PILLAR POINT WATERSHED PATHOGEN INDICATOR STRESSOR/SOURCE IDENTIFICATION

Prepared in support of provision C.8.e.iii of NPDES Permit # CAS612008

Project Work Plan

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program
Clean Water. Healthy Community.

San Mateo Countywide Water Pollution Prevention Program

March 31, 2018

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1.0 INTRODUCTION

This work plan supports the requirement to implement a Stressor/Source Identification (SSID) Project as required by Provision C.8.e.iii of the San Francisco Bay Region Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (MRP) (Order No. R2-2015-0049). Per MRP Provision C.8.e.ii, the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) is working with Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) members to collectively initiate eight new SSID projects during the five-year term of the MRP (i.e., 2016 – 2020). SSID projects follow-up on monitoring conducted in compliance with MRP Provision C.8 (or monitoring conducted through other programs) with results that exceed trigger thresholds identified in the MRP. Trigger thresholds are not necessarily equivalent to Water Quality Objectives (WQOs) established in the San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan, SFRWQCB 2017) by the San Francisco Bay Regional Water Quality Control Board (Regional Water Board); however, sites where triggers are exceeded may indicate potential impacts to aquatic life or other Beneficial Uses.

This SSID work plan describes the steps that will be taken to investigate urban sources of fecal indicator bacteria in three creeks and a catchment draining to Pillar Point Harbor in coastal San Mateo County, California. SMCWPPP will implement the work plan with assistance from and in close coordination with the San Mateo County Resource Conservation District (RCD) and the County of San Mateo. RCD work on this project is supported by funding provided by the San Mateo County Harbor District.

1.1 SSID Regulatory Background

SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. MRP Provision C.8.e.iii requires that SSID projects are conducted in a stepwise process:

Step 1: Develop a work plan. The work plan must:

- Define the problem (e.g., magnitude and temporal and geographic extent) to the extent known;
- Describe the SSID project objectives, including the management context within which the results of the investigation will be used;
- Consider the problem within a watershed context and look at multiple types of related indicators, where possible (e.g., basic water quality data and biological assessment results);
- List candidate causes of the problem (e.g., biological stressors, pollutant sources, and physical stressors);
- Establish a schedule for investigating the cause(s) of the trigger stressor/source to begin upon completion of the work plan. Investigations may include evaluation of existing data, desktop analyses of land uses and management actions, and/or collection of new data.

- Conduct a site specific study (or non-site specific if the problem is wide-spread) in a stepwise process to identify and isolate the cause(s) of the trigger stressor/source. Study approaches are listed depending on the stressor being investigated. For pathogen indicators, the study should generally follow the *California Microbial Source Identification Manual: A Tiered Approach for Identifying Fecal Pollution Sources to Beaches* (Griffith et al. 2013) or equivalent process or method.

Step 2: Conduct SSID investigations according to the schedule in the work plan and report on the status of the SSID investigation annually in the Urban Creeks Monitoring Report (UCMR) that is submitted to the Regional Water Board on March 31 of each year.

Step 3: Follow-up actions:

- If it is determined that discharges to the municipal separate storm sewer system (MS4) contribute to an exceedance of a water quality standard (WQS) or an exceedance of a trigger threshold such that the water body's beneficial uses are not supported, submit a report in the UCMR that describes Best Management Practices (BMPs) that are currently being implemented and additional BMPs that will be implemented to prevent or reduce the discharge of pollutants that are causing or contributing to the exceedance of WQS. The report must include an implementation schedule.
- If it is determined that MS4 discharges are not contributing to an exceedance of a WQS, the SSID project may end. The Executive Officer must concur in writing before an SSID project is determined to be completed.
- If the SSID investigation is inconclusive (e.g. the trigger threshold exceedance is episodic or reasonable methods do not reveal a stressor/source), the Permittee may request that the Executive Officer consider the SSID project complete.

1.2 SSID Work Plan Organization

This work plan fulfills **Step 1** of the SSID process described above in Section 1.1. It describes the steps that will be conducted to investigate urban sources of fecal pollution impacting Pillar Point Harbor. Consistent with MRP Provision C.8.e.iii.(1)(g), the study generally follows the *California Microbial Source Identification Manual: A Tiered Approach to Identifying Fecal Pollution Sources to Beaches* (Griffith et al. 2013). The work plan is organized according to the required work plan elements described in Step 1.

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2.0 Problem Definition and Study Objectives

2.1 Problem Definition

This SSID project was triggered by fecal indicator bacteria (FIB) densities exceeding Water Quality Objectives that have been measured in receiving waters and tributaries to Pillar Point Harbor. This SSID study builds on prior and ongoing investigations conducted in the Pillar Point Harbor watershed.

Prior to 2006, the Pacific Ocean at Pillar Point Beach (near the community of Princeton) (Figure 1) was added to the Clean Water Act Section 303(d) list of water quality limited segments due to high levels of coliform bacteria. The listing was partially based on weekly monitoring conducted at stations Pillar Point 7 and Pillar Point 8 by the San Mateo County Environmental Health Services Division with assistance from volunteers associated with the Surfrider Foundation. Environmental Health Services also conducts weekly monitoring at other locations in Pillar Point Harbor, including Capistrano Beach (station Pillar Point 5) and Mavericks Beach (station Pillar Point 9). See Figure 1 for Environmental Health Services station locations. The County's beach monitoring is conducted in compliance with Assembly Bill (AB) 411 which requires weekly testing of waters at public beaches from April 1 to October 31 of each year for FIB (total coliform, fecal coliform, enterococci) to determine whether beach closures or postings should be implemented due to potential fecal contamination. The County conducts year-round monitoring with financial assistance from the Public Beach Safety Grant Program through the State Water Resources Control Board Division of Water Quality.

Heal the Bay summarizes ocean water quality data in the weekly and annual Beach Report Card. The Beach Report Card gives letter grades to beaches in California, Oregon and Washington according to the estimated risk of illness to ocean users. Although it was not designated as a "Beach Bummer" in 2016-17, Heal the Bay has given Pillar Point Harbor (at the end of Westpoint Ave, station Pillar Point 7) a D grade in three of the past nine summers, including 2015-16, 2011-12, and 2010-11 (Heal the Bay 2017). This beach also commonly receives F grades during winter months and wet weather. Station Pillar Point 7 is mapped in Figure 1.

In an effort to understand the primary sources of fecal contamination at Pillar Point Harbor and to identify potential remediation strategies, the RCD and University of California, Davis (UCD) implemented a Proposition 50 Clean Beaches Initiative Grant-funded study in 2008 and 2011-12 (RCD 2014). The Pillar Point Harbor Source Identification Project consisted of extensive water quality and hydrologic monitoring in the harbor and watershed, including collection of water, sediment, and biofilm samples during wet and dry weather for analysis of FIB (*E. coli* and enterococci) and bacteroidales associated with human, bovine, dog, horse, and avian sources. The study indicated that high FIB was likely due to influences from storm drains and creeks rather than from sources at the beaches and within the harbor itself. Several sources such as horses and marine mammals were considered insignificant while others such as dog and bovine were observed at certain locations.

Figure 1. Pillar Point Harbor and Environmental Health Services sample stations.

2.2 Study Objectives

The objective of this SSID study is to build on the RCD/UCD Pillar Point Harbor Source Identification Project by focusing on bacteria sources to specific creeks and storms drains that discharge to Pillar Point Harbor. The study is designed to identify geographic, seasonal, and species-specific sources of bacteria to Pillar Point Harbor from the urban community of El Granada and surrounding areas, which are part of unincorporated San Mateo County, an MRP Permittee. The Study Area is drained by an MS4 with outfalls that discharge to local creeks, Pillar Point Harbor, and the Pacific Ocean south of the harbor. Management Questions that will be addressed by the SSID study include:

1. Are there specific areas within the Study Area that are contributing FIB to receiving waters during wet and dry conditions?
2. Are there downstream trends in FIB densities in creeks that flow through urban areas to Pillar Point Harbor during wet and dry conditions?
3. Are controllable sources of bacteria (especially human and dog) present in the urban areas?

If warranted, preliminary management actions to control bacteria densities in receiving waters will be identified.

2.3 Bacteria Water Quality Objectives

This SSID work plan is designed to identify whether urban areas drained by the MS4 in the Study Area are an important source of bacteria to Pillar Point Harbor and whether the sources of bacteria in the Study Area are controllable (especially human and dog). These are key steps towards the longer-term goal of reducing FIB densities in Pillar Point Harbor and, more specifically, reducing the risk of illness for recreators at the local beaches. In this effort, it is important to understand the regulatory context of the FIB WQOs, the behavior of bacteria in the environment, and risks associated with FIB.

The State Water Resources Control Board (SWRCB) is part of the California Environmental Protection Agency and administers water rights, water pollution control, and water quality functions for the state. It shares authority for implementation of the federal Clean Water Act (CWA) and the state Porter-Cologne Act with the nine Regional Water Quality Control Boards. The Regional Water Boards regulate surface water and groundwater quality through development and enforcement of WQOs and implementation of plans that will protect the Beneficial Uses of the State's waters. The Basin Plans designate Beneficial Uses, WQOs that ensure the protection of those uses, and programs of implementation to achieve the WQOs.

The Water Quality Control Plan for Ocean Waters of California (SWRCB 2015; Ocean Plan) provides the basis for protection of the quality of ocean waters. It is implemented by the SWRCB and the six coastal Regional Water Boards. The Ocean Plan identifies Beneficial Uses of California's ocean waters, establishes narrative and numerical WQOs protective of those Beneficial Uses, identifies areas where discharges are prohibited, and sets forth a program of implementation to ensure that the ocean water WQOs are achieved and Beneficial Uses are protected.

Several Beneficial Uses are designated in the Ocean Plan for ocean waters at Pillar Point Harbor including water contact recreation (REC-1) and noncontact water recreation (REC-2). In addition, one of the freshwater tributaries that discharge to Pillar Point Harbor (Denniston Creek[1]) has designated Beneficial Uses in the Basin Plan, including REC-1 and REC-2 which are defined in the Basin Plan as:

- **REC-1:** *"Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs."*

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[1] The REC-1 Beneficial Use designation for Denniston Creek is inferred. In reality, it is highly unlikely that water contact recreation would occur in Denniston Creek or other creeks draining to Pillar Point Harbor because they lack swimming holes, sandy beaches, and gently sloping banks.

- **REC-2: "***Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities."*

Bacteria WQOs apply to ocean and fresh waters with REC-1 and REC-2 Beneficial Uses.[2] REC-1 use of water with fecal contamination could cause gastrointestinal and other types of illnesses if pathogens (i.e., certain viruses, bacteria, or protozoa) are present. Testing water samples for specific pathogens is generally not practical for a number of reasons (e.g., concentrations of pathogens from fecal contamination may be small and difficult to detect but still of concern, laboratory analysis is often difficult and expensive, and the number of possible pathogens to potentially test for is large). Therefore, the presence of pathogens is inferred by testing for "pathogen indicator" organisms or FIB. Since the 1950's, numerous epidemiological investigations have been conducted to evaluate the relationship between illness rates and suitable pathogen indicators or FIB. The United States Environmental Protection Agency (USEPA) recommends using *E. coli* and enterococci as indicators of fecal contamination based on historical and recent epidemiological studies (USEPA 2012).

Current Basin Plan (SFRWQCB 2017) and the soon-to-be-adopted[3] USEPA (2012) bacteria WQOs are listed in Table 1. It is important to recognize that pathogen indicator thresholds were derived based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions found in urban creeks. Pathogen indicators observed at the Pillar Point Harbor stations may not be associated with human sources and therefore may pose a relatively low threat to human health compared to human sources. As a result, the comparison of pathogen indicator results to WQOs may not be appropriate and should be interpreted cautiously.

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[2] Bacteria WQOs also apply to waters with Shellfish Harvesting and Municipal Supply Beneficial Uses. Although Shellfish Harvesting does not apply to Pillar Point Harbor or its tributaries, Denniston Creek (upstream of the MS4) is used as a municipal supply for the Coastside County Water District (CCWD) which serves residents of coastal San Mateo County.

[3] The SWRCB is proposing amendments to the Water Quality Control Plans for Inland Surface Waters, Enclosed Bays and Estuaries and the Ocean Waters of California to include updated WQOs for bacteria to protect REC-1 Beneficial Uses. The proposed amendments will likely include *E. coli* and enterococci based on ambient recreational criteria developed by USEPA (2012).

Table 1. SFRWQCB and USEPA bacteriological criteria for water recreation (freshwater).

Indicator Organism	*(units)*	REC-1		REC-2		WQO Source
		GM	**90th PCTL**	**GM**	**90th PCTL**	
Total Coliform	*(MPN/100ml)*	240	10,000	NA	NA	SFRWQCB 2013
Fecal Coliform	*(MPN/100ml)*	200	400	2,000	4,000	SFRWQCB 2013
E. coli	*(CFU/100ml)*	100	320	NA	NA	USEPA 2012 [1]
Enterococci [2]	*(CFU/100ml)*	30	110	NA	NA	USEPA 2012

REC-1 = Water Contact Recreation
REC-2 = Noncontact Water Recreation
GM = geometric mean, NA = not available, PCTL = percentile
1. Based on estimated illness rate of 32 per 1,000 recreators.
2. Enterococci objective will likely only apply to waters where the salinity is equal to or greater than 10 ppt (approx. 17,022 umhos/cm) at least 95 percent of the time. It is unlikely that Pillar Point Harbor tributaries meet this criterion.

3.0 Study Area, Existing Data, and Candidate Causes

3.1 Study Area

Pillar Point Harbor (Figure 1) is an embayment located along the San Mateo County coastline that is enclosed by two sets of breakwaters (Wuertz et al. 2011). The inner breakwaters, constructed in 1982, protect the 45-acre inner boat harbor which contains an active marina with approximately 400 slips and an adjacent beach (Inner Harbor Beach). The outer breakwaters, constructed in 1961, protect an additional 280 acres of ocean waters with five beaches (Mavericks Beach, Pillar Point Marsh Beach, Yacht Club Beach, Capistrano Beach, and Beach House Beach).

The watershed draining to Pillar Point Harbor is approximately 3,923 acres and consists of several subwatershed areas (Figure 2), which are described below. The Study Area for this SSID project is limited to the Pillar Point Marsh, Denniston Creek, Capistrano Catchment, St. Augustine Creek, and Deer Creek subwatershed areas that are drained by the MS4 and regulated through the MRP. The small community of Princeton-by-the-Sea is not included in the Study Area.

- **Pillar Point Marsh.** This watershed includes a protected salt marsh that conveys runoff from the Half Moon Bay Airport, the Pillar Ridge Mobile Home Park, and several agricultural fields. Although the mouth of Pillar Point Marsh at the beach has been sampled for bacteria in the past, upstream locations have not been targeted.
- **Denniston Creek.** Denniston Creek is the largest tributary draining to Pillar Point Harbor. It's large upper watershed is mostly open space and is used as a municipal water supply for CCWD. There are a few agricultural fields scattered throughout the watershed. Residential areas of El Granada are located on the lower east side of the creek and are drained by an engineered MS4 to the creek. Commercial businesses are located near the creek mouth and also drain via the MS4. Dry season flow has been observed within the MS4 suggesting infiltration of groundwater and/or irrigation return flows.
- **Capistrano Catchment.** The Capistrano Catchment is a piped system that is comprised almost entirely of commercial businesses. Some storm drains in this catchment have a small amount of flow year-round which appear to be a result of ground water seepage into the pipes and/or irrigation return flows from the commercial businesses.
- **St. Augustine Creek.** The headwaters of St. Augustine Creek are comprised of open space; however, the creek enters a pipe at the upstream extent of the urban area. The pipe receives inputs from the MS4 along its length and discharges to the beach at the "bathhouse" outfall.
- **Deer Creek**. The Deer Creek watershed is larger than St. Augustine. Deer Creek maintains a natural bed and banks throughout most of its length; however, the creek channel is restricted by close-proximity to residential land uses. Deer Creek enters a culvert at Highway 1 and discharges to the beach via an outfall just east of the Harbor Launch Ramp.

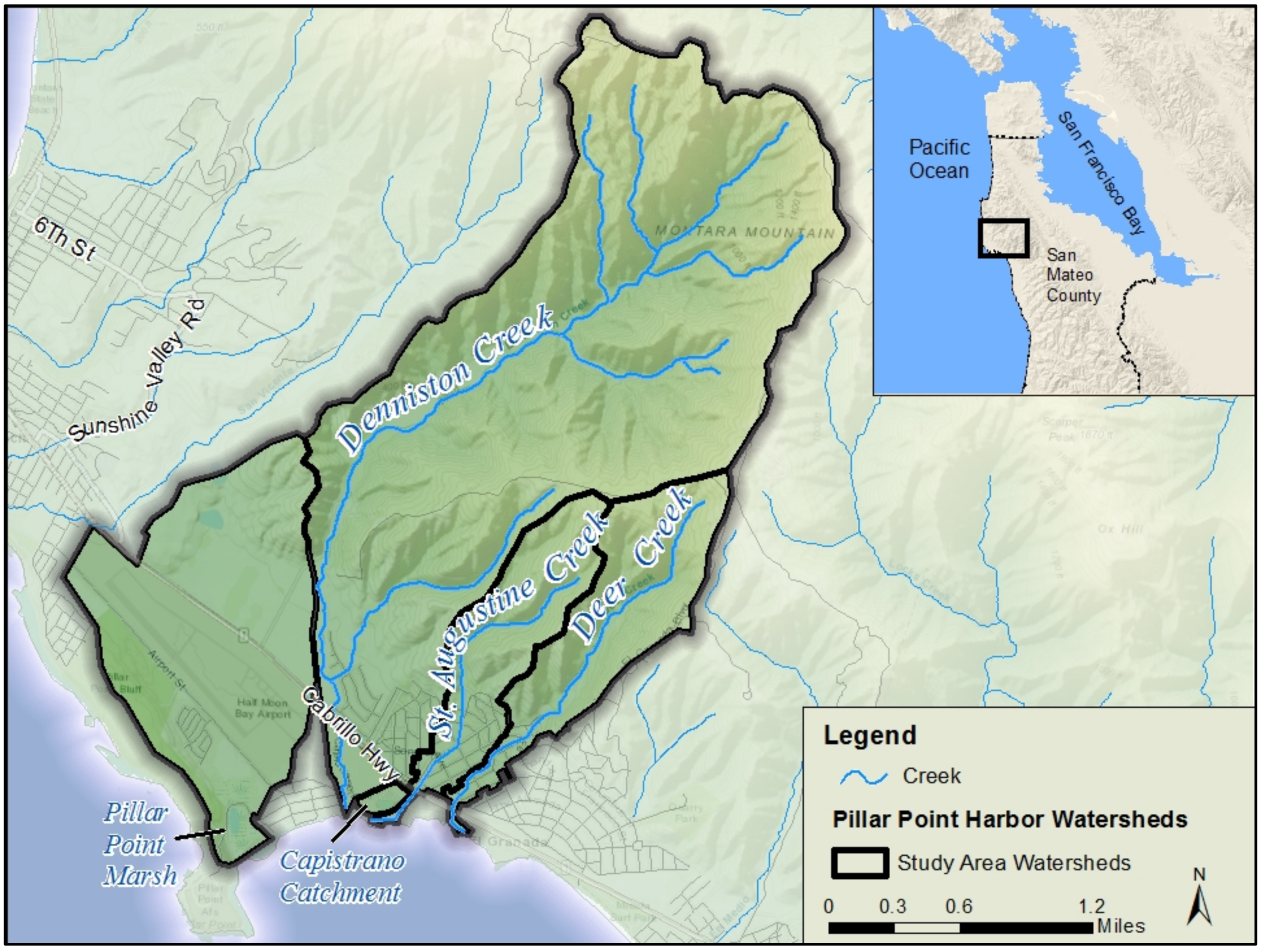
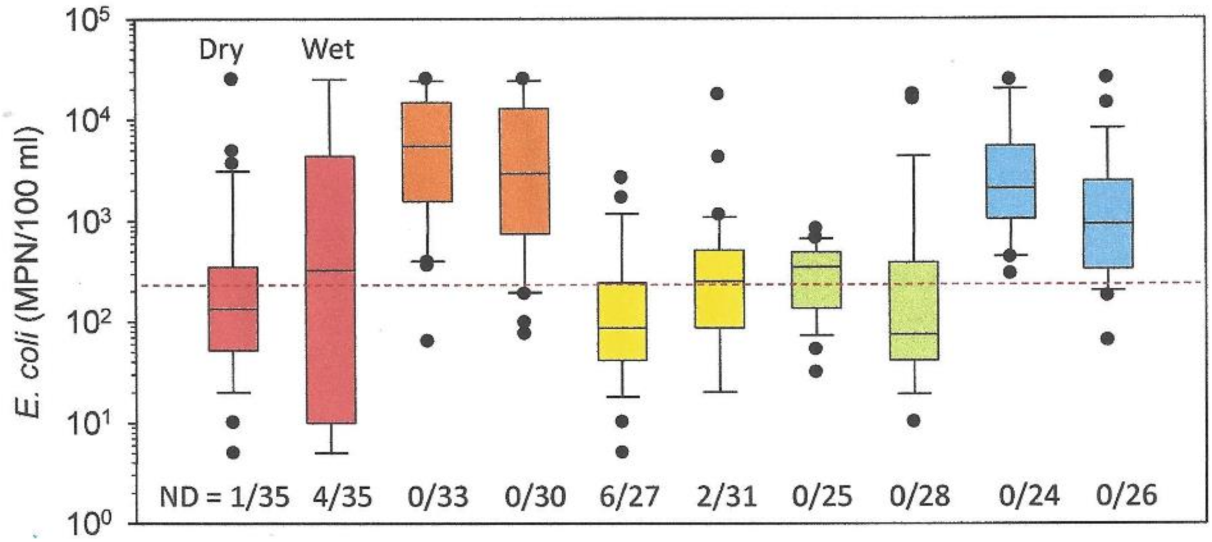


Figure 2. Pillar Point Harbor watershed and subwatersheds.

3.2 Existing Data

The range of FIB (*E. coli* and enterococcus) densities and seasonal patterns at four of the Study Area subwatershed outfalls to Pillar Point Harbor were reported by Kim and Wuertz (2014) as part of the RCD (2014) study. Figure 3 (from Kim and Wuertz 2014) shows box plots of biweekly *E. coli* densities at the four outfalls and Capistrano Beach from 2011-2012. The number of non-detects out of total samples measured is indicated for each station. The highest *E. coli* densities were measured at the St. Augustine and Deer Creek outfalls. These two stations, as well as Denniston Creek had slightly lower median *E. coli* densities during the wet season compared to the dry season. In contrast, median wet season *E. coli* densities at the Capistrano outfall and Capistrano Beach were higher than median dry season *E. coli* densities.

The Kim and Wuertz (2014) study also measured FIB in samples collected from stations upstream of the four main outfalls. Upstream stations were generally located above residential/developed areas. *E. coli* densities at the upper St. Augustine and Deer Creek stations were significantly lower than the respective outfall stations. There was not a significant difference between upstream and downstream *E. coli* densities in the Capistrano catchment or Denniston Creek.



Capistrano Outfall St. Augustine Capistrano Beach Denniston Cr Deer Cr

Figure 3. *E. coli* densities during the wet and dry season at four outfalls to Pillar Point Harbor and Capistrano Beach, 2011-2013. Figure 6 from Kim and Wuertz (2014).

In addition to FIB monitoring, the RCD also analyzed samples for species-specific bacteroidales using microbial source tracking (MST) techniques. Human, canine (dog), and bovine (cattle) markers were analyzed. Kim and Wuertz (2014) reported the findings listed in Table 2.

Table 2. Detections of species-specific bacteroidales markers at Pillar Point Harbor stations, 2008 and 2011-2012. Data from Kim and Wuertz (2014).

	Dry Season	**Wet Season**
Capistrano Outfall	*(number of detects/total number of samples)*	
Human	1/3	0/17
Dog	1/3	3/17
Bovine	0/3	0/17
St. Augustine Creek		
Human	0/3	2/15
Dog	1/3	6/15
Bovine	0/3	2/15
Capistrano Beach		
Human	0/3	3/15
Dog	1/3	5/15
Bovine	0/3	0/15
Denniston Creek		
Human	1/3	1/17
Dog	2/3	2/17
Bovine	0/3	0/3
Deer Creek		
Human	1/3	1/11
Dog	1/3	8/11
Bovine	3/3	6/11

3.3 Candidate Causes

Based on Kim and Wuertz (2014) *E. coli* and MST results, urban areas within the St. Augustine and Deer Creek watersheds are a likely source of FIB to Pillar Point Harbor and all three monitored markers (human, dog, and bovine) may be present. Table 3 lists potential sources of FIB that may be present in the Study Area. Potential sources are grouped into two categories: controllable and uncontrollable. Controllable sources are those that could be reduced through management actions implemented by municipalities; however, the magnitude of reduction may be constrained. Uncontrollable sources occur naturally and would be difficult or impossible to reduce through the types of management actions available to municipalities. This SSID study is designed to assess which sources are present in the Study Area.

Table 3. Potential sources of pathogen indicators in the Study Area within the Pillar Point Harbor watershed.

Controllable Sources
Pet waste (cats and dogs)
Wildlife waste (birds, rodents, deer, raccoons), associated with human activities, such as littering, which can attract wildlife by creating scavenging areas.
Trash receptacle leachate. Rodents and birds scavenge in trash bins. They may also contain discarded pet waste or diapers.
Illicit connections conveying greywater. Groundwater contaminated within the system by litter, grease, and sediment. Power-washing of mats, containers, and impervious surfaces into the MS4.
Human waste discharges (homeless encampments, RV discharges, leaking sewer lines and septic systems)
Domestic animals and livestock (cattle, horses, chickens, goats). *Likely not present in Study Area but may be present within upgradient areas.*
Uncontrollable Sources
Birds and other wildlife (e.g., deer, raccoons, ground squirrels, rabbit, skunk, opossum, wild turkey) in open space, creek corridors, and forested areas.
Bacteria naturally present in the environment (e.g., biofilms, soils, and sediments in the watershed, creek, and conveyance system).

4.0 SSID Investigation Approaches and Schedule

The Pillar Point Watershed Pathogen Indicator SSID Project seeks to better characterize the magnitude, seasonal variability, and predominant sources of FIB in the watershed area that is drained by the MS4 and regulated through the MRP (i.e., Study Area). Knowledge of the sources will be used to refine bacteria control measures. The SSID work plan includes both desktop and field tasks and is based on the tiered approach described in the *California Microbial Source Identification Manual: A Tiered Approach to Identifying Fecal Pollution Sources to Beaches* (Griffith et al. 2013).

4.1 Desktop Analysis

The core of the SSID Project is identification of FIB sources through information gathering. Potential sources of FIB in the Study Area will be identified and compiled with monitoring and geographic data in a geographic information system (GIS) database (geodatabase). Maps will be developed to visualize and interpret the data to understand relationships, patterns, and trends. Existing GIS data layers will be compiled and new GIS data layers will be developed, if necessary.

Listed below are GIS layers that will be useful in identifying potential sources of FIB and the likelihood that the sources will enter the MS4. These layers, which are related to environmental setting and potential FIB sources, will be incorporated into the geodatabase. Note: some of these layers may contain sensitive information that will not be shared with the public.

- **County Assessor Parcel Records/Land Use.** This layer provides use, ownership, and structural information for every parcel in the County. There are nearly 100 different Use Codes that identify whether the parcel is residential, industrial, commercial, agricultural, transportation, or public. A land use analysis will be conducted for each of the subwatersheds in the Study Area (i.e., Denniston Creek, Capistrano Catchment, St. Augustine Creek, Deer Creek).
- **Creeks.** This layer maps creeks and canals in the County based on the 2001 countywide orthophotos. It provides valuable information about hydrology in the Study Area.
- **Storm Drainage System**. This layer maps storm drainage pipes, open channels, stormwater detention basins, storm drainage pumps, and drainage areas. It provides information on storm runoff routing within the Study Area.
- **Sanitary Sewer System**. This layer maps the lines that convey sewage from residences and businesses to the Wastewater Treatment Plant (WWTP) located in Half Moon Bay.
- **Livestock Facilities.** Livestock manure, if not properly managed, is a potentially significant source of FIB in the study area. Although generally not present in the Study Area (and not the focus of this SSID work plan), livestock facilities in the upper watersheds will be mapped. This information will be gathered through interviews with RCD staff and aerial photo interpretation (e.g., Google Earth).
- **Sanitary Sewer Overflows**. Sanitary sewer overflows (SSOs) and leaking conveyance lines can contribute bacteria to MS4s and receiving waters through surface and

subsurface pathways. Sanitary sewer conveyance systems in the Study Area will be mapped. The SWRCB's online SSO database, which contains detailed information on reported overflow incidents including whether the discharge reached a receiving water or MS4, will be reviewed as part of this task.

- **Septic Systems**. Failing septic systems can allow untreated human wastes to flow into drainage ditches and MS4s. It is unlikely that onsite wastewater treatment systems (OWTS) are located in the Study Area; however, County staff will be queried for confirmation.
- **Direct Human Waste**. Homeless encampments and RV parking areas can contribute bacteria directly to receiving waters and MS4s. County and RCD staff will be interviewed to assess whether (and where) homeless encampments occur in the study area.
- **Pet Waste**. Pet waste, when left on the ground, can be a major source of bacteria in MS4s and receiving waters. Residential areas, parks, and favorite dog walking routes are the most likely areas where pet waste is found. These areas will be mapped through review of land use (i.e., the Assessor Parcel Records) and interviews with County and RCD staff.
- **Wildlife**. Birds, rodents, raccoons, opossums, wild pigs, deer, and other wildlife are often the primary source of bacteria in creeks. To the extent feasible within the project budget, areas where wildlife congregate will be mapped.

Development of the geodatabase, including creation of GIS layers representing results of the potential FIB source desktop investigation will be conducted in Fiscal Year (FY) 2017/2018.

4.2 Field Investigation

The SSID Project will implement a water sampling program that targets multiple sites in each of the Study Area watersheds, spans the wet and dry seasons of Water Year 2018[4], and includes both FIB and MST analyses.

4.2.1 Stations

Samples will be collected from up to fourteen stations that have been selected to characterize background water quality upstream of the areas drained by the MS4 and specific catchments within the Study Area. All fourteen stations will be sampled during each monitoring event unless flow is not present, which is a possibility during dry weather. Table 4 lists the station locations, goals for each station, and bacteria sampling history. Stations are mapped in Figure 4 and described by subwatershed below.

- **Pillar Point Marsh Watershed.** Urban runoff within this watershed will be characterized by samples collected at station ARPT which is located within a swale

[4] Most hydrologic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2018 (WY 2018) began on October 1, 2017 and will conclude on September 30, 2018.

downstream of MS4 discharges from the Pillar Ridge Mobile Home Park and a section of Airport Street where RVs are often parked.

- **Denniston Creek Watershed**. Stations DNUS and DNDS are located in Denniston Creek upstream and downstream of the area drained by the MS4. These stations were previously sampled by Kim and Wuertz (2014). In addition, two stations within the MS4 system (DNCS and DNPC) capture increasingly larger contributions of urban runoff and have not been monitored in the past.
- **Capistrano Catchment**. Storm drain stations CPNO and CPSO capture stormwater runoff from the north and south portions of the Capistrano Catchment respectively. Station CPDS is located at the outfall to the beach. CPDS includes the entire catchment and was previously sampled by Kim and Wuertz (2014).
- **St. Augustine Creek Watershed**. Stations AGUS and AGDS are located upstream and downstream of the area drained by the MS4. Station AGUS is within the natural creek just upstream of where the creek enters a pipe. Station AGDS is at the outfall to the beach. These stations were previously sampled by Kim and Wuertz (2014). Station AGCH accesses the engineered creek via a manhole and is located downstream of the residential area and upstream of Harbor District property.
- **Deer Creek Watershed**. Stations DRUS and DRDS are located upstream and downstream of the residential area which is drained by swales and gutters rather than an engineered network of pipes. Station DRVL is located within the creek approximately midway through the residential area. All stations were previously sampled by Kim and Wuertz (2014).

Table 4. Pillar Point Harbor Watershed Pathogen Indicator SSID Project sample stations.

Station ID	Latitude	Longitude	Location	Goal	Bacteria Sampling History
Pillar Point Marsh Subwatershed					
ARPT	37.50638	-122.49473	Swale draining Airport St.	Captures runoff from Airport St. and Pillar Ridge Mobile Home Park	None
Denniston Creek Subwatershed					
DNUS	37.51618	-122.48781	Creek at end of Bridgeport Dr.	Background station (upstream of MS4).	Approximate location of Kim and Wuertz (2014) station PPH-DN4. Sampled for FIB and MST in Dec 2012.
DNCS	37.50798	-122.48503	Drainage swale below MS4 outfall near Sonora Ave/Coral Reef Ave in upper watershed.	Isolates residential areas in upper watershed. Likely dry during dry weather.	None
DNPC	37.50471	-122.48657	Manhole near Prospect Way/Capistrano Rd.	Includes majority of MS4 discharges in watershed.	Limited sampling by RCD and SMCWPPP
DNDS	37.50522	-122.48700	Creek downstream of Prospect Way.	Downstream station near mouth of creek.	Kim and Wuertz (2014) station PPH-4. Sampled biweekly for FIB in 2011 and 2012. Sampled for MST in 2008, 2011, and 2012 (n=20). Limited sampling by RCD for the Harbor District (2014-2017) and during First Flush events.
Capistrano Catchment					
CPNO	37.50447	-122.48576	Manhole on Capistrano Rd in front of HMB Brewing Company	North portion of catchment. GW infiltration causes perennial flow.	Limited sampling by RCD and SMCWPPP
CPSO	37.50367	-122.48520	Inlet on Capistrano Rd in front of Barbara's Fishtrap	South portion of catchment.	Limited sampling by RCD and SMCWPPP
CPDS	37.50381	-122.48590	Outfall to beach	Captures entire Capistrano Catchment.	Kim and Wuertz (2014) station PPH-1. Sampled biweekly for FIB in 2011 and 2012. Sampled for MST in 2008, 2011, and 2012 (n=20). Limited sampling by RCD for the Harbor District (2014-2017) and during First Flush events (2008-2017). Some Surfrider data.

Station ID	Latitude	Longitude	Location	Goal	Bacteria Sampling History
St. Augustine Creek Subwatershed					
AGUS	37.50989	-122.47706	Creek at end of Montecito Ave	Background station (upstream of MS4).	Kim and Wuertz (2014) station PPH-2B. Limited sampling by RCD for the Harbor District.
AGCH	37.50548	-122.4814	Manhole on north side of Capistrano Rd/Hwy 1	Captures engineered creek and entire residential MS4 (upstream of Harbor District property).	None
AGDS	37.50330	-122.4845	Outfall to beach at "Bathhouse"	Downstream station. Sampling only possible during low tide.	Kim and Wuertz (2014) station PPH-2. Sampled biweekly for FIB in 2008, 2011, and 2012. Sampled for MST in 2008, 2011, and 2012 (n=18). Limited sampling by RCD for the Harbor District (2014-2017) and during First Flush events.
Deer Creek Subwatershed					
DRUS	37.50987	-122.47223	Creek near end of San Juan Ave	Background station (upstream of MS4).	Approximate location of Kim and Wuertz (2014) station PPH-DR6. Sampled for FIB and MST in Dec 2012.
DRVL	37.50642	-122.47670	Creek at Valencia Ave crossing	Captures creek and majority of non-engineered MS4 draining residential area.	Approximate location of Kim and Wuertz (2014) station PPH-DR4. Sampled for FIB and MST in Dec 2012.
DRDS	37.50272	-122.47710	Outfall to beach on east side of Launch Ramp	Downstream station. Sampling only possible during low tide.	Kim and Wuertz (2014) station PPH-8. Sampled biweekly for FIB in 2011 and 2012. Sampled for MST in 2008, 2011, and 2012 (n=14). Limited sampling by RCD for the Harbor District (2014-2017) and during First Flush events.

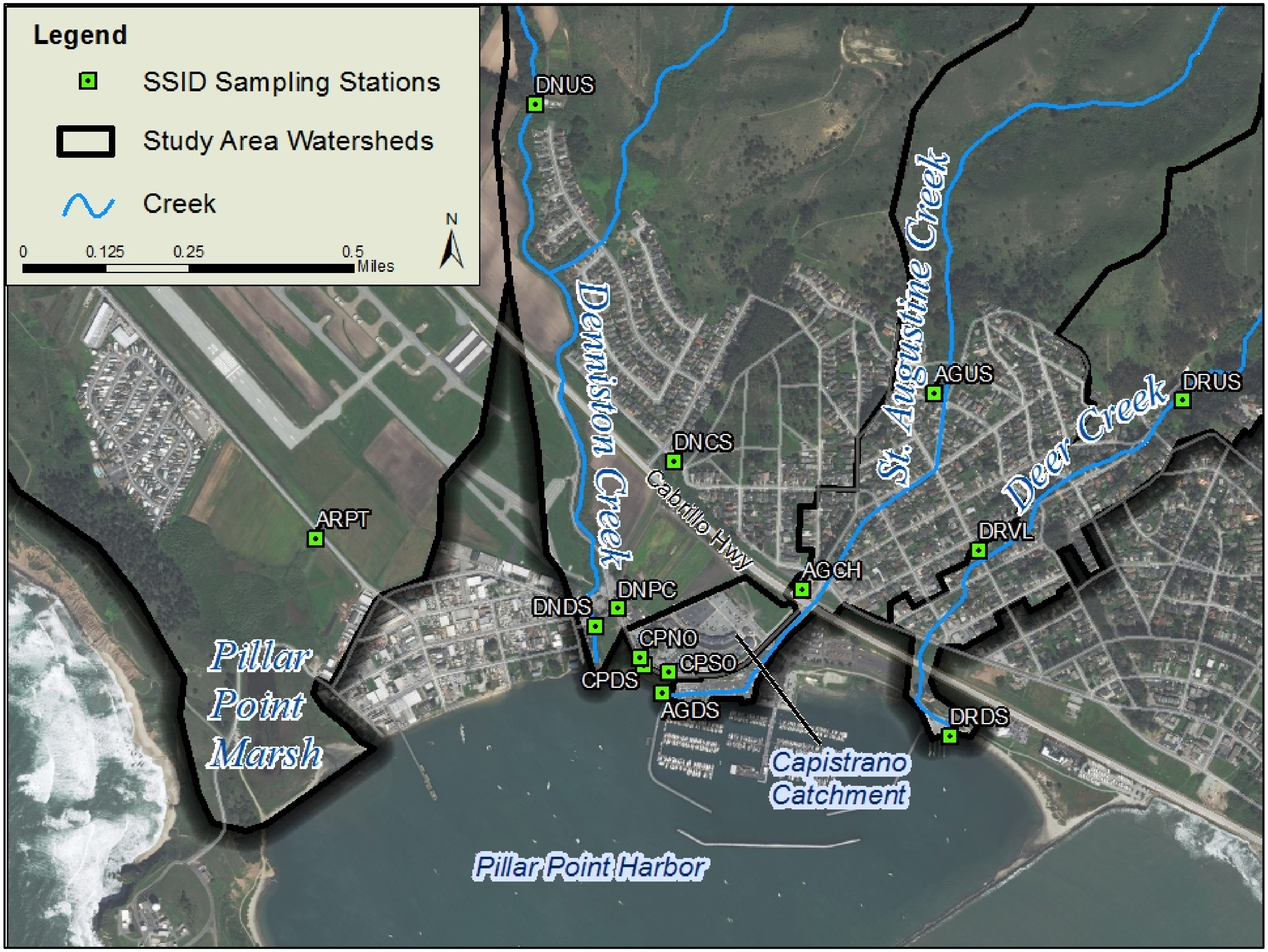


Figure 4. Pillar Point Harbor Watershed Pathogen Indicator SSID Project monitoring stations.

4.2.2 Schedule

This is a one-year study to be conducted in Water Year 2018. A total of four sampling events will be conducted, two during storm events and two during the dry season. The goal is to identify whether there are seasonal differences in the FIB and MST signatures within the watersheds.

- **Storm Sampling**. If possible, sampling will be conducted during active precipitation. Decisions to mobilize for storm sampling will be based on 0.20 inch of rainfall predicted to occur within a 6-hour period. The Forecast Weather Table Interface published by the National Oceanographic and Atmospheric Association (NOAA) should be tracked.[5] Sampling should only occur when conditions are safe. If necessary, storm sampling can be initiated within 48 hours after 0.20 inch of rainfall in 12 hours is recorded in the area.
- **Dry Season**. Dry season sampling will occur on any two occasions (at least two weeks apart) during May through September. Dry season sampling should not be conducted within 72 hours of a rain event. It is possible that some stations will be dry during dry season sampling events.
- **Tidal Conditions**. Two of the four subwatershed outfalls to the beach are known to be inundated during high tide (AGDS and DRDS). Therefore, all sampling events must be timed for low tide. Furthermore, the order in which stations are visited should consider tidal conditions, with the two impacted stations sampled as close to low tide as possible. Saltwatertides.com posts tidal predictions for Princeton-by-the-Sea in both desktop and mobile format.

4.2.2 Constituents

All grab samples will be analyzed for FIB (*E. coli*) and bacteroidales associated with humans and dogs. *E. coli* is selected because it is the USEPA (2012) recommended FIB for freshwater and will likely be adopted by the SWRCB as the applicable bacteria indicator, replacing fecal and total coliform. The MST markers (human and dog) are selected because they are the most likely "controllable" bacteria sources associated with urban development. Field measurements of pH, dissolved oxygen, specific conductance, and temperature will also be recorded with each grab sample. Table 5 lists the analytical method or field equipment associated with each constituent.

[5] http://www.wrh.noaa.gov/forecast/wxtables/index.php?lat=37.5047&lon=-122.4863

Table 5. Pillar Point Harbor Watershed Pathogen Indicator SSID Project sampling constituents.

Constituent	Sample Type	Method	Bottle Type	Hold Time
E. coli (MPN/100 mL)	Grab	SM9223B	100 ml sterile	8-24 hrs
Total bacteroides qPCR (present/absent)	Grab	EPA Method B	100 ml sterile	8-24 hrs
Human specific bacteroides (HF 183) qPCR (present/absent)	Grab	Griffith et al. 2013	100 ml sterile	8-24 hrs
Dog specific bacteroides (DogBact) qPCR (present/absent)	Grab	Griffith et al. 2013	100 ml sterile	8-24 hrs
pH	Field measurement	YSI multi-parameter sonde	NA	NA
Temperature (°C)	Field measurement	YSI multi-parameter sonde	NA	NA
Dissolved Oxygen (% saturation and mg/L)	Field measurement	YSI multi-parameter sonde	NA	NA
Specific Conductance (umhos/cm)	Field measurement	YSI multi-parameter sonde	NA	NA

4.2.3 Materials and Methods

Field crews, staffed by the RCD, will record field measurements (pH, temperature, dissolved oxygen, specific conductance) at the designated monitoring stations and will collect grab samples of water for analysis of FIB (*E. coli*) and bacteroidales. Sampling techniques will include direct measurement of water with the YSI multi-parameter sonde and filling of sterile sample containers (or filling of sterile sample *collection bottles or buckets* and immediate transfer of sample to sample containers), placement on ice, and delivery of samples to the analytical laboratory under chain-of-custody (COC) within specified hold time requirements. Samples must be collected in a consistent manner that neither contaminates, loses, or changes the form of the analytes of interest. In addition, quality control/quality assurance (QA/QC) measures should be performed. Details are provided below:

- **Pre-Sampling Procedures.** At the start of each sampling season (wet and dry), the analytical laboratory should be contacted to notify them of the likely sampling schedule and the number of samples to be delivered. At that time, FIB and MST sample containers and sterile intermediate collection containers should be ordered from the lab. Enough sample containers for 14 sites plus one field duplicate and one field blank should be ordered.

One or two days prior to collection of field data, the sample team should complete/assemble the following:

- Paperwork (Monitoring Plan, chain-of-custody forms, datasheets, maps, permits, gate keys).
- YSI hand-held multi-parameter sonde (calibrated <24 hours before event)
- Sample containers and sterile sample collection containers.
- Labels and marker to write on labels.
- Cooler(s) with cube ice and zip-top bags for double-bagging the ice.
- Sampling extension pole with device to hold sample bottles, and screw driver to loosen the band that holds the sample bottle to the pole.
- Ethanol solution 70 percent for field sterilization of sampling extension pole and the YSI sonde.
- Samples gloves (powder-free polyethylene, nitrile, or non-talc latex).
- Paper towels.
- Rubber boots or chest/hip waders for each person.
- Cell phone.
- Camera.
- First aid kit

- **Field Documentation**. A field datasheet is provided in Attachment 1. This form is for recording details about each sampling event at each sampling station. It includes the following information:

    - Date and time of sample collection
    - Project, Site ID, and Station Name
    - Names of field staff
    - Sampling method (e.g., use of extension pole/intermediate collection bottle)
    - Qualitative descriptions of relevant water conditions (e.g., color, flow level, clarity, odor, presence of debris or litter) and weather (e.g., current and antecedent rain) at the time of sample collection
    - Check box to indicate if the blind field duplicate was collected at the site
    - Field measurements (pH, temperature, dissolved oxygen, specific conductance)
    - Comments entered by field staff indicating any unusual occurrences that may affect sample or data quality and the number of photographs that were captured.

- **Sample Container Labels.** Each sample container will be labeled with the Site ID (see Table 4), matrix type (water), analysis type (*E. coli* or bacteroidales), and date and time of collection. To the extent feasible, containers will be pre-labeled prior to sampling, as it is difficult to write on labels once they are wet.

- **Sample Collection.** Grab samples for FIB are collected whenever feasible by direct submersion of the preserved sample container into the stream, or flow from an outfall. When feasible, the sample containers should be opened, filled and recapped below the water surface. Samples should always be collected upstream of sampling personnel and equipment, and with the sample container pointed upstream when the container is opened for sample collection. Care must be taken not to sample water downstream of areas where sediments have been disturbed in any manner by field personnel.

If the centroid of the stream cannot be sampled by wading, sampling devices can be used to reach the sampling location. Such devices typically involve a means to extend the reach of the sampler, with the sterile sample collection bottle attached to the end of the device for filling at the desired location. These methods do not allow opening of the sample container under water, so there is some potential for contamination when the container is opened prior to lowering the sample container into the stream. When sampling from a stream bank or at a manhole, the sample container or sterile sample intermediate collection container is attached to a device which is attached in turn to the end of an extendable sampling pole. When no other option is available, sites may be accessed by bridge or through a field inlet and sampled with a sample container-suspending device, lowered into the stream at the end of a pole or rope. Extreme care must be taken to avoid contaminating the sample with debris from the rope and bridge. Care must also be taken to sterilize all sampling devices with a 70 percent ethanol solution between stations. Allow the pole and equipment to air-dry before the sample is taken.

Proper gloves must be worn to both prevent contamination of the sample and to protect sampling personnel from environmental hazards. The user should wear at least one layer of gloves, but two layers help protect against leaks. All gloves must be powder-free. Disposable polyethylene, nitrile, or non-talc latex gloves are acceptable.

- **Field QA/QC Samples.** One set of field duplicates should be collected for each sample event. Field duplicates are used to estimate sampling and laboratory precision. Field duplicates are taken by collecting two sets of samples at the same location within five minutes of each other. Field blanks are used to assess whether the sampling method introduces contamination and are not required for this study.

- **Sample Handling and Custody**. Field crews should properly store and preserve samples as soon as possible after collection. Sample containers should be placed on crushed or cube ice in an insulated ice chest; ice should be placed into sealed, double-bagged zip-top bags prior to sampling to prevent any contamination of samples by melt water. Sufficient ice will be needed to lower the sample temperature to <6°C within 45 min after time of collection. Sample temperature should be maintained at <6°C until delivered to the laboratory.

  Sample transport should be arranged so that samples arrive at the laboratory well within hold time requirements, with a goal of 6 hours. The analytical laboratory should be informed in advance and reminded at time of sample delivery of the holding time requirements, so that required processing or analyses are initiated as soon as possible.

Chain-of-custody (COC) procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. COC forms will be completed and delivered with the samples to the laboratory. If multiple coolers are sent to a single laboratory on a single day, form(s) will be completed and sent with the samples for each cooler, either placed in an envelope and taped to the inside of the top of the cooler, or placed into a zip-top bag and placed within the cooler.

The COC will identify the contents of each cooler and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone's custody if it is either in someone's physical possession, in someone's view, locked up, or kept in a secured area that is restricted to authorized personnel. Until the samples are delivered to the laboratory, the custody of the samples will be the responsibility of the field crew. The sampling team leader or designee will sign the COC in the "relinquished by" box and note date and time.

Each receiving laboratory has a sample custodian who examines the samples for correct documentation, proper preservation and holding times. The laboratory will follow sample custody procedures outlined in their QA plan.

- **Laboratory Analysis**. Samples will be analyzed at a ELAP-certified laboratory for *E. coli* using either most probable number (MPN) (e.g., Colilert) or membrane filter methods and bacteroides using EPA Method B or procedures described in Griffith et al. (2013). The analytical methods should remain consistent throughout the SSID project.

- **Data Management**. All field data will be reviewed for legibility and errors as soon as possible after sampling events. Field sheets will be scanned to pdf and field data will be entered into the project excel database. Record keeping of laboratory analytical data for the Monitoring Plan will employ standard record-keeping and tracking practices. All laboratory analytical data will be entered into electronic files by the instrumentation being used or, if data are manually recorded, then they will be entered by the analyst in charge of the analyses, per laboratory standard procedures. Electronic data provided by the laboratory will be screened for the following major items:
    - Conformity check between electronic data provided by the laboratory and the narrative reports.
    - Conformity check between the COC forms and laboratory reports.
    - A check for laboratory data report completeness.
    - A check for typographical errors on the laboratory reports.
    - A check for suspect values.

4.3 Reporting

EOA will prepare a report describing the desktop analysis, field investigation, and results. The report will include data tables and maps illustrating the range of pathogen indicator densities measured during the study and the primary source organisms (as identified by the MST component). The data will be presented within the context of available historical data (i.e., RCD (2014), Kim and Wuertz (2014), County Environmental Health Services).

The Management Questions described in Section 2.2 will be addressed:

1. Are there specific areas within the Study Area that are contributing FIB to receiving waters during wet and dry conditions?
2. Are there downstream trends in FIB densities in creeks that flow through urban areas to Pillar Point Harbor during wet and dry conditions?
3. Are controllable sources of bacteria (especially human and dog) present in the urban areas?

If warranted, preliminary management actions to control bacteria densities in receiving waters will be identified.

5.0 References

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Heal the Bay. 2017. Heal the Bay's 2016-17 Annual Beach Report Card. https://healthebay.org/wp-content/uploads/2017/07/BRC_2017_FINAL_LowRes_07.05.17.pdf.

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United States Environmental Protection Agency (USEPA). 2012. Recreational Water Quality Criteria. Office of Water 820-F-12-058.

Wuertz, S., Wang, D., Zamani, K., and Bombardelli, F. 2011. An Analysis of Water Circulation in Pillar Point Harbor, Half Moon Bay, California, based on the Dye Distribution Study of September 27, 2008. Report prepared for San Mateo County Resource Conservation District.

Attachment 1

Field Datasheet

Pillar Point Harbor Watershed Pathogen Indicator SSID Project
Field Datasheet

General Information:

Site ID: ____________________ Date: _____________________ Time: __________________________

Field Crew: _____________________/_______________________

Current Precipitation: None, Fog, Drizzle, Rain

Antecedent Precipitation (last 72 hrs): Unknown, <1”, >1”, None

Sampling Method (check if applicable):

Sample Collection Depth: Sub-Surface (0.1 m/4 in below water surface), Surface (>0.1 m)

☐ Sample directly into preserved sample container

☐ Use of extension pole and intermediate container

☐ Field duplicate collection (Time:___________)

☐ Photographs (Number:_________ / File ID(s):_______________________)

Water Conditions (circle or describe as appropriate):

Flow: Dry, Isolated Pool, Trickle (<0.1cfs), 0.1-1cfs, 1-5cfs, 5-20 cfs, 20-50cfs, 50-200cfs, >200cfs

Dominant Substrate: Bedrock, Concrete, Cobble, Gravel, Sand, Mud, Unk, Other______

Color: Colorless, Green, Yellow, Brown, Gray, Other________________

Clarity: Clear (see bottom), Cloudy (>4” vis), Murky (<4” vis)

Odor: None, Sulfides, Manure, Sewage, Petroleum, Mixed, Other_____________

Other Presence: Vascular, Nonvascular, Oily Sheen, Foam, Trash, Other______________

Water Quality:

pH: ___________ Temperature (°C): ___________ Spec. Cond. (umhos/cm): ______________________

DO (% sat.): __________________________ DO (mg/L): ______________________________

Comments/Other Observations (unusual occurrences that may affect sample or data quality):

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