- 6.1.2 Geologic setting
- 6.1.3 Natural and human-made conditions
- 6.1.4 Sedimentation and beach sand shifting
- 6.1.5 Sewer and other sewerage inflow and infiltration studies
- 6.1.6 Existing microbial source tracking MST data
- 6.1.7 Enumeration data for fecal indicators with regard to tidal and flow conditions, temporal issues, weather, rain events, seasons, first flush events, etc.
- 6.1.8 Watershed sanitary surveys and similar analyses and related watershed data
- 6.1.9 Residency time for harbor water circulation

6.2 Investigate sources of fecal contamination impacting Pillar Point Harbor.
Several strategies can be undertaken to implement a multi-tiered approach. One method that shows great promise for the accurate evaluation of sources and human health risks is MST. To develop a cost-effective plan that will provide the greatest benefit toward understanding and eliminating sources of contamination, the approach must take advantage of all the available data, must account for all sources in the watershed, and also must focus on the areas of greatest concern.

MST is based on the assumption that characteristics of fecal bacteria vary according to their source. By identifying and accounting for the differences, the source of fecal pathogens can be ascertained. Generally, sources can be traced to warm blooded organisms such as human, canine, avian, bovine, or porcine. These linkages can enable the analyst to trace nonpoint sources of pathogens to a distinct land use or region and allows for a site-specific approach to deal with each source.

6.2.1 Investigate sources of fecal contamination known to impact Capistrano Beach.

6.2.1.1 Perform MST to identify and estimate relative contributions of fecal pollution arising from human, avian, dog, horse, cattle and other host sources.

6.2.1.2 Track pollutants to their sources by scoping storm drains and sewer lines and conducting hydrologic studies and sanitary surveys with FIB enumeration.

6.2.1.3 Investigate role of sediment as a potential source of elevated levels of fecal indicators, including sampling Denniston Creek and the Pillar Point Marsh during storms.

6.2.1.4 Investigate role of wrack as a potential source of elevated levels of fecal indicators, including sampling Denniston Creek and the Pillar Point Marsh during storms.

6.2.2 Investigate potential sources of fecal contamination to remaining beaches in Pillar Point Harbor: Mavericks, Yacht Club, Beach House, Inner Harbor, and Pillar Point Marsh beaches.

6.2.2.1 Sample beaches, lagoons, creeks, monitoring wells, bluff seeps, and storm drains, and assess by fecal indicator enumeration of *E. coli* and *Enterococcus* and by watershed sanitary surveys.

6.2.2.2 For sites which are identified as major sources of fecal pollution, perform microbial source tracking to identify and estimate relative contributions of fecal pollution arising from human, avian, dog, horse, cattle and other host sources.

6.2.3 Investigate other factors which may impact fecal contamination in Pillar Point Harbor with respect to the following and perform MST as required.

6.2.3.1 Hydrologic parameters, including currents, flow, and salinity where relevant.

6.2.3.2 A fluorometric dye tracing study will be conducted to observe flow direction, velocity and dispersion in the harbor to allow estimation of expected residence times of constituents in the harbor under late-summer or early-fall conditions.

6.2.3.3 Impact of birds, domestic animals, recreational vehicles, leach fields, and boats.

6.2.3.4 Sewer line integrity.

6.2.3.5 Inflow sources, including the marsh, surface runoff, discharge from Denniston Creek and Deer Creek, storm drains and storm sewers.

6.3 Conduct public outreach and community participation.

SMCRCD will facilitate public outreach and education about the project and coordinate stakeholders by notifying and encouraging the participation of affected and interested public and private landowners, utilities, resource agencies, and others as necessary and appropriate, providing opportunities for public input into the project effort. Outreach activities will include a public workshop, creation and maintenance of a web page for the project, and enabling/encouraging any member of the public to ask questions and provide input on the project at regularly scheduled public meetings of the Resource Conservation District Board of Directors.

6.4 Develop implementation goals and strategies.

The project will provide quarterly progress reports, including collected data, during the life of the project. At the end of the project, SMCRCD will provide a full listing and summary of the data collected. From these data SMCRCD will develop and prioritize specific objectives for implementation of water quality remediation projects based on the research and analysis.

6.4.1 Identify specific constraints, impediments, opportunities, and priorities to remediate water quality on the beaches in Pillar Point Harbor.

6.4.2 Offer specific cost-effective, feasible water quality improvement projects.

6.4.3 Develop milestones and timeline for implementing the proposed methods to achieve specific water quality objectives and the parties responsible for meeting these objectives.

6.4.4 Draft monitoring plan and specific performance measures to track implementation of specific projects.

Some opportunities for remediation that can be implemented during the project may be identified and undertaken, potentially earlier than March 2010.

6.5 Constituents to be monitored and measurement techniques.

The following data will be collected:

A) Total coliform, *E. coli*, *Enterococcus* and *Bacteroidales*. Total coliform, *E. coli and Enterococcus* will be determined by the Colilert-18® and Enterolert ® QuantiTray-2000 system.

B) *Bacteroidales* will be detected using a library-independent MST method based on quantitative PCR (qPCR) as detailed below.

C) Streamflow will be measured in Denniston Creek, Deer Creek, Pillar Point Marsh, and at accessible outfalls according to U.S. Geological Survey standard methods (Buchanan and Somers, 1976) which are available through the USGS website (*http://pubs.usgs.gov/twri/*) and upon request from Balance Hydrologics. At two or more stations, a continuous record of water stage (depth) will be obtained by installing instruments that sense and record water pressure. Streamflow measurements, made at various stages, will be used to develop stage-discharge rating curves at these stations in order to develop a continuous streamflow record.

D) Circulation data will be collected during two runs in late summer or early fall using a fluorometric dye study. First will be a small run to test the vertical distribution of dye in the water column in this harbor which has an average depth of 15'. The second run will be a full scale assessment of dye released from three points of interest in defining the circulation within the harbor. Sampling sites are allocated to a series of transects perpendicular to shore. The information gathered will be used during the analysis of FIB data as well as MST data to determine the effects of harbor circulation dynamics on FIB sources. The test and full scale events are planned for the summer/fall of 2008, a period when surface runoff is negligible, uncoupled from specific meteorological events. By sampling close to the onset of the winter rainy season, we hope to characterize the water quality characteristics of the harbor.

6.5. B MST based on *Bacteroidales* .

MST methods have been reviewed recently (Field and Samadpour, 2007; Santo Domingo et al., 2007; Stoeckel and Harwood, 2007) and there is agreement among most source trackers that methods relying on specific isolates of *E. coli* or other indicator organisms obtained from various geographic regions (called library-dependent methods) are only of limited use when the objective of source tracking is to allocate fecal loads to host-specific animals or certain land uses. They are useful when the objective is to describe as many potential animal sources as possible, provided a sufficiently large library of reference isolates is used (at least 10,000 strains). The library-independent methods include direct measurement of specific genetic markers in water samples using PCR, with or without filtration and extraction of DNA. Excellent genetic markers for a number of hosts, including human and cow, are available for the order *Bacteroidales,* a highly abundant group of bacteria in the intestine of warm-blooded animals. These markers have been developed in the laboratory of Dr. Kate Field (Bernhard and Field, 2000; Dick et al., 2005). In the past, monitoring studies only indicated the presence or absence of these genetic markers, because the exact number of gene copies could not be enumerated. During the last few years quantitative PCR (qPCR) assays have been developed by Dr. Field and other research groups (Dick and Field, 2004; Layton et al., 2006; Okabe et al., 2007; Reischer et al., 2007; Reischer et al., 2006; Seurinck et al., 2005), including the Wuertz Laboratory (Kildare et al., 2007). Dr. Wuertz has designed specific qPCR assays for universal *Bacteroidales* as well as human-, cow-, and dog-specific *Bacteroidales*. Current assays under development target horse and seagull populations. These assays will become available during the study and complement the existing assays.

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6.6 Project schedule

Table 2. (Element 6) Project schedule timeline.

Item	DESCRIPTION	COMPLETION DATE
A.	**PLANS AND COMPLIANCE REQUIREMENTS**	
1.	GPS information for Project site and monitoring locations	July 2007
2.	Project Assessment Evaluation Plan (PAEP)	July 2007
3.	Monitoring Plan (MP)	February2008
4.	Quality Assurance Project Plan (QAPP)	February 2008
5.	Copy of final CEQA/NEPA Documentation	June 2007
B.	**WORK TO BE PERFORMED BY GRANTEE**	
1.	PROJECT MANAGEMENT AND ADMINISTRATION	
1.1	List of Technical Advisory Committee Members	October 2007
2.	PROJECT IMPLEMENTATION	
2.1	Analysis of existing data	May 2008
2.3	Public Notices and meeting attendance information	Quarterly
A.	INVOICING	Quarterly
E.	REPORTS	Quarterly
1.	Grant Summary Form	90 days
2.	Progress Reports by the end of the month following the end of the calendar quarter (March, June, September, and December)	Quarterly
3.	Natural Resource Projects Inventory (NRPI) Project Survey Form	Before final invoice
4.	Draft Project Report	February 2010
5.	Final Project Report	March 2010

6.7 Geographical setting.

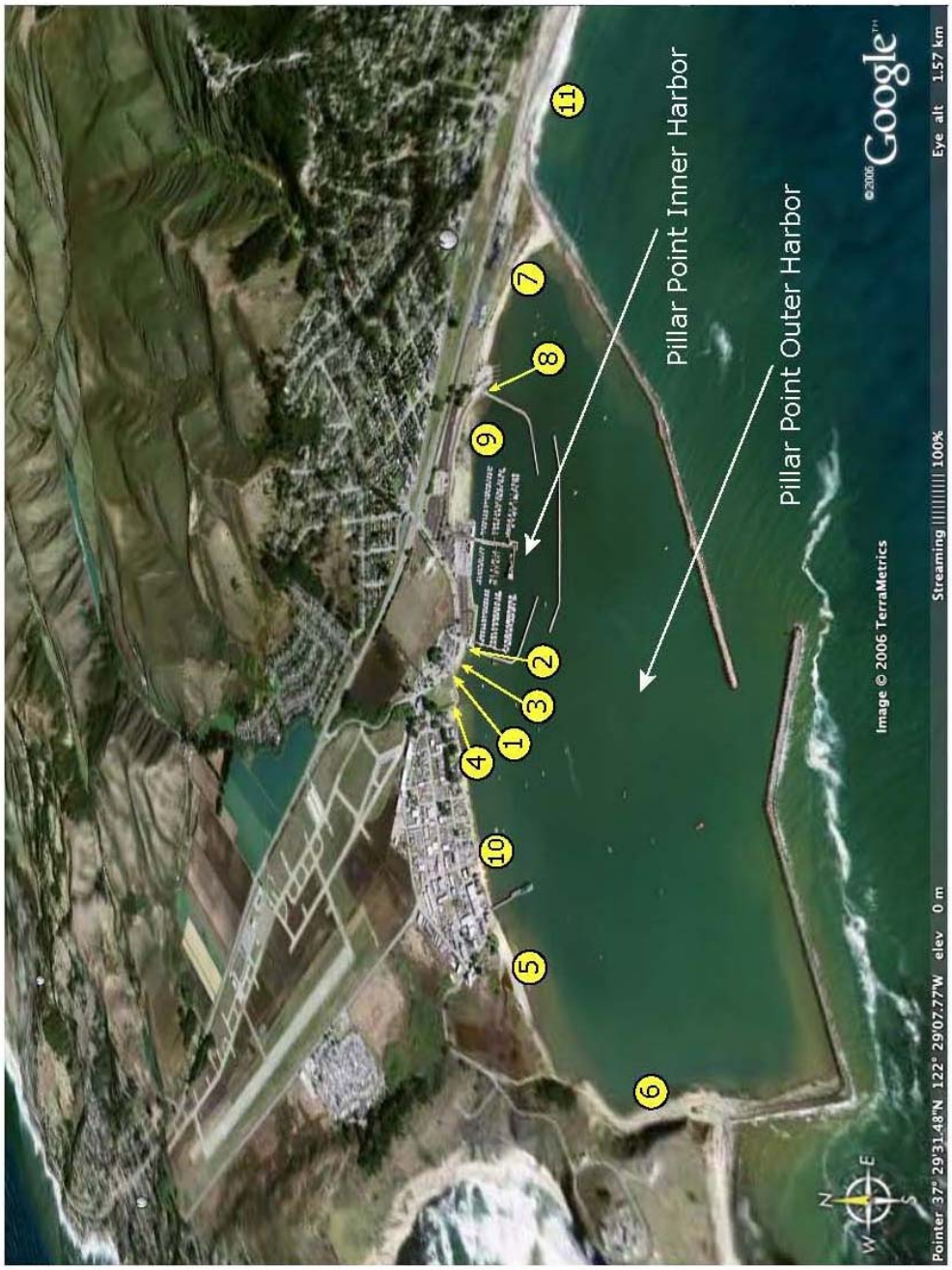
Pillar Point Harbor is an enclosed watershed with complex inputs and water flows. It contains an inner boat harbor, pier, and saltwater/brackish tidal marsh (Pillar Point Marsh). It receives drainage from Denniston and Deer Creeks, storm drains, outflow pipes, and large, mixed use areas including an airport, agricultural, commercial and residential sections. Pillar Point Harbor contains five beaches: Capistrano Beach, Yacht Club Beach, Marsh Beach, Mavericks Beach, Inner Harbor Beach, and Beach House Beach.

Pillar Point Harbor comprises an inner harbor and outer harbor. The inner harbor berths 180 commercial fishing vessels and approximately 200 recreational boats, and is encompassed within the much larger outer harbor area. The harbor area houses commercial ventures including several restaurants, hotels, shops, a fertilizer plant, three commercial fish buyers, sport fishing concessions, a yacht club, two kayak rental companies, a recreational vehicle

park, and a Naval Station situated on the bluff overlooking the Outer Harbor. Outside of the Outer Harbor area but within the project study area are conference facilities, residential areas, and additional commercial ventures as well as a pump station for the Sewer Authority Mid-coastside

The project area is also within the boundaries of the James V. Fitzgerald Marine Reserve Critical Coastal Area (CCA) Pilot Project. The Marine Reserve is a designated Area of Special Biological Significance (ASBS) and the CCA pilot project, jointly administered by the State Water Resources Control Board and the California Coastal Commission, is to foster collaboration among local stakeholders and government agencies to better coordinate resources and focus efforts on coastal watersheds in critical need of protection from polluted runoff. The CCA will develop an action plan to reduce non-point source pollution by 2010 and intends to coordinate closely with this project to identify and remediate sources of fecal contamination in Pillar Point Harbor.

Figure 2. Aerial perspective of the Study Area including watersheds and key locations



6.8 Constraints

There are a number of known and potential constraints to the ability to collect data during this project, including:

1. Drought /or inadequate rainfall during the project may limit the amount of surface flow in the creeks and marsh, restricting the ability to gather terrestrial hydrology data and may also affect the hydrology of the harbor.
2. Many of the storm drain outfalls to the harbor are submerged during high tide and inaccessible. As the tide recedes, flows at the culvert appear artificially high and do not represent true inflows to the harbor. Flows cannot be accurately measured during these conditions.

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7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

This section contains the measurement quality objectives for the monitoring program portions of this study and includes analyses both in the field and in the laboratory.

Representativeness indicates how well the data represent environmental conditions. This is addressed through the overall sampling design. Sites were selected to identify potential contributors to fecal contamination and the sample schedule was designed to maximize representativeness by optimizing the sampling frequency and location.
Precision describes how well repeated measurements agree.
Accuracy describes how close a measurement is to its true value.
Completeness is the percentage of how much of the data are available for use versus the total amount of data collected. It is calculated as the number of analyses generating useable data for each analysis divided by the total number of samples collected for that analysis. Data may be unavailable for use due to unavoidable circumstances such as laboratory error, samples lost or contaminated, etc.
Sensitivity is the ability of the instrument to detect one concentration from the next.

Data collected from previous studies and routine weekly FIB monitoring will be assessed against the same data quality objectives listed above, where appropriate. In addition data will also be reviewed in the context of its origins i.e. a certified lab or if not from a certified lab then the data should stem from several years of sampling and be consistent and consistent with certified data when appropriate.
Historical and recent flow, sediment, ground water and specific conductance data may be obtained from the USGS, local agency publications, or earlier consultant reports. Previously collected information will be assessed for: collection methods, units of measurement, reasonableness, and qualifications of observer/preparer. All previously collected data and information that does not meet these criteria and without appropriate QA/QC will not be included in the final analysis

Precision
Precision is a Data Quality Indicator (DQI) that measures the variability of repeated measurements of the same parameter in the same sample under the same analytical condition. When there are only two replicate measurements, the relative percent difference (RPD) is calculated and used to express the precision of the analysis. The percent relative standard deviation (% RSD) is calculated and used when more than two replicate measurements are available to evaluate precision. Precision is evaluated by calculating the RPD between duplicate spike, duplicate sample analyses or field duplicate samples and comparing it with appropriate precision objectives established in this QAPP. Analytical precision is developed using repeated analyses of identically prepared control samples. Field duplicate samples analyses results are used to measure the field QA and matrix precision.

Relative Percent Difference: $RPD = \frac{X_1 - X_2}{(X_1 - X_2)/2} \times 100$

Percent Relative Standard Deviation: $\%\ RSD = \frac{SD}{X^*} \times 100$

Standard Deviation: $SD = \sqrt{\Sigma \frac{(Xi - X^*)}{(n-1)}}$

Mean: $X^* = \frac{X_1 + X_2 + X_3 + \ldots\ldots\ldots\ldots X_n}{n}$

Where: X_1, X_2, and X_n represent the individual measurements; n represents the total number of replicate measurements made

Accuracy
Accuracy is how close a measurement is to the real truth; the extent of agreement between the measurement result and the accepted, or true, value of the characteristic being measured. Accuracy is measured by determining the percent recovery of known concentrations of analytes spiked into a field sample or reagent water before extraction.

The result of the calculation is evaluated against established acceptance limits. The accuracy objectives, or DQOs, for this QAPP are listed in Table 5. The percent spike recovery is calculated using the formula:

Percent Recovery: $\%R = \frac{X_i - X_B}{T} \times 100$

Where: X_i is the measured value, X_B is the background value, and T is the true or expected value.

Completeness

Completeness is a DQI defined as the number of samples collected (or valid results obtained) as compared to the number of samples (or valid results) called for in the Monitoring Plan. Completeness is based on the number of samples needed to enable use of the information, expressed as a percentage. Completeness does not use results that are qualified as rejected or unusable, or that were not reported as sample loss or breakage. The DQO for completeness for this Project is 90% (Table 4). Completeness is calculated with the following formula:

$\%C = [1 + (Y-X)/X] \times 100$

Where: %C = Percent completeness
Y = the number of valid data points
X = the total possible number of data points.

Data Quality Objectives

A: Enumeration

Method sensitivity is dealt with by the inclusion of the required SWAMP Target Reporting Limits, where such values exist, and by the application of the definition of a Minimum Level as provided by the Inland Surface Water and Enclosed Bays and Estuaries Policy. Target Reporting Limits exist for total coliforms, *E. coli* and *Enterococcus*. The Method Detection Limit (MDL) is the lowest possible concentration the instrument or equipment can detect. This is important to record because one can never determine that a pollutant was not present, only that one could not detect it. Both Colilert and Enterolert tests can detect a minimum of 1 MPN/100ml.

B: MST

For *Bacteroidales* analyses, we will perform 5 qPCR assays on one extract. Accuracy will be determined by repeatedly extracting a known fecal source and performing *Bacteroidales* assays. However, for qPCR analysis, the MDL is not identical with the sample limit of detection, which is variable and will be calculated separately for each sample for *Bacteroidales* genetic markers, according to an equation developed by the Wuertz Laboratory {Rajal, 2007b #209. }

C: Hydrology - terrestrial

Because streamflow is constantly changing, data quality objectives are based on accuracy and precision of the equipment rather than the individual measurement. Instruments for streamflow discharge measurements (velocity meters) are tested before every measurement. Velocity meters must spin a minimum duration of time to be used for a measurement (90 seconds for the Price AA meter, or 45 seconds for a bucket-wheel pygmy meter).

D: Hydrology - aquatic

Since we will be attempting to identify and characterize more than one set of different conditions {such as conditions of wind, swell, tidal stage, and terrestrial inputs (circulation during storms)}, data quality objectives are based on accuracy and precision of the equipment rather than the individual measurement. Instruments will be tested before each run. Rhodamine WT Red is approved for use as a conservative tracer by the US EPA. Using Rhodamine dye (at the manufacturers rated strength of 20%) will ensure detection after dilution. The fluorometer will be blank-adjusted using deionized water. Replicate analysis of the same sample collected in the field will give comparative errors to the dilution control measures.

Table 3. (Element 7) Data quality objectives for laboratory measurements.

Group	Parameter	Accuracy	Precision	Recovery	Method Detection Limit	Completeness
Bacterial Analyses *Colilert-18 (Idexx)*	Total coliforms and *E. coli*	Positive results for target organisms. Negative results for non-target organisms	The San Mateo Public Health Lab is ELAP certified Cert. #1591. Lab follows all of section 9020, Standard Methods 20th Edition	See appendix IDEXX 6I&6J, 12E&Budnick	10-24,191 MPN/100 mL	90%
Bacterial Analysis Enterolert (Idexx)	Enterococci	Positive results for target organisms. Negative results for non-target organisms	The San Mateo Public Health Lab is ELAP certified Cert. #1591. Lab follows all of section 9020, Standard Methods 20th Edition	See Appendix Idexx 12E & Budnick	10-24,191 MPN/100 mL	90%
UCD	PCR assays for *Bacteroidales* source markers (universal, human, cow, dog)	positive/negative controls	Lab duplicates same results (presence/ absence); one duplicate every day of testing	> 50% true recovery based on filtration and extraction	1-4 gene copies per PCR reaction	90%
UCD	New PCR assays for seagull source markers	positive/negative controls	Lab duplicates same results (presence/ absence); one duplicate every day of testing	> 50% true recovery based on filtration and extraction	To be determined	90%

Table 4. (Element 7) Data quality objectives for field measurements.

Group	Parameter	Representativeness	Accuracy	Precision	Method Detection Limit	Completeness
UCD/Balance Hydrologics	Total suspended solids (TSS)	With each MST monitoring event, based on 1Liter sample	± 0.5 mg or 10%	± 0.1 mg	0.1 mg	90%
UCD/ Balance Hydrologics/SMCRCD	Conductivity	With each monitoring event and then as part of the circulation study	± 0.5% FS	± 5%	200 µS conductivity	90%
UCD/ Balance Hydrologics/SMCRCD	pH	With each monitoring event and then as part of the circulation study	+ 0.1 pH unit within + 10°C of calibration temperature or + 0.2 pH unit within + 20°C of calibration temperature	± 0.1 pH unit	0	90%
UCD/ Balance Hydrologics/SMCRCD	Water Temperature	With each monitoring event and then as part of the circulation study	± 0.1 °C or ± 1 LSD	± 0.1°C	0.1°C	90%
UCD/ Balance Hydrologics	Harbor currents	With the preliminary and major dye-tracing events chosen to represent spatial, temporal and meteorological variation at a diagnostic time of year	Qualitative Comparison to Waverider Buoy; Calibrated Annually	1% Measured Value	0.5 cm/s to 10 m/s	each of two monitoring events
Balance Hydrologics	Water Pressure	Every 15 minutes throughout the assigned flow monitoring period	0.05% FS	.002-0.0006% FS	0.001ft	90%
Balance Hydrologics	Flow	With each flow monitoring event	+/- 8% depending on field conditions	+/- 8% depending on field conditions	0cfs	90%
Balance Hydrologics	Stream Depth	With each flow monitoring event, and in addition if necessary	+/- 0.01feet	+/- 0.01feet	0feet	90%
Balance Hydrologics	Rhodamine WT	Positive/negative controls	Quality control samples agreed to within 5% of measured undiluted samples	Not applicable	.1-100 micrograms per liter	80%

8. SPECIAL TRAINING NEEDS/CERTIFICATION

8.1 Specialized training or certifications.
No specialized training or certifications are required for SMCRCD field staff, for this project. All staff involved will be familiar with the field guidelines, fully trained in the aseptic technique of bacterial sample collection and procedures. Additional training will be provided by Professor Wuertz for the collection of the samples for MST. The Resource Specialist has access to the SWAMP Field Methods Course on CD_ROM and will review course materials prior to field work. The SWAMP Quality Assurance Management Plan (QAMP), Appendix D, Field collection of water samples (Appendix 1) will also be consulted prior to field work where applicable. The Resource Specialist has had volunteer training for two other SWAMP compliant field water quality sampling projects.

The Department of Health Services certifies San Mateo County Public Health Laboratory (SMCPHL). The Laboratory provides training to its staff as part of its Standard Operating Procedures. California ELAP Certificate No. 1591 CLIA certificate No. 05D0857622.

The Department of Civil and Environmental Engineering, UC Davis provides training to all personnel engaged in scientific research on an ongoing basis. An illness and injury prevention protocol is updated regularly by the department safety committee. Professor Wuertz is chair of the committee. Specific laboratory training is given to all personnel, including staff and students by the Laboratory Manager and Principal Investigator associated with the research in question.

Balance Hydrologics provides training to all personnel engaged in field investigations and hydrologic analysis on an ongoing basis. All work is conducted under supervision of a registered professional. Barry Hecht is registered in California as a Geologist (#3664). He is also certified in California as an Engineering Geologist (#1245) and a Hydrogeologist (#50).

8.2 Training and certification documentation.
SMCPHL maintains records of its training. Those records can be obtained if needed from SMCPHL through the Quality Assurance Officer. The SMCPHL is a certified Clinical and Environmental Microbiology Laboratory.

The Department of Civil and Environmental Engineering, UC Davis maintains training logs for all personnel engaged in scientific research as is required by law. Those records can be obtained if needed from the Safety Coordinator, Professor Wuertz.

8.3 Training personnel.
The SMCRCD Resource Specialist provides training in field sampling for enumeration samples.

SMCPHL's Lead and Senior personnel, along with the Laboratory Safety Officer, provide all necessary training to laboratory personnel.

The Department of Civil and Environmental Engineering UC Davis will provide training by the Laboratory Manager and Primary Investigator.

The Principal Hydrologist will direct training activities at Balance Hydrologics.

Table 5. (Element 8) Specialized personnel training or certification. n/a

9. DOCUMENTS AND RECORDS

All field parameters will be recorded at the time of collection, using the field data sheets. Data sheets will be reviewed for errors and omissions before leaving the sample site. Field data sheets as well as copies of all records held by SMCPHL and the Department of Civil and Environmental Engineering UC Davis, will be stored in hard copy form at the SMCRCD office. Field data sheets are archived for three years from the time they are collected. All data will be entered into an MS Excel or MS Access database. If data entry is ever performed at another location, duplicate data sheets will be used, with the originals remaining at the SMCRCD's office site. Hard copies of all data as well as computer back-up disks are maintained by the Resource Specialist.
Samples being sent to SMCPHL and the Wuertz Laboratory, UC Davis will include a COC form. SMCPHL and Wuertz Laboratory will generate records for sample receipt and storage, analyses and reporting.

The Resource Specialist will maintain sample collection, sample transport, and COC forms as well as maintain the database. Douglas Coffman and Lab Information Services at SMCPHL and graduate student, Dan Wang at The Wuertz Laboratory, UC Davis will maintain all records associated with the receipt and analysis of samples.
Copies of the records, for sample collection, and laboratory analysis will be maintained at the SMCRCD for 3 years after the final grant payment. Copies of records at the SMCPHL and the Wuertz Laboratory, UC Davis will be ***maintained for a minimum of 5 years.***
All records will be delivered to the SWRQCB'S Grant Manager, Jennifer Toney, at project completion.

Copies of the QAPP will be distributed to all parties involved with the project directly or by mail. Copies will be sent to the SMCPHL and The Wuertz Laboratory, UC Davis directors/managers for distribution within the laboratory. Any future amended QAPPs will be held and distributed in the same fashion. All originals of the first and subsequent amended QAPPs will be held at the SMCRCD office. The Resource Specialist will be responsible for the distribution of the QAPP.

A final data report will be prepared containing data collected for this project and summarizing activities conducted to generate that data. The data report package will include:

- Field data sheets and field notes
- COC forms
- Geographical locations of sampling sites determined by a Global Positioning System (GPS) device
- SMCPHL and the Wuertz Laboratory UC Davis, records of sample receipt and storage, analyses and reporting.

The data will be presented in a tabular format in a technical report to the Grant Manager. The report will include results of the analyses of the QC samples and an assessment of the overall quality of the data in comparison to the objectives described in the QAPP. The data report package will be submitted to the Grant Manager with the quarterly report following the sampling event. The technical report will include the following sections:

1.0 Introduction: background, problem, objective and the hypotheses proposed
2.0 Location and methods
3.0 Results and discussion
4.0 Conclusion and recommendations
5.0 References
Appendices, if necessary

Table 6. (Element 9) Document and record retention, archival, and disposition information. Not to be used.

GROUP B: DATA GENERATION AND ACQUISITION

10. SAMPLING PROCESS DESIGN

A and B: Enumeration and MST

The plan below outlines the proposed approach and is subject to modification as circumstances arise, such as drought or unexpected findings from enumerated samples. The project will measure *E. coli, Enterococcus* and *Bacteroidales* according to the sampling plan below. Refer to Figure 2 for location of sampling sites listed in the table below. Potential sources of bias or misrepresentation are unknown sources of fecal indicator bacteria and *Bacteroidales* for which no source tracking assays are available. To address this possibility fecal samples from a variety of animal species will also be collected to verify if any of the *Bacteroidales* assays could detect fecal bacteria from such sources in water samples. In particular, the ability of the universal *Bacteroidales* assay to detect fecal input from various birds frequenting the shore will be evaluated. Further, the number of samples collected from each site affects the ability to detect statistically significant differences in mean values among sites. Other factors that affect this ability are the "power" at which one wants to have confidence in results, the expected variability of the data, and the difference in means that one would like to observe. Using historical fecal indicator data, a power analysis will be performed establishing alpha value (i.e. the chance that a significant difference among two sites will be reported when none actually exists), power value (i.e. the chance that a significant change will be missed), and coefficient of variation. Taken together these steps will lead to a minimization of errors due to bias or misrepresentation.

Table 7 (Element 10) Sampling Plan

Site	Approach	Frequency		
		events per yr	samples per event	Years
Mavericks Beach	2 events per wet season	2	3	3
	2 events per dry season	2	3	3
	2 events per first flush	2	3	3
	upper watershed survey if spike found	3	8	1
	dog survey	2	2	1
	sediment/wrack survey	2	9	1
	avian survey	2	5	1
Marsh Beach	2 events per wet season	2	3	3
	2 events per dry season	2	3	3
	2 events per first flush	2	3	3
	upper watershed survey if spike found	3	8	1
	dog survey	2	5	1
	sediment/wrack survey	2	9	1
	avian survey	2	5	1
Yacht Club Beach	2 events per wet season	2	3	3
	2 events per dry season	2	3	3

	2 events per first flush	2	3	3
	upper watershed survey if spike found	3	8	1
	dog survey	2	5	1
	sediment/wrack survey	2	9	1
	avian survey	2	5	1
Denniston Creek	sanitary survey with 3 consecutive sampling events at 25 sites	3	25	1
	20 events at approximately 10 sites selected for follow-up	20	10	1
	biweekly sampling	26	10	2
	sediment/wrack survey	2	9	1
	dog survey	2	5	1
	avian survey	2	5	1
	Bacteroidales for MST, 4 events (wet, dry, first-flush, and other) at 5 sites with 2 samples per site	4	10	1
Capistrano Pipe	sanitary survey with 3 consecutive sampling events at 25 sites	3	25	1
	20 events at approximately 10 sites selected for follow-up	20	10	1
	biweekly sampling	26	10	2
	sediment/wrack survey	2	9	1
	dog survey	2	5	1
	avian survey	2	5	1
	Bacteroidales for MST, 4 events (wet, dry, first-flush, and other) at 5 sites with 2 samples per site	4	10	1
Capistrano Beach	25 events at 1 site	25	1	1
	biweekly sampling	26	7	3
	sediment/wrack survey	2	9	1
	dog survey	2	5	1
	avian survey	2	5	1
Bathroom Outfall	sanitary survey with 3 consecutive sampling events at 25 sites	3	25	1
	20 events at approximately 10 sites selected for follow-up	20	10	1
	biweekly sampling	26	10	2
	sediment/wrack survey	2	9	1
	dog survey	2	5	1
	avian survey	2	5	1
	Bacteroidales for MST, 4 events (wet, dry, first-flush, and other) at 5 sites with 2 samples per site	4	10	1
Beachhouse Beach	2 events per wet season	2	3	3
	2 events per dry season	2	3	3
	2 events per first flush	2	3	3
	upper watershed survey if spike found	3	8	1
	dog survey	2	2	1

	sediment/wrack survey	2	9	1
	avian survey	2	5	1
Live-aboard Boats	3 events at 10 sites	3	10	1
	sediment/wrack survey	2	9	1
	dog survey	2	5	1
	avian survey	2	5	1
Contingent MST	*Bacteroidales* MST for any of the above sites as follow-up to elevated bacteria levels as determined from enumeration studies. Preliminary estimates are for 5 triggers at 6 locations with 2 samples per site.	5	12	1

C: Hydrology - terrestrial

The general process of measuring streamflow discharge has been well document by the U.S. Geological Survey (Buchanan and Somers, 1976). Two factors went into the design of the flow monitoring component of the project: 1) sampling locations, and 2) sampling timing. Streamflow-discharge measurements will be collected at various sites throughout the watersheds. The sites have been selected so that the data collected should elucidate which portions of the watersheds are contributing significant amounts of flow to Pillar Point Harbor. The timing of the sampling will be done primarily when flows are high but will include dry weather stations where feasible.

D: Hydrology - aquatic

Circulation data will be collected during two runs in late summer or early fall using a fluorometric dye study. First will be a preliminary run to test the vertical distribution of dye in the water column in this harbor which has an average depth of 15'. The second run will be a full scale assessment of dye released from three points of interest in defining the circulation within the harbor. Sampling sites are allocated to a series of transects perpendicular to shore. The information gathered will be used during the analysis of FIB data as well as MST data to determine the effects of harbor circulation dynamics on FIB sources. The test and full scale events are planned for the summer/fall of 2008, a period when surface runoff is negligible, uncoupled from specific meteorological events. By sampling close to the onset of the winter rainy season, we hope to characterize the intrinsic water quality characteristics of the harbor.

11. SAMPLING METHODS

A: Enumeration Samples

Samples will be collected according to a combination of: a) Standard Operating Procedures as described in the SWAMP Quality Assurance Management Plan, Appendix D, Field Collection of Water Samples and b) Appendix E, SWAMP SOPs and recommended Methods for Field Data Measurements and c) Standard Methods for the Examination of Water and Wastewater 20th Ed., which describe the appropriate sampling procedures for collecting samples for water chemistry.

All samples will be grab samples, and are to be collected at the same time as the 4-100 liter water sample for MST analysis and a separate sample for TSS analysis. The TSS sample is to be collected in a 1 liter HDPE bottle with no preservation. Grab samples are to be collected at approximately mid-stream, mid-depth at the location of greatest flow (at least one inch below the surface) by direct submersion of the sample bottle depth. Whenever possible, samples will be taken away from the stream bank in the main current. Stagnant water will not be sampled. If it is necessary to wade into the water, the sample collector will stand downstream of the sample, taking a sample upstream. If the collector disturbs sediment when wading, the collector will wait until the effect of the disturbance is no longer present before taking the sample. The collector will also be careful to not touch the inside of the sample bottle at anytime. If the inside of the sample bottle is accidentally touched another sample bottle will be used. This is the preferred method for grab sample collection, and shall be adhered to as long as the safety of the sampling personnel is not jeopardized by doing so. Modifications are to be made only as necessary, and clean sampling techniques are always to be followed. An extension pole type sampling device will be provided by SMCRCD to all field staff. Samples will be collected in plastic sterile water sample bottles provided by SMCPHL. Bottles are from E+K Scientific, item# 690120: sterile coliform vial with Sodium Thiosulfate pill. After collection the samples will be immediately placed on ice in a cooler for transport to SMCPHL, coolers will contain freezer packs. All samples will be delivered to the SMCPHL in a suitable time so that the holding time (6 hours) will not be exceeded before analysis can begin. All specimen and test data will be captured in the Laboratory Information System. Control samples will be collected at the same time as the indicator samples, and also immediately placed on ice. The proper COC form (See Appendix) will be filled out and signed by the appropriate lab personnel prior to releasing the samples to them.

B: *Bacteroidales* Samples.

Sample Collection

Sample collection involves: collection of indicator samples for *E. coli*, total and fecal coliforms, and Enterococci; collection of up to 100 liters of water at each site for MST; collection of a 1 liter raw sample for TSS analysis; and field measurements of water quality parameters and flow characteristics at each site.

Field crews will always consist of at least two persons, and will only be mobilized for sampling when weather conditions and flow conditions are considered to be safe. For safety reasons, sampling will occur during daylight hours. A sampling event should proceed in the following manner:

1 Before leaving the sampling crew base of operations notify appropriate laboratories, and check sampling checklist to guarantee that all necessary equipment will be available during sampling event.
2 Proceed to the first sampling station.
3 Fill-out the general information on the field log sheet.
4 Take field measurements and observations, and record all on the field log sheet.
5 Take the samples indicated on the field log sheet in the manner described in this study plan. Sample will include indicator samples, suspended solid sample, and 100-liter water samples for pathogen analysis and MST efforts.
6 Take additional volume and blank samples for field-initiated QA/QC samples, if required. Place indicator sample bottles, and total suspended solids samples in the coolers with ice.
8 Double-check against the log sheet that all appropriate bottles were filled.
9 Repeat the procedures in steps 3, 4, and 5 for each of the remaining sampling stations.
10 Complete the COC forms using the field notes.

11 After collection is completed, deliver the samples to laboratory within 6 hours of the first sample collection.

Clean Sampling Techniques

Samples will be collected using "clean sampling techniques" to minimize the possibility of sample contamination. For this program, clean techniques must be employed whenever handling bottles, lids, or intermediate containers. Clean sampling techniques are summarized below:

- Samples are collected only into new, clean, laboratory provided sample bottles.
- At least two persons, wearing clean powder-free nitrile gloves at all times, are required on a sampling crews.
- Clean, powder-free nitrile gloves are changed whenever something not known to be clean has been touched.
- For this program, clean techniques must be employed whenever handling grab sample or intermediate bottles.
- To reduce the potential for contamination, sample collection personnel must adhere to the following rules while collecting samples:
  1. No smoking.
  2. Never sample near a running vehicle. Do not park vehicles in immediate sample collection area, even non-running vehicles.
  3. During wet weather events avoid allowing rainwater to drip from rain gear or any other surface into sample bottles.
  4. Do not eat or drink during sample collection.
  5. Do not breathe, sneeze or cough in the direction of an open sample bottle.

Control Samples

Quality control samples shall be collected according to a schedule pre-determined by SMCRCD. Specific collection methods for each type of quality control sample type are described below.

Field blanks should be collected for the stations and events specified by SMCRCD. The field crew will use blank water provided by the Wuertz Laboratory to generate field blanks by pouring blank water directly into the sample bottles. Field blanks should be submitted "blind" to the Wuertz Laboratory as Station PPH 1226-B designation. If detected values are reported for field blanks, the frequency of collection will be increased.

Field duplicates shall be collected immediately following the collection of normal samples. In cases where multiple intermediate bottles are used for a single analysis, field duplicates and normal sample containers should be filled in an alternating sequence (i.e., normal-duplicate-normal-duplicate). Field duplicates should be submitted "blind" to the Wuertz Laboratory as Station PPH 1226-XXX (Xs are for the duplicate field station)

Laboratory duplicate analyses should be requested for all constituents for the stations and events specified by the Wuertz Laboratory. No special sampling considerations are required. However, additional sample volume must be collected, per laboratory requirements, for each analysis.

Corrective actions for any problems associated with sampling methods will be the responsibility of the SMC Resource Specialist. Corrective actions may include locating alternate field sampling devices if equipment malfunctions and cannot be repaired before a sampling event and improvised procedures which will be clarified with the PI.
Corrective actions will be documented in the field logs and addressed in the quarterly report.

Water Samples for MST.

Clean plastic buckets are to be used to collect all MST samples. Samples are then to be poured into clean 4- or 20-liter plastic carboys. Up to 100 liters of water are to be collected at each site for filtration purposes, allowing for pathogen analysis and MST processing. Both buckets and carboys must be cleaned and disinfected prior to leaving for a sampling trip. Alternatively, water can be pumped using a clean Purge pump. Cleaning protocols are listed below.

Protocol for cleaning pumps and bottles for water sampling:

1. Water samples are to be collected in Nalgene polypropylene autoclavable bottles. Before the sampling trip, clean the bottles with soap (1% Alconox) and rinse with hot water. Then rinse 3 times with DI water. Autoclave using a cycle at 121 ºC for 15 min.*
2. Cleaning solutions are to be prepared before the sampling trip. One carboy (20-L) of 1%Alconox, one carboy of 70% ethanol, and 2 carboys of DI water are prepared. The carboys are to be cleaned before use by rinsing with soap (1% Alconox), rinse with hot water, rinse 3 times with DI water, and then autoclave.
3. On the day of the sampling, proceed to the first sampling station. Connect new tubing to a clean Purge pump (Geotech). Mark the tubing for 3 ft long. Place the pump into water and make the 3ft marker right at the water surface.
4. Start pumping by connecting the pump to the battery. Let the pump run without taking water into a container for 2-3 min to rinse the system. Then place the end of the tubing into the container. Make sure the container has a correct label for the current station. Fill up the container. Double check the label.
5. After the sampling, start cleaning the pump by pouring 1% detergent into a detergent bucket. Submerge the pump and place the end of the tubing inside the bucket. Run the pump for 2-3 min.
6. Pour 70% ethanol into an ethanol bucket. Submerge the pump and place the end of the tubing inside the bucket. Run the pump for 2-3 min.
7. Pour DI water into a DI bucket. Submerge the pump but do not place the end of the tubing back into the bucket. Run the pump for 2-3 min.
8. Put the clean pump aside for the next station. Remove the tubing and connect the pump with new tubing for the next station. Place lids on the buckets and stack them aside. If no lid was brought, stack the ethanol bucket on top of the Alconox bucket, and stack the DI water bucket on the very top, in order to avoid contamination.
9. Proceed to the next sampling station, and repeat steps 3-9.
10. After all stations have been sampled, complete the COC forms using the field notes.

* Ref: Microbiological Methods for Monitoring the Environment—Water and Wastes, US EPA, 1978.

All carboys shall be labeled with the following information: location of sample collection, as well as date and time collected. All labels shall be placed on the side of the carboy, and not on the lid. Carboys should be labeled at the time of sample collection to avoid any possible sample switches.

Water samples are to be processed within 48 hours of collection, and can be processed in the field or in the laboratory (see "Filtration and Processing of Large Water Samples"). Due to the size and number of large water samples, they are to be transported at the ambient temperature.

Water Quality Parameters and Field Observations

Additional lumped water quality parameters are to be taken, and observations made, at each sampling station before a sample is collected. These data are to be assembled for use as needed within the study, and as a reference in comparison to historical data. Field measurements will include flow, pH, water temperature, conductivity, and dissolved oxygen. Temperature, pH, conductivity, and dissolved oxygen measurements will be taken at approximately mid-stream, mid-depth at the location of greatest flow (if feasible). Flow measurements will be recorded with a flow meter or estimated at each sampling station before a sample is collected.

If at any time the collection of field measurements by wading appears unsafe, the attempt to collect mid-stream, mid-depth measurements will be abandoned. If in-stream field measurement is not safe, collect field measurements from a stable, unobstructed area at the reach's edge or use an expandable pole and intermediate container to obtain sample for field measurements. Field measurements in the harbor itself will involve usage of a boat operated by the harbor master or another qualified individual.

In addition to field measurements, observations will be made at each sampling station. Observations will include color, odor, floating materials, presence of wildlife, as well as observations of contact and non-contact recreation. All field measurement results and comments on field observations will be recorded in the field log provided.

Another water quality measurement that is to be performed in-lab is the measurement of suspended solids at each site. A portion of the 4 - to100-liter water sample is to be set aside previous to the filtration process of the water sample, and suspended solids determination is to be conducted according to Standard Methods, 20th edition, method 2450D.

Field Protocols

Field crews (2 persons per crew, minimum) will only be mobilized for sampling when weather conditions and flow conditions are considered to be safe. For safety reasons, sampling will occur during daylight hours. A sampling event should proceed in the following manner:

1. Before leaving the sampling crew base of operations, notify laboratory, confirm number and type of sample bottles as well as the complete equipment list.
2. Proceed to the first sampling station.
3. Fill-out the general information on the field log sheet.
4. Take field measurements and observations, and record on the field log sheet.
5. Take the samples indicated on the field log sheet in the manner described in this study plan. Take additional volume and blank samples for field-initiated QA/QC samples, if required. Place bottles in the coolers with ice. Double check against the log sheet that all appropriate bottles were filled.
6. Repeat the procedures in steps 3, 4, and 5 for each of the remaining sampling stations.
7. Complete the COC forms using the field notes.
8. After collection is completed, deliver the samples to Wuertz laboratory within 6 hours of the first sample collection.

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C: Hydrology - terrestrial

Streamflow- Flow measurement methods and computational procedures will conducted according to the U.S. Geological Survey (see Buchanan and Somers, 1976) and U.S. Army Corps of Engineers standards, enabling comparison with results of similar studies previously conducted by these agencies. The standards are available at the USGS website (http://pubs.usgs.gov/twri/) and upon request from Balance Hydrologics.

The frequency of streamflow measurements will be dictated by the weather, specifically how many and how often significant rainfall events occur and how long runoff continues. We would like to measure streamflow six to eight times during the wet season and will measure streamflow periodically during the dry season. The actual dates will depend on the weather, and the flows that are generated

Staff plates and Solinst leveloggers will be installed at the two or three gauging stations that will be used for this component of the study. Water level will be measured (by visual observation) at the staff plates during each site visit and leveloggers will be downloaded periodically according to the operator manual.

D: Hydrology - aquatic

Measurements for the circulation study will consist of Rhodamine WT fluorometric dye being released at three preselected sites in order to include the potential influences of wind, tide, swell and other driving forces. The dye release will then be monitored a) visually at preselected sites and b) by the organized collection of samples along transects for analysis using a fluorometer. Volunteer pilots/fliers from the airport will attempt to photograph the dye dispersion, although this is not an essential component of the study. Salinity data will be measured concurrently.

12. SAMPLE HANDLING AND CUSTODY

A: Enumeration samples:
After collection the samples will be immediately placed on ice in a cooler for transport to SMCPHL, coolers to contain freezer packs. All samples should be delivered to the SMCPHL in a suitable time for which the holding time (6 hours) will not be exceeded before analysis can begin. All specimen and test data will be captured in the Laboratory Information System. The COC form is used as a shipping record.

B: *Bacteroidales*:
Water samples will be placed on ice and transported to the Wuertz Laboratory. Analysis will occur within 24hours. COC forms will be filled out for all samples submitted to the Wuertz Laboratory. Sample data, sample location, sample collection crew names, and analysis requested shall be noted on each COC. See Appendix 1 for a blank COC form.

Sample Handling
Identification information for each sample will be recorded on the label on the plastic sample bottles when the sample is collected. Samples will be labeled with the water body name, sample location, sample number, date and time of collection, sampler's name. Subsequently, identification information for each sample will be recorded on the lab data sheet (see Appendix 1) before submission to SMCPHL.

Custody Procedures
The conventional water quality monitoring tests do not require specific custody procedures since they will be conducted immediately by SMCPHL. In special circumstances (such as severe weather conditions), sample collection will be rescheduled in a timely and orderly manner.

Disposal
All of the SMCPHL waste is handled as medical waste and discarded in accordance with a Medical Waste Management Plan and permit which meet all CLIA and California ELAP requirements.

All of the UCD waste resulting from qPCR analyses will handled as hospital waste and discarded in accordance with Hospital Waste Regulations and meets the California ELAP requirements.

Table 8. (Element 12). Sample handling and custody – Enumeration Samples

Parameter	Container	Volume	Initial Preservation	Holding Time
E. coli	125 ml sterile plastic (high density polyethylene or polypropylene) container	100 ml volume sufficient for both E. coli and Enterococci analyses	Cool to 4°C; dark.	STAT: 6 hours at 4°C, dark; lab must be notified well in advance
Enterococci	125 ml sterile plastic (high density polyethylene or polypropylene) container	100 ml volume sufficient for both E. coli and *Enterococcus* analyses	Cool to 4°C; dark.	STAT: 6 hours at 4°C, dark; lab must be notified well in advance
TOTAL COLIFORM	125 ml sterile plastic (high density polyethylene or polypropylene) container	100 ml volume sufficient for both fecal and total coliform analyses	Cool to 4°C; dark.	STAT: 6 hours at 4°C, dark; lab must be notified well in advance

Table 9. (Element 12). Sample handling and custody – *Bacteroidales* Samples

Parameter	Container	Volume	Initial Preservation	Holding Time
Bacteroidales	Autoclavable plastic container (polycarbonate)	4 -100 L	Keep on ice	24 h

Transport to Lab

Samples will be stored in coolers with ice and delivered to
A) Enumeration - SMCPHL, San Mateo and
B) qPCR - UC Davis at the address provided in the field protocols section of this plan.

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13. ANALYTICAL METHODS

Table 10. (Element 13) Field analytical methods.

Analyte	Laboratory / Organization	Project Action Limit (units, wet or dry weight)	Project Quantitation Limit (units, wet or dry weight)	Analytical Method		Achievable Laboratory Limits	
				Analytical Method/ SOP	Modified for Method yes/no	MDLs (1)	Method (1)
Surface water temperature	UCD/ SMCRCD/Balance	Not applicable	Not applicable	YSI handheld model manual	No	0° C	0° C
Conductivity	UCD/ SMCRCD/Balance	Not applicable	Not applicable	YSI handheld model manual	No	10 µS/cm	10 µS/cm
Dissolved Oxygen	UCD/ SMCRCD	Not applicable	Not applicable	YSI handheld model manual	No	0 mg/L	0 mg/L
pH	UCD/ SMCRCD	Not applicable	Not applicable	YSI handheld model manual	No	pH=0	pH=0
Fluorescence	Balance Hydrologics	Not applicable	Not applicable	10-AU Field Fluorometer manual	No	10ppt Rhodamine WT in potable water	10ppt Rhodamine WT in potable water

Table 7. (Element 13) Laboratory analytical methods – Enumeration Samples

Analyte	Laboratory / Organization	Project Action Limit (units, wet or dry weight)	Project Quantitation Limit (units, wet or dry weight)	Analytical Method		Achievable Laboratory Limits	
				Analytical Method/ SOP	Modified for Method yes/no	MDLs (1)	Method (1)
Total coliform	SMCPHL	< 1000 MPN/100 mL for Total coliform	10-24,191 MPN/100mL	Standard Methods 9223B Enzyme substrate: IDEXX and SMCPHL SOP	None	10 MPN/100 ml	10 MPN/100 mL
E. coli	SMCPHL	< 200 MPN/100 mL for *E. coli*	10-24,191 MPN/100mL	Standard Methods 9223B Enzyme substrate: IDEXX and SMCPHL SOP	None	10 MPN/100 ml	10 MPN/100 mL
Enterococcus	SMCPHL	< 35 MPN/100 mL for *Enterococcus*	10-24,191 MPN/100mL	Enzyme substrate Method: IDEXX and SMCPHL SOP	None	10 MPN/100 ml	10 MPN/100 mL

Each piece of equipment in the San Mateo Public Health Laboratory is on a preventive maintenance schedule. Full records and documentation is kept for each piece of equipment in the Preventive Maintenance Manual. Complete operating and handling instructions for each piece of equipment are covered in the lab SOP's.

When equipment failure occurs, the Lead Lab Tech, Douglas Coffman and/or Assistant Lab Director, James Carlson PhD is notified and the appropriate repair services are scheduled. In all cases there is enough redundancy within the lab to use another piece of equipment or to use the designated back-up equipment for each piece of equipment used for environmental testing. All backup equipment is physically contained within the lab. In all cases documentation is kept with all actions, to include date/time, action taken and all repairs performed.

All samples and test materials are disposed of in accordance with a Medical Waste Management Plan. The San Mateo Public Health Laboratory is a licensed facility with a complete MWMP that complies with the California Health and Safety Code, Title 22.

Table 8. Laboratory analytical methods – *Bacteroidales*

Analyte	Laboratory / Organization	Project Quantitation Limit (units, wet or dry weight)	Analytical Method		Achievable Laboratory Limits	
			Analytical Method/ SOP	Modified for Method yes/no	MDLs (1)	Method (1)
Filtration and concentration of target	UCD	10 gene copies per mL	Rajal et al. 2007a	No	1 gene copy per reaction	Rajal et al. 2007a
Bacteroidales genetic markers	UCD	10 gene copies per mL sample	Kildare et al. 2007	No	1 gene copy per reaction	Kildare et al. 2007

Bacteroidales

TaqMan® Analysis Procedures

Quantitative PCR will be used for to determine filtration recovery of virus and bacteria based on a surrogate *Acinetobacter* strain and for the detection of *Bacteroidales*. The following section will outline the general treatment used for TaqMan® analysis, as well as specific assays used in detection. For each run of *Bacteriodales* assays, both negative and positive controls are included. Should failures occur because these controls do not perform as expected the runs will be repeated. Dan Wang is the individual responsible for corrective action and appropriate documentation.

General Guidelines for all Samples Analyzed using TaqMan®

The following is basic protocol that is to be used for any TaqMan® assay, regardless of target sequence or organism type.

Protocol

1. Thaw samples to be analyzed, and mix well with a vortex. Extract nucleic acid using the Qiagen QiaAmp Viral RNA Mini Kit (small-scale extraction) according to manufacturer's instructions or the large-scale extraction protocol outlined previously.
2. Prepare the appropriate dilutions of sample RNA using RNase, DNase free molecular grade water. The dilutions for the extractions should not be made more than a half an hour ahead of time, and should remain covered at 4^{o}C until used.
3. Determine the total number of reactions needed (all dilutions in duplicate, plus a negative control, and a positive control when appropriate) and prepare a master mix appropriate for the microbe of interest. The negative control should be composed of the same water used to make the master mix. The master mix should always be made in a DNA/RNA free zone.
4. Load the master mix into a 96 well plate, and cover with foil adhesive cover before leaving the DNA/RNA free zone.
5. Load extract dilutions into the 96 well plate, which contains the previously made mastermix. Cover the plate with an optical adhesive cover, making sure that the adhesive cover is sealed across each well and at all sides of the cover. Pulse centrifuge to collect all liquid to the bottom of each well, and to remove any bubbles that may have been produced during the nucleic acid transfer.
6. Run the appropriate thermocycling profile for the microbe of interest.
7. Use Ct values to calculate total concentration of the microbe of interest per reaction by applying a standard curve (see, "Quantification with TaqMan® Results").
8. Calculate the corresponding concentration of the microbe of interest in the sample volume added to the TaqMan® reaction. Apply the appropriate equation to determine the original concentration of the microbe in the environmental water sample (see "Calculation of Target Quantity in Sample Retentate").
9. If no target is detected in a TaqMan® reaction, determine the detection limit for the microbe of interest (see, "Calculation of Sample Detection Limits").

Filtration and Processing of Large Water Samples

The samples collected for MST are to be concentrated by a two-step ultrafiltration process. The first step involves concentrating the water sample from 10 to 100 liters to approximately 1.5 liters using the "large" filtration system. The second step involves further concentrating the 1.5 liters of large system retentate to approximately 100 mL with the "small" filtration system. Both systems utilize the same principles and are discussed in more detail in the following sections of this report.

Large Filtration System

The following section will outline the procedures required during the concentration of each sample with the large filtration system. Strict application of this filtration protocol will ensure the quality control and quality assurance of the results of each sample relative to each other.

Protocol

1. Rinse filter with 20 liters of nanopure water (they were stored with 0.025% NaOH). Make sure that both the drain and the flow valves are closed before filling tank with the rinse water. Connect the feed line of the tank to the pump. Do not connect the return line to the feed tank, instead route it to waste. Open the permeate port, and allow a line to run to waste.
2. Turn pump on at 240 rpm. Run rinse water to waste with recirculate valve open so that the recirculate line alone is rinsing for 10 liters of water. Then close the recirculate valve slowly, without turning off the pump, to achieve an inlet pressure of 15-17 psi. Allow the rinse water to go to waste through the recirculate line and the permeate line simultaneously.
3. Pump until dry. Drain all liquid from permeate and retentate. All of the lines, and feed tank should be completely empty.
4. Connect the feed line of tank to the pump. Also, connect return line to feed tank.
5. Using sieves and funnel fill the tank to the 100-liter mark inside the tank, again making sure that the tank's flow valve and drain valves are closed. Take 2-liter water sample for suspended solids (Raw, see "Description of Filtration Subsamples"). If filtering in lab refrigerate "Raw" sample until analysis is performed. If filtering in field, place sample on dry ice and store at –20^{o}C until analysis in the lab. Refill the feed tank to the 100-liter mark.
6. Spike with 100 µL of bacteriophage PP7, and 400 µL of *Acinetobacter* sp**.** Each spike is to be prepared in advance, and stored in individual tubes in liquid nitrogen.
7. Mix well at full speed for 10 minutes. Take a subsample (Feed, see "Description of Filtration Subsamples"). Store as appropriate (see step 5).
8. Take a second feed sample. For this sample, place 10 ml of feed on lysis buffer for extraction. See "Large-Scale DNA/RNA Extraction" steps 3-6 in "TaqMan® Analysis Procedures" section. Store as appropriate (see step 5).
9. Open permeate port. Check that permeate line goes to clean and disinfected permeate tank, and that recirculate valve is open. Open the flow valve on the feed tank. Turn on pump at 240 rpm. Close recirculate valve slowly to achieve an inlet pressure of 15-17 psi.
10. When the permeate tank fills up, take a sample from the permeate tank (Permeate, see "Description of Filtration Subsamples"). Store as appropriate (see step 5). Run the permeate line to waste, and discard the remaining permeate.
11. Filter until the retentate in the feed tank is approximately near the black line in the bottom of the tank. This is important so that the volume of collected retentate will be about 1 liter. Turn pump off.
12. Drain the permeate port first, and discard the collected liquid.
13. Collect all of the retentate. Recovery will strongly depend on making sure all it collected. Open all drains on the feed tank and filter cart, collecting the retentate from within. Make sure that all lines are empty. Retentate volume should be around 1 liter. Measure the exact volume, and record in filtration check list. Place retentate in a clean beaker with a clean stir bar, and mix on a stir plate for 2 minutes. Take a sample while still on the stir plate. (Retentate, "Description of Filtration Subsamples"). Store as appropriate (see step 5).
14. Add "glycine 1" bottle to retentate (see "Filtration Bottle Definitions"). Bring the volume up to 1.5 liters with nanopure water. Make sure the feed tank drain valve is again closed, as well as the flow valve. Carefully pour retentate mixture back into feed tank. Avoid splashing the liquid, as it will cause bubbling to occur.
15. Close the permeate port and open the recirculate valve. Now open the tank flow valve, and turn the pump on at 130 rpm. Recirculate for 10 minutes to elute the membrane. Turn pump off. Disconnect feed and completely drain all lines, making sure to carefully collect all liquid within. Measure and record volume in the filtration check list. Place recirculate in a clean beaker with a clean stir bar, and mix on a stir plate for 2 minutes. Take a sample while still on the stir plate. (Recirculated, see "Description of Filtration Subsamples"). Store as appropriate (see step 5).
16. Place the remaining liquid, covered with clean foil, aside. Drain permeate liquid if necessary. Due to pressure some liquid can cross the membrane during the recirculation step.
17. Disconnect filter for a second elution step and later cleaning (see "Cleaning and Disinfection of Microza Filters"). Replace filter with dummy steel tube to clean the lines and feed tank.
18. For the second elution of the filter, add "glycine 2" bottle (see "Filtration Bottle Definitions") to one end of the filter, making sure that the other end is capped. Bubbles will be slowly displaced while the liquid fills the fibers. Cap the open end, and put the filter in the shaker. Shake at maximum speed for 20 minutes at room temperature. Drain the liquid completely from the filter, and register the volume in the filtration checklist. Place the liquid in a clean beaker with a

clean stir bar, and mix on a stir plate for 2 minutes. Take a sample while still on stir plate. (Membrane, see "Description of Filtration Subsamples"). Store as appropriate (see step 5).

19. Add the remaining membrane sample to the recirculated sample that was set aside. This will be further concentrated with the small filtration system. If processing in the lab, cover and store at 4°C until small system processing. If processing in field, carefully transfer liquid to a disinfected storage container with a tightly fitting lid. Label the container with sample name, sample date, and volume of retentate collected. Place sample on dry ice and store at –20°C until analysis in the lab.
20. Add 200 mL of "storage solution" (see "Filtration Bottle Definitions") to the filter for storage until cleaning.
21. To disinfect the lines and the feed tank, add approximately 3 liters of "disinfectant" (see "Filtration Bottle Definitions") to the feed tank. Make sure that the dummy bar is properly in place where the filter usually goes. Connect return line to feed tank, and open permeate port with a return line to feed tank also. Check that the recirculate valve is open. Turn pump on at maximum speed and recirculate for 10 minutes.
22. Spray the feed tank with 10% bleach solution, and scrub well with a brush. Rinse the feed tank with Deionized water thoroughly. The system is now ready for processing the next sample.

Small Filtration System

This section will outline the procedures required during the concentration of each sample with the small filtration system. Again, strict application of this filtration protocol is required to ensure the quality control and quality assurance of the results of each sample relative to each other.

Protocol

1. Divide the recirculate and membrane mixture between four large centrifuge tubes. Centrifuge at 2000 rpm for 5 minutes. If large system filtration was performed in field, the retentate will have to thaw at room temperature previous to this step.
2. Pour supernatant from each of the four centrifuge tubes into a clean beaker, with a clean stir bar. Cover and set aside.
3. Remove the solids from the centrifuge tubes. Measure and record volume in the filtration check list. Place solids in a labeled container. The label should contain the following information: sample location, Solids-SS, date collected, and volume collected.
    a. Example: ALP (Arroyo Las Posas), Solids-SS, 2/10/04, 14 mL.
4. Store solids at –20°C.
5. Place beaker with supernatant on a stir plate, and mix for two minutes. Collect subsample while still mixing (Feed, see "Description of Filtration Subsamples").
6. Pour feed into the feed tank of the small system. Make sure that the tank drain line is closed, and that the recirculate valve is open. Also, check that the permeate line is connected to the permeate port on the small filter, and that it is draining to a permeate tank. The recirculation line should feed into top of feed tank.
7. Turn on pump, and increase pump speed until it registers a reading of 10.
8. Make sure that the feed is recirculating properly, and then close recirculation valve slowly until an inlet pressure of about 18 psi is reached.
9. Allow system to filter liquid until retentate is at proper volume.
10. Collect a permeate subsample. (Permeate, see "Description of Filtration Subsamples").
11. Completely drain all of the retentate from all lines and from feed drain valve. Place in a clean beaker and set aside.
12. Remove filter, and place rubber fittings to each end. Fill a 60 CC syringe with 50 ml of a 1:10 dilution of glycine 1 solution (see "Filtration Bottle Descriptions"). Dilution should be made with nanopure water.
13. Insert the filled syringe into the end of one of the rubber fittings on the filter. Insert an empty syringe in the rubber fitting on the opposite end of the filter. Force liquid out of the syringe, through the filter, and allow it to fill the empty syringe. Continue this step, turning the filter upside down each time, for about 10 cycles.
14. Collect all liquid from the syringes and the filter. Use one of the syringes to force any of the remaining liquid from the filter.
15. Combine the eluted liquid, and the retentate liquid. Measure and record the volume in the filtration checklist. Place the mixture in a clean beaker, with a clean stir bar. Mix on stir plate for 2 minutes, and collect a subsample (Retentate, see "Description of Filtration Subsamples").
16. Also, place 10 ml of retentate on lysis buffer for extraction. See "Large-Scale DNA/RNA Extraction" steps 3-6 in "TaqMan® Analysis Procedures" section.
17. Place remaining liquid into a labeled container. The label should contain the following information: sample location, Retentate-SS, date collected, and volume collected.
    a. Example: ALP (Arroyo Las Posas), Retentate-SS, 2/10/04, 126 mL.
18. Store solids at –20°C.
19. Clean filter, and the small filtration system, by pouring about 2 liters of "cleaning solution" (see "Filtration Bottle Descriptions") to feed tank. Recirculate with the recirculation valve open at a speed of 30. Make sure that lid to feed tank is secured properly for this step! Run for at least 20 minutes.

20. Drain all liquid and rinse the system well with Deionized water. It is now clean for the next processing.
21. Rinse the filter well with Deionized water. The filter can be directly attached to the Deionized water faucet with a hose and allowed to run clean for at least 10 minutes.
22. Fill the filter with 50 mL of "storage solution" (see "Filtration Bottle Descriptions") until next use.

Filtration Bottle Definitions
Glycine 1: 150 mL of 0.5 M glycine/NaOH, pH 7.0 + 15 mL of 10% Tween 80.
It is added to the retentate to obtain (in 1.5 L volume) a final concentration of 0.05 M glycine/NaOH and 0.1% Tween 80.

Glycine 2: 200 mL of 0.05 M glycine/NaOH, pH 7.0

Storage Solution: 0.025% NaOH solution.

Disinfectant: 0.025 % NaOH + 200 ppm chlorine bleach.

Cleaning Solution: 4g/L NaOH with 7.5 ml/L of bleach.

Description of Filtration Subsamples
Raw: From original water sample, after sieving, and before any processing with the pump.

*Feed-Large System***:** Collected from feed tank, after addition of 100 L of sample, all appropriate spikes, and the completion of the mixing step for 10 minutes.

*Permeate-Large System***:** Collected from the permeate tank after at least 45 liters has accumulated.

*Retentate-Large System***:** The retentate after complete filtration of the whole volume of water sample. Subsample should be taken after mixing for 2 minutes on a stir plate.

*Recirculate-Large System***:** Retentate with the addition of glycine and Tween 80, after recirculation step. Subsample should be taken after mixing for 2 minutes on a stir plate.

*Membrane-Large System***:** The resultant liquid from eluting membrane with glycine, after shaking. Subsample should be taken after mixing for 2 minutes on a stir plate.

*Feed-Small System***:** The supernatant that remains from the centrifugation (at 2000 rpm for 5 minutes) of the mixture of the recirculate and the membrane from the large system. Subsample should be taken after mixing of supernatant for 2 minutes on a stir plate.

*Permeate-Small System***:** Collected from the permeate tank after the entire volume of the sample has been filtered.

Retentate-Small System: The mixture of the retentate remaining in the small system after filtration, and the volume that result from the elution of the small filter. Subsample should be taken after mixing for 2 minutes on a stir plate.

Subsampling Procedure
The subsample will consist of 10 mL.

To remove the subsample, use a sterile pipette each time. Place subsample in a sterile plastic 15 mL centrifuge tube, tighten the cap and label the tube with a waterproof sharpie. The label should contain the following information: sample location, type of subsample, small or large system, and date.

Example: ALP (Arroyo Las Posas), Feed - LS or SS, 2/10/04.

Subsamples shall be collected only from well-mixed sample volumes, and shall be stored at 4^{o}C if being analyzed within 8 hours, or at 20^{o}C for long-term storage.

Cleaning and Disinfection of Microza Filters

The Microza filters were designed for reuse. The disinfection of the filters is a very important step, due to the possibility of cross-contamination if the filter is not cleaned properly. The following is the protocol for disinfecting the Microza filters for the large system (small system filter disinfection is located in steps 17 and 18 of the "Small System Filtration" section of this report). This protocol is to be followed for the cleaning and disinfection of all Microza filters for each time they are used.

Protocol

Secure filter to stand and attach recirculation line. Route hose back to feed tank. Do not open permeate port.

1. Pour 2-3 liters of "cleaning solution" (see "Filtration Bottle Definitions") into feed tank. Turn on pump to maximum speed.
2. Pulse liquid through the lines and the filter. Stop pump, unhook feed line, and drain filter and lines.
3. Reconnect all lines and filter, and repeat steps 2-4 several times until liquid draining from filter and lines becomes clear. Repeat 5 more times.
4. Run cleaning solution through lines and filter continuously for about 20 minutes.
5. Stop pump, unhook feed line, and drain filter and lines.
6. Rinse feed tank well, and fill with about 50 liters of Deionized water. Repeat steps 2-4 and 6, this time with the Deionized water instead of the cleaning solution.
7. Open permeate port, and close recirculate valve slowly to achieve an inlet pressure of 15 psi. Allow 10 liters of water to pass through permeate before checking the flux of the filter. Flux must be at least 368 L / h. (9.7 sec per liter). Step 13 has detailed instructions for measuring the flux of the Microza filters.
8. Drain water from all lines. If flux is satisfactory, remove filter and fill with 200 mL of "storage solution" (see "Filtration Bottle Definitions"). If not, continue with steps 10-15. It is usually the case that the flux requirement has not been met by this point.
9. Fill feed container with 2-3 liters of citric acid solution (20 g/L citric acid). Turn on pump to maximum speed, with permeate port closed and recirculation valve open. Recirculate for 20 minutes at maximum speed. Then, open the permeate port, with the hose routed back to the feed tank, and slowly close the recirculation valve to reach an input pressure of 15 psi.
10. Run for as long as it takes to secure the approximate proper flux (368 L/hr).
11. Upon reaching the approximate proper flux, rinse the feed tank very well, and fill it with 60-70 liters of Deionized water.
12. Run a hose from the recirculation valve to waste. With the permeate port closed, allow 20-30 liters of Deionized water to pass through the open recirculation valve to waste with the pump set at 190 rpm. Turn off pump, connect a hose from the permeate port (now open) to waste. Turn on pump (again at 190 rpm), and slowly close the recirculate valve to achieve an input pressure of 15 psi.
    - After lines fill and equilibrate, place permeate line in a large graduated cylinder and measure time needed to pump 1 liter. Repeat.
    - Calculate flux in L/ hour. Flux must be at least 368 L / h. (9.7 sec per liter).
13. If flux is acceptable, test the pH of the permeate. The pH should be in the range of 6.0 – 7.0. Remove filter, drain all water, and fill with 200 mL "storage solution".
14. Cap and store at 4°C.

Nucleic Acid Extraction

Two different procedures are used for all DNA and RNA extraction needed for this project. The first procedure is for the extraction of nucleic acid from our samples requiring only "small scale DNA/RNA extraction". These consist mainly of subsamples taken and used for recovery calculations at differing times throughout the filtration process. The second procedure is for those samples that require a larger volume of nucleic acid extract, and is thus referred to as "large scale DNA/RNA extraction".

Small-Scale DNA/RNA Extraction

Samples requiring only small-scale extraction were extracted using the QIAamp Viral RNA kit (Qiagen, Valencia, CA) according to the manufacturer's directions. Final eluted volumes were approximately 80L.

Large Scale DNA/RNA Extraction

In order to analyze a larger fraction of the original sample, which is required for all final retentate samples, (and ultimately those samples contributing to global recovery calculations) a modified protocol for the Qiagen QIAampDNA Blood Kit (Qiagen, Valencia, CA) was developed. This new protocol involves the production of large quantities of lysis buffer (see preparation of lysis buffer in "Required Media and Solutions" section of this report). The following outlines the protocol to be used for all large-scale DNA/RNA extractions.

Protocol

1. Label a to a 200 ml conical plastic centrifuge bottle with the sample name and date of collection.
2. Turn on Bambino incubator to allow it to warm to 70°C. The incubator will be used later.

   Note: Steps 3-6 are performed in advance of extraction (See "Lab Filtration and Processing of Samples with Large System" and "Lab Filtration and Processing of Sample with Small System").
3. Add 40 mL of lysis buffer (1:4 ratio of sample:buffer) to the centrifuge tube. Make sure that the solids in the lysis buffer (which form due to refrigeration) are completely dissolved.
4. Completely mix the sample that will be extracted with a vortex (F-LS or R-SS).
5. While sample is still well mixed, and using a sterile pipette, transfer 10 ml of the sample into the centrifuge tube.
6. Pulse vortex 15 times, and let sit for 10 minutes at room temperature.

   Note: If steps 3-6 were previously performed, allow frozen sample to thaw at room temperature. Continue with steps 7-27.
7. Add 40 mL of ethanol (ethyl alcohol) to the centrifuge tube that contains the sample and the lysis buffer. Make sure to use either a sterile pipette or a sterile plastic tube to measure the ethanol. (1:1 ratio of ethanol:buffer).
8. Pulse vortex 15 times.
9. Centrifuge for 5 minutes at 4000 rpm.
10. Label all three pieces of a large extraction tube from the Qiagen QIAampDNA Blood Kit. Label with sample name and subsample collection date.
11. Place the spin column into an opening in a vacuum manifold. Replace the lids on the correctly labeled catch tube, and set aside. The vacuum apparatus should be very clean and sterile before use. Place tops on all un-used openings of the vacuum manifold.
12. Apply vacuum while slowly pouring centrifuged mixture into it. DO NOT pour the pellet into the spin column.
13. Add 5 ml of AW1 wash buffer from the Qiagen kit, and vacuum through. Apply evenly over filter. Use a sterile pipette when applying the wash buffer to each extraction column.
14. Add 5 ml of AW2 wash buffer from the Qiagen kit, and vacuum through. Use the same precautions as in step # 13.
15. Place the spin column in its appropriate catch tube, and centrifuge for 15 minutes at 4000 rpm.
16. Remove the lid, and place spin column on top of upside-down lid. Place both in 70°C Bambino incubator for 5 minutes to burn off excess ethanol. Discard catch tube.
17. Perform "smell test" for ethanol on each spin column. Place columns back into incubator until all ethanol smell is gone.
18. Upon validation of the absence of ethanol in the column, place the spin column into new catch tube with a new lid. Make sure to label both correctly.
19. Dilute filter evenly with 600 µl of Genemate DEPC treated water (nuclease free). Use a clean pipette tip for each spin column. Let spin column sit for 5 minutes.
20. Centrifuge 5 minutes at 4000 rpm.
21. Add another 600 µl of Genemate DEPC treated water, and let it sit again for 5 more minutes.
22. Centrifuge again for 5 minutes at 4000 rpm.
23. Measure the volume of the extract, and place into a labeled 1.5 ml centrifuge tube. Record volume in appropriate places.
24. Store samples at –20°C.

Sample Disposal Procedures

Samples that have been tested for FIB will be autoclaved. In the case of hollow fiber ultrafiltration, the retentate (remaining concentrated liquid) is frozen and stored for further nucleic acid extraction and analysis. Permeate from filtration is discarded as nontoxic laboratory waste.

C: Hydrology - terrestrial

Streamflow-discharge analytical methods used will be according to Balance SOPs. Measurement methods, analytical methods, and computational procedures will be according to the U.S. Geological Survey (see Buchanan and Somers, 1976) and U.S. Army Corps of Engineers standard methods. These standards are available upon request from Balance Hydrologics.

Water temperature and conductivity will be measured in the field using a handheld meter. Prior to deploying for the field, the meter will be checked for cleanliness, recent calibration, and battery supply. Field measurements are unlikely to foul the equipment. In the unlikely event that the equipment fails to function or that field staff are unable to take a field measurement, grab samples can be collected and measured upon return to the office. In this case, it should not be assumed that temperature

readings represent field conditions. Conductivity, however, is relatively conservative and is not expected to change during sample transport. Samples are untreated and can be disposed of in the sanitary sewer. Field staff will carefully record any deviations for the normal protocol in their field notes.

Flow is calculated from velocity measurements that are collected in the field using a spinning bucket velocity meter. Prior to deploying for the field, the equipment will be checked for cleanliness. At each station, a spin test is performed to check that the velocity meter spins freely. If necessary cleaning and the addition of mineral oil, or minor adjustments will be made to ensure that the correct spin test time is achieved. Spin test results are carefully recorded in the field notes. Sometimes suspended organic matter can get caught in the equipment during measurement. Field staff is trained to select measurement locations where this is less likely to occur. After each velocity measurement, the meter will be checked to be sure it is free of obstructions. If obstructions are noted, they will be cleared from the velocity meter and the previous station will be re-measured.

Disposal

All of the SMCPHL waste is handled as medical waste and discarded in accordance with a Medical Waste Management Plan and permit which meet all CLIA and California ELAP requirements.

All of the UCD waste resulting from qPCR analyses will handled as hospital waste and discarded in accordance with Hospital Waste Regulations and meets the California ELAP requirements.

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14. QUALITY CONTROL

Quality control samples will be taken to ensure valid data are collected.
Depending on the parameter, quality control samples will consist of blanks, replicate samples, and split samples. In addition, quality control sessions (a.k.a. intercalibration exercises) will be held twice a year to verify the proper working order of equipment, refresh volunteers in monitoring techniques and determine whether the data quality objectives are being met.

A. Enumeration

The laboratory will analyze the field blanks submitted. The expected results are the absence of total coliforms and *E. coli* and Enterococci.

The laboratory will analyze the 5 replicate samples and record the individual results and an average. At a frequency of 10% of the samples received, the laboratory will split the five samples and run them in duplicate – providing two sets of five replicates. The averages of each 5 replicate set represents the data that will be used in assessment of the Precision criteria. This is done in accordance with Standard Methods 9020B.

The laboratory will analyze reference samples consisting of one sample that contains total coliform, but not *E. coli*, *E. coli*, a non coliform organism, and a sterile sample. The results expected are as follows. Total coliform/not *E. coli* – positive total coliform/negative *E. coli*; *E. coli* – positive for both total coliform and *E. coli*; non coliform organism and sterile sample – negative for both total coliform and *E. coli*.

Table 9. (Element 14) Analytical QC - Enumeration.

Matrix: water
Sampling SOP: Standard SMCPHL
Analytical Parameter(s): *E. coli and Enterococcus*
Analytical Method/SOP Reference: IDEXX Colilert-18, Enterolert/ SMCPHL SOPs
Sample locations: variable

Laboratory QC	Frequency/Number	Acceptance Limits
Method Blank	Each lot	Pos/Neg
Reagent Blank	Each lot	Pos/Neg
Storage Blank	Daily and each batch	2-4 degrees C
Instrument control	Twice daily	35 +/- .5C (TC&EC) 41 +/- .5 C (Enterococci)
Lab. Duplicate	Not applicable	Not applicable
Lab. Matrix Spike	Each lot	Pos/Neg
Matrix Spike Duplicate	Not applicable	Not applicable
Lab. Control sample	Pos/Neg/Ster. Controls	Pos/Neg for each
Surrogates	Not applicable	Not applicable
Internal Standards	To comply with certification	100% or full review
Others:	Routine PT's performed	100% or full review

Parameter	Blank	Duplicate Sample	Split Sample to lab	QC session
Water quality				
Biological Parameters				
Total Coliform and *E. coli* Bacteria	daily	5% or a minimum of once per day	twice a year	twice a year
Enterococci	daily	5% or a minimum of once per day	twice a year	twice a year

Blanks, Replicates, Split Samples, and Standardization

Field/Laboratory Blanks:
A laboratory blank will be performed for each sampling/analysis event for bacterial analysis.

Instructions for Field and Lab Blanks:
For bacterial analysis, the reagents are added to sterile distilled water (in the same manner as for a field sample) and that blank is then sealed in a quantitray and incubated along with the field samples. The blank should be below detection limits (i.e., no positive wells) at the end of the incubation period.

Replicate Samples:
For bacterial analysis lab duplicates will be run at least once per sampling day, and when there are more than 20 samples run per day then there will be a minimum 5% of the samples analyzed in duplicate.

Standardization of Instruments and Procedures:
At the Quality Assurance Sessions the temperature measurements will be standardized by comparing our digital thermometers to a SMCPHL certified calibrated thermometer in ice water and ambient temperature water.

B. *Bacteroidales*

Quality control measures will be taken for each sample filtration and subsequent qPCR analysis. These steps consist of running field blanks for each event and testing the resulting concentrated water for target organisms. It is expected that these blanks show non-detects for the specific qPCR assays. Laboratory blanks (negative controls) will also be run for qPCR assays. Positive controls are included as part of the calibration curve.
The Wuertz laboratory has developed methodology and analytical procedures for the determination of true sample limits of detection (SLODs) {Rajal, 2007a #94; Rajal, 2007b #209}{Kildare, 2007 #116} for qPCR using environmental samples. These procedures include an equation that accounts for filtration recovery, DNA extraction efficiency, and enzyme inhibition {Rajal, 2007b #209}. All quantitative *Bacteroidales* assays to be used have been designed in the Wuertz laboratory and validated using blind samples {Kildare, 2007 #116}.

Control Samples

Quality control samples shall be collected according to a schedule pre-determined by SMCRCD. Specific collection methods for each type of quality control sample type are described below.

Field Blank

Field blanks should be collected for the stations and events to be specified. The field crew will use blank water provided by the laboratory to generate field blanks by pouring blank water directly into the sample bottles. Field blanks should be submitted "blind" to the laboratory as Station PPH 1226-B designation. If detected values are reported for field blanks, the frequency of collection will be increased.

Field Duplicates

Field duplicates shall be collected for the stations and events specified. Field duplicates shall be collected immediately following the collection of normal samples. In cases where multiple intermediate bottles are used for a single analysis, field duplicates and normal sample containers should be filled in an alternating sequence (i.e., normal-duplicate-normal-duplicate). Field duplicates should be submitted "blind" to the laboratory as Station PPH1226-XXX (X's are for the duplicate field station).

Laboratory Duplicates

Laboratory duplicate analyses should be requested for all constituents for the stations and events specified. No special sampling considerations are required. However, additional sample volume must be collected, per laboratory requirements, for each analysis.

Laboratory Blank

Each PCR run will include negative controls consisting of sterile purified water and reaction mixture but no added DNA. When control limits are exceeded, additional runs and blanks will be analyzed. If contamination persists the PCR work areas will be scrutinized and reaction solutions will be changed. If blanks continue to show positive detection the sample results will be classified as questionable until the contamination has been removed. At that time samples will be reanalyzed.

Data Quality Indicators: please refer to Element 7 for detailed DQI formulas.

Table 10. (Element 14) Analytical QC - qPCR.

Matrix: Water or sediment/biofilm
Sampling SOP: Attached
Analytical Parameter(s): Host-specific gene markers
Analytical Method/SOP Reference: Rajal et al. 2007 a,b; Kildare et al 2007
Sample locations: Variable

Laboratory QC	Frequency/Number	Acceptance Limits
Method Blank	Each event	Pos/Neg
Reagent Blank	Each run	Pos/Neg
Storage Blank	Daily	2-4 degrees C
Instrument Blank	Each run	Pos/Neg
Lab. Duplicate	Each run	Pos/Neg
Lab. Matrix Spike	Each lot	Pos/Neg
Matrix Spike Duplicate	Each event	Pos/Neg
Lab. Control sample	Pos/Neg/PCR controls	Pos/Neg for each
Surrogates	Each run	Pos/Neg
Internal Standards	Each run for DNA extraction efficiency	50% or full review
Others:	Check slope of sequential dilutions	90% or full review

Data quality indicators for quantitative polymerase chain reaction (PCR) analyses

Data quality objectives are listed in Table 3 (element 7). In the reactions used to identify the presence of *Bacteriodes*, DNA will be extracted and amplified along with a surrogate that will be spiked into the samples prior to PCR. This surrogate will be used to determine the impact of filtration losses and PCR inhibitors that often co-purify in environmental samples, thus controlling for false negatives. Calibration curves shall be prepared using known template standards that vary over three logs (25 to 25,000 templates). These reactions will be performed in triplicate and the slopes and efficiency statistics have been evaluated as part of the assay optimization (Kildare et al. 2007). Efficiency and reproducibility of RNA and DNA extractions and subsequent reactions will be evaluated by single blind positive and negative controls. Five percent of all samples will be replicated from the PCR step and the resulting data compared for similarity. Separate positive and negative control reactions will be included every time a set of samples is put into a thermocycler for PCR.

15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Field measurement equipment will be checked in accordance with the manufacturer's specifications. This includes battery checks and cleaning. All equipment will be inspected when first handed out and when returned from use for damage. Equipment will be maintained in accordance with its SOPs, which include those specified by the manufacturer and those specified by the method used in this study.

The Senior Research Associate at UCD, QA Manager/Lead Tech at SMCPHL, the equipment coordinator at Balance Hydrologics and the SMCRCD Resource Specialist will be responsible for equipment inspection, testing and maintenance relevant to their team. Field equipment inspection is carried out prior to each trip in the field. Testing is not conducted if equipment appears visibly worn or if field technicians report problems with the equipment upon returning from the field. If deficiencies are found, the necessary maintenance will be performed and then the equipment will be re-calibrated and re-inspected. A pre- and post-calibration will be run to determine if the problem has been fixed. If this does not correct the problem, then the equipment will be taken out of use and sent to the manufacturer for servicing.

A maintenance/calibration log is kept in the Wuertz and SMCPHL laboratories to log details including dates of instrument maintenance, calibration, and any problems noted. All necessary parts, reagents and calibration standards are kept on hand so that equipment can be kept in good repair and properly calibrated.

At Balance Hydrologics, the equipment coordinator is responsible for maintenance, repair, and purchase of field equipment. Any equipment maintenance needs are reported to him. Travis Baggett is Balance's equipment coordinator.

PCR micropipettes are calibrated at regular intervals, at least once every 6 months. Individual steps in PCR analysis are carried out in separate rooms or using enclosed PCR hoods.

Table 11. (Element 15) Testing, inspection, maintenance of sampling equipment and analytical instruments

Equipment / Instrument	Maintenance Activity, Testing Activity or Inspection Activity	Responsible Person	Testing/Inspection Frequency	SOP Reference
Thermocyclers (PCR)	Positive and negative samples are included in all sample runs	Field and General Laboratory Director	Every PCR event	Operator manual
YSI handheld meters for conductivity meter (salinity), dissolved oxygen, temperature, and pH	Inspected periodically throughout monitoring time period.	Field and General Laboratory Director	Weekly during water quality monitoring effort	Operator manual
All SMCPHL Instruments and equipment	In accordance with ELAP and CLIA regulations	QA Manager/Lead Tech	In accordance with ELAP and CLIA regulations	All data and records kept in accordance with SMCPHL SOPs
Solinst Levellogger	Data output Inspected periodically throughout monitoring time period.	Field Director	Conducted Periodically and as necessary during the life of the project	Operator manual/all data kept in accordance w/ Balance SOPs
Staff plate	Inspected periodically throughout monitoring time period.	Field personnel	Prior to each flow monitoring event	Operator manual/all data kept in accordance w/ Balance SOPs
Velocity meters	Spin test	Field personnel	Prior to each flow monitoring event	Operator manual/all data kept in accordance w/ Balance SOP

Equipment / Instrument	Maintenance Activity, Testing Activity or Inspection Activity	Responsible Person	Testing/Inspection Frequency	SOP Reference
Fluorometer	Inspection of Diagnostic screen displaying status of internal instrument electronics	Principal Hydrologist	Prior to each fluorometric dye study	Operator manual

Each piece of equipment in the San Mateo Public Health Laboratory is on a preventive maintenance schedule. Full records and documentation is kept for each piece of equipment in the Preventive Maintenance Manual. In most cases there is enough redundancy within the lab to use a second piece of equipment or use a back-up.
Service Contracts are available for the thermocycler and spare bulbs are kept in the Wuertz laboratory.

C: Hydrology Terrestrial
Instruments for streamflow discharge measurements (velocity meters) are tested before every measurement. Velocity meters must spin a minimum duration of time to be used for a measurement (90 seconds for the Price AA meter, or 45 seconds for a bucket-wheel pygmy meter.

16. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

All equipment and instruments are operated and calibrated according to the manufacturer's recommendations. Operation and calibration are performed by personnel properly trained in these procedures. Documentation of all calibration information is recorded in the appropriate logs. If equipment is not meeting the listed criteria (Table 16) it is the responsibility of the field director, Resource specialist and lead researcher/Dan Wang to address the problem. This may include repair or replacement of equipment. All corrective actions are documented in the appropriate log.

Table 12. (Element 16) Calibration of sampling equipment and analytical instruments.

Equipment / Instrument	SOP reference	Calibration Description and Criteria	Frequency of Calibration	Responsible Person
Thermocyclers (PCR)	Wuertz Lab protocols Operator manual	ABI 7000 thermocyclers run self calibration and diagnostic test	Every run	Field and General Laboratory Director Return to ABI for repair
Thermometers	Operator manual	compliance with ISO/IEC 17025 and ANSI/NCSL Z540-1	Semi-annually	Field and General Laboratory Director
YSI handheld DO, pH, conductivity and T meters	Operator manual	Internal calibration, verification against standard KCl solution. Two readings must be within + 20%	Monthly	Lab technicians. Replace membrane and recondition probe. If this fails, send equipment in for servicing.
All SMCPHL Instruments and equipment	All data and records are kept in accordance with SMCPHL SOPs	As described in SOPs and within maintenance log in accordance with ELAP and CLIA regulations	With any change or at least as often as described within SOPs for each instrument	QA Manager/Lead Tech
Velocity Meter	Operator manual	Spin test 99 sec for price AA, 45sec for	Prior to each measurement	Field personnel

		bucket-wheel pygmy		
Solinst Levellogger	Operator manual	Adjust data logger record to correspond to staff plate observation	Every site visit	Field director
Fluorometer	Operator manual	Inspection of Diagnostic screen displaying status of internal instrument electronics	Prior to each fluorometric dye study	Principal Hydrologist

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

SMCPHL
Upon receipt, all reagents are inspected for broken seals and to compare the age of each reagent to the manufacturer's designated shelf life. All other equipment is inspected for broken or missing parts, and is tested to ensure proper operation. Commercially prepared media for microbiological analyses are used within the manufacturer's designated shelf life. All manufacturer-supplied specifications, which may include shelf life, storage conditions, sterility, performance checks, and date, are kept by the laboratory.

Table 13. (Element 17) Inspection/acceptance testing requirements for consumables and supplies - SMCPHL.

Project-Related Supplies / Consumables	Inspection / Testing Specifications	Acceptance Criteria	Frequency	Responsible Individual
All SMCPHL supplies / consumables	All Inspection and testing specifications are contained within the SMCPHL QC/QA manual, SOPs and ELAP/CLIA regulations. All raw data is recorded in hard copy and/or the lab information system	Acceptance Criteria is contained within the QC/QA manual and SMCPHL SOPs	Frequency as established within SMCPHL SOPs and the QC/QA manual	Technician with daily review from QA Manager/Lead Tech

Wuertz Laboratory
Upon receipt, all reagents are inspected by the Senior Research Associate (SRA) for broken seals and to compare the age of each reagent to the manufacturer's designated shelf life. All other equipment is inspected for broken or missing parts, and is tested to ensure proper operation. Commercially prepared media for molecular biology analyses are used within the manufacturer's designated shelf life. All manufacturer-supplied specifications, which may include shelf life, storage conditions, sterility, performance checks, and date, are kept by the laboratory.

18. NON-DIRECT MEASUREMENTS (EXISTING DATA)

Assess and Analyze Existing Data Relevant to Potential Sources of Fecal Contamination Impacting Pillar Point Harbor
Perform a full search for all existing data, review and analyze with respect to the following:

- hydrology of contributing watersheds, marsh, and harbor
- geologic setting
- natural and human-made conditions
- sedimentation and beach sand shifting
- sewer and other sewerage inflow and infiltration studies
- existing MST data
- enumeration data for fecal indicators with regard to tidal and flow conditions, temporal issues, weather, rain events, seasons, first flush events, etc.
- watershed sanitary surveys and similar analyses and related watershed data
- residency time for harbor water circulation

All members of the Technical Advisory Committee (these include representatives from the local utility districts sewer, water and sanitary districts as well as the harbor commission) have been provided with a memo outlining the types of data being sought, requesting any and all potentially relevant sources of information of which they are aware or believe may exist and a form to complete and return to SMC RCD who will then collate and collect copies of all documents for review for relevance. Relevance to the project will be measured by the criteria established above and that the data are pertinent to the watershed that the project is taking place in.

The data will be reviewed by the lead researcher, microbiologist and hydrologists' for relevance to surface and ground water, harbor circulation (including tides and currents) and bacterial loading with respect to sewer lines, laterals and land use in the watersheds. All data will also be made available to the TAC for review and input.

Please see Element 7 for acceptance criteria for data sources and/or models.

19. DATA MANAGEMENT

Data will be maintained as established in Element 9 above. The Resource Specialist will keep hard copies of monitoring related project documents in a dedicated section of a file cabinet. Monitoring related documents include: the Monitoring Plan (MPP), the Quality Assurance Project Plan (QAPP), field logs, field data forms, COC forms and laboratory reports.
SMCPHL and Wuertz Laboratory will retain a "copy" of the COC at the lab for their records, the original COC forms are sent to the State with the final report. All data, plans and reports can be retrieved from the file during normal business hours. Electronic copies of documents such as the MPP and QAPP will be retained on the Resource Specialists' computer (C drive) as well as digitally on a compact disk in the file cabinet. This enables any employee in the office to access all information.

Field data sheets will be checked for completeness and accuracy and signed by graduate student Dan Wang at the Wuertz Laboratory and the SMCRCD Resource Specialist. Dan Wang and the SMCRCD Resource Specialist will identify any results where holding times have been exceeded, sample identification information is incorrect, samples were inappropriately handled, or calibration information is missing or inadequate. Such data will be marked as unacceptable and will either be flagged or not be entered into the electronic database

Field data, including field descriptions and water quality parameters will be entered into a SWAMP compatible database, which will allow export to SWAMP. After entering the data the field data sheets will be archived. Sample results, as well as site codes, times and dates will be transferred from lab data into the database.

SMCPHL uses Orchard/Harvest Corp. version 7.5(Carmel, Indiana, phone 800-856-1948) for its lab information system. This is an ELAP/CLIA approved LIS that is backed up daily with all records kept indefinitely. The San Mateo County IT Dept and Orchard/Harvest Corp maintain the LIS. All hard copy records are kept for 3 years on site and for 10 years total at a secure county record storage facility. SMCPHL standard record keeping practices are compliant with HIPAA, CLIA and ELAP regulations

The Wuertz Laboratory maintains all finalized sample data in MS Excel spreadsheets, which are easily incorporated into other databases. PCR raw data are kept with the original software supplied by Applied Biosystems.

Balance Hydrologics download data using datalogger software into MS Excel spreadsheets. All field notes and other data are stored in MS Excel spreadsheets.

GROUP C: ASSESSMENT AND OVERSIGHT

20. ASSESSMENTS & RESPONSE ACTIONS

Review of all field and data activities is the responsibility of graduate student Dan Wang at UCD and the Resource Specialist. All field staff will be trained by Dan Wang and Resource Specialist prior to the first sampling event. Dan Wang and the Resource Specialist will review the work of field staff at the end of each sampling day and additional instruction will be given if deemed necessary.

The Principal Hydrologist will be responsible for assessing all hydrologic data collected by Balance Hydrologics.

Corrective Actions

During the course of sample collection the SMCRCD Resource Specialist will be responsible for assuring that sample collection procedures and measurements are followed as specified in this QAPP and that the data meets the quality assurance objectives (QAO) described in this document for enumeration samples.

If a problem arises, prompt action to correct the immediate problem and identify its root causes is imperative. Any related systematic problems must also be identified. Problems about field data quality that may require corrective action are documented in the field data sheets. The SMCRCD Resource Specialist and Professor Wuertz have the authority to issue stop work orders to stop all sampling and analysis activities until the discrepancy can be resolved. The results of the resolution of the discrepancy will be documented in writing and placed in the project file, as well as mailed to the SWRCB Grant Manager.

21. REPORTS TO MANAGEMENT

Table 14. (Element 21) QA management reports.

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually, etc.)	Projected Delivery Dates(s)	Person(s) Responsible for Report Preparation	Report Recipients
Analysis of existing data		May 2008	Resource Specialist/	TAC
Public Notices and meeting attendance information	Quarterly		Resource Specialist/	
Grant Summary Form	90 days		Project Manager	SWRCB
Progress Reports by the end of the month following the end of the calendar quarter (March, June, September, and December)	Quarterly	Dec. 2007, March 2008, June 2008, Sep 2008, Dec. 2008, March 2009, June 2009, Sep 2009, Dec. 2009, March 2010, June 2010, Sep 2010, Dec. 2010	Resource Specialist/ Project Manager	TAC/SWRCB/Public Meetings
Natural Resource Projects Inventory (NRPI) Project Survey Form		Before final invoice	Project Manager	SWRCB
Draft Project Report		February 2010	Consultants and Resource Specialist/ Project Manager	SWRCB/TAC
Final Project Report		March 2010	Consultants and Resource Specialist/ Project Manager	SWRCB/TAC/Public Meetings

GROUP D: DATA VALIDATION AND USABILITY

22. DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

UCD will be performing all the lab data acquisition except microbial indicator enumeration, which will be performed by SMCRCD. Flow data will be obtained by Balance Hydrologics and made available as raw data, calibrated parameters, tabular and/or, graphical format, tied to the three gage locations, suitable for use by others in GIS and Google Earth images or maps.

Field data sheets will be checked for completeness and samples and sample information will be examined, at the SMCPHL and Wuertz Laboratory, upon receipt to be sure samples are within holding times, sample identification information is correct, and samples have been held and handled appropriately. Any samples that are not acceptable will be marked and not entered into the database. The lab director also will review lab data sheets completed by laboratory technicians to be sure there are no omissions or errors and that all entries are clear. The graduate student Dan Wang will review all field sheets and laboratory results and enter data into a database. MS Excel will be used.

Review of all field and data activities is the responsibility of each team leader along with the technical advisors. All field personnel will be trained by the lead scientist at UCD and the Resource Specialist prior to sampling. The work of the field crews will be reviewed by the lead scientist at UCD and the Resource Specialist at the end of each sampling day. Anyone in need of more instruction will receive it on site prior to the next sampling day.

Data files will be reviewed on a quarterly basis to identify outliers, spurious results, or omissions. Any problems will be reported to the project director. The lead scientist at UCD and the Resource Specialist will review data for compliance with data quality objectives. Any problems with data quality will be included in the final report.

23. VERIFICATION AND VALIDATION METHODS

Each of the data components (enumeration, MST and hydrology) will have field data sheets reviewed for completeness and any unusual results the day of the monitoring event. Data validation is covered with signed entries by the field and laboratory technicians on field data sheets and laboratory data sheets, respectively; review for completeness and accuracy by the field and general laboratory director; review by the team leaders for outliers and omissions; and the use of quality control criteria to accept or reject specific data. Verification of data will be performed by a designee. Any errors found will be noted and discussed by the technical advisory team before being corrected in the database. Then the validation process will begin. The verified data in the database will be compared to the DQO as written in the QAPP. When that process is complete, a report will describe the findings

24. RECONCILIATION WITH USER REQUIREMENTS

Each component set of data will be reviewed quarterly to determine if DQOs have been met. Any errors will be noted, the cause determined and corrective action suggested. If the problems cannot be corrected, then the DQOs will be reviewed for feasibility. If specific DQOs are not achievable, the lead researcher will recommend appropriate modifications. Any revisions would need approval by the project manager and TAC. Any revisions to DQOs will be appended to this QAPP with the revision date and the reason for modification

We will perform a power analysis to determine if a realistic number of samples collected from each site has been collected to detect statistically significant differences in mean values among sites and to test the hypotheses. Using existing data from fecal indicator bacteria monitoring conducted prior to and during the project we will determine the expected variability of the data, and define the desired difference in means at a given alpha (% chance that a significant difference among two sites will be reported when none actually exists) and power value (% chance that a significant change will not be missed). The results of this assessment may require some fine tuning of the field program to optimize the number of sampling locations and samples per site while remaining within the constraints of the available budget.

Limitations on data use will be reported to the data users by including explicit explanations in each report regarding the ability to make quantitative predictions of fecal sources.

APPENICES:

Appendix 1:
References:

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Dick, L.K. and Field, K.G., 2004. Rapid estimation of numbers of fecal *Bacteroidetes* by use of a quantitative PCR assay for 16S rNA genes. Applied and Environmental Microbiology 70(9), 5695-5697.

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Reischer, G.H., Kasper, D.C., Steinborn, R., Farnleitner, A.H. and Mach, R.L., 2007. A quantitative real-time PCR assay for the highly sensitive and specific detection of human faecal influence in spring water from a large alpine catchment area. Letters in Applied Microbiology 44(4), 351-356.

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Santo Domingo, J.W., Bambic, D.G., Edge, T.A. and Wuertz, S., 2007. Quo vadis source tracking? Towards a strategic framework for environmental monitoring of fecal pollution. Water Research 41, 3539-3552.

Seurinck, S., Defoirdt, T., Verstraete, W. and Siciliano, S.D., 2005. Detection and quantification of the human-specific HF183 *Bacteroides* 16S rRNA genetic marker with real-time PCR for assessment of human faecal pollution in freshwater. Environmental Microbiology 7(2), 249-259.

Appendix 2:

Balance Hydrologics, Inc.
841 Folger Ave.
Berkeley, California 94710

Project No.__________
Gage No. __________
Stream__________
Location__________
Date__________

Conditions and Observations

Observer(s): __________
Weather & Conditions: __________
Temperatures:__________

Hydrograph: __Rising __Falling __Uncertain __Baseflow
If falling, approximate time of previous peak: __________

Procedures

Measurement at: __________

Method: 0.6 0.2/0.8 Other
Meter No.__________
Spin Test:__________
Suspension: Rod Cable
Measurement rated: Excellent (±2%)
Good (±5%)
Fair (±8%)
Poor ( )

Gage Heights

Time	Staff	Other

Observed High-Water Marks

Approx. Gage Height	Est. date

Remarks

____

Hydraulic Geometry

Area:__________
Width: Top__________Bed__________
Depth:__________
Velocity:__________
Slope:__________

Crest Stage Data

Observed Crest G.H.__________
Adjustment:__________
Adjusted Crest G.H.:__________
Remarks:__________
Reset__________Repair__________

Coefficients Utilized and Explanation: __________

Changes in conditions since last visit?__________

Concurrent water quality, sediment or biological measurements/sampling conducted__________

Discharge Measurement Notes

Coeff.	Sta-tion	Width	Flow Depth	Obs. Depth	Revs.	Secs.	Velocity At point	Velocity Avg.	Horiz. or Vert. Adjust.	Area (ft^2)	Dis-charge (cfs)	Bed*
											cfs	
											gpm	

***Bed Key:** M (Mud, Muck), S(Silt, Sand), G(Gravel), C(Cobbles), B(Boulders), BR(Bedrock), RP(Riprap), CON(Concrete), FP(Floodplain, Overbank), Other

Hecht 3/88

Computations

Date:	By:	Reviewed:

Discharge form.xls, Q Form

Appendix 3:

LAB USE ONLY

DATE AND TIME RECEIVED /INITIALS

_____

County of San Mateo
Department of Health
Public Health Laboratory
225 West 37th Avenue, Room #113
San Mateo, CA 94403
(650) 573-2500
Bruce K. Fujikawa, Dr.P.H., Laboratory Director

ENVIRONMENTAL TEST REQUEST FORM

COLLECTED BY: _____ **DATE COLLECTED:** / /2008

SAMPLE # (MATCH WITH SAMPLE BOTTLE) _____ **TIME COLLECTED:** _____

TEST REQUEST ORDER CHOICE:

- ☐ MULTIPLE TUBE FERMENTATION TEST
- ☐ COLILERT TEST
- ☐ MEMBRANE FILTER TEST
- ☐ PRESENCE/ABSENCE TEST
- ☐ ENTEROLERT TEST
- ☐ SURFACE WATER/SEWAGE
- ☐ POOLS, HOT TUBS, BATHS, INTERACTIVE WATER ATTRACTIONS
- ☐ HETEROTROPHIC PLATE COUNT
- ☐ LEGIONELLA CULTURE
- ☐ SECONDARY EFFLUENTS
- ☐ NITRATE: DRINKING/ENVIRONMENTAL
- ☐ NITRITE: DRINKING/ENVIRONMENTAL
- ☐ DRINKING/SOURCE WATER (EH ONLY)
- ☐ AB 411 (EH ONLY)
- ☐ AB 1876 (EH ONLY)
- ☐ TURBIDITY
- ☐ PHYSICAL PROPERTIES
- ☐ OTHER _____

SAMPLE TYPE:

- ☐ WATER ☐ RECREATIONAL WATER
  - ☐ BEACH
  - ☐ CREEK
  - ☐ DRINKING WATER
    - ☐ CHLORINATED ____ mg/L
    - ☐ RAW
    - ☐ SOURCE
  - ☐ LAGOON
  - ☐ LAKE
  - ☐ OCEAN OR BAYSIDE (CIRCLE ONE)
- ☐ SOIL
- ☐ OTHER _____

SYSTEM NAME _____ **SYSTEM ID #** _____

SAMPLE SITE/ADDRESS: _____

_____

SEND REPORT TO (FULL ADDRESS):

_____
_____
_____
_____

BILL TO (NAME OF ORGANIZATION)

_____
_____
_____
_____

12/6/2007

Appendix 4:

San Mateo County Resource Conservation District

Ag Water Quality Grant

	Doc ID#	DATE (mm/dd/yy)
Field Data Sheet		START TIME (am/pm)

Please use one sheet for each site — NAME:

Please use back for additional comments

Waterbody Name	
Station (Site) ID:	Site location description

Weather Conditions

LOW/DISCHARG	SKY	RECIPITATIO	WIND
stagnate	no clouds	none	none
trickle(<1 quart/sec)	partly cloudy	foggy	breezy
moderate (<5 gal/sec	heavy clouds	misty	windy
high (>5gal/sec)	overcast	rain	blustery

TIME OF FIELD MEASUREMENT:

INSTRUMENT ID	PARAMETER	RESULT	REPLICATE	UNITS (circle appropriate unit)
	AIR TEMP			°F or °C
	WATER TEMP			°F or °C
	pH			pH units
	CONDUCTIVITY			µS/cm
	TURBIDITY			NTU
	FLOW			

NOTES AND OBSERVATIONS:

Include any equipment comments/problems or observations such as water color, trash, fish or wildlife observe
(describe number seen, length and behavious)

If you collect a sample to be processed at the lab fill out the following section:

Sample ID	Time Collected	Collected By	Container Type	Sample Comments:

SAMPLE CUSTODY	DATE/TIME	RECEIVED BY
RELINQUISHED BY		

Appendix 5:

LIST OF ACRONMYMS USED:

SWAMP	surface water ambient monitoring program
MPP	Monitoring Plan
QAPP	Quality Assurance Project Plan
SMCRCD	San Mateo County Resource Conservation District
SWRCB	State Water Resources Control Board
QA/QA	Quality Assurance/ quality control
US EPA	United States Environmental protection agency
NPS	non-point source
BMP	best management practices
EC	electrical conductivity
TSS	total suspended solids
GPS	global positioning system
DQO	data quality objectives
QAMP	Quality Assurance Monitoring Plan
COC	chain-of-custody forms
SOP	standard operating procedures
ELAP	environmental laboratory accreditation program
HDPE	high density poly ethylene
MQO	management quality objectives
RPD	Relative Percent Difference
PARC	Precision, Accuracy, Representativeness, Completeness
RL	Reporting Limit
LCS	Laboratory control spikes
EB	equipment blanks
MB	Method blanks
ND	non-detect
QAO	quality assurance objectives
QPR	Quarterly progress reports
MST	Microbial Source Tracking
UC Davis/UCD	University of California, Davis
SMCPHL	San Mateo County Public Health Laboratory
qPCR	Quantitative Polymerase Chain Reaction
AB411	Assembly Bill 411 for water quality in recreational waters
USGS	United States Geological Service
FIB	Fecal Indicator Bacteria
MPN	Most Probable Number
CCA	Critical Coastal Area
IDEXX	Brand of microbiological test media
MS	Microsoft
YSI	brand of field testing equipment
LIS	Laboratory Information System
TAC	Technical Advisory Committee

Appendix 6:

STANDARD OPERATION PROCEDURE
TURBIDITY
SOP

- Use Hach 2100P Turbidimeter
- Standardize turbidimeter with factory standards. Record the standard readings in log. Reading should be within marked limits.
- Ensure sample uniformity by inverting/shaking the sample several times.
- Fill the 15 mL measuring cell. Clean surface of the cell with a Kimwipe and silicone oil to remove fingerprints, water spots, and fill in scratches.
- Insert cell with the arrow in front lined up with the front mark on the turbidimeter.
- Signal average and auto range need to be on. Press read. Record the turbidity in NTUs in the sampling data sheet.

STANDARD OPERATION PROCEDURE
CONDUCTIVITY
SOP

- Use Conductivity Meter YSI
- Hit the ON/OFF button.
- Remove probe from storage chamber in the side of the meter.
- The screen should be in the specific conductance mode. The units on the screen will be in ‘uS’ or ‘mS’ and the ‘°C’ symbol on the temperature reading will be flashing. In this mode, the meter corrects the conductivity value based on temperature. If units are ‘ppt’, press the MODE button to get conductance.
- Insert the meter in the sample. The holes at the top of the probe must be submerged. Agitate the probe to ensure that water is reaching the probe.
- Wait for the meter reading to stabilize.
- After recording the reading and the units, rinse off probe with DI water and return probe to the storage chamber.
- Record salinity for each sample.
- Hit ON/OFF button to turn off meter.

Appendix 7:

SAMPLING EVENT PREPARATION

Sample Bottle Labeling

All samples will be pre-labeled before each sampling event to the extent practicable. Pre-labeling sample bottles simplifies field activities, leaving only sample collection time, sample number, and the names of sampling personnel to be filled out in the field. Custom labels will be produced using blank water-proof labels. Using this approach will allow the stations and analytical constituent information to be entered into the computer program in advance, and printed as needed prior to each sampling event.

Labels shall be placed on the appropriate bottles in a dry environment; attempting to apply labels to sample bottles after filling will cause problems, as labels usually do not adhere to wet bottles. The labels shall be applied to the bottles rather than to the caps. Field labels shall contain the following information:

- Program Name
- Station ID
- Event Number
- Date
- Time
- Sampling Personnel
- Sample ID (see next section for ID conventions)
- Analytical Requirements
- Laboratory Conducting Analysis

Sample ID Conventions

Sample bottles and jars submitted to laboratories for analysis shall be labeled with a sample ID devised as follows:

STATION- XX

Where: *STATION* = Station ID
XX = Event number (i.e., 01, 02, 03, …)

For example, 3-A-02 would be the sample ID for a sample collected at station 3-A during the second sampling event.

SAMPLE COLLECTION

Water Sample Collection

All water samples will be collected as grab samples. At most stations, grab samples will be collected at approximately mid-stream, mid-depth at the location of greatest flow (where feasible) by direct submersion of the sample bottle depth. This is the preferred method for grab sample collection; however, due to sampling station configurations and safety concerns, direct filling of sample bottles is not always feasible. Sampling station configuration will dictate grab sample collection technique. Grab samples will be collected directly into the appropriate bottles (containing the required preservations).

The grab sample technique that may be employed is described below.

Direct Submersion:

Where practical, all grab samples will be collected by direct submersion to mid-stream, mid-depth using the following procedures.

1. Wear clean powder-free nitrile gloves when handling bottles and caps. Change gloves if soiled or if the potential for cross-contamination occurs from handling sampling materials or samples;
2. Pre-label sample containers as described in **Sample Bottle Labeling** and **Sample ID Conventions**;
3. Submerge bottle to mid-stream/mid-depth, remove lid, let bottle fill, and replace lid. Place sample on ice;
4. Collect remaining samples including control samples, if needed, using the same protocols described above;
5. Fill out COC form, note sample collection on field form, and deliver to Wuertz lab.

Field Measurements and Observations

Field measurements will be taken and observations made at each sampling station before a sample is collected. Field measurements will include flow, pH, temperature, and conductivity. Temperature, pH, and conductivity measurements will be taken at approximately mid-stream, mid-depth at the location of greatest flow (if feasible). All field measurement results and comments on field observations will be recorded in the field log presented in Appendix 1.

Flow measurements will be recorded with a flow meter or estimated at each sampling station before a sample is collected. When a flow meter is unavailable or flow is not sufficiently deep to use a flow meter, depth, width, and velocity will be estimated to provide an estimate of flow. Depth will be estimated by using the average of several multiple measurements taken along the channel. Width will be measured by extending a tape measure from one side of the bank to the other. Velocity will be estimated by measuring the time it takes a floating object (e.g. stick, orange) to travel a known distance.

If at any time the collection of field measurements by wading appears unsafe, do not attempt to collect mid-stream, mid-depth measurements. If in-stream field measurement is not safe, collect field measurements from a stable, unobstructed area at the reach's edge or use an expandable pole and intermediate container to obtain sample for field measurements.

In addition to field measurements, observations will be made at each sampling station. Observations will include color, odor, floating materials, presence of wildlife, as well as observations of contact and non-contact recreation. All comments on field observations will be recorded in the field log presented in Appendix 1.

Chain-of-Custody

Chain-of-custody (COC) forms will be filled out for all samples submitted to the Wuertz laboratory. Sample data, sample location, sample collection crew names, and analysis requested shall be noted on each COC. See Appendix 1 for a blank COC form.

Transport to Lab

Samples will be stored in coolers with ice and delivered to UC Davis at the address provided in the field protocols section of this plan.

FIELD PROTOCOLS

Field crews (2 persons per crew, minimum) will only be mobilized for sampling when weather conditions and flow conditions are considered to be safe. For safety reasons, sampling will occur during daylight hours. A sampling event should proceed in the following manner:

9. Before leaving the sampling crew base of operations, notify laboratory, confirm number and type of sample bottles as well as the complete equipment list.
10. Proceed to the first sampling station.
11. Fill-out the general information on the field log sheet.
12. Take field measurements and observations, and record on the field log sheet.
13. Take the samples indicated on the field log sheet in the manner described in this study plan. Take additional volume and blank samples for field-initiated QA/QC samples, if required. Place bottles in the coolers with ice. Double check against the log sheet that all appropriate bottles were filled.
14. Repeat the procedures in steps 3, 4, and 5 for each of the remaining sampling stations.
15. Complete the chain of custody forms using the field notes.
16. After collection is completed, deliver the samples to Wuertz laboratory within 6 hours of the first sample collection.

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QUALITY ASSURANCE/QUALITY CONTROL

Field Blank

Field blanks should be collected for the stations and events to be specified. The field crew will use blank water provided by the laboratory to generate field blanks by pouring blank water directly into the sample bottles. Field blanks should be submitted "blind" to the laboratory as Station 86-A designation. If detected values are reported for field blanks, the frequency of collection will be increased.

Field Duplicates

Field duplicates shall be collected for the stations and events specified. Field duplicates shall be collected immediately following the collection of normal samples. In cases where multiple intermediate bottles are used for a single analysis, field duplicates and normal sample containers should be filled in an alternating sequence (i.e., normal-duplicate-normal-duplicate). Field duplicates should be submitted "blind" to the laboratory as Station 86-A.

Laboratory Duplicates

Laboratory duplicate analyses should be requested for all constituents for the stations and events specified. No special sampling considerations are required. However, additional sample volume must be collected, per laboratory requirements, for each analysis.