SAN MATEO COUNTYWIDE
Water Pollution Prevention Program
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March 31, 2018

Mr. Bruce H. Wolfe
Executive Officer
San Francisco Bay Region
Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Subject: SMCWPPP Urban Creeks Monitoring Report and Electronic Monitoring Data Submittal for **Water Year 2017**

Dear Mr. Wolfe:

On behalf of all San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) Permittees, I am pleased to submit SMCWPPP's Urban Creeks Monitoring Report (UCMR) and Electronic Monitoring Data for the water quality monitoring projects conducted in Water Year (WY) 2017 (October 1, 2016 through September 30, 2017).

The UCMR is submitted in compliance with Provision C.8.h.iii of the Municipal Regional Stormwater Permit (MRP, NPDES #CAS612008, Order R2-2015-0049) which became effective on January 1, 2016. The UCMR contains summaries of monitoring conducted in WY 2017 pursuant to Provision C.8 of the MRP, including: Creek Status Monitoring (Provision C.8.d), Stressor/Source Identification Projects (Provision C.8.e), Pollutants of Concern Monitoring (Provision C.8.f), and Pesticides and Toxicity Monitoring (C.8.g). The UCMR consists of a main report and five appendices.

Electronic Monitoring Data are submitted in compliance with Provision C.8.h.ii of the MRP. Please note that although the UCMR summarizes data collected by SMCWPPP and third-party organizations[1], the electronic data files include only those data collected by SMCWPPP pursuant to the MRP provisions listed in Table 1.

[1] See the Third-Party Monitoring Statement attached at end of this letter.

Table 1. Project, date range, and applicable MRP provision for data included in the Water Year 2017 Electronic Monitoring Data submittal.

Project	Date Range	MRP Provision
Creek Status Monitoring	May - September 2017	C.8.d
Pollutants of Concern Monitoring	December 2016 – April 2017	C.8.f
Pesticides and Toxicity Monitoring	July 2017	C.8.g

The quality of all Creek Status Monitoring (MRP Provision C.8.d) and Pesticides and Toxicity Monitoring (MRP Provision C.8.g) data and the Pollutants of Concern (MRP Provision C.8.f) nutrient data in the electronic data files was evaluated consistent with the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition's *Creek Status Monitoring Program Quality Assurance Project Plan* (QAPP), which is comparable with the latest version of the State of California's Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP). The quality of all Pollutants of Concern Monitoring (MPR Provision C.8.f) PCBs and mercury data in the electronic data files was evaluated consistent with the Clean Watersheds for Clean Bay (CW4CB) project QAPP.

In compliance with Provision C.8.h.ii (Electronic Reporting) of the MRP, all CEDEN-acceptable data (i.e., data collected from a receiving water) were provided to the Regional Data Center for the California Environmental Data Exchange Network (CEDEN), located at the San Francisco Estuary Institute (SFEI), via upload to their FTP site. These data are submitted in a format comparable with the SWAMP database. Pollutants of Concern Monitoring data collected in non-receiving waters are included in the attached electronic files but will not be submitted to the Regional Data Center at this time. For more details on the non-receiving waters data submittal to CEDEN see the BASMAA letter to CEDEN (dated March 20, 2017) which was cc'd to several of your staff.

Monitoring data included in this submittal suggest that water quality conditions in San Mateo County creeks vary substantially among sites and between monitoring events. Temporal and spatial variability adds to the challenge of interpreting and evaluating the data and using it to help identify potential persistent water quality issues warranting a programmatic response. The UCMR includes detailed analyses of the monitoring data.

We look forward to discussing the findings, conclusions, and recommended next steps included in the UCMR and to continuing to work with you and your staff to successfully address new challenges regarding water quality monitoring. Please contact me if you have any comments or questions.

Certification Regarding SMCWPPP Program Urban Creeks Monitoring Report

"I certify, under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted, is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Sincerely,

Matthew Fabry, P.E.
Program Manager

Attachments: SMCWPPP UCMR Water Year 2017
One compact disc with electronic data collected by SMCWPPP for Creek Status Monitoring, Pollutants of Concern Monitoring, and Pesticides and Toxicity Monitoring
Third Party Monitoring Statement (one page)

Third Party Monitoring Statement

Please note that consistent with Provision C.8.a.iii of the MRP, one water quality monitoring requirement was partially fulfilled by third party monitoring in Water Year 2017:

- The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) conducted a portion of the data collection in Water Year 2017 on behalf of Permittees, pursuant to MRP Provision C.8.f – Pollutants of Concern Monitoring. The results of that monitoring are summarized in Section 5 of the attached UCMR. Data collected from stations monitored by the RMP will be submitted to the California Environmental Data Exchange Network directly by the RMP following completion of their quality assurance review.
- Data collected by the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Stream Pollutant Trend (SPoT) Monitoring Program at the San Mateo location is used to partially fulfill MRP Provision C.8.f - Pollutants of Concern Monitoring requirements addressing trends evaluation. Data collected from stations monitored by the SPoT Program will be submitted directly to the California Environmental Data Exchange Network according to the SWAMP schedule for review and reporting of data, which may not occur for several years.

Urban Creeks Monitoring Report

Water Quality Monitoring

Water Year 2017 (October 2016 – September 2017)

Submitted in Compliance with
NPDES Permit No. CAS612008 (Order No. R2-2015-0049),
Provision C.8.h.iii

SAN MATEO COUNTYWIDE
Water Pollution
Prevention Program

A Program of the City/County Association of Governments

March 31, 2018

CREDITS

This report is submitted by the participating agencies in the

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program
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Town of Atherton
City of Belmont
City of Brisbane
City of Burlingame
Town of Colma
City of Daly City
City of East Palo Alto
City of Foster City
City of Half Moon Bay
Town of Hillsborough
City of Menlo Park
City of Millbrae
City of Pacifica
Town of Portola Valley
City of Redwood City
City of San Bruno
City of San Carlos
City of San Mateo
City of South San Francisco
Town of Woodside
County of San Mateo
SMC Flood Control District

Prepared for:

San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
555 County Center, Redwood City, CA 94063
A Program of the City/County Association of Governments (C/CAG)

Prepared by:

EOA, Inc.
1410 Jackson St., Oakland, CA 94610

Preface

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the San Francisco Bay Area regional municipal stormwater permit, which is a National Pollutant Discharge Elimination System (NPDES) permit (in this document the permit is referred to as the Municipal Regional Permit, or MRP)[1]. The RMC includes the following participants:

- Alameda Countywide Clean Water Program (ACCWP)
- Contra Costa Clean Water Program (CCCWP)
- San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
- Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)
- Fairfield-Suisun Urban Runoff Management Program (FSURMP)
- City of Vallejo and Vallejo Flood and Wastewater District (Vallejo)

This Urban Creeks Monitoring Report complies with MRP provision C.8.h.iii for reporting of all data in Water Year 2017 (October 1, 2016 through September 30, 2017). Data were collected pursuant to provision C.8 of the MRP. Data presented in this report were produced under the direction of the RMC and the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) using probabilistic and targeted monitoring designs as described herein.

Consistent with the BASMAA RMC Multi-Year Work Plan (Work Plan; BASMAA 2011) and the Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2016a) and the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2016b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP)[2]. Data presented in this report were also submitted in electronic SWAMP-comparable formats by SMCWPPP to the Regional Water Board on behalf of SMCWPPP Permittees and pursuant to Provision C.8.h.ii of the MRP.

[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) issued the MRP to 76 cities, counties, and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (SFRWQCB 2015). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP QAPrP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

List of Acronyms

ACCWP	Alameda County Clean Water Program
AFDM	Ash Free Dry Mass
BASMAA	Bay Area Stormwater Management Agency Association
BMI	Benthic Macroinvertebrate
BMP	Best Management Practice
C/CAG	San Mateo City/County Association of Governments
CCCWP	Contra Costa Clean Water Program
CEC	Chemicals of Emerging Concern
CEDEN	California Environmental Data Exchange Network
CSCI	California Stream Condition Index
CW4CB	Clean Watersheds for a Clean Bay
DO	Dissolved Oxygen
ECWG	Emerging Contaminant Workgroup
EPA	Environmental Protection Agency
FIB	Fecal Indicator Bacteria
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information system
IBI	Benthic Macroinvertebrate Index of Biological Integrity
IPM	Integrated Pest Management
LID	Low Impact Development
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Water Sewer System
MWAT	Maximum Weekly Average Temperature
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PEC	Probable Effect Concentration
PFAS	Perfluoroalkyl Sulfonates
PFOS	Perfluorooctane Sulfonates
PHAB	Physical Habitat

POC	Pollutant of Concern
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QAO	Quality Assurance Officer
RCD	San Mateo County Resource Conservation District
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
S&T	Status and Trends
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SFRWQCB	San Francisco Regional Water Quality Control Board
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SOP	Standard Operating Procedures
SPLWG	Sources, Pathways, and Loadings Work Group
SPoT	Statewide Stream Pollutant Trend Monitoring
SRP	San Mateo Countywide Stormwater Resource Plan
SSC	Suspended sediment concentration
SSID	Stressor/Source Identification
STLS	Small Tributaries Loading Strategy
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TRC	Technical Review Committee
TRE	Toxicity Reduction Evaluation
TU	Toxic Unit (equivalent)
UCD	University of California, Davis
UCMR	Urban Creeks Monitoring Report
USEPA	US Environmental Protection Agency
USGS	US Geological Survey
WLA	Waste Load Allocation
WMA	Watershed Management Areas
WQO	Water Quality Objective

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Table E.1. Water Year 2017 Creek Status Monitoring Stations

In compliance with Provision C.8.h.iii.(1), this table of all Creek Status Monitoring stations sampled in Water Year 2017 is provided immediately following the Table of Contents. See Section 3.0 for additional information on Creek Status Monitoring.

Map ID *	Station ID	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
								Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont. WQ**	Pathogen Indicators
550	202R00550	Coastside	Pescadero Creek	Jones Gulch	NU	37.278796	-122.26832	X	X				
552	202R00552	Coastside	San Gregorio Cr	Lawrence Creek	NU	37.388456	-122.31340	X	X				
2472	204R02472	Bayside	Redwood Creek	Redwood Creek	U	37.465155	-122.23462	X	X				
2611	204R02611	Bayside	Atherton Creek	Atherton Creek	U	37.450833	-122.20592	X	X				
3240	204R03240	Bayside	Atherton Creek	Atherton Creek	U	37.427321	-122.22682	X	X				
3252	204R03252	Bayside	San Mateo Creek	San Mateo Creek	U	37.563132	-122.32754	X	X				
3272	204R03272	Bayside	San Mateo Creek	San Mateo Creek	U	37.533846	-122.35018	X	X				
3316	204R03316	Bayside	Redwood Creek	Ojo de Aqua	U	37.48119	-122.23427	X	X				
3336	204R03336	Bayside	Belmont Creek	Belmont Creek	U	37.516284	-122.27867	X	X				
3496	204R03496	Bayside	Redwood Creek	Redwood Creek	U	37.447749	-122.23470	X	X				
005	202SPE005	Coastside	San Pedro Creek	San Pedro Creek	U	37.59441	-122.50520			X			
17	202DEN017	Coastside	Denniston Creek	NA (MS4)	U	37.50499	-122.48641						X
5	202DEN005	Coastside	Denniston Creek	Denniston Creek	U	37.50465	-122.48697						X
20	202DEN020	Coastside	Denniston Creek	Denniston Creek	U	37.50638	-122.48714						X
1	202CAP001	Coastside	Capistrano Drainage	NA (MS4)	U	37.50377	-122.48568						X
25	202CAP025	Coastside	Capistrano Drainage	NA (MS4)	U	37.50391	-122.48574						X
19	202SPE019	Coastside	San Pedro Creek	San Pedro Creek	U	37.58853	-122.49943				X		
40	202SPE040	Coastside	San Pedro Creek	San Pedro Creek	U	37.58200	-122.48708				X	X	
50	202SPE050	Coastside	San Pedro Creek	San Pedro Creek	U	37.58198	-122.47819				X		
70	202SPE070	Coastside	San Pedro Creek	San Pedro Creek	NU	37.57974	-122.47371				X	X	
85	202SPE085	Coastside	San Pedro Creek	San Pedro Creek	NU	37.57826	-122.47156				X		

U = urban, NU = non-urban, NA = not applicable, MS4 = municipal separate storm sewer system
* Map ID applies to Figure 3.1.
**General water quality monitoring (temperature, dissolved oxygen, pH and specific conductivity) conducted continuously during two 2-week periods (spring and late summer).

Executive Summary

This Urban Creeks Monitoring Report was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) in compliance the National Pollutant Discharge Elimination System stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP; Order No. R2-2015-0049). This report, including all appendices and attachments, fulfills the requirements of Provision C.8.h.iii of the MRP for reporting of all data collected in Water Year 2017 (WY 2017; October 1, 2016 through September 30, 2017) pursuant to Provision C.8 of the MRP. Data presented in this report were also submitted in electronic SWAMP-comparable formats by SMCWPPP to the Regional Water Board on behalf of SMCWPPP Permittees and pursuant to Provision C.8.h.ii of the MRP.

Water quality monitoring required by Provision C.8 of the MRP is intended to assess the condition of water quality in Bay Area receiving waters (creeks and the Bay); identify and prioritize stormwater associated impacts, stressors, sources, and loads; identify appropriate management actions; and detect trends in water quality over time and the effects of stormwater control measure implementation.

The organization of this Executive Summary follows the sub-provisions of Provision C.8 (Water Quality Monitoring) of the MRP. Each section very briefly describes what was done and summarizes key results. More details are provided in the body of the report and in its corresponding appendices.

Compliance Options (C.8.a)

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a “regional collaborative effort,” their countywide stormwater program, and/or individually. On behalf of San Mateo County Permittees, SMCWPPP conducts creek water quality monitoring and monitoring projects in San Mateo County in collaboration with the Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition (RMC), and actively participates in the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), which focuses on assessing Bay water quality and associated impacts.

Monitoring Protocols and Data Quality (C.8.b)

Creek status and pesticides & toxicity monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP) and the BASMAA RMC Standard Operating Procedures (SOP). Where applicable, and in compliance with Provision C.8.b, methods described in the QAPP and SOP are comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP).

San Francisco Estuary Receiving Water Monitoring (C.8.c)

In accordance with Provision C.8.c of the MRP, Permittees are required to provide financial contributions towards implementing an Estuary receiving water monitoring program on an annual basis that, at a minimum, is equivalent to the RMP. SMCWPPP complies with this provision by making financial contributions to the RMP. Additionally, SMCWPPP representatives actively participate in RMP committees, workgroups, and strategy teams, such as the Small

Tributaries Loading Strategy (STLS) to help oversee RMP activities and look out for MRP Permittee interests.

Creek Status Monitoring (C.8.d)

The RMC's creek status monitoring strategy includes both a regional ambient/probabilistic monitoring design and a local "targeted" monitoring design. The probabilistic monitoring design was developed to remove bias from site selection such that ecosystem conditions can be objectively assessed on local (i.e., San Mateo County) and regional (i.e., RMC) scales. The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns. Monitoring results are compared to "triggers" listed in Provision C.8.d of the MRP. Some triggers are equivalent to regulatory Water Quality Objectives (WQOs); others are thresholds above (or below) which potential impacts to aquatic life or other beneficial uses may occur. Sites were triggers are exceeded (or not met) are considered for future stressor/source identification (SSID) projects.

During WY 2017, the SMCWPPP conducted biological assessments at ten probabilistic sites. Bioassessments include the collection of benthic macro-invertebrate and algae samples, physical habitat measurements, water chemistry (i.e., nutrient analyses) and general water quality. The California Stream Condition Index (CSCI), a statewide tool that translates benthic macroinvertebrate data into an overall measure of stream health, was used to assess biological condition at all probabilistic sites. Of the ten sites monitored in WY 2017, eight sites (80%) scored below the trigger CSCI score of 0.795 and were rated as altered or degraded. Low CSCI scores are related impacts to physical habitat typical for urbanized areas, such as creek channel modifications (e.g., lining with concrete) and contributing watersheds with a high percentages of impervious surface.

Targeted monitoring parameters consist of water temperature, general water quality, and pathogen indicators. In WY 2017, continuous temperature data were collected at five targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) were collected at two targeted stations in San Pedro Creek. San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County. Water quality appears to be fully supporting juvenile steelhead rearing and spawning life stages. There were no exceedances of the MRP trigger thresholds for temperature or any of the general water quality parameters.

In WY 2017, pathogen indicator samples (i.e., enterococci, *E. coli*) were collected at two stations on Denniston Creek near Pillar Point Harbor, one storm drain discharging to Denniston Creek, one outfall pipe discharging directly to the beach Pillar Point Harbor, and one storm drain upstream of the outfall pipe. Triggers for enterococci were exceeded at four of the five sites and triggers for *E. coli* were exceeded at three of the five sites. Pillar Point Harbor is the site of an SSID project that will examine the extent and sources of pathogen indicators in the area. In addition, local municipalities are actively implementing bacteria control measures (e.g., outreach regarding pet wastes and programs to reduce discharges from sanitary sewer systems). Impacts to urban streams identified through creek status monitoring are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications associated with the urban development, along with pollutant discharges typically found in urban watersheds. SMCWPPP Permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. Through the continued implementation of MRP-associated and other watershed stewardship programs, SMCWPPP anticipates that stream conditions and water quality in local creeks will continue to improve over time.

Stressor/Source Identification (SSID) Projects (C.8.e)

Provision C.8.e of the MRP requires that Permittees evaluate creek status (Provision C.8.d) and pesticides and toxicity (Provision C.8.g) monitoring data with respect to triggers defined in the MRP and maintain a list of all results exceeding trigger thresholds. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are therefore considered as candidates for future SSID projects. The MRP requires SMCWPPP and its RMC partners to collectively initiate a region-wide minimum of eight SSID projects. In WY 2017, SMCWPPP initiated the Pillar Point Watershed Pathogen Indicator SSID Project. The project work plan describes the steps that will be taken to investigate urban sources of fecal indicator bacteria in the Pillar Point Watershed. SMCWPPP will implement the work plan in WY 2018 with assistance from and in close coordination with the San Mateo County Resource Conservation District (RCD).

Pollutants of Concern Monitoring (C.8.f)

Pollutants of Concern (POC) monitoring is required by Provision C.8.f of the MRP. POC monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, provide information to support implementation of Total Maximum Daily Load (TMDL) water quality restoration plans and other pollutant control strategies, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for POCs. In WY 2017, SMCWPPP met or exceeded the MRP's minimum yearly requirements for all POC monitoring parameters.

The MRP requires that Permittees provide a list of management areas in which new PCBs and mercury control measures will be implemented during the permit term. These management areas are designated "Watershed Management Areas" (WMAs), and are defined as all San Mateo County catchments containing high interest parcels (i.e., properties with land uses associated with PCBs such as old industrial, electrical and recycling) and/or existing or planned PCBs and mercury controls. During WY 2017, SMCWPPP collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs and 67 sediment samples (of which 6 were duplicates) within WMAs. As part of continuing to develop strategies for reducing PCBs and mercury loads in stormwater runoff, SMCWPPP evaluated these data, along with additional WY 2017 stormwater runoff sample data collected through the STLS, and data from previous water years collected by SMCWPPP and through the STLS. Objectives included attempting to identify source properties within WMAs, identifying which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls, and prioritizing WMAs for future investigations. Each WMA was provisionally designated as higher, medium, or lower priority. In addition, SMCWPPP is working with the City of San Carlos to develop referrals for three source properties, and evaluating next steps at several other potential source properties.

One of the 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs was also analyzed for total and dissolved copper. An additional four creek water samples were collected for copper analysis from upstream and downstream locations in two creeks (Atherton and Redwood Creeks) during a large January 2017 storm event. One of the downstream stations was also sampled for copper during spring baseflow conditions. Copper concentrations were higher at bottom-of-the-watershed stations in both creeks compared to stations higher in the watersheds), suggesting an influence by stormwater runoff. The upstream and downstream stations in Atherton and Redwood Creeks were concurrently sampled for nutrients during the large January 2017 storm event. Three of these stations were also sampled for nutrients during spring baseflow conditions. In Atherton Creek, nitrate, total nitrogen, dissolved orthophosphate and phosphorus concentrations were higher at the downstream station compared to the upstream station. However, TKN and ammonia concentrations were lower at the downstream station, suggesting an organic source of nitrogen in the upper watershed. Nutrient concentrations in both creeks were higher during the January storm sampling event compared to the spring baseflow event, suggesting that nutrient loads to San Francisco Bay from these creeks is higher during storm events.

With one exception, none of the WY 2017 POC monitoring water samples exceeded applicable WQOs. The exception was the stormwater runoff sample analyzed for copper. However, WQOs generally are applied to receiving waters, not stormwater runoff, and it is likely that mixing in the receiving water downstream of the outfall would have diluted the copper. In addition, higher hardness in the creek compared to the stormwater runoff would have reduced the bioavailability of the copper in the receiving water.

Pesticides and Toxicity Monitoring (C.8.g)

In WY 2017, SMCWPPP conducted dry weather pesticides and toxicity monitoring at one station (San Pedro Creek) in compliance with Provision C.8.g of the MRP. Statistically significant toxicity to *C. dubia* and *P. promelas* was observed in water samples collected during the dry season. However, the magnitude of the toxic effects in the samples compared to laboratory controls was relatively low and did not exceed MRP trigger criteria of 50 Percent Effect. The cause of the observed toxicity is unknown.

Pesticide concentrations in the sediment sample were all relatively low, with most below the method detection limits (MDLs). Toxic Unit (TU) equivalents were also relatively low (did not exceed 0.04). Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) quotients were calculated for all metals and total poly aromatic hydrocarbons (PAHs) measured in sediment samples. Some TEC and PEC trigger exceedances were observed for chromium and nickel but are likely related to natural occurrences of these metals associated with the area’s serpentine geology.

1.0 Introduction

This Urban Creeks Monitoring Report (UCMR), was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), on behalf of its 22 member agencies (20 cities/towns, the County of San Mateo, and the San Mateo County Flood Control District) subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP).

The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009). On November 19, 2015, the SFRWQCB updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015). This report fulfills the requirements of Provision C.8.h.iii of the MRP for comprehensively interpreting and reporting all monitoring data collected during the foregoing October 1 – September 30 period (i.e., Water Year 2017). Data were collected pursuant to water quality monitoring requirements in provision C.8 of the MRP. Monitoring data presented in this report were submitted electronically to the Regional Water Board by SMCWPPP and, if collected from a receiving water, may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN).[3]

Major sections in this report are organized according to the following topics and MRP provisions. Some topics are summarized briefly in this report but described more fully in the appendices.

1.0 Introduction

2.0 San Francisco Estuary Receiving Water Monitoring (MRP Provision C.8.c)

3.0 Creek Status Monitoring (MRP Provision C.8.d) and Pesticides and Toxicity Monitoring (MRP Provision C.8.g) (**Appendix A**)

4.0 Stressor/Source Identification (SSID) Projects (MRP Provision C.8.e) (**Appendix B and C**)

5.0 Pollutants of Concern (POC) Monitoring (MRP Provision C.8.f) (**Appendices D and E**)

6.0 Recommendations and Next Steps

Figure 1.1 maps locations of monitoring stations associated with Provision C.8 compliance in Water Year 2017 (WY 2017), including Creek Status Monitoring, Pesticides and Toxicity Monitoring, and POC Monitoring conducted by SMCWPPP and the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). This figure illustrates the geographic extent of monitoring conducted in San Mateo County in WY 2017.

[3] http://www.ceden.org/

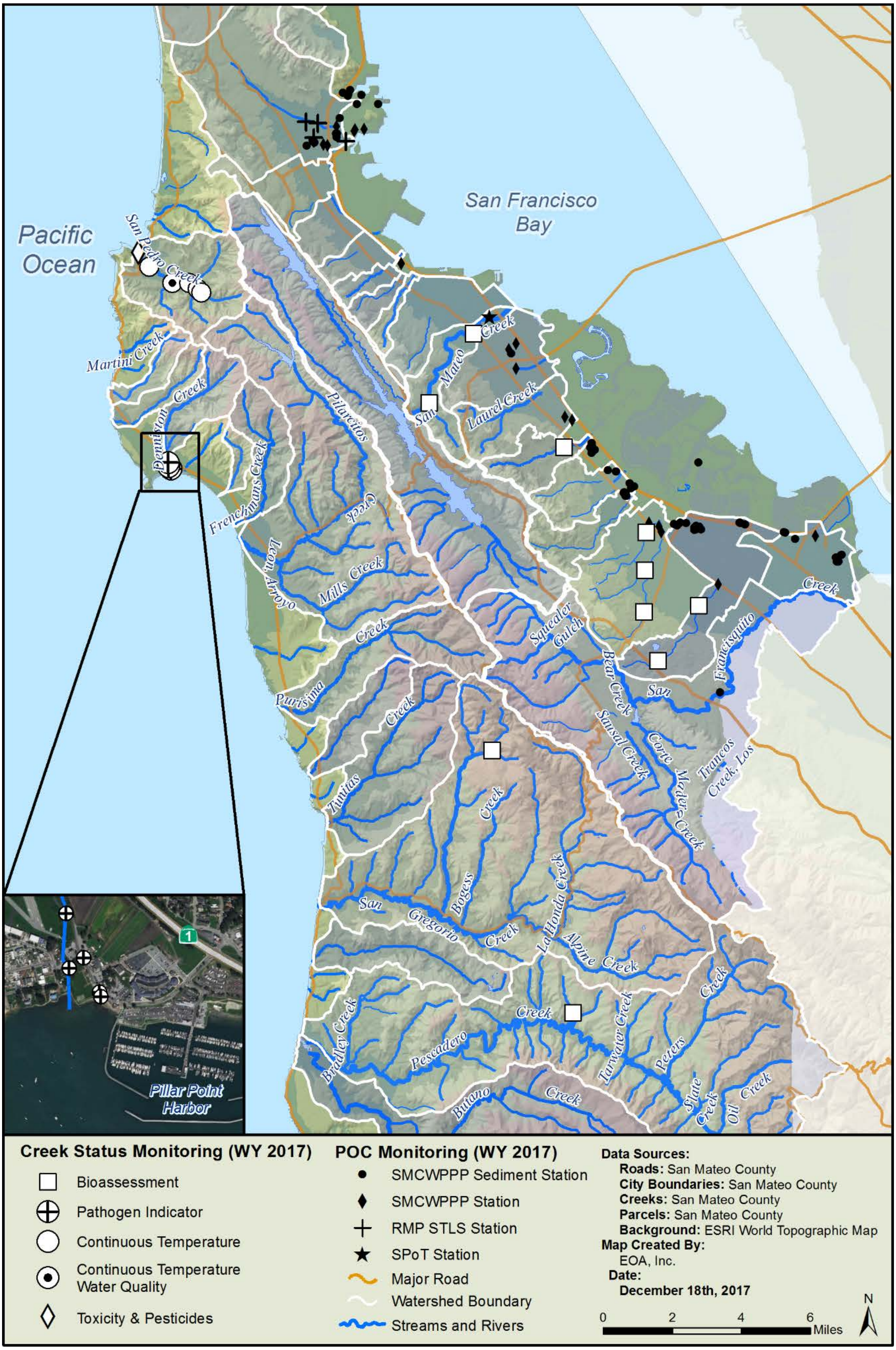

Figure. 1.1. San Mateo County MRP Provision C.8 monitoring locations: Creek Status Monitoring, Pesticides and Toxicity Monitoring, and POC Monitoring, WY 2017.

1.1 RMC Overview

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a "regional collaborative effort," their countywide stormwater program, and/or individually. In June 2010, Permittees notified the Regional Water Board in writing of their agreement to participate in a regional monitoring collaborative to address requirements in Provision C.8. The regional monitoring collaborative is referred to as the Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition (RMC). In a November 2, 2010 letter to the Permittees, the Regional Water Board's Assistant Executive Officer (Dr. Thomas Mumley) acknowledged that all Permittees have opted to conduct monitoring required by the MRP through a regional monitoring collaborative, the BASMAA RMC. Participants in the RMC are listed in Table 1.1.

In February 2011, the RMC developed a Multi-Year Work Plan (RMC Work Plan; BASMAA 2011) to provide a framework for implementing regional monitoring and assessment activities required under Provision C.8 of the 2009 MRP. The RMC Work Plan summarizes RMC projects planned for implementation between Fiscal Years 2009-10 and 2014-15 (BASMAA 2011). Projects were collectively developed by RMC representatives to the BASMAA Monitoring and Pollutants of Concern Committee (MPC), and were conceptually agreed to by the BASMAA Board of Directors (BASMAA BOD). Although there are no plans to update the Multi-Year Work Plan, several additional regional projects were identified to be conducted in compliance with the 2015 MRP. Current regional projects relevant to Provision C.8 compliance include projects to maintain and update the regional database, coordinate the RMC Workgroup meetings, and conduct POC monitoring.

Regionally implemented activities in the RMC Work Plan are conducted under the auspices of BASMAA, a 501(c)(3) non-profit organization that represents the municipal stormwater programs in the San Francisco Bay Area. Scopes, budgets, and contracting or in-kind project implementation mechanisms for BASMAA regional projects follow BASMAA's Operational Policies and Procedures and are approved by the BASMAA BOD. MRP Permittees, often through their stormwater program representatives on the BOD and its subcommittees, collaboratively authorize and participate in BASMAA regional projects or tasks. Regional project costs are usually shared by either all BASMAA members or among those Phase I municipal stormwater programs that are subject to the MRP.

Table 1.1 Regional Monitoring Coalition (RMC) participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Flood and Wastewater District

1.2 Coordination with Third-party Monitoring Programs

SMCWPPP strives to work collaboratively with its water quality monitoring partners to find mutually beneficial monitoring approaches. Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives.

In WY 2017, SMCWPPP continued to coordinate with water quality monitoring programs conducted by third parties that supplement Bay Area stormwater monitoring conducted via the MRP. These programs include the RMP's Small Tributaries Loading Strategy (STLS), and the Stream Pollutant Trends (SPoT) monitoring conducted by the State of California's Surface Water Ambient Monitoring Program (SWAMP). Water quality data from these programs are reported in this document and were utilized to comply with or supplement MRP Provision C.8 monitoring, consistent with Provision C.8.a.iii.[4,5] These data are described in Section 5.0 (POC Monitoring) of this report.

[4] Data reported by these programs are summarized in this report, however, the data were not included in the SMCWPPP electronic data submittal.

[5] In most years, the SPoT Program collects sediment samples from one station in San Mateo Creek and analyzes for one or more of the constituents required by Provision C.8.f of the MRP. In WY 2017, the SPoT station sample was analyzed for one of those constituents (PCBs).

2.0 San Francisco Estuary Receiving Water Monitoring (C.8.c)

In accordance with Provision C.8.c of the MRP, Permittees are required to provide financial contributions towards implementing an Estuary receiving water monitoring program on an annual basis that at a minimum is equivalent to the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Since the adoption of the 2009 MRP, SMCWPPP has complied with this provision by making financial contributions to the RMP. Additionally, SMCWPPP representatives actively participate in RMP committees, workgroups, and strategy teams as described in the following sections, which also provide a brief description of the RMP and associated monitoring activities conducted during WY 2017.

Now in its 25th year, the RMP is a long-term discharger-funded monitoring program that shares direction and participation by regulatory agencies and the regulated community with the goal of assessing water quality in the San Francisco Bay. The regulated community includes municipal separate storm water sewer systems (MS4s), publicly owned treatment works (POTWs), dredger, and industrial dischargers. The San Francisco Estuary Institute (SFEI) is the implementing entity for the RMP and the fiduciary agent for RMP stakeholder funds. SFEI helps identify stakeholder information needs, develops workplans that address these needs, and implements the workplans. SFEI's work is overseen by a Board and various committees that include representatives from the dischargers and regulators.

The RMP is intended to answer the following core management questions:

1. Are chemical concentrations in the Estuary potentially at levels of concern and are associated impacts likely?
2. What are the concentrations and masses of contaminants in the Estuary and its segments?
3. What are the sources, pathways, loadings, and processes leading to contaminant related impacts in the Estuary?
4. Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?
5. What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?

The RMP budget is generally broken into two major program elements: Status and Trends and Pilot/Special Studies. The following sections provide a brief overview of these programs. The *RMP 2017 Detailed Workplan and Budget*[6] provides more details and establishes deliverables for each component of the RMP budget. The RMP publishes annual summary reports. In odd years, the *Pulse of the Estuary Report* focuses on Bay water quality and summarizes information from all sources. In even years, the *RMP Update Report* has a narrower and specific focus on a selected topic. The *2017 Pulse of the Estuary*[7] celebrates the 25th

[6] http://www.sfei.org/documents/2017-rmp-detailed-workplan-and-budget
[7] http://www.sfei.org/documents/pulse-bay-25th-anniversary-rmp

anniversary of the RMP with a look back at the history of the program, along with articles on emerging contaminants, nutrients, and the Bay margins.

2.1 RMP Status and Trends Monitoring Program

The Status and Trends Monitoring Program (S&T Program) is the long-term contaminant-monitoring component of the RMP. The S&T Program was initiated as a pilot study in 1989, implemented thereafter, and was redesigned in 2007 based on a more rigorous statistical design that enables the detection of trends. The RMP Technical Review Committee (TRC), in which the BASMAA RMC participates, continues to assess the efficacy and value of the various elements of the S&T Program and to recommend modifications to S&T Program activities based on ongoing findings. The current S&T sampling schedule, established in 2014, is summarized in Table 2.1 with 2017 accomplishments and 2018 goals.

Table 2.1. RMP Status and Trends Monitoring Schedule.

Program Element	Schedule	2017 Sampling	2018 Sampling
Water	Every two years	Yes	No
Bird Eggs	Every three years	No	Yes
Sediment	Every four years	Yes (Bay margins only)	Yes
Sport Fish	Every five years	No	No
Bivalves	Every two years	No	Yes
Support to the USGS for suspended sediment and nutrient monitoring	Every year	Yes	Yes

Additional information on the S&T Program and associated monitoring data are available for download via the RMP website at http://www.sfei.org/content/status-trends-monitoring.

2.2 RMP Pilot and Special Studies

The RMP also conducts Pilot and Special Studies[8] on an annual basis. Studies are typically designed to investigate and develop new monitoring measures related to anthropogenic contamination or contaminant effects on biota in the Estuary. Special Studies address specific scientific issues that RMP committees, workgroups, and strategy teams identify as priority for further study. These studies are developed through an open selection process at the workgroup level and selected for funding through the TRC and the RMP Steering Committee.

In 2017, Pilot and Special Studies focused on the following topics:

- Nutrients Management Strategy
    - Continuous monitoring of nutrients, phytoplankton biomass, and dissolved oxygen at moored sensors

[8] Results and summaries of the most pertinent Pilot and Special Studies can be found on the RMP website (http://www.sfei.org/rmp/rmp_pilot_specstudies).

  - Continuous monitoring of dissolved oxygen in shallow margin habitats
  - Ship-based nutrient sampling
  - Data analysis and quantitative mechanistic interpretations to identify factors contributing to observed conditions
- Small Tributary Loadings Strategy (see below and Section 5.0 for more details)
- Chemicals of emerging concern (CEC) monitoring (imidacloprid, perfluorochemicals, phosphate flame retardants, bisphenol compounds, triclosan) and update of CEC Strategy
- Development of conceptual PCB models for prioritized Bay margin units
- Dioxin data synthesis report
- Selenium in fish tissue monitoring
- Evaluation of toxicity testing protocols for marine sediments
- Development of Sediment Monitoring Strategy

In WY 2017, the RMP continued to devote a considerable amount of resources towards overseeing and implementing Special Studies associated with the RMP's Small Tributary Loading Strategy (STLS). Pilot and Special Studies associated with the STLS are intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small local tributaries to San Francisco Bay. Additional information on STLS-related studies is included in Section 5.0 (POC Monitoring) of this report.

2.3 Participation in Committees, Workgroups and Strategy Teams

In WY 2017, BASMAA and/or SMCWPPP representatives actively participated in the following RMP Committees and workgroups:

- Steering Committee (SC)
- Technical Review Committee (TRC)
- Sources, Pathways and Loadings Workgroup (SPLWG)
- Emerging Contaminant Workgroup (ECWG)
- Nutrient Technical Workgroup
- Strategy Teams (e.g., PCBs, Dioxins, Selenium, Small Tributaries)

Committee, workgroup, and strategy team representation was provided by Permittee, countywide stormwater program (including SMCWPPP) staff, and/or individuals designated by RMC participants and the BASMAA BOD. Representation typically includes participating in meetings, reviewing technical reports and work products, co-authoring or reviewing RMP articles and publications, and providing general program direction to RMP staff. Representatives of the RMC also provided timely summaries and updates to, and received input from stormwater program and Permittee representatives during BASMAA Monitoring and Pollutants of Concern Committee (MPC) and/or BASMAA BOD meetings to ensure Permittees' interests were represented.

3.0 Creek Status Monitoring (C.8.d) and Pesticides and Toxicity Monitoring (C.8.g)

This section summarizes the results of creek status monitoring and pesticides and toxicity monitoring required by Provisions C.8.d and C.8.g of the MRP, respectively. Creek Status and Pesticides and Toxicity monitoring stations are listed in Table E-1 and mapped in Figure 3.1. Detailed methods and results are provided in **Appendix A**. Consistent with Provision C.8.h.ii of the MRP, creek status and pesticides and toxicity monitoring data were submitted to the Regional Water Board by SMCWPPP in electronic SWAMP-comparable formats. These data were also provided to the Regional Data Center (i.e., SFEI) for upload to CEDEN.

Creek Status Monitoring (C.8.d)

Provision C.8.d of the MRP requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

1. *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?*
2. *Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?*

Creek status monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each Bay Area countywide stormwater program are described in Provision C.8.d of the MRP. The RMC's regional monitoring strategy for complying with creek status monitoring requirements is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). The strategy includes a regional ambient/probabilistic monitoring component and a component based on local "targeted" monitoring. The combination of these monitoring designs allows each individual RMC participating countywide stormwater program to assess the status of beneficial uses in local creeks within its jurisdictional area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks). Implementation began in WY 2012.

The probabilistic monitoring design was developed to remove bias from site selection such that ecosystem conditions can be objectively assessed on local (i.e., San Mateo County) and regional (i.e., RMC) scales. Probabilistic parameters consist of bioassessments, nutrients, and conventional analytes conducted according to methods described in the SWAMP SOP (Ode et al. 2016). Free chlorine and total chlorine residual were also measured at probabilistic sites. Ten probabilistic sites were sampled by SMCWPPP in WY 2017 (Table E-1).

The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns. Targeted monitoring parameters consist of water temperature, general water quality, and pathogen indicators using methods, sampling frequencies, and number of stations required in Provision C.8.d of the MRP. Hourly water temperature measurements were recorded during the dry season at five sites using HOBO® temperature data loggers in the San Pedro Creek watershed. General water quality monitoring (temperature, dissolved oxygen, pH and specific conductivity) was conducted using YSI® continuous water quality equipment (sondes) for two 2-week periods (spring and late summer) at two sites in the same watershed. Water samples for analysis of pathogen indicators (*E. coli* and enterococcus) were collected at five sites located in the Pillar Point Harbor watershed.

Pesticides and Toxicity Monitoring (C.8.g)

Provision C.8.g of the MRP requires Permittees to conduct wet weather and dry weather pesticides and toxicity monitoring. Test methods, sampling frequencies, and number of stations required are described in the MRP. In WY 2017, SMCWPPP conducted dry weather pesticides and toxicity monitoring at one bottom-of-the-watershed station. Consistent with Provision C.8.g.iii, wet weather pesticides and toxicity monitoring will be conducted on a regional basis in WY 2018.

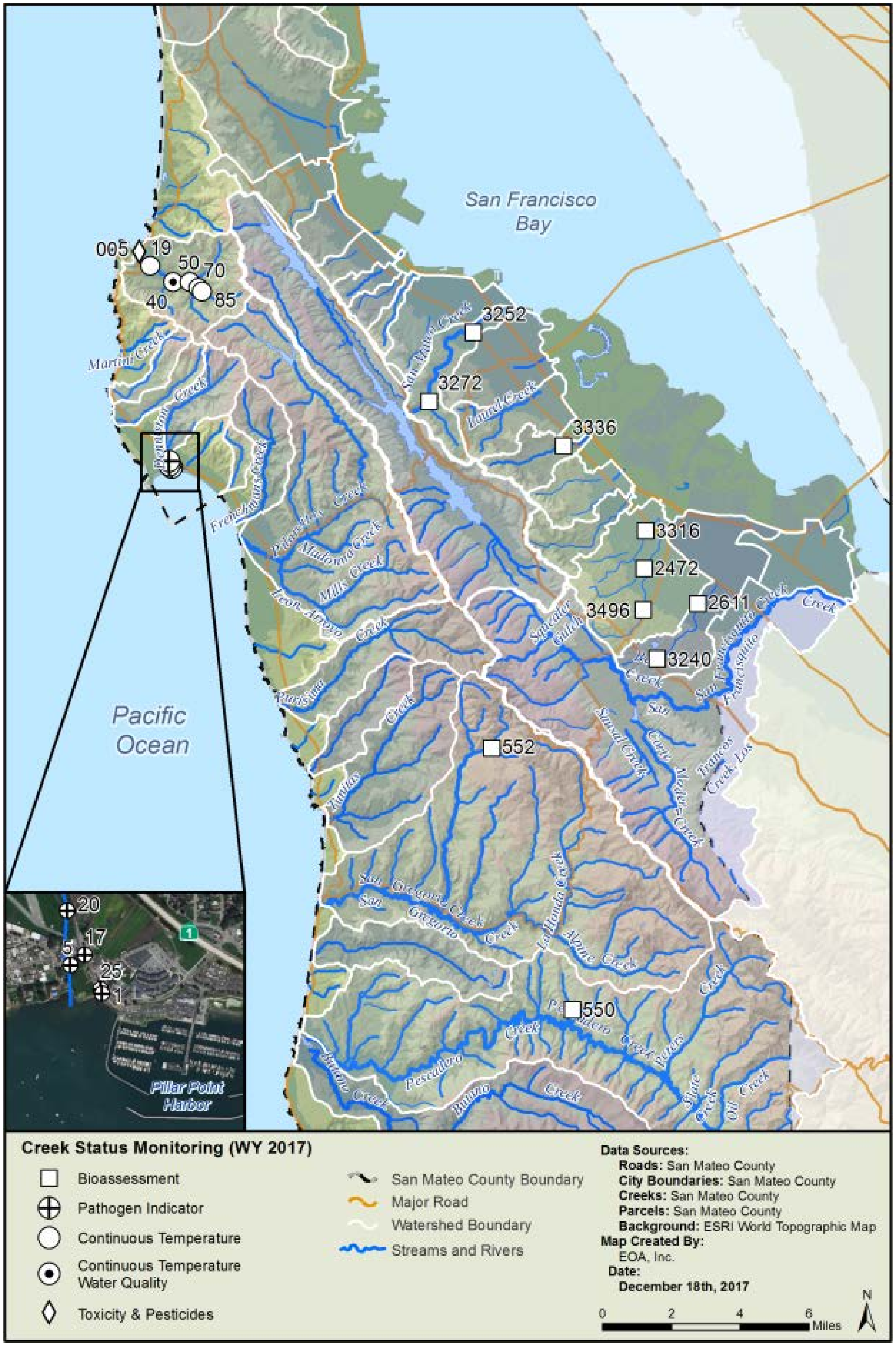

Figure 3.1. SMCWPPP Creek Status and Pesticides and Toxicity monitoring stations, WY 2017.

3.1 Approach to Management Questions

The first MRP creek status management question (*Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?*) is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to the triggers defined in the MRP. The MRP also defines triggers for pesticides and toxicity monitoring data. A summary of trigger exceedances observed for each site is presented below in Table 3.1. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are considered for future stressor/source identification (SSID) projects (see Section 4.0 for a discussion of SSID projects).

The second MRP creek status management question (*Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?*) is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate (BMI) and algae data collected at probabilistic sites. Although a total of 60 probabilistic sites in San Mateo County have been sampled since WY 2012, the analysis presented in **Appendix A** is limited to the ten sites monitored in WY 2017.

The BASMAA RMC is currently conducting a *regional* analysis of biological condition using a five-year dataset (WY 2012 – WY 2016). The BASMAA regional study will conduct the following analyses:

- Assess the biological condition of streams in the region and each county using indices of biological integrity (IBIs) based on benthic macroinvertebrate and algae data collected by each countywide program and SWAMP.
- Evaluate IBIs in distinct groupings such as imperviousness categories and type of stream.
- Assess stressors associated with poor stream condition using multivariate modeling analyses.
- Summarize regional data for each year in the five-year dataset.
- Introduce the analyses that will be needed to make recommended changes to the probabilistic monitoring design.

Results of the BASMAA regional study will be available by late 2018. Analytical tools that are found to be useful in evaluating stressor association with biological condition may be implemented in future annual monitoring reports.

3.2 Monitoring Results and Conclusions

3.2.1 Bioassessment Monitoring Results/Conclusions

Bioassessment monitoring in WY 2017 was conducted in compliance with Provision C.8.d.i of the MRP. Ten sites were sampled for benthic macro-invertebrates, benthic algae, physical habitat observations, and nutrients using methods consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b). Stations were randomly selected using a probabilistic monitoring design. Eight of the sites (80%) were classified as urban and two (20%) were classified as non-urban.

The following conclusions are based on the WY 2017 data. An assessment of biological condition is provided and potential stressors are compared to applicable water quality objectives

(WQOs) and triggers identified in the MRP. Sites with monitoring results that exceed WQOs and triggers are considered as candidates for further investigation as SSID projects, consistent with provision C.8.e of the MRP. See **Appendix A** for detailed explanations of the findings.

Biological Conditions Assessment

The California Stream Condition Index (CSCI) is a statewide tool that translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI is currently the most robust method of assessing aquatic biological health. There are also three benthic algae indices of biological integrity available (D18, H20, S2); however, the applicability of the algae IBIs in San Mateo County streams is uncertain due to several factors including:

- There is an overall dearth of soft algae taxa found in San Mateo County streams. This may not reflect stream health, but it significantly lowers the scores of two of the algae IBIs (H20 and S2).
- The algae IBIs were developed for Southern California streams and may not provide adequate interpretations of Northern California algae communities.
- Statewide Algae Stream Condition Indices are currently being developed and are anticipated to be available in 2018.

Of the ten sites monitored in WY 2017, two sites (20%) were rated in good condition (CSCI scores ≥ 0.795), two sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and six sites (60%) rated as very likely altered condition (≤ 0.635). The two sites in good condition were classified as non-urban and located in protected open space or County Park land. Three of the lowest CSCI scores occurred at sites located in concrete channels.

Relationships between potential stressors (physical habitat and water chemistry) and biological condition were explored on a limited basis using the WY 2017 dataset.

- Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. PHAB consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate and sediment deposition. Total PHAB scores were moderately correlated with CSCI scores (r^2=0.51, p value = 0.02) suggesting that physical habitat (e.g., substrate quality, channel alteration) has an influence on the BMI community. Individual physical habitat metrics associated with substrate size and composition were also correlated with CSCI scores.
- Landscape variables were calculated for each of the watershed areas draining into the bioassessment sites. CSCI scores were inversely correlated with impervious area and road density.

Stressor Assessment

Sites with CSCI scores and/or stressor levels exceeding applicable WQOs and triggers identified in the MRP will be considered as candidates for SSID projects.

- The eight sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.
- **General water quality** (pH, temperature, dissolved oxygen, specific conductance). Measurements exceeded water quality objectives for pH at sites 204R02472 (Redwood

Creek), 204R02611 (Atherton Creek), and 204R03316 (Ojo de Agua). These sites will be considered as candidates for SSID projects.

- **Nutrients and conventional analytes** (ammonia, unionized ammonia, chloride, AFDM, chlorophyll a, nitrate, nitrite, TKN, ortho-phosphate, phosphorus, silica). There were no water quality objective exceedances for water chemistry parameters.

3.2.2 Targeted Monitoring Results/Conclusions

Targeted monitoring in WY 2017 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at five sites in the San Pedro Creek watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at two sites in the San Pedro Creek watershed during two 2-week periods in May/June (Event 1) and August/September (Event 2). Pathogen indicator grab samples were collected at five sites in the Pillar Point Harbor watershed during a sampling event in August. Targeted monitoring stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2017 are listed below. The sections below are organized on the basis of three management questions. See **Appendix A** for detailed explanations of the findings.

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*
3. *What are the pathogen indicator concentrations at creek sites where there is potential for water contact recreation to occur?*

Spatial and Temporal Variability of Water Quality Conditions

- **Spatial**. There was minimal spatial variability in water temperature across the five stations in the San Pedro Creek watershed. Temperature increased slightly at each downstream site but remained 4 to 7 °C below the instantaneous trigger threshold. Likewise, pH and specific conductivity increased slightly in the downstream direction and dissolved oxygen decreased slightly in the downstream direction.
- **Temporal**. Water temperature increased gradually at all five stations between April and early-September, in response to one of the hottest summers on record. In mid-September, water temperatures dropped relatively quickly in response to a much cooler air mass. Differences in general water quality measurements (pH, specific conductivity, dissolved oxygen) between the two two-week monitoring periods (May/June and August/September) were less pronounced.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at five targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) collected at two targeted stations in San Pedro Creek. San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County.

- The two lowermost temperature stations in San Pedro Creek exceeded the maximum weekly average temperature (MWAT) of 17°C once; however, this is not considered an exceedance of the trigger which requires two consecutive weeks of exceedance. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- None of the general water quality parameters (temperature, pH, dissolved oxygen, and specific conductance) exceeded any of the MRP trigger thresholds.

Potential Impacts to Water Contact Recreation

- In WY 2017, pathogen indicator samples were collected at two stations on Denniston Creek near Pillar Point Harbor and one storm drain discharging to Denniston Creek, one outfall pipe discharging directly to the beach Pillar Point Harbor, and one storm drain upstream of the outfall pipe. Pillar Point Harbor is the site of an SSID project that will examine the extent and sources of pathogen indicators in the area. Pathogen indicator triggers for enterococci were exceeded at four of the five sites. Triggers for *E. coli* were exceeded at three of the five sites.

- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater and may not be applicable to conditions found in urban creeks or beaches that receive bacteria from natural and/or animal sources rather than wastewater discharges. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and should be interpreted cautiously. Furthermore, the WQOs for pathogens used in this report cannot be applied to waters sampled directly from the MS4, as dilution occurs when water from the MS4 discharges to a receiving water body. It should also be noted that the WQOs for pathogens used in this report are subject to change in the near future due to adoption by the State Board of new statistical threshold values based on USEPA criteria.

- Municipalities near Half Moon Bay are aware of the bacteria exceedances found in Pillar Point Harbor. Results of the coming SSID study will be used to further inform these municipalities about the nature and extent of the bacteria presence and any potential steps they can take to resolve the issue.

3.2.3 Chlorine Monitoring Results/Conclusions

Free chlorine and total chlorine residual was measured concurrently with bioassessments at the ten probabilistic sites in compliance with Provision C.8.c.ii. While chlorine residual is generally not a concern in San Mateo County creeks, WY 2017 and prior monitoring results suggest there are occasional free chlorine and total chlorine residual exceedances in the County. In WY 2017, exceedances of the MRP trigger for chlorine (0.1 mg/L) were observed at one station on Redwood Creek. Redwood City illicit discharge staff was notified and conducted an immediate follow-up investigation. The Redwood City staff reported that the source of the chlorine was unknown. They tracked the elevated chlorine measurements upstream to the jurisdictional boundary between Redwood City and the Town of Woodside and subsequently reported this information to Woodside. Chlorine exceedances are typically the result of one-time potable water discharges, and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. SMCWPPP will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

3.2.4 Pesticides and Toxicity Monitoring Results/Conclusions

In WY 2017, SMCWPPP conducted dry weather pesticides and toxicity monitoring at one station (San Pedro Creek) in compliance with Provision C.8.g of the MRP.

Statistically significant toxicity to *C. dubia* and *P. promelas* was observed in water samples collected during the dry season. However, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria of 50 Percent Effect. The cause of the observed toxicity is unknown. Pesticide concentrations in the sediment sample were all very low, most below the MDL. TU equivalents did not exceed 0.04.

Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC) quotients were calculated for all metals and total PAHs (calculated as the sum of 24 individual PAHs) measured in sediment samples according to methods described in MacDonald et al. (2000). Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, San Pedro Creek will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that the TEC and PEC quotient exceedances may be related to naturally occurring chromium and nickel originating from the area's serpentine geology.

SMCWPPP will continue to sample one station per year for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SMCWPPP will work with the BASMAA RMC partners to implement a regional approach to wet weather pesticides and toxicity monitoring.

3.3 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Trigger thresholds against which to compare the data are provided for most monitoring parameters in the MRP and are described in the foregoing sections of this report. Stream condition was determined based on CSCI scores that were calculated using BMI data. Water and sediment chemistry and toxicity data were evaluated using numeric trigger thresholds specified in the MRP. Nutrient data were evaluated using applicable water quality standards from the Basin Plan (SFRWQCB 2017). In compliance with Provision C.8.e.i of the MRP, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects maintained throughout the permit term. Follow-up SSID projects will be selected from this list. Table 3.1 lists candidate SSID projects based on WY 2017 Creek Status and Pesticides/Toxicity monitoring data.

Additional analysis of the data is provided in the foregoing sections of this report and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in this report also include historical and spatial perspectives that help provide context and greater understanding of the trigger exceedances.

Table 3.1. Summary of SMCWPPP MRP trigger threshold exceedance analysis, WY 2017. "No" indicates samples were collected but did not exceed the MRP trigger; "Yes" indicates an exceedance of the MRP trigger.

Station Number	Creek Name	Bioassessment [1]	Nutrients [2]	Chlorine [3]	Water Toxicity [4]	Sediment Toxicity [4]	Sediment Chemistry [5]	Continuous Temperature [6]	Dissolved Oxygen [7]	pH [8]	Specific Conductance [9]	Pathogen Indicators [10]
202R00550	Jones Gulch	No	No	No	--	--	--	--	--	--	--	--
202R00552	Lawrence Creek	No	No	No	--	--	--	--	--	--	--	--
204R02472	Redwood Creek	Yes	No	Yes	--	--	--	--	--	Yes	--	--
204R02611	Atherton Creek	Yes	No	No	--	--	--	--	--	Yes	--	--
204R03240	Atherton Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03252	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03272	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03316	Arroyo Ojo de Agua	Yes	No	No	--	--	--	--	--	Yes	--	--
204R03336	Belmont Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03496	Redwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
202SPE005	San Pedro Creek	--	--	--	No	No	Yes	--	--	--	--	--
202DEN017	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202DEN005	Denniston Creek	--	--	--	--	--	--	--	--	--	--	No
202DEN020	Denniston Creek	--	--	--	--	--	--	--	--	--	--	Yes
202CAP001	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202CAP025	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202SPE019	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--
202SPE040	San Pedro Creek	--	--	--	--	--	--	No	No	No	No	--
202SPE050	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--
202SPE070	San Pedro Creek	--	--	--	--	--	--	No	No	No	No	--
202SPE085	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--

1. CSCI score ≤ 0.795.
2. Unionized ammonia (as N) ≥ 0.025 mg/L, nitrate (as N) ≥ 10 mg/L, chloride > 250 mg/L.
3. Free chlorine or total chlorine residual ≥ 0.1 mg/L.
4. Test of Significant Toxicity = Fail and Percent Effect ≥ 50 %.
5. TEC or PEC quotient ≥ 1.0 for any constituent.
6. Two or more MWAT ≥ 17.0°C or 20% of results ≥ 24°C.
7. DO < 7.0 mg/L in COLD streams or DO < 5.0 mg/L in WARM streams.
8. pH < 6.5 or pH > 8.5.
9. Specific conductance > 2000 uS.
10. Enterococcus ≥ 130 cfu/100ml or *E. coli* ≥ 410 cfu/100ml.

3.4 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with MRP provisions C.8.c and C.8.g, respectively) focus on assessing the water quality condition of urban creeks in San Mateo County and identifying stressors and sources of impacts observed. Although the sample size from WY 2017 (overall n=10; urban n=8) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks, it builds on data collected in WY 2012 through WY 2016 which are currently being analyzed by a BASMAA RMC regional project. The BASMAA regional project will assess stream conditions and stressors for the five-year dataset (WY 2012 – WY 2016) on regional and countywide basis. It will review and develop statistical tools that can be utilized in the future to analyze the growing dataset. It will also recommend options for modifying the RMC creek status monitoring program during the next reissue of the MRP, perhaps with a focus on trends monitoring.

Like previous years, WY 2017 data suggest that most urban streams have likely or very likely altered populations of aquatic life indicators (e.g., aquatic macroinvertebrates). These conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over the past 50 plus years.

SMCWPPP Permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. For example:

- In compliance with MRP Provision C.3, new and redevelopment projects in the Bay Area are now designed to more effectively reduce water quality and hydromodification impacts associated with urban development. Low impact development (LID) methods, such as rainwater harvesting and use, infiltration and biotreatment are required as part of development and redevelopment projects. In addition, planning for and implementing Green Infrastructure projects in the public right-of-way is increasingly being incorporated into the municipal master planning process. All of these measures are expected to reduce the impacts of urbanization on stream health.
- In compliance with MRP Provision C.9, Permittees are implementing pesticide toxicity control programs that focus on source control and pollution prevention measures. The control measures include the implementation of integrated pest management (IPM) policies/ordinances, public education and outreach programs, pesticide disposal programs, the adoption of formal State pesticide registration procedures, and sustainable landscaping requirements for new and redevelopment projects. These efforts should reduce pyrethroids and other pesticides in urban stormwater runoff and reduce the magnitude and extent of toxicity in local creeks.
- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with MRP Provision C.10 and other efforts by Permittees to reduce the impacts of illegal dumping directly into waterways. These actions include the installation and maintenance of trash capture systems, the adoption of ordinances to reduce the impacts of litter prone items, enhanced institutional controls such as street sweeping, and the on-going removal and control of direct dumping. The MRP establishes a mandatory trash load reduction schedule, minimum areas to be treated by full trash capture systems, and requires development of receiving water monitoring programs for trash.

- In compliance with MRP Provisions C.2 (Municipal Operations), C.4 (Industrial and Commercial Site Controls), C.5 (Illicit Discharge Detection and Elimination), and C.6 (Construction Site Controls), Permittees continue to implement Best Management Practices that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of stormwater and sediments to contaminants during rainfall events.
- In compliance with MRP Provision C.13, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, prohibition of discharges from water features treated with copper, and industrial facility inspections.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. In compliance with MRP Provisions C.11 (mercury) and C.12 (PCBs), the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve load reduction goals. Monitoring activities conducted in WY 2017 that specifically target mercury and PCBs are described in Section 5.0 of this report.

In addition to the Program and Co-permittee controls implemented in compliance with the MRP, numerous other efforts and programs designed to improve the biological, physical and chemical condition of local creeks are underway. For example, C/CAG recently developed the San Mateo Countywide Stormwater Resource Plan (SRP) to satisfy state requirements and guidelines to ensure C/CAG and SMCWPPP member agencies are eligible to compete for future voter-approved bond funds for stormwater or dry weather capture projects. The SRP identifies and prioritizes opportunities to better utilize stormwater as a resource in San Mateo County through a detailed analysis of watershed processes, surface and groundwater resources, input from stakeholders and the public, and analysis of multiple benefits that can be achieved through strategically planned stormwater management projects. These projects aim to capture and manage stormwater more sustainably, reduce flooding and pollution associated with runoff, improve biological functioning of plants, soils, and other natural infrastructure, and provide many community benefits, including cleaner air and water and enhanced aesthetic value of local streets and neighborhoods.

Through the continued implementation of MRP-associated and other watershed stewardship programs, SMCWPPP anticipates that stream conditions and water quality in local creeks will continue to improve over time. In the near term, toxicity observed in creeks should decrease as pesticide regulations better incorporate water quality concerns during the pesticide registration process. In the longer term, control measures to “green” the “grey” infrastructure and disconnect impervious areas constructed over the course of the past 50 plus years will take decades to fully implement. Consequently, it may take several decades to observe the outcomes of these important, large-scale improvements to local creeks in San Mateo County watersheds. Long-term creek status monitoring programs designed to detect these changes over time should therefore help SMCWPPP and San Mateo County municipalities to better understand the condition and health of the local waterways.

4.0 Stressor/Source Identification Projects (C.8.e)

Provision C.8.e of the MRP requires that Permittees evaluate creek status (provision C.8.d) and pesticides and toxicity (provision C.8.g) monitoring data with respect to triggers defined in the MRP and maintain a list of all results exceeding trigger thresholds. Table 3.1 lists the results of the trigger evaluation for WY 2017 data. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses, and are therefore considered as candidates for future SSID projects. SSID projects are selected from the list of trigger exceedances based on criteria such as magnitude of threshold exceedance, parameter, and likelihood that stormwater management action(s) could address the exceedance. The MRP requires that Permittees initiate a minimum number of SSID projects during the permit term. SMCWPPP and its RMC partners must collectively initiate a region-wide minimum of eight new SSID Projects during the permit term, with a minimum of one for toxicity. Four of the SSID projects must be initiated with a work plan by the third year of the permit term (i.e., 2018). All SSID project reports must be presented in a unified, regional-level report. In 2017, SMCWPPP, SCVURPPP, ACCWP, and CCCWP each developed an SSID project work plan in compliance with the 2015 MRP. These new SSID projects are summarized in the regional SSID report (**Appendix B**). All SSID projects initiated in compliance with the 2009 MRP are now complete including the two projects initiated by SMCWPPP.

SSID projects must identify and isolate potential sources and/or stressors associated with observed water quality impacts. They are intended to be oriented to taking action(s) to alleviate stressors and reduce sources of pollutants. The 2015 MRP describes the stepwise process for conducting SSID projects initiated under the current permit:

- Step 1: Develop a work plan for each SSID project that defines the problem to the extent known, describes the SSID project objectives, considers the problem within a watershed context, lists candidate causes of the problem, and establishes a schedule for investigating the cause(s) of the trigger exceedance. The MRP recommends study approaches for specific triggers. For example, toxicity studies should follow guidance for Toxicity Reduction Evaluations (TRE) or Toxicity Identification Evaluations (TIE), physical habitat and conventional parameter (e.g., dissolved oxygen, temperature) studies should generally follow Step 5 (Identify Probable Causes) of the Causal Analysis/Diagnosis Decision Information System (CADDIS), and pathogen indicator studies should generally follow the *California Microbial Source Identification Manual* (Griffith et al. 2013).
- Step 2: Conduct SSID investigation according to the schedule in the SSID work plan and report on the status of SSID investigations annually in the UCMR.
- Step 3: Conduct follow-up actions based on SSID investigation findings. These may include development of an implementation schedule for new or improved best management practices (BMPs). If a Permittee determines that municipal separate storm sewer system (MS4) discharges are not contributing to an exceedance of a water quality standard, the Permittee may end the SSID project upon written concurrence of the Executive Officer. If the SSID investigation is inconclusive, the Permittee may request that the Executive Officer consider the SSID project complete.

In 2017, SMCWPPP initiated the Pillar Point Watershed Pathogen Indicator SSID Project. This project is summarized below and the work plan is included as **Appendix C**. SMCWPPP will continue to collaborate with RMC partners on additional SSID projects.

4.1 Pillar Point Watershed Pathogen Indicator SSID Project

The Pillar Point Watershed Pathogen Indicator 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. The Work Plan (**Appendix C**) describes the steps that will be taken to investigate urban sources of fecal indicator bacteria in the Pillar Point Watershed. SMCWPPP will implement the work plan in WY 2018 with assistance from and in close coordination with the San Mateo County Resource Conservation District (RCD). Consistent with Provision C.8.e.iii.(1)(g), the study generally follows the *California Microbial Source Identification Manual* (Griffith et al. 2013).

The objective of the SSID study is to build on a Proposition 50 Clean Beaches Initiative Grand-funded study that was conducted by the RCD and University of California, Davis (UCD) in 2008 and 2001-12. The RCD/UCD study indicated that high FIB measured at Pillar Point beaches was likely due to influences from storm drains and creeks rather than from sources at the beaches and within the harbor itself. The Pillar Point SSID study is designed to identify whether urban areas drained by the MS4 in the urban community of El Granada are an important source of bacteria to Pillar Point Harbor and whether the sources of bacteria 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. The study includes a desktop analysis consisting of historical data review and mapping and a water sampling program that targets multiple sites in study area watersheds. The field investigation spans the wet and dry seasons of WY 2018 and includes both FIB analysis and microbial source tracking techniques.

It is anticipated that the SSID Project Report will be included with the WY 2018 UCMR.

5.0 Pollutants of Concern Monitoring (C.8.f)

Pollutants of Concern (POC) monitoring is required by Provision C.8.f of the MRP. POC monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, provide information to support implementation of Total Maximum Daily Load (TMDL) water quality restoration plans and other pollutant control strategies, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for POCs. The MRP identifies five priority POC management information needs that need to be addressed though POC monitoring:

1. **Source Identification** – identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff;
2. **Contributions to Bay Impairment** – identifying which watershed source areas contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location);
3. **Management Action Effectiveness** – providing support for planning future management actions or evaluating the effectiveness or impacts of existing management actions;
4. **Loads and Status** – providing information on POC loads, concentrations, and presence in local tributaries or urban stormwater discharges; and
5. **Trends** – evaluating trends in POC loading to the Bay and POC concentrations in urban stormwater discharges or local tributaries over time.

MRP Provision C.8.f requires monitoring of the following POCs: polychlorinated biphenyls (PCBs), mercury, copper, emerging contaminants, and nutrients.[9] The MRP defines yearly and total (i.e., over the MRP permit term) minimum number of samples for each POC and specifies the minimum number of samples for each POC that must address each information need.

To help meet these requirements, and to develop mutually beneficial monitoring approaches, SMCWPPP continued to work collaboratively with other organizations and projects that conduct water quality monitoring in the Bay Area. Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives. Samples collected in San Mateo County through the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP), Clean Watersheds for a Clean Bay (CW4CB, a recently completed project that was funded by a grant from USEPA), and the State's Stream Pollution Trends (SPoT) Monitoring Program supplemented SMCWPPP's efforts towards achieving Provision C.8.f monitoring requirements.

In particular, SMCWPPP continued to be an active participant in the RMP's Small Tributary Loading Strategy (STLS). The STLS typically conducts annual monitoring for POCs on a region-wide basis, including collecting composite samples of stormwater runoff and analyzing for PCBs and mercury. As in past years, during WY 2017 SMCWPPP helped the STLS select its PCBs and mercury monitoring stations that are located in San Mateo County and evaluated the data from those stations along with PCBs and mercury data collected directly by SMCWPPP.

[9] Emerging contaminant monitoring requirements will be met through participation in RMP special studies and will address at least PFOS, PFAS, and alternative flame retardants being used to replace PBDEs.

5.1 SMCWPPP POC Monitoring

In WY 2017, SMCWPPP complied with Provision C.8.f of the MRP by conducting POC monitoring for PCBs, mercury, copper, and nutrients. Specific activities included:

- Collection of stormwater runoff samples from the bottom of selected urban catchments for PCBs and mercury analysis (n=17) and copper analysis (n=1);
- Collection of grab sediment samples in selected urban catchments for PCBs and mercury analysis (n=67, including 6 duplicate samples);
- Collection of wet and dry weather creek water samples for nutrients and copper analysis (n=5);
- Participation in SWAMP's Stream Pollutant Trends monitoring program; and
- Continued participation in the RMP's STLS.

Progress toward POC monitoring requirements accomplished in WY 2017 and the planned allocation of effort for WY 2018 are described in a report dated October 10, 2017 (SMCWPPP 2017) which was submitted to the Regional Water Board in compliance with MRP Provision C.8.h.iv. The yearly minimum number of samples specified in MRP Provision C.8.f was exceeded for all POCs. A report with further details about WY 2017 POC monitoring conducted by SMCWPPP is included as **Appendix D**. A report documenting the WY 2015 - 2017 POC monitoring conducted by the STLS is included as **Appendix E**.

General methods employed for POC monitoring were similar to previous years (SMCWPPP 2016). A comprehensive QA/QC program was implemented by SMCWPPP covering all aspects of POC monitoring with similar protocols to previous years. SMCWPPP (2016) provides further details. Overall, the results of the QA/QC review suggested that most of the POC monitoring data generated during WY 2017 were of sufficient quality. Although some data were flagged in the project database, none was rejected according to Data Quality Objectives (DQOs). However, most of the concentrations of mercury in stormwater runoff samples reported in WY 2017 were lower than prior years by about an order of magnitude. There was no reason to expect these lower mercury concentrations, since the population monitored was similar to prior years (e.g., based upon geography, storm size, land use). Therefore, all mercury in stormwater data were rejected by the SMCWPPP Quality Assurance Officer. Additional details about the QA/QC review are provided in **Appendix D.**

5.1.1 PCBs and Mercury

MRP Provisions C.11.a.iii and C.12.a.iii require that Permittees provide a list of management areas in which new PCBs and mercury control measures will be implemented during the permit term. These management areas are designated "Watershed Management Areas" (WMAs) in this report, and are defined as all catchments containing high interest parcels (i.e., properties with land uses associated with PCBs such as old industrial, electrical and recycling) and/or existing or planned PCBs and mercury controls.

WMAs are the framework used by SMCWPPP to plan its current PCBs and mercury monitoring program in San Mateo County. During WY 2017, SMCWPPP collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs and 67 sediment samples (of which 6 were duplicates) within WMAs. As part of continuing to develop strategies for reducing PCBs and mercury loads in stormwater runoff, SMCWPPP evaluated these data, along with additional WY 2017 stormwater runoff sample data collected through the STLS, and data from previous water years collected by SMCWPPP and through the STLS. Objectives included attempting to identify source properties within WMAs, identifying which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls, and prioritizing WMAs for future investigations.

Stormwater Runoff Monitoring

During WY 2017, SMCWPPP collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs that contain high interest parcels. An additional four stormwater runoff samples were collected in San Mateo County through the RMP's STLS, also from WMAs with high interest parcels. These combined 21 samples address Management Questions #1 (Source Identification) and #2 (Contributions to Bay Impairment). Data will also be used by the RMP STLS to improve calibration of the Regional Watershed Spreadsheet Model (RWSM) which is a land use based planning tool for estimation of overall POC loads from small tributaries to San Francisco Bay at a regional scale (i.e., Management Question #4 – Loads and Status).

WMAs were identified and prioritized for stormwater runoff sampling by evaluating several types of data, including: land use data, PCBs and mercury concentrations from prior sediment and stormwater runoff sampling efforts, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), and logistical/safety considerations. Composite samples, consisting of six to eight aliquots collected during the rising limb and peak of the storm hydrograph (as determined through field observations), were analyzed for the 40 PCBs congeners designated by the RMP as those most likely to be found in the Bay[10] (method EPA 1668C, total PCBs were calculated as the sum of these 40 congeners), total mercury (method EPA 1631E), and suspended sediment concentration (SSC; method ASTM D3977-97). Detailed results are presented in **Appendix D**. One of these samples was also analyzed for total and dissolved copper (method EPA 200.8) and hardness (method SM 2340C). See Section 5.1.2 for a discussion of the copper results.

Sediment Sampling

During WY 2017, SMCWPPP collected 67 grab sediment samples (of which 6 were duplicates) as part of the program to attempt to identify source properties within WMAs, potentially for referral to the Regional Water Board for further investigation and potential abatement. These samples were collected in the public right-of-way (ROW), including locations adjacent to high interest parcels with land uses associated with PCBs such as old industrial, electrical and recycling and/or other characteristics potentially associated with pollutant discharge (e.g., poor housekeeping, unpaved areas). Individual and composite sediment samples were collected from manholes, storm drain inlets, driveways, streets, and sidewalks.

Each sample was analyzed for total mercury and for the 40 PCBs congeners designated by the RMP as those most likely to be found in the Bay (see the previous section). Total PCBs were calculated as the sum of the 40 congeners. The laboratory sieved all samples to 2 mm prior to analysis. Detailed results are presented in **Appendix D**.

[10] PCBs congeners 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, l05, 110, 118, 128, 132, 138, 141, 149, l51, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, 203.

Watershed Management Area Prioritization

SMCWPPP evaluated the WY 2017 and all other PCBs stormwater runoff and sediment monitoring data collected to-date to help prioritize WMAs for further investigation and control measure implementation. WMAs with one or more sediment and/or stormwater runoff samples with PCBs concentrations (particle ratio concentrations for stormwater runoff) greater than 0.5 mg/kg (or 500 ng/g) were provisionally designated as higher priority. WMAs with samples in the 0.2 – 0.5 mg/kg (200 – 500 ng/g) range were designated medium priority. WMAs with stormwater runoff sample PCBs particle ratio concentrations less than 0.2 mg/kg (200 ng/g) were designated lower priority. Sediment sample results were not used to designate a WMA lower priority due to the high potential for false negatives. Figure 5.1 is a map illustrating the current status of WMAs in San Mateo County, based on this provisional prioritization scheme and sediment and stormwater runoff monitoring results to-date.[11] Only WMAs with high interest parcels were included in Figure 5.1.

[11] Where sediment and stormwater runoff particle ratio concentration analysis results conflict, the higher result was conservatively applied.

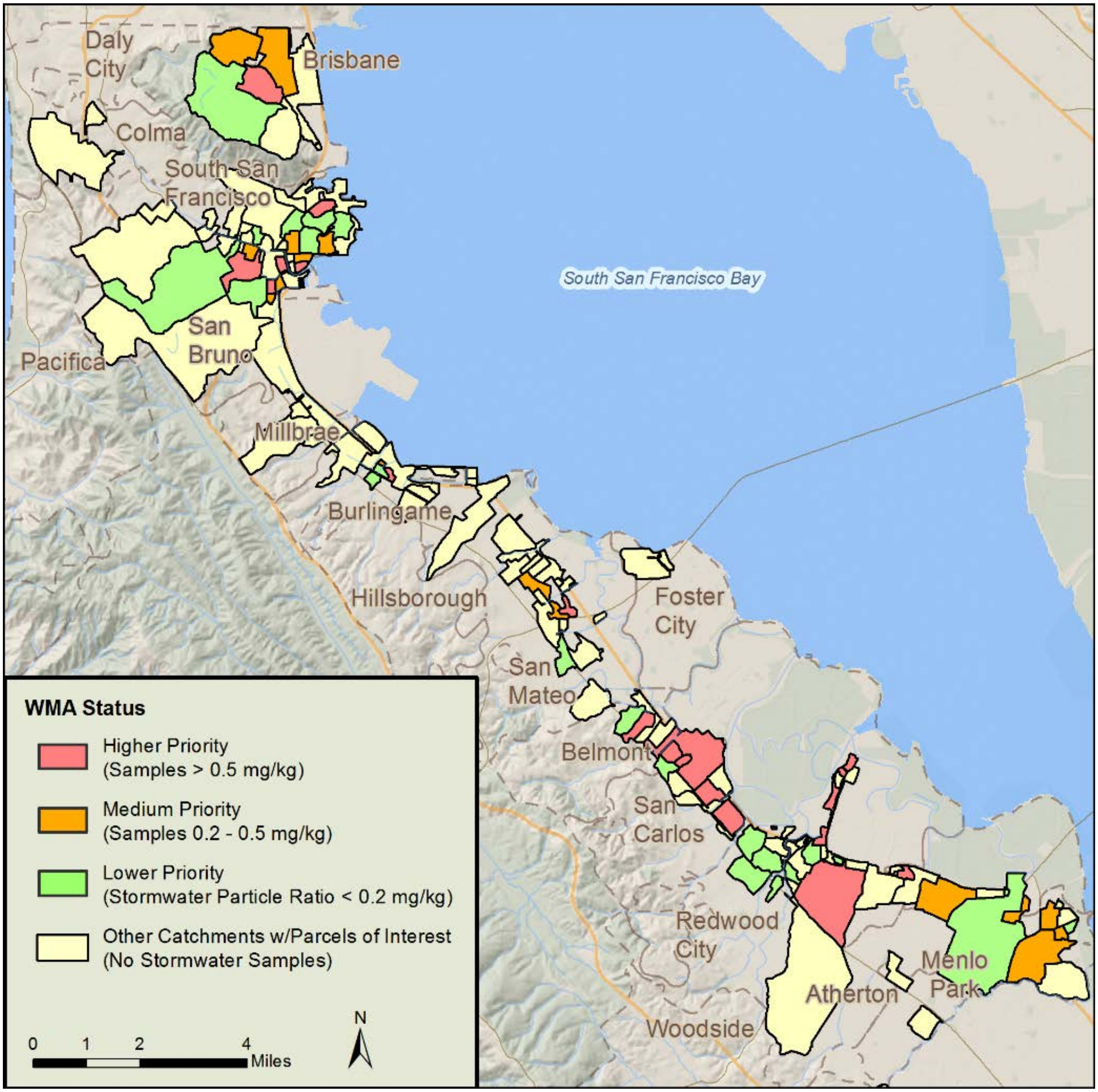

Figure 5.1. San Mateo County PCBs WMA **status based on sediment and stormwater runoff data collected through WY 2017**.

5.1.2 Copper

In WY 2017, SMCWPPP collected a total of four water samples for copper analysis (i.e., total and dissolved copper, and hardness) during a large storm event in January 2017, two from upstream and two from downstream stations in two creeks (Atherton Creek and Redwood Creek). The goal was to address loads and status (Management Question #4, see Section 5.0). A field crew also visited the downstream stations during spring baseflow conditions to assess seasonal trends (Management Question #5, see Section 5.0). At that time an additional water sample was collected from the Redwood Creek downstream station, but the Atherton Creek downstream station was dry. In addition, one of the stormwater runoff samples collected from industrial catchments for PCBs and mercury analysis was also analyzed for copper. Thus a total of six samples were analyzed for copper in WY 2017.

Based on the laboratory results, the following findings are noted:

- Copper concentrations were higher at bottom-of-the-watershed stations in both Atherton and Redwood Creeks compared to stations higher in the watersheds, suggesting an influence by stormwater runoff.

- Copper concentrations at the bottom-of-the-watershed station in Redwood Creek were similar between spring baseflow conditions compared to during January storm flows. However, the higher water hardness during spring baseflows compared to storm flows reduces the bioavailability of the copper. The downstream Atherton Creek station was dry during the spring and could not be sampled.

- Copper concentrations reported for the stormwater runoff sample collected from an outfall (sample SM-SSF-316A) were comparable to concentrations measured in the creeks. However, the hardness of the outfall water sample was an order of magnitude lower than the creek water samples.

- With the exception of the stormwater outfall sample, all dissolved copper concentrations were below hardness-dependent acute and chronic WQOs. WQOs do not apply to the stormwater runoff and it is likely that mixing in the receiving water downstream of the outfall would dilute the copper. In addition, higher hardness in the creek compared to the stormwater runoff would reduce the bioavailability of the copper.

5.1.3 Nutrients

In WY 2017, SMCWPPP collected samples (concurrent with the above copper sampling) from four creek stations (upstream and downstream locations in Atherton Creek and Redwood Creek) for nutrients analysis (i.e., ammonium[12], nitrate, nitrite, total Kjeldahl nitrogen (TKN), dissolved orthophosphate, and total phosphorus). The goal was to address loads and status (Management Question #4). All four stations were sampled during a large storm event in January 2017 and three of the four stations were also sampled during spring baseflow conductions to assess seasonal trends (Management Question #5). The downstream station in Atherton Creek was dry during the spring sampling event and could not be sampled.

Based on the laboratory results, the following findings are noted:

[12] Ammonium was calculated as the difference between ammonia and un-ionized ammonia. Un-ionized ammonia was calculated using the formula provided by the American Fisheries Society Online Resources (http://fishculture.fisheries.org/resources/fish-hatchery-management-calculators/).

- Nutrient concentrations in Atherton Creek were generally slightly higher than nutrient concentrations in Redwood Creek.
- In Redwood Creek, concentrations of all nutrients measured were higher at the downstream station compared to the upstream station during both storm flows and spring baseflows.
- In Atherton Creek, nitrate, total nitrogen, dissolved orthophosphate and phosphorus concentrations were higher at the downstream station compared to the upstream station. However, TKN and ammonia concentrations were lower at the downstream station. This suggests an organic source of nitrogen in the upper watershed.
- Nutrient concentrations in both creeks were higher during the January storm sampling event compared to the spring baseflow event. This finding is consistent with the draft conceptual model developed by the “San Francisco Bay Nutrient Management Strategy” which suggests that nutrient loads to San Francisco Bay from creeks are highest during the wet season, although considerably less than loads from publicly owned wastewater treatment works (POTWs) (Senn and Novick 2014).
- No applicable WQOs were exceeded.

5.1.4 SMCWPPP WY 2017 POC Monitoring - Conclusions

In WY 2017, the SMCWPPP collected and analyzed POC samples in compliance with Provision C.8.f of the MRP. Yearly minimum requirements were met for all monitoring parameters. In addition, SMCWPPP continued helping the RMP’s STLS to select its WY 2017 PCBs and mercury monitoring stations that are located in San Mateo County. The data from those stations was evaluated along with PCBs and mercury data collected directly by SMCWPPP. Conclusions from WY 2017 POC monitoring included the following:

- SMCWPPP’s PCBs and mercury monitoring focuses on San Mateo County WMAs containing high interest parcels with land uses potentially associated with PCBs such as old industrial, electrical and recycling. During WY 2017 SMCWPPP collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs and 67 grab sediment samples (of which 6 were duplicates) within the WMAs. SMCWPPP evaluated the PCBs stormwater runoff and sediment monitoring data to help prioritize WMAs for further investigation and identify which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls.
- Based on the sediment and stormwater runoff monitoring data collected to-date in San Mateo County by SMCWPPP and other parties (e.g., the RMP’s STLS), WMAs were provisionally designated as higher, medium, or lower priority. Figure 4 is a map illustrating the current status of WMAs in San Mateo County, based on this provisional prioritization scheme.
- The WY 2017 grab sediment samples and other data collected to-date informed identification of source properties within WMAs, potentially for referral to the Regional Water Board for further investigation and potential abatement. The sediment samples were collected from manholes, storm drain inlets, driveways, streets, and sidewalks in the public right-of-way (ROW), including locations adjacent to high interest parcels with land uses associated with PCBs such as old industrial, electrical and recycling and/or other characteristics potentially associated with pollutant discharge (e.g., poor housekeeping, unpaved areas). Based on the data gathered to-date, SMCWPPP is

working with the City of San Carlos to develop referrals for three properties, and evaluating next steps at several other potential source properties.

- One of the 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs was also analyzed for total and dissolved copper. An additional four creek water samples were collected for copper analysis from upstream and downstream locations in two creeks (Atherton and Redwood Creeks) during a large January 2017 storm event. One of the downstream stations was also sampled for copper during spring baseflow conditions. Copper concentrations were higher at bottom-of-the-watershed stations in both creeks compared to stations higher in the watersheds), suggesting an influence by stormwater runoff.
- The upstream and downstream stations in Atherton and Redwood Creeks were concurrently sampled for nutrients during the large January 2017 storm event. Three of these stations were also sampled for nutrients during spring baseflow conditions. In Atherton Creek, nitrate, total nitrogen, dissolved orthophosphate and phosphorus concentrations were higher at the downstream station compared to the upstream station. However, TKN and ammonia concentrations were lower at the downstream station, suggesting an organic source of nitrogen in the upper watershed. Nutrient concentrations in both creeks were higher during the January storm sampling event compared to the spring baseflow event, suggesting that nutrient loads to San Francisco Bay from these creeks is higher during storm events.
- With one exception, none of the WY 2017 water samples exceeded applicable water quality objectives (WQOs). The exception was the stormwater runoff sample analyzed for copper. However, WQOs generally are applied to receiving waters, not stormwater runoff, and it is likely that mixing in the receiving water downstream of the outfall would have diluted the copper. In addition, higher hardness in the creek compared to the stormwater runoff would have reduced the bioavailability of the copper in the receiving water.

5.1.5 POC Monitoring Planned by SMCWPPP in WY 2018

In WY 2018, SMCWPPP will continue to collect and analyze POC samples in compliance with Provision C.8.f of the MRP. Yearly minimum requirements will be met for all monitoring parameters. In addition, SMCWPPP will continue helping the RMP's STLS to select its WY 2018 PCBs and mercury monitoring stations that are located in in San Mateo County. POC monitoring activities in WY 2018 will include the following:

- SMCWPPP, in coordination with the RMP STLS, will continue conducting PCBs and mercury monitoring that focuses on San Mateo County WMAs containing high interest parcels with land uses potentially associated with PCBs such as old industrial, electrical and recycling. This will include collecting additional composite samples of stormwater runoff from outfalls at the bottom of WMAs and grab sediment samples within the WMAs. Objectives will include attempting to identify source properties within WMAs, identifying which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls, and prioritizing WMAs for potential future investigations.
- At least eight PCBs and mercury samples that address Management Question #3 (Management Action Effectiveness) must be collected by the end of year four of the permit (i.e., by 2020). SMCWPPP is currently working with BASMAA to implement a regional project that addresses POC Management Action Effectiveness. The study design, approved in August 2017 by the BASMAA Project Management Team (which

includes representatives from the SMCWPPP), addresses the effectiveness of hydrodynamic separator (HDS) units and various types of biochar-amended bioretention soil media (BSM) at removing PCBs and mercury from stormwater. Findings from the regional project will be reported in the WY 2018 UCMR which will be submitted by March 31, 2019. Findings will also be used to support SMCWPPP's Reasonable Assurance Analysis (RAA).

- At least eight samples that address Management Question #5 (Trends) must be collected by the end of year four of the permit (i.e., 2020). SMCWPPP will continue to participate in the STLS Trends Strategy Team to help meet this requirement. The STLS Trends Strategy Team, initiated in WY 2015, is currently developing a regional monitoring strategy to assess trends in POC loading to San Francisco Bay from small tributaries. The STLS Trends Strategy will initially focus on PCBs and mercury, but will not be limited to those POCs. Analysis of recent and historical data collected at region-wide loadings stations suggests that PCB concentrations are highly variable. Therefore, a monitoring design to detect trends with statistical confidence may require more samples than is feasible with current financial resources. The STLS Trends Strategy Team is continuing to evaluate available data from the Guadalupe River watershed to explore more economical monitoring opportunities. The Team is also considering modeling options that could be used in concert with monitoring to detect and predict trends in POC loadings. A Trends Strategy Road Map is currently being developed.
- SMCWPPP will also continue to work with the State's Stream Pollution Trends (SPoT) Monitoring Program to help address Management Question #5 (Trends). SPoT conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Monitoring Program is to investigate long-term trends in water quality. Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including a station near the mouth of San Mateo Creek. In most years, sediment analytes include PCBs, mercury, toxicity, pesticides (Phillips et al. 2014).
- SMCWPPP will collect two copper and two nutrient water samples concurrently with its MRP Provision C.8.g.iii, Wet Weather Pesticides and Toxicity Monitoring, which targets two bottom-of-the-watershed stations during storm events. An additional two copper and nutrient samples will be collected at the same stations during the spring season when hydrographs are receding.
- SMCWPPP will continue to participate in the RMP, including the RMP's STLS and CEC Strategy (see Section 2.5).

5.2 Small Tributaries Loading Strategy

The RMP Small Tributaries Loading Strategy was developed in 2009 by the STLS Team, which includes representatives from BASMAA, Regional Water Board staff, RMP staff, and technical advisors and is overseen by the Sources, Pathways, and Loadings Workgroup (SPLWG). The objective of the STLS is to develop a comprehensive planning framework to coordinate POC monitoring/modeling between the RMP and RMC participants. In 2017, the following management policies and decisions were identified:

- Refining pollutant loading estimates for future TMDL updates,
- Informing provisions of the current and future versions of the MRP,
- Identifying small tributaries to prioritize for management actions, and
- Informing decisions on the best management practices for reducing concentrations and loads.

The sections below describe the tasks implemented by the RMP STLS in WY 2017 to address the relevant management policies.

5.2.1 Wet Weather Characterization

With a goal of identifying watershed sources of PCBs and mercury, STLS field monitoring in WY 2017 continued to focus on collection of storm composite samples in the downstream reaches of catchments located throughout the region. In WY 2017, 17 catchments ranging in size from 0.09 km^2 to 36.57 km^2 and representing engineered MS4 drainage areas throughout the Bay Area were sampled during storm events. Storm composite water samples were analyzed for concentrations of PCBs, total mercury, and suspended sediment concentration. In addition, a pilot study was continued at a subset of locations to collect fine sediments using specialized settling chambers. A full description of the methods and results from WY 2015, WY 2016, and WY 2017 monitoring is included in **Appendix E** (Pollutants of Concern Reconnaissance Monitoring Final Progress Report, Water Years 2015, 2016, and 2017).

In WY 2017, four catchments were targeted in San Mateo County based on recommendations by SMCWPPP staff evaluating land uses in the County that have the highest likelihood of generating PCBs in stormwater runoff. Three of the San Mateo County sampling stations were located at manholes accessing the MS4; one was located in Colma Creek. The SMCWPPP considered these data during the process to prioritize WMAs (see Section 5.1.1).

Wet weather characterization monitoring by the RMP STLS is planned to continue in WY 2018.

Findings

The RMP STLS has a growing database of nearly 75 stations that have been sampled at least once during wet weather events for PCBs, mercury, and SSC since 2003. (Some stations have also been sampled for a larger suite of constituents.) Prior to WY 2015, most of the stations were located in natural creeks, whereas the 55 stations sampled in WY 2015 through WY 2017 were primarily located in small catchments draining primarily old industrial land uses. At 16 of the stations, a second sample was collected with either a Hamlin or Walling tube remote sediment sampler.

Acknowledging that dynamic climatic conditions and individual storm characteristics may affect data interpretation, the following conclusions have been identified:

- PCBs positively correlate with impervious cover, old industrial land use, and mercury. They inversely correlate with watershed area.
- The positive relationship between PCBs and mercury is relatively weak, probably due to the larger role of atmospheric recirculation in the mercury cycle and the differences in use history of each POC.
- Neither PCBs nor mercury have strong correlations with other trace metals (As, Cu, Cd, Pb, and Zn). Therefore, there is no support for the use of trace metals as surrogate investigative tools for either PCBs or mercury sources.
- The testing of the remote samplers showed mixed results and further testing is needed to determine their utility in investigating PCB and mercury sources.
- Resampling of some stations (i.e., those that return lower than expected concentrations) is recommended to test for false negatives.

5.2.2 Regional Watershed Spreadsheet Model

The Regional Watershed Spreadsheet Model (RWSM) is a land use based planning tool for estimation of annual POC loads from small tributaries to San Francisco Bay at a regional scale. Development of the RWSM began in 2010 and, in WY 2017, the STLS Team (with support and input from BASMAA representatives) published a beta version of the RWSM tool-kit.

The RWSM is based on the idea that to accurately assess total contaminant loads entering San Francisco Bay, it is necessary to estimate loads from local watersheds. “Spreadsheet models” of stormwater quality provide a useful and relatively inexpensive means of estimating regional scale watershed loads. Spreadsheet models have advantages over mechanistic models because the data for many of the input parameters required by mechanistic models may not currently exist; mechanistic models also require large calibration datasets which require a significant investment of time and resources to collect.

The RWSM is based on the assumption that an estimate of mean annual **volume** for each land use type within a watershed can be combined with an estimate of mean annual **concentration** for that same land use type to derive a **load** which can be aggregated for a watershed or many watersheds within a region of interest. It may be used to provide hypotheses about which sub-regions or watersheds export relatively higher or lower loads to the Bay relative to area. It can also serve as a baseline for analyzing changes in loadings due to large scale changes in land use (e.g., associated with redevelopment and new development) and runoff (e.g., associated with climate change and changes in impoundment). However, the RWSM is less reliable for predicting real loadings for individual watersheds and for estimating load changes in relation to implementation of treatment BMPs.

The RWSM beta tool-kit published in June 2017 includes:

- Hydrology Model coded using ArcPy and drawing on a user interface accessible through ArcGIS;

- Pollutant Model Spreadsheet for taking the outputs from the Hydrology Model and inputting land use coefficients to estimate pollutant loads;
- Two optional calibration tools – a spreadsheet for manual calibration, and an R script for an optimized automated calibration; and
- User Manual

Testing of the RWSM beta tool-kit by some of the BASMAA RMC partners began in WY 2017 and will continue into WY 2018. The STLS will continue to support the RWSM in WY 2018. If warranted, and in consultation with the STLS and the SPLWG, a more sophisticated dynamic simulation model (i.e., SWMM, HSPF) may be developed in future years. As the modeling team at SFEI becomes more proficient with alternative water-based platforms (i.e., SWMM, HEC-RAS) through development of the Green Plan-IT tool, a more sophisticated basis may be adopted in future years. Decisions on model improvements will be made in consultation with the STLS and the SPLWG.

5.2.3 STLS Trends Strategy

In WY 2017, the STLS Trends Strategy team continued to meet periodically. The STLS Trends Strategy was initiated in 2015 by recommendation of from the SPLWG which advised the STLS to define where and how trends may be most effectively measured in relation to management effort so that data collection methods deployed over the next several years will support this management information need. The STLS Trends Strategy team is comprised of SFEI staff, RMC participants, and Regional Water Board staff. Invitations to key meetings are expanded to additional interested parties (e.g., EPA), and technical advisors (e.g., USGS) are consulted to review specific technical work products.

The Trends Strategy document and Technical Appendix, drafted in WY 2016, serves as a foundation for this effort. The main document summarizes the background, management questions, and guiding principles of the Trends Strategy. It also describes coordination between the RMP and BASMAA within the context of the MRP, proposed tasks to answer the management questions, anticipated deliverables, and the overall timeline. The current priority POCs are PCBs and mercury, and trend indicators under consideration (i.e., PCBs concentrations and particle-ratio concentrations) were identified within the context of existing datasets (e.g., POC loading stations) and TMDL timelines. However, the Strategy recognizes that priorities can change in the future. The Technical Appendix (Melwani et al. 2016) presents an evaluation of variability and statistical power for detecting trends based on POC loading station PCBs data. It presents sample size and revisit frequency scenarios needed to detect declining trends in PCBs in 25 years with > 80% statistical power. Due to high variability in baseline PCBs concentrations, the modeled sampling scenarios would likely be too expensive and thus unrealistic to implement. Therefore, the Technical Appendix recommends additional analyses and monitoring that should be considered prior to developing a trends monitoring design.

In WY 2017, the STLS Trends Strategy team followed up on some of the recommendations from the Technical Appendix. A statistical model for trends in PCBs loads in the Guadalupe River (as a case study) was developed. The model incorporates the significant turbidity-PCB relationships that exist and evaluates climatic, seasonal, and inter-annual factors as potential drivers of PCB loads. More intensive review of the Guadalupe River dataset resulted in two main findings: 1) No trends in PCBs loads were apparent for the period of 2003 through 2014: 2) A monitoring design that includes sampling least two storms in 13 out of 20 years (with 4 to 6 grab samples per storm) would detect inter-annual trends of 25% or more over 20 years with >

80% power[13] (Melwani et al. 2018). Results of the statistical analyses were presented at key stages in the analysis to USGS technical advisors with expertise in trends analysis of water data. It is uncertain how the Guadalupe River model and analysis could be applied to other watersheds which have distinct characteristics.

In WY 2018, the Trends Strategy team is updating the Trends Strategy document to include an evaluation of how various tasks to date have and could be used to address the five POC information needs from the MRP (see list at the beginning of Section 5.0). This review will focus on the Guadalupe River statistical analysis, RWSM, BASMAA source identification and BMP effectiveness monitoring, and POC loads monitoring (loading stations and wet weather characterization). The updated document will also propose conceptual ideas for a regional load model that may be supplemented, optimized, and/or calibrated with data from field monitoring. A five-year workplan with estimates of annual budget allocations will be presented.

5.2.4 Guadalupe River Loading Station Contingency Monitoring

POC loads monitoring activities were conducted from 2003 through 2014 in the Guadalupe River near the Highway 101 overpass. These efforts occurred via a combination of RMP, SCVURPPP and Santa Clara Valley Water District (SCVWD) funding and were generally aimed at developing robust estimates of annual mercury and other POC loading to the Bay from the watershed (see Section 5.2.3 for more information). One key information gap that remains is the concentrations and loading associated with high intensity storm events that necessitate the release of water from reservoirs located in the upper watershed. These events rarely occur and, for the past few years, the Program has been prepared to institute contingency monitoring to sample water at the Highway 101 station in the event of a qualifying storm. In WY 2017, a qualifying event occurred and was successfully sampled.

McKee et al. (2018) describes monitoring methods and results from the five-day sampling event that occurred in January 2017. SFEI staff implemented an adaptive sampling strategy and captured a total of 14 samples over five days. During that time, flow peaked three times in response to heavy and prolonged rainfall. **Figure 5.2** (i.e., Figure 4 from McKee et al. 2018) illustrates how mercury concentrations varied throughout the storm hydrograph.

[13] Power is defined as the probability of detecting a trend of a certain magnitude during a specified monitoring period (years), where a Type I error rate is set at 5%.

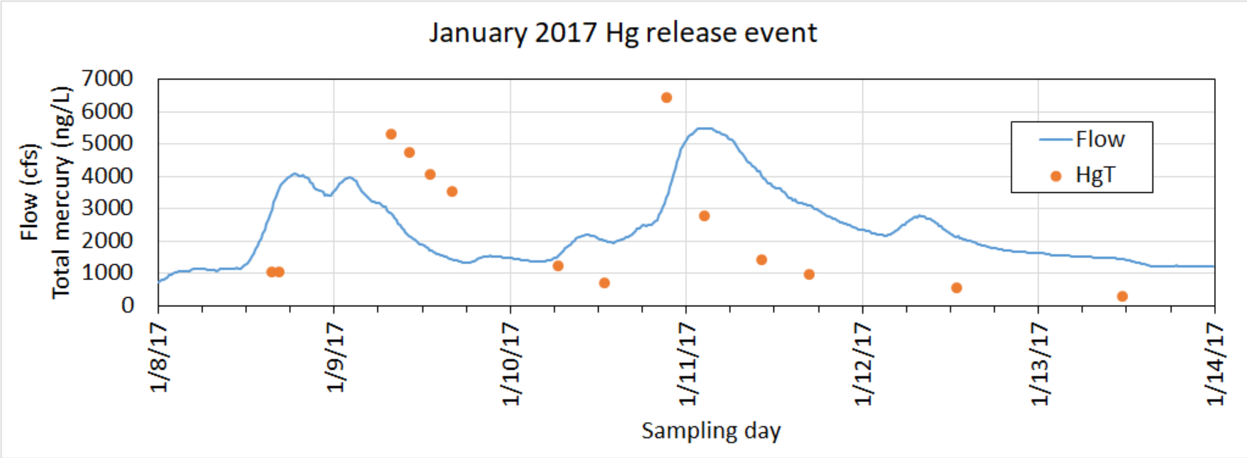

Figure 5.2. January 2017 storm hydrograph and total mercury concentrations in Guadalupe River at Highway 101 (Figure 4 from McKee et al. 2017; flow data are provisional and subject to change).

Two methods were applied to estimate mercury loads during the event. The first method was used to generate a load estimate for every 15-minute interval during the sampling period (using linear interpolation between grab samples) and resulted in a total event load of 70 kg. The second method combined a flow-weighted average concentration with total event flow for a load estimate of 82 kg. Approximately 86% of the load is assumed to emanate from the historic mining district in the upper watershed, rather than the urbanized areas in the lower watershed. Regardless of which method is used, a load equivalent of more than half of the previously estimated average annual baseline load for the Guadalupe River was transported during this one storm. The loads during this one storm exceeded the TMDL wasteload allocation of 9.4 kg/year by a factor of greater than 7. These findings illustrate the very episodic nature of loads in this system.

Comparison to Applicable Water Quality Standards

MRP provision C.8.g.iii requires RMC participants to assess all data collected pursuant to provision C.8 for compliance with applicable water quality standards. In compliance with this requirement, comparisons of data collected in the Guadalupe River in WY 2017 to applicable numeric WQO is provided below.

When conducting a comparison to applicable WQOs/criteria, certain considerations should be taken into account to avoid the mischaracterization of water quality data:

Discharge vs. Receiving Water – WQOs apply to receiving waters, not discharges. WQOs are designed to represent the maximum amount of pollutants that can remain in the water column without causing any adverse effect on organisms using the aquatic system as habitat, on people consuming those organisms or water, and on other current or potential beneficial uses. POC monitoring data collected as part of the wet weather characterization effort (Section 5.2.1) were not collected in receiving waters; instead, they were collected within the engineered storm drain network where WQOs do not apply.

Freshwater vs. Saltwater - POC monitoring data were collected in freshwater, above tidal influence and therefore comparisons were made to freshwater WQOs/criteria.

Aquatic Life vs. Human Health - Comparisons were primarily made to objectives/criteria for the protection of aquatic life, not objectives/criteria for the protection of human health to support the consumption of water or organisms. This decision was based on the assumption that water and organisms are not likely being consumed from the stations monitored.

Acute vs. Chronic Objectives/Criteria - Monitoring was conducted during episodic storm events and results do not likely represent long-term (chronic) concentrations of monitored constituents. POC monitoring data were therefore compared to “acute” WQOs/criteria for aquatic life that represent the highest concentrations of an analyte to which an aquatic community can be exposed briefly (e.g., 1-hour) without resulting in an unacceptable effect.

Of the analytes monitored in Guadalupe River in WY 2017, WQOs or criteria have only been promulgated for total mercury. Therefore, the comparison of data collected in WY 2017 to applicable numeric WQOs or criteria adopted by the Regional Water Board is limited to total mercury.

Six of the 14 samples collected in the Guadalupe River in WY 2017 were above the freshwater acute objective for mercury of 2.4 µg/L. Total mercury concentrations ranged from 0.28 µg/L to 6.45 µg/L with the highest concentrations occurring during storm peak flows. Mercury discharges from urban areas that drain through the MS4 are being addressed through provision C.11 of the MRP which implements the San Francisco Bay and Guadalupe River Watershed mercury TMDLs.

6.0 Next Steps

Water quality monitoring required by Provision C.8 of the MRP is intended to assess the condition of water quality in Bay Area receiving waters (creeks and the Bay); identify and prioritize stormwater associated impacts, stressors, sources, and loads; identify appropriate management actions; and detect trends in water quality over time and the effects of stormwater control measure implementation. On behalf of San Mateo County Permittees, SMCWPPP conducts creek water quality monitoring and other monitoring projects in San Mateo County in collaboration with the Regional Monitoring Coalition, and actively participates in the San Francisco Bay Regional Monitoring Program, which focuses on assessing Bay water quality and associated impacts.

In WY 2018, SMCWPPP will continue to comply with water quality monitoring requirements of the MRP. The following list of next steps will be implemented in WY 2018:

- SMCWPPP will continue to collaborate with the RMC (MRP Provision C.8.a).
- Where applicable, monitoring data collected and reported by SMCWPPP will be compatible with SWAMP (MRP Provision C.8.b).
- SMCWPPP will continue to provide financial contributions towards the RMP and to assist BASMAA to actively participate in the RMP committees and work groups described in Sections 2.0 and 5.0 (MRP Provision C.8.c).
- SMCWPPP will continue to conduct probabilistic and targeted Creek Status Monitoring consistent with the specific requirements of MRP Provision C.8.d.
- SMCWPPP will continue to conduct dry weather Pesticides and Toxicity Monitoring consistent with MRP Provisions C.8.g.i and C.8.g.ii.
- SMCWPPP will work with the RMC to develop and implement a wet weather Pesticides and Toxicity Monitoring program consistent with MRP Provision C.8.g.iii.
- SMCWPPP will continue to review monitoring results and maintain a list of all results exceeding trigger thresholds (MRP Provision C.8.e.i). SMCWPPP will coordinate with the RMC to initiate a region-wide goal of eight new SSID projects by the end of the permit term, including four new SSID projects by the third year of the permit (MRP Provision C.8.e.iii). This will include implementation of the Pillar Point Harbor Bacteria SSID Project.
- SMCWPPP will continue to participate in the STLS and SPLWG which address MRP Provision C.8.f POC management information needs and monitoring requirements through wet weather characterization monitoring, refinement of the RWSM, and development and implementation of the STLS Trends Strategy.
- SMCWPPP will continue implementing a POC monitoring framework to comply with Provision C.8.f of the MRP. The monitoring framework addresses the annual and total minimum number of samples required for each POC (i.e., PCBs, mercury, copper, emerging contaminants, nutrients) and each management information need (i.e., Source Identification, Contributions to Bay Impairment, Management Action Effectiveness, Loads and Status, Trends). WY 2018 monitoring will include conducting PCBs and mercury monitoring that focuses on San Mateo County WMAs containing high interest parcels with land uses potentially associated with PCBs such as old industrial, electrical and recycling. This will include collecting additional composite samples of stormwater runoff from outfalls at the bottom of WMAs and grab sediment samples within the

WMAs. Objectives will include attempting to identify source properties within WMAs, identifying which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls, and prioritizing WMAs for potential future investigations. WY 2018 monitoring will also include sampling for nutrients and copper.

- WY 2018 POC monitoring accomplishments and allocation of sampling efforts for POC monitoring in WY 2019 will be submitted in the Pollutants of Concern Monitoring Report that is due to the Water Board by October 15, 2018 (MRP Provision C.8.h.iv).
- Results of WY 2018 monitoring will be described in the Programs WY 2018 Urban Creeks Monitoring Report that is due to the Water Board by March 31, 2019 (MRP Provision C.8.h.iii).

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Appendix A

SMCWPPP Creek Status Monitoring Report, Water Year 2017

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program

Appendix A

SMCWPPP Creek Status Monitoring Report

Water Year 2017 (October 2016 – September 2017)

Submitted in compliance with Provision C.8.h.iii of
NPDES Permit No. CAS612008 (Order No. R2-2015-0049)

March 31, 2018

Preface

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined together to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (in this document the permit is referred to as MRP)[1]. The RMC includes the following participants:

- Alameda Countywide Clean Water Program (ACCWP)
- Contra Costa Clean Water Program (CCCWP)
- San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)
- Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)
- Fairfield-Suisun Urban Runoff Management Program (FSURMP)
- City of Vallejo and Vallejo Flood and Wastewater District (Vallejo)

This Creek Status Monitoring Report complies with provision C.8.h.iii of the MRP for reporting of all data in Water Year 2017 (October 1, 2016 through September 30, 2017). Data were collected pursuant to Provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of the MRP. Data presented in this report were produced under the direction of the RMC and the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) using probabilistic and targeted monitoring designs as described herein

Consistent with the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2016a) and BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2016b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP)[2]. Data presented in this report were also submitted in electronic SWAMP-comparable formats by SMCWPPP to the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) on behalf of San Mateo County Permittees and pursuant to Provision C.8.h.ii of the MRP.

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[1] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB or Regional Water Board) issued the MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). On November 19, 2015, the Regional Water Board updated and reissued the MRP (SFRWQCB 2015). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

[2] The current SWAMP QAPrP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

List of Acronyms

ACCWP	Alameda Countywide Clean Water Program
AFDM	Ash Free Dry Mass
AFS	American Fisheries Society
BASMAA	Bay Area Stormwater Management Agency Association
BMI	Benthic Macroinvertebrate
C/CAG	City/County Association of Governments
CCCWP	Contra Costa Clean Water Program
CDFW	California Department of Fish and Wildlife
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
DO	Dissolved Oxygen
EDD	Electronic Data Delivery
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information System
GRTS	Generalized Random Tessellation Stratified
IBI	Index of Biological Integrity
IPM	Integrated Pest Management
LID	Low Impact Development
MDL	Method Detection Limit
MIGR	Fish Migration
MPC	Monitoring and Pollutants of Concern Committee
MPN	Most Probable Number
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Sewer System
MUN	Municipal Beneficial Use
MWAT	Maximum Weekly Average Temperature
NPDES	National Pollution Discharge Elimination System
NT	Non-Target
O/E	Observed to Expected
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
PHAB	Physical Habitat Assessments

pMMI	Predictive Multi-Metric Index
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RARE	Preservation of Rare and Endangered Species
RM	Reporting Module
RMC	Regional Monitoring Coalition
RWB	Reachwide Benthos
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Stormwater Monitoring Coalition
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
SPWN	Fish Spawning
SRP	Stormwater Resource Plan
SSID	Stressor/Source Identification
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effects Concentrations
TMDL	Total Maximum Daily Load
TNS	Target Non-Sampleable
TOC	Total Organic Carbon
TS	Target Sampleable
TU	Toxicity Unit
UCMR	Urban Creeks Monitoring Report
USEPA	Environmental Protection Agency
WARM	Warm Freshwater Habitat
WQO	Water Quality Objective
WY	Water Year

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1.0 Introduction

This Creek Status Monitoring Report was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP or Program). SMCWPPP is a program of the City/County Association of Governments (C/CAG) of San Mateo County. Each incorporated city and town in the county and the County of San Mateo share a common National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The MRP was first adopted by the San Francisco Regional Water Quality Control Board (SFRWQCB or Regional Water Board) on October 14, 2009 as Order R2-2009-0074 (SFRWQCB 2009). On November 19, 2015, the SFRWQCB updated and reissued the MRP as Order R2-2015-0049 (SFRWQCB 2015). This report fulfills the requirements of Provision C.8.h.iii of the MRP for comprehensively interpreting and reporting all Creek Status and Pesticides & Toxicity monitoring data collected during the foregoing October 1 – September 30 (i.e., Water Year 2017) [3]. Data were collected pursuant to water quality monitoring requirements in Provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) of the MRP. Monitoring data presented in this report were submitted electronically to the SFRWQCB by SMCWPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN).[4]

Sections of this report are organized according to the following topics:

- **Section 1.0** – Introduction including overview of the Program goals, background, monitoring approach, and statement of data quality
- **Section 2.0** – Biological condition assessment and stressor analysis at probabilistic sites
- **Section 3.0** – General water quality monitoring (continuous temperature, continuous general water quality, and pathogen indicators) at targeted sites
- **Section 4.0** – Chlorine monitoring at probabilistic sites
- **Section 5.0** – Pesticides & Toxicity monitoring
- **Section 6.0** – Conclusions and recommendations

1.1 Monitoring Goals

Provision C.8.d of the MRP requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

1. ***Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?***
2. ***Are conditions in local receiving water supportive of or likely supportive of beneficial uses?***

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[3] Monitoring data collected pursuant to other C.8 provisions (e.g., Pollutants of Concern Monitoring, Stressor/Source Identification Monitoring Projects) are reported in the SMCWPPP Urban Creeks Monitoring Report (UCMR) for WY 2017 to which this Creek Status Monitoring Report is appended.

[4] http://water100.waterboards.ca.gov/ceden/sfei.shtml

Creek Status and Pesticides & Toxicity monitoring parameters, methods, occurrences, durations and minimum number of sampling sites are described in Provisions C.8.d and C.8.g of the MRP, respectively. The monitoring requirements in the 2015 MRP are similar to the 2009 MRP requirements (which began implementation on October 1, 2011) and build upon earlier monitoring conducted by SMCWPPP. Creek Status and Pesticides & Toxicity monitoring is coordinated through the Regional Monitoring Coalition (RMC). Monitoring results are evaluated to determine whether triggers are met and further investigation is warranted as a potential Stressor/Source Identification (SSID) Project, as described in Provision C.8.e of the MRP. Results of Creek Status Monitoring conducted in Water Years 2012 through 2016 were submitted in prior reports (SMCWPPP 2017, SMCWPPP 2016, SMCWPPP 2015, SMCWPPP 2014).

1.2 Regional Monitoring Coalition

Provision C.8.a (Compliance Options) of the MRP allows Permitees to address monitoring requirements through a regional collaborative effort, their Stormwater Program, and/or individually. The RMC was formed in early 2010 as a collaboration among a number of the Bay Area Stormwater Management Agencies Association (BASMAA) members and MRP Permittees (Table 1.1) to develop and implement a regionally coordinated water quality monitoring program to improve stormwater management in the region and address water quality monitoring required by the MRP[5]. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) allows Permittees and the Regional Water Board to improve their ability to collectively answer core management questions in a cost-effective and scientifically rigorous way. Participation in the RMC is facilitated through the BASMAA Monitoring and Pollutants of Concern (MPC) Committee.

[5] The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued the first five-year MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities.

Table 1.1. Regional Monitoring Coalition participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Flood and Wastewater District

The goals of the RMC are to:

1. Assist Permittees in complying with requirements in MRP Provision C.8 (Water Quality Monitoring);

2. Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area, through the improved coordination among RMC participants and other agencies (e.g., Water Board) that share common goals; and

3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining reporting.

The RMC's monitoring strategy for complying with Creek Status monitoring is described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). The strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring. The combination of these two components allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its jurisdictional area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks). The current MRP, updated and reissued in 2015, specifies the probabilistic/targeted approach most of the details of the RMC Creek Status and Long-Term Trends Monitoring Plan. Table 1.2 provides a list of which parameters are included in the probabilistic and targeted programs in the 2015 MRP. This report includes data collected in San Mateo County under both monitoring components. Data are organized into report sections that reflect the format of monitoring requirements in the MRP.

Table 1.2. Creek Status Monitoring parameters in compliance with MRP Provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides & Toxicity Monitoring) and associated monitoring component.

Monitoring Elements	Monitoring Component		Report Section
	Regional Ambient (Probabilistic)	Local (Targeted)	
Creek Status Monitoring (C.8.d)			
Bioassessment & Physical Habitat Assessment	X	(X)[1]	2.0
Nutrients	X	(X)[1]	2.0
General Water Quality (Continuous)		X	3.0
Temperature (Continuous)		X	3.0
Pathogen Indicators		X	3.0
Chlorine	X	(X)[2]	4.0
Pesticides & Toxicity Monitoring (C.8.g)			
Water Toxicity		X	5.0
Sediment Toxicity		X	5.0
Sediment Chemistry		X	5.0

Notes:
[1] Provision C.8.d.i.(6) allows for up to 20% of sample locations to be selected on a targeted basis.
[2] Provision C.8.d.ii.(2) provides options for probabilistic or targeted site selection. In WY 2017, chlorine was measured at probabilistic sites.

1.3 Monitoring and Data Assessment Methods

1.3.1 Monitoring Methods

Water quality data were collected in accordance with California Surface Water Ambient Monitoring Program (SWAMP) comparable methods and procedures described in the BASMAA RMC Standard Operating Procedures (SOPs; BASMAA 2016b) and associated Quality Assurance Project Plan (QAPP; BASMAA 2016a). These documents and the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012) are updated as needed to maintain their currency and optimal applicability. Where applicable, monitoring data were collected using methods comparable to those specified by the SWAMP Quality Assurance Program Plan (QAPrP)[6], and were submitted in SWAMP-compatible format to the SFRWQCB. The SOPs were developed using a standard format that describes health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and de-mobilization activities to preserve and transport samples.

[6]The current SWAMP QAPrP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/qaprp082209.pdf

1.3.2 Laboratory Analysis Methods

RMC participants, including SMCWPPP, agreed to use the same laboratories for individual parameters (except pathogen indicators), developed standards for contracting with the labs, and coordinated quality assurance samples. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2016a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also described in BASMAA (2016a). Analytical laboratory contractors included:

- BioAssessment Services, Inc. – Benthic macroinvertebrate (BMI) identification
- EcoAnalysts, Inc. – Algae identification
- CalTest, Inc. – Sediment chemistry, nutrients, chlorophyll a, ash free dry mass
- Pacific EcoRisk, Inc. - Water and sediment toxicity
- Alpha Analytical – Pathogen indicators

1.3.3 Data Analysis Methods

Monitoring data generated during WY 2017 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives (WQOs). Creek Status Monitoring and Pesticides & Toxicity Monitoring data must be evaluated with respect to numeric thresholds, specified in the "Followup" sections in Provision C.8.d and C.8.g of the MRP (SFRWQCB 2015) that, if not met, require consideration for further evaluation as part of a Stressor/Source Identification (SSID) project. SSID projects are intended to be oriented toward taking action(s) to alleviate stressors and reduce sources of pollutants. A stepwise process for conducting SSID projects is described in Provision C.8.e.iii.

In compliance with Provision C.8.e.i of the MRP, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Follow-up SSID projects are selected from this list.

1.4 Setting

There are 34 watersheds in San Mateo County draining an area of about 450 square miles. The San Mateo Range, which runs north/south, divides the county roughly in half. The eastern half ("Bayside") drains to San Francisco Bay and is characterized by relatively flat, urbanized areas along the Bay. The western half ("coastside") drains to the Pacific Ocean and consists of approximately 50 percent parkland and open space, with agriculture and relatively small urban areas.

The complete list of probabilistic and targeted monitoring sites samples by SMCWPPP in WY 2017 is presented in Table 1.3. Monitoring locations with monitoring parameter(s) are mapped in Figure 1.1.

Table 1.3. Sites and parameters monitored in WY 2017 in San Mateo County.

Map ID	Station Number	Bayside or Coastside	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic	Targeted				
								Bioassessment, Nutrients, General WQ	Chlorine	Toxicity, Sediment Chemistry	Temp	Cont. WQ	Pathogen Indicators
550	202R00550	Coastside	Pescadero Creek	Jones Gulch	NU	37.278796	-122.26832	X	X				
552	202R00552	Coastside	San Gregorito Cr	Lawrence Creek	NU	37.388456	-122.31340	X	X				
2472	204R02472	Bayside	Redwood Creek	Redwood Creek	U	37.465155	-122.23462	X	X				
2611	204R02611	Bayside	Atherton Creek	Atherton Creek	U	37.450833	-122.20592	X	X				
3240	204R03240	Bayside	Atherton Creek	Atherton Creek	U	37.427321	-122.22682	X	X				
3252	204R03252	Bayside	San Mateo Creek	San Mateo Creek	U	37.563132	-122.32754	X	X				
3272	204R03272	Bayside	San Mateo Creek	San Mateo Creek	U	37.533846	-122.35018	X	X				
3316	204R03316	Bayside	Redwood Creek	Arroyo Ojo de Agua	U	37.48119	-122.23427	X	X				
3336	204R03336	Bayside	Belmont Creek	Belmont Creek	U	37.516284	-122.27867	X	X				
3496	204R03496	Bayside	Redwood Creek	Redwood Creek	U	37.447749	-122.23470	X	X				
005	202SPE005	Coastside	San Pedro Creek	San Pedro Creek	U	37.59441	-122.50520			X			
17	202DEN017	Coastside	Denniston Creek	NA (MS4)	U	37.50499	-122.48641						X
5	202DEN005	Coastside	Denniston Creek	Denniston Creek	U	37.50465	-122.48697						X
20	202DEN020	Coastside	Denniston Creek	Denniston Creek	U	37.50638	-122.48714						X
1	202CAP001	Coastside	Capistrano Drainage	NA (MS4)	U	37.50377	-122.48568						X
25	202CAP025	Coastside	Capistrano Drainage	NA (MS4)	U	37.50391	-122.48574						X
19	202SPE019	Coastside	San Pedro Creek	San Pedro Creek	U	37.58853	-122.49943				X		
40	202SPE040	Coastside	San Pedro Creek	San Pedro Creek	U	37.58200	-122.48708				X	X	
50	202SPE050	Coastside	San Pedro Creek	San Pedro Creek	U	37.58198	-122.47819				X		
70	202SPE070	Coastside	San Pedro Creek	San Pedro Creek	NU	37.57974	-122.47371				X	X	
85	202SPE085	Coastside	San Pedro Creek	San Pedro Creek	NU	37.57826	-122.47156				X		

U = urban, NU = non-urban, NA = not applicable, MS4 = municipal separate storm sewer system

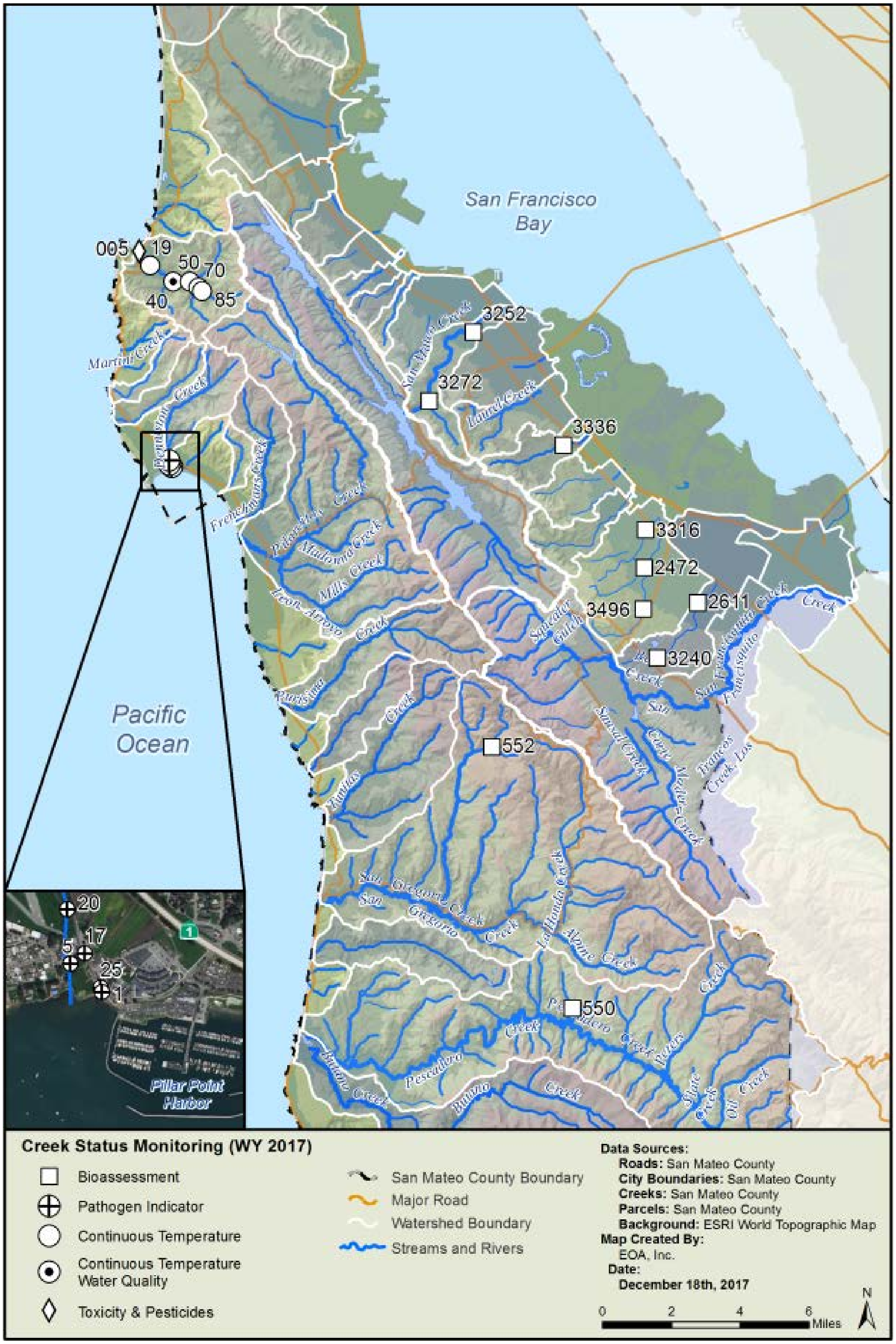

Figure 1.1. Map of SMCWPPP sites monitored in WY 2017.

1.4.1 Designated Beneficial Uses

Beneficial Uses in San Mateo County creeks are designated by the SFRWQCB for specific water bodies and generally apply to all its tributaries. Uses include aquatic life habitat, recreation, and municipal supply. Table 1.4 lists Beneficial Uses designated by the SFRWQCB (2017) for water bodies monitored by SMCWPPP in WY 2017.

Table 1.4. Creeks Monitored by SMCWPPP in WY2017 and their Beneficial Uses (SFRWQCB 2017).

Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
Bayside Creeks																			
Arroyo Ojo de Agua															E	E	E	E	
Atherton Creek															E	E	E	E	
Belmont Creek															E	E	E	E	
Redwood Creek															E	E	E	E	
San Mateo Creek			E						E			E	E	E	E	E	E	E	
Coastside Creeks																			
Denniston Creek	E	E							E			E	E	E	E	E	E	E	
Jones Gulch									E						E	E	E	E	
Lawrence Creek[1]	E								E			E	E	E	E	E	E	E	
San Pedro Creek		E							E			E	E	E	E	E	E	E	

[1] No Beneficial Uses listed specifically for waterbody. Table shows Beneficial Uses for receiving waterbody.

E = Existing Use

Notes:

AGR = Agricultural Supply
COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
SHELL = Shellfish Harvesting
IND = Industrial Service Supply
EST = Estuarine
NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
SPWN = Fish Spawning
COMM = Commercial, and Sport Fishing
REC-2 = Non-contact Recreation
WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
PROC = Industrial Process Supply
MAR = Marine Habitat

1.4.2 Climate

San Mateo County experiences a Mediterranean-type climate with cool, wet winters and hot, dry summers. The wet season typically extends from October through April with local long-term, mean annual precipitation ranging from 20 inches near the Bay to over 40 inches along the highest ridges of the San Mateo Mountain Range (PRISM Climate Group 30-year normals, 1981-2010[7]). Figure 1.2 illustrates the geographic variability of mean annual precipitation in the area. It is important to understand that mean annual precipitation depths are statistically

[7] http://www.prism.oregonstate.edu/normals/

calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Figure 1.3 illustrates the temporal variability in annual precipitation measured at the San Francisco International Airport from WY 1946 to WY 2017. This record illustrates that extended periods of drought are common and often punctuated by above average years. Creek Status Monitoring in compliance with the MRP began in WY 2012 which was the first year of a severe statewide drought that persisted through WY 2016. In WY 2017, rainfall was above average but was followed by the hottest recorded summer in California history (California Weather Blog[8]).

Climate patterns (e.g., extended droughts) and individual weather events (e.g., extreme storms, hot summers) influence biological communities (i.e., vegetation, wildlife) and their surrounding physical habitat and should therefore be considered when evaluating the type of data collected by the Creek Status Monitoring Program. For example, periods of drought (rather than individual dry years) can result in changes in riparian and upland vegetation communities. Long drought periods are associated with increased streambed sedimentation which can persist directly or indirectly for many years, depending on the occurrence and magnitude of flushing flow events. Furthermore, in response to prolonged drought, the relative proportion of pool habitat can increase at the expense of riffle habitat.

It is uncertain what effect these factors have on indices of biotic integrity (IBIs) based on data collected by the Creek Status Monitoring Program, such as benthic macroinvertebrates or algae. A study evaluating 20 years of bioassessment data collected in northern California showed that, although benthic macroinvertebrate taxa with certain traits may be affected by dry (and wet) years and/or warm (and cool) years, IBIs based on these organisms appear to be resilient (Mazor et al. 2009, Lawrence et al. 2010). However, this study did not specifically examine the impact of longer *periods* of extended drought or heat on IBIs, which would require analysis of a dataset with a much longer period of record. The Herbst Lab at the Sierra Nevada Aquatic Research Laboratory, University of California Santa Barbara is currently exploring how changing climate affects Sierra Nevada stream ecosystems.

Extreme heat certainly does affect general water quality such as water temperature and parameters that are influenced by water temperature (e.g., specific conductance, dissolved oxygen). By some measures, WY 2017 was the hottest summer in over 120 years of recorded measurements.[9] The late summer general water quality monitoring results from WY 2017 reflect the high air temperatures during that period.

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[8] http://weatherwest.com/archives/5860

[9] https://www.ncdc.noaa.gov/cag/time-series/us/4/4/tavg/4/9/1895-2017?base_prd=true&firstbaseyear=1901&lastbaseyear=2000

Figure 1.2. Average annual precipitation in San Mateo County, modeled by the PRISM Climate Group for the period of 1981-2010.

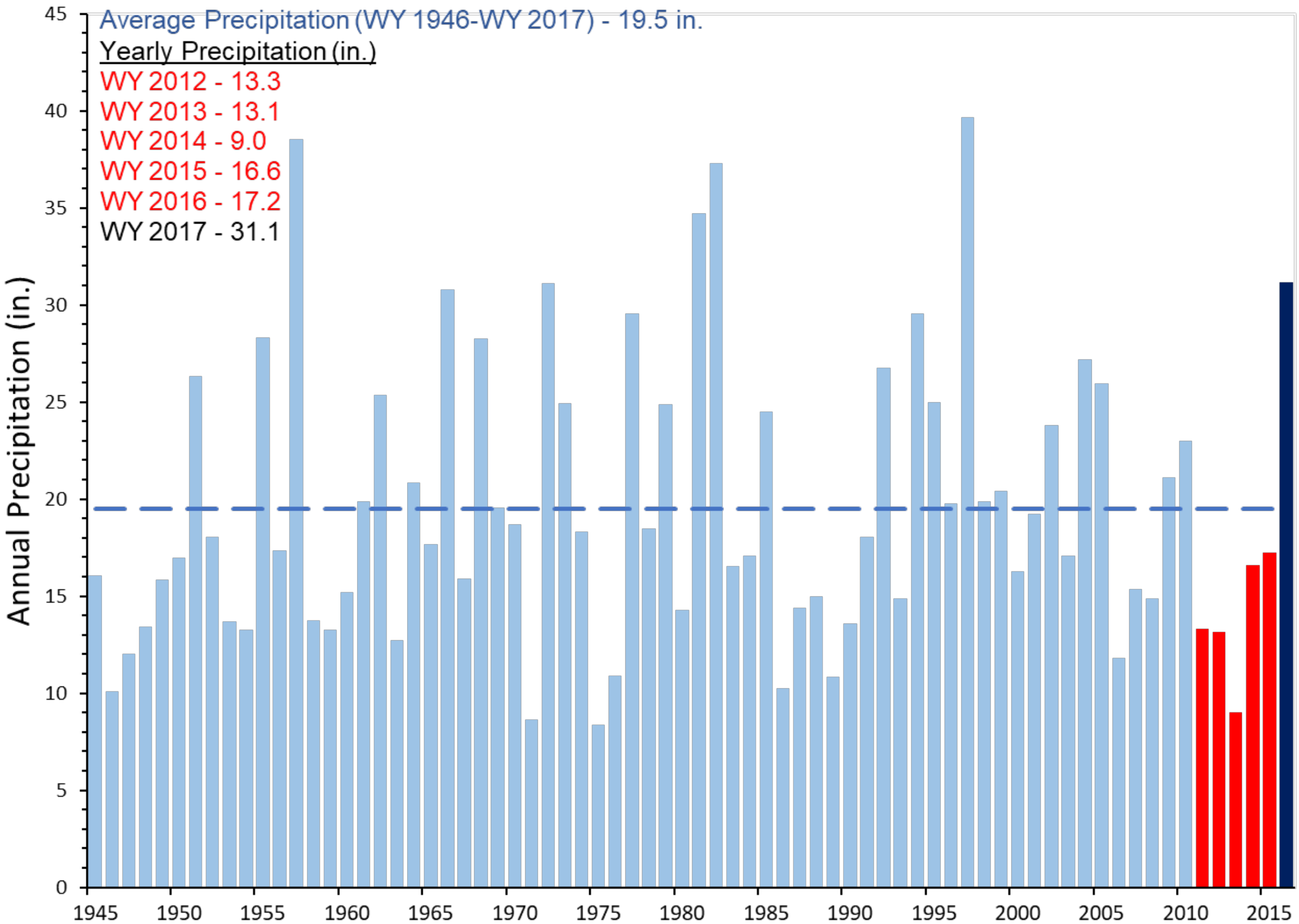

Figure 1.3. Annual rainfall recorded at the San Francisco International Airport, WY 1946 – WY 2017.

1.5 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SMCWPPP covering all aspects of the probabilistic and targeted monitoring. In general QA/QC procedures were implemented as specified in the BASMAA RMC QAPP (BASMAA, 2016a), and monitoring was performed according to protocols specified in the BASMAA RMC SOPs (BASMAA, 2016b), and in conformity with methods specified by the SWAMP QAPrP[10]. A detailed QA/QC report is included as Attachment 1.

Based on the QA/QC review, no WY 2017 data were rejected, but some data were flagged. Overall, WY 2017 data met QA/QC objectives.

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[10] The current SWAMP QAPrP is available at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf

2.0 Biological Condition Assessment

2.1 Introduction

In compliance with Creek Status Monitoring Provision C.8.d.i, SMCWPPP conducted bioassessment monitoring in WY 2017. All bioassessment monitoring was performed at sites selected randomly using the probabilistic monitoring design[11]. The probabilistic monitoring design allows each individual RMC participating program to objectively assess stream ecosystem conditions within its program area (County boundary) while contributing data to answer regional management questions about water quality and beneficial use condition in San Francisco Bay Area creeks. The survey design provides an unbiased framework for data evaluation that will allow a condition assessment of ambient aquatic life uses within known estimates of precision. The monitoring design was developed to address the management questions for both RMC participating county and overall RMC area described below:

1. *What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?*
    i. *What is the condition of aquatic life in the urbanized portion of the RMC area; are water quality objectives met and are beneficial uses supported?*
    ii. *What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?*
    iii. *To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?*
    iv. *To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?*
2. *What are major stressors to aquatic life in the RMC area?*
    i. *What are major stressors to aquatic life in the urbanized portion of the RMC area?*
3. *What are the long-term trends in water quality in creeks over time?*

The first question (i.e., *What is the condition of aquatic life in creeks in the RMC?*) is addressed by assessing indicators of aquatic biological health at probabilistic sampling locations. Once a sufficient number of samples have been collected, ambient biological condition can be estimated for streams at a regional scale. Over the past six years (WY 2012 through WY 2017), SMCWPPP and the Regional Water Board have sampled 70 probabilistic sites in San Mateo County, providing a sufficient sample size to estimate ambient biological condition for urban streams countywide. There are still an insufficient number of samples to accurately assess the biological condition of non-urban streams in the county, or of individual watersheds or smaller jurisdictional areas (i.e., cities).[12]

The second question (i.e., *What are major stressors to aquatic life in the RMC area?*) is addressed by the collection and evaluation of physical habitat and water chemistry data

[11] The option to conduct 20% of bioassessment surveys at targeted sites was not exercised in WY 2017.

[12] For each of the strata, it is necessary to obtain a sample size of at least 30 in order to evaluate the condition of aquatic life within known estimates of precision. This estimate is defined by a power curve from a binomial distribution (BASMAA 2012).

collected at the probabilistic sites, as potential stressors to biological health. The extent and magnitude of these potential stressors above certain thresholds is also assessed for streams in San Mateo County. In addition, the stressor levels can be compared to biological indicator data through correlation and relative risk analyses. Assessing the extent and relative risk of stressors can help prioritize stressors at a regional scale and inform local management decisions.

The last question (i.e., *What are the long-term trends in water quality in creeks over time?*) is addressed by assessing the change in biological condition over several years. Changes in biological condition over time can help evaluate the effectiveness of management actions. However, trend analysis for the RMC probabilistic survey will require more than six years of data collection.

The following sections of this report present biological condition and stressor data collected at the ten probabilistic sites sampled by SMCWPPP in WY 2017. This WY 2017 report presents biological indicator data and potential stressor data. Data are compared to triggers and water quality objectives identified in the MRP; however, statistical analyses evaluating stressor association with biological condition are not presented in this report. Those analyses are being conducted through an ongoing BASMAA RMC regional study.

The BASMAA RMC is currently conducting a *regional* analysis of biological condition using a five-year data set (WY 2012 – WY 2016). The BASMAA regional study will conduct the following analyses:

- Assess the biological condition of streams in the region and each county using IBIs based on benthic macroinvertebrates and algae collected by each countywide program and the SWRCB SWAMP.
- Evaluate IBIs in distinct groupings such as imperviousness categories and type of stream.
- Assess stressors associated with poor stream condition using multivariate modeling analyses.
- Summarize regional data for each year in the five-year dataset.
- Introduce the analyses that will be needed to make recommended changes to the probabilistic monitoring design.

Results of the BASMAA regional study will be available by late 2018. Analytical tools that are found to be useful in evaluating stressor association with biological condition may be implemented in future annual monitoring reports.

2.2 Methods

2.2.1 Probabilistic Survey Design

The RMC probabilistic design was developed using the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olson 2004). GRTS offers multiple benefits for coordinating amongst monitoring entities including the ability to develop a spatially balanced design that produces statistically representative data with known confidence intervals. The GRTS approach has been implemented recently in California by several agencies including the statewide Perennial Streams Assessment (PSA) conducted by Surface Water Ambient

Monitoring Program (SWAMP) (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's (SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SMC 2007).

Sample sites were selected and attributed using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the 3,407-square mile RMC area (BASMAA 2012). The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the storm water programs associated with the RMC. The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for future data coordination with these programs.

The RMC sample frame was classified by county and land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the areas within the RMC area. Some sites classified as urban fall near the non-urban edge of the city boundaries and have little upstream development. For the purposes of consistency, these urban sites were not re-classified. Therefore, data values within the urban classification represent a wide range of conditions.

The RMC participants weight their annual sampling efforts so that approximately 80% are in in urban areas and 20% in non-urban areas. In addition, between WY 2012 and WY 2015, the SFRWQCB SWAMP conducted 34 bioassessments throughout the RMC region at non-urban probabilistic sites selected from the sample frame, including 10 sites in San Mateo County[13].

2.2.2 Site Evaluations

Sites identified in the regional sample draw are evaluated by each RMC participant in chronological order using a two-step process described in RMC Standard Operating Procedure FS-12 (BASMAA 2016b), consistent with the procedure described by Southern California Coastal Water Research Project (SCCWRP) (2012). Each site is evaluated to determine if it meets the following RMC sampling location criteria:

1. The location (latitude/longitude) provided for a site is located on or is within 300 meters of a non-impounded receiving water body[14];
2. Site is not tidally influenced;
3. Site is wadeable during the sampling index period;
4. Site has sufficient flow during the sampling index period to support standard operation procedures for biological and nutrient sampling.
5. Site is physically accessible and can be entered safely at the time of sampling;
6. Site may be physically accessed and sampled within a single day;

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[13] SFRWQCB SWAMP staff have indicated that they will not conduct RMC related bioassessment monitoring during MRP 2.0.

[14] The evaluation procedure permits certain adjustments of actual site coordinates within a maximum of 300 meters.

7. Landowner(s) grant permission to access the site[15].

In the first step, these criteria were evaluated to the extent possible using a "desktop analysis." Site evaluations were completed during the second step via field reconnaissance visits. Based on the outcome of site evaluations, sites were classified into one of three categories:

- **Target** – Target sites were grouped into two subcategories:
  - **Target Sampleable (TS)** - Sites that met all seven criteria and were successfully sampled.
  - **Target Non-Sampleable (TNS)** - Sites that met criteria 1 through 4, but did not meet at least one of criteria 5 through 7 were classified as TNS.
- **Non-Target (NT)** - Sites that did not meet at least one of criteria 1 through 4 were classified as non-target status.
- **Unknown (U)** - Sites were classified with unknown status when it could be reasonably inferred either via desktop analysis or a field visit that the site was a valid receiving water body and information for any of the seven criteria was unconfirmed.

All site evaluation information was documented on field forms and entered into a standardized database. The overall percent of sites classified into the three categories will eventually be evaluated to determine the statistical significance of local and regional average ambient conditions calculated from the multi-year dataset.

2.2.3 Field Sampling Methods

Biological sample collection and processing was consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b).

In accordance with the RMC QAPP (BASMAA 2016a) bioassessments were planned during the spring index period (approximately April 15 – July 15) with the goal to sample a minimum of 30 days after any significant storm (defined as at least 0.5-inch of rainfall within a 24-hour period). A 30-day grace period allows diatom and soft algae communities to recover from peak flows that may scour benthic algae from the bottom of the stream channel. During WY 2017, there was a small storm on April 7 (0.56 inches in 24-hour period). Field sampling in San Mateo County began on May 22 and ended on May 31.

Each bioassessment sampling site consisted of an approximately 150-meter stream reach that was divided into 11 equidistant transects placed perpendicular to the direction of flow. Benthic macroinvertebrate (BMI) and algae samples were collected at 11 evenly spaced transects using the Reachwide Benthos (RWB) method described in the SWAMP SOP (Ode et al. 2016). The most recent SWAMP SOP (i.e., Ode et al. 2016) combines the BMI and algae methods that are referenced in the MRP (Ode et al. 2007, Fetscher 2009), provides additional guidance, and adds two new physical habitat analytes (assess scour and engineered channels). The full suite of physical habitat data were collected within the sample reach using methods described in Ode et al. (2016). The presence of micro- and macroalgae was assessed during the pebble counts following methods described in Ode et al. (2016).

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[15] If landowners did not respond to at least two attempts to contact them either by written letter, email, or phone call, permission to access the respective site was effectively considered to be denied.

Immediately prior to biological and physical habitat data collection, water samples were collected for nutrients, conventional analytes, ash free dry mass, and chlorophyll a analysis using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2016b). Water samples were also collected and analyzed for free and total chlorine using a Pocket Colorimeter™ II and DPD Powder Pillows according to SOP FS-3 (BASMAA 2016b) (see Section 4.0 for chlorine monitoring results). In addition, general water quality parameters (DO, pH, specific conductivity and temperature) were measured at or near the centroid of the stream flow using pre-calibrated multi-parameter probes.

Biological and water samples were sent to laboratories for analysis. The laboratory analytical methods used for BMIs followed Woodward et al. (2012), using the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Level 1 Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). Soft algae and diatom samples were analyzed following SWAMP protocols (Stancheva et al. 2015). The taxonomic resolution for all data was compared SWAMP master taxonomic list. All taxa identified in samples collected were on the SWAMP Master List and are included in the data submittal for WY 2017.

2.2.4 Data Analysis

BMI and algae data were analyzed to assess the biological condition of the sampled reaches using condition index scores. Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. Additional physical habitat metric scores (see Stressor Variable section below) and water chemistry data were evaluated as potential stressors to biological health using triggers and water quality objectives identified in the MRP. Data analysis methods are described below.

2.2.4.1 Biological Indicators

Benthic Macroinvertebrates

The benthic (i.e., bottom-dwelling) macroinvertebrates collected through this monitoring program are organisms that live on, under, and around the rocks and sediment in the stream bed. Examples include dragonfly and stonefly larvae, snails, worms, and beetles (Figure 2.1). Different BMIs respond differently to changes in water chemistry and physical habitat. Some are relatively sensitive; others more tolerant of poor habitat and pollution. Therefore, the abundance and variety of BMIs in a stream indicates the biological condition of the stream.

The California Stream Condition Index (CSCI) is an assessment tool that was developed by the State Water Resources Control Board (State Board) to support the development of California's statewide Biological Integrity Plan[16]. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that represents the full range of natural conditions in California and by the use of site-specific models for predicting biological communities. The CSCI combines two types of indices: 1) taxonomic completeness, as measured by the ratio of observed-to-expected taxa (O/E); and 2) ecological structure and function, measured as a predictive multi-metric index (pMMI) that is

[16] The Biological Integrity Assessment Implementation Plan has been combined with the Biostimulatory Substances Amendment project. The State Water Board is proposing to adopt a statewide water quality objective for biostimulatory substances (e.g., nitrate) along with a program of implementation. A draft policy document for public review is anticipated in late 2018.

based on reference conditions. The CSCI score is computed as the average of the sum of O/E and pMMI.

The CSCI is calculated using a combination of biological and environmental data following methods described in Rehn et al. (2015). Biological data include benthic macroinvertebrate data collected and analyzed using protocols described in the previous section. The environmental predictor data are generated in GIS using drainage areas upstream of each BMI sampling location. The environmental predictors and BMI data were formatted into comma delimited files and used as input for the RStudio statistical package and the necessary CSCI program scripts, developed by Southern California Coastal Water Research Project (SCCWRP) staff (Mazor et al. 2016).

The State Board is continuing to evaluate the performance of CSCI in a regulatory context. In the current MRP, the Regional Water Board defined a CSCI score of 0.795 as a threshold for identifying sites with degraded biological condition that may be considered as candidates for a Stressor Source Identification (SSID) project.

Odonata cordulegastridae
"Spiketail Dragonfly"

Megaloptera corydalidae
"Dobsonflies"

Ephemeroptera ephemerellidae
"Spiny Crawler Mayflies"

Trichoptera limnephilidae
"Northern Caddisflies"

Diptera ceratopogonidae
"Biting Midges"

Coleoptera psephenidae
"Water Penny Beetle"

Source: http://www.dfg.ca.gov/abl/Reference/California/CA_digital_ref_familylevel_home.asp

Figure 2.1. Examples of benthic macroinvertebrates.

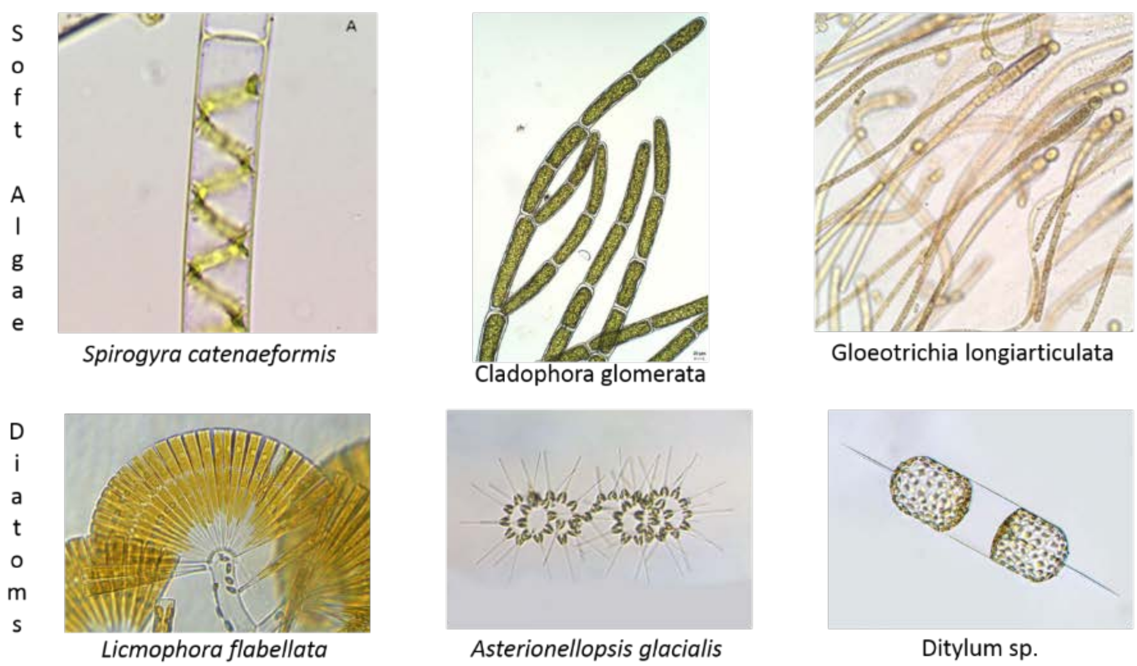
<u>Benthic Algae</u>

Similar to BMI's, the abundance and type of benthic algae species living on a streambed can indicate stream health. Biological indices based on benthic algae can provide a more complete picture of the streams biological condition because algae respond most directly to nutrients and water chemistry; whereas BMIs are more responsive to physical habitat. Figure 2.2 shows examples of benthic algae common in Bay Area streams.

The State Board and Southern California Coastal Water Research Project (SCCWRP) are currently developing and testing a statewide index using benthic algae data as a measure of biological condition for streams in California. The statewide Algae Stream Condition Indices (ASCIs) are expected to be available in 2018. The ASCIs will build upon studies by Fetscher et al. (2014) that developed and tested algal IBIs for streams in Southern California (SoCal Algae IBIs). The SoCal Algae IBIs were developed from data comprised of either single-assemblage metrics (i.e., either diatoms or soft algae) or combinations of metrics presenting both assemblages (i.e, “hybrid” IBI).

Algae data collected in San Mateo County were evaluated using the existing SWAMP Algae Reporting Module, (Algae RM) which was developed in 2013 using the SoCal Algae IBI as the basis for metric and IBI calculations (Marco Sigala, personal communication). Three algal IBIs that performed well against stressor gradients at sites in Southern California were calculated using the algae data collected in San Mateo County. These include a soft algae index (S2), a diatom index (D18) and a soft algae-diatom hybrid index (H20). The interpretation of algae data collected in San Mateo County is considered preliminary since the IBIs were developed and tested on data collected in Southern California.

New taxa (i.e., not on the SWAMP Master List) are typically identified by SWAMP laboratory each year. Additional new taxa are initially identified by contracting labs for stormwater projects and, depending on available resources, may be “harmonized” with taxa on the SWAMP Master List. Once harmonized, the new taxa are eventually added to the SWAMP Algae RM. However, autecological information (i.e., traits that associate taxa response to environmental stressors) has not been assigned to the new taxa since May 2013 (Marco Sigala, personal communication). As a result, some of the taxa identified in samples collected since 2013 are not included in the IBI calculations. Thus, the SoCal Algae IBI scores should be considered preliminary until all possible taxa and their trait attributes are incorporated into the Algae RM.



Source: http://dbmuseblade.colorado.edu/DiatomTwo/sbsac_site/IDResourceTool.html
http://nathistoc.bio.uci.edu/Diatoms

Figure 2.2. Examples of soft algae and diatoms.

2.2.4.2 Biological Condition Thresholds

Existing thresholds for biological indicators defined in Mazor (2015) were used to evaluate the bioassessment data collected in San Mateo County and analyzed in this report (Table 2.1). The thresholds for each index were based on the distribution of scores for data collected at reference calibration sites in California (CSCI) or in Southern California (algae). Four condition categories are defined by these thresholds: "likely intact" (greater than 30th percentile of reference site scores); "possibly intact" (between the 10th and the 30th percentiles); "likely altered" (between the 1st and 10th percentiles; and "very likely altered" (less than the 1st percentile).

A CSCI score below 0.795 is referenced in the MRP as a threshold indicating a potentially degraded biological community, and thus should be considered for a SSID Project. The MRP threshold is the division between "possibly intact" and "likely altered" condition category described in Mazor (2015).

Table 2.1. Condition categories used to evaluate CSCI, Algae IBI, and Total PHAB scores.

Index	Likely Intact	Possibly Intact	Likely Altered	Very Likely Altered
Benthic Macroinvertebrates (BMI)				
CSCI Score	≥ 0.92	≥ 0.795 to < 0.92	≥ 0.63 to < 0.795	< 0.63
Benthic Algae				
S2 Score	≥ 60	≥ 47 to < 60	≥ 29 to < 47	< 29
D18 Score	≥ 72	≥ 62 to < 72	≥ 49 to < 62	< 49
H20 Score	≥ 70	≥ 63 to < 70	≥ 54 to < 63	< 54
Physical Habitat (PHAB)				
PHAB Score	≥ 46	≥ 30 to < 46	≥ 15 to < 30	< 15

Physical Habitat Assessment Scores

The Physical Habitat Assessment score consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate, and sediment deposition. Each attribute is individually scored on a scale of 0 to 20, with a score of 20 representing good condition. The total PHAB score is the sum of three individual attribute scores with a score of 60 representing the highest possible score. Condition categories for Total PHAB score were created by dividing the highest possible score of 60 into quartiles (Table 2.1).

2.2.4.3 Stressor Variables

Physical habitat, general water quality, and water chemistry data collected at the bioassessment sites were compiled and evaluated as potential stressor variables for biological condition. Some of the data required conversion to other analytes or units of measurement:

- Conversion of measured total ammonia to the more toxic form of unionized ammonia was calculated to compare with the 0.025 mg/L annual median standard provided in the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2017). The conversion was based on a formula provided by the American Fisheries Society (AFS)[17]. The calculation requires total ammonia and field-measured parameters of pH, temperature, and specific conductance.

- Total nitrogen concentration was calculated by summing nitrate, nitrite and Total Kjeldahl Nitrogen concentrations.
- The volumetric concentrations (mass/volume) for ash free dry mass and chlorophyll a (as measured by the laboratory) were converted to an area concentration (mass/area). Calculations required using both algae sampling grab size and composite volume.

Physical habitat metrics were calculated using the SWAMP Bioassessment Reporting Module (RM). The SWAMP RM output includes calculations based on parameters that are measured using EPA's Environmental Monitoring and Assessment Program (EMAP) for freshwater wadeable streams (Kaufmann et al. 1999). The RM also includes additional metrics generated from parameters collected under the SWAMP protocol (Marco Sigala, personal communication, 2017). The RM produces a total of 176 different metrics based on data collected using the SWAMP "Full" habitat protocol.

The California Department of Fish and Wildlife (CDFW) is currently developing a statewide index for physical habitat data collected using the SWAMP bioassesment protocol. The CDFW evaluated a range of physical habitat metrics for their ability to discriminate between reference and stressed sites and provide unbiased representation of waterbodies across the different ecoregions of California. Ten of the top performing metrics (Table 2.2) were selected from the SWAMP RM output to analyze physical habitat data collected from the ten bioassessment sites in San Mateo County during WY 2017.

Table 2.2. Physical habitat metrics used to assess physical habitat data collected at bioassessment sites in WY 2017.

Type	Variable Name	Variable
Channel Morphology	Evenness of Flow Habitat Types	Ev_FlowHab
Channel Morphology	Percent Fast Water of Reach	PCT_FAST
Habitat Complexity and Cover	Mean Filamentous Algae Cover	XFC_ALG
Habitat Complexity and Cover	Natural Shelter cover - SWAMP	XFC_NAT_SWAMP
Habitat Complexity and Cover	Shannon Diversity (H) of Aquatic Habitat Types	H_AqHab
Human Disturbance	Combined Riparian Human Disturbance Index - SWAMP	W1_HALL_SWAMP
Substrate Size and Composition	Evenness of Natural Substrate Types	Ev_SubNat
Substrate Size and Composition	Percent Gravel - coarse	PCT_GC
Substrate Size and Composition	Percent Substrate Smaller than Sand (<2 mm)	PCT_SAFN
Substrate Size and Composition	Shannon Diversity (H) of Natural Substrate Types	H_SubNat

Additional environmental variables were calculated in GIS by overlaying the drainage area for sample locations with land use and road data. The variables included percent urbanization, percent impervious, total number of road crossings and road density at three different spatial scales (1 km, 5 km, and entire watershed).

Another potential stressor is climate. During the first five years of probabilistic sampling (WY 2012 – WY 2016), average precipitation and dry season base flows were lower than average.

[17] https://fisheries.org/wp-content/uploads/2016/03/Copy-of-pub_ammonia_fwc.xls

Comparison of sampling results from the wetter than average WY 2017 and other future wet years will provide useful information to evaluate the impacts of drought on biological integrity of the streams.

2.2.4.4 Stressor Thresholds

In compliance with Provision C.8.h.iii.(4), water chemistry data collected at the bioassessment sites during WY 2017 were compared to stressor thresholds and applicable water quality standards (Table 2.3). Thresholds for pH, specific conductance, dissolved oxygen, and temperature (for waters with COLD Beneficial Use only) are listed in Provision C.8.d.iv of the MRP. With the exception of temperature, these conform to Water Quality Objectives (WQOs) in the Basin Plan (SFRWQCB 2017). Of the eleven nutrients analyzed synoptically with bioassessments, WQOs only exist for three: ammonia (unionized form), and chloride and nitrate (for waters with MUN Beneficial Use only). See Table 1.4 for a list designated Beneficial Uses of creeks monitored in WY 2017. Denniston Creek and San Pedro Creeks are the only creeks sampled in WY 2017 with MUN designated.

Table 2.3. Thresholds for nutrient and general water quality variables.

	Units	Threshold	Direction	Source
Nutrients and Ions				
Nitrate as N [a]	mg/L	10	Increase	Basin Plan
Un-ionized Ammonia [b]	mg/L	0.025	Increase	Basin Plan
Chloride [a]	mg/L	250	Increase	Basin Plan
General Water Quality				
Oxygen, Dissolved	mg/L	5.0 or 7.0	Decrease	Basin Plan
pH		6.5 and 8.5		Basin Plan
Temperature, instantaneous maximum	°C	24	Increase	MRP
Specific Conductance	µScm	2000	Increase	MRP

[a] Nitrate and chloride WQOs only apply to waters with MUN designated Beneficial Uses.

[b] This threshold is an annual median value and is not typically applied to individual samples.

2.3 Results and Discussion

A comprehensive analysis of bioassessment data collected by the Program over a five-year period will be presented in the RMC Five-Year Bioassessment Report (5-Year Report). This BASMAA-funded project will evaluate bioassessment data collected at all RMC (n=312) and Water Board (n=45) probabilistic monitoring sites sampled between WY 2012 and WY 2016. The data will be evaluated to assess overall biological condition of streams within the RMC, as well as the extent and influence of stressor data on biological conditions. In addition, the 5-Year Report will evaluate the RMC Sample Frame and provide potential recommendations for revising the monitoring design in the future. The 5-Year Report will be completed by late-2018.

The section below summarizes results from bioassessment sampling conducted during WY 2017.

2.3.1 Site Evaluations

During WY 2017, SMCWPPP conducted site evaluations at a total of 16 potential probabilistic sites in San Mateo County that were drawn from the Sample Frame. Of these sites, a total of ten were sampled in WY 2017 (rejection rate of 38%). Five sites were rejected due to access issues and one site was rejected due to low flow conditions. Two of the sampled sites were classified as non-urban land use and the remaining sites were classified as urban. Land use classification, sampling location, and date for each sampled site are listed are Table 2.4. Sites are mapped in Figure 1.1.

The two non-urban sites were located in coastal watersheds draining into the Pacific Ocean; the remaining eight sites were located in urban watersheds draining into the San Francisco Bay. Three of the urban sites were located in Redwood Creek watershed. Two sites were located on Atherton Creek, two sites were located in San Mateo Creek, and one site was located in Belmont Creek. Two of the lowest elevation sites on Atherton and Redwood Creek, and one location on Arroyo Ojo de Agua, were located in modified (concrete) channels.

Table 2.4. SMCWPPP bioassessment sampling locations and dates in San Mateo County in WY 2017.

Station Code	Creek	Land Use	Modified Channel	Sample Date	Latitude	Longitude
202R00550	Jones Gulch	NU	N	5/30/2017	37.27708	-122.26750
202R00552	Lawrence Creek	NU	N	5/24/2017	37.38802	-122.31349
204R02611	Atherton Creek	U	Y	5/23/2017	37.45228	-122.20451
204R02472	Redwood Creek	U	Y	5/22/2017	37.46660	-122.23534
204R03240	Atherton Creek	U	N	5/23/2017	37.42731	-122.22635
204R03252	San Mateo Creek	U	N	5/31/2017	37.56320	-122.32761
204R03272	San Mateo Creek	U	N	5/31/2017	37.53400	-122.35022
204R03316	Arroyo Ojo de Agua	U	Y	5/24/2017	37.48085	-122.23453
204R03336	Belmont Creek	U	N	5/25/2017	37.51644	-122.27866
204R03496	Redwood Creek	U	N	5/22/2017	37.44764	-122.48500

Since WY 2012, a total of 70 probabilistic sites were sampled by SMCWPPP (n=60) and SWAMP (n=10) in San Mateo County. During the six-year sampling period, SMCWPPP sampled 49 urban sites and 11 non-urban sites; SWAMP sampled 10 non-urban sites. There are sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for urban streams in San Mateo County. These analyses are currently being conducted through a BASMAA regional project with results anticipated in late-2018. More samples are needed however, to estimate biological condition for non-urban streams, as well streams at more local scales (e.g., watershed and jurisdictional areas).

2.3.2 Biological Condition Assessment

A total of 103 unique BMI taxa were identified in samples collected at ten bioassessment sites in San Mateo County during WY 2017. A total of 177 benthic algae taxa were identified in samples collected at the same sites, including 138 diatom taxa and 39 soft algae taxa. The total number of unique BMI, diatom, and soft algae taxa identified at each bioassessment location is presented in Table 2.5. BMIs and diatoms were relatively well represented across all sites, with BMIs ranging from 16 to 50 taxa, and diatoms ranging from 25 to 51 taxa. Soft algae taxa were less common across sites, ranging from 1 to 13 taxa.

Table 2.5. The total number of unique BMI, diatom, and soft algae taxa identified in samples collected at 10 bioassessment sites in San Mateo County during WY 2017.

Station ID	Creek	Elevation (m)	Land Use	BMIs	Diatoms	Soft Algae
202R00550	Jones Gulch	88	NU	34	36	1
202R00552	Lawrence Creek	295	NU	50	37	3
204R02472	Atherton Creek	13	U	19	25	9
204R02611	Redwood Creek	21	U	17	25	13
204R03240	Atherton Creek	57	U	18	38	3
204R03252	San Mateo Cr	8	U	19	46	7
204R03272	San Mateo Cr	39	U	21	47	9
204R03316	Ojo de Agua	6	U	16	31	11
204R03336	Belmont Creek	16	U	22	51	3
204R03496	Redwood Creek	31	U	25	43	4

NU = non-urban, U = urban

The total number of BMI taxa was positively correlated with site elevation (r^2=0.88, p value < 0.001) (Figure 2.3). In contrast, total taxa for soft algae generally decreased with increasing site elevation (r^2=0.20, p value = 0.191). Diatoms did not show any association with elevation.

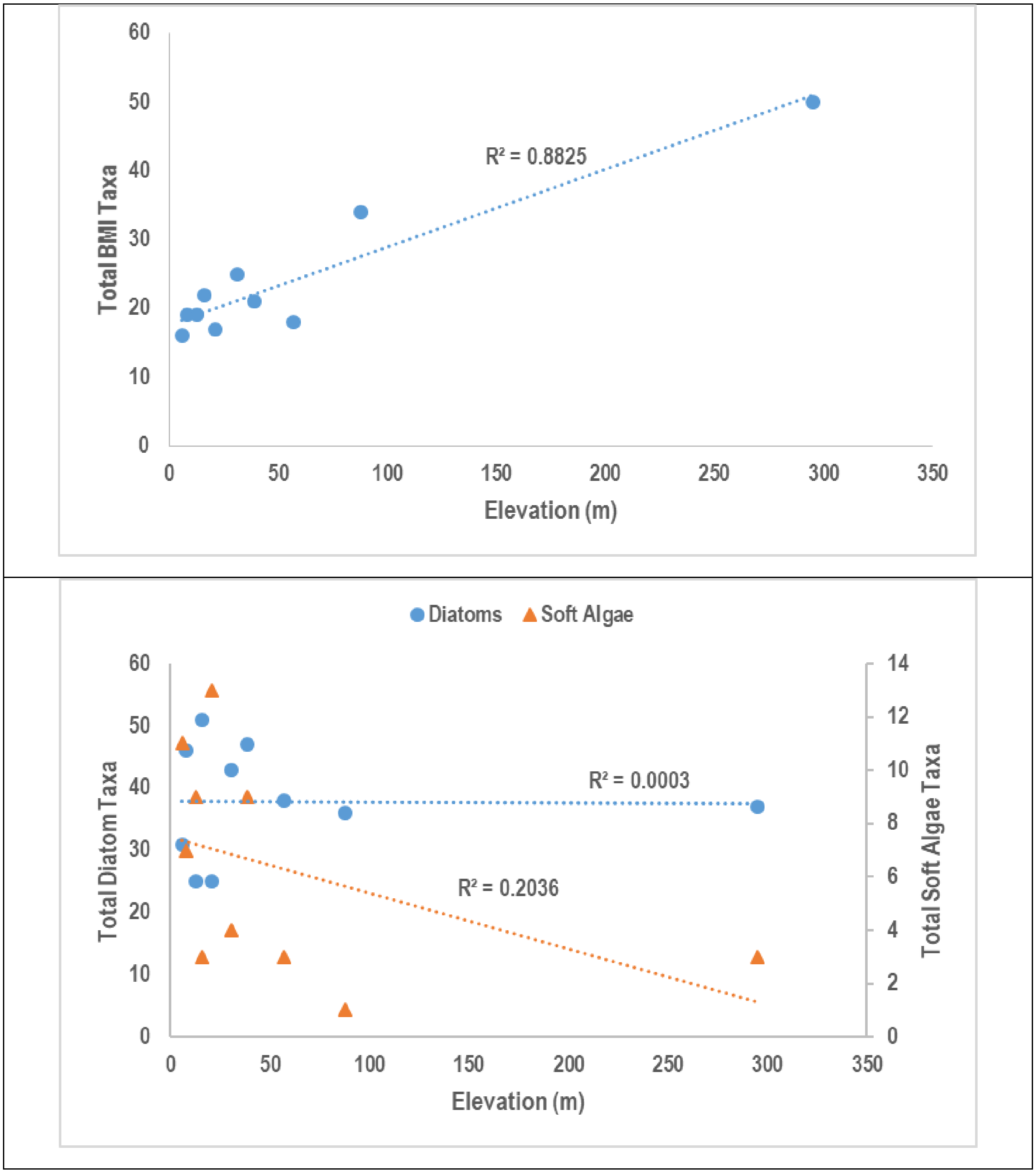


Figure 2.3. Total BMI and soft algae taxa compared to elevation of bioassessment site.

Biological condition, as represented by CSCI scores and algae IBI scores (S2, D18 and H20), for the ten probabilistic sites sampled by SMCWPPP in WY 2017 is presented in Table 2.6. Scores for each indicator that were in the two higher condition categories are indicated in bold. The condition categories for three of the biological indicator scores (CSCI, D18 and H20), as defined in Table 2.1, are illustrated for the ten sites in Figure 2.4. Total PHAB scores for each site are also presented in Table 2.6.

Table 2.6. Biological condition scores, presented as CSCI, SoCal Algae IBIs (S2, D18 and H20) for ten probabilistic sites sampled in San Mateo County during WY 2017. PHAB scores are also presented for comparison. Site characteristics related to channel modification and flow condition are also presented. Scores in the two higher condition categories are indicated in bold.

Station Code	Creek	Land Use[1]	Impervious Watershed Area (%)	Modified Channel[2]	Flow [3]	CSCI Score	Diatom "D18" IBI Score	Soft Algae "S2" IBI	Hybrid "H20" IBI Score	Total PHAB Score
202R00550	Jones Gulch	NU	1%	N	P	0.87	54	46	67	43
202R00552	Lawrence Creek	NU	2%	N	P	1.16	61	66	77	43
204R02472	Atherton Creek	U	22%	Y	P	0.54	41	64	2	16
204R02611	Redwood Creek	U	24%	Y	P	0.43	40	46	18	18
204R03240	Atherton Creek	U	12%	N	P	0.41	51	42	67	32
204R03252	San Mateo Creek	U	8%	N	P	0.67	60	68	57	21
204R03272	San Mateo Creek	U	7%	N	P	0.63	40	52	15	36
204R03316	Ojo de Aqua	U	45%	Y	P	0.42	38	56	17	18
204R03336	Belmont Creek	U	40%	N	P	0.50	44	30	67	30
204R03496	Redwood Creek	U	19%	N	P	0.60	52	44	67	28

[1] Land Use classification from RMC Sample Frame (NU = Non Urban, U = Urban)
[2] Highly modified channel is defined as having armored bed and banks (e.g., concrete, gabion, rip rap) for majority of the reach or characterized as highly channelized earthen levee.
[3] Flow status (P = perennial, NP = non-perennial) was based on visual observations at each site made during fall or spring seasons.

CSCI Scores

The CSCI scores ranged from 0.41 to 1.16 across the ten bioassessment sites sampled in WY 2017 (Table 2.6). Two of the ten (20%) sites had CSCI scores in the two higher condition categories "possibly intact" and "likely intact", referred to as "good" biological condition in this report. The combined classifications are above the MRP trigger threshold value of 0.795. The good condition sites were classified as non-urban and are located in protected Open Space or County Park land. Site 202R00552, located in El Corte de Madera Creek Preserve, had a CSCI score of 1.16, which is typically a score for reference sites.

The two sites sampled in San Mateo Creek had CSCI scores that ranked as "likely altered" (0.63 to 0.795). The remaining six sites were ranked as "very likely altered" (< 0.63). Three of these sites were located in concrete channel sections of Redwood Creek, Arroyo Ojo de Agua, and Atherton Creek.

Sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.

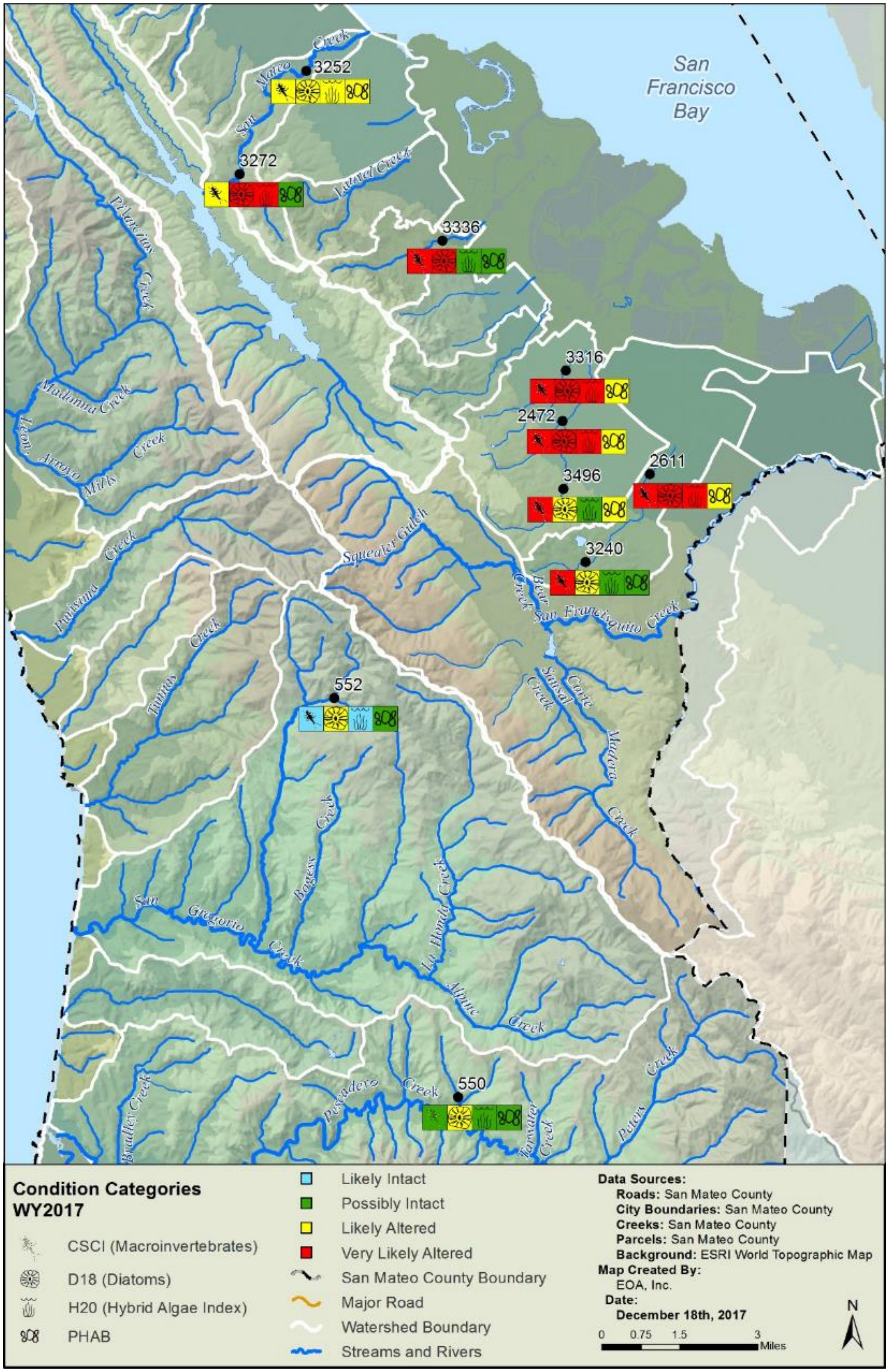


Figure 2.4. Condition category as represented by CSCI, D18, H20 and PHAB for ten probabilistic sites sampled in San Mateo County in WY2017.

Algae IBI Scores

Benthic algae taxa identified in the ten samples collected in San Mateo County were used to calculate scores for three algae IBIs (S2, D18 and H20) (Table 2.6).

- **D18** IBI scores ranged from 38 to 61 across all sites. There were no sites that were ranked in the two higher condition categories (>62). Five sites were ranked as "likely altered" (49 - 62) and five sites were ranked as "very likely altered" (<49) condition categories.
- **S2** IBI scores ranged from 30 to 68 for all sites. There were five sites that ranked in the two higher condition categories for S2 IBI score. One of these sites was non-urban site (also had highest CSCI score 1.16) and the remaining were urban sites. Two of the high ranking urban sites were concrete channels with high impervious watershed area (>22%), suggesting that S2 IBI scores are relatively independent of physical habitat conditions.
- **H20** IBI scores ranged from 17 to 77. There were five sites that were ranked in the two higher condition categories for H20 IBI scores. The lowest four scores ranged from 2 to 18. Three of the low-scoring sites were in concrete channels and had high percent impervious watershed area.

The total number of soft algae taxa identified in samples collected in WY 2017 was much higher (39 taxa) compared to number of taxa identified in samples collected the previous two years (12 taxa in WY 2016 and 3 taxa in WY 2015). The wetter than average winter of WY 2017 may be one reason that higher numbers of soft algae taxa were observed in WY 2017.

Reasons for the lack of soft algae at San Mateo County sites in prior years are unknown but may be related to range of factors, including: sand-dominated substrate, low flow conditions related to prolonged drought, dense canopy cover limiting exposure to sunlight, and/or competition with diatoms. None of these factors, however, appear to explain the consistent lack of soft algae in samples across all ten sites.

Currently, some soft algae taxa are not incorporated into the calculation for S2 and H20 IBI scores. The SWAMP Algae Reporting Module requires each taxa to have trait assignments (i.e., fields to indicate if taxa is sensitive or tolerant to a particular stressor). The current version of the RM has not been updated since 2013. As a result, many taxa that have been added to SWAMP Master List in the past five years have not been assigned traits, and thus do not get incorporated into the metric calculations. It is anticipated that the ASCI tool, currently under development, will incorporate the full SWAMP Master List.

Total PHAB Scores

Individual PHAB metrics and total PHAB scores assessed at the ten bioassessment sites in WY 2017 are presented in Table 2.7. The lowest scores for channel alteration and epifaunal substrate attributes (0) were given to sites at concrete channels (i.e., highly modified channel with no quality substrate). High sediment deposition scores were given to sites with little or no fine sediment present. Total PHAB scores were moderately correlated with both CSCI scores (r^2=0.51, p value = 0.020) and H20 IBI scores (r^2=0.42, p value = 0.044) (Figure 2.5). D18 IBI scores had no association with PHAB scores.

Table 2.7. Individual and Total PHAB scores for ten probabilistic sites in San Mateo County sampled in WY 2017. CSCI and D18 IBI scores are shown for comparison.

Station Code	Creek	CSCI Score	Diatom "D18" IBI Score	Channel Alteration	Epifaunal Substrate	Sediment Deposition	Total PHAB Score
202R00550	Jones Gulch	0.87	54	20	15	8	43
202R00552	Lawrence Creek	1.16	61	20	17	6	43
204R02472	Atherton Creek	0.54	41	0	1	15	16
204R02611	Redwood Creek	0.43	40	0	0	18	18
204R03240	Atherton Creek	0.41	51	12	8	12	32
204R03252	San Mateo Creek	0.67	60	11	6	4	21
204R03272	San Mateo Creek	0.63	40	14	13	9	36
204R03316	Ojo de Agua	0.42	38	0	0	18	18
204R03336	Belmont Creek	0.50	44	14	9	7	30
204R03496	Redwood Creek	0.60	52	12	8	8	28

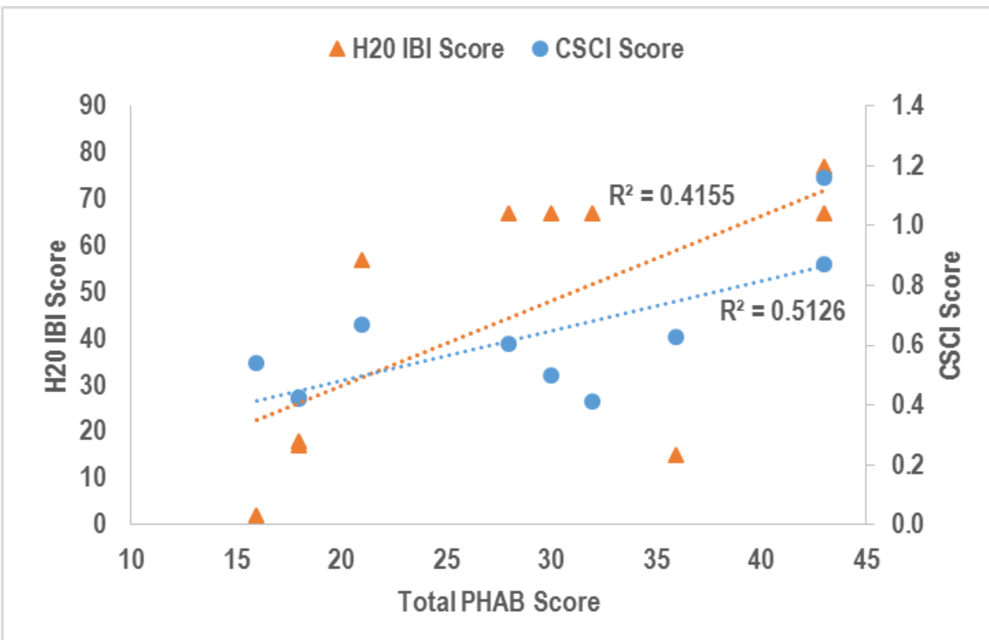


Figure 2.5. CSCI and H20 scores plotted with Total PHAB scores for ten bioassessment sites sampled during WY 2017.

2.3.3 Stressor Assessment

The section below summarizes results for stressor data collected at 10 bioassessment sites during WY 2017. Association between stressor data and biological condition is presented for some of the stressors. However, due to the small number of samples, associations with biological condition are not expected to be very strong. More robust analyses of stressor extent and their association with biological condition will be made in the RMC 5-Year Report.

General Water Chemistry

General water quality measurements sampled at the ten bioassessment sites in WY 2017 are listed in Table 2.8. Sites with general water quality results exceeding water quality objectives or MRP trigger thresholds are indicated in bold. Three measurements exceeded water quality objectives for pH: site 204R02472 (Redwood Creek), site 204R02611 (Atherton Creek) and site 204R03316 (Ojo de Agua) were slightly above the threshold of 8.5. The MRP acute temperature threshold trigger (24°C) for salmonid fish was exceeded at site 205R02472 (Redwood Creek). The MRP trigger for specific conductance was exceeded at both sites on Atherton Creek. All three sites had very low flow conditions in concrete channels with little to no shading. The MRP triggers apply to continuous data and are not considered exceeded unless 20% of the results exceed the trigger. Therefore, these sites with single sample exceedances will not be added to the list of candidate SSID projects

Table 2.8. General water quality measurements for ten probabilistic sites in San Mateo County sampled in WY 2017.

Station Code	Waterbody	Temp (C)	DO (mg/L)	pH	Specific Conductance (uS/cm)
202R00550	Pescadero Creek	11.7	10.1	8.0	519
202R00552	Lawrence Creek	11.9	10.4	8.2	443
204R02472	Redwood Creek	**26.2**	13.1	**8.9**	945
204R02611	Atherton Creek	20.6	13.9	**8.6**	**2626**
204R03240	Atherton Creek	14.4	7.2	7.9	**5322**
204R03252	San Mateo Creek	15.8	10.0	8.1	336
204R03272	San Mateo Creek	14.7	9.6	7.9	249
204R03316	Ojo de Agua	21.8	9.2	**8.6**	778
204R03336	Belmont Creek	14.6	8.2	7.8	1324
204R03496	Redwood Creek	15.6	9.3	8.1	922

Landscape Variables

Landscape variables associated with the drainage area for each bioassessment site sampled in WY 2017 are presented in Table 2.9. Landscape variables include percent urban area, percent impervious area, total number of road crossings, and road density (road length/watershed area). CSCI scores are presented for comparison. CSCI scores were moderately correlated with impervious area (r^2 = 0.46, p value = 0.311) and road density (r^2 = 0.51, p value = 0.022) (Figure 2.6).

Table 2.9. Landscape variables for watershed areas of the 10 bioassessment sites sampled in San Mateo County during WY 2017.

SiteID	CSCI Score	Drainage Area (km2)	Percent Urban	Percent Impervious	Road Crossings Watershed	Road Density Watershed (km/km2)
202R00550	0.87	2	0%	1%	2	2.1
202R00552	1.16	3	1%	2%	0	0.4
204R02472	0.54	7	81%	22%	25	8.0
204R02611	0.43	9	70%	24%	26	7.1
204R03240	0.41	3	30%	12%	3	3.7
204R03252	0.67	85	13%	8%	44	2.7
204R03272	0.63	79	8%	7%	35	2.2
204R03316	0.42	9	93%	45%	75	12.2
204R03336	0.5	7	73%	40%	6	9.1
204R03496	0.6	5	79%	19%	15	7.6

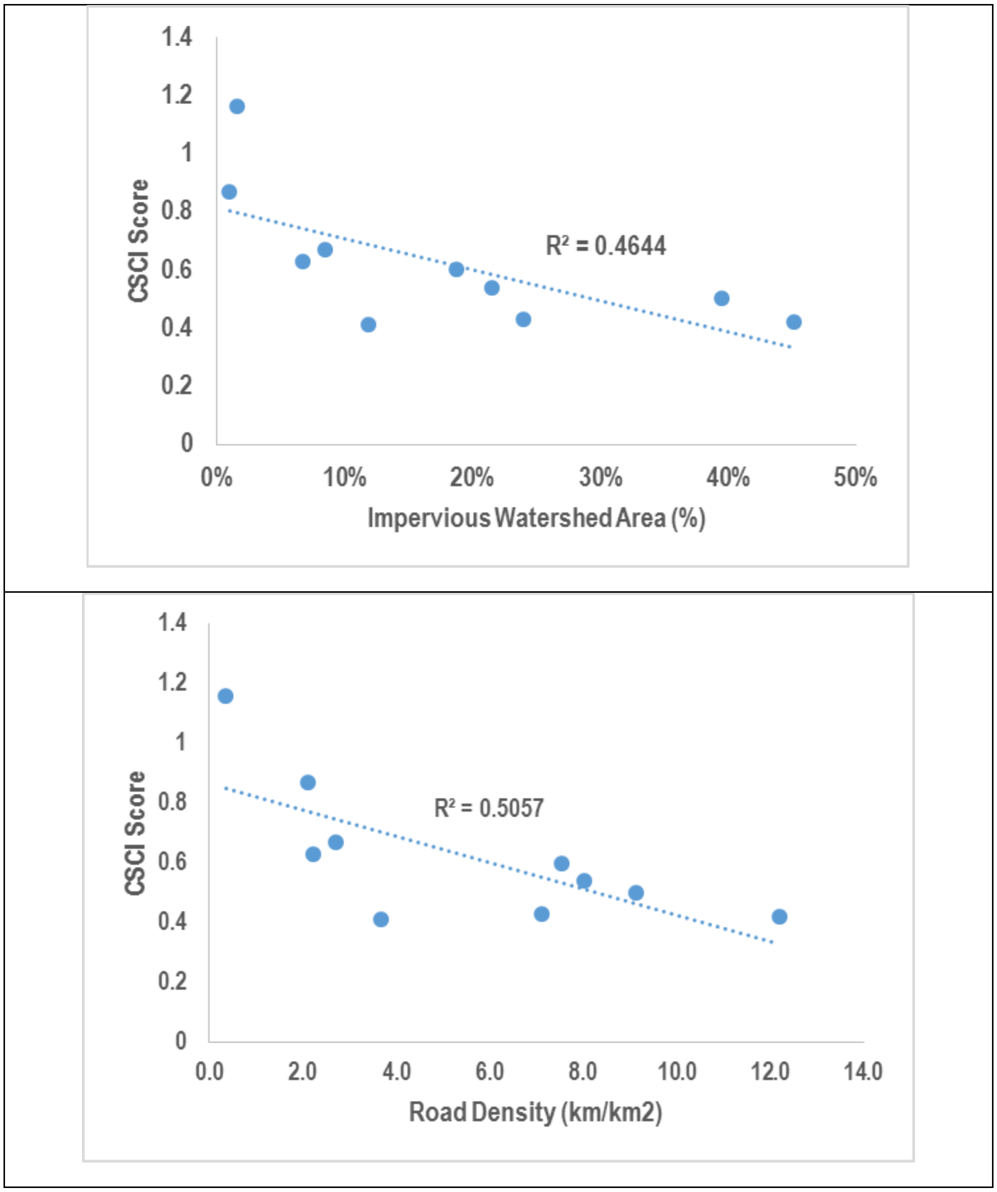


Figure 2.6. CSCI Scores compared to landscape variables (percent impervious and road density) for 10 bioassessment sites sampled in San Mateo County in WY 2017.

Physical Habitat

Scores for ten of PHAB metrics that were generated from the physical habitat data collected at bioassessment sites in WY 2017 are listed in Table 2.109. CSCI scores were positively correlated with *Natural Shelter Cover* (r^2 = 0.77, p-value < 0.001) and negatively correlated with *Human Disturbance* (r^2 = 0.68, p-value = 0.003) (Figure 2.7). The remaining physical habitat metrics were poorly correlated with CSCI scores.

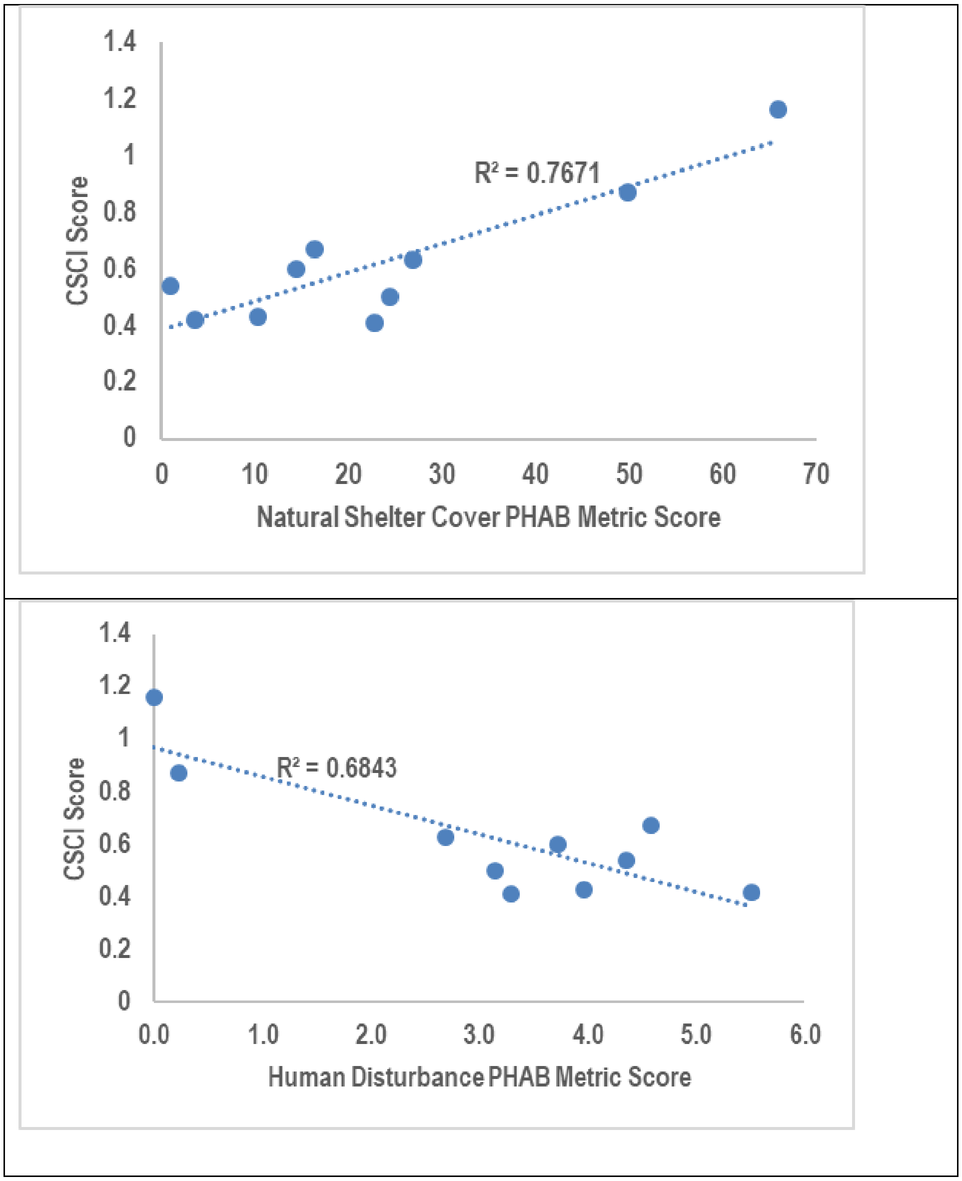


Figure 2.7. CSCI Scores compared to PHAB metric scores Natural Shelter Cover and Human Disturbance Index for 10 bioassessment sites sampled in San Mateo County in WY 2017.

Water Chemistry (nutrients)

Nutrient and conventional analyte concentrations measured in water samples collected at ten bioassessment sites in San Mateo County during WY 2017 are listed in Table 2.11. There were no water quality objective exceedances for water chemistry parameters. Chloride concentrations were above the 250 mg/L at site 204R03240, however Atherton Creek is not designated as Municipal Water Supply Beneficial Use.

Total Nitrogen concentrations ranged from 0.24 to 2.4 mg/L. The two highest concentrations measured for all samples (>2 mg/L) occurred at site 204R02472 in Redwood Creek and site 204R03316 on Arroyo Ojo de Agua (tributary to Redwood Creek). Both sites are located in concrete channels. Total phosphorus concentrations ranged from 0.02 to 0.66 mg/L. The two highest concentrations of total phosphorus (> 0.4 mg/l) occurred at site 204R02472 in Redwood Creek and site 202R00550 (Pescadero Creek).

Table 2.10. Scores for 10 PHAB metrics calculated from physical habitat data collected at ten probabilistic sites in San Mateo County during WY 2017.

Station Code	Creek	Channel Morphology		Habitat Complexity and Cover			Substrate Size and Composition				Human Disturbance
		Evenness of Flow Habitat Types	Percent Fast Water of Reach	Shannon Diversity of Aquatic Habitat Types	Natural Shelter Cover	Mean Filamentous Algae Cover	Evenness of Natural Substrate Types	Shannon Diversity of Natural Substrate Types	Percent Gravel - Coarse	Percent Substrate Smaller than Sand (<2 mm)	Riparian Human Disturbance Index
202R00550	Pescadero Creek	0.6	26.0	1.7	49.9	0.0	0.9	1.8	19.0	40.0	0.2
202R00552	Lawrence Creek	0.7	64.0	1.6	65.9	0.0	0.8	1.7	16.0	50.0	0.0
204R02472	Redwood Creek	0.0	0.0	0.1	1.0	60.5	0.4	0.5	0.0	30.0	4.4
204R02611	Atherton Creek	0.0	0.0	0.6	10.4	57.5	0.7	0.5	0.0	6.0	4.0
204R03240	Atherton Creek	0.3	3.0	1.8	22.8	2.3	0.8	1.2	13.0	78.0	3.3
204R03252	San Mateo Creek	0.9	64.0	1.3	16.4	0.0	1.0	1.3	37.0	33.0	4.6
204R03272	San Mateo Creek	0.8	60.0	1.6	26.9	23.4	0.9	1.6	21.0	46.0	2.7
204R03316	Arroyo Ojo de Agua	0.0	0.0	0.7	3.6	3.6	0.6	0.7	0.0	14.0	5.5
204R03336	Belmont Creek	0.5	18.0	1.5	24.4	0.0	0.9	1.5	30.0	37.0	3.2
204R03496	Redwood Creek	0.6	16.0	1.5	14.5	0.0	0.9	1.5	23.0	59.0	3.7

Table 2.11. Nutrient and conventional constituent concentrations in water samples collected at ten sites in San Mateo County during WY 2017. No water quality objectives were exceeded. See Table 2.1 for WQO values.

Station Code	Creek	Ammonia as N	Unionized Ammonia (as N)	Chloride	AFDM	Chlorophyll a	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen As N	Total Nitrogen	Ortho-Phosphate as P	Phosphorus as P	Total Phosphorus	Silica as SiO2
		mg/L	mg/L	mg/L	g/m2	mg/m2	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Water Quality Objective:	*NA*	*0.025* [b]	*250* [a]	*NA*	*NA*	*10* [a]	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
202R00550	Pescadero Creek	0.1	0.002	46	206	<3.6	0.23	0.006	0.62	0.86	0.32	0.34	0.66	50
202R00552	Lawrence Creek	0.015 J	0.000	32	276	5	<0.02	<0.001	0.22	0.24	0.014	0.02	0.034	20
204R02472	Redwood Creek	0.087	0.025	58	179	292	0.47	0.032	1.9	2.40	0.18	0.23	0.41	30
204R02611	Atherton Creek	0.039	0.004	230	297	203	<0.02	<0.001	1.0	1.02	0.007 J	0.01	0.02	14
204R03240	Atherton Creek	0.034	0.001	440	546	20	<0.02	0.002 J	1.2	1.22	0.05	0.06	0.11	19
204R03252	San Mateo Creek	0.052	0.002	24	163	10	0.046 J	0.004 J	0.4	0.45	0.012	0.03	0.04	11
204R03272	San Mateo Creek	0.079	0.002	18	48	40	0.05	0.003 J	0.26	0.31	0.008 J	0.02	0.03	10
204R03316	Arroyo Ojo de Agua	0.049	0.006	54	158	193	1.80	0.011	0.53	2.34	0.01	0.11	0.12	59
204R03336	Belmont Creek	0.017 J	0.000	160	57	8	0.31	0.001 J	0.66	0.97	0.052	0.048	0.1	22
204R03496	Redwood Creek	0.093	0.003	54	84	24	0.37	0.034	0.83	1.23	0.14	0.15	0.29	33
Number of exceedances		NA	0	0	NA	NA	0	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

J = The reported result is an estimate.

a. Chloride and nitrate WQOs only apply to waters with MUN designated Beneficial Uses.

b. This threshold is an annual median value and is not typically applied to individual samples.

2.4 Conclusions and Recommendations

Bioassessment monitoring in WY 2017 was conducted in compliance with Provision C.8.d.i of the MRP. Ten sites were sampled for BMIs, benthic algae, physical habitat measurements, and nutrients using methods consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b). Stations were randomly selected using a probabilistic monitoring design. Eight of the ten sites (80%) were classified as urban and two (20%) were classified and non-urban.

The following conclusions and recommendations are made based on the WY 2017 data. An assessment of biological condition is provided and potential stressors are compared to applicable WQOs and triggers identified in the MRP. Sites with monitoring results that exceed WQOs and triggers are considered as candidates for further investigation as SSID projects, consistent with provision C.8.e of the MRP.

A more comprehensive analysis of a five-year dataset (i.e., WY 2012 – WY 2016) is currently being conducted by a BASMAA regional project which is assessing stream conditions and potential stressors on a regional and countywide basis. Tools and approaches developed by the regional project may be applied to the growing SMCWPPP probabilistic dataset in future annual monitoring reports.

Biological Condition Assessment

Stream condition was assessed using three different types of indices/tools: the BMI-based CSCI, the benthic algae-based IBIs developed for Southern California (D18, H2O, and S2), and Physical Habitat Assessment scores.

- **CSCI**. The California Stream Condition Index translates benthic macroinvertebrate data into an overall measure of stream health. Of the ten sites monitored in WY 2017, two sites (20%) were rated in good condition (CSCI scores ≥ 0.795); two sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and six sites (60%) rated as very likely altered condition (≤ 0.635). The two sites in good condition were classified as non-urban and located in protected open space or County Park land. Three of the lowest CSCI scores occurred at sites located in concrete channels.
  - The eight sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.
- **Algae IBIs (D18, H2O, S2)**. Algae IBIs translate benthic algae data (diatoms and soft algae) into overall measures of stream health Three algae IBIs (developed for streams in Southern California) were calculated: D18 (diatoms), S2 (soft algae), and H2O (combination of diatoms and soft algae). Statewide Algae Stream Condition Indices are currently being developed and anticipated to be available in 2018.
  - Based on D18 scores, five sites (50%) were ranked in likely altered condition (D18 score 62-72), and five sites (56%) were ranked in very likely altered condition (< 49). No sites had D18 scores that were ranked in good condition (D18 ≥ 62).
  - Based on S2 scores, five sites (50%) were ranked as possibly intact or likely intact (S2 score > 47). One of these sites was non-urban and also had the highest CSCI score (1.16); the remaining were urban sites. Two of the high

ranking urban sites had a high level of human disturbance (concrete channel and high percent impervious area).

    - Based on H20 scores, five sites (50%) were ranked as possibly intact or likely intact (H20 score >63). The lowest four H20 scores ranged from 2 to 18. Three of these low-scoring sites were in concrete channels and had high percent impervious watershed areas.

- Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. PHAB consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate and sediment deposition
    - Total PHAB scores were moderately correlated with CSCI scores and H20 scores. No relationship was observed between Total PHAB scores and D18 scores

Stressor Assessment

Relationships between potential stressors (physical habitat and water chemistry) and biological condition were explored using the WY 2017 dataset. Sites with stressor levels exceeding applicable WQOs and triggers identified in the MRP will be considered as candidates for SSID projects.

- **General water quality** (pH, temperature, dissolved oxygen, specific conductance). Water quality objectives for pH were exceeded at three sites. These sites will be considered as candidates for SSID projects. The MRP acute temperature threshold trigger (24°C) for salmonid fish was exceeded at one site, and the MRP trigger for specific conductance (2,000 us/cm) was exceeded at two sites on Atherton Creek. These MRP triggers apply to continuous data and are not considered exceeded unless 20% of the results exceed the trigger. Therefore, these sites with single sample exceedances will not be added to the list of candidate SSID projects.
- **Nutrients and conventional analytes** (ammonia, unionized ammonia, chloride, AFDM, chlorophyll a, nitrate, nitrite, TKN, ortho-phosphate, phosphorus, silica). There were no water quality objective exceedances for water chemistry parameters.
- **PHAB metric scores** were generated from the physical habitat data. CSCI scores were positively correlated with metrics associated with habitat complexity and negatively correlated with human disturbance index.
- **Landscape variables** were calculated for each of the watershed areas draining into the bioassessment sites. CSCI scores were moderately correlated (negatively) with impervious area and road density.

Recommendations

- The BASMAA RMC is currently conducting a regional project to assess stream conditions and potential stressors on a regional and countywide basis using a five-year dataset (WY 2012 – WY 2016). SMCWPPP should consider applying tools and approaches developed by the regional project to the growing San Mateo County probabilistic dataset in future annual monitoring reports.

- Trend analysis for the RMC probabilistic survey will require more than five years of data collection. Preliminary long-term trend analysis of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.
- Targeted re-sampling at probabilistic sites can provide additional data to evaluate longer term trends at selected locations. Recommendations for addressing trends will be forthcoming in the RMC Five-Year Bioassessment Report.

3.0 Targeted Monitoring

3.1 Introduction

During WY 2017 water temperature, general water quality, and pathogen indicators were monitored in compliance with Creek Status Monitoring Provisions C.8.d.iii – v of the MRP. Monitoring was conducted at selected sites using a targeted design based on the directed principle[18] to address the following management questions:

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*
3. *What are the pathogen indicator concentrations at creek sites where there is potential for water contact recreation to occur?*

The first management question is addressed primarily through evaluation of water quality results in the context of existing aquatic life and recreational uses. Temperature and general water quality data were evaluated for potential impacts to potential lifestage and overall population of fish community present within monitored reaches.

The second and third management questions are addressed primarily through the evaluation of targeted data with respect to water quality objectives and thresholds from published literature. Sites where exceedances occur may indicate potential impacts to aquatic life or other beneficial uses and are considered as candidates for future Stressor Source Identification projects.

3.2 Study Area

In compliance with Provision C.8.d.iii of the MRP, temperature was monitored at four sites, general water quality was monitored at two sites, and pathogen indicator samples were collected at five sites. The targeted monitoring design focuses on sites selected based on the presence of significant fish and wildlife resources as well as historical and/or recent indications of water quality concerns.

3.2.1 Temperature and General Water Quality

Continuous (hourly) temperature measurements were recorded at five stations in San Pedro Creek from April 5 through September 26, 2017[19]. Continuous (15-minute) general water quality measurements (temperature, dissolved oxygen, pH, specific conductance) were recorded at two stations in San Pedro Creek during two two-week sampling events. Sample Events 1 and 2 were conducted in May/June and August/September of 2017, respectively. Temperature and general water quality monitoring stations are mapped in Figure 3.1.

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[18] Directed Monitoring Design Principle: A deterministic approach in which points are selected deliberately based on knowledge of their attributes of interest as related to the environmental site being monitored. This principle is also known as "judgmental," "authoritative," "targeted," or "knowledge-based."

[19] SMCWPPP typically monitors water temperature at more stations than the MRP requires to mitigate for potential equipment loss.

San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County (Titus et al. 2010 Draft). Although degradation of physical habitat and the presence of fish barriers such as bridge culverts may threaten the steelhead population, restoration efforts are helping to reestablish and enhance habitat. For example, in 2005 the City of Pacifica removed a fish passage and migration barrier at Capistrano Avenue Bridge and restored approximately 1,300 linear feet of channel. The City also implemented the San Pedro Creek Flood Control Project which reconstructed a meandering channel and active floodplain in the lower 3,100-feet of San Pedro Creek. In WY 2015, SMCWPPP conducted bioassessment monitoring at two locations on the Middle Fork of San Pedro Creek. CSCI scores were in the "possibly intact" and "likely intact" stream condition categories.

The San Pedro Creek watershed is approximately 8 square miles and encompasses the urban communities of Linda Mar, Sun Valley and Park Pacifica. The majority of South and Middle Fork subwatersheds are located within the undeveloped and public lands of San Pedro Valley County Park; these sub-watersheds account for approximately 25% of the total watershed area.

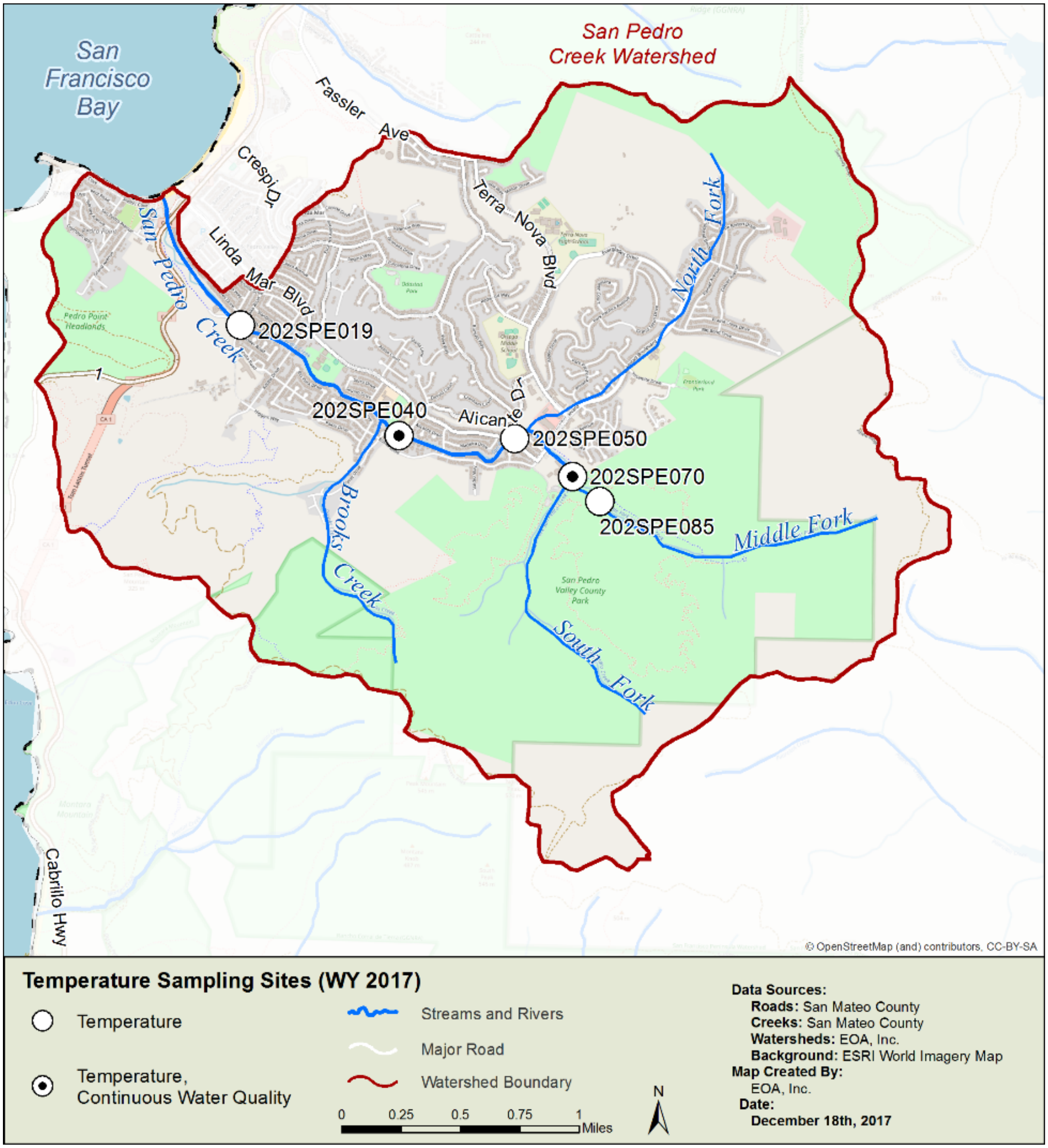

Figure 3.1. Continuous temperature and water quality stations in the San Pedro Creek watershed, San Mateo County, WY 2017.

3.2.2 Pathogen Indicators

Pathogen indicator densities were measured during one sampling event in WY 2017 at two stations on Denniston Creek near Pillar Point Harbor, one storm drain discharging to Denniston Creek, one storm drain discharging to Pillar Point Harbor, and one outfall pipe discharging to Pillar Point Harbor (Figure 3.2). The sites were selected to characterize geographic patterns of pathogen indicator densities within the watershed. Samples collected from these sites were used to gather preliminary information that will support a planned SSID study investigating the extent and source(s) of pathogen indicators near Pillar Point Harbor.

Denniston Creek is a water body designated for REC-1 and REC-2 Beneficial Uses in the Basin Plan, although it is unlikely that the creek supports significant water recreation. Pillar Point Harbor is also designated for REC-1 and REC-2 Beneficial Uses in the Ocean Plan (SWRCB 2015) and contains several popular bathing beaches.

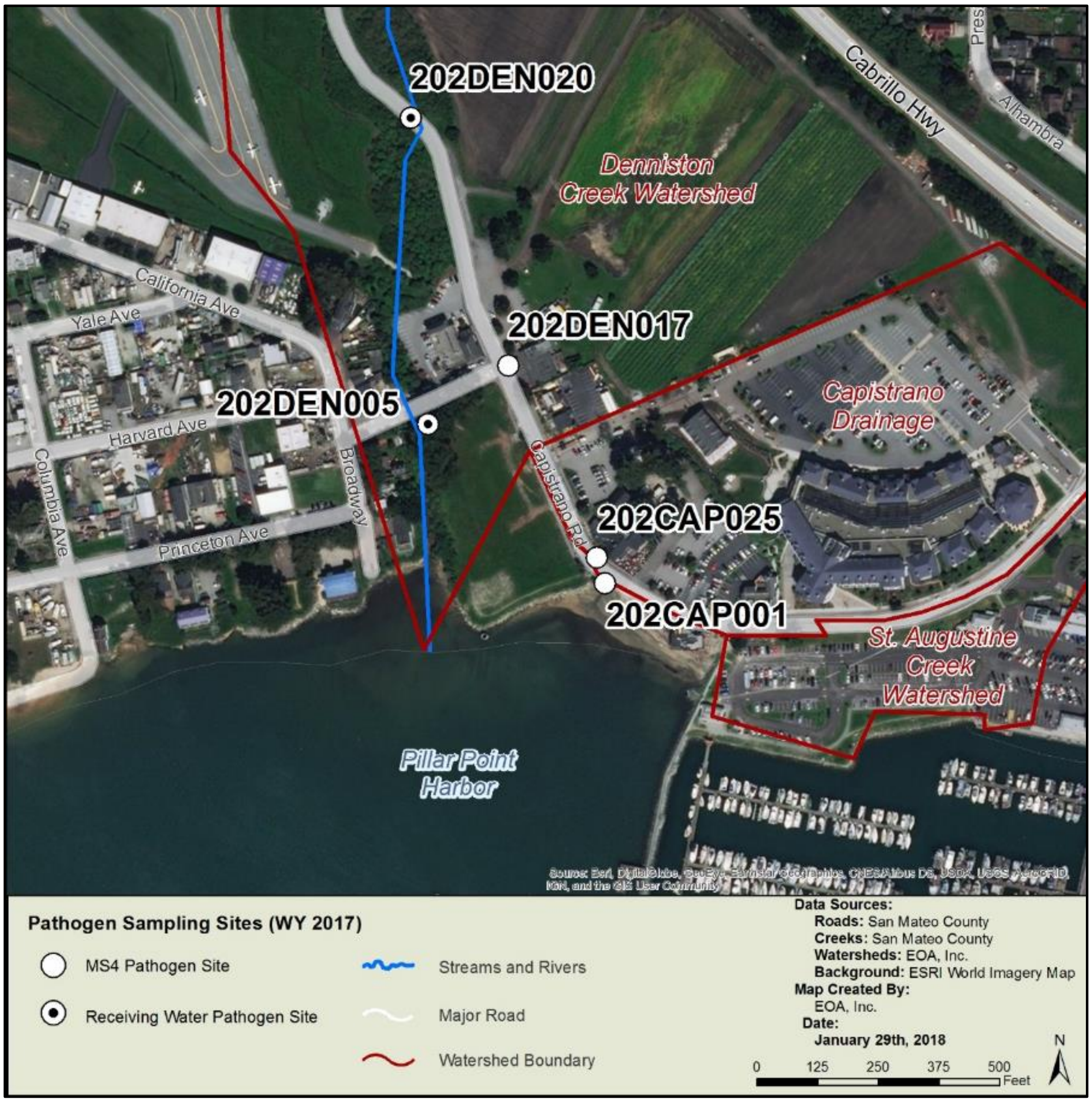

Figure 3.2. Pathogen indicator monitoring sites, Denniston Creek, WY 2017.

3.3 Methods

Water quality data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016b) and associated QAPP (BASMAA 2016a). Data were evaluated with respect to the MRP Provision C.8.d “Followup” triggers for each parameter.

3.3.1 Continuous Temperature

Digital temperature loggers (Onset HOBO Water Temp Pro V2) programmed to record data at 60-minute intervals were deployed at targeted sites from April 5 through September 26, 2017. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-5 (BASMAA 2016b).

3.3.2 Continuous General Water Quality

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH at 15-minute intervals (YSI 6600 data sondes) was deployed at targeted sites for two 2-week periods: once during spring season (Event 1) and once during summer season (Event 2) in 2017. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016b).

3.3.3 Pathogen Indicators

Water samples were collected during the dry season. Sampling techniques for pathogen indicators (Enterococci and *E. coli*) include direct filling of containers at targeted sites (or use of intermediate sampling containers) and transfer of samples to analytical laboratories within specified holding time requirements. Procedures used for sampling and transporting samples are described in RMC SOP FS-2 (BASMAA 2016b).

3.3.4 Data Evaluation

Continuous temperature, water quality, and pathogen indicator data generated during WY 2017 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions, including exceedances of water quality objectives. Provision C.8.d of the MRP identifies trigger criteria as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. Sites with targeted monitoring results exceeding the trigger criteria are identified as candidate SSID projects. The relevant trigger criteria for continuous temperature, continuous water quality, and pathogen indicator data are listed in Table 3.1.

Table 3.1. Water Quality Objectives and thresholds used for trigger evaluation.

Monitoring Parameter	Objective/Trigger Threshold	Units	Source
Temperature	Two or more weekly average temperatures exceed the MWAT of 17.0°C for a Steelhead stream, or when 20% of the results at one sampling station exceed the instantaneous maximum of 24°C.	^{o}C	MRP Provision C.8.d.iii.
General Water Quality Parameters	20% of results at each monitoring site exceed one or more established standard or threshold - applies individually to each parameter		
Conductivity	2000	uS/cm	MRP Provision C.8.d.iii.
Dissolved Oxygen	WARM < 5.0, COLD < 7.0	mg/L	SF Bay Basin Plan Ch. 3, p. 3-4
pH	> 6.5, < 8.5 [1]	pH	SF Bay Basin Plan Ch. 3, p. 3-4
Temperature	Same as Temperature (See Above)		
Pathogen Indicators			
Enterococci	≥ 130	cfu/ 100ml	EPA's statistical threshold value for estimated illness rate of 36 per 1000 primary contact recreators
E. coli	≥ 410	cfu/ 100ml	EPA's statistical threshold value for estimated illness rate of 36 per 1000 primary contact recreators

[1] Special consideration will be used at sites where imported water is naturally causing higher pH in receiving waters.

3.4 Results and Discussion

3.4.1 Continuous Temperature

Temperature loggers were deployed at five sites on April 5, 2017, checked on June 12, 2017, and removed on September 30, 2017. All stations remained wet during the entire sampling period.

Summary statistics for the water temperature data collected at the five sites are listed in Table 3.2. The recorded temperatures were relatively consistent between sites, with median values gradually increasing in the downstream direction. Median temperatures ranged from 13.3 °C at the most upstream station, 202SPE085 to 14.7 °C at 202SPE019. All instantaneous temperature data are plotted in Figure 3.3, with the instantaneous maximum temperature threshold (24.0 °C) shown for reference. There were no exceedances of the threshold at any site during WY 2017.

Table 3.2 Descriptive statistics for continuous water temperature measured at five sites in San Mateo County from April 5 through September 26, 2017.

Site ID		202SPE019	202SPE040	202SPE050	202SPE070	202SPE085
Start Date		4/5/2017	4/5/2017	4/5/2017	4/5/2017	4/5/2017
End Date		9/26/2017	9/26/2017	9/26/2017	9/26/2017	9/26/2017
Temperature (ºC)	Minimum	10.9	10.4	10.1	10.1	9.8
	Median	14.7	14.5	13.3	13.3	13.5
	Mean	14.7	14.6	13.3	13.3	13.7
	Maximum	20.4	20.0	17.3	17.3	19.6
	Max 7-day mean	17.6	17.0	16.8	16.8	15.4
	N	4177	4177	4177	4177	4177
MWAT > 17		1	1	0	0	0
MAX > 24		0	0	0	0	0

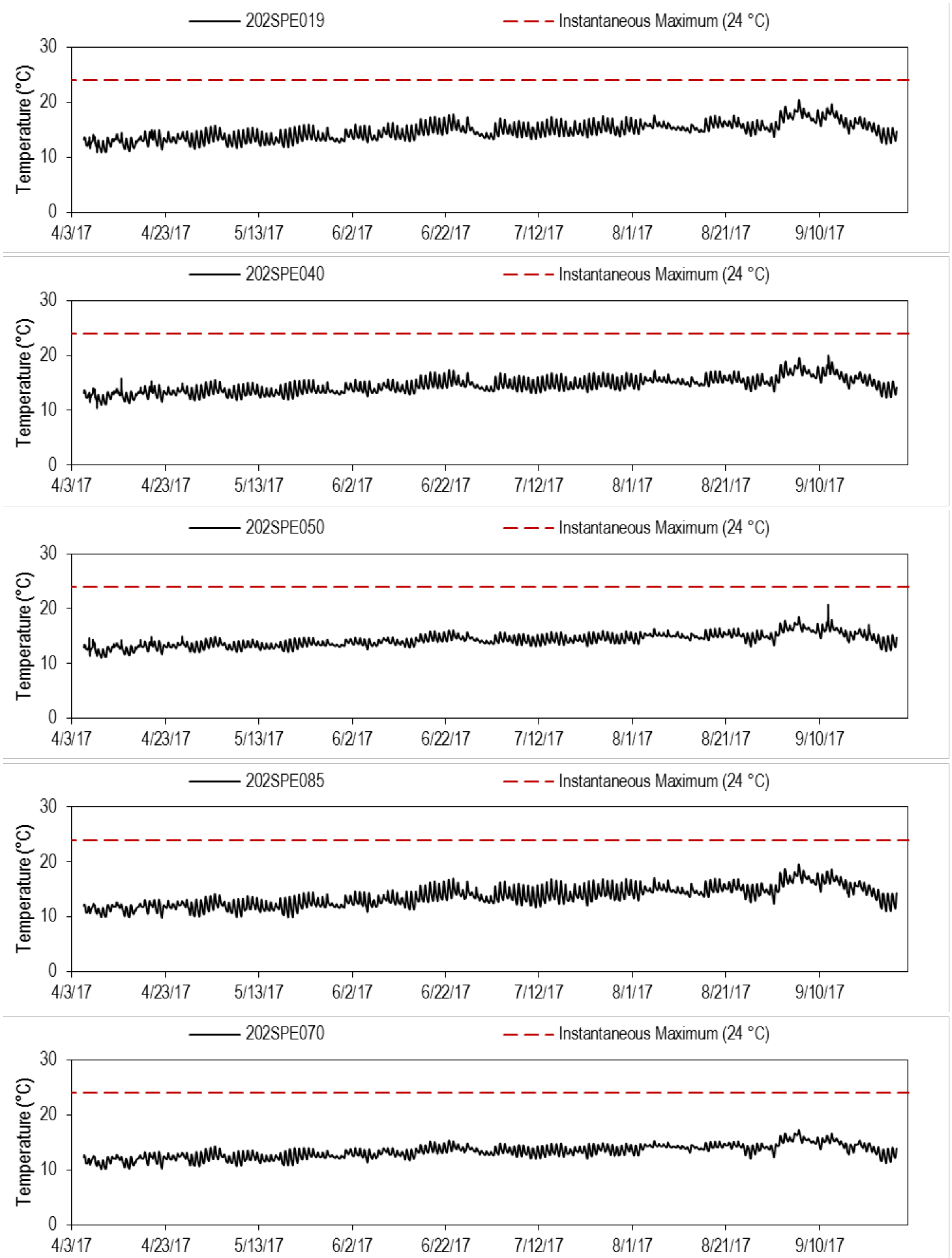

Figure 3.3. Plots of temperature data collected sites in San Pedro Creek, WY 2017.

Consistent with MRP requirements, the Maximum Weekly Average Temperature (MWAT) was calculated for non-overlapping, 7-day periods. Two sites (202SPE019 and 202SPE040) exceeded the MWAT trigger of >17°C during the same week. Of the five sites monitored, these two sites are lowest in the watershed, with the most urban influence and highest percentage of open channel. The exceedances occurred during the week of September 10, during which air temperatures were higher than usual for the time and region. MWAT decreased over the next 10 sampling days and there were no further exceedances. The MRP trigger for MWAT is an exceedance of >17°C for two consecutive weeks; no exceedance of that trigger was observed at any of the sample locations.

The MWAT values calculated from temperatures recorded at five stations are plotted in Figure 3.4. Temperatures only exceeded the MRP threshold for MWAT at sites 202SPE019 and 202SPE040 during the week of September 10.

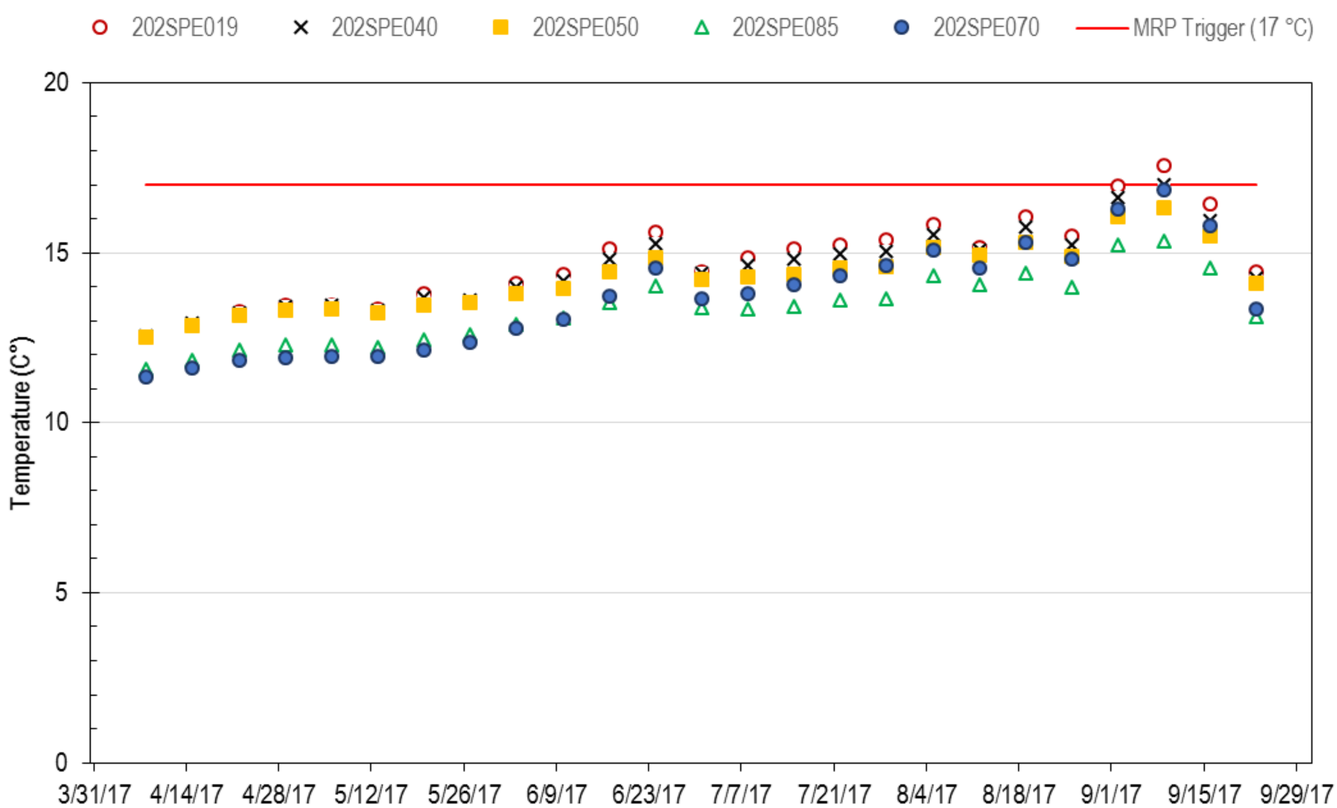

Figure 3.4 Plot showing MWAT values calculated for water temperature collected at five sites in San Pedro Creek in WY 2017.

A summary of the MRP trigger analyses for water temperature collected in WY 2017 is presented in Table 3.3.

Table 3.3. Trigger analysis of WY2017 temperature data, San Pedro Creek. Trigger exceedances are shown in bold.

Site ID	Creek	Number of Weeks MWAT > 17ºC	Trigger Exceeded	% of Results Inst. Max > 24ºC	Trigger Exceeded
202SPE019	San Pedro Creek	1	No	0	No
202SPE040		1	No	0	No
202SPE050		0	No	0	No
202SPE085		0	No	0	No
202SPE070		0	No	0	No

The Basin Plan (SFRWQCB 2017) designates several Beneficial Uses for San Pedro Creek that are associated with aquatic life uses, including COLD, WARM, MIGR, SPWN and RARE (Table 1.4). Rearing and spawning habitat for steelhead trout is supported predominantly though the habitat of the protected Middle Fork San Pedro Creek. The restored section of the main stem of the creek is best suited for rearing to smolt size. Measured water quality and temperature are likely not limiting factors for steelhead trout in the creek.

3.4.2 General Water Quality

Summary statistics for general water quality measurements collected at the two stations in San Pedro Creek are listed in Table 3.4. For Event 1, sondes were deployed on May 30 and retrieved on June 12, 2017. For Event 2, sondes were deployed on August 25 and retrieved on September 5, 2017. Time series plots of the data for Event 1 and Event 2 are shown in Figures 3.5 and 3.6, respectively. MRP trigger thresholds are shown for reference. Station locations are mapped in Figure 3.1.

Table 3.4. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at sites in San Mateo County during WY 2017. Data were collected every 15 minutes over a two two-week time periods during May/June (Event 1) and August/September (Event 2).

Parameter	Data Type	202SPE040 San Pedro Creek near the Dog Park		202SPE070 San Pedro Creek Middle Fork	
		May/June WY17	Aug/Sept WY17	May/June WY17	Aug/Sept WY17
Temperature (°C)	Minimum	12.5	13.2	11.5	12.0
	Median	13.9	15.7	13.0	14.4
	Mean	14.0	15.7	13.1	14.6
	Maximum	15.6	18.8	14.1	16.7
	% > 24	0%	0%	0%	0%
Dissolved Oxygen (mg/L)	Minimum	9.9	9.7	10.2	9.8
	Median	10.3	10.7	10.5	10.4
	Mean	10.2	10.6	10.5	10.4
	Maximum	10.6	11.5	10.9	11.1
	% < 7	0%	0%	0%	0%
pH	Minimum	8.13	8.12	7.83	7.81
	Median	8.24	8.22	7.92	7.96
	Mean	8.24	8.24	7.92	7.93
	Maximum	8.32	8.45	7.98	8.02
	% < 6.5 or > 8.5	0%	0%	0%	0%
Specific Conductivity (uS/cm)	Minimum	379	362	255	219
	Median	409	374	260	229
	Mean	409	374	260	229
	Maximum	442	383	264	239
	% > 2000	0%	0%	0%	0%
Total number of data points (N)		1220	1045	1217	1043

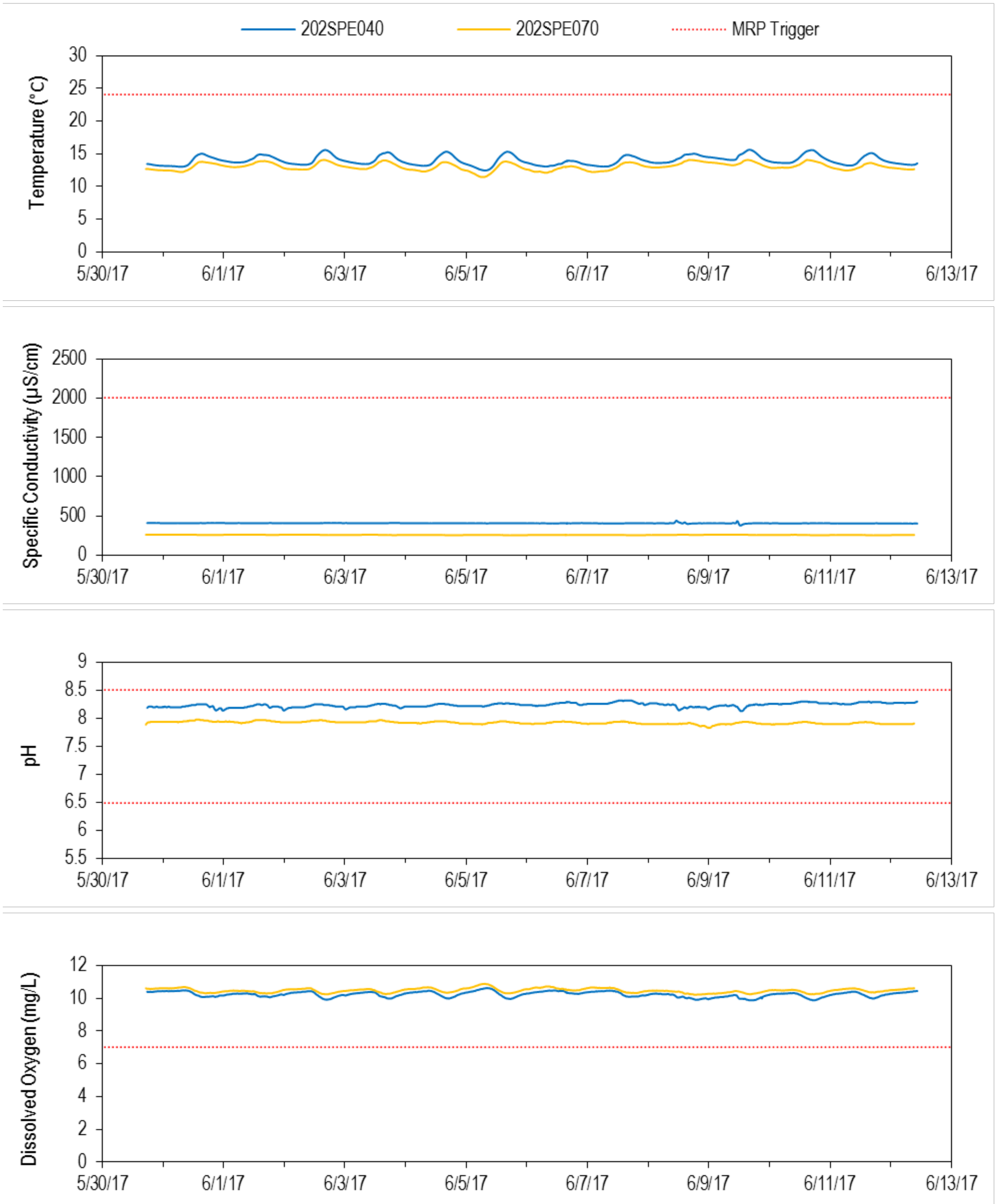

Figure 3.5 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at San Pedro Creek Main Stem (202SPE40) and below the confluence of Middle and South Fork San Pedro Creek (202SPE070) during May 30 – June 12, 2017 (Event 1).

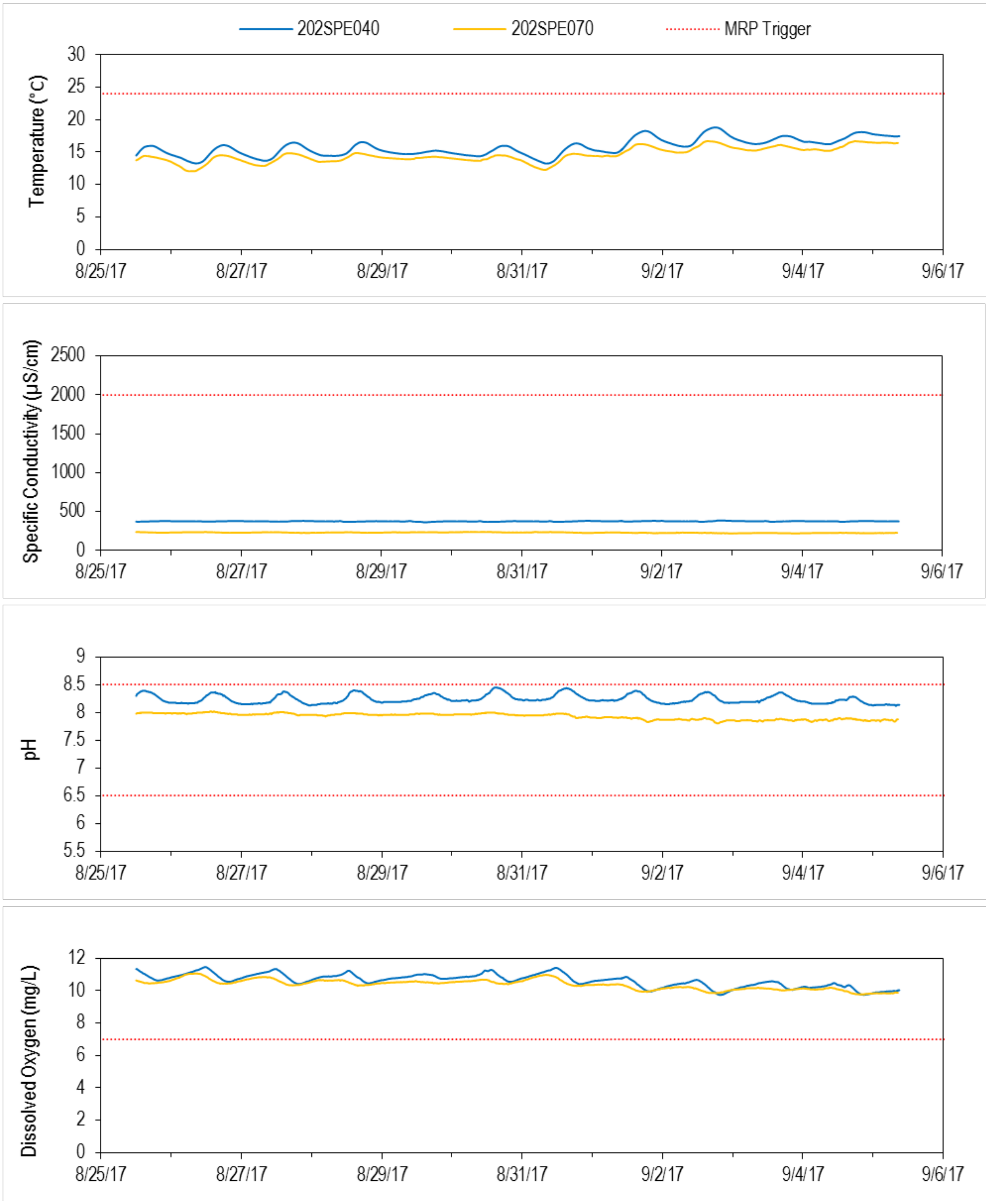

Figure 3.6 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at San Pedro Creek Main Stem (202SPE40) and below the confluence of Middle and South Fork San Pedro Creek (202SPE070) during August 25 – September 6, 2017 (Event 2).

Temperature

Water temperatures never exceeded the 24°C maximum trigger threshold for salmonids at any of the sites for either sampling event (Table 3.4). There were also no exceedances of this trigger during the longer period of record measured with the hobo devices at the same station. MWAT was not calculated for temperature data collected by sondes due to limited number of data points (at least two 7-day periods are required to determine MRP trigger). However, MWAT was calculated for temperature data collected by hobos at both sonde locations. Section 3.4.1 noted that the MWAT threshold of 17°C was exceeded once at the Middle Fork San Pedro Creek station (202SPE040); however, the MRP trigger threshold, which requires that two or more weeks exceed the MWAT was not exceeded.

Dissolved Oxygen

Dissolved oxygen (DO) concentrations were above the Basin Plan minimum WQOs for WARM (5.0 mg/L) and COLD (7.0 mg/L) at both sites during both sampling events. DO concentrations were similar at both locations, ranging between 9.8 mg/L and 11.5 mg/L. The high concentrations are likely a result of the consistent flows observed at both locations during WY 2017, which are supported by several springs in the upper watershed.

pH

During the two sampling events, all pH measurements fell within the Basin Plan WQOs for pH (< 6.5 and/or > 8.5). pH was higher at the downstream site (202SPE040) where it fluctuated between 8.12 and 8.45, with the higher measurements recorded during Event 2 (Figure 3.6). The site is located in a more urbanized part of the creek, and run-off from the surrounding land uses may contribute to the higher pH.

Specific Conductivity

Specific conductance measurements did not exceed the MRP trigger of 2000 µs/cm during either sampling event. Conductivity was slightly higher at the downstream station (202SPE040) compared to the upstream station. Conductivity was also slightly higher during Event 1 compared to Event 2.

3.4.3 Pathogen Indicators

Pathogen indicator (*E. coli* and enterococci) densities measured in grab samples collected on August 28, 2017 are listed in Table 3.5. Stations are mapped in Figure 3.2. Four samples exceeded the MRP trigger for enterococci (202CAP001, 202DEN017, 202CAP025, and 202DEN005). Three samples exceeded the MRP trigger for *E. coli* (202CAP001, 202DEN017, and 202CAP0250). Both of the stations in the Capistrano drainage catchment had pathogen indicator densities exceeding the trigger, with no differences between stations. In the Denniston Creek watershed, the "upstream" station (202DEN020) had relatively low pathogen indicator densities. The "downstream" station (202DEN005) had higher pathogen indicator densities, with enterococci exceeding the trigger. Station 202DEN005 is just downstream of the municipal separate storm sewer system (MS4) outfall that was characterized at station 202DEN017 and which had high levels of both pathogen indicators. Discharges from the MS4 may have contributed to the trigger exceedance at 202DEN005; however, there may also be other sources of bacteria between 202DEN020 and 202DEN005, such as wildlife and homeless encampments.

The pathogen indicator data collected near Pillar Point Harbor in WY 2017 will be used to initiate an SSID study based on pathogen indicators in the area. The purpose of this study is to identify geographic, seasonal, and species-specific sources of bacteria to Pillar Point Harbor from urban areas drained by the MS4 and covered by the MRP. Potential sources of pathogen indicators include, but are not limited to, pet waste, wildlife, bacterial growth within the conveyance system, and leaking public and private sewer lines.

It is important to recognize that a) the REC-1 WQOs for pathogen indicators in the Basin Plan and Ocean Plan do not distinguish among sources of bacteria; and b) pathogen indicators do not directly represent actual pathogen concentrations. Animal fecal waste is much less likely to contain pathogens of concern to human health than human sources. In most cases, it is the human sources that are associated with REC-1 health risks rather than wildlife or domestic animal sources (USEPA 2012b). It should also be noted that WQOs for pathogen indicators used in this monitoring effort are not applicable to the water that discharges from storm drains or outfall pipes. WQOs represent the maximum level of pollutants that can remain in the water column without adversely affecting the beneficial uses designated for a receiving water body. Since dilution occurs when water from the MS4 mixes with receiving waters, the pollutant concentrations present in the MS4 would not be an accurate representation of the pollutant concentrations present after discharge to a receiving water body.

The State Board is currently in the process of adopting modified WQOs for enterococci and *E. coli* based on USEPA criteria that will serve as new MRP Trigger Thresholds. A statistical threshold value for enterococci of 320 cfu/100mL will likely be used for samples in waters where the salinity is less than 10 parts per thousand 95% of the time, and a statistical threshold value for *E. coli* of 110 cfu/100mL will likely be used for samples in waters where the salinity is equal to or greater than 10 parts per thousand 95% of the time. The new statistical threshold values correspond with an Estimated Illness Rate (NGI) of 32 per 1,000 water contact recreators.[20]

[20] See http://www.waterboards.ca.gov/bacterialobjectives/ for more information.

Table 3.5. Enterococci and *E. coli* levels measured in San Mateo County during WY 2017.

Site ID	Creek Name	Site Name	*Enterococci (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)*[1]	Sample Date
MRP Trigger Threshold (USEPA 2012b)			*130*	*410*	
202CAP025	NA	Capistrano North Drain	>2419.6	>2419.6	8/28/17
202CAP001	NA	Capistrano Outfall	>2419.6	>2419.6 [2]	8/28/17
202DEN020	Denniston Creek	Denniston at Capistrano Road	62	98.5	8/28/17
202DEN017	NA	Denniston Storm Drain	>2419.6	>2419.6	8/28/17
202DEN005	Denniston Creek	Denniston at Prospect Way	435.2	166.4	8/28/17

[1] USEPA 2012 water quality criteria are given in cfu/100ml; whereas, the analytical method used by the Program gives results in MPN/100ml. These units are used interchangeably in this analysis.

[2] The actual concentration of *E. coli* at 202CAP001 was reported as 15,531 MPN/100 mL. This value was obtained using a dilution factor of 10. Other samples were not diluted and did not have quantitative resolution above 2,419.6 MPN/100mL.

3.5 Conclusions and Recommendations

Targeted monitoring in WY 2017 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at five sites in the San Pedro Creek watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at two sites in the San Pedro Creek watershed during two 2-week periods in May/June (Event 1) and August/September (Event 2). Pathogen indicator grab samples were collected at five sites in the Pillar Point Harbor watershed during a sampling event in August. Targeted monitoring stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2017 are listed below. The sections below are organized on the basis of the management questions listed at the beginning of this section:

1. *What is the spatial and temporal variability in water quality conditions during the spring and summer season?*
2. *Do general water quality measurements indicate potential impacts to aquatic life?*
3. *What are the pathogen indicator concentrations at creek sites where there is potential for water contact recreation to occur?*

Spatial and Temporal Variability of Water Quality Conditions

- **Spatial**. There was minimal spatial variability in water temperature across the five stations in the San Pedro Creek watershed. Temperature increased slightly at each downstream site but remained 4 to 7 °C below the instantaneous trigger threshold. Likewise, pH and specific conductivity increased slightly in the downstream direction and dissolved oxygen decreased slightly in the downstream direction.
- **Temporal**. Water temperature increased gradually at all five stations between April and early-September, in response to one of the hottest summers on record. In mid-September, water temperatures dropped relatively quickly in response a much cooler air mass. Differences in general water quality measurements (pH, specific conductivity, dissolved oxygen) between the two two-week monitoring periods (May/June and August/September) were less pronounced.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at five targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, and temperature) collected at two targeted stations in San Pedro Creek. San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County.
- The two lowermost temperature stations in San Pedro Creek exceeded the maximum weekly average temperature (MWAT) of 17°C once; this is not considered an exceedance of the trigger which requires two consecutive weeks of exceedance. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- None of the general water quality parameters (temperature, pH, dissolved oxygen, and specific conductance) exceeded any of the MRP trigger thresholds.

Potential Impacts to Water Contact Recreation

- In WY 2017, pathogen indicator samples were collected at two stations on Denniston Creek near Pillar Point Harbor and one storm drain discharging to Denniston Creek, one outfall pipe discharging directly to the beach Pillar Point Harbor, and one storm drain upstream of the outfall pipe. Pillar Point Harbor is the site of an SSID project that will examine the extent and sources of pathogen indicators in the area. Pathogen indicator triggers for enterococci were exceeded at four of the five sites. Triggers for *E. coli* were exceeded at three of the five sites.

- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater, and may not be applicable to conditions found in urban creeks or beaches that do not receive wastewater discharges. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and therefore should be interpreted cautiously. Furthermore, the WQOs for pathogens used in this report cannot be applied to waters sampled directly from the MS4, as dilution occurs when water from the MS4 discharges to a receiving water body. It should also be noted that the WQOs for pathogens used in this report are subject to change in the near future upon adoption by the State Board of new statistical threshold values based on USEPA criteria.

- Municipalities near Half Moon Bay are aware of the bacteria exceedances found in Pillar Point Harbor. Results of the coming SSID study will be used to further inform these municipalities about the nature and extent of the bacteria presence and any potential steps they can take to resolve the issue.

4.0 Chlorine Monitoring

4.1 Introduction

Chlorine is added to potable water supplies and wastewater to kill microorganisms that cause waterborne diseases. However, the same chlorine can be toxic to the aquatic species. Chlorinated water may be inadvertently discharged to the MS4 and/or urban creeks from residential activities, such as pool dewatering or over-watering landscaping, or from municipal activities, such as hydrant flushing or water main breaks.

In compliance with Provision C.8.d.ii of the MRP and to assess whether chlorine in receiving waters is potentially toxic to aquatic life, SMCWPPP field staff measured total and free chlorine residual in creeks where bioassessments were conducted. Total chlorine residual is comprised of combined chlorine and free chlorine, and is always greater than or equal to the free chlorine residual. Combined chlorine is chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is chlorine that remains unbound.

4.2 Methods

In accordance with the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY2017 field testing for free chlorine and total chlorine residual was conducted at all ten probabilistic sites concurrent with spring bioassessment sampling (May-June. Probabilistic site selection methods are described in Section 2.0.

Field testing for free and total chlorine residual conformed to methods and procedures described in the BASMAA RMC SOPs (BASMAA 2016b), which are comparable to those specified in the SWAMP QAPP. Per SOP FS-3 (BASMAA 2016b), water samples were collected and analyzed for free and total chlorine using a Pocket Colorimeter™ II and DPD Powder Pillows, which has a method detection limit of 0.02 mg/L. If concentrations exceed the trigger criteria of 0.1 mg/L, the site was immediately resampled. Per Provision C.8.d.ii(4) of the MRP, "if the resample is still greater than 0.1 mg/L, then Permittees report the observation to the appropriate Permittee central contact point for illicit discharges so that the illicit discharge staff can investigate and abate the associated discharge in accordance with its Provision C.5.e – Spill and Dumping Complaint Response Program."

4.3 Results

In WY 2017, SMCWPPP monitored the ten probabilistic sites for free chlorine and total chlorine residual. These measurements were compared to the MRP trigger threshold of 0.1 mg/L. Results are listed in Table 4.1.

The trigger thresholds for free chlorine and total chlorine residual were exceeded at one of the stations in Redwood Creek on May 22, 2017. In compliance with Provision C.8.d.ii(4), SMCWPPP staff immediately informed City of Redwood City illicit discharge staff of the exceedances. Redwood City staff conducted follow-up investigations on May 23 and June 20, 2017, during which they sampled for chlorine at the original station and four upstream locations. Elevated concentrations of chlorine were detected at all locations, and the City determined that it came from an upstream (but unknown) source in the Town of Woodside. City and SMCWPPP staff contacted the Town of Woodside and will continue to follow up on elevated chlorine levels in Redwood Creek.

Table 4.1. Summary of SMCWPPP chlorine testing results compared to MRP trigger of 0.1 mg/L, WY 2017.

Station Code	Date	Creek	Free Chlorine (mg/L)[1, 2]	Total Chlorine Residual (mg/L)[1, 2]	Exceeds Trigger?[3] (0.1 mg/L)
202R00550	5/30/2017	Jones Gulch	0.02	0.06	No
202R00552	5/24/2017	Lawrence Creek	< 0.02	< 0.02	No
204R02472	5/22/2017	Redwood Creek	0.06 / 0.15	0.58 / 0.51	Yes
204R02611	5/23/2017	Atherton Creek	0.02	0.05	No
204R03240	5/23/2017	Atherton Creek	0.06	0.07	No
204R03252	5/31/2017	San Mateo Creek	< 0.02	< 0.02	No
204R03272	5/31/2017	San Mateo Creek	0.02	0.05	No
204R03316	5/24/2017	Arroyo Ojo de Agua	0.03	0.04	No
204R03336	5/25/2017	Belmont Creek	0.02	0.02	No
204R03496	5/22/2017	Redwood Creek	0.02	0.07	No
Number of sites exceeding 0.1 mg/L:			1	1	1

[1] The method detection limit is 0.02 mg/L; however, the Statewide General Permit for Drinking Water Discharges (Order WQ 2014-0194-DWQ) uses 0.1 mg/L as a reporting limit (minimum level) for field measurements of total chlorine residual.
[2] Original and repeat samples are reported where conducted. The first value is the original result.
[3] The MRP trigger threshold applies to both free chlorine and total chlorine residual measurements.

4.4 Conclusions and Recommendations

While chlorine residual is generally not a concern in San Mateo County creeks, WY 2017 and prior monitoring results suggest there are occasional trigger exceedances of free chlorine and total chlorine residual in the County. Exceedances may be the result of one-time potable water discharges, and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. SMCWPPP will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

5.0 Toxicity and Sediment Chemistry Monitoring

5.1 Introduction

Toxicity testing provides a tool for assessing the combined toxic effects (acute and chronic) of all chemicals present in samples of receiving waters or sediments. Because different test organisms are sensitive to different classes of chemicals and pollutants, several different organisms are monitored. Sediment chemistry monitoring for a variety of potential pollutants conducted synoptically with toxicity monitoring provides preliminary insight into the possible causes of toxicity should they be found.

Provision C.8.g of the MRP requires both wet and dry weather monitoring of pesticides and toxicity in urban creeks.

Dry Weather

SMCWPPP is required to conduct water toxicity and sediment chemistry and toxicity monitoring at one location per year during the dry season, for each year of the permit term beginning in WY 2016. The water and sediment samples do not necessarily need to be collected at the same locations. The permit provides examples of possible monitoring locations, including sites with suspected or past toxicity results, or existing bioassessment sites.

- Toxicity testing in water is required using five species: *Ceriodaphnia* dubia (chronic survival and reproduction), *Pimephales promelas* (larval survival and growth), *Selenastrum capricornutum* (growth), *Hyalella azteca* (survival) and *Chironomus dilutes* (survival).
- Toxicity testing in sediment is required using two species: *Hyella azteca* (survival) and *Chironomus dilutes* (survival).
- Sediment chemistry analytes include pyrethroids, fipronil, carbaryl, total polycyclic aromatic hydrocarbons (PAHs), metals, Total Organic Carbon (TOC) and sediment grain size.

Wet Weather

The wet weather monitoring requirements include collection of water column samples during storm events for toxicity testing and analysis of pyrethroids, fipronil, imidacloprid and indoxacarb. The MRP states that monitoring locations should be representative of urban watersheds (i.e., bottom of watersheds).

The MRP states that if the wet season monitoring is conducted by the RMC on behalf of all Permittees, a total of ten collective samples are required over the permit term, with at least six samples collected by WY 2018. At the RMC Monitoring Workgroup meeting on January 25, 2016, RMC members agreed to collaborate on implementation of the wet weather monitoring requirements. The first wet weather samples will occur in WY 2018. SCVURPPP and ACCWP will each collect three samples and SMCWPPP and CCCWP will each collect two samples. The RMC is still in the process of defining the monitoring approach.

Toxicity and pesticides monitoring methods and results are described in the sections below.

5.2 Methods

5.2.1 Site Selection

In WY 2017, in compliance with MRP Provision C.8.g.i, water and sediment toxicity and sediment chemistry samples were collected from one creek during dry weather: San Pedro Creek in the City of Pacifica (see Figure 1.2). The site was selected to represent and mixed-land use urban watershed that was not already being monitored for toxicity or pesticides by other programs, such as the SWAMP Stream Pollution Trends (SPoT) program. The specific station within the watershed was identified based on the likelihood that it would contain fine depositional sediments during dry season sampling and would be safe to access during potential future wet weather sampling. SMCWPPP monitored Laurel Creek in WY 2016 and it is anticipated that SMCWPPP will select a different creek to target for dry weather pesticides and toxicity monitoring during each year of the permit term with the goal of building a geographically diverse dataset.

5.2.2 Sample Collection

Before conducting sampling, field personnel surveyed the proposed sampling area for appropriate fine-sediment depositional areas. Personnel carefully entered the stream to avoid disturbing sediment at collection sub-sites.

Water samples were collected using standard grab sampling methods. The required number of 4-L labeled amber glass bottles were filled and placed on ice to cool to < 6C. The laboratory was notified of the impending sampling delivery to meet 24-hour sample hold time. Procedures used for sampling and transporting water samples are described in SOP FS-2 (BASMAA 2016b).

Sediment samples were collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. Sediment samples were placed in a compositing container, thoroughly homogenized, and then aliquoted into separate jars for chemical or toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA 2016b).

Sample were submitted to respective laboratories and field data sheets were reviewed per SOP FS-13 (BASMAA 2016b).

5.2.3 Data Evaluation

Water and Sediment Toxicity

Data evaluation required by the MRP involves first determining whether the samples are toxic to the test organisms relative to the laboratory control treatment via statistical comparison using the Test of Significant Toxicity (TST) statistical approach. For samples with toxicity (i.e., those that “failed” the TST), the Percent Effect is evaluated. The Percent Effect compares sample endpoints (survival, reproduction, growth) to the laboratory control endpoints. Follow-up sampling is required if any test organism is reported as “fail” and the Percent Effect is ≥ 50 % Percent Effect. Both the TST result and the Percent Effect are determined by the laboratory.

Sediment Chemistry

In compliance with MRP Provision C.8.g.iv, sediment sample results are compared to Probable Effects Concentrations (PECs) and Threshold Effects Concentrations (TECs) as defined by

MacDonald et al. (2000). PEC and TEC quotients are calculated as the ratio of the measured concentration to the respective PEC and TEC values from MacDonald et al. (2000). All results where a PEC or TEC quotient was equal to or greater than 1.0 were identified and added to the list of candidate SSID projects.

Total PAH concentrations were calculated by summing the concentrations of 24 individual PAHs. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that calculations and statistics could be computed. Therefore, some of the TEC and PEC quotients may be artificially elevated (and contribute to trigger exceedances) due to the method used to account for non-detect data.

The TECs for bedded sediments are very conservative values that do not consider site specific background conditions, and are therefore not very useful in identifying real water quality concerns in receiving waters in the San Mateo County. All sites in the County are likely to have at least one TEC quotient equal to or greater than 1.0. This is due to high levels of naturally-occurring chromium and nickel in geologic formations (i.e., serpentinite) and soils that contribute to TEC and PEC quotients. These conditions will be considered when making decisions about SSID projects.

The current MRP does not require consideration of pyrethroid, fipronil, or carbaryl sediment chemistry data for follow-up SSID projects, perhaps because pyrethroids are ubiquitous in the urban environment and little is known about fipronil and carbaryl distribution. However, SMCWPPP computed toxicity unit (TU) equivalents for individual pyrethroid results, based on available literature values for pyrethroids in sediment LC50 values.[21,22] Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized concentrations. Therefore, the pesticide concentrations as reported by the lab were divided by the measured total organic carbon (TOC) concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each constituent. Concentrations equal to one-half of the respective laboratory method detection limits were substituted for non-detect data so that these statistics could be computed, potentially resulting in artificially elevated results.

5.3 Results and Discussion

5.3.1 Toxicity

Table 5.1 provides a summary of toxicity testing results for WY 2017 dry weather water and sediment samples. Based on the results, it is not necessary to add San Pedro Creek to the list of potential SSID projects.

The water sample was significantly toxic to two of the test organisms (*C. dubia and P. promelas*); however, the Percent Effect did not exceed the 50% threshold for follow-up. The cause of the water toxicity is unknown. The sediment sample was not toxic to either of the test organisms.

[21] The LC50 is the concentration of a given chemical that is lethal on average to 50% of test organisms.

[22] No LC50 is published for carbaryl.

Table 5.1. Summary of SMCWPPP water toxicity results, San Pedro Creek, WY 2017.

Site	Organism	Test Type	Unit	Results		% Effect	TST Value	Follow up needed (TST "Fail" and ≥50%)
				Lab Control	Organism Test			
202SPE005 San Pedro Creek	Water							
	Ceriodaphnia dubia	Survival	%	100	100	0%	NA [1]	No
		Reproduction	Num/Rep	30.2	16.2	46.4%	Fail	No
	Pimephales promelas	Survival	%	97.5	80	18.0%	Fail	No
		Growth	mg/ind	0.548	0.497	9.27%	Pass	No
	Chironomus dilutus	Survival	%	95	92.5	3%	Pass	No
	Hyalella azteca	Survival	%	98	97.8	0.23%	Pass	No
	Selenastrum capricornutum	Growth	cells/ml	3000000	5580000	-85.5%	Pass	No
	Sediment							
	Chironomus dilutus	Survival	%	96.2	97.5	-1.30%	Pass	No
	Hyalella azteca	Survival	%	97.5	98.8	-1.28%	Pass	No

[1] TST analysis is not performed for survival endpoint - a percent effect <25% is considered a "Pass", and a percent effect ≥25% is considered a "Fail."

5.3.2 Sediment Chemistry

Sediment chemistry results are evaluated as potential stressors based on TEC quotients and PEC quotients according to criteria in Provision C.8.g.iv of the MRP. SMCWPPP also evaluated TU equivalents of pyrethroids.

Table 5.2 lists concentrations and TEC quotients for sediment chemistry constituents (metals and total PAHs). TEC quotients are calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000)[23]. TECs are extremely conservative and are intended to identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. The site on San Pedro Creek exceeded the relevant trigger criterion from the MRP of having at least one result exceeding the TEC and will be added to the list of potential SSID projects. However, the TEC exceedances were of chromium and nickel as expected in watersheds draining hillsides underlain by serpentinite formations.

Table 5.3 provides concentrations and PEC quotients for sediment chemistry constituents (metals and total PAHs), calculated as the measured concentration divided by the PEC value,

[23] MacDonald et al. (2000) does not provide TEC or PEC values for pyrethroids, fipronil, or carbaryl. Pyrethroids are compared to LC50 values in Table 5.4. However, LC50 values for fipronil and carbaryl in sediment have not been published.

per MacDonald et al. (2000). PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. The PEC quotient for nickel was greater than 1.0.

Table 5.2. Threshold Effect Concentration (TEC) quotients for WY 2017 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

	TEC	202SPE005 San Pedro Creek	
		Concentration	Quotient
Metals (mg/kg DW)			
Arsenic	9.79	5.2	0.53
Cadmium	0.99	0.09	0.091
Chromium	43.4	48	1.1
Copper	31.6	29	0.92
Lead	35.8	8.9	0.25
Nickel	22.7	61	3
Zinc	121	74	0.61
PAHs (ug/kg DW)			
Total PAHs	1,610	41 [a]	0.025
# Constituents with TEC quotient >= 1.0		2	

[a] Total PAHs calculated using ½ MDLs.

Table 5.3. Probable Effect Concentration (PEC) quotients for WY 2017 sediment chemistry constituents. Bolded and shaded values indicate PEC quotient ≥ 1.0.

	PEC	202SPE005 San Pedro Creek	
		Concentration	Quotient
Metals (mg/kg DW)			
Arsenic	33.0	5.2	0.16
Cadmium	4.98	0.09	0.018
Chromium	111	48	0.43
Copper	149	29	0.19
Lead	128	8.9	0.070
Nickel	48.6	61	**1.3**
Zinc	459	74	0.16
PAHs (ug/kg DW)			
Total PAHs	22,800	41 [a]	0.0018
# Constituents with PEC quotient >= 1.0		**1**	

[a] Total calculated using ½ MDLs.

Table 5.4 lists the concentrations of pesticides measured in sediment samples and calculated TU equivalents for the pesticides for which there are published LC50 values in the literature. Because organic carbon mitigates the toxicity of pyrethroids and fipronil in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Similarly, the constituent concentrations as reported by the lab were divided by the measured TOC concentration in the sample, and the TOC-normalized concentrations were used to compute TU equivalents. Most of the pesticides measured were below method detection limits (MDLs) and are listed as ½ MDLs in Table 5.4. Others were below the reporting limits as noted in Table 5.4. All of the calculated TU equivalents were less than 0.04. The highest TU equivalent was for bifenthrin (0.036) which is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013).

Table 5.4. Pesticide concentrations and calculated toxic unit (TU) equivalents, WY 2017.

			202SPE005 San Pedro Creek		
	Unit	LC50 [d]	Concentration	Normalized to TOC	TU Equivalent
Total Organic Carbon	%		2.1		
Pyrethroids					
Bifenthrin	µg/g dw	0.52	0.00039	0.019	0.036
Cyfluthrin	µg/g dw	1.08	0.00006 [a]	0.0026	0.0024
Cypermethrin	µg/g dw	0.38	0.00005 [a]	0.0024	0.0063
Deltamethrin	µg/g dw	0.79	0.00006 [a]	0.0029	0.0036
Esfenvalerate	µg/g dw	1.54	0.00007 [a]	0.0031	0.0020
Lambda-Cyhalothrin	µg/g dw	0.45	0.00003 [a]	0.0015	0.0032
Permethrin	µg/g dw	10.83	0.00024 [b]	0.011	0.0011
Other Pesticides					
Carbaryl	mg/Kg dw	NA [c]	0.01 [a]	NA	NA
Fipronil	ng/g dw	NA [c]	0.12 [b]	NA	NA
Fipronil Desulfinyl	ng/g dw	NA [c]	0.05 [a]	NA	NA
Fipronil Sulfide	ng/g dw	NA [c]	0.05 [a]	NA	NA
Fipronil Sulfone	ng/g dw	NA [c]	0.27 [b]	NA	NA

a. Concentration was below the method detection limit (MDL). Value listed is 1/2 MDL.
b. Concentration below the reporting limit (J-flagged).
c. No available LC50 value for Carbaryl or Fipronil.
d. Sources: Amweg et al. 2005 and Maund et al. 2002

In compliance with the MRP, a grain size analysis was conducted on the sediment sample (Table 5.5). The San Pedro Creek sample was 18% fines (i.e., 6.5% clay and 11% silt). It unknown whether the relatively high percent fines in the sample influenced the toxicity tests or sediment chemistry analyses.

Table 5.5. Summary of grain size for site 202SPE005 in San Mateo County during WY 2017.

Grain Size (%)		202SPE005
		San Pedro Creek
Clay	<0.0039 mm	6.5%
Silt	0.0039 to <0.0625 mm	11%
Sand	V. Fine 0.0625 to <0.125 mm	5.3%
	Fine 0.125 to <0.25 mm	7.4%
	Medium 0.25 to <0.5 mm	16%
	Coarse 0.5 to <1.0 mm	27%
	V. Coarse 1.0 to <2.0 mm	26%
Granule	2.0 to <4.0 mm	16%
Pebble	Small 4 to <8 mm	26%
	Medium 8 to <16 mm	4.5%
	Large 16 to <32 mm	0%
	V. Large 32 to <64 mm	0%

5.4 Conclusions and Recommendations

Statistically significant toxicity to *C. dubia* and *P. promelas* was observed in water samples collected during the dry season. However, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria of 50 Percent Effect. The cause of the observed toxicity is unknown. Pesticide concentrations in the sediment sample were all very low, most below the MDL and TU equivalents did not exceed 0.04.

TEC and PEC quotients were calculated for all metals and total PAHs measured in sediment samples. Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, San Pedro Creek will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in local watersheds.

6.0 Conclusions and Recommendations

In WY 2017, in compliance with Provisions C.8.d and C.8.g of the MRP and the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), SMCWPPP continued to implement a two-component monitoring design that was initiated in WY 2012. The strategy includes a regional ambient/"probabilistic" bioassessment monitoring component and a component based on local "targeted" monitoring for general water quality parameters and pesticides/toxicity. The combination of these monitoring designs allows each individual RMC participating program to assess the status of Beneficial Uses in local creeks within its Program (jurisdictional) area, while also contributing data to eventually answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks).

The following conclusions from the MRP Creek Status and Pesticides/Toxicity Monitoring conducted during WY 2017 in San Mateo County are based on the management questions presented in Section 1.0 of this report:

1) *Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers, and tributaries?*
2) *Are conditions in local receiving water supportive of or likely supportive of beneficial uses?*

The first management question is addressed primarily through the evaluation of probabilistic and targeted monitoring data with respect to the triggers defined in the MRP. A summary of trigger exceedances observed for each site is presented in Table 6.1. Sites where triggers are exceeded may indicate potential impacts to aquatic life or other beneficial uses and are considered for future evaluation of stressor source identification (SSID) projects.

The second management question is addressed primarily by assessing indicators of aquatic biological health using benthic macroinvertebrate and algae data collected at probabilistic sites. Biological condition scores were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether any correlations exist that may explain the variation in biological condition scores. These analyses were limited to the WY 2017 dataset which does not contain a statistically significant number of records. A more comprehensive analysis of the much larger bioassessment dataset from the previous five years (WY 2012 – WY 2016) is currently being conducted by the BASMAA RMC on a regional and countywide basis. Results of the BASMAA regional study will be available by late 2018. Analytical tools that are found to be useful in evaluating stressor association with biological condition may be implemented in future annual monitoring reports.

6.1 Conclusions

6.1.1 Biological Condition Assessment (WY 2017)

Bioassessment monitoring was conducted at ten sites in WY 2017. The sites were sampled for BMIs, benthic algae, physical habitat, and nutrients using methods consistent with the BASMAA RMC QAPP (BASMAA 2016a) and SOPs (BASMAA 2016b). Stations were randomly selected using a probabilistic monitoring design. Eight of the sites (80%) were classified as urban and two (20%) were classified as non-urban.

The California Stream Condition Index is a statewide tool that translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI is currently the most robust method of assessing aquatic biological health. There are also three benthic algae indices of biological integrity available (D18, H20, S2); however, the applicability of the algae IBIs in San Mateo County streams is uncertain. This is due to several factors including:

- There is an overall dearth of soft algae taxa found in San Mateo streams. This may not reflect stream health, but it significantly lowers the scores of two of the algae IBIs (H20 and S2).
- The algae IBIs were developed for Southern California streams and may not provide adequate interpretations of Northern California algae communities.
- Statewide Algae Stream Condition Indices are currently being developed and are anticipated to be available in 2018.

Of the ten sites monitored in WY 2017, two sites (20%) were rated in good condition (CSCI scores ≥ 0.795); two sites (20%) rated as likely altered condition (CSCI score 0.635 – 0.795), and six sites (60%) rated as very likely altered condition (≤ 0.635). The two sites in good condition were classified as non-urban and located in protected open space or County Park land. Three of the lowest CSCI scores occurred at sites located in concrete channels.

Relationships between potential stressors (physical habitat and water chemistry) and biological condition were explored on a limited basis using the WY 2017 dataset.

- Physical Habitat Assessment (PHAB) scores, a qualitative tool that assesses the overall habitat condition of the sampling reach during the assessment, were compared to biological condition indictor scores. PHAB consists of three attributes that are assessed for the entire bioassessment reach. These include channel alteration, epifaunal substrate and sediment deposition. Total PHAB scores were moderately correlated with CSCI scores (r^2=0.51, p value = 0.02) suggesting that physical habitat (e.g., substrate quality, channel alteration) has an influence on the BMI community. Individual physical habitat metrics associated with substrate size and composition were also correlated with CSCI scores.
- Landscape variables were calculated for each of the watershed areas draining into the bioassessment sites. CSCI scores were moderately correlated (negatively) with impervious area and road density.

Stressor Assessment

Sites with CSCI scores and/or stressor levels exceeding applicable WQOs and triggers identified in the MRP will be considered as candidates for SSID projects.

- The eight sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.
- **General water quality** (pH, temperature, dissolved oxygen, specific conductance). Two measurements exceeded water quality objectives for pH site 204R02472 (Redwood Creek), site 204R02611 (Atherton Creek) and site 204R03316 (Ojo de Agua). These sites will be considered as candidates for SSID projects.
- **Nutrients and conventional analytes** (ammonia, unionized ammonia, chloride, AFDM, chlorophyll a, nitrate, nitrite, TKN, ortho-phosphate, phosphorus, silica). There were no water quality objective exceedances for water chemistry parameters.

6.1.2 Targeted Monitoring for Temperature and General Water Quality

Targeted monitoring in WY 2017 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at five sites in the San Pedro Creek watershed from April through September. Continuous (15-minute) general water quality measurements (pH, DO, specific conductance, temperature) were recorded at two of the sites in the San Pedro Creek subwatershed during two 2-week periods in May/June (Event 1) and August/September (Event 2). Pathogen indicator grab samples were collected at five sites in the Pillar Point Harbor watershed during a sampling event in June.

Continuous temperature, water quality, and pathogen indicator data generated during WY 2017 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or impacted biological conditions. The MRP identifies trigger criteria as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. Sites with targeted monitoring results exceeding the trigger criteria are identified as candidate SSID projects.

Temperature and General Water Quality

San Pedro Creek, located in the City of Pacifica, was targeted for temperature and general water quality monitoring because it contains the northern-most population of naturally producing steelhead trout (*Oncorhynchus mykiss*) in San Mateo County.

- There was minimal spatial variability in water temperature across the five stations in the San Pedro Creek watershed. Temperature increased slightly at each downstream site but remained 4 to 7 °C below the instantaneous trigger threshold. Likewise, pH and specific conductivity increased slightly in the downstream direction and dissolved oxygen decreased slightly in the downstream direction.
- Water temperature increased gradually at all five stations between April and early-September, in response to one of the hottest summers on record. In mid-September, water temperatures dropped relatively quickly in response a much cooler air mass. Differences in general water quality measurements (pH, specific conductivity, dissolved oxygen) between the two two-week monitoring periods (May/June and August/September) were less pronounced.
- None of the temperature or general water quality parameters (temperature, pH, dissolved oxygen, and specific conductance) exceeded any of the MRP trigger thresholds.

Pathogen Indicators

In WY 2017, pathogen indicator samples were collected at two stations on Denniston Creek near Pillar Point Harbor and one storm drain discharging to Denniston Creek, one outfall pipe discharging directly to the beach Pillar Point Harbor, and one storm drain upstream of the outfall pipe. Pillar Point Harbor is the site of an ongoing SSID project that is examining the extent and sources of pathogen indicators in the area. Pathogen indicator triggers for enterococci were exceeded at four of the five sites. Triggers for *E. coli* were exceeded at three of the five sites.

- It is important to recognize that pathogen indicator thresholds are based on human recreation at beaches receiving bacteriological contamination from human wastewater and may not be applicable to conditions found in urban creeks or beaches that do not receive wastewater discharges. As a result, the comparison of pathogen indicator results to body contact recreation water quality objectives may not be appropriate and should be interpreted cautiously. Furthermore, the WQOs for pathogens used in this report cannot be applied to waters sampled directly from the MS4, as dilution occurs when water from the MS4 discharges to a receiving water body. It should also be noted that the WQOs for pathogens used in this report are subject to change in the near future due to adoption by the State Board of new statistical threshold values based on USEPA criteria.

- Municipalities near Half Moon Bay are aware of the bacteria exceedances found in Pillar Point Harbor. Results of the coming SSID study will be used to further inform these municipalities about the nature and extent of the bacteria presence and any potential steps they can take to resolve the issue.

6.1.3 Chlorine Monitoring

Free chlorine and total chlorine residual was measured concurrently with bioassessments at the ten probabilistic sites in compliance with Provision C.8.c.ii. While chlorine residual is generally not a concern in San Mateo County creeks, WY 2017 and prior monitoring results suggest there are occasional free chlorine and total chlorine residual exceedances in the County. In WY 2017, exceedances of the MRP trigger for chlorine (0.1 mg/L) were detected at one station on Redwood Creek. Redwood City illicit discharge staff were notified and conducted an immediate followup investigation. The elevated chlorine measurements were tracked to the upstream edge of the Redwood City jurisdication and subsequently report to the Town of Woodside. Chlorine exceedances are typically the result of one-time potable water discharges and it is generally very difficult to determine the source of elevated chlorine from such episodic discharges. SMCWPPP will continue to monitor chlorine in compliance with the MRP and will follow-up with illicit discharge staff as needed.

6.1.4 Pesticides and Toxicity Monitoring

In WY 2017, SMCWPPP conducted dry weather pesticides and toxicity monitoring at one station (San Pedro Creek) in compliance with Provision C.8.g of the MRP.

Statistically significant toxicity to *C. dubia* and *P. promelas* was observed in water samples collected during the dry season. However, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria of 50 Percent Effect. The cause of the observed toxicity is unknown. Pesticide concentrations in the sediment sample were all very low, most below the MDL and TU equivalents did not exceed 0.04.

TEC and PEC quotients were calculated for all metals and total PAHs (calculated as the sum of 24 individual PAHs) measured in sediment samples. Two TEC and one PEC quotients exceeded 1.0. In compliance with the MRP, San Pedro Creek will therefore be placed on the list of candidate SSID projects. Decisions about which SSID projects to pursue should be informed by the fact that the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel due to serpentine soils in local watersheds.

SMCWPPP will continue to sample one station per year for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SMCWPPP will work with the BASMAA RMC partners to implement a regional approach to wet weather pesticides and toxicity monitoring.

6.2 Trigger Assessment

The MRP requires analysis of the monitoring data to identify candidate sites for SSID projects. Trigger thresholds against which to compare the data are provided for most monitoring parameters in the MRP and are described in the foregoing sections of this report. Stream condition was determined based on CSCI scores that were calculated using BMI data. Water and sediment chemistry and toxicity data were evaluated using numeric trigger thresholds specified in the MRP. Nutrient data were evaluated using applicable water quality standards from the Basin Plan (SFRWQCB 2017). In compliance with Provision C.8.e.i of the MRP, all monitoring results exceeding trigger thresholds are added to a list of candidate SSID projects that will be maintained throughout the permit term. Followup SSID projects will be selected from this list. Table 6.1 lists of candidate SSID projects based on WY 2017 Creek Status and Pesticides/Toxicity monitoring data.

Additional analysis of the data is provided in the foregoing sections of this report and should be considered prior to selecting and defining SSID projects. The analyses include review of physical habitat and water chemistry data to identify potential stressors that may be contributing to degraded or diminished biological conditions. Analyses in this report also include historical and spatial perspectives that help provide context and deeper understanding of the trigger exceedances.

Table 6.1. Summary of SMCWPPP MRP trigger threshold exceedance analysis, WY 2017. "No" indicates samples were collected but did not exceed the MRP trigger; "Yes" indicates an exceedance of the MRP trigger.

Station Number	Creek Name	Bioassessment [1]	Nutrients [2]	Chlorine [3]	Water Toxicity [4]	Sediment Toxicity [4]	Sediment Chemistry [5]	Continuous Temperature [6]	Dissolved Oxygen [7]	pH [8]	Specific Conductance [9]	Pathogen Indicators [10]
202R00550	Jones Gulch	No	No	No	--	--	--	--	--	--	--	--
202R00552	Lawrence Creek	No	No	No	--	--	--	--	--	--	--	--
204R02472	Redwood Creek	Yes	No	Yes	--	--	--	--	--	Yes	--	--
204R02611	Atherton Creek	Yes	No	No	--	--	--	--	--	Yes	--	--
204R03240	Atherton Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03252	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03272	San Mateo Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03316	Arroyo Ojo de Agua	Yes	No	No	--	--	--	--	--	Yes	--	--
204R03336	Belmont Creek	Yes	No	No	--	--	--	--	--	--	--	--
204R03496	Redwood Creek	Yes	No	No	--	--	--	--	--	--	--	--
202SPE005	San Pedro Creek	--	--	--	No	No	Yes	--	--	--	--	--
202DEN017	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202DEN005	Denniston Creek	--	--	--	--	--	--	--	--	--	--	No
202DEN020	Denniston Creek	--	--	--	--	--	--	--	--	--	--	Yes
202CAP001	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202CAP025	NA (MS4)	--	--	--	--	--	--	--	--	--	--	NA
202SPE019	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--
202SPE040	San Pedro Creek	--	--	--	--	--	--	No	No	No	No	--
202SPE050	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--
202SPE070	San Pedro Creek	--	--	--	--	--	--	No	No	No	No	--
202SPE085	San Pedro Creek	--	--	--	--	--	--	No	--	--	--	--

1. CSCI score ≤ 0.795.
2. Unionized ammonia (as N) ≥ 0.025 mg/L, nitrate (as N) ≥ 10 mg/L, chloride > 250 mg/L.
3. Free chlorine or total chlorine residual ≥ 0.1 mg/L.
4. Test of Significant Toxicity = Fail and Percent Effect ≥ 50 %.
5. TEC or PEC quotient ≥ 1.0 for any constituent.
6. Two or more MWAT ≥ 17.0°C or 20% of results ≥ 24°C.
7. DO < 7.0 mg/L in COLD streams or DO < 5.0 mg/L in WARM streams.
8. pH < 6.5 or pH > 8.5.
9. Specific conductance > 2000 uS.
10. Enterococcus ≥ 130 cfu/100ml or *E. coli* ≥ 410 cfu/100ml.

6.3 Management Implications

The Program's Creek Status and Pesticides and Toxicity Monitoring programs (consistent with MRP provisions C.8.c and C.8.g, respectively) focus on assessing the water quality condition of urban creeks in San Mateo County and identifying stressors and sources of impacts observed. The sample size from WY 2017 (overall n=10; urban n=8) is not sufficient to develop statistically representative conclusions regarding the overall condition of all creeks. However, it builds on data collected in WY 2012 through WY 2016 which are currently being analyzed by a BASMAA RMC regional project. The BASMAA regional project will assess stream conditions and stressors for the five-year dataset (WY 2012 – WY 2016) on regional and countywide basis. It will review and develop statistical tools that can be utilized in the future to analyze the growing dataset. It will also recommend options for modifying the RMC creek status monitoring program during the next reissue of the MRP, perhaps with a focus on trends monitoring.

Like previous years, WY 2017 data suggest that most urban streams have likely or very likely altered populations of aquatic life indicators (e.g., aquatic macroinvertebrates). These conditions are likely the result of long-term changes in stream hydrology, channel geomorphology, in-stream habitat complexity, and other modifications to the watershed and riparian areas associated with the urban development that has occurred over the past 50 plus years.

SMCWPPP Permittees are actively implementing many stormwater management programs to address these and other stressors and associated sources of water quality conditions observed in local creeks, with the goal of protecting these natural resources. For example:

- In compliance with MRP Provision C.3, new and redevelopment projects in the Bay Area are now designed to more effectively reduce water quality and hydromodification impacts associated with urban development. Low impact development (LID) methods, such as rainwater harvesting and use, infiltration and biotreatment are required as part of development and redevelopment projects. In addition, Green Infrastructure planning is now part of all municipal projects. These LID measures are expected to reduce the impacts of urban runoff and associated impervious surfaces on stream health.
- In compliance with MRP Provision C.9, Permittees are implementing pesticide toxicity control programs that focus on source control and pollution prevention measures. The control measures include the implementation of integrated pest management (IPM) policies/ordinances, public education and outreach programs, pesticide disposal programs, the adoption of formal State pesticide registration procedures, and sustainable landscaping requirements for new and redevelopment projects. Through these efforts, it is estimated that the amount of pyrethroids observed in urban stormwater runoff will decrease by 80-90% over time, and in turn significantly reduce the magnitude and extent of toxicity in local creeks.
- Trash loadings to local creeks have been reduced through implementation of new control measures in compliance with MRP Provision C.10 and other efforts by Permittees to reduce the impacts of illegal dumping directly into waterways. These actions include the installation and maintenance of trash capture systems, the adoption of ordinances to reduce the impacts of litter prone items, enhanced institutional controls such as street sweeping, and the on-going removal and control of direct dumping. The MRP establishes a mandatory trash load reduction schedule, minimum areas to be treated by full trash capture systems, and requires development of receiving water monitoring programs for trash.

- In compliance with MRP Provisions C.2 (Municipal Operations), C.4 (Industrial and Commercial Site Controls), C.5 (Illicit Discharge Detection and Elimination), and C.6 (Construction Site Controls) Permittees continue to implement Best Management Practices that are designed to prevent non-stormwater discharges during dry weather and reduce the exposure of contaminants to stormwater and sediment in runoff during rainfall events.
- In compliance with MRP Provision C.13, copper in stormwater runoff is reduced through implementation of controls such as architectural and site design requirements, prohibition of discharges from water features treated with copper, and industrial facility inspections.
- Mercury and polychlorinated biphenyls (PCBs) in stormwater runoff are being reduced through implementation of the respective TMDL water quality restoration plans. In compliance with MRP Provisions C.11 (mercury) and C.12 (PCBs), the Program will continue to identify sources of these pollutants and will implement control actions designed to achieve new minimum load reduction goals. Monitoring activities conducted in WY 2017 that specifically target mercury and PCBs are described in the Pollutants of Concern Monitoring Data Report that is included as Appendix D to the WY 2017 UCMR.

In addition to the Program and Co-permittee controls implemented in compliance with the MRP, numerous other efforts and programs designed to improve the biological, physical and chemical condition of local creeks are underway. For example, C/CAG recently developed the Draft San Mateo Countywide Stormwater Resource Plan (SRP) to satisfy state requirements and guidelines to ensure C/CAG and SMCWPPP member agencies are eligible to compete for future voter-approved bond funds for stormwater or dry weather capture projects. The SRP identifies and prioritizes opportunities to better utilize stormwater as a resource in San Mateo County through a detailed analysis of watershed processes, surface and groundwater resources, input from stakeholders and the public, and analysis of multiple benefits that can be achieved through strategically planned stormwater management projects. These projects aim to capture and manage stormwater more sustainably, reduce flooding and pollution associated with runoff, improve biological functioning of plants, soils, and other natural infrastructure, and provide many community benefits, including cleaner air and water and enhanced aesthetic value of local streets and neighborhoods.

Through the continued implementation of MRP-associated and other watershed stewardship programs, SMCWPPP anticipates that stream conditions and water quality in local creeks will continue to improve overtime. In the near term, toxicity observed in creeks should decrease as pesticide regulations better incorporate water quality concerns during the pesticide registration process. In the longer term, control measures implemented to “green” the “grey” infrastructure and disconnect impervious areas constructed over the course of the past 50 plus years will take time to implement. Consequently, it may take several decades to observe the outcomes of these important, large-scale improvements to our watersheds in our local creeks. Long-term creek status monitoring programs designed to detect these changes over time are therefore beneficial to our collective understanding of the condition and health of our local waterways.

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ATTACHMENTS

Attachment 1

QA/QC Report

Quality Assurance/Quality Control Report

Prepared by:

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Prepared for:

San Mateo Countywide Water Pollution Prevention Program

March 31, 2018

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ACRONYMS

BASMAA	Bay Area Stormwater Management Agencies Association
BMI	Benthic Macroinvertebrates
CDFW	California Department of Fish and Wildlife
DQO	Data Quality Objective
EDDs	Electronic data deliverables
EV	Expected Value
KLI	Kinnetic Laboratories, Inc.
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MPN	Most Probably Number
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MV	Measured Value
ND	Non-detect
NIST	National Institute of Standards and Technology
NPDES	National Pollution Discharge Elimination System
NV	Native Value
PAH	Polycyclic Aromatic Hydrocarbon
PR	Percent Recovery
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RPD	Relative Percent Difference
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCCWRP	Southern California Coastal Water Research Project

SFRWQCB	San Francisco Regional Water Quality Control Board
SMCWPPP	San Mateo County Urban Pollution Prevention Program
SOP	Standard Operating Procedures
STE	Standard Taxonomic Effort
SV	Spike Value
SWAMP	Surface Water Ambient Monitoring Program
TKN	Total Kjeldahl Nitrogen
WY	Water Year

1. INTRODUCTION

In Water Year 2017 (WY 2017; October 1, 2016 through September 30, 2017), the San Mateo County Water Pollution Prevention Program (SMCWPPP) conducted Creek Status Monitoring in compliance with provision C.8.d and dry weather Pesticide & Toxicity Monitoring in compliance with provision C.8.g of the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities referred to as the Municipal Regional Permit (MRP). The monitoring strategy includes regional ambient/probabilistic monitoring and local "targeted" monitoring as described in the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012). SMCWPPP implemented a comprehensive data quality assurance and quality control (QA/QC) program, covering all aspects of the probabilistic and targeted monitoring. QA/QC for data collected was performed according to procedures detailed in the Quality Assurance Project Plan (QAPP) developed by the BASMAA RMC (BASMAA 2016a) and BASMAA RMC Standard Operating Procedures (SOP; BASMAA 2016b), SOP FS-13 (Standard Operating Procedures for QA/QC Data Review). The BASMAA RMC SOP and QAPP are based on the SOP and QAPP developed by the Surface Water Ambient Monitoring Program (SWAMP; SCCWRP 2008).

Based on the QA/QC review, no WY 2017 data were rejected and some data were flagged. Overall, WY 2017 data met QA/QC objectives. Details are provided in the sections below.

1.1. Data Types Evaluated

During creek status monitoring, several data types were collected and evaluated for quality assurance and quality control. These data types include the following:

1. Bioassessment data
    a. Benthic Macroinvertebrates (BMI)
    b. Algae
2. Physical Habitat Assessment
3. Field Measurements
4. Water Chemistry
5. Pathogen Indicators
6. Continuous Water Quality (2-week deployment; 15-minute interval)
    a. Temperature
    b. Dissolved Oxygen
    c. Conductivity
    d. pH
7. Continuous Temperature Measurements (5-month deployment; 1-hour interval)

During pesticide & toxicity monitoring the following data types were collected and evaluated for quality assurance and quality control:

1. Water Toxicity (dry weather; MRP Provision C.8.g.i)
2. Sediment Toxicity (dry weather; MRP Provision C.8.g.ii)
3. Sediment Chemistry (dry weather; MRP Provision C.8.g.ii)

1.2. Laboratories

Laboratories that provided analytical and taxonomic identification support to SMCWPPP and the RMC were selected based on demonstrated capability to adhere to specified protocols. Laboratories are certified and are as follows:

- Caltest Analytical Laboratory (nutrients, chlorophyll a, ash free dry mass, sediment chemistry)
- Pacific EcoRisk, Inc. (water and sediment toxicity)

- Alpha Analytical Laboratories, Inc. (pathogen indicators)
- BioAsessment Services (benthic macroinvertebrate (BMI) identification)
- Jon Lee Consulting (BMI identification Quality Control)
- EcoAnalysts, Inc. (algae identification)

1.3. QA/QC ATTRIBUTES

The RMC SOP and QAPP identify seven data quality attributes that are used to assess data QA/QC. They include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Precision, (6) Accuracy, and (7) Contamination. These seven attributes are compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. DQOs address both quantitative and qualitative assessment of the acceptability of data – representativeness and comparability are qualitative while completeness, sensitivity, precision, accuracy, and contamination are quantitative assessments.

Specific DQOs are based on Measurement Quality Objectives (MQOs) for each analyte. Chemical analysis relies on repeatable physical and chemical properties of target constituents to assess accuracy and precision. Conversely, biological data are quantified by experienced taxonomists relying on organism morphological features.

1.3.1. Representativeness

Data representativeness assesses whether the data were collected so as to represent actual conditions at each monitoring location. For this project, all samples and field measurements are assumed to be representative if they are performed according to protocols specified in the RMC QAPP and SOPs.

1.3.2. Comparability

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For RMC Creek Status monitoring, individual stormwater programs try to maintain comparability within in RMC. The key measure of comparability for all RMC data is the California Surface Water Ambient Monitoring Program (SWAMP).

1.3.3. Completeness

Completeness is the degree to which all data were produced as planned; this covers both sample collection and analysis. For chemical data and field measurements an overall completeness of greater than 90% is considered acceptable for RMC chemical data and field measurements. For bioassessment-related parameters – including BMI and algae taxonomy samples/analysis and associated field measurement – a completeness of 95% is considered acceptable.

1.3.4. Sensitivity

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the chemical analyses in this project, sensitivity is considered to be adequate if the reporting limits (RLs) comply with the specifications in RMC QAPP Appendix E: RMC Target Method Reporting Limits. For benthic macroinvertebrate data, taxonomic identification sensitivity is acceptable provided taxonomists use standard taxonomic effort (STE) Level I as established by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). There is no established level of sensitivity for algae taxonomic identification.

1.3.5. Accuracy

Accuracy is assessed as the percent recovery of samples spiked with a known amount of a specific chemical constituent. Chemistry laboratories routinely analyze a series of spiked samples; the results of these analyses are reported by the laboratories and evaluated using the RMC Database QA/QC Testing Tool. Acceptable levels of accuracy are specified for chemical analytes and toxicity test parameters in

RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.6. Precision

Precision is nominally assessed as the degree to which replicate measurements agree, nominally determined by calculation of the relative percent difference (RPD) between duplicate measurements. Chemistry laboratories routinely analyze a series of duplicate samples that are generated internally. The RMC QAPP also requires collection and analysis of field duplicate samples 5% of all samples for all parameters[1]. The results of the duplicate analyses are reported by the laboratories and evaluated using RMC Database QA/QC Testing Tool. Results of the Tool are confirmed manually. Acceptable levels of precision are specified for chemical analytes and toxicity test parameters in RMC QAPP Appendix A: Measurement Quality Objectives for RMC Analytes, and for biological measurements in Appendix B: Benthic Macroinvertebrate MQOs and Data Production Process.

1.3.7. Contamination

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples. The RMC QAPP also requires collection and analysis of field blank samples at a rate of 5% for orthophosphate.

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[1] The QAPP also requires the collection of field duplicate samples for 10% of biological samples (BMI and algae). However, there are no prescribed methods for determining the precision of these duplicate samples.

2. METHODS

2.1. REPRESENTATIVENESS

To ensure representativeness, each member of the SMCWPPP field crew received and reviewed all applicable SOPs and the QAPP. Field crew members also attended a two-day bioassessment and field sampling training session from the California Water Boards Training Academy. The course was taught by California Department of Fish and Wildlife, Aquatic Bioassessment Laboratory staff and covered procedures for sampling benthic macroinvertebrates, algae, and measuring physical habitat characteristics using the applicable SWAMP SOPs. As a result, each field crew member was knowledgeable of, and performed data collection according to the protocols in the RMC QAPP and SOP, ensuring that all samples and field measurements are representative of conditions in San Mateo County urban creeks.

2.2. COMPARABILITY

In addition to the bioassessment and field sampling training, SMCWPPP field crew members participated in an inter-calibration exercise with other stormwater programs prior to field assessments at least once during the permit term. During the inter-calibration exercise, the field crews also reviewed water chemistry (nutrient) sample collection and water quality field measurement methods. Close communication throughout the field season with other stormwater program field crews also ensured comparability.

Sub-contractors collecting samples and the laboratories performing analyses received copies of the RMC SOP and QAPP, and have acknowledged reviewing the documents. Data collection and analysis by these parties adhered to the RMC protocols and was included in their operating contracts.

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the SMCWPPP Program Quality Assurance staff, and were compared against the methods and protocols specified in the SOPs and QAPP. Specifically, staff checked for conformance with field and laboratory methods as specified in SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.

Electronic data deliverables (EDDs) were submitted to the San Francisco Regional Water Quality Control Board (SFRWQCB) in Microsoft Excel templates developed by SWAMP, to ensure data comparability with the SWAMP program. In addition, data entry followed SWAMP documentation specific to each data type, including the exclusion of qualitative values that do not appear on SWAMP's look up lists[2]. Completed templates were reviewed using SWAMP's online data checker[3], further ensuring SWAMP-comparability.

2.3. COMPLETENESS

2.3.1. Data Collection

All efforts were made to collect 100% of planned samples. Upon completion of all data collection, the number of samples collected for each data type was compared to the number of samples planned and the number required by the MRP, and reasons for any missed samples were identified. When possible, SMCWPPP staff resampled sites if missing data were identified prior to the close of the monitoring period. Specifically, continuous water quality data was reviewed immediately following deployment, and if data were rejected, samplers were redeployed immediately.

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[2] Look up lists available online at http://swamp.waterboards.ca.gov/swamp_checker/LookUpLists.php
[3] Checker available online at http://swamp.waterboards.ca.gov/swamp_checker/SWAMPUpload.php

For bioassessments, the SMCWPPP field crew made all efforts to collect the required number of BMI and algae subsamples per site; in the event of a dry transect, the samples were slid to the closest sampleable location to ensure 11 total subsamples in each station's composite sample.

2.3.2. Field Sheets

Following the completion of each sampling event, the field crew leader/local monitoring coordinator reviewed any field generated documents for completion, and any missing values were entered. Once field sheets were returned to the office, a second SMCWPPP staff member reviewed the field sheets again, and noted any missing data.

2.3.3. Laboratory Results

SMCWPPP staff assessed laboratory reports and EDDs for the number and type of analysis performed to ensure all sites and samples were included in the laboratory results.

2.4. Sensitivity

2.4.1. Biological Data

Benthic macroinvertebrates were identified to SAFIT STE Level I.

2.4.2. Chemical Analysis

The reporting limits for analytical results were compared to the target reporting limits in Appendix E (RMC Target Method Reporting Limits) of the RMC QAPP. Results with reporting limits that exceeded the target reporting limit were flagged.

2.5. Accuracy

2.5.1. Biological Data

Ten percent of the total number of BMI samples collected was submitted to a separate taxonomic laboratory, Jon Lee Consulting, for independent assessment of taxonomic accuracy, enumeration of organisms, and conformance to standard taxonomic level. For SMCWPPP, two samples were evaluated for QC purposes. Results were compared to measurement quality objectives (MQOs) in Appendix B (Benthic macroinvertebrate MQOs and Data Production Process).

2.5.2. Chemical Analysis

Caltest evaluated and reported the percent recovery (PR) of laboratory control samples (LCS; in lieu of reference materials) and matrix spikes (MS), which were recalculated and compared to the applicable MQOs set by Appendix A (Measurement Quality Objectives for RMC Analytes) of the RMC QAPP MQOs. If a QA sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

For reference materials, percent recovery was calculated as:

$$PR = MV / EV \times 100\%$$

Where: MV = the measured value
EV = the expected (reference) value

For matrix spikes, percent recovery was calculated as:

$$PR = [(MV - NV) / SV] \times 100\%$$

Where: MV = the measured value of the spiked sample
NV = the native, unspiked result
SV = the spike concentration added

2.5.3. Water Quality Data Collection

Accuracy for continuous water quality monitoring sondes was assured via continuing calibration verification for each instrument before and after each two-week deployment. Instrument drift was calculated by comparing the instrument's measurements in standard solutions taken before and after deployment. The drift was compared to measurement quality objectives for drift listed on the SWAMP calibration form, included as an attachment to the RMC SOP FS-3.

Temperature data were checked for accuracy by comparing measurements taken by HOBO temperature loggers with NIST thermometer readings in room temperature water and ice water prior to deployment. The mean difference and standard deviation for each HOBO was calculated, and if a logger had a mean difference exceeding 0.2 ^{o}C, it is replaced.

2.6. PRECISION

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (one) of the 10 probabilistic sites and duplicate water chemistry samples were collected at 10% (one) of the probabilistic sites sampled to evaluate precision of field sampling methods. The relative percent difference (RPD) for water chemistry field duplicates was calculated and compared to the MQO (RPD < 25%) set by Table 26-1 in Appendix A of the RMC QAPP. If the RPD of the two field duplicates did not meet the MQO, the results were flagged.

The RMC QAPP requires collection and analysis of duplicate sediment chemistry and toxicity samples at a rate of 5% of total samples collected for the project. For WY 2017, one field duplicate was collected in Alameda County for dry weather sediment chemistry, sediment toxicity, and water toxicity sample to account for the six pesticide & toxicity sites collectively monitored by the RMC in WY 2017. The sediment sample and field duplicate were collected together using the Sediment Scoop Method described in the RMC SOP, homogenized, and then distributed to two separate containers. For sediment chemistry field duplicates, the RPD was calculated for each analyte and compared to the MQOs (RPD < 25%) set by Tables 26-7 through 26-11 in Appendix A of the RMC QAPP. For sediment and water toxicity field duplicates, the RPD of the batch mean was calculated and compared to the recommended acceptable RPD (< 20%) set by Tables 26-12 and 26-13 in Appendix A. If the RPD of the field duplicates did not meet the MQO, the results were flagged.

The RPD is calculated as:

RPD = ABS ([X1-X2] / [(X1+X2) / 2])

Where: X1 = the first sample result
X2 = the duplicate sample result

No field duplicate is required for pathogen indicators.

2.6.2. Chemical Analysis

The analytical laboratory, Caltest, evaluated and reported the RPD for laboratory duplicates, laboratory control duplicates, and matrix spike duplicates. The RPDs for all duplicate samples were recalculated and compared to the applicable MQO set by Appendix A of the RMC QAPP. If a laboratory duplicate sample did not meet MQOs, all samples in that batch for that particular analyte were flagged.

2.7. CONTAMINATION

Blank samples were analyzed for contamination, and results were compared to MQOs set by Appendix A of the RMC QAPP. For creek status monitoring, the RMC QAPP requires all blanks (laboratory and field) to be less than the analyte reporting limits. If a blank sample did not meet this MQO, all samples in that batch for that particular analyte were flagged.

3. RESULTS

3.1. Overall Project Representativeness

The SMCWPPP staff and field crew members were trained in SWAMP and RMC protocols, and received significant supervision from the local monitoring coordinator and QA officer. As a result, creek status monitoring data was considered to be representative of conditions in San Mateo County Creeks.

3.2. Overall Project Comparability

SMCWPPP creek status monitoring data was considered to be comparable to both other agencies in the RMC and to SWAMP due to trainings, use of the same electronic data templates, and close communication.

3.3. Bioassessments and Physical Habitat Assessments

In addition to algae and BMI taxonomic samples, the SMCWPPP field crew collected chlorophyll a and ash free dry mass samples during bioassessments. The taxonomic and analytical laboratories received and reviewed the RMC QAPP, and communicated with the local QA officer. The BMI taxonomic laboratory, BioAssessment Services, confirmed that the laboratory QA/QC procedures aligned with the procedures in Appendices B through D of the RMC QAPP and meet the BMI MQOs in Appendix B.

3.3.1. Completeness

SMCWPPP completed bioassessments and physical habitat assessments for 10 of 10 planned/required sites for a 100% sampling completion rate. However, physical habitat assessments could not be taken at several transects due to inaccessibility.

3.3.2. Sensitivity

The benthic macroinvertebrate taxonomic identification met sensitivity objectives; the taxonomy laboratory, BioAssessment Services, and QC laboratory, Jon Lee Consulting, confirmed that organisms were identified to SAFIT STE Level I, with the exception of Chironomidae which was analyzed to SAFIT level 1a.

The reporting limit for ash free dry mass analysis (8 mg/L) was much higher than the RMC QAPP target reporting limits (2 mg/L) due to high concentrations requiring large dilutions. The results were several orders of magnitude higher than the actual and target reporting limit and were not affected by the higher reporting limit. Similarly, the chlorophyll a analytical reporting limits (50 mg/L) were an order of magnitude higher than the QAPP target limits (5 mg/L). Again, reporting limits were elevated due to large dilutions as concentrations were well above the analytical reporting limit and were not impacted by the elevated reporting limit.

Note that the target reporting limits in the RMC QAPP are set by the SWAMP, but there are currently no appropriate SWAMP targets for either ash free dry mass and chlorophyll a. Limits in the RMC QAPP are meant to reflect current laboratory capabilities. At lower analyte concentrations where a dilution would not be necessary, the analytical reporting limits would have met the target reporting limits.

3.3.3. Accuracy

The BMI sample that was submitted to an independent QC taxonomic laboratory had one specimen misidentifications and three minor counting errors. The specimen misidentification was speculated to be due to a sorting error. The QC laboratory calculated sorting and taxonomic identification metrics, which were compared to the measurement quality objectives in Table 27-1 in Appendix B of the RMC QAPP. All MQOs were met. A comparison of the metrics with the MQOs is shown in Table 1. A copy of the QC laboratory report is available upon request.

There is currently no protocol for evaluating the accuracy of algae taxonomic identification.

Table 1. Quality control metrics for taxonomic identification of benthic macroinvertebrates collected in San Mateo County in WY 2017 compared to measurement quality objectives.

Quality Control Metric	MQO	Error Rate	Exceeds MQO?
Recount Accuracy	> 95%	99.84%	No
Taxa ID	≤ 10%	4%	No
Individual ID	≤ 10%	0.33%	No
Low Taxonomic Resolution Individual	≤ 10%	0%	No
Low Taxonomic Resolution Count	≤ 10%	0%	No
High Taxonomic Resolution Individual	≤ 10%	0.33%	No
High Taxonomic Resolution Count	≤ 10%	4%	No

3.3.4. Precision

Field blind duplicate chlorophyll a and ash free dry mass samples were collected at one site in WY 2017 and were sent to the laboratory for analysis.

Duplicate field samples do not provide a valid estimate of precision in the sampling and are of little use to assessing precision, because there is no reasonable expectation that duplicates will produce identical data. Nonetheless, the RPD of the cholorophyll a and ash free dry mass duplicate results were calculated and compared to the MQO (< 25%) for conventional analytes in water (Table 26-1 in Appendix B of the RMC QAPP). Due to the nature of chlorophyll a and ash free dry mass collection, the RPDs for both parameters are expected to exceed the MQO, and did. The field duplicate results and their RPDs are shown in Table 2.

Again, discrepancies were to be expected due to the potential natural variability in algae production within the reach and the collection of field duplicates at different locations along each transect (as specified in the protocol). As a result, both parameters have frequently exceeded the field duplicate RPD MQOs during past years' monitoring efforts.

Table 2. Field duplicate water chemistry results for sites 205R03272, collected on May 31, 2017

Analyte	Units	205R00609 May 10, 2017			
		Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	mg/m^2	40.3	115.2	96%	Yes
Ash Free Dry Mass	g/m^2	48.1	223.1	129%	Yes

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.3.5. Contamination

All field collection equipment was decontaminated between sites in accordance with the RMC SOP FS-8 and CDFW protocols. As a result, it is assumed that samples were free of biological contamination.

3.4. FIELD MEASUREMENTS

Field measurements of temperature, dissolved oxygen, pH, specific conductivity, and chlorine residual were collected concurrently with bioassessments and water chemistry samples. Chlorine residual was measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. All other parameters were measured with a YSI Professional Plus or YSI 600XLM-V2-S multi-parameter instrument. All data collection was performed according to RMC SOP FS-3 (Performing Manual Field Measurements).

3.4.1. Completeness

Temperature, dissolved oxygen, pH, specific conductivity, total chlorine residual, and free chlorine residual were collected at all 10 bioassessment sites for a 100% completeness rate.

3.4.2. Sensitivity

Free and total chlorine residual were measured using a HACH Pocket Colorimeter™ II, which uses the DPD method. For this method, the estimated detection limit for the low range measurements (0.02-2.00 mg/L) was 0.02 mg/L. There is, however, no established method reporting limit. Based on industry standards and best professional judgment, the method reporting limit is assumed to be 0.1 mg/L, which is much lower than the 0.5 mg/L target reporting limit listed in the RMC QAPP for free and total chlorine residual.

There are also no method reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.4.3. Accuracy

Data collection occurred Monday through Thursday, and the multi-parameter instrument was calibrated at least 12 hours prior to the first sample on Monday, with the dissolved oxygen probe calibrated every morning to ensure accurate measurements. Calibration solutions are certified standards, whose expiration dates were noted prior to use. The chlorine kit is factory-calibrated and is sent into the manufacturer every other year to be calibrated.

3.4.4. Precision

Precision could not be measured as no duplicate field measurements are required or were collected.

3.5. WATER CHEMISTRY

Water chemistry samples were collected by SMCWPPP staff concurrently with bioassessment samples and analyzed by Caltest Analytical Laboratory (Caltest) within their respective holding times. Caltest performed all internal QA/QC requirements as specified in the QAPP and reported their findings to the RMC. Key water chemistry Measurement Quality Objectives (MQOs) are listed in RMC QAPP Table 26-2.

3.5.1. Completeness

SMCWPPP collected 100% of planned/required water chemistry samples at the 10 bioassessment sites including one field duplicate sample. Samples were analyzed for all requested analytes, and 100% of results were reported. Water chemistry data were flagged when necessary, but none were rejected.

3.5.2. Sensitivity

Laboratory reporting limits met or were lower than target reporting limits for all nutrients except chloride and nitrate. The reporting limit for all chloride samples exceeded the target reporting limit, but concentrations were much higher than reporting limits, and the elevated reporting limits do not decrease confidence in the measurements.

The reporting limit (0.05 mg/L) and method detection limit (0.02 mg/L) for nitrate samples were higher than the target reporting limit (0.01 mg/L). As a result, one sample was flagged as “detected, not quantified,” but it would have been quantified at the lower reporting limit. Additionally, the nitrate concentrations at three other sites were below the method detection limit. SMCWPPP has discussed the reporting limits with Caltest, and there is the possibility for a lower reporting limit for future analysis. Target and actual reporting limits are shown in Table 3.

Table 3. Target and actual reporting limits for nutrients analyzed in SMCWPPP creek status monitoring. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.02	0.02
Chloride	0.25	10-100
Total Kjeldahl Nitrogen	0.5	0.1
Nitrate	0.01	0.05
Nitrite	0.01	0.005
Orthophosphate	0.01	0.01
Silica	1	1
Phosphorus	0.01	0.01

3.5.3. Accuracy

Recoveries on all laboratory control samples (LCS) were within the MQO target range of 80-120% recovery, and most matrix spikes (MS) and matrix spike duplicates (MSD) percent recoveries (PR) were within the target range. Two MS/MSD percent recoveries exceeded the MQO range listed in the RMC QAPP for conventional analytes, including ammonia, and total Kjeldahl nitrogen (TKN). The QA samples affected eight sites, whose results have been assigned the appropriate SWAMP flag.

The PR ranges on laboratory reports were 70-130%, 85-115% or 90-110% for some conventional analytes (nutrients) while the RMC QAPP lists the PR as 80-120% for all conventional analytes in water. As a result, some QA samples that exceeded RMC MQOs were flagged by the local QA officer, but not by the laboratory and vice versa.

3.5.4. Precision

The relative percent differences (RPD) for all laboratory control sample and matrix spike duplicate pairs were consistently below the MQO target of < 25%.

Nutrient field duplicates were collected at two sites in San Mateo County and were compared against the original samples. For WY 2017, the total Kjeldahl nitrogen duplicate sample exceeded the RPD MQO. In past years of sampling, total Kjeldahl nitrogen has been common among the analytes that exceed the field duplicate RPD MQOs. Field crews will continue to make an effort in subsequent years to collect the original and duplicate samples in an identical fashion.

The field duplicate water chemistry results and their RPDs are shown in Tables 4. Because of the variability in reporting limits, values less than the Reporting Limit (RL) were not evaluated for RPD. For those analytes whose RPDs could be calculated and did not meet the RMC MQO, they were assigned the appropriate SWAMP flag.

Table 4. Field duplicate water chemistry results for site 204R03272, collected on May 31, 2017. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Ammonia as N	Total	mg/L	0.079	0.082	4%	No
Chloride	None	mg/L	18	18	0%	No
Nitrate as N	None	mg/L	0.051	J 0.044	N/A	N/A
Nitrite as N	None	mg/L	J 0.003	J 0.003	N/A	N/A
Nitrogen, Total Kjeldahl	None	mg/L	0.26	0.4	42%	Yes
Orthophosphate as P	Dissolved	mg/L	J 0.008	J 0.008	N/A	N/A
Phosphorus as P	Total	mg/L	0.022	0.021	5%	No
Silica as SiO2	Total	mg/L	9.8	9.6	2%	No

[a]In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.5.5. Contamination

None of the target analytes were detected in any of the laboratory blanks at levels above their reporting limit. All analytes were non-detect in the laboratory blanks. The RMC QAPP does not require field blanks to be collected, and possible contamination from sample collection could not be assessed. However, the SMCWPPP field crew takes appropriate precautions to avoid contamination, including wearing gloves during sample collection and rinsing sample containers with stream water when preservatives are needed.

3.6. Pathogen Indicators

Pathogen indicator samples were collected by SMCWPPP staff and were analyzed by Alpha Analytical Laboratories, Inc. Samples were collected August 28, 2017, and were received and incubated by the laboratory well within the 8-hour hold time. The laboratory tested the samples for the presence of *E. coli* and enterococcus.

3.6.1. Completeness

All five required/planned pathogen indicator samples were collected for a 100% completeness rate.

3.6.2. Sensitivity

The reporting limits for *E. coli* and enterococcus (1 MPN/100mL and 2 MPN/100m, respectively) met the target RL of 2 MPN/100mL listed in the project QAPP.

3.6.3. Accuracy

Negative and positive laboratory controls were run for microbial media. A negative response was observed in the negative control and a positive response was observed in the positive control required by the project QAPP Table 26-4.

3.6.4. Precision

The RMC QAPP requires one laboratory duplicate to be run per 10 samples or per analytical batch, whichever is more frequent. In WY 2017, five *E.coli* and five enterococcus samples were collected, and one laboratory duplicate was run for each analyte. However, determining precision for pathogen indicators requires 15 duplicates sets. Due to the small number of samples collected for this project, there were not enough laboratory duplicates to determine precision. The RPD for the laboratory duplicates that were run could not be calculated as the original and duplicate samples for both *E. coli* and enterococcus were greater than the method's upper threshold. See Table 5 for the lab duplicate results.

The RMC QAPP does not require a field duplicate to be collected for pathogen indicators. However, one field duplicate was collected in WY 2017 at 202DEN005. The RDP for *E.coli* was 75% and 17% for enterococcus. Since there is no requirement for pathogen field duplicates, there is no corresponding MQO, and the precision could not be assessed. See Table 5 for the field duplicate results.

Table 5. Lab and field duplicate pathogen results collected on August 29, 2017.

Duplicate Type	Analyte	Original Result (MPN/100mL)	Duplicate Result (MPN/100mL)	RPD
Lab Duplicate	E.Coli	> 2419.6	> 2419.6	NA
Lab Duplicate	Enterococcus	> 2419.6	> 2419.6	NA
Field Duplicate	E.Coli	166.4	365.4	75%
Field Duplicate	Enterococcus	435.2	365.4	17%

3.6.5. Contamination

One method blank (sterility check) was run in the batch for *E. coli* and enterococcus. No growth was observed in the blank.

3.7. Continuous Water Quality

Continuous water quality measurements were recorded at two sites during the spring (May/June 2017), concurrent with bioassessments, and again in the summer (August/September 2017) in compliance with the MRP. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes for approximately two-weeks using a multi-parameter water quality sonde (YSI 6600-V2).

3.7.1. Completeness

The MRP requires one to two-week deployments, and both deployments exceeded the one week minimum. The first deployment lasted 14 days while the second deployment lasted 12 days. Sondes collected data for 100% of the planned deployments, and no data were rejected.

3.7.2. Sensitivity

There are no method reporting limits for temperature, dissolved oxygen, pH, and conductivity measurements, but the actual measurements are much higher than target reporting limits in the RMC QAPP, so it is assumed that target reporting limits are met for all field measurements.

3.7.3. Accuracy

The SMCWPPP staff conduct pre- and post- deployment sonde calibrations for the two sondes used during monitoring events and calculate the drift during the deployments. A summary of the drift measurements is shown in Table 6. During the second monitoring event, the sonde deployed at 202SPE040 exceeded the drift MQO for dissolved oxygen. Oxygen results at this site were subsequently flagged for this deployment, but not rejected.

Table 6. Drift measurements for two continuous water quality monitoring events in San Mateo County urban creeks during WY 2017. Bold and highlighted values exceeded measurement quality objectives. N/A indicates that a drift check could not be calculated due to missing records.

Parameter	Measurement Quality Objectives	202SPE040		202SPE070	
		Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	-0.21	-0.86	-0.15	-0.49
pH 7.0	± 0.2	-0.09	-0.09	0.05	0.02
pH 10.0	± 0.2	0.01	-0.04	0.03	-0.03
Specific Conductance (uS/cm)	± 10%	1.7%	-0.6%	2.3%	-0.2%

3.7.4. Precision

There is no protocol listed in the RMC QAPP for measuring the precision of continuous water quality measurements.

3.8. Continuous Temperature Monitoring

Continuous temperature monitoring was conducted from April through September 2016 at nine sites in San Mateo County. Onset HOBO Water Temperature data loggers recorded one measurement per hour.

3.8.1. Completeness

The MRP requires SMCWPPP to monitor four stream reaches for temperature each year, but anticipating the potential for a HOBO temperature logger to be lost during such a long deployment, SMCWPPP deployed one extra temperature logger, for a total of five loggers. In the middle of the deployment, SMCWPPP staff checked the loggers to ensure that they were still in the present and recording. During the field check, staff also downloaded the existing data and redeployed the loggers. Since all nine loggers recorded 100% of the deployment period, SMCWPPP achieved a completion rate of over 100%.

3.8.2. Sensitivity

There is no target reporting limit for temperature listed in the RMC QAPP, thus sensitivity could not be evaluated for continuous temperature measurements.

3.8.3. Accuracy

A pre-deployment accuracy check was run on the temperature loggers in March 2017. Several of the loggers exceeded the 0.2 °C mean difference for the room temperature bath (<0.25 °C), but none exceeded the 0.2 °C mean difference for the ice bath. The deviations were attributed to poor mixing. Consequently, the accuracy check was conducted again for all loggers. During the second accuracy check none of the loggers exceeded the mean difference for either temperature. All tested loggers were deployed, and no data were flagged.

3.8.4. Precision

There are no precision protocols for continuous temperature monitoring.

3.9. Sediment Chemistry

The dry season sediment chemistry sample was collected by Kinnetic Laboratories, Inc (KLI) concurrently with the dry season toxicity sample on July 13, 2017. Inorganic and synthetic organic compounds were analyzed by Caltest and grain size distribution was analyzed by Soil Control Laboratories, a subcontractor laboratory. The sample was analyzed within the one year holding time for analytes in sediment, set by the RMC SOP. Caltest conducted all QA/QC requirements as specified in the RMC QAPP and reported their findings to the RMC. Key sediment chemistry MQOs are listed in RMC QAPP Tables 26-9 through 26-11. Sediment chemistry data were flagged when necessary, but none were rejected

3.9.1. Completeness

The MRP requires a sediment chemistry sample to be collected at one location each year. In WY 2017, SMCWPPP collected the sediment chemistry sample at 202SPE005. The laboratories analyzed and reported 100% of the required analytes.

3.9.2. Sensitivity

A comparison of target and actual reporting limits for those parameters is shown in Table 7. For sediment chemistry analysis conducted in WY 2017, laboratory reporting limits were higher than RMC QAPP target reporting limits for analytes except for except for bifenthrin. Since reporting limits for a sample are dependent on the percent solids of that sample, it is likely that the amount of solids in the sample resulted in these exceedances.

Table 7. Comparison of target and actual reporting limits for sediment analytes where reporting limits exceeded target limits. Sediment samples were collected in San Mateo County creeks in WY 2017.

Analyte	Target RL mg/kg	Actual RL mg/kg
Arsenic	0.3	0.50
Cadmium	0.01	0.04
Chromium	0.1	0.5
Copper	0.01	0.2
Lead	0.01	0.1
Nickel	0.02	0.1
Zinc	0.1	1.0
Bifenthrin	0.33	0.33
Permethrin	0.03	0.33

3.9.3. Accuracy

Inorganic Analytes

No QA samples exceeded the QAPP MQO for LCS percent recovery (PR) for metals (75-125%), but the MS and/or MSD samples exceeded the PR MQO for chromium, copper, lead, nickel, and zinc. These samples were flagged but not rejected.

Synthetic Organic Compounds

The percent recovery MQO for pyrethroids and other synthetic organic compounds in sediment is 50-150% in the RMC QAPP. However, the PR MQOs listed in the laboratory reports for synthetic organic compounds varied by analyte and were much larger than PR ranges listed in the QAPP. The MQOs ranged from 1 to 275% in certain cases. As a result, several analytes were flagged by the local QA officers, but not by the laboratory.

None of the laboratory control sample (LCS) percent recoveries exceeded the RMC MQO range. However, the MS/MSD percent recoveries exceeded the RMC MQO range for 12 PAHs and one pyrethroid (deltamethrin). The PAHs MS/MSD samples that exceeded the PR MQO include benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(k)fluoranthene, dibenz(a,h)anthracene, fluoranthene, 1-methylphenanthrene, naphthalene, perylene, phenanthrene, and pyrene.

3.9.4. Precision

Inorganic Analytes

The RMC QAPP lists the maximum RPD for inorganic analytes (metals) as 25%, while the laboratory report lists the maximum as 30% for most metals and 35% for mercury. Nevertheless, all the matrix spike duplicates for metals were well below the RMC RPD MQO of 25%.

Synthetic Organic Compounds

The maximum RPD for synthetic organics listed in the sediment laboratory report lists ranges from 30 to 50% for most analytes. However, the RMC QAPP lists the MQO as < 25% RPD for most synthetic organics, < 35% for pyrethroids and fipronil, and < 40% for carbaryl. Three MS/MSD pairs slightly exceeded the QAPP MQOs for RPD (< 25%), including benz(a)anthracene, benzo(k)fluoranthene, and perylene. These three analytes were flagged by the local QA officer, but not by the laboratory. None of the LCS duplicates exceeded the RPD MQO.

Field Duplicates

A sediment sample field duplicate was collected in Alameda County on July 13, 2017 and was evaluated for precision. The field duplicate sample and corresponding RPDs are shown in Table 7. Because of the variability in reporting limits, values less than the Reporting Limit (RL) were not evaluated for RPD. Analytes that exceeded the MQO of RPD < 25% were very coarse sand (1 to <2 mm), granules (2 to <4 mm), small pebbles (4 to <8 mm), and benzo(e)pyrene. The three particle size distribution categories that exceeded the MQOs are adjacent in size bins. When the three categories are combined into one larger category (1 to <8 mm), the RPD for the two samples is 25% as compared to 46-87%.

Given the inherent variability associated with field duplicates, the low number of analytes with RPDs outside of the MQO limits is notable. The method used to collect sediment field duplicates provides more insight to laboratory precision than precision of field methods; however, the results do suggest that field methods are very precise.

Table 8. Sediment chemistry duplicate field results for site 205R01198, collected on July 13, 2017 in Alameda County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

	Analyte	Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
Grain Size Distribution	Clay: <0.0039 mm	%	20.48	22.95	11.4%	No
	Silt: 0.0039 to <0.0625 mm	%	45.53	42.26	7%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	12.71	12.93	2%	No
	Sand: Fine 0.125 to <0.25 mm	%	13.3	13.09	2%	No
	Sand: Medium 0.25 to <0.5 mm	%	5.53	5.91	7%	No
	Sand: Coarse 0.5 to <1.0 mm	%	1.62	1.86	14%	No
	Sand: V. Coarse 1.0 to <2.0 mm	%	1.62	1.01	46%	Yes
	Granule: 2.0 to <4.0 mm	%	0.28	0.71	87%	Yes
	Pebble: Small 4 to <8 mm	%	0.93	0.48	64%	Yes
	Pebble: Medium 8 to <16 mm	%	ND	ND	N/A	N/A
	Pebble: Large 16 to <32 mm	%	ND	ND	N/A	N/A
	Pebble: V. Large 32 to <64 mm	%	ND	ND	N/A	N/A
Metals	Arsenic	mg/Kg dw	4.2	4.7	11%	No
	Cadmium	mg/Kg dw	0.55	0.57	4%	No
	Chromium	mg/Kg dw	45	47	4%	No
	Copper	mg/Kg dw	27	30	11%	No
	Lead	mg/Kg dw	38	37	3%	No
	Nickel	mg/Kg dw	56	57	2%	No
	Zinc	mg/Kg dw	130	140	7%	No
Pyrethroids (MQO <35%)	Bifenthrin	ng/g dw	3.1	3.2	3%	No
	Cyfluthrin, total	ng/g dw	0.49	0.58	17%	No
	Cyhalothrin, Total lambda-	ng/g dw	DNQ	DNQ	N/A	N/A
	Cypermethrin, total	ng/g dw	DNQ	DNQ	N/A	N/A
	Deltamethrin/Tralomethrin	ng/g dw	ND	ND	N/A	N/A
	Esfenvalerate/Fenvalerate, total	ng/g dw	ND	ND	N/A	N/A
	Permethrin, Total	ng/g dw	ND	0.96	N/A	N/A
	Total Organic Carbon	%	7.2	6.2	15%	No
	Carbaryl	mg/Kg dw	ND	ND	N/A	N/A
Fipronil	Fipronil	ng/g dw	ND	ND	N/A	N/A
	Fipronil Desulfinyl	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfide	ng/g dw	ND	ND	N/A	N/A
	Fipronil Sulfone	ng/g dw	0.35	0.37	6%	No
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	ND	ND	N/A	N/A
	Acenaphthylene	ng/g dw	ND	ND	N/A	N/A
	Anthracene	ng/g dw	ND	ND	N/A	N/A
	Benz(a)anthracene	ng/g dw	ND	ND	N/A	N/A
	Benzo(a)pyrene	ng/g dw	36	38	5%	No
	Benzo(b)fluoranthene	ng/g dw	60	63	5%	No
	Benzo(e)pyrene	ng/g dw	36	25	36%	Yes
	Benzo(g,h,i)perylene	ng/g dw	ND	ND	N/A	N/A
	Benzo(k)fluoranthene	ng/g dw	ND	ND	N/A	N/A
	Biphenyl	ng/g dw	ND	ND	N/A	N/A
	Chrysene	ng/g dw	120	130	8%	No
	Dibenz(a,h)anthracene	ng/g dw	ND	ND	N/A	N/A

Table 8. Sediment chemistry duplicate field results for site 205R01198, collected on July 13, 2017 in Alameda County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
	Dibenzothiophene	ng/g dw	ND	ND	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	36	38	5%	No
	Fluoranthene	ng/g dw	240	250	4%	No
	Fluorene	ng/g dw	ND	ND	N/A	N/A
	Indeno(1,2,3-c,d)pyrene	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	ND	ND	N/A	N/A
	Methylnaphthalene, 2-	ng/g dw	ND	ND	N/A	N/A
	Methylphenanthrene, 1-	ng/g dw	ND	ND	N/A	N/A
	Naphthalene	ng/g dw	ND	ND	N/A	N/A
	Perylene	ng/g dw	ND	ND	N/A	N/A
	Phenanthrene	ng/g dw	48	51	6%	No
	Pyrene	ng/g dw	120	130	8%	No

[a] MQO for pyrethroids is <35%. In accordance with the RMC QAPP, if the native concentration of either sample is less than the reporting limit, the RPD is not applicable

3.9.5. Contamination

Lead was detected in an instrument (lab) blank at a concentration above the reporting limit. As a result, lead samples were flagged. None of the other target analytes were detected in any of the blanks.

3.10. Toxicity Testing

Dry season water and sediment toxicity samples were collected by KLI concurrently with dry season sediment chemistry samples at one San Mateo County site on July 13, 2015. All toxicity tests were performed by Pacific EcoRisk. The water samples were analyzed for toxicity to four organisms (*Selenastrum capricornutum, Ceriodaphnia dubia, Pimephales promelas, and Hyalella azteca*) and the sediment samples were analyzed for toxicity to *Hyalella azteca* and *Chironomus dilutus.*

3.10.1. Completeness

The MRP requires the collection of dry season water toxicity samples and dry season sediment toxicity samples at one site per year in San Mateo County. SMCWPPP staff collected the planned/required dry season water and sediment toxicity samples for WY 2017. Pacific EcoRisk tested required organisms for toxicity, and 100% of results were reported.

3.10.2. Sensitivity and Accuracy

Internal laboratory procedures that align with the RMC QAPP, including water and sediment quality testing and reference toxicant testing, were performed and submitted to SMCWPPP. The laboratory data QC checks found that all conditions and responses were acceptable. A copy of the laboratory QC report is available upon request.

3.10.3. Precision

One field duplicate was collected in Alameda County and tested for toxicity by Pacific EcoRisk. The mean toxicity endpoints of test organisms (mean survival, mean cell count, mean biomass, and mean young per female) for the field duplicates were compared, and the RPD for each for toxicity test was calculated. These RPDs are compared to the RMC QAPP MQO of <20% for acute and chronic freshwater toxicity testing (Appendix A, Table 26-12 and 26-13) in Table 8. There is no MQO for sediment toxicity field duplicates listed in the RMC QAPP, so the recommended MQO listed in the RMC QAPP for the water toxicity field duplicates (< 20%) was used as an MQO for to sediment toxicity field duplicates.

Samples met the MQO for toxicity testing for all species and endpoints with the exception of the *Ceriodaphnia dubia* growth endpoint (see Table 8). This was the same outcome in WY 2016 sampling, suggests that *Ceriodaphnia dubia* growth is highly variable and perhaps is not a good indicator of toxicity in Bay Area creeks.

Table 9. Water and sediment toxicity duplicate results for site 20501198, collected on July 13, 2017 in Alameda County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Matrix	Organism	Endpoint	Original Sample Mean	Duplicate Sample Mean	RPD	Exceeds Recommended MQO (<20%)?
Water	Pimephales promelas	% Survival	97.5	92.5	5%	No
Water	Pimephales promelas	Biomass (mg/individual)	0.537	0.556	3%	No
Water	Ceriodaphnia dubia	% Survival	100	100	0%	No
Water	Ceriodaphnia dubia	Young per female	18.7	26.3	34%	Yes
Water	Selenastrum capricornutum	Total Cell Count (cells/mL)	4750000	4940000	4%	No
Water	Hyalella azteca	% Survival	98	96	2%	No
Water	Chironomus dilutus	% Survival	93	92.5	0.5%	No
Sediment	Hyalella azteca	% Survival	63.8	60	6%	No
Sediment	Chironomus dilutus	% Survival	46.2	31.2	39%	No

3.10.4. Contamination

There are no QA/QC procedures for contamination of toxicity samples, but staff followed applicable RMC SOPs to limit possible contamination of samples.

4. CONCLUSIONS

Sample collection and analysis followed MRP and RMC QAPP requirements and data that exceeded measurement quality objectives were flagged. However, no data were rejected.

5. REFERENCES

Bay Area Stormwater Management Agency Association (BASMAA). 2012. Regional Monitoring Coalition Final Creek Status and Long-Term Trends Monitoring Plan. Prepared By EOA, Inc. Oakland, CA. 23 pp.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2016a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 128 pp.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2016b. Creek Status Monitoring Program Standard Operating Procedures Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 192 pp.

Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Team. 2008. SWAMP Quality Assurance Program Plan, Version 1.0. Prepared for the California State Water Quality Control Board by Moss Landing Marine Laboratories and San Jose State University Research Foundation. 1 September. 108 pp.

Appendix B

Regional Stressor/Source Identification (SSID) Report

MRP 2.0 SSID Project Locations, Rationales, Status

Updated March 2018

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
AL-1	2/23/18	ACCWP	Palo Seco Creek		Exploring Unexpected CSCI Results and the Impacts of Restoration Activities	X									Sites where there is a substantial difference in CSCI score observed at a location relative to upstream or downstream sites, including sites on Palo Seco Creek upstream of the Sausal Creek restoration-related sites, that had substantial and unexpected differences in CSCI scores.	The project will provide additional data to aid consideration of unexpected and unexplained CSCI results from previous water year sampling on Palo Seco Creek, enable a more focused study of monitoring data collected over many years in a single watershed, and allow analysis of before and after data at sites upstream and downstream of previously completed restoration activities.	The work plan is under development. Completion planned June 2018.	
AL-2		ACCWP																
CC-1	2/1/18	CCCWP	Lower Marsh Creek		Stressor Source Identification Study of Marsh Creek Fish Kills					X					9 fish kills have been documented in Marsh Creek between September 2005 and October 2017. A conclusive cause has not been identified.	Fish kills are clear indicators that aquatic habitat beneficial uses are not attained in this reach of Marsh Creek. These events are of interest to the public as well as regulatory and resource agencies in SF Bay and Central Valley regions. Past monitoring data from CCCWP and other parties are being used to develop a phased work plan investigating multiple potential causes, including low dissolved oxygen, warm temperatures, daily pH swings, fluctuating flows, physical stranding, and pesticide exposure.	The work plan is under development. Completion planned June 2018.	
SC-1	1/22/18	SCVURPPP	Coyote Creek		Coyote Creek Toxicity SSID Project						X				The SWRCB recently added Coyote Creek to the 303(d) list for toxicity.	This SSID study will investigate sources of toxicity to Coyote Creek.	The work plan will be submitted with SCVURPPP's WY 2017 UCMR.	
SC-2		SCVURPPP																
SM-1	1/31/18	SMCWPPP	Pillar Point / Deer Creek / Denniston Creek		Pillar Point Harbor Bacteria SSID Project								X		FIB samples from 2008, 2011-2012 exceeded WQOs.	The Pillar Point Harbor MST study conducted in 2008, 2011-2012 pointed to urban runoff as a primary contributor to bacteria at Capistrano Beach and Pillar Point Harbor. However, the specific urban locations were not identified nor were the contributing organisms established. This SSID project will investigate bacteria contributions from the urban areas within the watershed.	The work plan will be submitted with SMCWPPP's WY 2017 UCMR.	

BASMAA Regional Monitoring Coalition
Regional Stressor/Source Identification (SSID) Report, prepared in compliance with Municipal Regional Stormwater NPDES Permit (MRP; Order No. R2-2015-0049) Provision C.8.e.ii(1)
MRP 2.0 SSID Project Locations, Rationales, Status
Updated March 2018

SSID Project ID	Date Updated	County/ Program	Creek/ Channel Name	Site Code(s) or Other Site ID	Project Title	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project or Date Completed	EO Concurrence of project completion (per C.8.e.iii.(b))
						Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
FS-1		FSURMP																
TBD		RMC/TBD																

Appendix C

Pillar Point Harbor Bacteria SSID Work Plan

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

March 31, 2018

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ATTACHMENTS

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.

Section 2.0 Problem Definition and Study Objectives

Section 3.0 Study Area, Existing Data, and Candidate Causes

Section 4.0 SSID Investigation Approaches and Schedule

Section 5.0 References

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."*

[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.

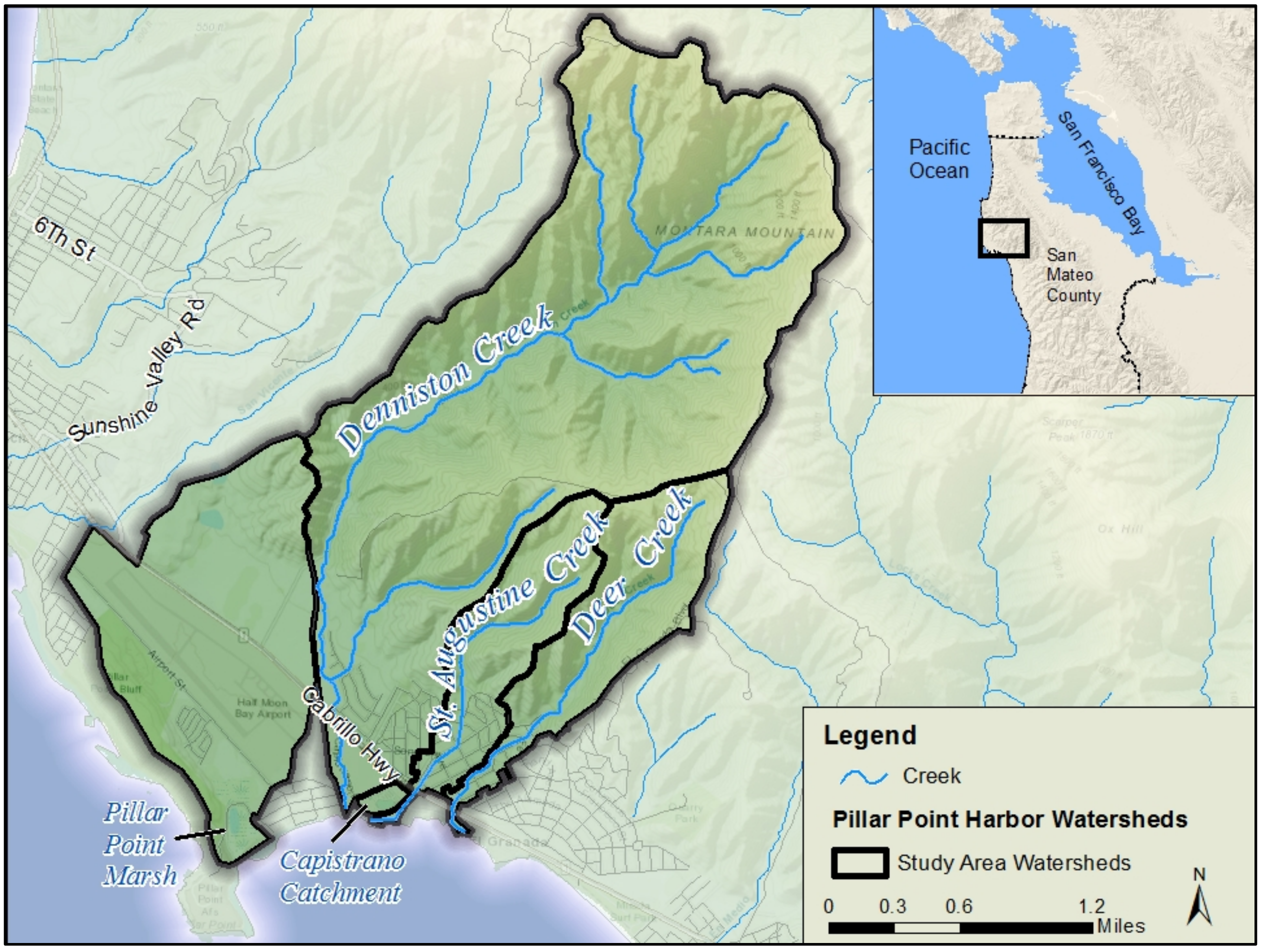

Figure 2. Pillar Point Harbor watershed and subwatersheds.

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.

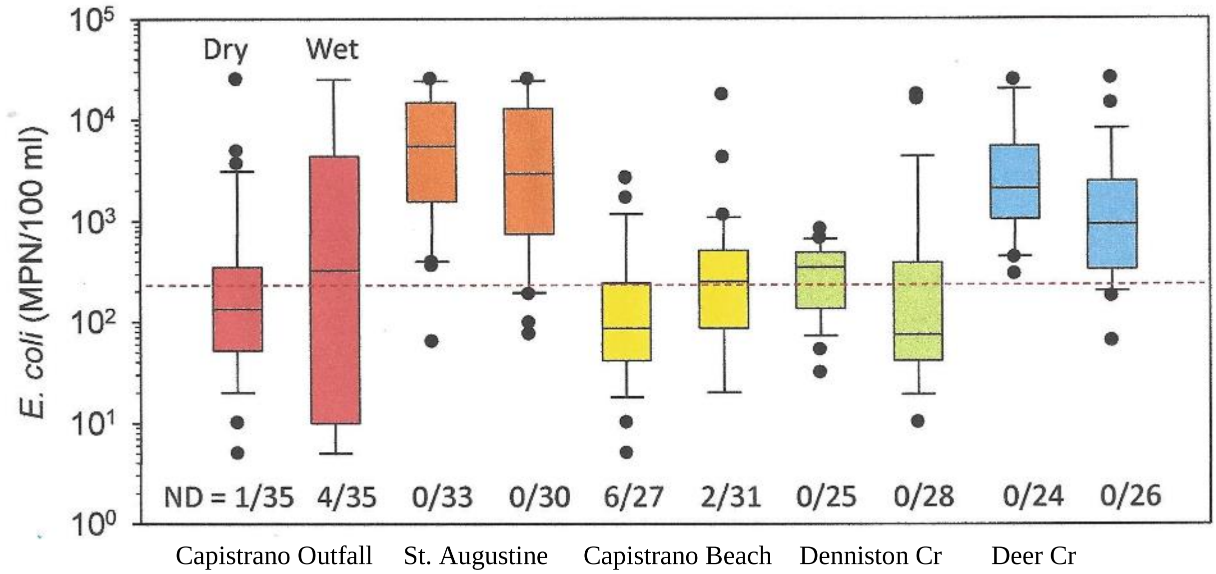

Figure 3. *E. coli* densities during the wet and dry season at four outfalls to Pillar Point Harbor and Capistrano Beach, 2011-2013. Figure 6 from Kim and Wuertz (2014).

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.

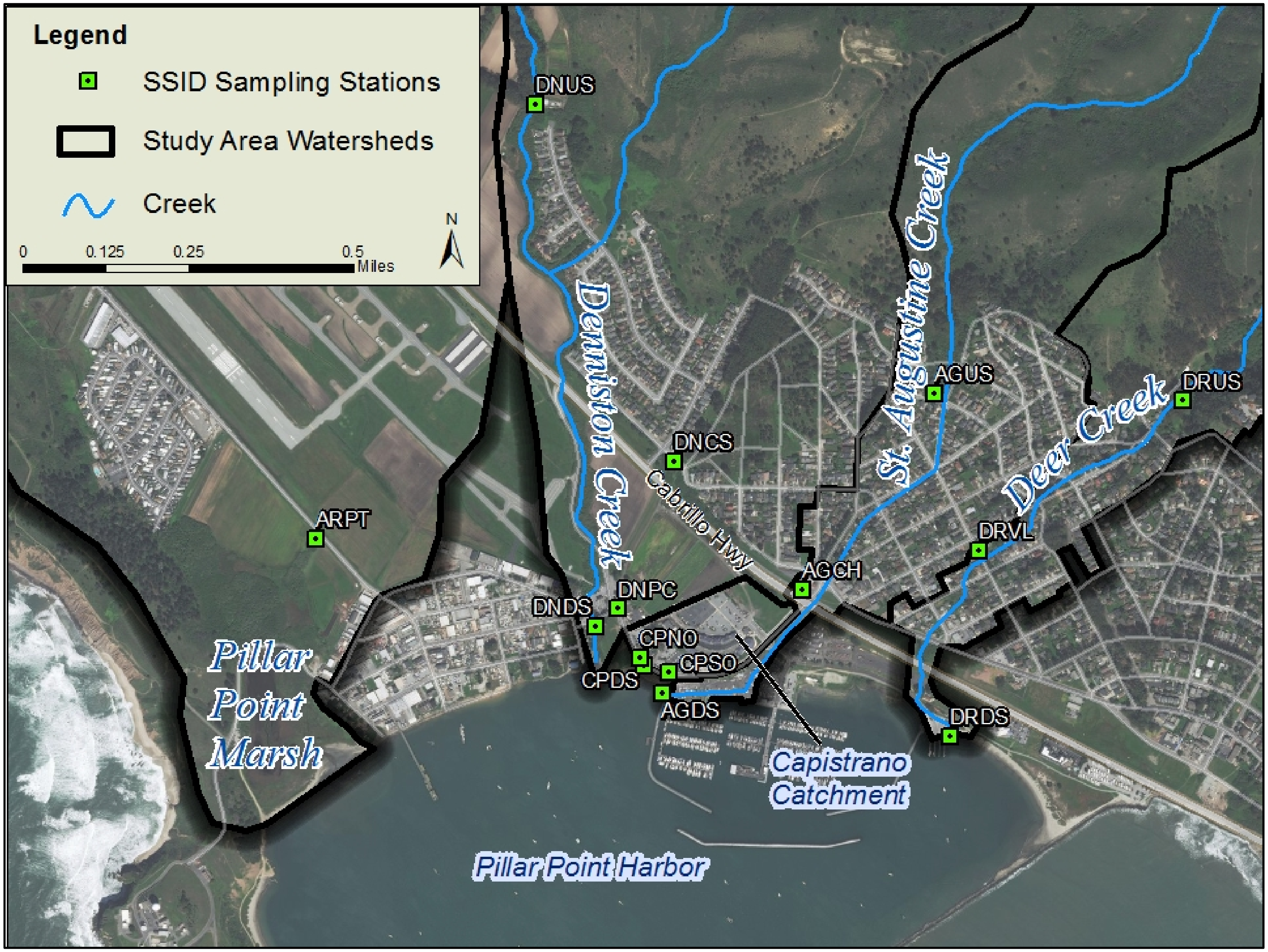

Figure 4. Pillar Point Harbor Watershed Pathogen Indicator SSID Project monitoring stations.

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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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):

____

____

____

____

Appendix D

SMCWPPP Pollutants of Concern Data Report, Water Year 2017

Pollutants of Concern Monitoring Data Report

Water Year 2017

Submitted in Compliance with
NPDES Permit No. CAS612008 (Order No. R2-2015-0049)
Provision C.8.h.iii

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program

A Program of the City/County Association of Governments

March 29, 2018

CREDITS

This report is submitted by the participating agencies in the

SAN MATEO COUNTYWIDE
Water Pollution Prevention Program
Clean Water. Healthy Community.
www.flowstobay.org

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City of Belmont	City of Half Moon Bay	City of San Carlos
City of Brisbane	Town of Hillsborough	City of San Mateo
City of Burlingame	City of Menlo Park	City of South San Francisco
Town of Colma	City of Millbrae	Town of Woodside
City of Daly City	City of Pacifica	County of San Mateo
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LIST OF ABBREVIATIONS

BASMAA	Bay Area Stormwater Management Agency Association
BMP	Best Management Practice
CEC	Chemicals of Emerging Concern
CEDEN	California Environmental Data Exchange Network
CSCI	California Stream Condition Index
CW4CB	Clean Watersheds for Clean Bay
DTSC	California Department of Toxic Substances Control
ECWG	Emerging Contaminants Work Group of the RMP
MRP	Municipal Regional Permit
NPDES	National Pollution Discharge Elimination System
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PFAS	Perfluoroalkyl Sulfonates
PFOS	Perfluorooctane Sulfonates
POC	Pollutant of Concern
RMC	Regional Monitoring Coalition
RMP	San Francisco Estuary Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
SAP	Sampling and Analysis Plan
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program (Countywide Program)
SFEI	San Francisco Estuary Institute
SPoT	Statewide Stream Pollutant Trend Monitoring
SSC	Suspended Sediment Concentration
STLS	Small Tributary Loading Strategy
TOC	Total Organic Carbon
UCMR	Urban Creeks Monitoring Report
USEPA	US Environmental Protection Agency
WY	Water Year

1.0 INTRODUCTION

This Pollutants of Concern (POC) Monitoring Data Report (POC Data Report) was prepared by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP or Countywide Program) on behalf of its member agencies subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for Bay Area municipalities, referred to as the Municipal Regional Permit (MRP). The MRP was reissued by the San Francisco Regional Water Quality Control Board (Regional Water Board) on November 19, 2015 (Regional Water Board, 2015). This report fulfills the requirements of MRP Provision C.8.h.iii for reporting a summary of Provision C.8.f POC Monitoring conducted during Water Year (WY) 2017[1].

This POC Data Report builds on the POC Monitoring Report dated October 10, 2017. In accordance with MRP Provision C.8.h.iv, the POC Monitoring Report included POC monitoring locations, number and types of samples collected, purpose of sampling (i.e., Management Questions addressed), and analytes measured (SMCWPPP 2017b). The October 15, 2017 POC Monitoring Report also described the allocation of sampling effort for POC monitoring planned for WY 2017.

This POC Data Report is included as an appendix to the WY 2017 Urban Creeks Monitoring Report (UCMR). In addition, consistent with MRP Provision C.8.h.ii, POC monitoring data generated from sampling of receiving waters (e.g., creeks) were submitted to the San Francisco Bay Area Regional Data Center for upload to the California Environmental Data Exchange Network (CEDEN)[2].

1.1. POC Monitoring Requirements

Provision C.8.f of the MRP requires monitoring of several POCs including polychlorinated biphenyls (PCBs), mercury, copper, emerging contaminants[3], and nutrients. POC monitoring is conducted on a Water Year (WY) basis. Provision C.8.f specifies yearly (i.e., WY) and total (i.e., permit term) minimum numbers of samples for each POC. In addition, POC monitoring must address the five priority management information needs (i.e., Management Questions) identified in C.8.f:

1. **Source Identification** – identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff;
2. **Contributions to Bay Impairment** – identifying which watershed source areas contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location);
3. **Management Action Effectiveness** – providing support for planning future management actions or evaluating the effectiveness or impacts of existing management actions;

[1] 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 2017 (WY 2017) began on October 1, 2016 and concluded on September 30, 2017.

[2] CEDEN has historically only accepted and shared data collected in streams, lakes, rivers, and the ocean (i.e., receiving waters). In late-2016, we were notified that there were changes to the types of data that CEDEN would accept and share. However, pending further clarification, SMCWPPP will continue to submit only receiving water data to CEDEN.

[3] Emerging contaminant monitoring requirements will be met through participation in the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) special studies. The special studies will account for relevant constituents of emerging concern (CECs) in stormwater and will address at least PFOS, PFAS, and alternative flame retardants being used to replace PBDEs.

4. **Loads and Status** – providing information on POC loads, concentrations or presence in local tributaries or urban stormwater discharges; and
5. **Trends** – providing information on trends in POC loading to the Bay and POC concentrations in urban stormwater discharges or local tributaries over time.

The MRP specifies the minimum number of samples for each POC that must address each Management Question. For example, over the first five years of the permit, a minimum total of 80 PCBs samples must be collected and analyzed. At least eight PCB samples must be collected each year. By the end of year four[4] of the permit term, each of the five Management Questions must be addressed with at least eight PCB samples. It is possible that a single sample can address more than one information need. POC Monitoring requirements are summarized in Table 1.

Data gathering needed to comply with MRP provisions C.11 (Mercury Controls) and C.12 (PCBs controls) is partly addressed through Provision C.8.f (i.e., POC Monitoring). Similarly, certain samples collected per C.11 and C.12 count towards POC monitoring requirements. The specific provisions and their associated timelines are:

- Provisions C.11.a.iii and C.12.a.iii require that Permittees provide a list of management areas in which new PCBs and mercury control measures will be implemented during the permit term. These management areas are designated “Watershed Management Areas” (WMAs) in this report. Progress toward developing the list was initially submitted in a report dated April 1, 2016 (SMCWPPP 2016b). The initial list was expanded upon in the Countywide Program’s September 2016 Annual Report by designating all catchments with high interest parcels (i.e., with land uses associated with PCBs such as old industrial, electrical and recycling) and/or existing or planned PCBs and mercury controls as WMAs (SMCWPPP 2016c). The WMA list was further updated in the Countywide Program’s September 2017 Annual Report (SMCWPPP 2017a) and will be further updated with each subsequent Annual Report, per MRP Provision C.11.a.iii(3). MRP Provision C.8.f (POC Monitoring) supports C.11/12.a requirements by requiring monitoring directed toward source identification (i.e., identifying which WMAs have source areas and provide the greatest opportunities for implementing cost-effective controls that reduce loads of PCBs in urban stormwater runoff).
- Provision C.12.e requires that Permittees collect at least 20 composite samples (region-wide) of the caulks and sealants used in storm drains or roadway infrastructure in public rights-of-way. Results of the investigation must be reported with the 2018 Annual Report, due by September 30, 2018. The Countywide Program is participating in a Bay Area Stormwater Management Agencies Association (BASMAA) regional project to address this requirement. Development of the monitoring plan is anticipated in 2017 with implementation in Fiscal Year 2017/18.

[4] Note that the minimum sampling requirements addressing information needs must be completed by the end of year four of the permit (i.e., WY 2019); whereas, the minimum number of total samples does not need to be met until the end of year five of the permit (i.e., WY 2020).

1.2. Third-Party Data

The Countywide Program strives to work collaboratively with water quality monitoring partners to develop mutually beneficial monitoring approaches. Provision C.8.a.iii of the MRP allows Permittees to use data collected by third-party organizations to fulfill monitoring requirements, provided the data are demonstrated to meet the required data quality objectives. For example, samples collected in San Mateo County through the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP), Clean Watersheds for a Clean Bay (CW4CB, a recently completed project that was funded by a grant from USEPA), and the State's Stream Pollution Trends (SPoT) Monitoring Program may supplement the Countywide Program's efforts towards achieving Provision C.8.f monitoring requirements. Third party monitoring conducted by the RMP, SPoT, and CW4CB also provides context for reviewing and interpreting Countywide Program monitoring results.

Table 1. MRP Provision C.8.f pollutants of concern monitoring requirements.

Pollutant of Concern	Media	Total Samples by the End of Year Five[d]	Yearly Minimum	Minimum Number of Samples That Must Be Collected for Each Information Need by the End of Year Four				
				Source Identification	Contributions to Bay Impairment	Management Action Effectiveness	Loads and Status	Trends
PCBs	Water or sediment	80	8	8	8	8	8	8
Total Mercury	Water or sediment	80	8	8	8	8	8	8
Total & Dissolved Copper	Water	20	2	--	--	--	4	4
Nutrients[a]	Water	20	2	--	--	--	20	--
Emerging Contaminants[b]	--	--	--	--	--	--	--	--
Ancillary Parameters[c]	--	--	--	--	--	--	--	--

a. Ammonium[5], nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, total phosphorus (analyzed concurrently in each nutrient sample).

b. Must include perfluorooctane sulfonates (PFOS, in sediment), perfluoroalkyl sulfonates (PFAS, in sediment), alternative flame retardants. The Permittee shall conduct or cause to be conducted a special study that addresses relevant management information needs for emerging contaminants. The special study must account for relevant Chemicals of Emerging Concern (CECs) in stormwater and would address at least PFOS, PFAS, and alternative flame retardants being used to replace PBDEs.

c. Total Organic Carbon (TOC) should be collected concurrently with PCBs data when normalization to TOC is deemed appropriate. Suspended sediment concentration (SSC) should be collected in water samples used to assess loads, loading trends, or BMP effectiveness. Hardness data are used in conjunction with copper concentrations collected in fresh water.

d. Total samples that must be collected over the five-year Permit term.

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[5] There are several challenges to collecting samples for "ammonium" analysis. Therefore, samples will be analyzed for total ammonia which is the sum of un-ionized ammonia (NH_3) and ionized ammonia (ammonium, NH_{4+}). Ammonium concentrations will be calculated by subtracting the calculated concentration of un-ionized ammonia from the measured concentration of total ammonia. Un-ionized ammonia concentrations will be calculated using a formula provided by the American Fisheries Society that includes field pH, field temperature, and specific conductance. This approach was approved by Regional Water Board staff in an email dated June 21, 2016.

2.0 POC MONITORING RESULTS

In compliance with Provision C.8.f of the MRP, the Countywide Program conducted POC monitoring for PCBs, mercury, copper, and nutrients in WY 2017. General methods employed for POC monitoring and quality assurance/quality control (QA/QC) procedures were similar to previous years (SMCWPPP 2016a). The MRP-required yearly minimum number of samples was met or exceeded for all POCs. The total number of samples collected for each POC, the agency conducting the monitoring, and the Management Questions addressed are shown in Table 2. Specific monitoring stations are shown in Table 3 and mapped in Figure 1. The sections below describe the results of the WY 2017 monitoring. Compliance with applicable water quality standards is discussed in Section 3.0.

2.1. Statement of Data Quality

A comprehensive QA/QC program was implemented by the Countywide Program covering all aspects of POC monitoring with similar protocols to previous years. SMCWPPP (2016a) provides further details and references the CW4CB Quality Assurance Project Plan (QAPP; AMS 2012) and the BASMAA Regional Monitoring Coalition (RMC) QAPP (BASMAA 2016) as bases for QA/QC procedures.

Overall, the results of the QA/QC review suggested that most of the POC monitoring data generated during WY 2017 were of sufficient quality for the purposes of the project. Although some data were flagged in the project database, none was rejected according to Measurement Quality Objectives (MQOs) or Data Quality Objectives (DQOs). However, most of the concentrations of mercury in stormwater runoff samples reported in WY 2017 were lower than prior years by about an order of magnitude. These data were rejected by the project QA/QC officer based on comparison to the results of similar sampling of the same population of urban catchments in recent years by SMCWPPP and other Bay Area countywide stormwater programs. Additional details about the QA/QC review are provided in Attachment 1.

It should be noted that although the WY 2017 mercury stormwater runoff sample results were rejected, these samples still count towards meeting the yearly (i.e., WY) and total (i.e., permit term) minimum numbers of samples for mercury specified in Provision C.8.f (see Table 1). The Countywide Program will consider collecting additional stormwater runoff mercury samples in future years if an evaluation of the San Mateo County and overall Bay Area datasets were to suggest that such additional data were essential for addressing relevant Management Questions (see Section 1.1).

Table 2. Countywide Program and third-party POC monitoring accomplishments, WY 2016 and WY 2017.

Pollutant of Concern/ Organization	Number of Samples	Management Question Addressed[a]					Sample Type and Comments
		1. Source Identification	2. Contributions to Bay Impairment	3. Management Action Effectiveness	4. Loads and Status	5. Trends	
PCBs & Mercury							
WY 2017							
SMCWPPP	17	17	17	--	17	--	Stormwater runoff samples to characterize WMAs
SMCWPPP	67	67	--	--	--	--	Sediment samples to identify source areas
RMP STLS	4	4	4	--	4	--	Stormwater runoff samples to characterize WMAs
SPoT	1	--	--	--	--	1	Sediment sample to assess trends (PCBs only, no mercury)
WY 2016							
SMCWPPP	8	8	8	--	8	--	Stormwater runoff samples to characterize WMAs
RMP STLS	7	7	7	--	7	--	Stormwater runoff samples to characterize WMAs
CW4CB	--	--	--	3	--	--	BMP effectiveness samples at Bransten Road bioretention facilities
Total / MRP Minimum[b]	104 / 80	103 / 8	36 / 8	3 / 8	36 / 8	1 / 8	
Copper							
WY 2017							
SMCWPPP	1	NA	NA	NA	1	--	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
SMCWPPP	5[c]	NA	NA	NA	5	2	Creek water samples collected during storm event and following spring base flows
WY 2016							
SMCWPPP	3	NA	NA	NA	3	--	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
Total / MRP Minimum[b]	9 / 20	NA	NA	NA	9 / 4	2 / 4	

Pollutant of Concern/ Organization	Number of Samples	Management Question Addressed[a]					Sample Type and Comments
		1. Source Identification	2. Contributions to Bay Impairment	3. Management Action Effectiveness	4. Loads and Status	5. Trends	
Nutrients							
WY 2017							
SMCWPPP	5	NA	NA	NA	5	NA	Creek water samples collected during storm event and following spring base flows
WY 2016							
SMCWPPP	2	NA	NA	NA	2	NA	Creek water samples collected from bottom-of-the-watershed stations
Total / MRP Minimum[b]	7 / 20	NA	NA	NA	7 / 20	NA	

NA = The MRP does not require sampling to address the management question.

[a] Individual samples can address more than one Management Question simultaneously.

[b] The MRP overall minimum number of samples must be met by the end of the five-year permit term. The MRP minimum number of samples for each Management Question must be met by the end of year four of the permit.

[c] The number of creek water samples analyzed for copper was incorrectly reported as four in SMCWPPP (2017b).

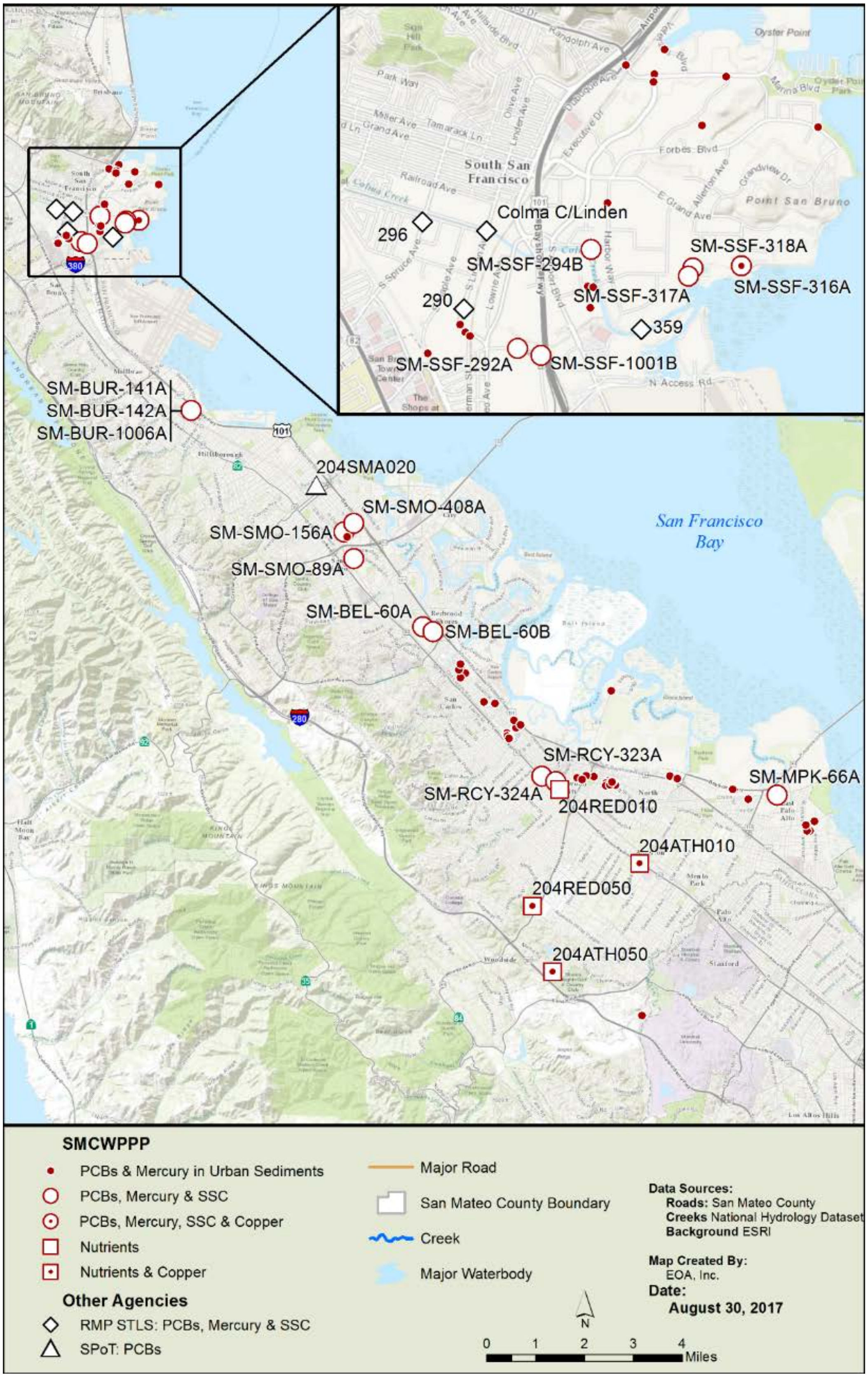

Figure 1. WY 2017 POC monitoring stations in San Mateo County.

Table 3. POC monitoring stations in San Mateo County, WY 2017.

Organization	Station Code	Sample Date	Latitude	Longitude	Matrix	PCBs	Mercury	Suspended Sediment	Total Copper	Dissolved Copper	Hardness as CaCO3	Nutrients[a]
SMCWPPP												
SMCWPPP	SM-SSF-316A	12/10/2016	37.64795	-122.38726	water	x	x	x	x	x	x	
SMCWPPP	SM-SSF-317A	12/10/2016	37.64771	-122.39193	water	x	x	x				
SMCWPPP	SM-SSF-318A	12/10/2016	37.64707	-122.39234	water	x	x	x				
SMCWPPP	SM-SSF-292A	12/15/2016	37.64126	-122.40866	water	x	x	x				
SMCWPPP	SM-SSF-1001B	12/15/2016	37.64077	-122.40637	water	x	x	x				
SMCWPPP	SM-SSF-294B	12/15/2016	37.64896	-122.40178	water	x	x	x				
SMCWPPP	SM-BUR-141A	12/15/2016	37.59184	-122.36627	water	x	x	x				
SMCWPPP	SM-BUR-142A	12/15/2016	37.59183	-122.36626	water	x	x	x				
SMCWPPP	SM-BUR-1006A	12/15/2016	37.59186	-122.36628	water	x	x	x				
SMCWPPP	SM-RCY-323A	1/8/2017	37.48505	-122.23276	water	x	x	x				
SMCWPPP	SM-RCY-324A	1/8/2017	37.48355	-122.22763	water	x	x	x				
SMCWPPP	SM-SMO-89A	1/10/2017	37.54878	-122.30455	water	x	x	x				
SMCWPPP	SM-BEL-60A	2/9/2017	37.52884	-122.27823	water	x	x	x				
SMCWPPP	SM-BEL-60B	2/9/2017	37.52746	-122.27438	water	x	x	x				
SMCWPPP	SM-SMO-156A	2/20/2017	37.55662	-122.30845	water	x	x	x				
SMCWPPP	SM-SMO-408A	2/20/2017	37.55916	-122.30476	water	x	x	x				
SMCWPPP	SM-MPK-66A	3/24/2017	37.48074	-122.14501	water	x	x	x				
SMCWPPP	67 samples, including 6 duplicates. See Appendix A				sediment	x	x					
SMCWPPP	204ATH010	1/9/2017	37.45973	-122.19573	water				x	x	x	x
SMCWPPP	204ATH050[b]	1/9/2017	37.42707	-122.22752	water				x	x	x	x
SMCWPPP	204RED010	1/9/2017	37.48130	-122.22620	water				x	x	x	x
SMCWPPP	204RED010	5/22/2017	37.48130	-122.22620	water				x	x	x	x
SMCWPPP	204RED050[b]	1/9/2017	37.44652	-122.23541	water				x	x	x	x
Third Party Organizations												
RMP STLS	290	1/8/2017	37.6442	-122.4139	water	x	x	x				
RMP STLS	296	1/8/2017	37.6508	-122.4181	water	x	x	x				
RMP STLS	Colma C/Linden	2/7/2017	37.6502	-122.4119	water	x	x	x				
RMP STLS	359	2/7/2017	37.6429	-122.3968	water	x	x	x				
SPoT	204SMA020	June 2017	37.5703	-122.3186	sediment	x						

[a]Ammonia (for ammonium), nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus are analyzed concurrently in each nutrient sample.

[b]204ATH050 and 204RED050 were also sampled for nutrients as part of the spring bioassessment monitoring program.

2.2. PCBs and Mercury

The Countywide Program's PCBs and mercury monitoring focuses on San Mateo County WMAs (see Section 1.1) containing high interest parcels with land uses potentially associated with PCBs such as old industrial, electrical and recycling. During WY 2017 the Countywide Program collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs and 67 grab sediment samples (of which 6 were duplicates) within the WMAs. As part of continuing to develop strategies for reducing PCBs and mercury loads in stormwater runoff, the Countywide Program evaluated all of these data, additional WY 2017 stormwater runoff sample data collected through the RMP's Small Tributary Loading Strategy (STLS), and data from previous water years collected by the Countywide Program and through the STLS. Objectives include attempting to identify source properties within WMAs, identifying which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls, and prioritizing WMAs for future investigations.

2.2.1. Stormwater Runoff Monitoring

During WY 2017, the Countywide Program collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs that contain high interest parcels. An additional four stormwater runoff samples were collected in San Mateo County through the RMP's STLS, also from WMAs with high interest parcels. These combined 21 samples address Management Questions #1 (Source Identification) and #2 (Contributions to Bay Impairment). Data will also be used by the RMP STLS to improve calibration of the Regional Watershed Spreadsheet Model (RWSM) which is a land use based planning tool for estimation of overall POC loads from small tributaries to San Francisco Bay at a regional scale (i.e., Management Question #4 – Loads and Status).

WMAs were identified and prioritized for stormwater runoff sampling by evaluating several types of data, including: land use data, PCBs and mercury concentrations from prior sediment and stormwater runoff sampling efforts, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), and logistical/safety considerations. Composite samples, consisting of six to eight aliquots collected during the rising limb and peak of the storm hydrograph (as determined through field observations), were analyzed for the 40 PCBs congeners designated by the RMP as those most likely to be found in the Bay[6] (method EPA 1668C, total PCBs were calculated as the sum of these 40 congeners), total mercury (method EPA 1631E), and suspended sediment concentration (SSC; method ASTM D3977-97). One of these samples was also analyzed for total and dissolved copper (method EPA 200.8) and hardness (method SM 2340C). See Section 2.3 for a discussion of the copper results.

The RMP's STLS team typically conducts annual monitoring for POCs on a region-wide basis. The Countywide Program is an active participant in the STLS and works with other Bay Area municipal stormwater programs to identify opportunities to direct RMP funds and monitoring activities towards meeting both short- and long-term municipal stormwater permit requirements. During WY 2013 – WY 2014 POC monitoring activities by the STLS focused on pollutant loading monitoring at six region-wide stations, including one station in San Mateo County. In WY 2015, the loading stations were discontinued and STLS monitoring shifted to wet weather characterization in WMAs. In WY 2017, the STLS Team continued wet weather characterization sampling using a similar approach to the PCBs and mercury sampling that was implemented by the Countywide Program. Seven WMAs (i.e., seven storm composite

[6] PCBs congeners 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, l05, 110, 118, 128, 132, 138, 141, 149, l51, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, 203.

samples) were sampled for PCBs and mercury by the RMP's STLS in San Mateo County in WY 2016, six WMAs were sampled in WY 2015, and four were sampled in WY 2017.

Table 4 summarizes PCBs, mercury, and SSC monitoring results for samples collected by the Countywide Program and RMP in WYs 2015 - 2017. "Total PCBs" was calculated as the sum of the RMP 40 congeners. The PCBs particle ratio concentration is calculated by dividing Total PCBs by SSC; likewise, the Hg particle ratio concentration is calculated by dividing mercury concentrations by SSC. The particle ratio concentrations, which are sometimes referred to as particle concentrations, estimate the concentration of pollutant on the suspended sediment within the water sample. Since PCBs and mercury are hypothesized to primarily be bound to sediment, particle ratio concentrations may be used to normalize pollutant concentrations in samples with varying levels of suspended sediment.

Table 4. PCB, mercury, and suspended sediment concentrations in stormwater runoff samples collected by SMCWPPP and the RMP, WYs 2015 - 2017.

Station Code	Permittee	Sample Date	SSC (mg/L)	Total PCBs (ng/L)[a]	PCBs Particle Ratio Concentration (ng/g)[b]	Hg (ng/L)	Hg Particle Ratio Concentration (ng/g)
SMCWPPP Samples							
SM-BEL-60A	Belmont	2/9/2017	34	6.1	178	(c)	(c)
SM-BEL-60B	Belmont	2/9/2017	36	37.2	1022	(c)	(c)
SM-BUR-1006A	Burlingame	12/15/2016	52	18.9	365	(c)	(c)
SM-BUR-141A	Burlingame	12/15/2016	51	8.5	165	(c)	(c)
SM-BUR-142A	Burlingame	12/15/2016	52	34.5	670	(c)	(c)
SM-MPK-238A	Menlo Park	3/5/2016	80	3.2	40	13	159
SM-MPK-238B	Menlo Park	3/5/2016	51	6.2	121	9	173
SM-MPK-66A	Menlo Park	3/24/2017	21	8.4	390	(c)	(c)
SM-MPK-71A	Menlo Park	2/17/2016	14	0.6	43	7	496
SM-RCY-254A	Redwood City	3/5/2016	14	1.6	113	10	712
SM-RCY-323A	Redwood City	1/8/2017	8	1.6	191	(c)	(c)
SM-RCY-324A	Redwood City	1/8/2017	44	7.4	169	(c)	(c)
SM-RCY-327A	Redwood City	2/17/2016	44	5.7	130	15	341
SM-RCY-379A	Redwood City	3/5/2016	123	13.0	106	18	149
SM-RCY-379B	Redwood City	3/5/2016	43	7.9	182	11	252
SM-RCY-388A	Redwood City	2/17/2016	50	2.5	50	15	311
SM-SMO-156A	San Mateo	2/20/2017	91	18.5	204	(c)	(c)
SM-SMO-408A	San Mateo	2/20/2017	29	55.3	1900	(c)	(c)
SM-SMO-89A	San Mateo	1/10/2017	28	4.0	145	(c)	(c)
SM-SSF-1001B	South San Francisco	12/15/2016	32	55.2	1714	(c)	(c)
SM-SSF-292A	South San Francisco	12/15/2016	719	7.9	11	(c)	(c)
SM-SSF-294A	South San Francisco	12/15/2016	29	10.5	367	(c)	(c)
SM-SSF-316A	South San Francisco	12/10/2016	44	4.3	96	(c)	(c)
SM-SSF-317A	South San Francisco	12/10/2016	6	2.6	450	(c)	(c)
SM-SSF-318A	South San Francisco	12/10/2016	9	2.3	266	(c)	(c)

Station Code	Permittee	Sample Date	SSC (mg/L)	Total PCBs (ng/L)[a]	PCBs Particle Ratio Concentration (ng/g)[b]	Hg (ng/L)	Hg Particle Ratio Concentration (ng/g)
RMP Samples							
SM-SCS-210A (Pulgas South)	San Carlos[d]	33 Samples (Results are Averaged)	54	448.0	8222		
SM-SCS-31A (Pulgas North)	San Carlos[d]	4 Samples (Results are Averaged)	68	60.3	893		
SM-BRI-1004A	Brisbane	3/5/2016	96	10.5	109	71	741
SM-BRI-17A	Brisbane	3/5/2016	96	10.4	109	27	276
SM-EPA-70A	East Palo Alto	2/6/2015	265	28.5	108	52	194
SM-EPA-72A	East Palo Alto	2/6/2015	82	6.5	79	35	427
SM-RCY-267A	Redwood City	12/2/2014	148	9.2	62	55	372
SM-RCY-337A	Redwood City	12/15/2014	29	3.5	121	14	469
SM-SCS-32A	San Carlos	3/11/2016	25	4.2	169	29	1156
SM-SCS-75A	San Carlos	3/11/2016	26	159.6	6139	14	535
SM-SSF-291A	South San Francisco	1/8/2017	16	11.8	736	12	775
SM-SSF-293A	South San Francisco	2/6/2015	45	5.2	117	20	436
SM-SSF-296A	South San Francisco	1/8/2017	111	3.4	30	39	350
SM-SSF-306A	South San Francisco	2/6/2015	43	7.8	182	29	679
SM-SSF-314A	South San Francisco	3/5/2016	10	8.6	859	6	562
SM-SSF-315A	South San Francisco	3/5/2016	33	5.8	175	10	315
SM-SSF-319A	South San Francisco	3/5/2016	23	1.8	80	15	639
SM-SSF-359A	South San Francisco	2/7/2017	43	33.9	788	9	210

[a] Total PCBs calculated as sum of RMP 40 congeners.
[b] PCB and Hg Particle Ratios calculated by dividing Total PCBs and Hg concentrations by SSC.
[c] SMCWPPP WY 2017 mercury data were rejected by SMCWPPP's QA/QC Officer (see Section 2.1).
[d] Pulgas Pump Station watershed data were collected during Water Years 2011-2014.

2.2.2. Evaluation of Region-wide Stormwater Runoff Sampling Results

This section evaluates data collected by the Countywide Program to-date on PCBs concentrations in stormwater runoff in the context of similar data collected throughout the Bay Area. The analysis included data from RMP STLS monitoring (Gilbreath et al. 2018 DRAFT). The stormwater runoff sample dataset includes samples collected from 107 municipal separate storm water sewer system (MS4) catchments and 20 natural waterways throughout the Bay Area. The MS4 catchment sites included storm drain manholes, outfalls, pump stations, and artificial channels.[7] Many of the sites have been sampled more than once and/or have multiple sample results reported for individual storm events. Nine of the 107 MS4 sites have multiple sample results (sample counts of 4 to 80) and 15 of the 20 natural waterway sites have multiple sample results (sample counts of 3 to 125). For sites with more than one sample, the particle ratio concentration was calculated by dividing the sum of PCBs concentrations by the sum of suspended sediment concentrations. This averaging is essentially equivalent to compositing

[7] Stormwater runoff samples have also been collected from inlets and/or treatment systems (e.g., bioretention) during special studies. However, those are not included in this analysis.

all the individual samples that have been collected at a site. This is consistent with the RMP STLS approach to data evaluation (Gilbreath et al. 2018 DRAFT).

PCBs concentrations in stormwater runoff samples for the Bay Area dataset (n=127) are plotted in Figure 2. PCBs particle ratio concentrations are plotted in Figure 3. Figures 2 and 3 identify sites by location (i.e., County) and sample type (i.e., MS4 or natural waterway/creek). There are 46 sites in San Mateo County. Seventeen of the sites were sampled by the Countywide Program in WY 2017, sixteen sites were sampled by the RMP STLS in WY 2015-2017, and four sites were sampled multiple times by the RMP in prior water years.

Two of the top three highest PCB concentrations in the dataset were for samples collected in San Mateo County, with Pulgas Creek Pump Station South having the highest concentration (average 448 ng/L) and SM-SCS-75A (Industrial Rd Ditch) having the third highest concentration (160 ng/L). The 33 samples collected at Pulgas Creek Pump Station South station had consistently very elevated PCBs concentrations. The site has had by far the two highest PCBs concentrations (6,669 ng/L and 4,084 ng/L) measured out of 647 total individual samples and the four highest PCB particle ratio concentrations (37,363 ng/g, 20,733 ng/g, 15,477 ng/g, and 14,744 ng/g).

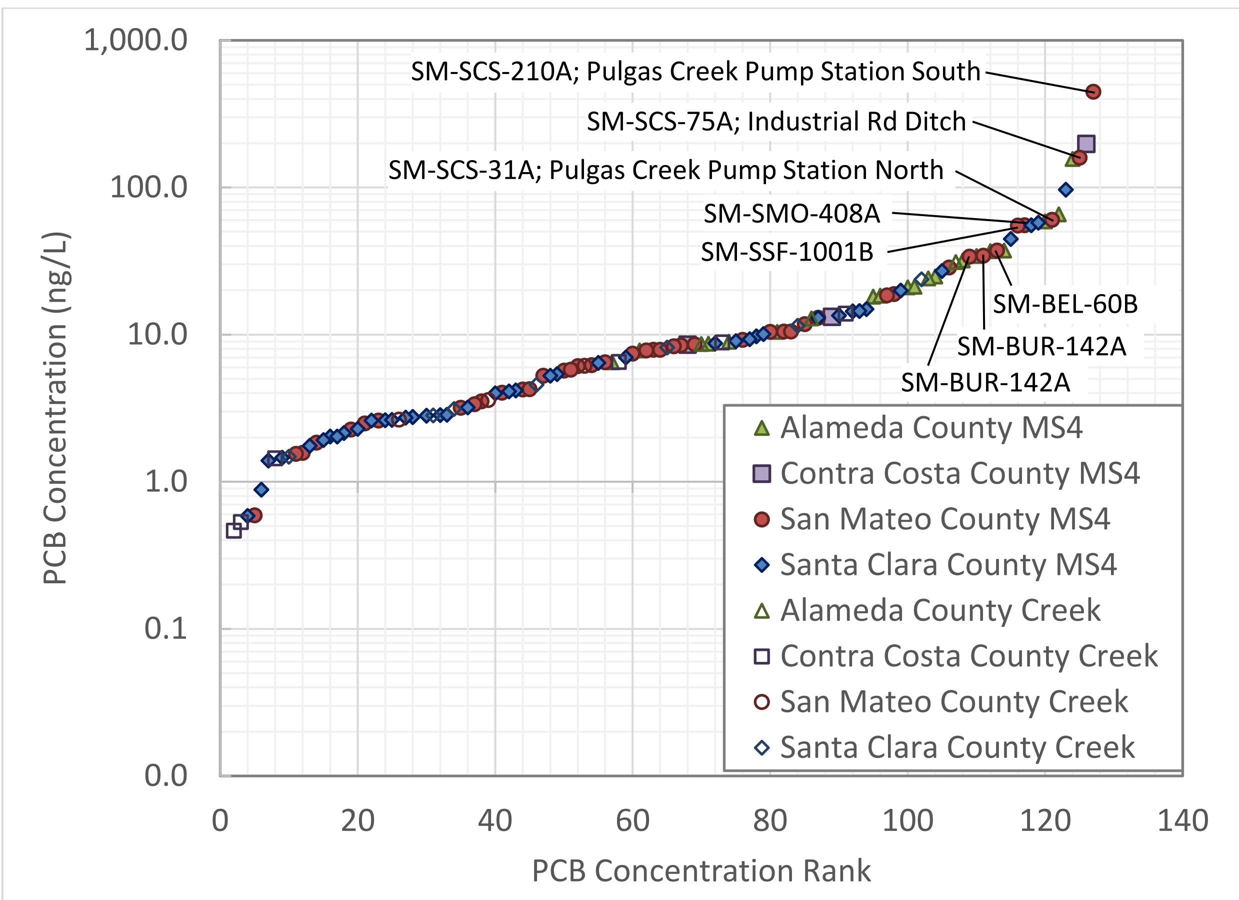

Figure 2. PCBs concentrations for stormwater runoff samples collected in MS4s and creeks in the Bay Area.

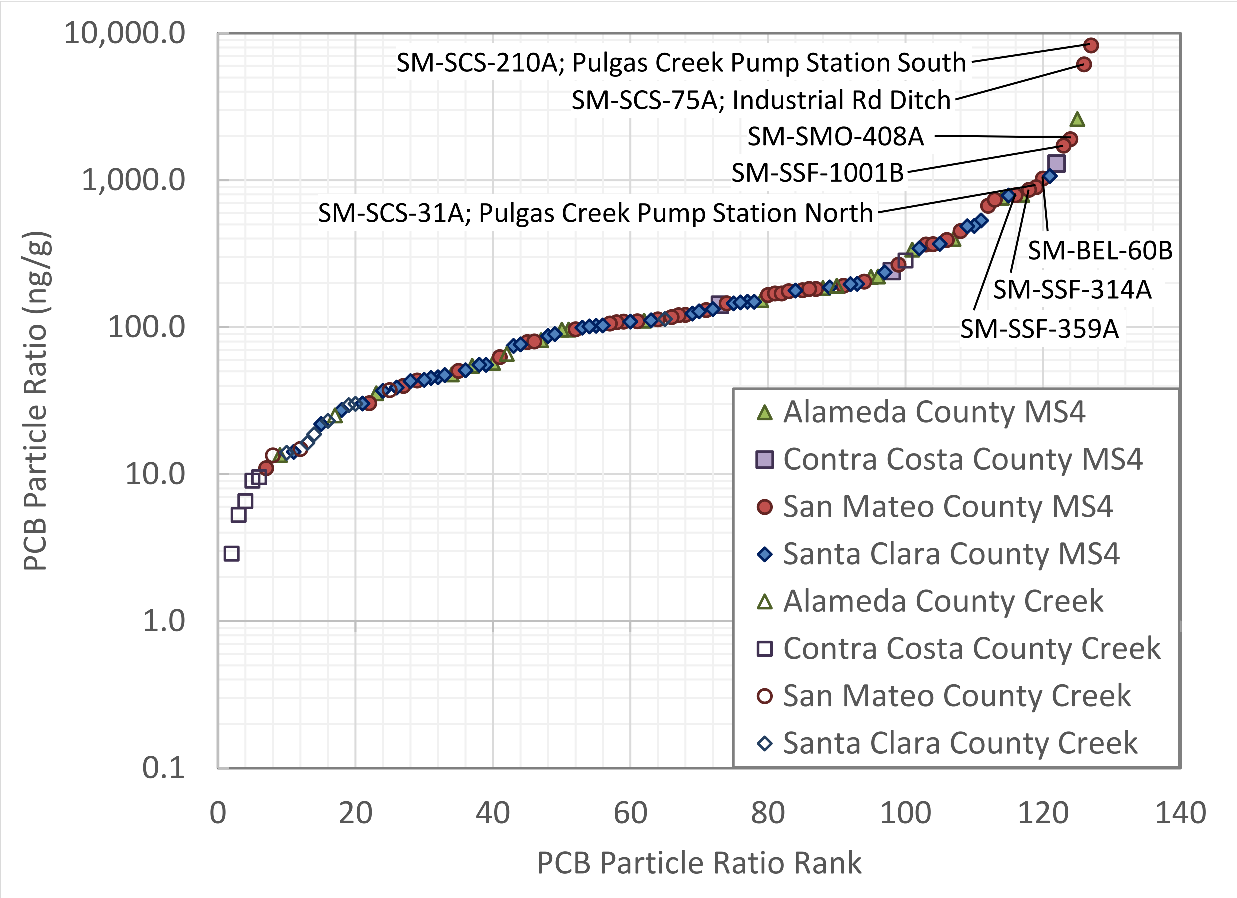

Figure 3. PCBs particle ratio concentrations for stormwater runoff samples collected in large MS4s in the Bay Area.

Table 5 provides descriptive statistics for PCBs and mercury concentrations in the Bay Area stormwater runoff dataset (n=127). The median PCB concentration in stormwater runoff samples is 7.89 ng/L and the mean is 20.5 ng/L. The median PCB particle ratio concentration is 113 ng/g and the mean is 350 ng/g. As can be seen in Figures 2 and 3, which are plotted on a log scale, there are a few catchments with highly elevated in PCBs (such as the Pulgas Creek Pump Station) that greatly influence the mean concentration statistic but have less impact on the median (i.e., 50th percentile) statistic. Both the Countywide Program and the RMP are collecting more stormwater runoff composite samples in WY 2018 which will expand this dataset. In future years, it may be informative to correlate measured concentrations to various factors such as storm size, rainfall intensity, antecedent dry weather, and land use characteristics.

Table 5. Descriptive statistics – Bay Area stormwater runoff sample concentrations of PCBs and mercury

	PCBs (ng/L)[a]	Hg (ng/L)	SSC (mg/L)	PCBs Particle Ratio Concentration (ng/g)[b]	Hg Particle Ratio Concentration (ng/mg)[b]
Number of Samples	127	71	127	127	71
Min	ND	3.90	5.80	ND	0.045
10th Percentile	1.71	6.65	19.2	16.0	0.155
25th Percentile	2.84	11.5	35.0	45.6	0.215
50th Percentile	7.89	22.9	58.0	113	0.346
75th Percentile	18.4	42.5	131	221	0.557
90th Percentile	46.8	85.7	296	784	0.896
Max	448	1,050	2,630	8,220	5.29
Mean	20.5	54.7	146	350	0.505

[a] Total PCBs calculated as sum of RMP 40 congeners.

[b] PCB and Hg Particle Ratios calculated by dividing Total PCBs and Hg concentrations by SSC.

2.2.3. WY 2017 Sediment Sampling by the Countywide Program

During WY 2017 the Countywide Program collected 67 grab sediment samples (of which 6 were duplicates) as part of the program to attempt to identify source properties within WMAs, potentially for referral to the Regional Water Board for further investigation and potential abatement. These samples were collected in the public right-of-way (ROW), including locations adjacent to high interest parcels with land uses associated with PCBs such as old industrial, electrical and recycling and/or other characteristics potentially associated with pollutant discharge (e.g., poor housekeeping, unpaved areas). Individual and composite sediment samples were collected from manholes, storm drain inlets, driveways, streets, and sidewalks.

Each sample was analyzed for total mercury and for the 40 PCBs congeners designated by the RMP as those most likely to be found in the Bay (see Section 2.2.1). Total PCBs were calculated as the sum of the 40 congeners. The laboratory sieved all samples to 2 mm prior to analysis. Attachment 2 summarizes WY 2017 sediment monitoring locations and analytical results. The results are discussed by WMA in the following section, along with sediment data from previous water years and the stormwater runoff data collected to-date.

2.2.4. Watershed Management Area Prioritization and Descriptions

The Countywide Program evaluated PCBs stormwater runoff and sediment monitoring data to help prioritize WMAs for further investigation and control measure implementation. Based upon the data collected in San Mateo County to-date by the Countywide Program and other parties (e.g., the RMP's STLS), WMAs with one or more sediment and/or stormwater runoff samples with PCBs concentrations (particle ratio concentrations for stormwater runoff) greater than 0.5 mg/kg (or 500 ng/g) were provisionally designated as higher priority. WMAs with samples in the 0.2 – 0.5 mg/kg (200 – 500 ng/g) range were designated medium priority. WMAs with stormwater runoff sample PCBs particle ratio concentrations less than 0.2 mg/kg (200 ng/g) were designated lower priority. Sediment sample results were not used to designate a WMA lower priority due to the high potential for false negatives. Figure 4 is a map illustrating the current status of WMAs in San Mateo County, based on this provisional prioritization scheme and sediment and stormwater runoff monitoring results to-date.[8] Only WMAs with high interest parcels of were included in Figure 4.

Attachment 3 provides a summary of PCBs and mercury monitoring results for San Mateo county WMAs. For each WMA, Attachment 3 includes:

- The WMA area, the area of high interest parcels in the WMA, and the percent of the total WMA area that is comprised of high interest parcels;
- A summary of the number of stormwater runoff and sediment samples collected to-date in the WMA; and
- The median and range of PCBs concentrations in the samples collected to-date in the WMA (particle ratio concentration for stormwater runoff samples).

Of the 41 stormwater runoff samples collected in San Mateo County from WY 2015-2017 by the Countywide Program and the RMP, eight samples had PCBs particle ratio concentrations over 0.5 mg/kg, six were between 0.2 and 0.5 mg/kg, and the remainder were below 0.2 mg/kg. WMAs with PCBs particle ratio concentrations over 0.2 mg/kg, elevated concentrations of PCBs in sediment samples, and/or other features relevant to PCBs investigations are described in more detail below.[9]

[8] Where sediment and stormwater runoff particle ratio concentration analysis results conflict, the higher result was conservatively applied.

[9] The WMA IDs in San Mateo County are numerical (1 – 1017). Sample names consist of a prefix for the county (SM), followed by a three-letter prefix for the Permittee where the sample was collected (e.g., SSF for South San Francisco, SCS for San Carlos), followed by the WMA ID, and followed by a letter (e.g., A, B, C) to distinguish the sampling site from the WMA in which that sample was collected. Samples collected previously may have a different sample naming convention.

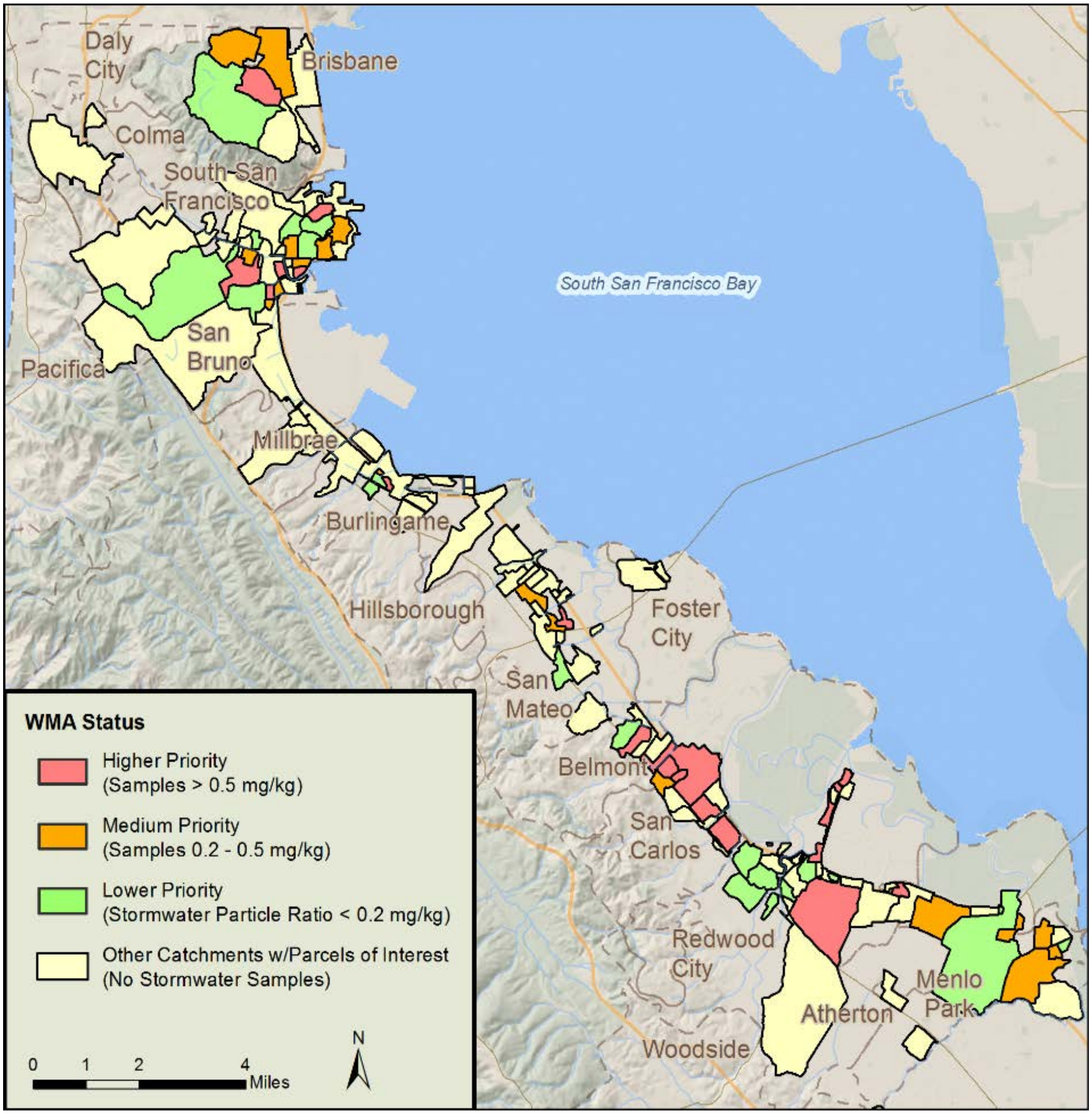

Figure 4. San Mateo County WMA status based on sediment and stormwater runoff data collected through WY 2017.

City of Brisbane

WMAs in the City of Brisbane with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 5 and briefly described below. It should be noted that the industrial area in the northeast corner of Figure 5 drains to San Francisco's combined sewer and is therefore considered non-jurisdictional.

WMA 17

WMA 17 is a large catchment that corresponds to the watershed of the now underground Guadalupe Creek. It contains a large industrial area developed mostly in the 1960s and buildings of the type that would be expected to potentially have PCBs in building materials. Several old railroad lines used to support the industries. A sediment sample in one of the two main lines under Valley Drive had elevated levels of PCBs (1.22 mg/kg) despite potential dilution due to the large size of the watershed. Additional followup samples have not yet been collected. A stormwater runoff sample collected by the RMP in WY 2016 (SM-BRI-17A or Valley Dr SD) had a PCBs particle ratio concentration of 109 ng/g, a relatively moderate level of PCBs for the Bay Area.

WMA 1004

WMA 1004 is located along Tunnel Avenue in the Brisbane Baylands area. Sample SM-BRI-1004A (Tunnel Avenue Ditch) was collected by the RMP in WY 2016 and (as with the above WMA 17 sample) had a PCBs particle ratio concentration of 109 ng/g, a relatively moderate level of PCBs for the Bay Area. The catchment contains all of the Brisbane Baylands old railyard and a large PG&E property on Geneva Avenue. The Baylands area is an active cleanup site (although not for PCBs) and will eventually be redeveloped. Several sediment samples collected in past years in the vicinity of the PG&E property and historical railroad lines had relatively low PCBs concentrations.

WMA 350

WMA 350 is upstream of WMA 1004, and contains a PCBs cleanup site Bayshore Elementary which was redeveloped in 2017. The PCBs were associated with the original building materials and it therefore appears unlikely that there is an ongoing source of PCBs to the MS4.

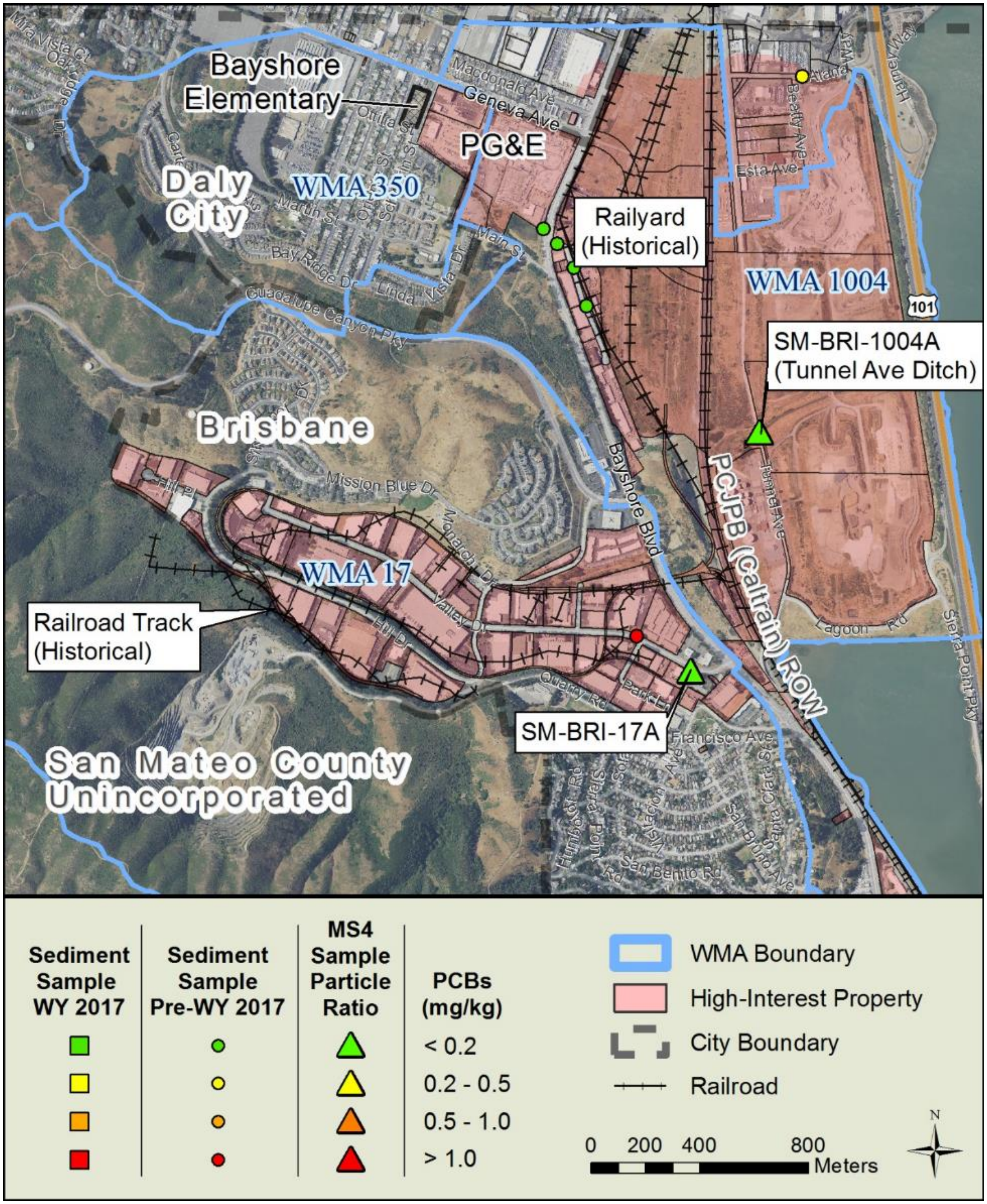

Figure 5. WMAs 17, 350, and 1004.

City of South San Francisco

WMAs in the City of South San Francisco with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figures 6 through 10 and briefly described below.

WMA 291

WMA 291 is a relatively large catchment that is comprised almost entirely of old industrial land uses. A stormwater runoff sample collected by the RMP in WY 2017 had an elevated PCB particle ratio concentration (736 ng/g). A 2002 sediment sample at 245 S. Spruce Avenue had an elevated PCBs concentration of 2.72 mg/kg. Samples in WY 2015 and WY 2017 on Linden Avenue near Dollar Avenue were also moderately elevated for PCBs (0.48 and 0.44 mg/kg).

WMA 294

WMA 294 is a 67 acre catchment that drains into Colma Creek at Mitchell Avenue. Within the WMA is 166 Harbor Way, also known in the DTSC Envirostor database as "Caltrans/SSF Maintenance Station." This property was purchased by Caltrans which tested the soil and found several contaminants including PCBs. The contaminated soil has been capped since at least 2005 and the property is currently mostly vacant with a small portion devoted to k-rail storage. A sediment sample was collected in the driveway of this property in WY 2017 had a moderate PCBs concentration of 0.28 mg/kg. A stormwater runoff sample collected in WY 2017 had a moderately elevated PCBs particle ratio concentration (367 ng/g).

WMA 314

WMA 314 is a 66 acre catchment located near Oyster Point that is comprised of light industrial land uses along with an old railroad right-of-way. Site SM-SSF-314A (Gull Dr. SD) was sampled by the RMP in WY 2016 and had an elevated PCBs particle ratio concentration (859 ng/g), with a relatively low suspended sediment concentration (SSC) of 10 mg/L. Two sediment samples collected in WY 2017 both had relatively low (urban background) concentrations of PCBs, with the highest concentration being 0.15 mg/kg.

WMA 319

WMA 319 is also located near Oyster Point. Sample SM-SSF-319A (Forbes Blvd Outfall) was collected by the RMP in WY 2016 and had a relatively low PCBs particle ratio concentration of 80 ng/g. Although the catchment was historically industrial, it is now mostly redeveloped and composed of biotechnology corporations. A sediment sample in WY 2017 also had a relatively low (urban background) PCBs concentration.

WMA 358

WMA 358 is a small 32 acre catchment that drains into Colma Creek at Utah Avenue. A sediment sample in WY 2015 had elevated concentrations of PCBs (1.46 mg/kg). Three followup samples in WY 2017 all had relatively low (urban background) levels of PCBs, with the highest concentration being 0.09 mg/kg.

WMA 359

WMA 359 is a small 23 acre catchment that drains into Colma Creek behind 222 Littlefield Avenue. In WY 2017 the RMP collected a storm sample elevated in PCBs that had an elevated PCBs particle ratio concentration of 788 ng/g. The catchment is composed of all old industrial land uses including an old railroad.

WMA 1001

WMA 1001 is a large catchment that is composed of all the non-contiguous small catchments along Colma Creek that have outfall diameters of 18-inches and smaller. In WY 2017 a stormwater runoff sample collected on Shaw Road near the catchment outfall (SM-SSF-1001B) had an elevated PCBs particle ratio (1,710 ng/g). The catchment for this sample is very small and only drains about five light industrial properties along Shaw Road. A sediment sample collected from a storm drain inlet just south of the catchment in WY 2015 had a PCBs concentration of 0.46 mg/kg, providing more evidence that there is a PCBs source(s) in the area.

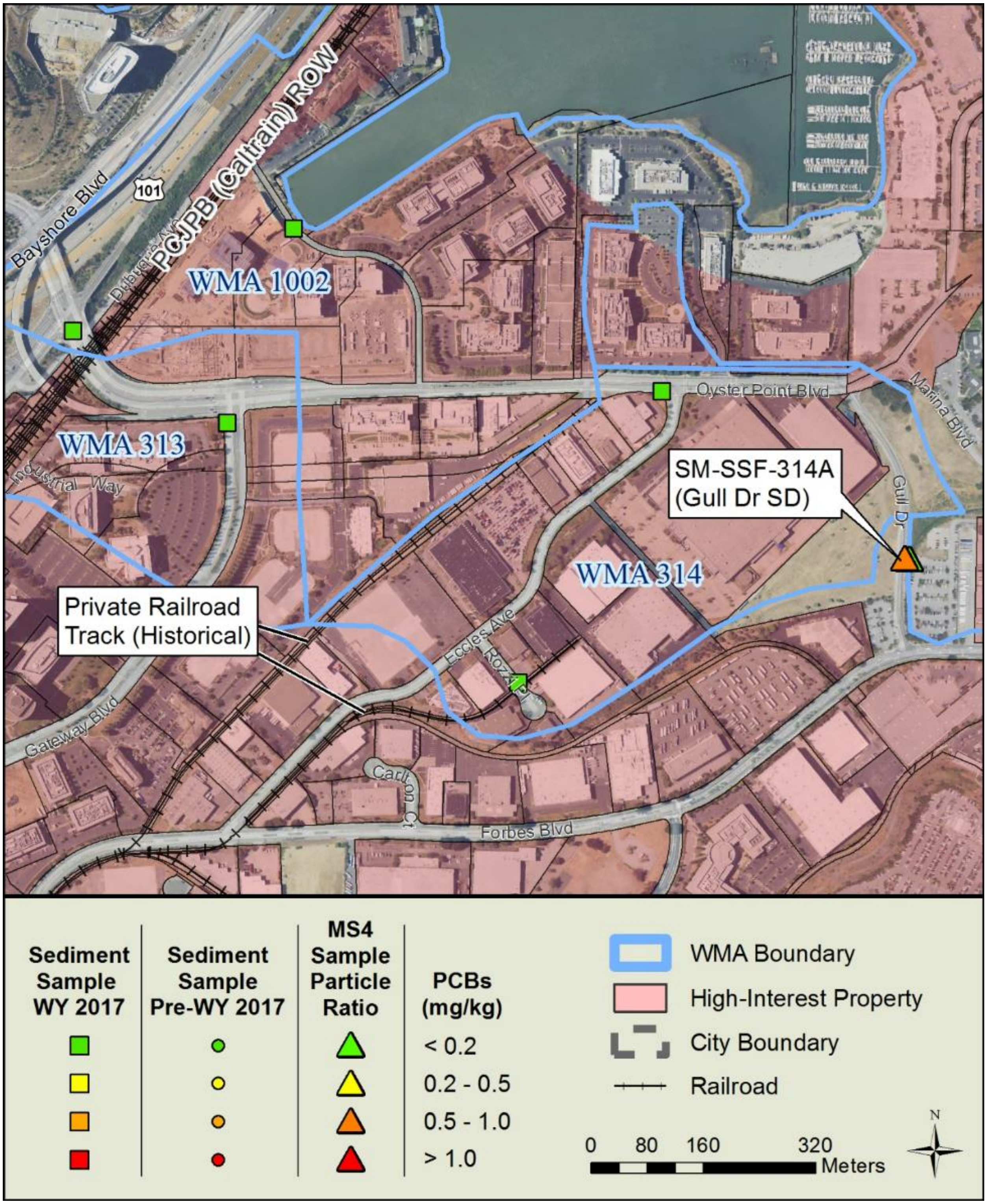

Figure 6. WMAs 313, 314, and 1002

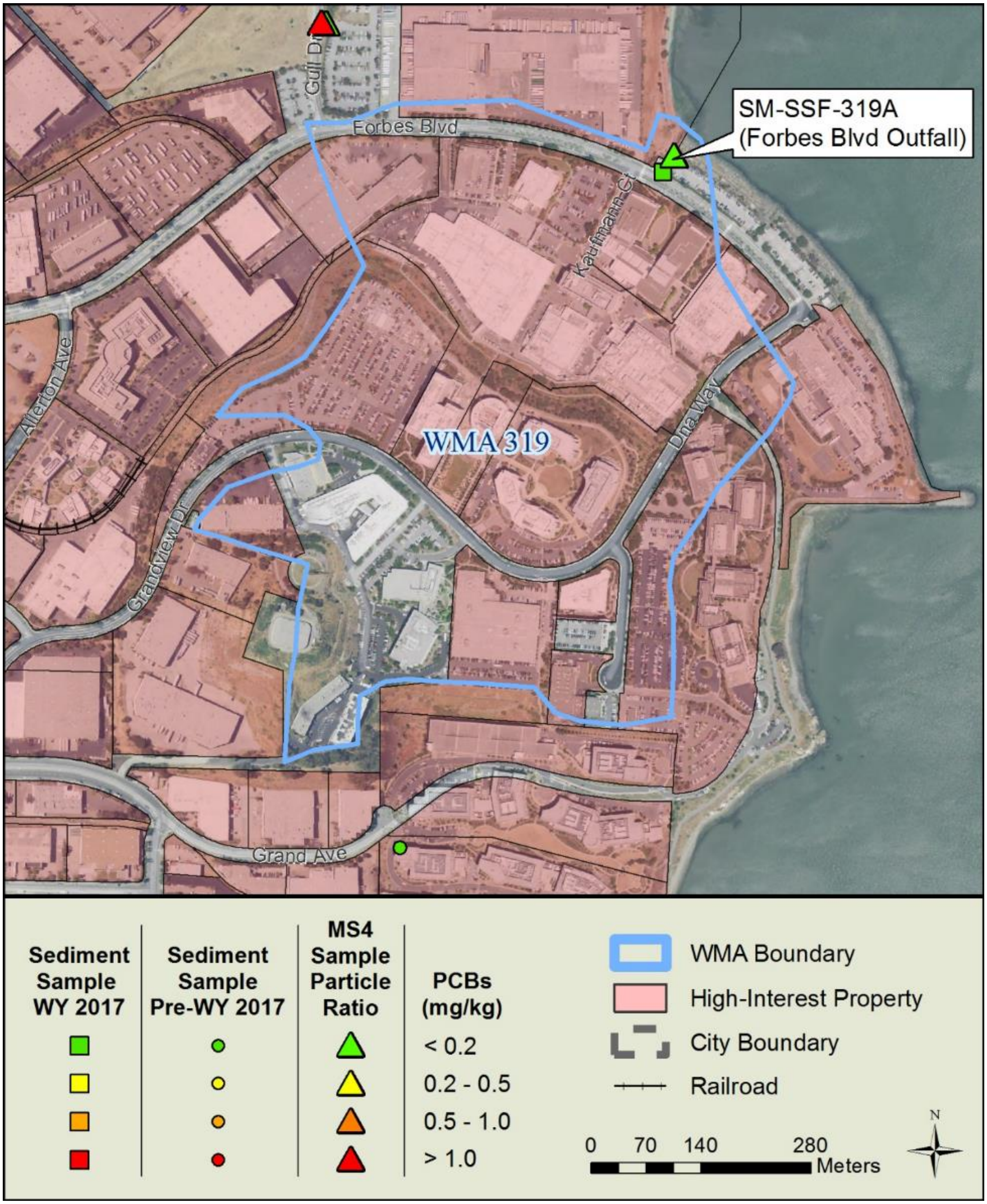

Figure 7. WMA 319

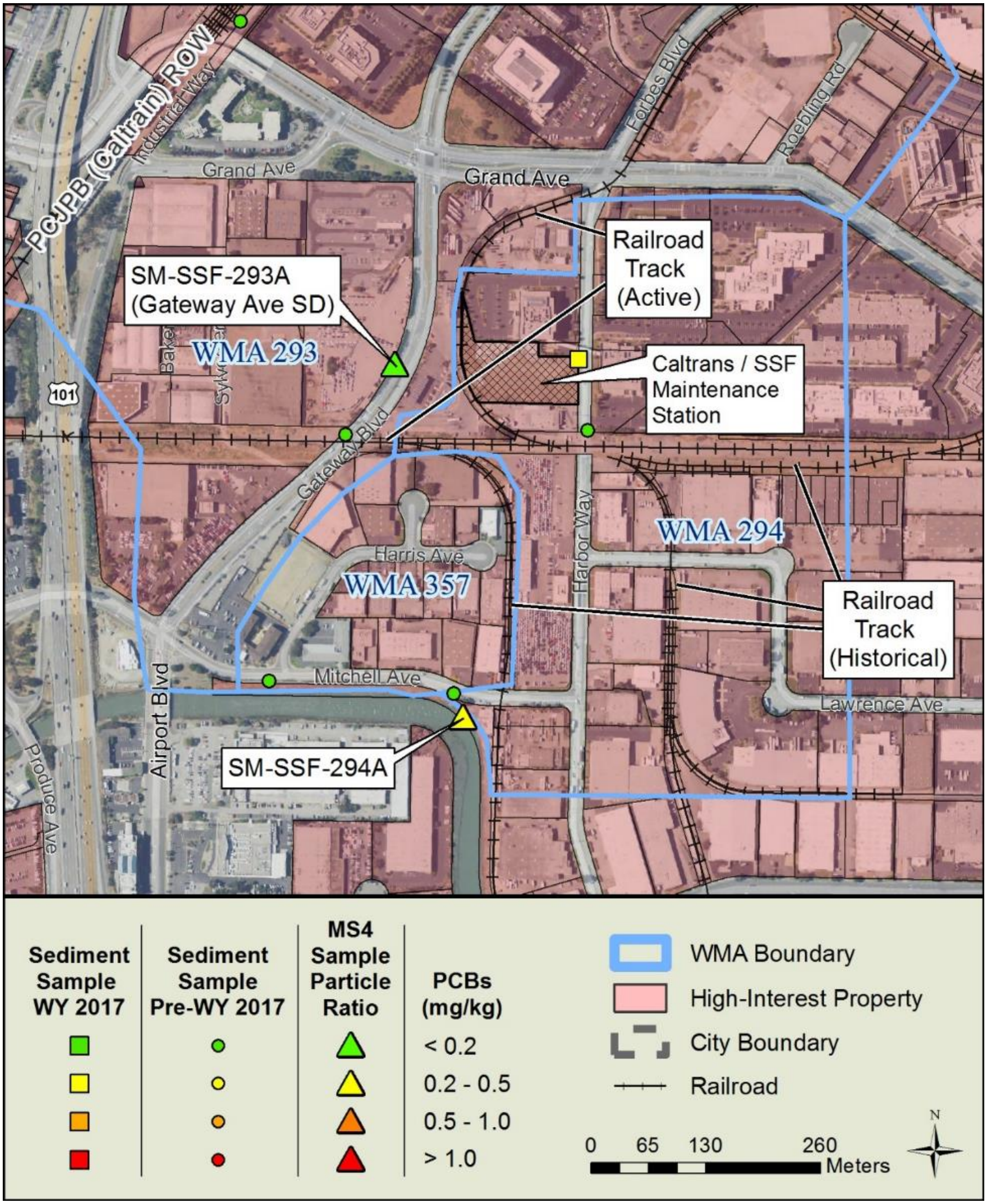

Figure 8. WMAs 293, 294, and 357

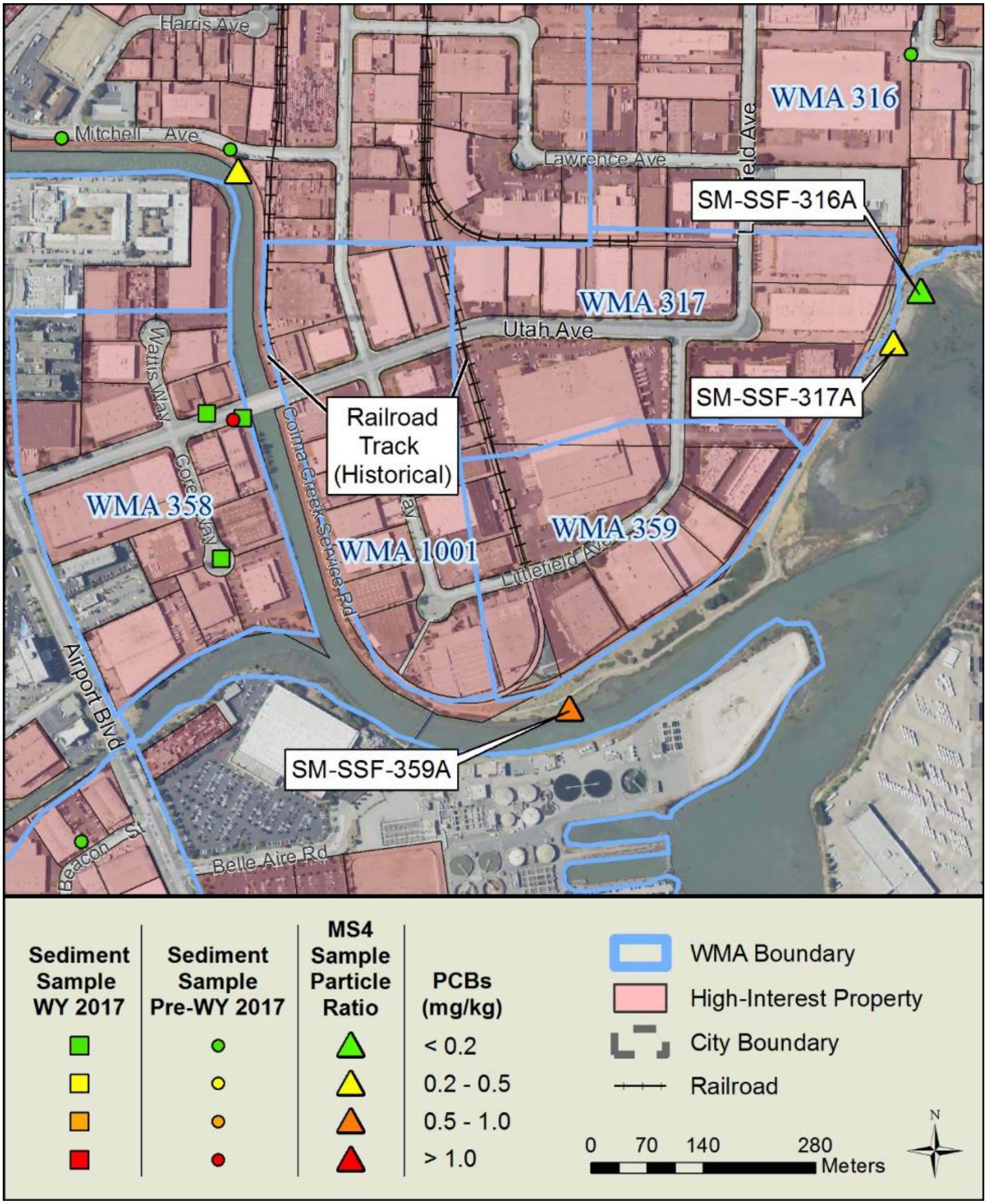

Figure 9. WMAs 316, 317, 358, 359, and 1001

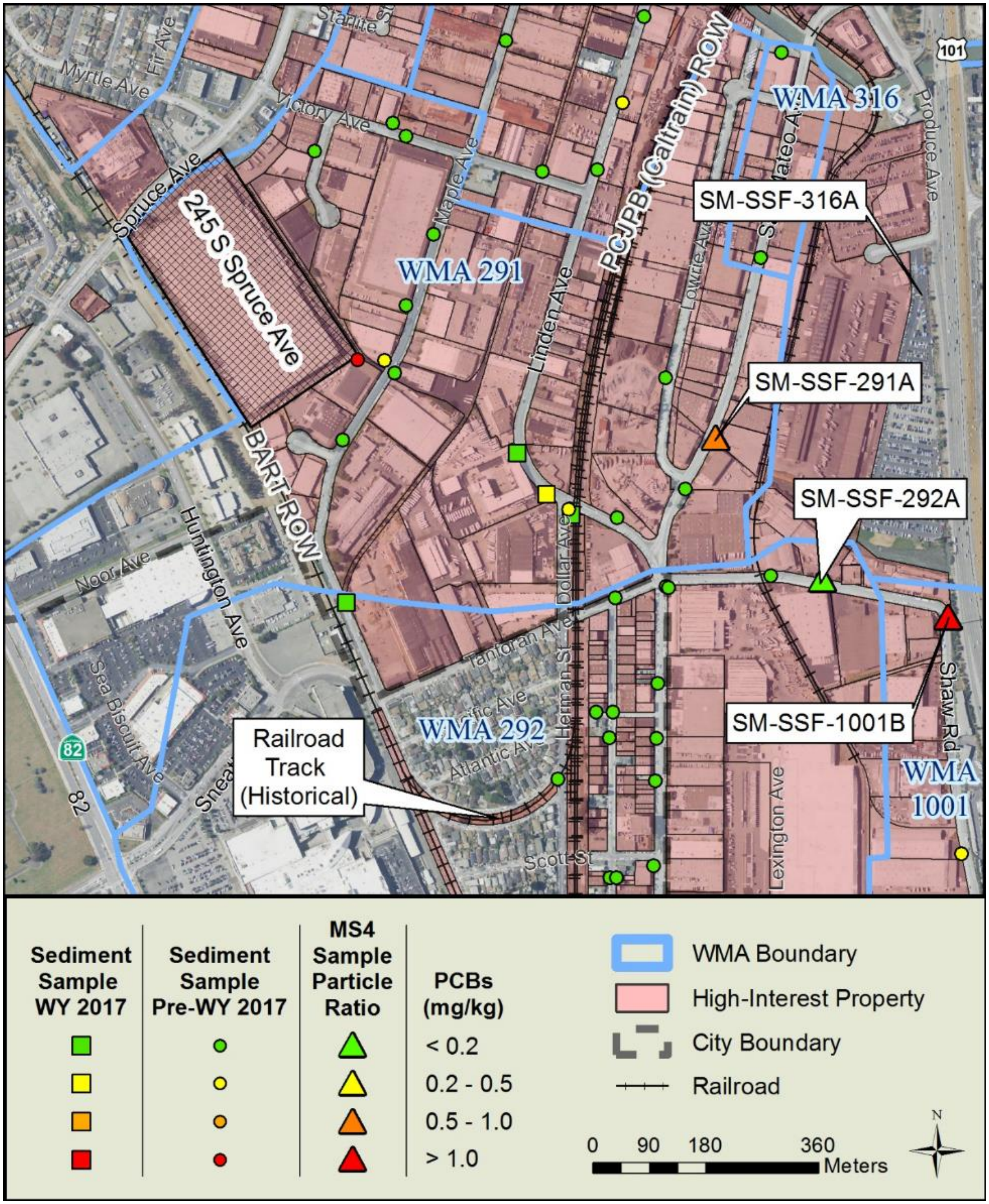

Figure 10. WMAs 291, 292, 316, and 1001

City of Burlingame

WMAs in the City of Burlingame with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 11 and briefly described below. The PCBs concentrations in fourteen previous sediment samples in the industrial parts of Burlingame have all been relatively low. The larger industrial WMAs in Burlingame, WMAs 85 and 164, were both sampled in WY 2018 but the results are not yet available.

WMA 142

WMA 142 is a small 20 acre catchment that is comprised mostly of industrial land uses. Sample SM-BUR-142A was part of a trio of stormwater runoff samples collected at the forebay of the Marsten Road pump station. It had a relatively high PCBs particle ratio concentration (670 ng/g). SM-BUR-1006A, which was collected at the same location but drains adjacent WMA 1006, had a moderately elevated PCBs particle ratio concentration (365 ng/g). A sediment sample collected in WY 2015 in WMA 142 had a PCBs concentration of 0.15 mg/kg, which falls within the range considered urban background.

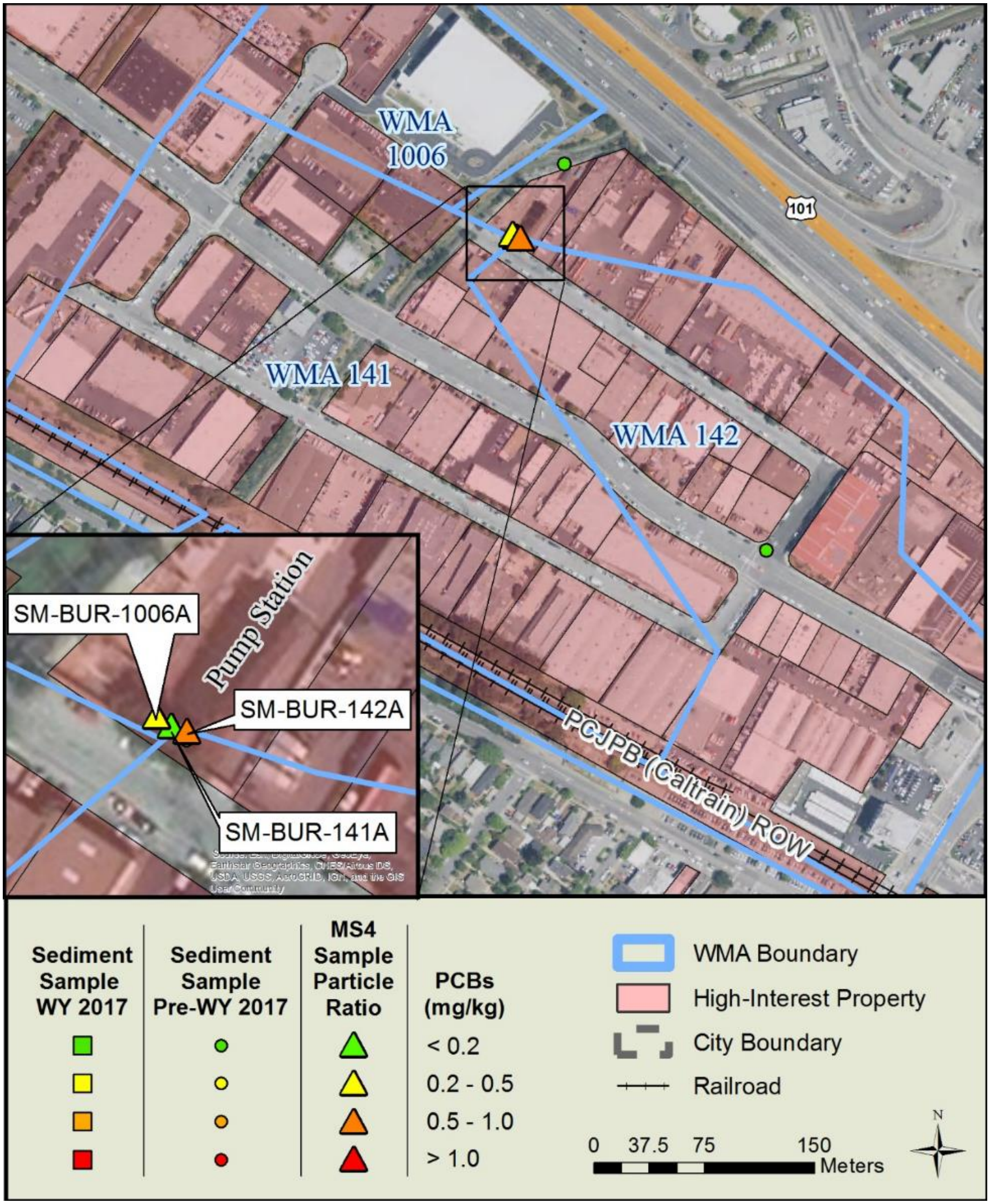

Figure 11. WMAs 141, 142, and 1006

City of San Mateo

WMAs in the City of San Mateo with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 12 and briefly described below.

WMA 156

WMA 156 is a 40 acre catchment that flows north into the 16th Street Channel at Delaware Street. Historically it contained old industrial land uses. It drains Caltrain property including the Hayward Park Station. There is a major retail redevelopment project currently underway in the WMA. A stormwater runoff sample collected in WY 2017 near the catchment outfall had a moderately elevated PCB particle ratio concentration (204 ng/g) but a sediment sample collected upstream did not have an elevated PCBs concentration.

WMA 408

WMA 408 is a 43 acre catchment next to WMA 156. It does not contain any old industrial land uses and is a mix of retail, commercial and residential land uses, with a relatively low proportion (16%) of high interest parcels (see Attachment 3). A stormwater runoff sample collected in WY 2017 had a relatively high PCB particle ratio concentration (1,900 ng/g). This result is notable given the lack of industrial land uses and low percentage of high interest parcels.

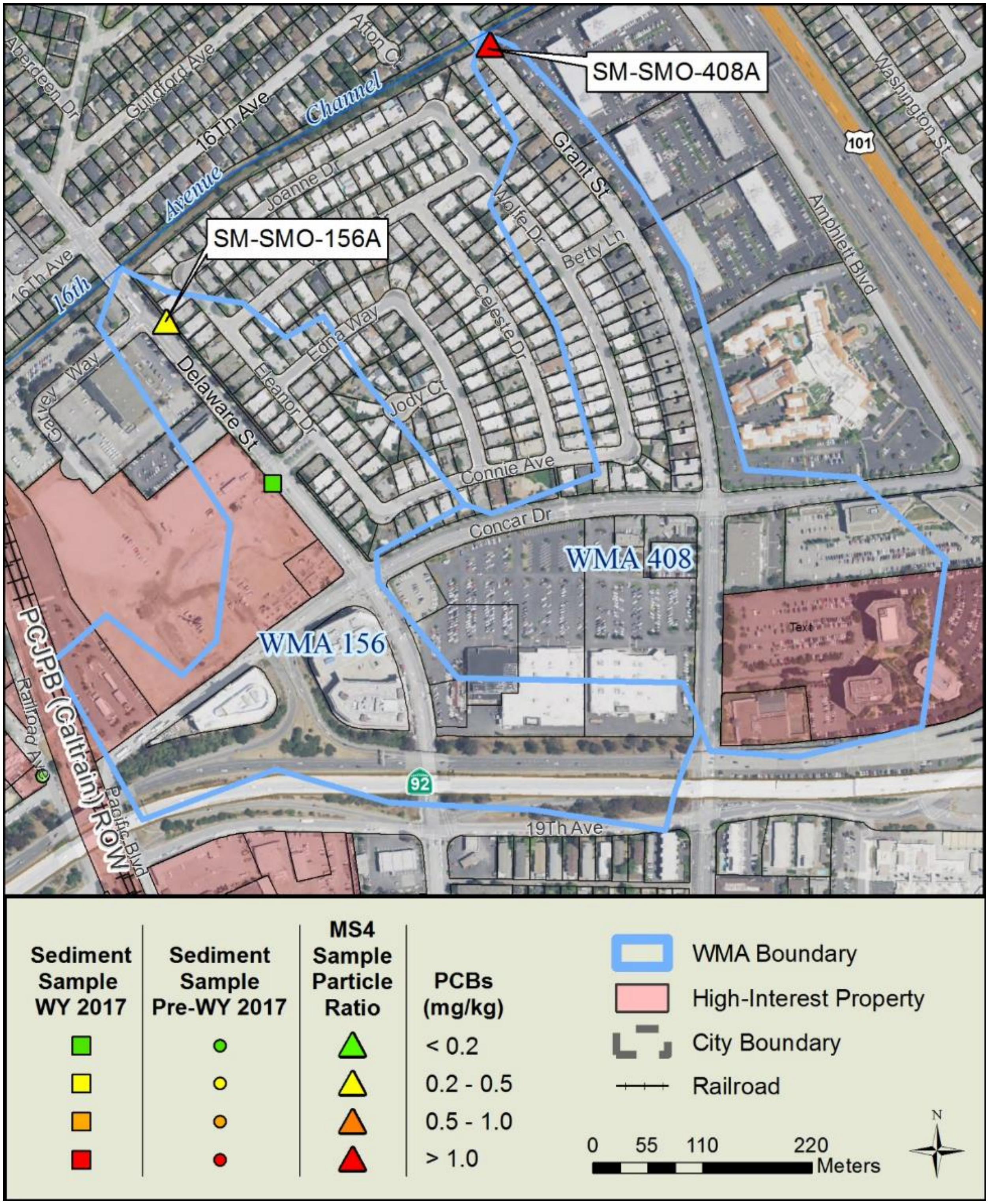

Figure 12. WMAs 156 and 408

City of Belmont

WMAs in the City of Belmont with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 13 and briefly described below.

WMA 60

WMA 60 is a 298 acre catchment that drains north into Laurel Creek. Two stormwater runoff samples were collected in the catchment in WY 2017 (SM-BEL-60A and SM-BEL-60B). Sample SM-BEL-60A was not elevated but SM-BEL-60B had a relatively high PCBs particle ratio concentration (1022 ng/g). This result was notable since the sample catchment is mostly residential with few high interest parcels.

Figure 13. WMA 60

City of San Carlos

WMAs in the City of San Carlos with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 14 – 17 and briefly described below.

WMA 75

WMA 75 is a 66 acre catchment comprised entirely of old industrial land uses. Sample SM-SCS-75A (Industrial Rd Ditch) was collected by the RMP in WY 2016 and had a PCBs particle ratio concentration of 6,140 ng/g, which is among the highest levels found in Bay Area stormwater samples collected to-date. The sample station is located where the MS4 daylights into a ditch on the east side of Industrial Road downstream of the adjacent Delta Star and Tiegel Manufacturing properties. The Countywide Program collected seven sediment samples in WY 2017 in the area. Two of these samples were collected near the Delta Star and Tiegel properties. One was collected in the storm drain line directly downstream of both properties and had a very elevated PCBs concentration (49.4 mg/kg). The other was also elevated, with a PCBs concentration of 1.20 mg/kg, and was collected from surface sediments at the location where the Tiegel property drains into the public right-of-way. The remaining samples were not elevated, suggesting that there are no other sources of PCBs in this WMA other than these two properties (Figure 14).

Delta Star manufactures transformers, including transformers with PCBs historically (from 1961 to 1974). This is a cleanup site with elevated PCBs found in on-site soil and groundwater samples. PCBs migrated to the adjacent Tiegel property at 495 Bragato Road, a roughly three acre site that is largely unpaved. A “Removal Action” under DTSC oversight was implemented between June 1989 and January 1991 to remove soil impacted with PCBs exceeding 25 ppm. The Delta Star and Tiegel properties are currently determined to be in compliance with public health, safety, and the environmental cleanup goals based on exposure at the site. However, based on the PCBs concentrations in the sediment and stormwater runoff samples, the site appears to be a source of PCBs to the MS4 and San Francisco Bay at levels that are a concern from the standpoint of the Bay PCBs TMDL (i.e., contribute to bioaccumulation in Bay fish and other wildlife). The Countywide Program is currently working with the City of San Carlos to prepare the documentation to refer this property to the Regional Water Board for potential additional abatement.

WMA 31 (Pulgas Creek Pump Station North)

WMA 31 is a 99 acre catchment that drains to the Pulgas Creek pump station from the north. The RMP collected four stormwater runoff samples from this catchment during two storms in WY 2011. The samples were all elevated, with an average PCBs particle ratio concentration of 893 ng/g. In addition, street dirt and sediment samples with elevated PCBs have been collected in front of and in the vicinity of 977 Bransten Road, a property within WMA 31 (Figure 15). The current occupant of this property is GC Lubricants. 977 Bransten Road is a DTSC cleanup site due to soil and groundwater contamination with PCBs and other pollutants associated with activities at GC Lubricants and California Oil Recyclers, Inc., a previous tenant at the site. 1007/1011 Bransten Road is the property located adjacent to and immediately north of 977 Bransten Road and designated the “Estate of Robert E. Frank.” A DTSC “Site Screening Form” describes PCBs in the subsurface on both sides of border between the two properties and states there may have been a historic source on both sides of the property line. Abatement measures have been implemented to reduce movement of contaminated soils from the properties, including a concrete cap over contaminated areas. However, the available information suggest that soils/sediments with PCBs are migrating from these properties into the public ROW, including the street and the MS4. The Countywide Program is currently working with the City of San Carlos to prepare the documentation to refer this property to the Regional Water Board for potential additional abatement.

WMA 210 (Pulgas Creek Pump Station South)

WMA 210 drains to the Pulgas Creek pump station from the south (Figures 16 and 17). The RMP has collected 33 storm samples from this catchment with an average PCBs particle ratio concentration of 8,220 ng/g, the highest of any stormwater runoff sampling location in the Bay Area. There appear to be several sources of PCBs within this WMA.

The best documented of these sites is the property at 1411 Industrial Road. A sediment sample with a very elevated PCBs concentration (193 mg/kg) was previously collected from a storm drain inlet located in the parking lot of this about 1.3 acre property. The property drains to the MS4 at a sidewalk manhole where other elevated sediment samples have been collected. Since 2012 the occupant of this property has been a Habitat for Humanity Re-Store. Before that the property was occupied by an auto body shop and an automotive paint company. Between 1958 and 1994, Adhesive Engineering / Master Builders, Inc. was the occupant and conducted manufacturing, research and development of construction grade epoxy resin and products. Adhesive Engineering / Master Builders, Inc. had a history of violations for leaky wastewater drums and improper storage of hazardous wastes in the late 1980s and early 1990s, and PCBs were reportedly used on the site in the past. An environmental assessment report conducted as part of a business closure in 1994 revealed that 93 mg/kg PCBs was found in a soil sample collected in 1987. The soil sample was collected beneath an aboveground tank that was heated by oil-containing PCBs circulating in coils around the tank. The report also described the removal in 1987 of 44 cubic yards of contaminated soil from the area where the tank was located. As part of the 1994 environmental assessment, a soil sample was collected from the same area and PCBs were not detected at that time, but soil samples from other areas on the property were not collected and tested for PCBs. The above information suggests that the 1411 Industrial Road property is a source of PCBs to the MS4. The Countywide Program is currently working with the City of San Carlos to prepare the documentation to refer this property to the Regional Water Board for potential additional abatement.

In WY 2017, the Countywide Program collected ten sediment samples from the WMA 210 to better delineate the sources of PCBs in this catchment. Three samples were collected in the vicinity of 1411 Industrial Road to help rule out that neighboring properties are PCBs sources. All three of these samples had relatively low PCBs concentrations, with the highest having a PCBs concentration of 0.07 mg/kg, which helps to verify that the properties to the east and south are not also sources. Multiple sediment samples previously collected around the PG&E substation across the street also had relatively low levels of PCBs, suggesting that this property is not a source. PCBs from unknown sources were previously found in inlets and manholes in the vicinity of Center, Washington and Varian Streets and Bayport Avenue (Figure 17). The PCBs in these samples could have originated from any of about 20 small industries on these streets. During WY 2017, seven additional samples were collected in this area. The results suggest that three small properties may be PCBs sources. Two samples collected from the driveways of 1030 Washington Street, a construction business, had elevated PCBs (1.29 and 3.73 mg/kg). A sample from the driveway of 1029 Washington Street was also elevated with a concentration of 5.64 mg/kg. In addition, samples from the driveway of 1030 Varian Street, an unpaved lot used for storage, had an elevated PCBs concentration of 1.84 mg/kg. It should be noted that all of the buildings in this area appear to be of the type and age that may have PCBs in building materials. The Countywide Program is currently working with the City of San Carlos to determine next steps for these properties.

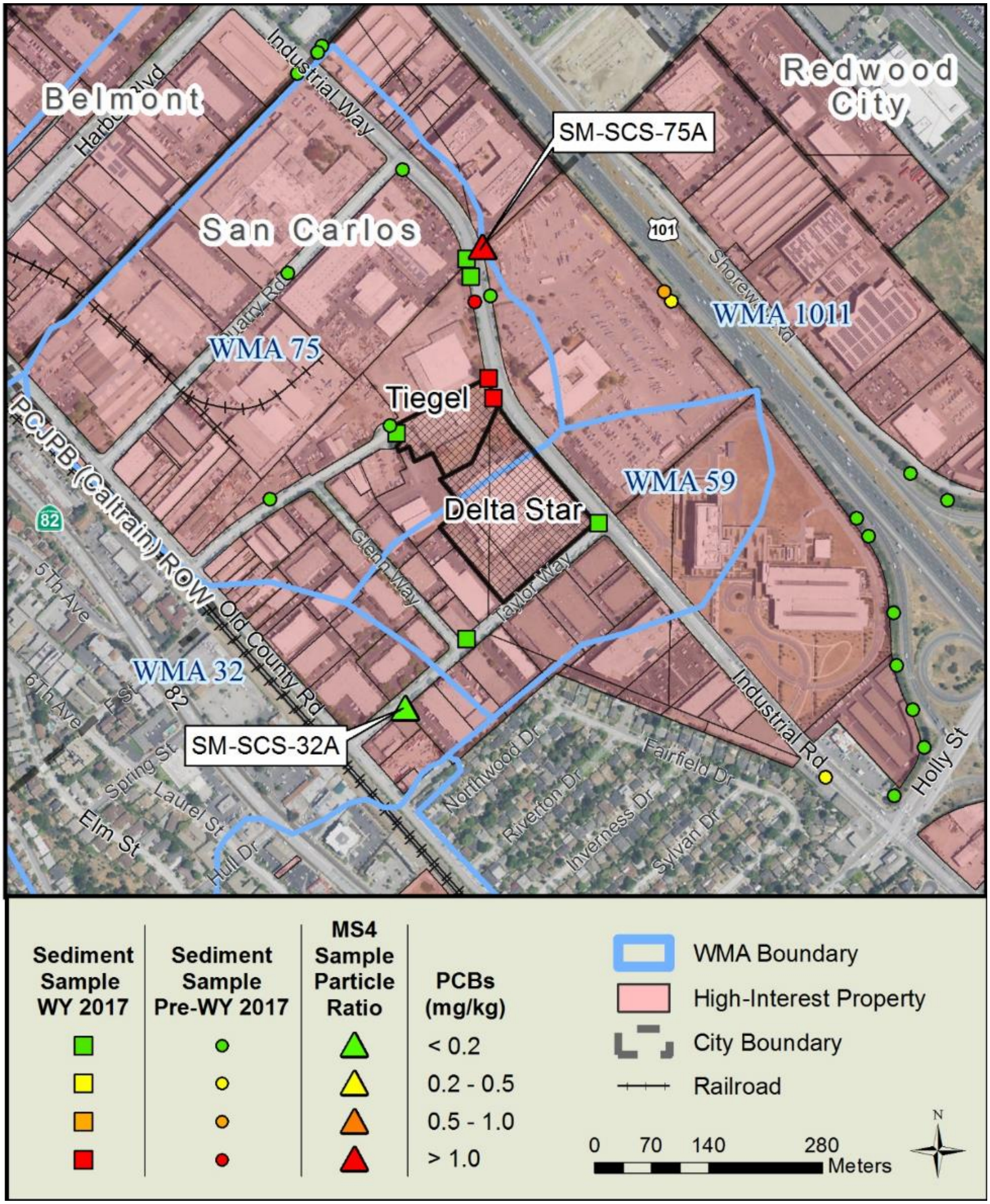

Figure 14. WMAs 59, 75, and 1011

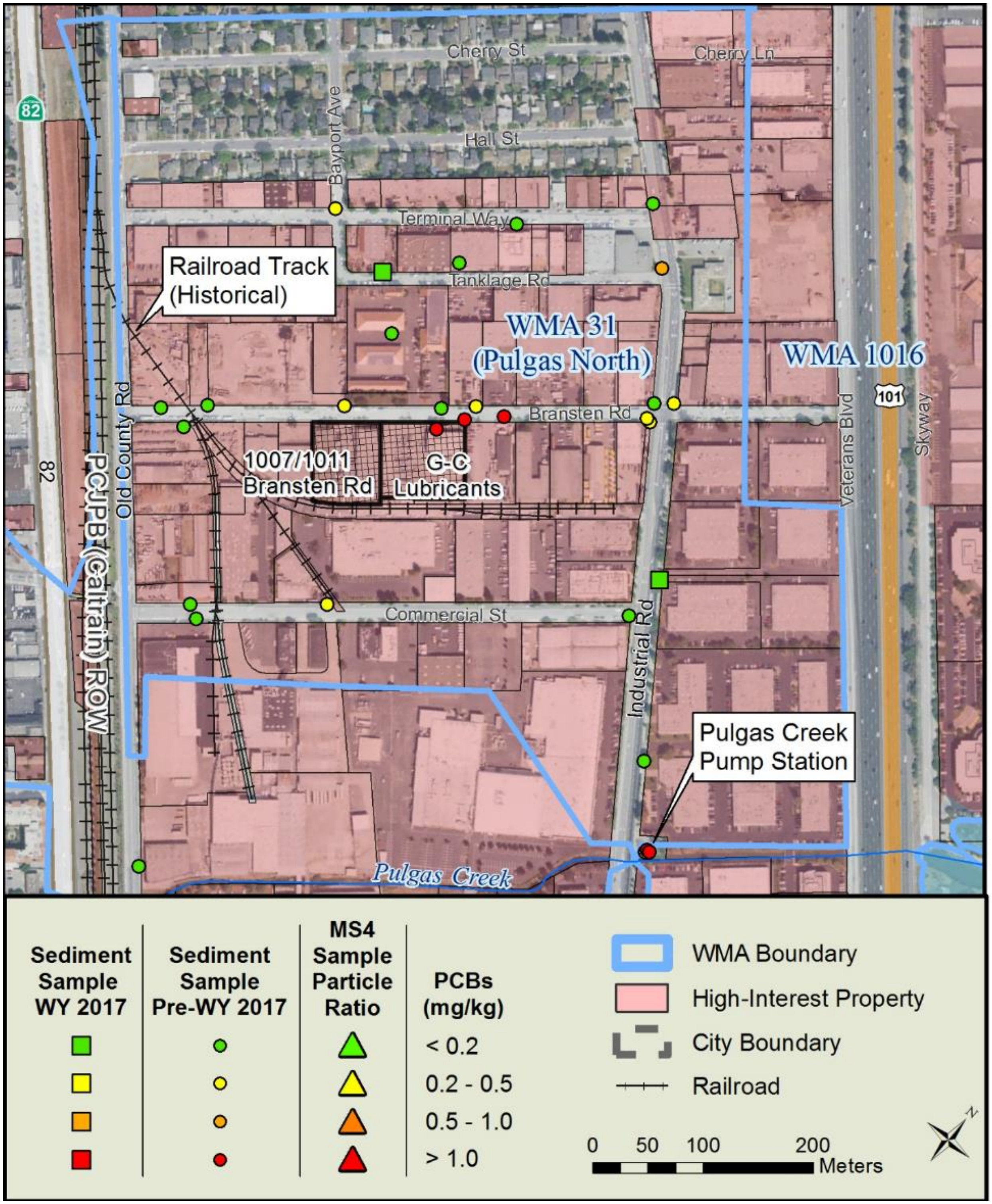

Figure 15. WMA 31

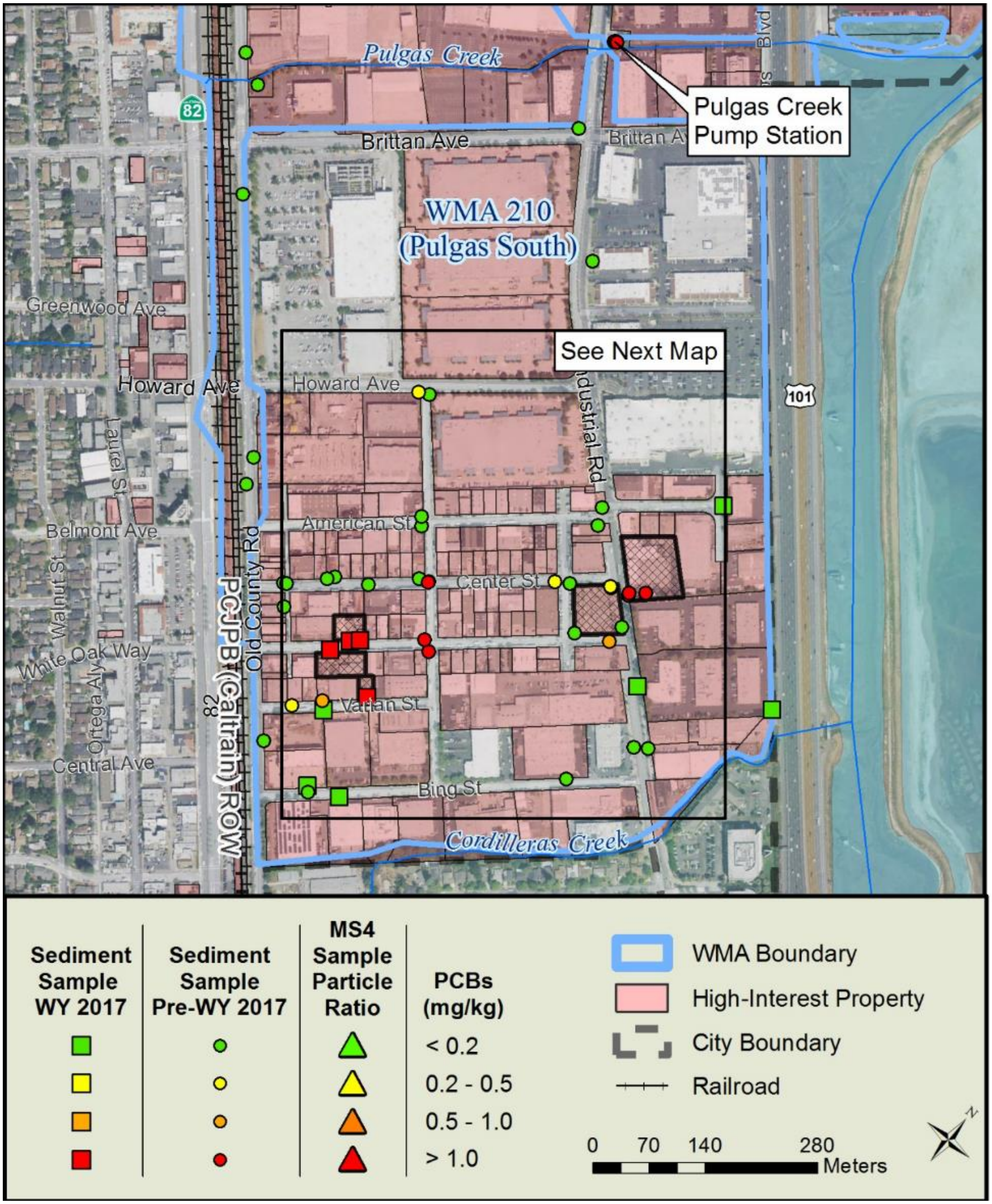

Figure 16. WMA 210

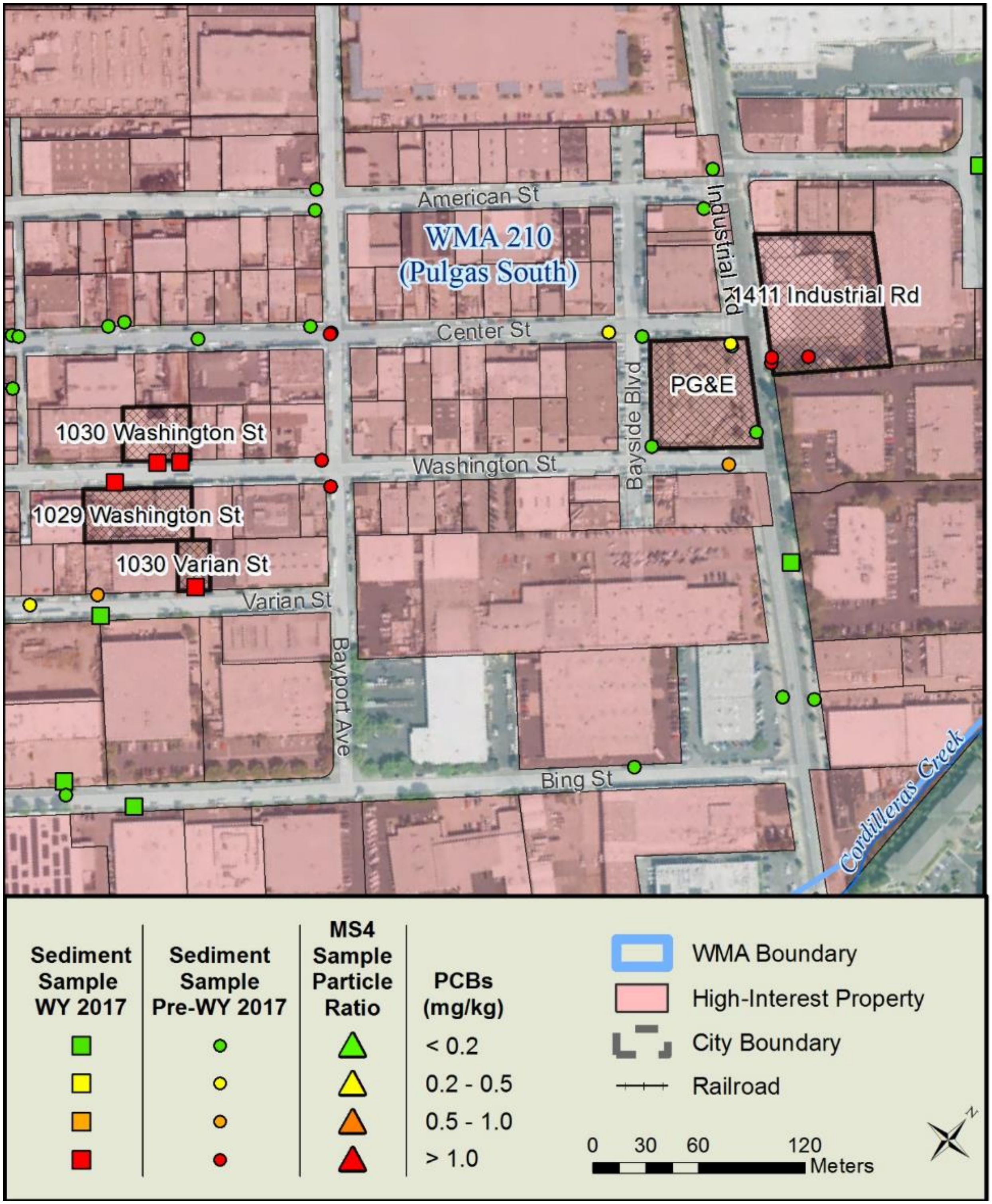

Figure 17. WMA 210 – Enlargement of Sampled Area

City of Redwood City

WMAs in the City of Redwood City with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 18 – 21 and briefly described below.

WMA 239

WMA 239 (Figure 21) is a 36 acre mostly industrial catchment that is half in Redwood City and half in Menlo Park. In WY 2015 SMCWPPP collected a sediment sample that had an elevated PCBs concentration of 0.57 mg/kg. Five additional sediment samples were collected in WY 2017, all of which had relatively low (urban background) PCBs concentrations, with the highest concentration being 0.16 mg/kg. Currently in this WMA there is a large housing redevelopment that is almost complete. One of the industries that was redeveloped (Haven Avenue Industrial Condominiums) at 3633 Haven Ave is in Geotracker and was remediated for PCBs contamination in 2006. Stormwater runoff sampling has not been conducted in this catchment and would be challenging since there is no public access to the catchment outfall (which discharges to the Bay).

WMA 379

WMA 379 (Figures 18 and 19) is an 802 acre catchment located in Redwood City and the unincorporated North Fair Oaks census-designated place (CDP). The catchment is divided into a northerly half (A) and a southerly half (B), each with a distinct MS4 outfall. Both were sampled by the Countywide Program in WY 2016. Sample SM-RCY-379A had a relatively low PCBs particle ratio concentration (105 ng/g). Sample SM-RCY-379B also had a relatively low PCBs particle ratio concentration (182 ng/g). In WY 2017, the Countywide Program collected fifteen samples in WMA 379 in an attempt to identify PCBs source along Bay Road and Spring Street, in follow-up to elevated sediment samples collected during previous years. None of nine samples collected in the Bay Road near Hurlingame Avenue area was elevated, with the highest PCBs concentration being 0.14 mg/kg. A single sample collected from an inlet at the back of the sidewalk in front of 2201 Bay Road had a PCBs concentration of 1.97 mg/kg. This site is the location of two properties on Geotracker listed for PCBs: Tyco Engineering Products and the railroad spur next to the property. The Tyco site was remediated and redeveloped (MRP Provision C.3 compliant) and is currently a parking lot for Stanford Hospital. Four sediment samples were collected on Spring Street in WY 2017. None was elevated, with the highest PCBs concentration being 0.08 mg/kg.

WMA 405

WMA 405 (Figure 20) consists almost entirely of SIMS Metal Management at the Port of Redwood City. A sample from the driveway of SIMS in WY 2017 was moderately elevated with a PCBs concentration of 0.75 mg/kg. The site has recently made efforts to prevent metal fluff potentially containing a variety of contaminants (including PCBs) from entering the Bay.

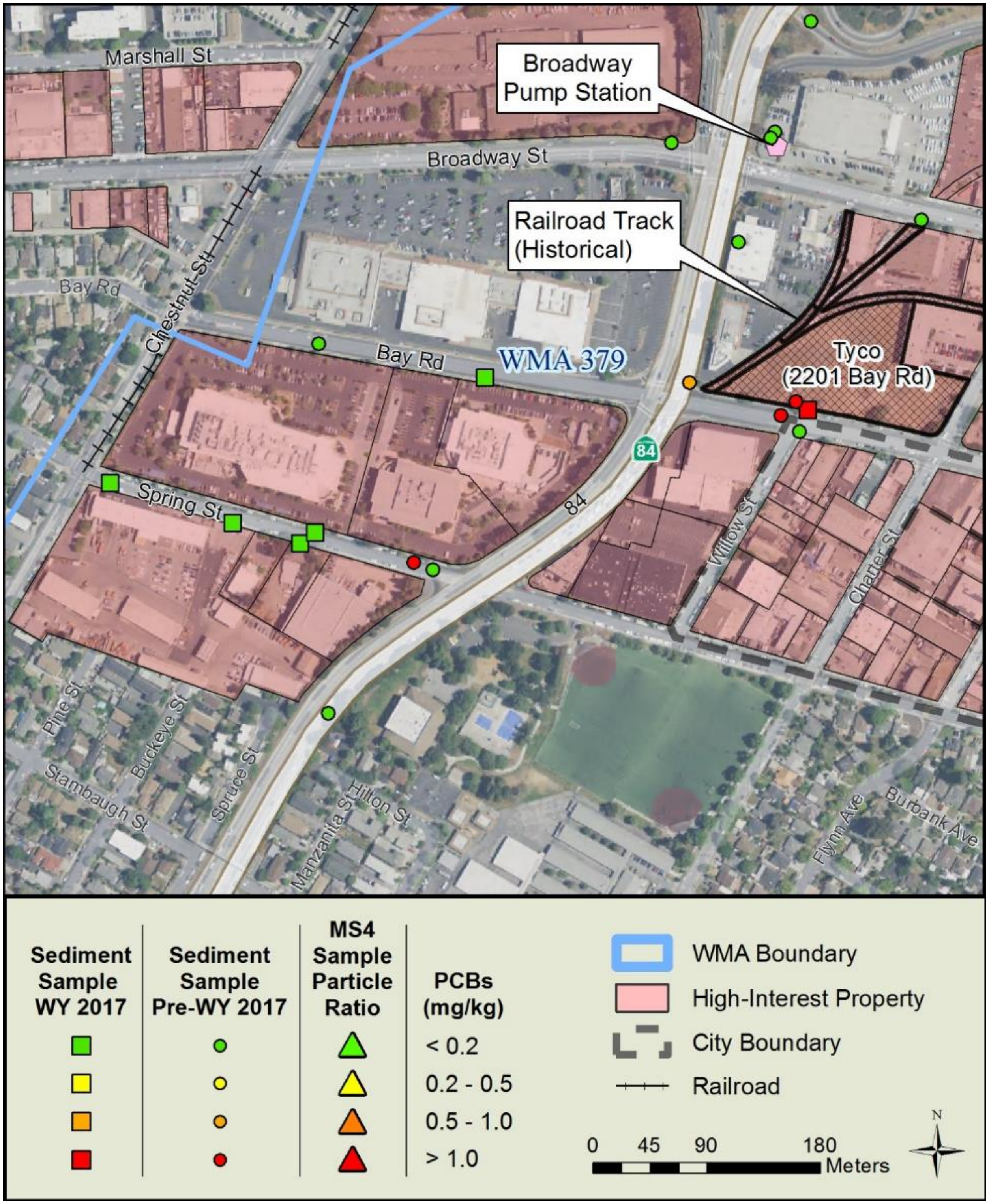

Figure 18. WMA 379 northwest

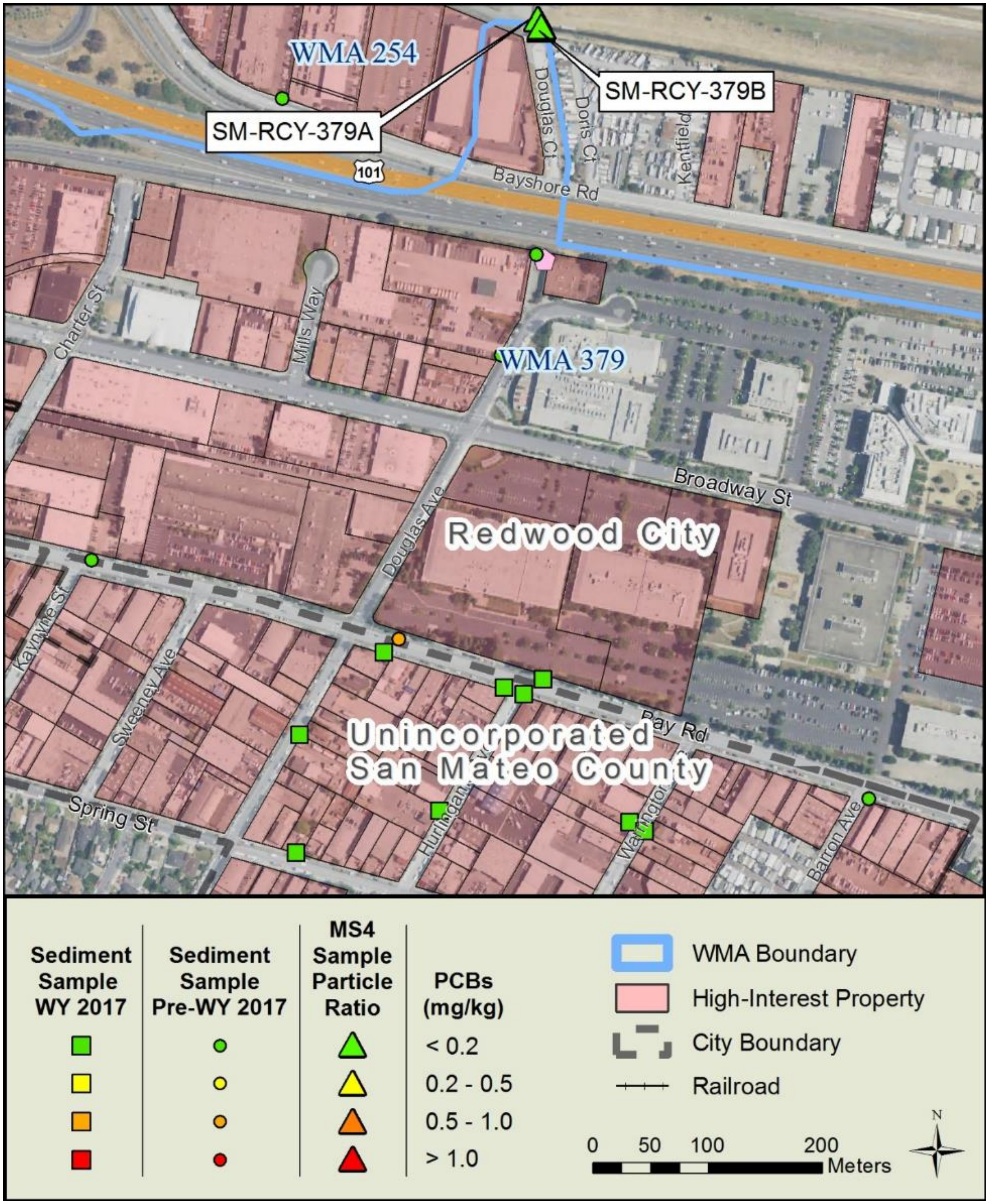

Figure 19. WMAs 254 and 379 southeast

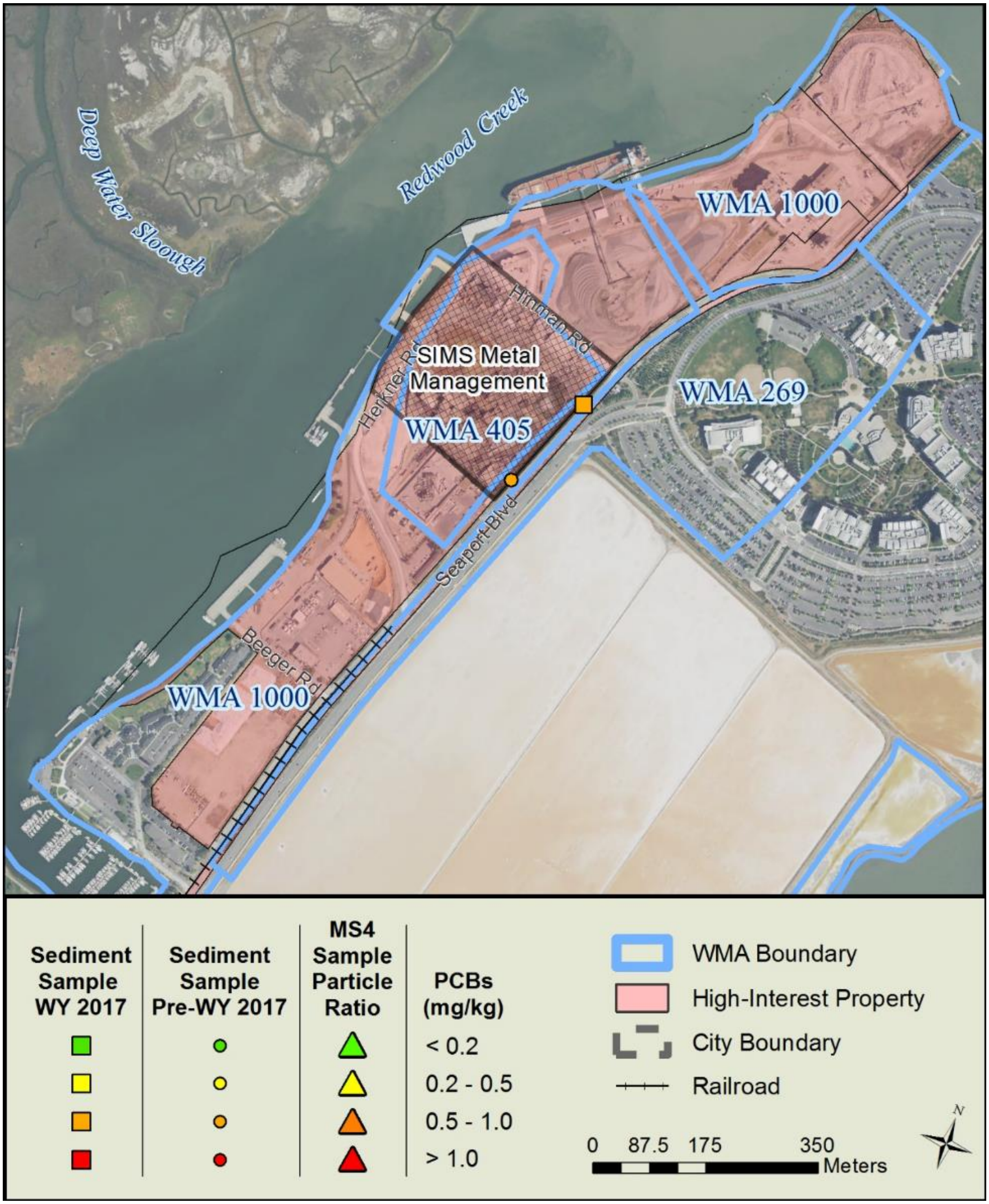

Figure 20. WMAs 269, 405, 1000

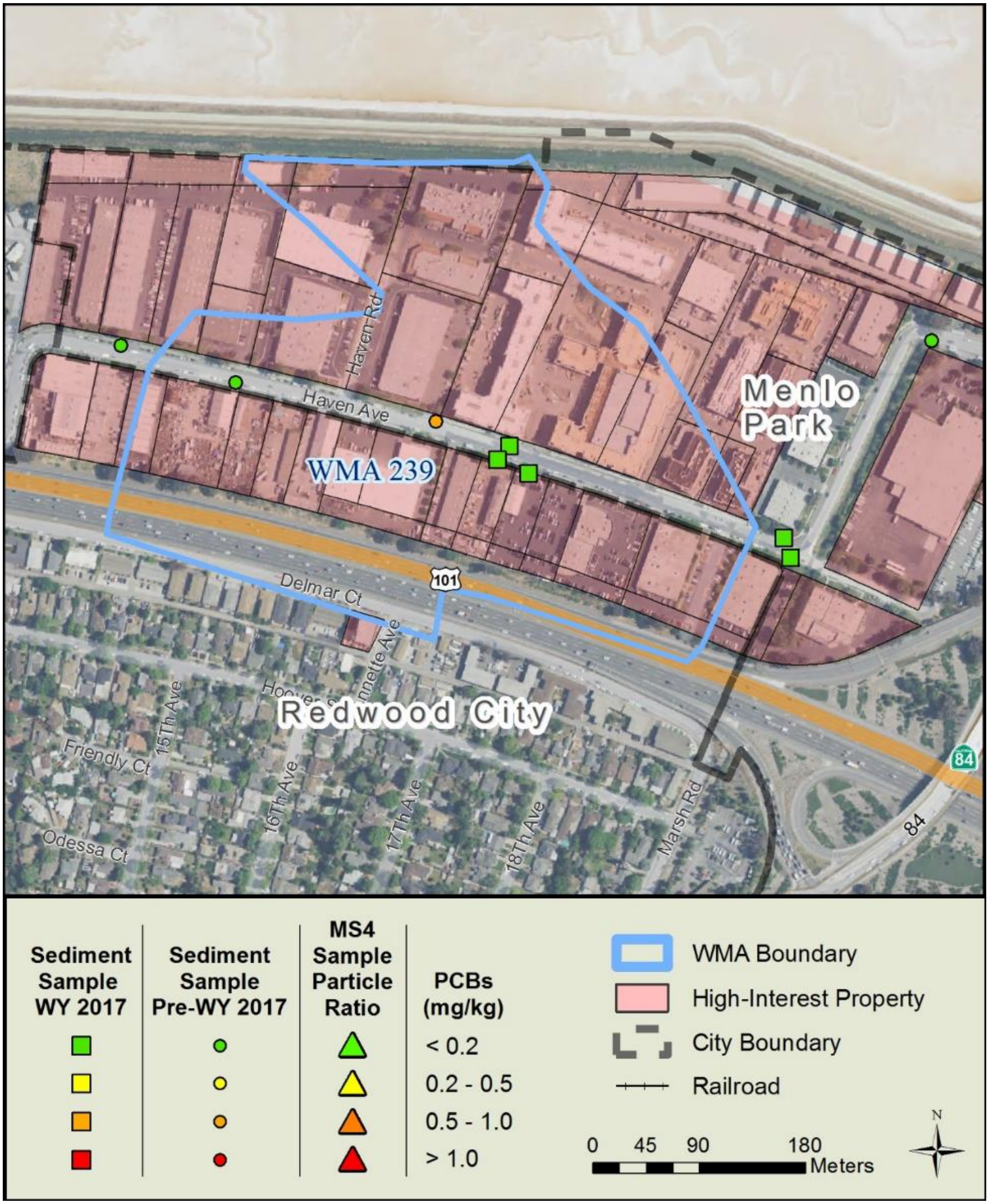

Figure 21. WMA 239

City of East Palo Alto

WMAs in the City of East Palo Alto with PCBs particle ratio concentrations over 0.2 mg/kg in stormwater runoff samples, elevated concentrations of PCBs in sediment samples, and/or other features relevant to investigating sources of PCBs are shown in Figure 22 and briefly described below.

WMA 70

WMA 70 is a 490 acre catchment in the City of East Palo Alto. A storm sample collected by the RMP in WY 2015 had a relatively high PCBs concentration (28.5 ng/L) and a relative average PCB particle ratio (108 ng/g). Three samples were collected in the area in WY 2017 with the highest having a concentration of 0.03 mg/kg.

WMA 1015

WMA 1015 consists of multiple catchments in the City of East Palo Alto. The WMA contains Romic Environmental Technologies Corporation, a property that is known to be contaminated with PCBs and has been vacant for many years. A stormwater sample (SM-EPA-72A) and two sediment samples near the driveway to Romic have all been low in PCBs. However, the property drains directly to the Bay and the outfall is inaccessible. The WMA also contains 391, a landfill that is also known to be contaminated with PCBs. The site is expected to be redeveloped in the future. This property also drains directly to the Bay and is not possible to sample since it is all private property and inaccessible. A sediment sample from an inlet at the north end of Demeter Street was moderately elevated in PCBs with a concentration of 0.21 mg/kg.

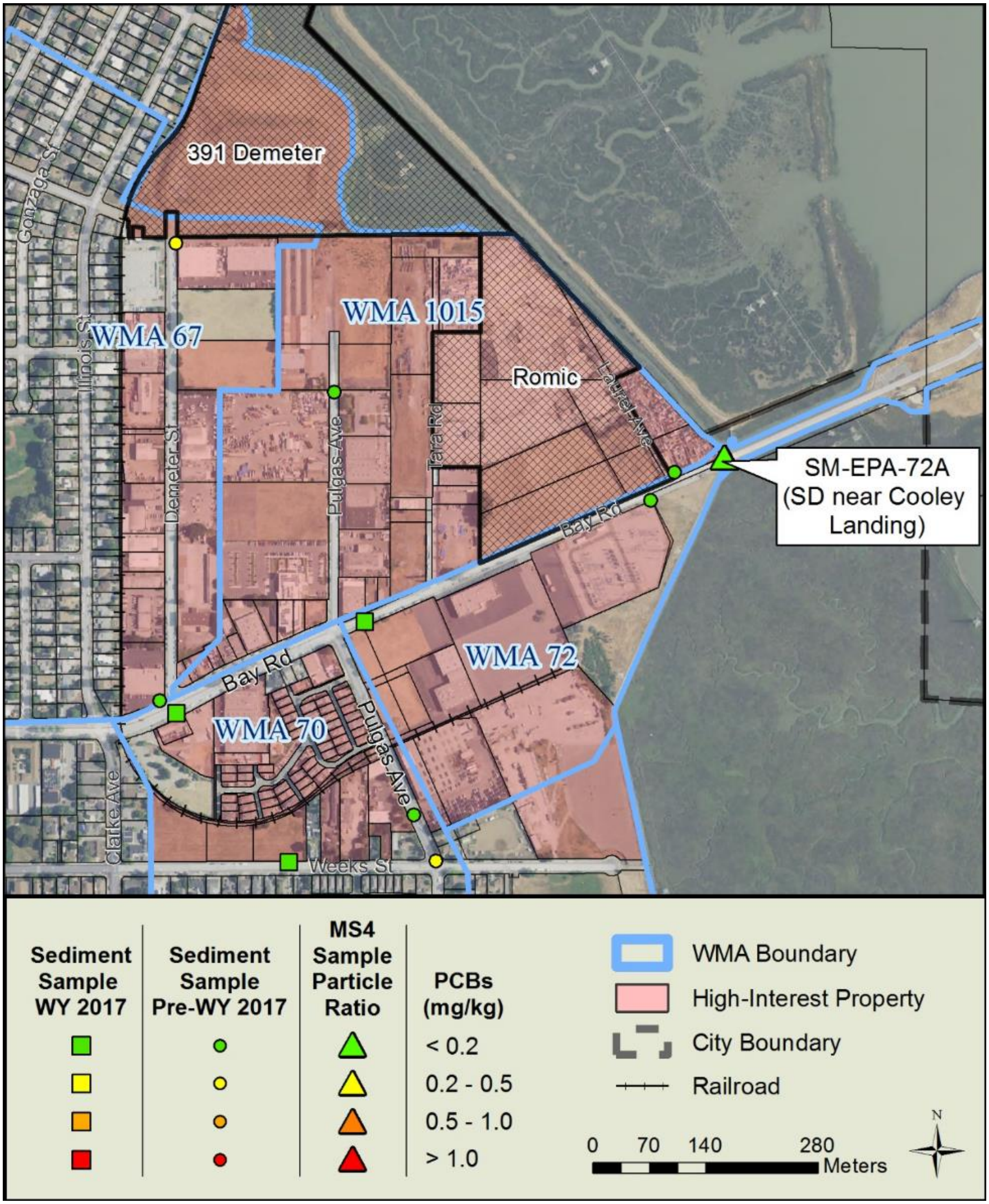

Figure 22. WMAs 70, 72, 1015

2.3. Copper

In WY 2017, the Countywide Program collected a total of six samples for copper analysis[10]:

- One stormwater runoff sample analyzed for copper was collected from a storm drain outfall (SM-SSF-316A) concurrently with one of the PCBs and mercury storm composite samples. The goal of this sample was to address Management Question #4 (Loads and Status) by characterizing copper concentrations in stormwater runoff from highly urban catchments.
- A total of four creek water samples were collected during a large storm event, two samples at upstream and two samples at downstream locations in two creeks: Atherton Creek (samples 204ATH050 and 204ATH010) and Redwood Creek (samples 204RED050 and 204RED010). The goal of this approach was to address Management Question #4 (Loads and Status) by characterizing copper concentrations at upstream and downstream locations in creeks in mixed land-use catchments during a storm event (i.e., while stormwater runoff was being discharged to the creeks).
- The downstream Redwood Creek station (204RED010) was also sampled for copper in May. The goal of this sample (along with the sample collected during a storm event at the same location) was to address Management Question #5 (Trends) by comparing spring baseflow concentrations to stormwater event concentrations measured at this bottom-of-the-watershed location. A similar approach was planned in Atherton Creek but could not be conducted due to dry conditions at the downstream station in the spring (204ATH010).

All samples were analyzed for total copper, dissolved copper[11], and hardness. Results are summarized in Table 6. Comparisons to freshwater water quality objectives are described in Section 3.0.

Table 6. Total and dissolved copper concentrations in water samples collected by the Countywide Program, WY 2017.

Station Code	Description	Sample Date	Total Copper (µg/L)	Dissolved Copper (µg/L)	Hardness as $CaCO_3$ (mg/L)
SM-SSF-316A	Stormwater runoff in urban catchment	12/10/2016	12.7	6.5	34.8
204ATH010	Atherton Creek – downstream station	1/9/2017	12	9.8	260
204ATH050	Atherton Creek – upstream station	1/9/2017	8.4	6.2	200
204RED010	Redwood Creek – downstream station	1/9/2017	13	11	260
204RED010	Redwood Creek – downstream station (spring)	5/22/2017	14	12	380
204RED050	Redwood Creek – upstream station	1/9/2017	8.1	6.4	260

[10] The October 10, 2017 POC Monitoring Report (SMCWPPP 2017b) incorrectly reported that five copper samples were collected in WY 2017. The report inadvertently omitted that the spring sample collected at 204RED010 was analyzed for copper.

[11] In order to simplify the field effort and reduce the risk of sample contamination, SMCWPPP requested that the analytical laboratory conduct the sample filtration required for dissolved copper analysis.

Based on the laboratory results, the following findings were noted:

- As expected, dissolved copper concentrations are lower than total copper concentrations.
- Copper concentrations reported for the stormwater outfall (SM-SSF-316A) were comparable to concentrations measured in creeks. However, the hardness of the outfall water was an order of magnitude less than the creek water.
- Copper concentrations during the January storm event were higher at bottom-of-the-watershed stations in both Atherton and Redwood Creeks (204ATH010 and 204RED010) compared to the upstream stations (204ATH050 and 204RED050), suggesting an influence by stormwater runoff.
- Copper concentrations at the bottom-of-the-watershed station in Redwood Creek (204RED010) were similar between spring baseflow conditions and during the January storm event. However, the higher water hardness during spring baseflows reduces the bioavailability of the copper (see Section 3.0).

2.4. Nutrients

Nutrients were included in the POC monitoring requirements to support Regional Water Board efforts to develop nutrient numeric endpoints (NNE) for the San Francisco Bay Estuary. The "San Francisco Bay Nutrient Management Strategy" (NMS) is part of a statewide initiative to address nutrient over-enrichment in State waters (Regional Water Board 2012). Its goal is to lay out a well-reasoned and cost-effective program to generate the scientific understanding needed to fully support major management decisions such as establishing/revising objectives for nutrients and dissolved oxygen, developing/implementing a nutrient monitoring program, and specifying nutrient limits in NPDES permits. The NMS monitoring program currently focuses on stations located within San Francisco Bay.

MRP Provision C.8.f requires monitoring for a suite of nutrients (i.e., ammonium, nitrate, nitrite, total Kjeldahl nitrogen (TKN), orthophosphate, and total phosphorus). This list closely reflects the list of analytes measured by the RMP and BASMAA partners at the six regional loading stations (including a San Mateo County station at the Pulgas Creek Pump Station in the City of San Carlos) monitored in WY 2012 - WY 2014. The prior data collected in freshwater tributaries to San Francisco Bay were used by the Nutrient Strategy Technical Team to develop and calibrate nutrient loading models.

In WY 2017, POC monitoring for nutrients in San Mateo County was conducted at four stations (upstream and downstream locations in two creeks: Atherton Creek and Redwood Creek) during a large storm event, concurrent with the copper monitoring described in the previous section. Follow-up monitoring at all four stations was attempted during the dry season concurrent with bioassessment monitoring; however, the downstream Atherton Creek station was dry when the field crew returned in the spring. Two of the three dry season samples are not counted towards Provision C.8.f POC monitoring requirements because they apply instead to Provision C.8.d Creek Status Monitoring. These were stations 204ATH050 (bioassessment station 204R03240) and 204RED050 (bioassessment station 20403496). Nutrient POC monitoring addresses Management Question #4 (Loads and Status). Results are summarized in Table 7. Comparisons to applicable freshwater water quality objectives are described in Section 3.0.

Table 7. Nutrient concentrations in POC water samples collected by the Countywide Program, WY 2017.

Station	Date	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen (TKN)	Ammonia as N	Un-ionized Ammonia as N[1]	Ammonium[2]	Total Nitrogen[3]	Dissolved Orthophosphate as P	Phosphorus as P	Upstream (u/s) Station or Downstream (d/s) Station
Atherton Creek											
204ATH010	1/9/2017	2.2	0.006	1.7	0.057	0.0013	0.06	3.91	0.19	0.29	d/s
204ATH050	1/9/2017	1.5	0.006	1.8	0.064	0.0007	0.06	3.31	0.1	0.24	u/s
204ATH050	5/23/2017	ND[4]	0.002	1.2	0.034	0.0005	0.03	1.21	0.05	0.06	u/s
Redwood Creek											
204RED010	1/9/2017	1.5	0.005	1.6	0.046	0.0017	0.04	3.11	0.27	0.36	d/s
204RED010	5/22/2017	0.57	0.028	1.3	0.069	0.0122	0.06	1.9	0.11	0.16	d/s
204RED050	1/9/2017	1.2	0.004	1.4	0.038	0.0011	0.04	2.6	0.2	0.27	u/s
204RED050	5/22/2017	0.37	0.034	0.83	0.093	0.0027	0.09	1.23	0.14	0.16	u/s

Notes:
All constituents reported as mg/L.
[1] Un-ionized ammonia calculated using formula provided by the American Fisheries Society Online Resources.
[2] Ammonium = ammonia – un-ionized ammonia.
[3] Total nitrogen = TKN + nitrate + nitrite. Non-detects valued at ½ method detection limit in calculation
[4] ND - Not Detected.

Based on the laboratory results, the following findings are noted:

- Nutrient concentrations in Atherton Creek were generally slightly higher than nutrient concentrations in Redwood Creek.
- In Redwood Creek, concentrations of all nutrients measured were higher at the downstream station (204RED010) compared to the upstream station (204RED050) during both storm flows and spring baseflows.
- In Atherton Creek, nitrate, total nitrogen, dissolved orthophosphate and phosphorus concentrations were higher at the downstream station (204ATH010) compared to the upstream station (204ATH050). However, TKN and ammonia concentrations were lower at the downstream station. This suggests an organic source of nitrogen in the upper watershed.
- Nutrient concentrations in both creeks were higher during the January storm runoff sampling event compared to the spring baseflow event. This finding is consistent with the draft conceptual model developed by the NMS which suggests that nutrient loads to San Francisco Bay from creeks are highest during the wet season, although considerably less than loads from publicly owned wastewater treatment works (POTWs) (Senn and Novick 2014).

2.5. Emerging Contaminants

Emerging contaminant monitoring is being addressed through Countywide Program's participation in the RMP. The RMP has been investigating Chemicals of Emerging Concern (CECs) since 2001 and established the RMP Emerging Contaminants Work Group (ECWG) in 2006. The goal of the ECWG is to identify CECs that have the potential to impact beneficial uses in the Bay and to develop cost-effective strategies to identify and monitor CECs and minimize their impacts. The RMP published a CEC Strategy "living" document in 2013 and completed a full revision in 2017 (Sutton et al. 2013; Sutton and Sedlak 2015; Sutton et al. 2017). The CEC Strategy document guides RMP special studies on CECs using a tiered risk and management action framework. PFOS compounds are identified in the CEC Strategy as "moderate" concern due to Bay occurrence data suggesting a high probability of a low level effect on Bay wildlife. PFAS compounds and alternative flame retardants (AFRs) are identified as "possible" concern due to uncertainties in measured or predicted Bay concentrations or in toxicity thresholds. RMP staff recently published reports summarizing PFOS and PFAS monitoring results (Houtz et al. 2016; Sedlak et al. 2017). The RMP is currently reviewing data available on AFRs to help inform a conceptual model that will be developed in the future.

3.0 COMPLIANCE WITH APPLICABLE WATER QUALITY STANDARDS

MRP provision C.8.h.i requires RMC participants to assess all data collected pursuant to Provision C.8 for compliance with applicable water quality standards. In compliance with this requirement, POC monitoring water sampling data collected in WY 2017 by the Countywide Program were compared to applicable numeric water quality objectives (WQOs). There were no exceedances of applicable WQOs. The comparison to applicable WQOs accounted for the following:

- **Discharge vs. Receiving Water** – WQOs apply to receiving waters, not discharges. WQOs are designed to represent the maximum amount of pollutants that can remain in the water column without causing any adverse effect on organisms using the aquatic system as habitat, on people consuming those organisms or water, and on other current or potential beneficial uses. Only nutrient and most of the copper data were collected in receiving waters. PCB, mercury, and one copper sample were collected within the engineered storm drain network. Dilution is likely to occur when the MS4 discharges urban stormwater (and non-stormwater) runoff into the local receiving water. Therefore, it is unknown whether discharges that exceed WQOs result in exceedances in the receiving water itself, the location where there is the potential for exposure by aquatic life.
- **Freshwater vs. Saltwater** - POC monitoring data were collected in freshwater, above tidal influence and therefore comparisons were made to freshwater WQOs.
- **Aquatic Life vs. Human Health** - Comparisons were primarily made to WQOs for the protection of aquatic life, not WQOs for the protection of human health to support the consumption of water or organisms. This decision was based on the assumption that water and organisms are not likely being consumed from the stations monitored.
- **Acute vs. Chronic Objectives/Criteria** – All monitoring of water for PCBs and mercury and a portion of the copper and nutrient monitoring was conducted during episodic storm events and the results likely do not represent long-term concentrations of the monitored constituents. Storm monitoring data should therefore compared to acute WQOs for aquatic life that represent the highest concentrations of a pollutant to which an aquatic community can be exposed briefly (e.g., 1-hour) without resulting in an unacceptable effect. Spring baseflow monitoring data should be compared to chronic WQOs.

Of the WY 2017 POC monitoring station analytes, WQOs for the protection of aquatic life have only been promulgated for total mercury, dissolved copper, and unionized ammonia.

- **Total Mercury**. Most of the concentrations of mercury in water reported in WY 2017 were lower than prior years by about an order of magnitude. These data were rejected by the Countywide Program QA/QC Officer (see Section 2.1). In addition, these stormwater runoff sample data (discharge, not receiving water) are not directly comparable to WQOs, as described above. However, all of the WY 2017 and prior water year (see Table 4) mercury concentrations were well below the freshwater acute objective for mercury of 2.4 µg/L.
- **Dissolved Copper.** Acute (1-hour average) and chronic (4-day average) WQOs for copper are expressed in terms of the dissolved fraction of the metal in the water column and are hardness dependent[12]. The copper WQOs were calculated using the measured hardness values and are compared to the measured dissolved copper concentrations in Table 8. For the station located within the MS4 (SM-SSF-316A), hardness was not measured in the receiving water and it is unknown whether the same calculated WQO would apply to the receiving water. This is the only station with a dissolved copper concentration that exceeded the calculated WQO (Table 8). However, as stated above, the sample was collected in the MS4, not the receiving water. Dilution of the MS4 discharge would occur in the receiving water and it is unknown whether the discharge would result in an exceedance of the copper WQO in the receiving water. Furthermore, it is unknown whether the receiving water has the same hardness as the discharge. If the hardness in the receiving water was higher, a higher WQO would be applicable.
- **Nutrients**. The un-ionized ammonia concentrations measured in Countywide Program samples (see Table 7) were well below the annual median objective for un-ionized ammonia of 0.025 mg/L.

Table 8. Comparison of WY 2017 Copper Monitoring Data to WQOs.

Station Code	Sample Date	Hardness as $CaCO_3$ (mg/L)	Acute WQO for Dissolved Copper at Measured Hardness (µg/L)	Chronic WQO for Dissolved Copper at Measured Hardness (µg/L)	Dissolved Copper (µg/L)
SM-SSF-316A	12/10/2016	34.8	5.0	3.6	**6.5**
204ATH010	1/9/2017	260	33	20	9.8
204ATH050	1/9/2017	200	26	16	6.2
204RED010	1/9/2017	260	33	20	11
204RED010	5/22/2017	380	47	28	12
204RED050	1/9/2017	260	33	20	6.4

[12] The current copper standards for freshwater in California do not account for the effects of pH or natural organic matter and can be overly stringent or under-protective (or both, at different times). Therefore, the California Stormwater Quality Association (CASQA) has asked the USEPA to considering updating the California Toxics Rule for copper using the Biotic Ligand Model (BLM) which accounts for the effect of water chemistry in addition to hardness (i.e., temperature, pH, dissolved organic carbon, major cations and anions).

4.0 CONCLUSIONS

In WY 2017, the Countywide Program collected and analyzed POC samples in compliance with Provision C.8.f of the MRP. Yearly minimum requirements were met for all monitoring parameters. In addition, the Countywide Program continued helping the RMP's STLS to select its WY 2017 PCBs and mercury monitoring stations that are located in in San Mateo County. The data from those stations was evaluated along with PCBs and mercury data collected directly by the Countywide Program. Conclusions from WY 2017 POC monitoring included the following:

- The Countywide Program's PCBs and mercury monitoring focuses on San Mateo County WMAs containing high interest parcels with land uses potentially associated with PCBs such as old industrial, electrical and recycling. During WY 2017 the Countywide Program collected 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs and 67 grab sediment samples (of which 6 were duplicates) within the WMAs. The Countywide Program evaluated the PCBs stormwater runoff and sediment monitoring data to help prioritize WMAs for further investigation and identify which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls.
- Based on the sediment and stormwater runoff monitoring data collected to-date in San Mateo County by the Countywide Program and other parties (e.g., the RMP's STLS), WMAs were provisionally designated as higher, medium, or lower priority. Figure 4 is a map illustrating the current status of WMAs in San Mateo County, based on this provisional prioritization scheme.
- The WY 2017 grab sediment samples and other data collected to-date informed identification of source properties within WMAs, potentially for referral to the Regional Water Board for further investigation and potential abatement. The sediment samples were collected from manholes, storm drain inlets, driveways, streets, and sidewalks in the public right-of-way (ROW), including locations adjacent to high interest parcels with land uses associated with PCBs such as old industrial, electrical and recycling and/or other characteristics potentially associated with pollutant discharge (e.g., poor housekeeping, unpaved areas). Based on the data gathered to-date, the Countywide Program is working with the City of San Carlos to develop referrals for three properties, and evaluating next steps at several other potential source properties.
- One of the 17 composite samples of stormwater runoff from outfalls at the bottom of WMAs was also analyzed for total and dissolved copper. An additional four creek water samples were collected for copper analysis from upstream and downstream locations in two creeks (Atherton and Redwood Creeks) during a large January 2017 storm event. One of the downstream stations was also sampled for copper during spring baseflow conditions. Copper concentrations were higher at bottom-of-the-watershed stations in both creeks compared to stations higher in the watersheds), suggesting an influence by stormwater runoff.
- The upstream and downstream stations in Atherton and Redwood Creeks were concurrently sampled for nutrients during the large January 2017 storm event. Three of these stations were also sampled for nutrients during spring baseflow conditions. In Atherton Creek, nitrate, total nitrogen, dissolved orthophosphate and phosphorus concentrations were higher at the downstream station compared to the upstream station. However, TKN and ammonia concentrations were lower at the downstream station, suggesting an organic source of nitrogen in the upper watershed. Nutrient concentrations in both creeks were higher during the January storm sampling event compared to the spring baseflow event, suggesting that nutrient loads to San Francisco Bay from these creeks is higher during storm events.

- With one exception, none of the WY 2017 water samples exceeded applicable water quality objectives (WQOs). The exception was the stormwater runoff sample analyzed for copper. However, WQOs generally are applied to receiving waters, not stormwater runoff, and it is likely that mixing in the receiving water downstream of the outfall would have diluted the copper. In addition, higher hardness in the creek compared to the stormwater runoff would have reduced the bioavailability of the copper in the receiving water.

5.0 NEXT STEPS

In WY 2018, the Countywide Program will continue to collect and analyze POC samples in compliance with Provision C.8.f of the MRP. Yearly minimum requirements will be met for all monitoring parameters. In addition, the Countywide Program will continue helping the RMP's STLS to select its WY 2017 PCBs and mercury monitoring stations that are located in in San Mateo County. POC monitoring activities in WY 2018 will include the following:

- The Countywide Program, in coordination with the RMP STLS, will continue conducting PCBs and mercury monitoring that focuses on San Mateo County WMAs containing high interest parcels with land uses potentially associated with PCBs such as old industrial, electrical and recycling. This will include collecting additional composite samples of stormwater runoff from outfalls at the bottom of WMAs and grab sediment samples within the WMAs. Objectives will include attempting to identify source properties within WMAs, identifying which WMAs provide the greatest opportunities for implementing cost-effective PCBs controls, and prioritizing WMAs for potential future investigations.
- At least eight PCBs and mercury samples that address Management Question #3 (Management Action Effectiveness) must be collected by the end of year four of the permit (i.e., by 2020). The Countywide Program is currently working with BASMAA to implement a regional project that addresses POC Management Action Effectiveness. The study design, approved in August 2017 by the BASMAA Project Management Team (which includes representatives from the Countywide Program), addresses the effectiveness of hydrodynamic separator (HDS) units and various types of biochar-amended bioretention soil media (BSM) at removing PCBs and mercury from stormwater. Findings from the regional project will be reported in the WY 2018 UCMR which will be submitted by March 31, 2019. Findings will also be used to support the Countywide Program's Reasonable Assurance Analysis (RAA).
- At least eight samples that address Management Question #5 (Trends) must be collected by the end of year four of the permit (i.e., 2020). The Countywide Program will continue to participate in the STLS Trends Strategy Team to help meet this requirement. The STLS Trends Strategy Team, initiated in WY 2015, is currently developing a regional monitoring strategy to assess trends in POC loading to San Francisco Bay from small tributaries. The STLS Trends Strategy will initially focus on PCBs and mercury, but will not be limited to those POCs. Analysis of recent and historical data collected at region-wide loadings stations suggests that PCB concentrations are highly variable. Therefore, a monitoring design to detect trends with statistical confidence may require more samples than is feasible with current financial resources. The STLS Trends Strategy Team is continuing to evaluate available data from the Guadalupe River watershed to explore more economical monitoring opportunities. The Team is also considering modeling options that could be used in concert with monitoring to detect and predict trends in POC loadings. A Trends Strategy Road Map is currently being developed.
- The Countywide Program will also continue to work with work with the State's Stream Pollution Trends (SPoT) Monitoring Program to help address Management Question #5 (Trends). SPoT conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Monitoring Program is to investigate long-term trends in water quality. Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including a station near the mouth of San Mateo Creek. In most years, sediment analytes include PCBs, mercury, toxicity, pesticides (Phillips et al. 2014).

- The Countywide Program will collect two copper and two nutrient water samples concurrently with its MRP Provision C.8.g.iii, Wet Weather Pesticides and Toxicity Monitoring, which targets two bottom-of-the-watershed stations during storm events. An additional two copper and nutrient samples will be collected at the same stations during the spring season when hydrographs are receding.
- The Countywide Program will continue to participate in the RMP, including the RMP's STLS and CEC Strategy (see Section 2.5).

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Attachment 1

Quality Assurance / Quality Control Report

Pollutants of Concern Monitoring - Quality Assurance/Quality Control Report, WY 2017

1.0 INTRODUCTION

The San Mateo Countywide Pollution Prevention Program (SMCWPPP) conducted Pollutants of Concern (POC) Monitoring in Water Year (WY) 2017 to comply with Provision C.8.f (Pollutants of Concern Monitoring) of the National Pollutant Discharge Elimination Program (NPDES) Municipal Regional Permit for the San Francisco Bay Area (i.e., MRP). Monitoring included analysis for polychlorinated biphenyls (PCBs), total mercury, total and dissolved copper, suspended sediment concentration (SSC), and nutrients (i.e., ammonia, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus).

This project utilized the Clean Watersheds for Clean Bay Project (CW4CB) Quality Assurance Project Plan (QAPP; BASMAA 2013) as a basis for Quality Assurance and Quality Control (QA/QC) procedures. Missing components were supplemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) QAPP (BASMAA 2016) and the QAPP for the California Surface Water Ambient Monitoring Program (SWAMP), specifically for nutrient and copper samples, respectively. Data were assessed for seven data quality attributes, which include (1) Representativeness, (2) Comparability, (3) Completeness, (4) Sensitivity, (5) Contamination, (6) Accuracy, and (7) Precision. These seven attributes are compared to Data Quality Objectives (DQOs), which were established to ensure that data collected are of adequate quality and sufficient for the intended uses. DQOs address both quantitative and qualitative assessment of the acceptability of data – representativeness and comparability are qualitative while completeness, sensitivity, precision, accuracy, and contamination are quantitative assessments. Specific DQOs are based on Measurement Quality Objectives (MQOs) for each analyte.

The MQOs for each of the POC analytes are summarized in Table 1 for water and Table 2 for sediment. As there was no reporting limit listed in the QAPP for copper, results were compared the SWAMP recommended reporting limits for inorganic analytes in freshwater. Overall, the results of the QA/QC review suggest that the data generated during this study were of sufficient quality for the purposes of the project. Further details regarding the QA/QC review are provided in the sections below. While some data were flagged in the project database, none of the data was rejected based on the MQOs or DQOs identified in the QAPPs. However, mercury data collected in water were later rejected by the project QA/QC officer based on comparison of results to similar data collected in recent years by SMCWPPP and other programs sampling the same population of urban catchments. Mercury concentrations were generally about an order-of-magnitude lower than expected. There was no reason to expect these lower concentrations, since the population of catchments and storms monitored was generally similar to the previous years based upon factors such as geography, land use, and storm size. Thus, the WY 2017 data were rejected due to the low probability that the WY 2017 sample results were representative of the population that they were collected from.

Table 1. Measurement quality objectives for analytes in water from the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan (BASMAA 2013) and BASMAA RMC Quality Assurance Project Plan (BASMAA 2016)

Sample	Nutrients[1]	Hardness[1]	SSC[2]	Copper[2]	Mercury[2]	PCBs[2]
Laboratory Blank	< RL	<RL	< RL	< RL	< RL	< RL
Reference Material (Laboratory Control Sample) Recovery	90-110%	80-120%	NA	75-125%	75-125%	50-150%
Matrix Spike Recovery	80-120%	80-120%	NA	75-125%	75-125%	50-150%
Duplicates (Matrix Spike, Field, and Laboratory)[3]	RPD < 25%	RPD < 25%	RPD < 25%	RPD < 25%	RPD < 25%	RPD < 25%
Reporting Limit	0.01mg/L for all except: Ammonia (0.02mg/L) TKN[4] (0.5mg/L)	1 mg/L[5]	0.5 mg/L	0.10 µg/L[6]	0.0002 µg/L (0.2 ng/L)	0.002 µg/L (2000 pg/L)

RL = Reporting Limit; RPD = Relative Percent Difference

[1] From the BASMAA QAPP

[2] From the CW4CB QAPP

[3] NA if native concentration for either sample is less than the reporting limit

[4] TKN = Total Kjeldahl Nitrogen

[5] No hardness RL listed in either QAPP. Value is from SWAMP-recommended reporting limits for conventional analytes in freshwater. (https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/tools/19_tables_fr_water/1_conv_fr_water.pdf)

[6] No copper RL listed in either QAPP. Value is from SWAMP-recommended reporting limits for inorganic analytes in freshwater. (http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/tools/19_tables_fr_water/4_inorg_fr_water.pdf)

Table 2. Measurement quality objectives for analytes in sediment from the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan (BASMAA 2013).

Sample	Total Solids	Mercury	PCBs
Laboratory Blank	< RL	< RL	< RL
Reference Material (Laboratory Control Sample) Recovery	N/A	75-125%	50-150%
Matrix Spike Recovery	N/A	75-125%	50-150%
Duplicates [1] (Matrix Spike, Field, and Laboratory)	RPD < 25%	RPD < 25%	RPD < 25%[2]
Reporting Limit	0.1%[3]	30 µg/kg 0.03 mg/kg 30,000 ng/kg	0.2 µg/kg 0.0002 mg/kg 200 ng/kg

RL = Reporting Limit; RPD = Relative Percent Difference

[1] NA if native concentration for either sample is less than the reporting limit

[2] Only applicable for matrix spike duplicates. Method specific for field and laboratory duplicates

[3] RL for total solids in water

2.0 REPRESENTATIVENESS

Data representativeness assesses whether the data were collected so as to represent actual conditions at each monitoring location. For this project, all samples are assumed to be representative if they are collected and analyzed according to protocols specified in the CW4CB QAPP and RMC QAPP. All field and laboratory personnel received and reviewed the QAPPs, and followed prescribed protocols including laboratory methods.

3.0 COMPARABILITY

The QA/QC officer ensures that the data may be reasonably compared to data from other programs producing similar types of data. For POC monitoring, individual stormwater programs try to maintain comparability within in RMC. The key measure of comparability for all RMC data is the California Surface Water Ambient Monitoring Program.

Electronic data deliverables (EDDs) are submitted to the San Francisco Regional Water Quality Control Board (SFRWQCB) in Microsoft Excel templates developed by SWAMP, to ensure data comparability with SWAMP. In addition, data entry follows SWAMP documentation specific to each data type, including the exclusion of qualitative values that do not appear on SWAMP's look up lists[1]. Completed templates are reviewed using SWAMP's online data checker[2], further ensuring SWAMP-comparability.

[1] Look up lists available online at http://swamp.waterboards.ca.gov/swamp_checker/LookUpLists.php.

[2] Checker available online at http://swamp.waterboards.ca.gov/swamp_checker/SWAMPUpload.php

4.0 COMPLETENESS

Completeness is the degree to which all data were produced as planned; this covers both sample collection and analysis. For chemical data and field measurements an overall completeness of greater than 90% is considered acceptable for RMC chemical data and field measurements.

During WY 2017, SMCWPPP collected over 100% of planned samples. Nutrients (ammonia, nitrate, nitrite, total Kjeldahl nitrogen, phosphorus, and orthophosphate), copper, and hardness were collected during two events – four samples were collected in January and one was collected in May 2017. A total of 17 aqueous samples were collected in WY 2017 and analyzed for PCBs, mercury, and SSC. Two additional aqueous samples were collected for copper and six additional samples were collected for hardness. Sixty-one (61) sediment samples were also collected in WY 2017 and analyzed for PCBs and mercury. A comparison of the total and actual samples collected for POC monitoring in WY 2017 is shown in Table 2.

Table 2. Comparison of the targeted number of samples with the actual number of samples collected during POC monitoring in WY 2017

Analyte	Matrix	Target	Actual
Nutrients[1]	Water	2	5
Suspended Sediment Concentration	Water	10-20	17
Hardness	Water	2	11
Copper	Water	2	7
Mercury	Water	10-20	17
PCBs	Water	10-20	17
Mercury	Sediment	40-60	61
PCBs	Sediment	40-60	61
Total Solids	Sediment	40-60	67

[1] Nutrients include ammonia, nitrate, nitrite, total Kjeldahl nitrogen, phosphorus, orthophosphate.

5.0 SENSITIVITY

5.1. Water

Sensitivity analysis determines whether the methods can identify and/or quantify results at low enough levels. For the aqueous chemical analyses in this project, sensitivity is considered to be adequate if the reporting limits (RLs) comply with the specifications in RMC QAPP Appendix E (RMC Target Method Reporting Limits) and the CW4CB QAPP Appendix B (CW4CB Target Method Reporting Limits).

A summary of the target and actual reporting limits for each analyte is shown in Table 3. Nutrient analysis, except for nitrate, and PCB analysis met their respective target reporting limits listed in the RMC QAPP and CW4CB QAPP. However, the reporting limits for all nitrate, suspended sediment concentration (SSC), hardness, and mercury samples exceeded their respective target reporting limits. Additionally, all but one copper sample exceeded the target reporting limit for copper.

Table 3. Target and actual reporting limits for SMCWPPP pollutants of concern monitoring in water in WY 2017

Analyte	Unit	Target	Actual	Exceeds Target RL?
Ammonia	mg/L	0.02	0.02	No
Nitrate	mg/L	0.01	0.1	Yes
Nitrite	mg/L	0.01	0.005	No
Total Kjeldahl Nitrogen	mg/L	0.5	0.1	No
Phosphorus	mg/L	0.01	0.01	No
Orthophosphate	mg/L	0.01	0.01	No
Suspended Sediment Concentration	mg/L	0.5	0.95-1.6	Yes
Copper	µg/L	0.1	0.1-0.5	Yes
Hardness	mg/L	1	5-10	Yes
Mercury	ng/L	0.2	0.5-12.5	Yes
PCBs	pg/L	2000	18.8-316	No

5.2. Sediment Analysis

The project manager identified 0.5 mg/kg as an elevated/high total PCBs concentration threshold for sites to be considered for additional investigation. Because a different analytical method was used in this project for PCBs congeners (i.e., 8082M) compared to the CW4CB project (i.e., 1668A), a reporting limit requirement had to be developed. To maintain a conservative approach, QA/QC goals for this project focused on concentrations greater than 1/5 of the high concentration threshold (i.e., 0.1 mg/kg), and applied a reporting limit requirement of 10 µg/kg (i.e., 0.01 mg/kg), or 1/10 of this new lower threshold, for each of the forty PCB congeners analyzed.

Approximately 5% of congener samples (145 of 2680) did not meet the reporting limit requirement of 10 µg/kg. However, the majority of these exceedances are explained by dilutions, necessary to conduct the analysis, resulting in elevated reporting limits. Only one sample that did not meet the reporting limit requirements (PCB 101 at SM-SSF-02-D) was not diluted, and therefore, did not have a justification for the elevated reporting limits. However, the reporting limit for this sample was 13 µg/kg, only slightly higher than the project reporting limit of 10 µg/kg.

The target reporting limit for mercury (0.3 mg/kg) was met for all but two samples. The two samples that were greater than the target limit were slightly higher at 0.0304 and 0.0507 mg/kg. The analysis for total solids also met the target reporting limit (0.1%) for all samples.

6.0 CONTAMINATION

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples.

6.1. Water Analysis

Several laboratory and equipment (filter) blanks were run during the nutrient, copper, and hardness analyses. All blanks were non-detect, except for one hardness blank. However, this blank was below the reporting limit, and therefore met the measurement quality objectives for hardness. Similarly, analytes were detected in laboratory blanks for mercury and several PCBs above the method detection limit, but below the reporting limit. The PCBs that were detected in laboratory blanks include the following:

- PCB 008
- PCB 011
- PCB 015
- PCB 052
- PCB 044/047/065
- PCB 068
- PCB 070/061/074/076
- PCB 126
- PCB 155
- PCB 152
- PCB 136
- PCB 153/168
- PCB 129/138/163
- PCB 167
- PCB 156/157
- PCB 169
- PCB 188
- PCB 187
- PCB 180/193
- PCB 202
- PCB 198/199

6.2. Sediment Analysis

Several laboratory blanks were analyzed during sediment analysis. Mercury was detected in several blanks above the method detection limit, but below the reporting limit. Similarly, PCB 49 was detected in a laboratory blank, but was detected at a concentration below the reporting limit. Since concentrations were detected below the reporting limit, all laboratory blanks met the MQOs.

7.0 ACCURACY

Accuracy is assessed as the percent recovery of samples spiked with a known amount of a specific chemical constituent. The analytical laboratory evaluated and reported the Percent Recovery (PR) of Laboratory Control Samples (LCS; in lieu of reference materials) and Matrix Spikes (MS)/Matrix Spike Duplicates (MSD), which were recalculated and compared to the target ranges in the RMC and CW4CB QAPPs. If a QA sample did not meet MQOs, all samples in that batch for that analyte were flagged.

7.1. Water Analysis

All laboratory LCS and MS/MSD samples for nutrients, hardness, copper, and mercury were within their respective MQOs, except for one total copper matrix spike in May. The May copper sample was consequently flagged. Thirty-three (33) laboratory control samples and 14 MS/MSD samples exceeded the MQOs for PCBs. All associated samples were flagged.

7.2. Sediment Analysis
All mercury and total solids laboratory control samples met their corresponding MQOs, but 23 LCS for PCB did not meet their MQOs. Additionally, 23 MS/MSD samples for PCBs did not meet their MQO. The list of congeners that exceeded LCS MQOs differed slightly from the list of PCBs that exceeded the MS/MSD MQOs. One mercury MS/MSD did not meet the MQO.

8.0 PRECISION

Precision is the repeatability of a measurement and is quantified by the Relative Percent Difference (RPD) of two duplicates samples. Three measures of precision were used for this project – matrix spikes duplicates, laboratory duplicates, and field duplicates. The MQO for RPD specified by both the CW4CB QAPP and the BASMAA QAPP is <25%.

8.1. Water Analysis

8.1.1. Laboratory Duplicates
Matrix spike duplicates and laboratory control sample duplicates for nutrients, copper, and hardness were well below the targeted range of < 25%. One MS/MSD pair did not meet the MQO for PCB 121.

Laboratory duplicates were analyzed for PCBs, and most of the duplicates (99 of 162 congeners) exceeded the MQO (RPD < 25%). The PCB samples associated with these QA samples were flagged.

8.1.2. Field Duplicates
Two nutrient field duplicates were collected during WY 2017 creek status monitoring, and are considered representative of nutrient sampling for POC monitoring. The field duplicate samples met the MQO for RPD for all analytes except for total Kjeldahl nitrogen and ammonia. Refer to the SMCWPPP Creek Status Monitoring QA/QC Report for more information.

One field duplicate was collected for copper and hardness during the January event, and all RPDs met the MQO. However, no field duplicate was collected in WY 2017 in San Mateo County for mercury, PCBs, or SSC in water.

8.2. Sediment Analysis

8.2.1. Laboratory Duplicates
Seven mercury matrix spike duplicates and 40 PCB matrix spike duplicates exceeded the corresponding MQO. Eight laboratory duplicates were run for total solids and were well below the MQO (<25%). No mercury or PCB laboratory duplicates were run during the sediment analysis.

8.2.2. Field Duplicates
Six sediment field blind duplicates were collected in WY 2017. The field duplicates exceed the RPD MQO for mercury and 17 PCBs. Most duplicates exceeded the MQO for two to three analytes, but the sample at SM-SMC-06-E exceeded the MQO for 13 analytes. The analytes that exceeded the MQO include the following (the number of samples that exceeded the MQO for that analyte are included in parentheses:

- Mercury (3)
- PCB 52 (1)
- PCB 60 (3)

- PCB 70 (1)
- PCB 87 (1)
- PCB 101 (1)
- PCB 110 (2)
- PCB 118 (1)
- PCB138 (1)
- PCB149 (2)
- PCB 153 (1)
- PCB 174 (1)
- PCB 177 (1)
- PCB 180 (1)
- PCB 187 (1)
- PCB 194 (1)
- PCB 201 (1)
- PCB 203 (2)

9.0 REFERENCES

Bay Area Stormwater Management Agency Association (BASMAA). 2013. Quality Assurance Project Plan. Clean Watersheds for a Clean Bay – Implementing the San Francisco Bay's PCB and Mercury TMDL with a Focus on Urban Runoff. Revision Number 1. EPA San Francisco Bay Water Quality Improvement Fund Grant # CFDA 66.202. Prepared for Bay Area Stormwater Management Agencies Association (BASMAA) by Applied Marine Sciences (AMS). August 2013.

Bay Area Stormwater Management Agency Association (BASMAA) Regional Monitoring Coalition. 2016. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 3. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program and the Contra Costa Clean Water Program. 128 pp.

Surface Water Ambient Monitoring Program (SWAMP). 2017. Quality Assurance Program Plan. May 2017. 140 pp.

Attachment 2

WY 2017 Sediment Monitoring Locations and Analytical Results

Permittee	WMA	WY 2017 Sample ID	Date Collected	Latitude	Longitude	Total PCBs (mg/kg)	Mercury (mg/kg)
East Palo Alto	70	SM-EPA-02-G	3/27/2017	37.47029	-122.13244	0.03	0.05
		SM-EPA-02-H	3/27/2017	37.47194	-122.13406	0.01	0.05
	72	SM-EPA-02-F	3/27/2017	37.47300	-122.13143	0.02	0.08
Menlo Park	71	SM-MPK-05-B	3/27/2017	37.47939	-122.15569	0.01	0.13
	239	SM-MPK-02-D	3/27/2017	37.48592	-122.18493	0.01	0.06
		SM-MPK-02-F (Dup)				0.02	0.28
	1012	SM-MPK-05-A	3/27/2017	37.48209	-122.16096	0.06	0.10
	1014	SM-MPK-02-E	3/27/2017	37.48525	-122.18228	0.03	0.04
Redwood City	239	SM-RCY-10-C	3/27/2017	37.48581	-122.18504	0.16	0.05
		SM-RCY-10-D	3/27/2017	37.48571	-122.18474	0.02	0.04
	379	SM-RCY-07-D	3/28/2017	37.48532	-122.21334	1.97	0.14
		SM-RCY-12-A	3/28/2017	37.48444	-122.21848	0.02	0.07
		SM-RCY-12-B	3/28/2017	37.48430	-122.21787	0.08	0.09
		SM-RCY-12-C	3/30/2017	37.48438	-122.21774	0.00	0.01
		SM-RCY-12-E	3/28/2017	37.48471	-122.21958	0.01	0.05
		SM-RCY-12-F	3/28/2017	37.48551	-122.21624	0.01	0.08
	1000	SM-RCY-05-C	4/5/2017	37.51096	-122.20742	0.75	0.35
	1014	SM-RCY-10-E	3/27/2017	37.48510	-122.18221	0.01	0.05
San Carlos	31	SM-SCS-05-A	4/3/2017	37.50645	-122.25071	0.12	0.06
		SM-SCS-05-C (Dup)				0.11	0.06
		SM-SCS-05-B	4/3/2017	37.50686	-122.25492	0.14	0.07
	59	SM-SCS-01-L	3/30/2017	37.51528	-122.26202	0.18	0.17
		SM-SCS-01-M	3/30/2017	37.51397	-122.26382	0.04	2.36
	75	SM-SCS-01-G	3/30/2017	37.51664	-122.26351	1.20	0.11
		SM-SCS-01-H	4/3/2017	37.51623	-122.26485	0.06	0.14
		SM-SCS-01-I	4/3/2017	37.51798	-122.26386	0.02	0.05
		SM-SCS-01-J	4/3/2017	37.51818	-122.26392	0.09	0.09
		SM-SCS-01-N	3/30/2017	37.51686	-122.26358	49.40	0.80
	210	SM-SCS-06-A	3/30/2017	37.49628	-122.24492	0.01	0.17
		SM-SCS-06-B	3/30/2017	37.49690	-122.24589	0.03	0.08
		SM-SCS-06-C	3/30/2017	37.49746	-122.24638	5.64	0.04
		SM-SCS-06-J (Dup)				5.44	0.09
		SM-SCS-06-D	3/30/2017	37.49733	-122.24555	1.84	3.93
		SM-SCS-06-E	3/30/2017	37.49614	-122.24537	0.00	0.02
		SM-SMC-06-M (Dup)				0.03	0.04
		SM-SCS-06-F	3/30/2017	37.49768	-122.24626	3.73	0.12
		SM-SCS-06-G	3/30/2017	37.49776	-122.24615	1.29	0.07
		SM-SCS-06-H	3/30/2017	37.49942	-122.24278	0.07	0.06
		SM-SCS-06-I	3/30/2017	37.50158	-122.24354	0.03	0.27

Permittee	WMA	WY 2017 Sample ID	Date Collected	Latitude	Longitude	Total PCBs (mg/kg)	Mercury (mg/kg)
		SM-SCS-06-L	4/5/2017	37.50021	-122.24113	0.06	0.13
San Mateo	156	SM-SMO-07-C	4/5/2017	37.55516	-122.30717	0.01	0.05
South San Francisco	291	SM-SSF-06-F	4/5/2017	37.64299	-122.41425	0.04	0.08
		SM-SSF-06-H	4/5/2017	37.64240	-122.41370	0.44	0.08
		SM-SSF-06-I	4/5/2017	37.64212	-122.41325	0.04	0.24
		SM-SSF-06-J (Dup)				0.05	0.23
	292	SM-SSF-06-G	4/5/2017	37.64079	-122.41729	0.15	0.06
	294	SM-SSF-03-D	4/5/2017	37.65253	-122.40021	0.28	0.47
	313	SM-SSF-02-F	4/5/2017	37.66189	-122.39608	0.01	0.05
	314	SM-SSF-01-E	4/3/2017	37.65864	-122.39130	0.15	0.19
		SM-SSF-01-G	4/3/2017	37.66241	-122.38908	0.05	0.03
	319	SM-SSF-01-I	4/3/2017	37.65870	-122.38012	0.06	0.22
	358	SM-SSF-04-C	4/3/2017	37.64613	-122.40198	0.01	0.08
		SM-SSF-04-F (Dup)				0.01	0.09
		SM-SSF-04-D	4/3/2017	37.64450	-122.40173	0.09	0.11
		SM-SSF-04-E	4/3/2017	37.64608	-122.40147	0.05	0.07
	1002	SM-SSF-02-C	4/5/2017	37.66440	-122.39508	0.02	0.05
		SM-SSF-02-D	4/5/2017	37.66303	-122.39861	0.08	0.15
Unincorporated San Mateo County	247	SM-SMC-01-A	3/27/2017	37.41451	-122.19379	0.00	0.04
	379	SM-SMC-06-D	3/28/2017	37.48389	-122.20673	0.05	0.06
		SM-SMC-06-E	3/28/2017	37.48384	-122.20653	0.01	0.07
		SM-SMC-06-F	3/28/2017	37.48291	-122.20734	0.02	0.07
		SM-SMC-06-G	3/28/2017	37.48285	-122.20546	0.05	0.30
		SM-SMC-06-H	3/28/2017	37.48278	-122.20531	0.03	0.07
		SM-SMC-06-I	3/28/2017	37.48415	-122.20792	0.14	3.15
		SM-SMC-06-J	3/28/2017	37.48349	-122.20874	0.08	0.09
		SM-SMC-06-K	3/28/2017	37.48396	-122.20634	0.02	0.04
		SM-SMC-06-L	3/28/2017	37.48256	-122.20875	0.03	0.10

Attachment 3

Summary of PCBs and Mercury Monitoring Results To-date for San Mateo County WMAs

WMA ID	Permittee	Area (acres)	Area High Interest Parcels (acres)	Percent High Interest Parcels	Sediment Samples			Water Samples		
					n	[PCBs] Median (ppm)	[PCBs] Range (ppm)	n	[PCBs] Particle Ratio Median (ppm)	[PCBs] Particle Ratio Range (ppm)
210	San Carlos	141	33	23.2%	45	0.12	0 - 192.91	33	1.78	0.20 - 373.36
17	Brisbane	1,639	55	3.4%	1	1.22	1.22 - 1.22	1	--	0.1
142	Burlingame	20	9	44.3%	2	0.10	0.06 - 0.15	1	--	0.7
359	South San Francisco	23	12	51.2%	0	--	--	1	--	1.4
408	San Mateo	43	7	16.3%	0	--	--	1	--	1.9
60	Belmont	298	6	1.9%	0	--	--	2	0.60	0.18 - 1.02
379	Redwood City	802	110	13.7%	41	0.06	0 - 6.93	2	0.14	0.11 - 0.18
291	South San Francisco	194	64	33.1%	17	0.06	0 - 2.72	1	--	0.7
1000	Redwood City	148	108	73.0%	3	0.57	0.02 - 0.75	0	--	--
75	San Carlos	66	38	58.3%	11	0.09	0.02 - 49.4	1	--	6.1
31	San Carlos	99	27	27.2%	26	0.19	0 - 1.61	4	1.12	0.41 - 2.15
1016	San Carlos	142	27	19.0%	8	0.54	0 - 6.19	0	--	--
239	Menlo Park	36	11	29.1%	5	0.04	0.01 - 0.57	0	--	--
358	South San Francisco	32	7	21.8%	4	0.07	0.01 - 1.46	0	--	--
70	East Palo Alto	490	16	3.3%	4	0.04	0.01 - 0.34	1	--	0.11
314	South San Francisco	66	4	5.4%	2	0.10	0.05 - 0.15	1	--	0.94
294	South San Francisco	67	21	31.2%	3	0.19	0.07 - 0.28	1	--	0.37
1001	South San Francisco	413	107	26.0%	11	0.04	0.01 - 0.43	1	--	1.71
407	Redwood City	18	10	52.9%	1	0.01	0.01 - 0.01	0	--	--
85	Burlingame	121	13	10.4%	2	0.03	0.03 - 0.03	0	--	--
164	Burlingame	241	79	32.6%	4	0.07	0.04 - 0.09	0	--	--
336	Redwood City	66	4	6.6%	0	--	--	0	--	--
1011	Redwood City	507	63	12.3%	25	0.03	0 - 0.72	0	--	--
25	San Mateo	219	6	2.9%	1	0.03	0.03 - 0.03	0	--	--
149	Burlingame	480	5	1.1%	2	0.13	0.07 - 0.19	0	--	--

WMA ID	Permittee	Area (acres)	Area High Interest Parcels (acres)	Percent High Interest Parcels	Sediment Samples			Water Samples		
					n	[PCBs] Median (ppm)	[PCBs] Range (ppm)	n	[PCBs] Particle Ratio Median (ppm)	[PCBs] Particle Ratio Range (ppm)
266	Redwood City	91	4	4.1%	0	--	--	0	--	--
77	Belmont	86	4	4.7%	0	--	--	0	--	--
59	San Carlos	28	9	32.1%	2	0.11	0.04 - 0.18	0	--	--
356	South San Francisco	10	2	18.0%	2	0.02	0 - 0.03	0	--	--
333	Redwood City	15	4	29.4%	1	0.02	0.02 - 0.02	0	--	--
111	San Mateo	95	5	4.8%	2	0.06	0.05 - 0.06	0	--	--
1008	San Mateo	111	1	0.5%	0	--	--	0	--	--
139	Burlingame	63	2	3.0%	0	--	--	0	--	--
181	Daly City	75	12	15.6%	0	--	--	0	--	--
298	South San Francisco	122	3	2.7%	0	--	--	0	--	--
307	Daly City	1,277	5	0.4%	0	--	--	0	--	--
401	Millbrae	52	7	12.6%	0	--	--	0	--	--
238	Menlo Park	345	84	24.2%	4	0.14	0.01 - 0.29	2	0.08	0.04 - 0.12
67	East Palo Alto	95	11	12.0%	2	0.12	0.02 - 0.21	0	--	--
114	San Mateo	85	8	9.3%	1	0.23	0.23 - 0.23	0	--	--
295	South San Francisco	25	3	11.7%	3	0.30	0 - 0.33	0	--	--
362	South San Francisco	18	9	51.6%	1	0.46	0.46 - 0.46	0	--	--
350	Daly City	317	15	4.8%	0	--	--	0	--	--
32	Belmont	67	2	3.3%	0	--	--	1	--	0.48
317	South San Francisco	32	9	27.1%	0	--	--	1	--	0.45
66	Menlo Park	64	19	29.8%	1	0.06	0.06 - 0.06	1	--	0.39
1006	Burlingame	306	49	15.9%	5	0.10	0.01 - 0.14	1	--	0.36
319	South San Francisco	99	31	31.2%	1	0.06	0.06 - 0.06	1	--	0.36
318	South San Francisco	70	32	45.4%	1	0.01	0.01 - 0.01	1	--	0.27
1004	Brisbane	804	507	63.0%	4	0.02	0.01 - 0.04	1	--	0.25

WMA ID	Permittee	Area (acres)	Area High Interest Parcels (acres)	Percent High Interest Parcels	Sediment Samples			Water Samples		
					n	[PCBs] Median (ppm)	[PCBs] Range (ppm)	n	[PCBs] Particle Ratio Median (ppm)	[PCBs] Particle Ratio Range (ppm)
156	San Mateo	40	7	17.0%	1	0.01	0.01 - 0.01	1	--	0.20
323	Redwood City	185	2	0.9%	0	--	--	1	--	0.19
306	South San Francisco	37	7	18.4%	0	--	--	1	--	0.18
315	South San Francisco	108	34	31.8%	1	0.12	0.12 - 0.12	1	--	0.17
324	Redwood City	44	1	2.0%	0	--	--	1	--	0.17
141	Burlingame	62	4	6.9%	0	--	--	1	--	0.17
89	San Mateo	98	10	10.3%	1	0.01	0.01 - 0.01	1	--	0.14
327	Redwood City	126	7	5.1%	3	0.05	0 - 0.08	1	--	0.13
337	Redwood City	138	16	11.5%	4	0.04	0.02 - 0.08	1	--	0.12
293	South San Francisco	654	58	8.9%	2	0.04	0.01 - 0.07	1	--	0.12
254	Redwood City	39	4	9.9%	1	0.09	0.09 - 0.09	1	--	0.11
316	South San Francisco	117	26	21.9%	2	0.01	0 - 0.02	1	--	0.10
72	East Palo Alto	26	12	44.4%	2	0.02	0.02 - 0.02	1	--	0.08
267	Redwood City	75	16	20.9%	1	0.01	0.01 - 0.01	1	--	0.06
388	Redwood City	42	1	1.4%	0	--	--	1	--	0.05
71	Menlo Park	1,394	22	1.6%	1	0.01	0.01 - 0.01	1	--	0.04
296	South San Francisco	1,272	7	0.6%	0	--	--	1	--	0.03
292	San Bruno	220	37	16.9%	19	0.12	0 - 0.18	1	--	0.01
313	South San Francisco	77	11	14.3%	1	0.01	0.01 - 0.01	0	--	--
1005	Millbrae	791	59	7.4%	1	0.01	0.01 - 0.01	0	--	--
1007	San Mateo	87	7	8.4%	1	0.01	0.01 - 0.01	0	--	--
1014	Menlo Park	176	18	10.3%	3	0.02	0.01 - 0.03	0	--	--
354	South San Francisco	10	4	44.7%	1	0.02	0.02 - 0.02	0	--	--
403	San Mateo	48	1	1.4%	1	0.02	0.02 - 0.02	0	--	--
332	Menlo Park	17	1	5.1%	1	0.03	0.03 - 0.03	0	--	--

WMA ID	Permittee	Area (acres)	Area High Interest Parcels (acres)	Percent High Interest Parcels	Sediment Samples			Water Samples		
					n	[PCBs] Median (ppm)	[PCBs] Range (ppm)	n	[PCBs] Particle Ratio Median (ppm)	[PCBs] Particle Ratio Range (ppm)
1009	San Mateo	175	43	24.3%	2	0.03	0.03 - 0.04	0	--	--
1015	East Palo Alto	52	48	92.7%	2	0.04	0.02 - 0.06	0	--	--
253	Redwood City	280	16	5.8%	1	0.05	0.05 - 0.05	0	--	--
16	Burlingame	24	8	31.4%	1	0.05	0.05 - 0.05	0	--	--
1012	Menlo Park	54	42	79.4%	1	0.06	0.06 - 0.06	0	--	--
101	San Mateo	221	10	4.3%	1	0.08	0.08 - 0.08	0	--	--
1002	South San Francisco	316	66	20.9%	3	0.08	0.02 - 0.12	0	--	--
357	South San Francisco	17	3	18.5%	1	0.09	0.09 - 0.09	0	--	--
1010	Foster City	273	8	3.1%	0	--	--	0	--	--
1013	Redwood City	40	4	8.9%	0	--	--	0	--	--
1017	San Mateo	19	4	21.1%	0	--	--	0	--	--
120	San Mateo	10	1	4.9%	0	--	--	0	--	--
138	Burlingame	15	5	29.9%	0	--	--	0	--	--
207	San Carlos	82	7	8.2%	0	--	--	0	--	--
247	Menlo Park	239	20	8.5%	0	--	--	0	--	--
252	Menlo Park	108	5	4.9%	0	--	--	0	--	--
261	Atherton	1,679	3	0.2%	0	--	--	0	--	--
269	Redwood City	45	4	9.2%	0	--	--	0	--	--
290	San Bruno	2,017	9	0.4%	0	--	--	0	--	--
297	South San Francisco	30	2	6.7%	0	--	--	0	--	--
311	South San Francisco	111	3	2.8%	0	--	--	0	--	--
325	Redwood City	21	1	4.8%	0	--	--	0	--	--
329	Colma	806	4	0.5%	0	--	--	0	--	--
334	Redwood City	19	4	18.3%	0	--	--	0	--	--
335	Redwood City	24	0	0.0%	0	--	--	0	--	--

WMA ID	Permittee	Area (acres)	Area High Interest Parcels (acres)	Percent High Interest Parcels	Sediment Samples			Water Samples		
					n	[PCBs] Median (ppm)	[PCBs] Range (ppm)	n	[PCBs] Particle Ratio Median (ppm)	[PCBs] Particle Ratio Range (ppm)
352	South San Francisco	40	7	16.7%	0	--	--	0	--	--
378	Menlo Park	138	4	2.9%	0	--	--	0	--	--
395	Millbrae	480	8	1.6%	0	--	--	0	--	--
399	San Mateo	32	1	4.6%	0	--	--	0	--	--
405	Redwood City	22	22	100.0%	0	--	--	0	--	--
57	San Carlos	63	4	5.6%	0	--	--	0	--	--
68	East Palo Alto	317	0.5	0.2%	0	--	--	0	--	--
80	San Carlos	21	1	4.7%	0	--	--	0	--	--
90	San Mateo	21	0.3	1.4%	0	--	--	0	--	--
92	San Mateo	136	4	2.7%	0	--	--	0	--	--
Other -	Unincorporated	10,917	343	3.1%	3	0.00	0 - 0.04	0	--	--
Other -	Woodside	7,286	5	0.1%	1	0.00	0 - 0	0	--	--
Other -	Menlo Park	2,487	25	1.0%	1	0.02	0.02 - 0.02	0	--	--
Other -	Colma	1,139	5	0.4%	4	0.03	0 - 16.81	0	--	--
Other -	San Carlos	2,517	2	0.1%	1	0.06	0.06 - 0.06	0	--	--
Other -	East Palo Alto	274	4	1.4%	1	0.07	0.07 - 0.07	0	--	--
Other -	Redwood City	6,030	6	0.1%	6	0.07	0.01 - 0.34	0	--	--
Other -	San Mateo	5,800	55	0.9%	1	0.09	0.09 - 0.09	0	--	--
Other -	South San Francisco	1,554	3	0.2%	1	0.19	0.19 - 0.19	0	--	--
Other -	Atherton	2,315	1	0.0%	0	--	--	0	--	--
Other -	Belmont	2,511	5	0.2%	0	--	--	0	--	--
Other -	Brisbane	245	0.4	0.2%	0	--	--	0	--	--
Other -	Burlingame	1,827	9	0.5%	0	--	--	0	--	--
Other -	Daly City	1,131	11	1.0%	0	--	--	0	--	--
Other -	Foster City	2,065	0	0.0%	0	--	--	0	--	--

WMA ID	Permittee	Area (acres)	Area High Interest Parcels (acres)	Percent High Interest Parcels	Sediment Samples			Water Samples		
					n	[PCBs] Median (ppm)	[PCBs] Range (ppm)	n	[PCBs] Particle Ratio Median (ppm)	[PCBs] Particle Ratio Range (ppm)
Other -	Hillsborough	3,974	3	0.1%	0	--	--	0	--	--
Other -	Millbrae	1,309	3	0.2%	0	--	--	0	--	--
Other -	Portola Valley	5,790	0	0.0%	0	--	--	0	--	--
Other -	San Bruno	542	0	0.0%	0	--	--	0	--	--

Appendix E

RMP's POC Reconnaissance Monitoring Final Progress Report, Water Years 2015, 2016, and 2017

RMP
REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

sfei.org/rmp

Pollutants of Concern Reconnaissance Monitoring Water Years 2015, 2016, and 2017

Draft Progress Report

Prepared by

Alicia Gilbreath, Jing Wu, Jennifer Hunt and Lester McKee

SFEI

CONTRIBUTION NO. 840 / JANUARY 2018

Preface

Reconnaissance monitoring for water years 2015, 2016, and 2017 was completed with funding provided by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). This report is designed to be updated each year until completion of the study. At least one additional water year (2018) is planned for this study. This initial full draft report was prepared for BASMAA in support of materials submitted on or before March 31st 2018 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049. Changes are likely after further RMP review and prior to the final report being made available on the RMP website in early summer 2018.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways, and Loadings Workgroup of the RMP. The detailed work plan behind this study was developed by the Small Tributaries Loading Strategy (STLS) Team during a series of meetings in the summer of 2014, with slight modifications made during the summers of 2015, 2016, and 2017. Local members on the STLS Team at that time were Arleen Feng (Alameda Countywide Clean Water Program), Bonnie de Berry (San Mateo Countywide Water Pollution Prevention Program), Lucile Paquette (Contra Costa Clean Water Program), Chris Sommers and Lisa Sabin (Santa Clara Valley Urban Runoff Pollution Prevention Program), and Richard Looker and Jan O'Hara (Regional Water Board). San Francisco Estuary Institute (SFEI) field and logistical support over the first year of the project was provided by Patrick Kim, Carolyn Doehring, and Phil Trowbridge, in the second year of the project by Patrick Kim, Amy Richey, and Jennifer Sun, and in the winter of WY 2017 by Ila Shimabuku, Amy Richey, Steven Hagerty, Diana Lin, Margaret Sedlak, Jennifer Sun, Katie McKnight, Emily Clark, Don Yee, and Jennifer Hunt. SFEI's data management team is acknowledged for their diligent delivery of quality-assured well-managed data. This team was comprised of Amy Franz, Adam Wong, Michael Weaver, John Ross, and Don Yee in WYs 2015, 2016, and 2017. Helpful written reviews of this report were provided by members of BASMAA (Bonnie DeBerry, EOA Inc.; Lucile Paquette, Contra Costa Clean Water Program; Jim Scanlin, Alameda Countywide Clean Water Program).

Suggested citation:

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Executive Summary

The San Francisco Bay polychlorinated biphenyl (PCB) and mercury (Hg) total maximum daily loads (TMDLs) called for implementation of control measures to reduce PCB and Hg loads entering the Bay via stormwater. Subsequently, in 2009, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP). This first MRP contained provisions aimed at improving information on stormwater pollutant loads in selected watersheds (Provision C.8.) and piloted a number of management techniques to reduce PCB and Hg loading to the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). In 2015, the Regional Water Board issued the second iteration of the MRP. "MRP 2.0" placed an increased focus on identifying those watersheds, source areas, and source properties that are potentially most polluted and are therefore most likely to be cost-effective areas for addressing load reduction requirements through implementation of control measures.

To support this increased focus, a stormwater screening monitoring program was developed and implemented in water years (WYs) 2015, 2016, and 2017. Most of the sites monitored were in Alameda, Santa Clara, and San Mateo Counties, with a few sites in Contra Costa County. At the 55 sampling sites, time-weighted composite water samples collected during individual storm events were analyzed for 40 PCB congeners, total Hg (HgT), suspended sediment concentration (SSC), selected trace metals, organic carbon (OC), and grain size. Where possible, sampling efficiency was increased by sampling two sites during a single storm that were near enough to one another that alternating between the two sites was safe and rapid. This same design is being implemented in the winter of WY 2018 by the RMP. The San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program are also implementing the design with their own funding.

During this study, the RMP began piloting the use of un-manned "remote" suspended sediment samplers (i.e., Hamlin samplers and Walling tube samplers). These remote samplers are designed to enhance settling and capture of suspended sediment from the water column. At nine of the manual sampling sites, a sample was collected in parallel using a Hamlin remote suspended sediment sampler, and at seven sites a sample was collected in parallel using a Walling tube suspended sediment sampler.

Key Findings

Based on this monitoring, a number of sites with elevated PCB and Hg concentrations in stormwater and estimated particle concentrations were identified. Total PCB concentrations measured in the composite water samples collected from the 55 sites ranged 300-fold, from 533 to 160,000 pg/L (excluding one sample where PCBs were below the detection level). The three highest ranking sites for PCB whole water concentrations from WYs 2015-2017 were Industrial Rd Ditch in San Carlos (160,000 pg/L), Line 12H at Coliseum Way in Oakland (156,000 pg/L), and the Outfall at Gilman St. in Berkeley (65,700 pg/L). When normalized by SSC to generate estimated particle concentrations, the three sites with highest estimated particle concentrations were slightly different: Industrial Rd Ditch in San Carlos (6,139 ng/g), Line 12H at Coliseum Way in Oakland (2,601 ng/g), and Gull Dr. SD in South San Francisco (859 ng/g). Estimated particle concentrations of this magnitude are among the highest observed in the Bay Area. Prior to this reconnaissance study, maximum concentrations were measured at Pulgas Pump Station-

South (8,222 ng/g), Santa Fe Channel (1,295 ng/g), Pulgas Pump Station-North (893 ng/g) and Ettie St. Pump Station (759 ng/g).[1]

Total Hg concentrations in composite water samples collected during WYs 2015-2017 ranged over 78-fold, from 5.6 to 439 ng/L. The lower variation in HgT concentrations as compared to PCBs is consistent with conceptual models for these substances (McKee et al., 2015). HgT is expected to be more uniformly distributed than PCBs because it has more widespread sources in the urban environment and a larger influence of atmospheric redistribution in the global mercury cycle. The greatest HgT concentrations were measured at the Outfall at Gilman St. in Berkeley (439 ng/L), Line 12K at the Coliseum Entrance in Oakland (288 ng/L), and Rodeo Creek at Seacliff Ct. Pedestrian Bridge in Rodeo (119 ng/L). For the estimated particle concentrations, the highest ranked site was the same, Outfall at Gilman St. in Berkeley (5.3 µg/g), but the second and third ranked sites were different, Meeker Slough in Richmond (1.3 µg/g), and Line 3A-M at 3A-D in Union City (1.2 µg/g). Estimated particle concentrations of this magnitude are similar to the upper range of those observed previously (mainly in WY 2011).

The sites with the highest particle concentrations for PCBs were typically not the sites with the highest concentrations for HgT. The ten highest ranking sites for PCBs based on estimated particle concentrations only ranked 18th, 12th, 15th, 1st, 48th, 26th, 6th, 10th, 37th, and 52nd, respectively, in relation to estimated HgT particle concentrations.

Remote Suspended Sediment Samplers

Results from the two remote suspended sediment sampler types used (Walling tube sampler and Hamlin sampler) generally characterized sites similarly to the composite stormwater sampling methods. Sites with higher concentrations with the remote samplers lined up with sites with higher concentrations in the composite samples and vice versa. The match appears to be better for PCBs (R^2 = 0.69) than for HgT (R^2 = -0.22), and the results suggest that the Walling tube sampler (R^2 = 0.84 for PCBs) performs better than the Hamlin (R^2 = 0.64 for PCBs). These results indicate that one option to consider is using Walling tube samplers to do preliminary screening of sites before doing a more thorough sampling of the water column during multiple storms at selected higher priority sites. However, further testing is needed to determine the overall reliability and practicality of deploying these remote instruments instead of, or to augment, manual composite stormwater sampling.

Further Data Interpretations

Relationships between the PCB and HgT estimated particle concentrations, watershed characteristics, and other water quality measurements were evaluated using Spearman Rank correlation analysis. Based on data collected by SFEI since WY 2003, PCB particle concentrations positively correlate with

[1]Note, these estimated particle concentrations do not all match those reported in McKee et al. (2012) because of the slightly different method of computing the central tendency of the data (see the Methods section of this report above) and, in the case of Pulgas Pump Station – South, because of the extensive additional sampling that has occurred since McKee et al. (2012) reported the reconnaissance results from the WY 2011 field season.

impervious cover (r_s = 0.56), old industrial land use (r_s = 0.58), and HgT particle concentrations (r_s = 0.43). PCB particle concentrations inversely correlate with watershed area and trace metal particle concentrations (other than Hg, i.e., As, Cu, Cd, Pb, and Zn). HgT particle concentrations do not correlate with any of the other trace metals and showed similar but weaker relationships to impervious cover, old industrial land use, and watershed area than did PCBs. In contrast, the trace metals other than HgT (i.e., As, Cd, Cu, Pb, and Zn) all correlate with one another more generally. Overall, the data collected to date do not support the use of any of the trace metals analyzed as a tracer for either PCB or HgT pollution sources.

Old industrial land use is believed to yield the greatest mass of PCB loads in the region. The watersheds for the 79 sites that have been sampled by SFEI since WY 2003 cover about 34% of the old industrial land use in the region. The largest proportion of old industrial area sampled so far in each county has occurred in Santa Clara (96% of old industrial area in this county is in the watershed of a sampling site), followed by San Mateo (51%), Alameda (41%), and Contra Costa (11%). The higher coverage in Santa Clara County is due to sampling of a number of large watersheds and the prevalence of older industrial areas upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining areas in the region with older industrial land use yet to be sampled in the region (~100 km^2), 46% of it lies within 1 km of the Bay and 67% of it is within 2 km of the Bay. These areas are more likely to be tidal, include heavy industrial areas that were historically serviced by rail and ship based transport, and are often very difficult to sample due to a lack of public rights of way. A different sampling strategy may be needed to effectively determine what pollution levels might be associated with these areas. In the short term, this study will continue into WY 2018 and possibly beyond in the attempt to continue to identify areas for follow up investigation and possible management action. The focus will continue to be on finding new areas of concern, although follow up sampling may occur at some sites in order to verify initial sampling results, and there will also be effort towards continuing the remote sampler pilot study.

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Introduction

The San Francisco Bay polychlorinated biphenyl (PCB) and mercury total maximum daily loads (TMDLs) (SFBRWQCB, 2006; 2007) called for implementation of control measures to reduce stormwater polychlorinated biphenyl (PCB) loads from an estimated annual baseline load of 20 kg to 2 kg by 2030 and total mercury (HgT) loads from about 160 kg to 80 kg by 2028. Shortly after adoption of the TMDLs, in 2009, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued the first combined Municipal Regional Stormwater Permit (MRP) for MS4 phase I stormwater agencies (SFBRWQCB, 2009; 2011). In support of the TMDLs, MRP 1.0, as it came to be known, contained a provision for improved information on stormwater loads for pollutants of concern (POCs) in selected watersheds (Provision C.8.) as well as specific provisions for Hg, methylmercury and PCBs (Provisions C.11 and C.12) that called for reducing Hg and PCB loads from smaller urbanized tributaries. To help address these permit requirements, a Small Tributaries Loading Strategy (STLS) was developed that outlined four key management questions (MQs) as well as a general plan to address these questions (SFEI, 2009).

MQ1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from POCs?

MQ2. What are the annual loads or concentrations of POCs from tributaries to the Bay?

MQ3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay?

MQ4. What are the projected impacts of management actions (including control measures) on tributaries and where should these management actions be implemented to have the greatest beneficial impact?

During the first MRP term (2009-15), the majority of STLS effort was focused on refining pollutant loading estimates and finding and prioritizing potential "high leverage" watersheds and subwatersheds which contribute disproportionately high concentrations or loads to sensitive Bay margins, through the funding from both RMP and Bay Area Stormwater Management Agencies Association (BASMAA)[2]. As a result of these efforts, sufficient pollutant data were collected at 11 urban sites, making it possible to estimate pollutant loads from these sites with varying degrees of certainty (McKee et al. 2015, Gilbreath et al. 2015a). During the first MRP term, a Regional Watershed Spreadsheet Model (RWSM) was also developed as a regional-scale planning tool primarily to estimate long-term pollutant loads from the small tributaries, and secondarily to provide supporting information for prioritizing watersheds or sub-watershed areas for management (Wu et al., 2016; Wu et al., 2017).

In November 2015, the Regional Water Board issued the second iteration of the MRP (SFBRWQCB, 2015). MRP "2.0" places an increased focus on finding high leverage watersheds, source areas, and

[2] BASMAA is made up of a number of programs which represent Permittees and other local agencies

source properties that are more polluted, and that are located upstream of sensitive Bay margin areas. Specifically, the permit adds a new stipulation that calls for the identification of sources or watershed source areas that provide the greatest opportunities for reductions of PCBs and Hg in urban stormwater runoff. To help support this focus and also refine information to address Management Questions, the Sources, Pathways and Loadings Work Group (SPLWG) and the Small Tributaries Loading Strategy (STLS) Team developed and implemented a stormwater reconnaissance screening monitoring program in WYs 2015, 2016, and 2017 to provide data, as part of multiple lines of evidence, for the identification of potential high leverage areas. The monitoring program was adapted from the one first implemented in WY 2011 (McKee et al., 2012) and benefited from lessons learned from that effort. This same design was also implemented in WYs 2016 and 2017 by the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program (EOA, 2017a and 2017b).

This report summarizes and provides a preliminary interpretation of data collected during WYs 2015, 2016, and 2017. The data collected and presented here are contributing to a broad effort of identifying potential management areas for pollutant reduction. During Calendar Year (CY) 2018, the RMP is funding a data analysis project that aims to mine and analyze all the existing stormwater data. The primary goals of that analysis are to develop an improved method for identifying and ranking watersheds of management interest for further screening or investigation, and to guide future sampling design. In addition, the STLS team is evaluating sampling programs for monitoring stormwater loading trends in response to management efforts (Melwani et al., 2017 in preparation). Reconnaissance data collected in WYs 2011, 2015, 2016, and 2017 may provide baseline data for identifying concentration or particle concentration trends over time.

The report is designed to be updated annually and will be updated again in approximately 12 months to include the WY 2018 sampling data that is currently being collected.

Sampling Methods

Sampling locations

Four objectives were used as bases for site selection.

1. Identifying potential high leverage watersheds and subwatersheds
    a. Watersheds with suspected high pollution
    b. Sites with ongoing or planned management actions
    c. Source identification within a larger watershed of known concern (nested sampling design)
2. Sampling strategic large watersheds with USGS gauges to provide first-order loading estimates and to support calibration of the Regional Watershed Spreadsheet Model (RWSM)
3. Validating unexpected low (potential false negative) concentrations (to address the possibility of a single storm composite poorly characterizing a sampling location)
4. Filling gaps along environmental gradients or source areas (to support the RWSM)

The majority of samples each year (60-70% of the effort) were dedicated to identifying potential high leverage watersheds and subwatersheds. The remaining resources were allocated to address the other three objectives. SFEI worked with the respective Countywide Clean Water Programs to identify priority drainages for monitoring including storm drains, ditches/culverts, tidally influenced areas, and natural areas. During the summers of 2014, 2015, and 2016, a large number of sites were visited, and each of them was surveyed for safety, logistical constraints, and feasible drainage-line entry points. From this larger set, a final set of about 25 sites was selected each year to form the pool from which field staff would select sampling locations for each storm depending on logistics.

Watershed sites with a wide variety of characteristics were sampled in WYs 2015, 2016, and 2017 (Figure 1 and Table 1). Of these sites, 17 were in Santa Clara County, 17 in San Mateo County, 15 in Alameda County, five in Contra Costa County[3] and one site in Solano County. The drainage area for each sampling location ranged from 0.09 km^2 to 233 km^2 and typically was characterized by a high degree of imperviousness (2%-88%: mean = 64%; dataset used is the National Land Cover Database). The percentage of the watersheds designated as old industrial[4] ranged from 0% to 87% (mean 24%) (dataset used included the land use dataset input to the Regional Watershed Spreadsheet Model (in prep; estimated 2018 release to public)). While the majority of sampling sites were selected to primarily identify potential high leverage watersheds and subwatersheds, Lower Penitencia Creek was resampled to verify whether the first sample collected there (WY 2011) was a false negative (unexpectedly low concentration). Guadalupe River at Hwy 101 was also resampled in WY 2017 during a large and rare storm to assess trends for mercury (McKee et al., in prep). A matrix of site characteristics for sampling strategic larger watersheds was also developed (Table 2), but none of them were sampled in WYs 2015 or 2016 because the sampling trigger criteria for rainfall and flow were not met and only one (Colma Creek) was sampled in WY 2017. Trigger criteria were met in January and February 2017 for other strategic larger watersheds under consideration (Alameda Creek, Dry Creek at Arizona Street, San Francisquito Creek at University Avenue, Matadero Creek at Waverly Street, and Colma Creek at West Orange Avenue), but none were sampled because staff and budgetary resources were allocated elsewhere.

[3] Given the long history of industrial zoning along much of the Contra Costa County waterfront relative to other counties, still more sampling is needed to characterize these areas.

[4] Note the definition of “old Industrial” land use used here is based on definitions developed by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) building on GIS development work completed during the development of the RWSM (Wu et al., 2016; 2017).

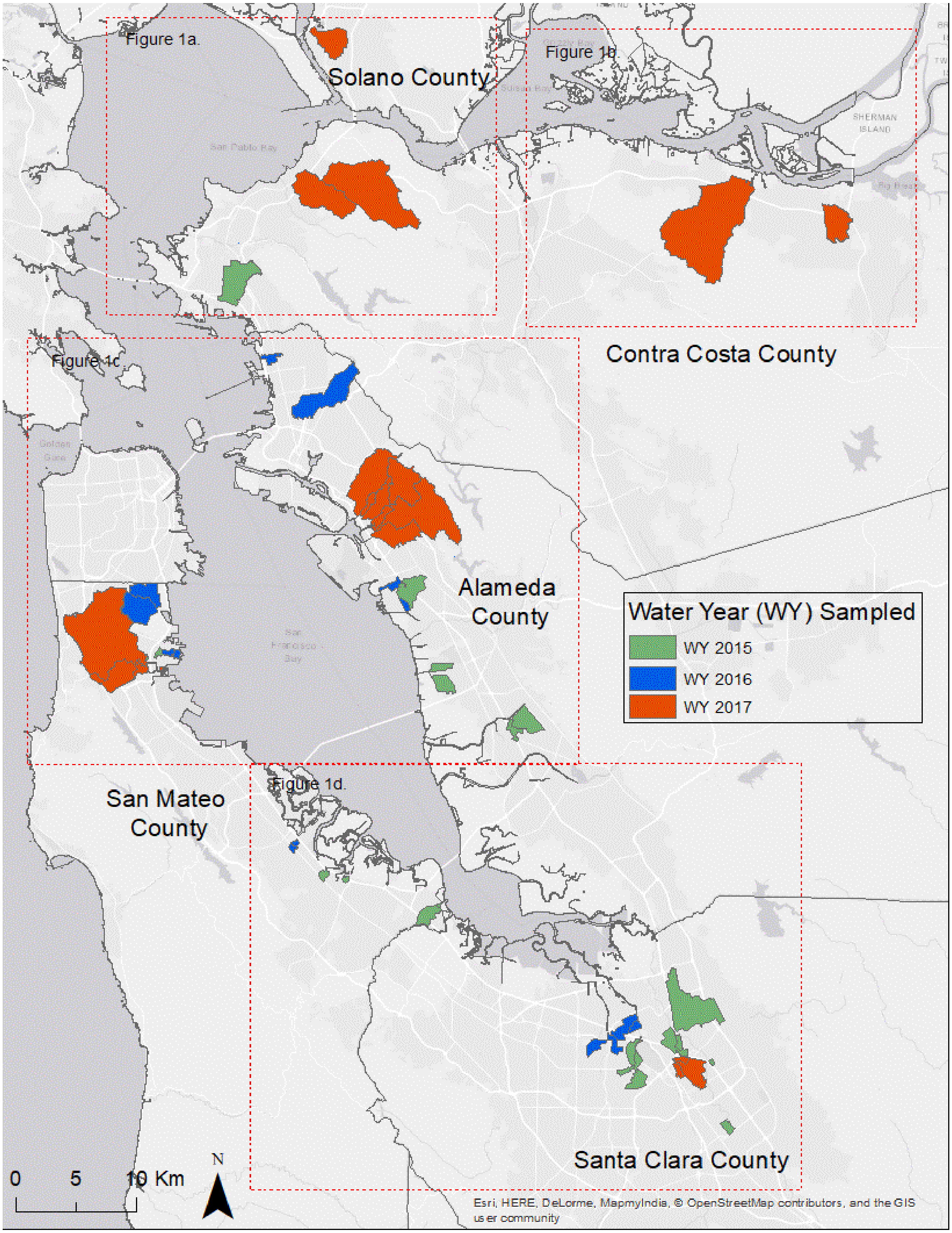

Figure 1. Watersheds sampled in water years 2015, 2016, and 2017.

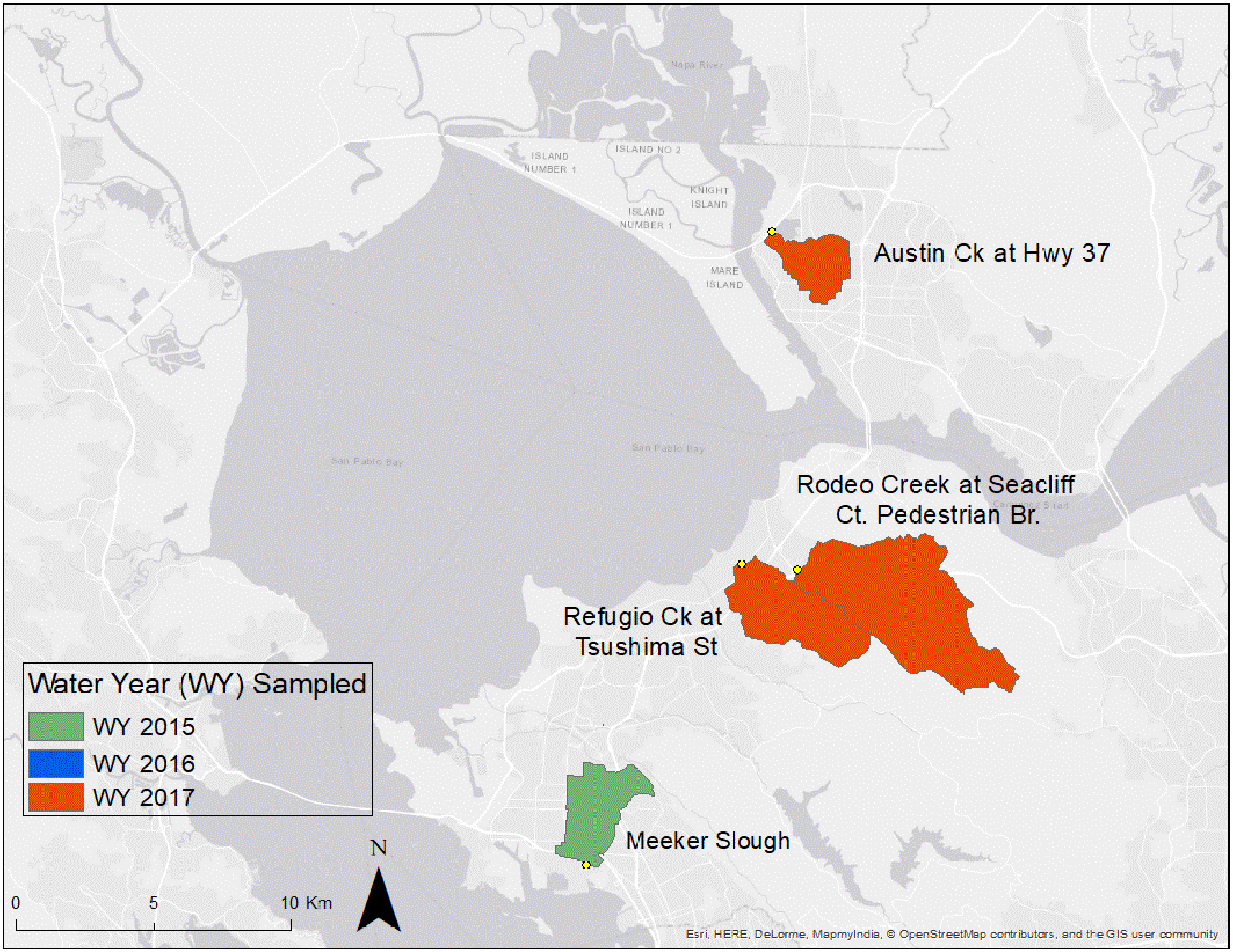

Figure 1a. Sampling locations (marked by yellow dots) and watershed boundaries in western Contra Costa County and Solano County.

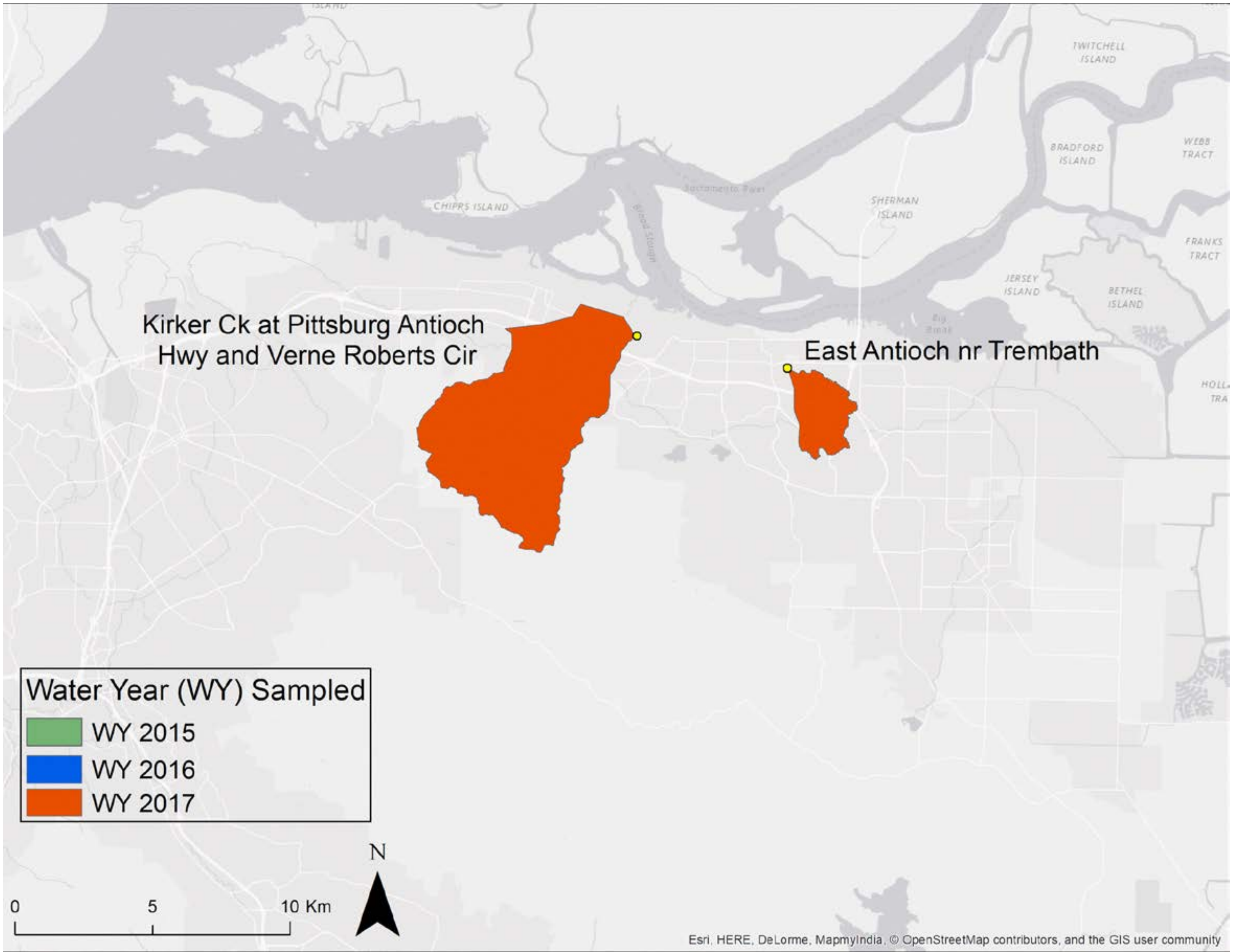

Figure 1b. Sampling locations (marked by yellow dots) and watershed boundaries in eastern Contra Costa County.

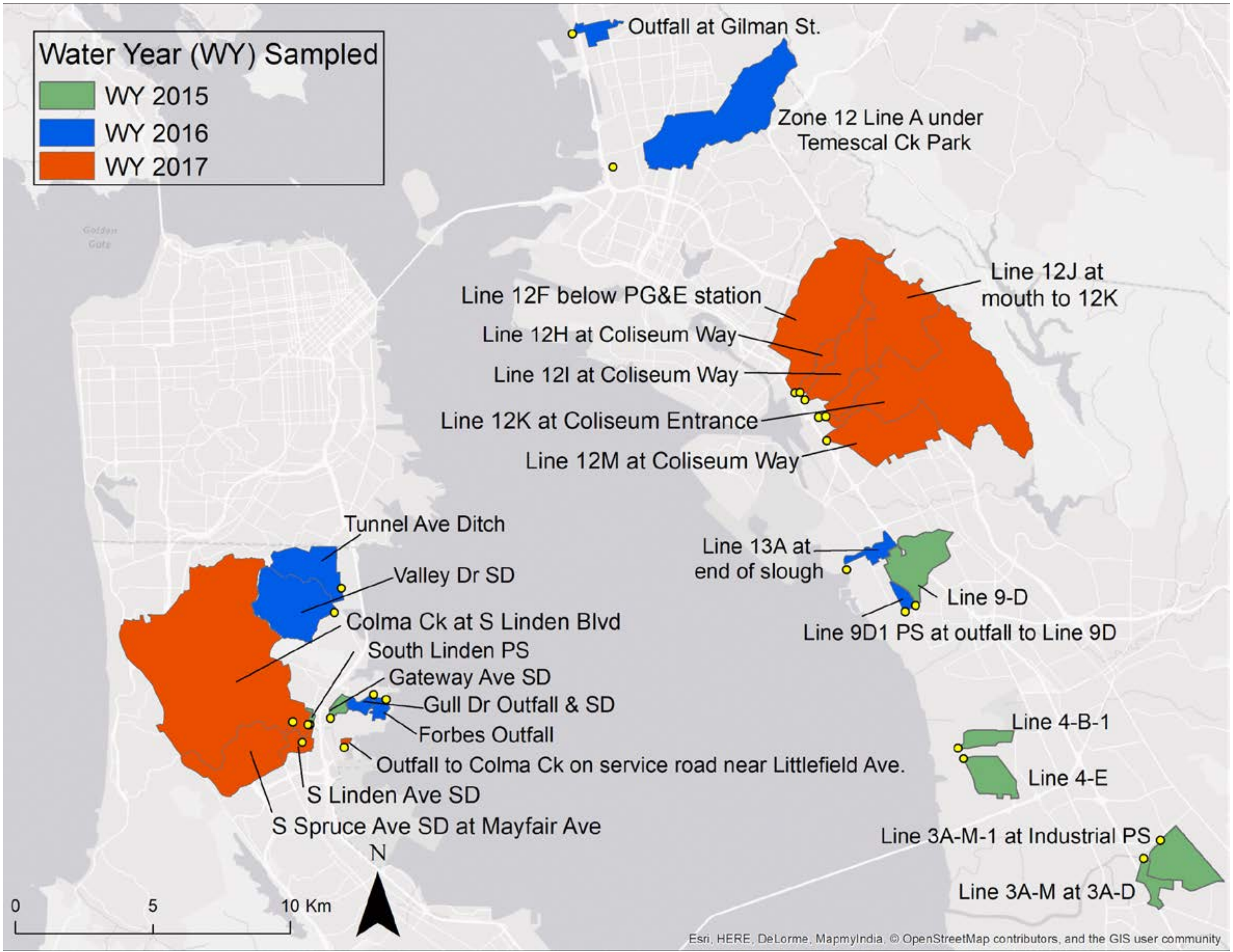

Figure 1c. Sampling locations (marked by yellow dots) and watershed boundaries in Alameda County and northern San Mateo County.

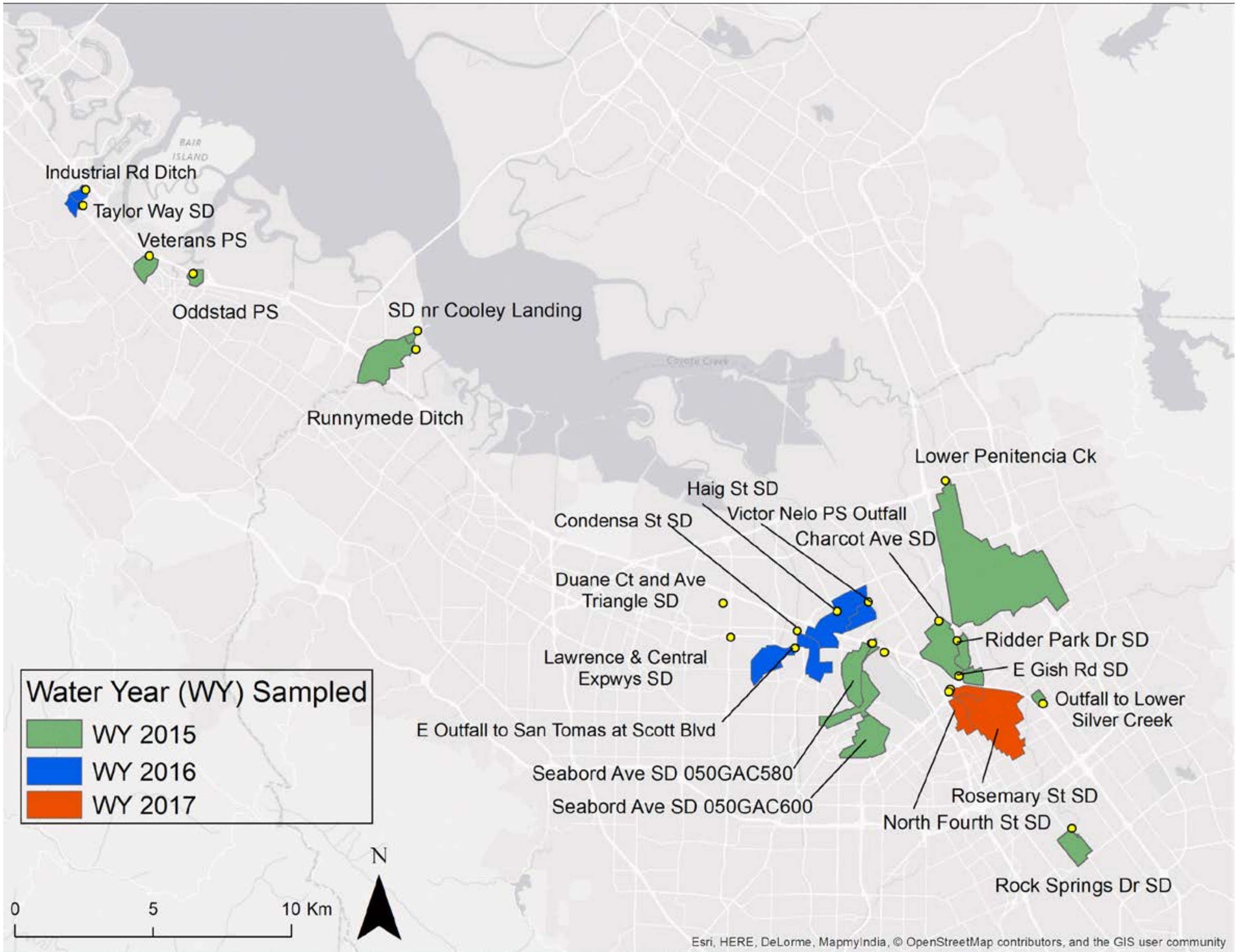

Figure 1d. Sampling locations (marked by yellow dots) and watershed boundaries in northern San Mateo County and Santa Clara County.

Table 1. Key characteristics of water years 2015, 2016, and 2017 sampling locations.

County	City	Watershed Name	Catchment Code	MS4 or Receiving Water	Latitude	Longitude	Sample Date	Area (sq km)	Impervious Cover (%)	Old Industrial (%)
Alameda	Union City	Line 3A-M-1 at Industrial PS	AC-Line 3A-M-1	MS4	37.61893	-122.05949	12/11/14	3.44	78%	26%
Alameda	Union City	Line 3A-M at 3A-D	AC-Line 3A-M	MS4	37.61285	-122.06629	12/11/14	0.88	73%	12%
Alameda	Hayward	Line 4-B-1	AC-Line 4-B-1	MS4	37.64752	-122.14362	12/16/14	0.96	85%	28%
Alameda	Hayward	Line 4-E	AC-Line 4-E	MS4	37.64415	-122.14127	12/16/14	2.00	81%	27%
Alameda	San Leandro	Line 9-D	AC-Line 9-D	MS4	37.69383	-122.16248	4/7/15	3.59	78%	46%
Alameda	Berkeley	Outfall at Gilman St.	AC-2016-1	MS4	37.87761	-122.30984	12/21/15	0.84	76%	32%
Alameda	San Leandro	Line 9-D-1 PS at outfall to Line 9-D	AC-2016-15	MS4	37.69168	-122.16679	1/5/16	0.48	88%	62%
Alameda	Emeryville	Zone 12 Line A under Temescal Ck Park	AC-2016-3	MS4	37.83450	-122.29159	1/6/16	17.47	30%	4%
Alameda	San Leandro	Line 13-A at end of slough	AC-2016-14	MS4	37.70497	-122.19137	3/10/16	0.83	84%	68%
Alameda	Oakland	Line 12F below PG&E station	Line12F	MS4	37.76218	-122.21431	12/15/16	10.18	56%	3%
Alameda	Oakland	Line 12H at Coliseum Way	Line12H	MS4	37.76238	-122.21217	12/15/16	0.97	71%	10%
Alameda	Oakland	Line 12I at Coliseum Way	Line12I	MS4	37.75998	-122.21020	12/15/16	3.41	63%	9%
Alameda	Oakland	Line 12J at mouth to 12K	Line12J	MS4	37.75474	-122.20136	12/15/16	8.81	30%	2%
Alameda	Oakland	Line 12K at Coliseum Entrance	Line12KEntrance	MS4	37.75446	-122.20431	2/9/17	16.40	31%	1%
Alameda	Oakland	Line 12M at Coliseum Way	Line12MColWay	MS4	37.74689	-122.20069	2/9/17	5.30	69%	22%
Contra Costa	Richmond	Meeker Slough	Meeker Slough	Receiving Water	37.91786	-122.33838	12/3/14	7.34	64%	6%
Contra Costa	Pittsburg	Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	KirkerCk	Receiving Water	38.01275	-121.84345	1/8/17	36.67	18%	5%
Contra Costa	Antioch	East Antioch nr Trembath	EAntioch	Receiving Water	38.00333	-121.78106	1/8/17	5.26	26%	3%
Contra Costa	Hercules	Refugio Ck at Tsushima St	RefugioCk	Receiving Water	38.01775	-122.27710	1/18/17	10.73	23%	0%
Contra Costa	Rodeo	Rodeo Creek at Seacliff Ct. Pedestrian Br.	RodeoCk	Receiving Water	38.01604	-122.25381	1/18/17	23.41	2%	3%
San Mateo	Redwood City	Oddstad PS	SM-267	MS4	37.49172	-122.21886	12/2/14	0.28	74%	11%
San Mateo	Redwood City	Veterans PS	SM-337	MS4	37.49723	-122.23693	12/15/14	0.52	67%	7%
San Mateo	South San Francisco	Gateway Ave SD	SM-293	MS4	37.65244	-122.40257	2/6/15	0.36	69%	52%
San Mateo	South San Francisco	South Linden PS	SM-306	MS4	37.65018	-122.41127	2/6/15	0.14	83%	22%

San Mateo	East Palo Alto	Runnymede Ditch	SM-70	MS4	37.46883	-122.12701	2/6/15	2.05	53%	2%
San Mateo	East Palo Alto	SD near Cooley Landing	SM-72	MS4	37.47492	-122.12640	2/6/15	0.11	73%	39%
San Mateo	South San Francisco	Forbes Blvd Outfall	SM-319	MS4	37.65889	-122.37996	3/5/16	0.40	79%	0%
San Mateo	South San Francisco	Gull Dr Outfall	SM-315	MS4	37.66033	-122.38502	3/5/16	0.43	75%	42%
San Mateo	South San Francisco	Gull Dr SD	SM-314	MS4	37.66033	-122.38510	3/5/16	0.30	78%	54%
San Mateo	Brisbane	Tunnel Ave Ditch	SM-350/368/more	Receiving Water	37.69490	-122.39946	3/5/16	3.02	47%	8%
San Mateo	Brisbane	Valley Dr SD	SM-17	MS4	37.68694	-122.40215	3/5/16	5.22	21%	7%
San Mateo	San Carlos	Industrial Rd Ditch	SM-75	MS4	37.51831	-122.26371	3/11/16	0.23	85%	79%
San Mateo	San Carlos	Taylor Way SD	SM-32	MS4	37.51320	-122.26466	3/11/16	0.27	67%	11%
San Mateo	South San Francisco	S Linden Ave SD (291)	SLinden	MS4	37.64420	-122.41390	1/8/17	0.78	88%	57%
San Mateo	South San Francisco	S Spruce Ave SD at Mayfair Ave (296)	SSpruce	MS4	37.65084	-122.41811	1/8/17	5.15	39%	1%
San Mateo	South San Francisco	Colma Ck at S. Linden Blvd	ColmaCk	MS4	37.65017	-122.41189	2/7/17	35.07	41%	3%
San Mateo	South San Francisco	Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	ColmaCkOut	MS4	37.64290	-122.39677	2/7/17	0.09	88%	87%
Santa Clara	Milpitas	Lower Penitencia Ck	Lower Penitencia	Receiving Water	37.42985	-121.90913	12/11/14	11.50	65%	2%
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC580	SC-050GAC580	MS4	37.37637	-121.93793	12/11/14	1.35	81%	68%
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC600	SC-050GAC600	MS4	37.37636	-121.93767	12/11/14	2.80	62%	18%
Santa Clara	San Jose	E. Gish Rd SD	SC-066GAC550	MS4	37.36632	-121.90203	12/11/14	0.44	84%	71%
Santa Clara	San Jose	Ridder Park Dr SD	SC-051CTC400	MS4	37.37784	-121.90302	12/15/14	0.50	72%	57%
Santa Clara	San Jose	Outfall to Lower Silver Ck	SC-067SCL080	MS4	37.35789	-121.86741	2/6/15	0.17	79%	78%
Santa Clara	San Jose	Rock Springs Dr SD	SC-084CTC625	MS4	37.31751	-121.85459	2/6/15	0.83	80%	10%
Santa Clara	San Jose	Charcot Ave SD	SC-051CTC275	MS4	37.38413	-121.91076	4/7/15	1.79	79%	25%
Santa Clara	Santa Clara	Lawrence & Central Expwys SD	SC-049CZC800	MS4	37.37742	-121.99566	1/6/16	1.20	66%	1%
Santa Clara	Santa Clara	Condensa St SD	SC-049STA710	MS4	37.37426	-121.96918	1/19/16	0.24	70%	32%
Santa Clara	San Jose	Victor Nelo PS Outfall	SC-050GAC190	MS4	37.38991	-121.93952	1/19/16	0.58	87%	4%
Santa Clara	Santa Clara	E Outfall to San Tomas at Scott Blvd	SC-049STA550	MS4	37.37991	-121.96842	3/6/16	0.67	66%	31%
Santa Clara	San Jose	Haig St SD	SC-050GAC030	MS4	37.38664	-121.95223	3/6/16	2.12	72%	10%

Santa Clara	San Jose	North Fourth St SD 066GAC550B	NFourth	MS4	37.36196	-121.90535	1/8/17	1.01	68%	27%
Santa Clara	San Jose	Rosemary St SD 066GAC550C	Rosemary	MS4	37.36118	-121.90594	1/8/17	3.67	64%	11%
Santa Clara	San Jose	Guadalupe River at Hwy 101	Guad 101	Receiving Water	37.37355	-121.93269	1/8/17	233.00	39%	3%
Santa Clara	Santa Clara	Duane Ct and Ave Triangle SD	SC-049CZC200	MS4	37.38852	-121.99901	12/13/15 and 1/6/2016	1.00	79%	23%
Solano	Vallejo	Austin Ck at Hwy 37	AustinCk	Receiving Water	38.12670	-122.26791	3/24/17	4.88	61%	2%

Table 2. Characteristics of larger watersheds to be monitored, proposed sampling location, and proposed sampling trigger criteria. None of these watersheds were sampled during water years 2015 or 2016 because sampling trigger criteria for flow and rainfall were not met, and in WY 2017 large watershed sampling was focused on the Guadalupe River rather than the watersheds in this list.

Proposed sampling location							Relevant USGS gauge fo 1st order loads computations	
Watershed system	**Watershed Area (km²)**	**Impervious Surface (%)**	**Industrial (%)**	**Sampling Objective**	**Commentary**	**Proposed Sampling Triggers**	**Gauge number**	**Area at USGS Gauge (sq²)**
Alameda Creek at EBRPD Bridge at Quarry Lakes	913	8.5	2.3	2, 4	Operating flow and sediment gauge at Niles just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for a large, urbanizing type watershed.	7" of antecedent rainfall in Livermore (reliable web published rain gauge), after at least an annual storm has already occurred (~2000 cfs at the Niles gauge), and a forecast for the East Bay interior valleys of 2-3" over 12 hrs.	11179000	906
Dry Creek at Arizona Street (purposely downstream from historic industrial influences)	25.3	3.5	0.3	2, 4	Operating flow gauge at Union City just upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mostly undeveloped land use type watersheds.	7" of antecedent rainfall in Union City, after at least a common annual storm has already occurred (~200 cfs at the Union City gauge), and a forecast for the East Bay Hills of 2-3" over 12 hrs.	11180500	24.3
San Francisquito Creek at University Avenue (as far down as possible to capture urban influence upstream from tide)	81.8	11.9	0.5	2, 4	Operating flow gauge at Stanford upstream will allow the computation of 1st order loads to support the calibration of the RWSM for larger mixed land use type watersheds. Sample pair with Matadero Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~1000 cfs at the Stanford gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11164500	61.1
Matadero Creek at Waverly Street (purposely downstream from the railroad)	25.3	22.4	3.7	2, 4	Operating flow gauge at Palo Alto upstream will allow the computation of 1st order loads to support the calibration of the RWSM for mixed land use type watersheds. Sample pair with San Francisquito Ck.	7" of antecedent rainfall in Palo Alto, after at least a common annual storm has already occurred (~200 cfs at the Palo Alto gauge), and a forecast for the Peninsula Hills of 3-4" over 12 hrs.	11166000	18.8
Colma Creek at West Orange Avenue or further downstream (as far down as possible to capture urban and historic influence upstream from tide)	27.5	38	0.8	2, 4 (possibly 1)	Historic flow gauge (ending 1996) in the park a few hundred feet upstream will allow the computation of 1st order loads estimates to support the calibration of the RWSM for mixed land use type watersheds.	Since this is a very urban watershed, precursor conditions are more relaxed: 4" of antecedent rainfall, and a forecast for South San Francisco of 2-3" over 12 hrs. Measurement of discharge and manual staff plate readings during sampling will verify the historic rating.	11162720	27.5

Field methods

Mobilization and preparing to sample

The mobilization for sampling was typically triggered by storm forecast. When a minimum rainfall of at least one-quarter inch[5] over 6 hours was forecasted, sampling teams were deployed, ideally reaching the sampling site about 1 hour before the onset of rainfall[6]. When possible, one team sampled two sites close to one another to increase efficiency and reduce staffing costs. Upon arrival, the team assembled equipment and carried out final safety checks. Sampling equipment used at a site depended on the accessibility of drainage lines. Some sites were sampled by attaching laboratory-prepared trace-metal-clean Teflon sampling tubing to a painter's pole and a peristaltic pump with laboratory-cleaned silicone pump-roller tubing (Figure 2a). During sampling, the tube was dipped into the channel or drainage line at mid-channel mid-depth (if shallow) or depth integrating if the depth was more than 0.5 m. In other cases, a DH 84 (Teflon) sampler was used without a pump.

Manual time-paced composite stormwater sampling procedures

At each site, a time-paced composite sample was collected with a variable number of sub-samples, or aliquots. Based on the weather forecast, prevailing on-site conditions, and radar imagery, field staff estimated the duration of the storm and selected an aliquot size for each analyte (0.1-0.5 L) and number of aliquots (minimum=2; mode=5) to ensure the minimum volume requirements for each analyte (Hg, 0.25L; SSC, 0.3L; PCBs, 1L; Grain Size, 1L; TOC, 0.25L) would be reached before the storm's end. Because the minimum volume requirements were less than the size of sample bottles, there was flexibility to add aliquots in the event when a storm continued longer than predicted. The final volume of the aliquots was determined just before the first aliquot was taken and remained fixed for the sampling event. All aliquots for a storm were collected into the same bottle, which was kept in a cooler on ice and/or refrigerated at 4 °C before transport to a lab (see Yee et al. (2017)) for information about bottles, preservatives and hold times).

Remote suspended sediment sampling procedures

Two remote samplers, the Hamlin (Lubliner, 2012) and the Walling tube (Phillips et al., 2000), were deployed approximately at mid-channel/ storm drain to collect suspended sediment samples. To date, 9 locations have been sampled with the Hamlin and 7 locations with the Walling tube sampler (Table 3). During each deployment, the Hamlin sampler[7] was stabilized on the bed of stormdrain or concrete channel either by its own weight (approximately 25 lbs) or additionally by attaching barbell weight plates to the bottom of the sampler (Figure 2b). The Walling tube could not be deployed in storm drains due to its size and the need for staying horizontal, and therefore was secured in open channels either by barbell weights secured with hose clamps to a concrete bed, or to a natural bed with hose clamps

[5] Note, this was relaxed due to a lack of larger storms. Ideally, mobilization would only proceed with a minimum forecast of at least 0.5".

[6] Antecedent dry-weather was not considered prior to deployment. Antecedent conditions can have impacts on the concentration of certain build-up/wash-off pollutants like metals. For PCBs, however, antecedent dry-weather may be less important than the mobilization of in-situ legacy sources.

[7] In future years, if the Hamlin is deployed within a natural bed channel, elevating the sampler more off the bed may be considered but was not done in WYs 2015 or 2016.

attached to temporarily installed rebar (Figure 2c). To minimize the chances of sampler loss, both samplers were secured by a stainless steel cable to a temporary rebar anchor or another object such as a tree or fencepost.

The remote samplers were deployed for the duration of the manual sampling, and removed from the channel bed/storm drain bottom shortly after the last water quality sample aliquot was collected. Water and sediment collected in the samplers were decanted into one or two large glass bottles. When additional water was needed to flush the settled sediments from the remote samplers into the collecting bottles, site water from the sampled channel was used. The collected samples were split and placed into laboratory containers and then shipped to the laboratory for analysis. Most samples were analyzed as whole water samples (due to insufficient solid mass to analyze as a sediment sample), and only one location was analyzed as a sediment sample. Between sampling sites, the remote samplers were thoroughly cleaned using a brush and Alconox detergent, followed by a DI rinse.

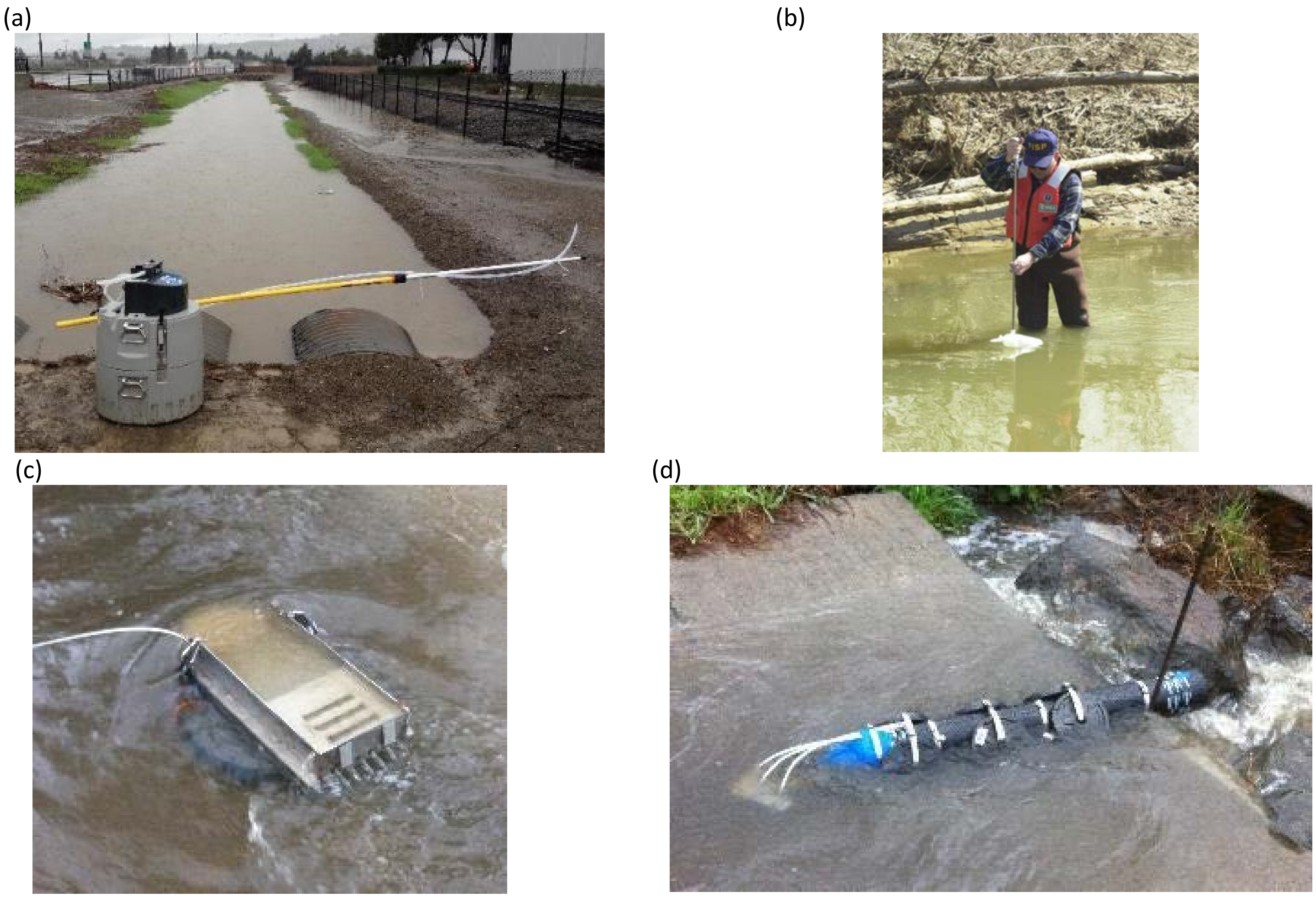

Figure 2. Sampling equipment used in the field. (a) Painter's pole, Teflon tubing and an ISCO used as a slave pump; (b) Teflon bottle attached to the end of a DH81 sampling pole; (c) a Hamlin suspended sediment sampler secured atop a 45 lb plate; and (d) a Walling tube suspended sediment sampler secured by 5 lb weights along the body of the tube (because it is sitting atop a concrete bed) and rebar driven into the natural bed at the back of the sampler.

Table 3. Locations where remote sediment samplers were pilot tested.

Site	Date	Sampler(s) deployed	Comments
Meeker Slough	11/2015	Hamlin and Walling	Sampling effort was unsuccessful due to very high velocities. Both samplers washed downstream because they were not weighted down enough and debris caught on the securing lines.
Outfall to Lower Silver Creek	2/06/15	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Charcot Ave Storm Drain	4/07/15	Hamlin	Sampling effort was successful. This sample was analyzed as a sediment sample.
Cooley Landing Storm Drain	2/06/15	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Duane Ct and Ave Triangle SD	1/6/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Victor Nelo PS Outfall	1/19/2016	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Forbes Blvd Outfall	3/5/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Tunnel Ave Ditch	3/5/2016	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Taylor Way SD	3/11/2016	Hamlin	Sampling effort was successful. This sample was analyzed as a water sample.
Colma Creek Outfall	2/7/2017	Walling	Sampling effort was successful; however, sampler became submerged for several hours during a high tide cycle and was retrieved afterwards. We hypothesize that this may have had the effect of adding cleaner sediment into the sampler and therefore the result may be biased low. This sample was analyzed as a water sample.
Austin Creek	3/24/2017	Hamlin and Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Refugio Creek	1/18/2017	Walling	Sampling effort was successful. This sample was analyzed as a water sample.
Rodeo Creek	1/18/2017	Walling	Sampling effort was successful. This sample was analyzed as a water sample.

Laboratory analytical methods

The target analytes for this study are listed in Table 4. The analytical methods and quality control tests are further described in the RMP Quality Assurance Program Plan (Yee et al., 2017). Laboratory methods were chosen based on a combination of factors of method detection limits, accuracy and precision, and costs (BASMAA, 2011; 2012) (Table 4). For some sites where the remote samplers were deployed, Hg, PCBs and organic carbon (OC) were analyzed for both particulate and dissolved phases to be compared with total water concentrations and particulate-only concentrations from manually collected water samples.

Table 4. Laboratory analysis methods.

Analysis	Matrix	Analytical Method	Lab	Filtered	Field Preservation	Contract Lab / Preservation Hold Time
PCBs (40)[8]-Dissolved	Water	EPA 1668	AXYS	Yes	NA	NA
PCBs (40)[8]-Total	Water	EPA 1668	AXYS	No	NA	NA
SSC	Water	ASTM D3977	USGS	No	NA	NA
Grain size	Water	USGS GS method	USGS	No	NA	NA
Mercury-Total	Water	EPA 1631E	BRL	No	BrCl	BRL preservation within 28 days
Metals-Total (As, Cd, Pb, Cu, Zn)	Water	EPA 1638 mod	BRL	No	HNO_3	BRL preservation with Nitric acid within 14 days
Mercury-Dissolved	Water	EPA 1631E	BRL	Yes	BrCl	BRL preservation within 28 days
Organic carbon-Total (WY 2015)	Water	5310 C	EBMUD	No	HCL	NA
Organic carbon-Dissolved (WY 2015)	Water	5310 C	EBMUD	Yes	HCL	NA
Organic carbon-Total (WY 2016, 2017)	Water	EPA 9060A	ALS	No	HCL	NA
Organic carbon-Dissolved (WY 2016, 2017)	Water	EPA 9060A	ALS	Yes	HCL	NA
Mercury	Particulate	EPA 1631E, Appendix	BRL	NA	NA	
PCBs (40)[8]	Particulate	EPA 1668	AXYS	NA	NA	NA
Organic carbon (WY 2016, 2017)	Particulate	EPA 440.0	ALS	NA	NA	NA

[8] Samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203).

Interpretive methods

Estimated particle concentrations

The reconnaissance monitoring is designed to collect only one composite sample during a single storm at each site to provide “screening level” information. Measured PCB and Hg concentrations from this single sample could exhibit large inter-storm variability associated with storm size and intensity, as observed from previous studies when a large number of storms were sampled (Gilbreath et al., 2015a). However, this variability can be reduced when the concentrations are normalized to SSC, which produces an estimate of the pollutant concentration on particles in the sample. It was therefore reasoned that the estimated particle concentration (EPC) is likely a better characterization of water quality for a site, and therefore a better metric for comparison between sites (McKee et al., 2012; Rügner et al., 2013; McKee et al., 2015). For each analyte the estimated particle concentration (mass of a given pollutant of concern in relation to mass of suspended sediment) was computed for each composite water sample (Equation 1) at each site:

$$EPC\ (ng/mg) = \ (pollutant\ concentration\ (ng/L))/(SSC\ (mg/L)\ ) \qquad (1)$$

where SSC is the suspended sediment concentration in the sample in units of mg/L. These EPCs were used as the primary index to compare sites without regard to climate or rainfall intensity.

While normalizing PCB and Hg concentrations with SSC provides an improved metric to compare sites, climatic conditions can influence relative ranking based on EPCs. The absolute nature of that influence may differ between watershed locations depending on source characteristics. For example, dry years or lower storm intensity might result in a greater estimated particle concentration for some watersheds if transport of the polluted sediment is triggered but the sediment is less diluted by erosion of less contaminated particles from other parts of the watershed. This is most likely to occur in mixed land use watersheds with large amounts of pervious area. For other watersheds, the source may be a patch of polluted soil that can only be eroded and transported when antecedent conditions and/or rainfall intensity reach some threshold. In this instance, a false negative could occur during a dry year. Only with many years of data during many types of storms can such processes be teased out.

Therefore, relative ranking of sites based on EPC data from one or two storms should be interpreted with caution. Such comparisons may be sufficient for providing evidence to differentiate a group of sites with higher pollutant concentrations from a contrasting group with lower pollutant concentrations (acknowledging the risk that some data for watersheds in this group will be false negatives). However, to generate information on the absolute relative ranking between individual sites, a much more rigorous sampling campaign targeting many storms over many years would be required (c.f. the Guadalupe River study: McKee et al., 2006, or the Zone 4 Line A study: Gilbreath et al., 2012a), or a more advanced data analysis would need to be performed that that takes into account a variety of parameters (PCB and suspended sediment sources and mobilization processes, PCB congeners, rainfall intensity, rainfall antecedence, flow production and volume) in the normalization and ranking procedure. As mentioned above, the RMP has funded in project in CY 2018 to complete this type of investigation.

Derivations of central tendency for comparisons with past data

Mean, median, geometric mean, time-weighted mean, or flow-weighted mean can be used as measures of a dataset's central tendency. Most of these measures have been used to summarize data from RMP studies with discrete stormwater samples. To best compare composite data from WY 2015, 2016, and 2017 monitoring with previously collected discrete sample data, a slightly different approach was used to re-compute the central tendency of the discrete stormwater samples. For older data which were collected as multiple discrete samples within a storm, it was reasoned that a water composite collected over a single storm with timed intervals is equivalent to mixing all discrete samples collected during a storm into a single bottle. Mathematically, this is done by taking the sum of all PCB or HgT concentrations in discrete samples and dividing that by the sum of SSCs from the same samples collected within the same storm event (Equation 2):

$$EPCd\ (ng/mg) = \ (\Sigma POCd\ (ng/L))/(\Sigma SSCd\ (mg/L)) \qquad (2)$$

where *EPCd* is the estimated particle concentration for a site with discrete sampling, *POCd* is the pollutant concentration of the discrete sample at a site, and *SSCd* is suspended sediment concentration of a discrete sample at a site.

Note that this method is mathematically not equivalent to averaging together the EPCs of each discrete PCB:SSC or HgT:SSC pair. Because of the use of this alternative method, EPCs reported here differ slightly from those reported previously for some sites (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

Results and Discussion

The data collected in WYs 2015, 2016 and 2017 were presented in the context of two key questions.

a) What are the concentrations and EPCs observed at each of the sites based on the composite water samples?
b) How do the EPCs measured at each of the sites from the composite water samples compare to EPCs derived from the remote suspended-sediment samplers?

These data contribute to a broad effort to identify potential management areas, and the rankings based on either stormwater concentration or EPCs are part of a weight-of-evidence approach for locating and prioritizing areas that may be disproportionately impacting downstream water quality. As the number of sample sites has increased over time, the relative rankings of particular sites have been changing, but the highest-ranking sites have generally remained in the top quarter of sites.

PCBs stormwater concentrations and estimated particle concentrations

Total PCB concentrations from composite water samples across the 55 sampling sites ranged from 533 to 159,606 pg/L excluding one <MDL (Table 5). The highest concentration was measured at Industrial Rd Ditch in San Carlos, located downstream of a known PCB contamination site (Delta Star) with 85% of impervious cover and 79% of old industrial within its drainage area. The second highest concentration (156,060 pg/L) was measured at Line 12H at Coliseum Way in Oakland, with 71% of its watershed

impervious but only 10% classified as old industrial. Sediment and soil samples upstream from this sampling location indicated the existence of some localized sources (Geosyntec, 2011). We often associate high PCB concentrations with old industrial land use, but these results suggest there is not a perfect correlation. Rather, localized sources are likely the most important factor, and these sources tend to be located within old industrial areas. These two highest concentrations are 3 times higher than the concentrations measured at the third and fourth highest sites: Outfall at Gilman Street (65,370 pg/L) and Ridder Park Dr SD location (55,503 pg/L), as well as measurements of PCBs in Bay Area stormwater taken prior to this study[9] (Gilbreath et al., 2012a; McKee et al., 2012).

There was good correspondence between the highest-ranking sites based on stormwater concentrations and those based on EPCs. The four highest ranking sites based on EPCs (Table 5) were the Industrial Rd Ditch in San Carlos (6,140 ng/g), Line 12H at Coliseum Way (2,601 ng/g), Gull Dr Storm Drain in South San Francisco (859 ng/g), and the Outfall at Gilman St. in Berkeley (794 ng/g). These EPCs are of similar magnitude to high values from previous studies in the Bay Area (McKee et al., 2012; Gilbreath et al., 2016)[10]. The repeat sample collected at Lower Penitencia Creek in WY 2015 was consistent with a previous measurement in WY 2011 (McKee et al., 2012). Similarly, two samples taken at the Duane Ct and Ave Triangle SD site during separate storm events on December 2015 and January 2016 showed relatively consistent and low EPCs (24.6 ng/g and 17.3 ng/g, respectively). Overall, the EPCs from WY 2015, 2016, and 2017 sampling were higher than those from WY 2011 (McKee et al., 2012), probably because the sites selected in the more recent study have a much greater proportion of old industrial in their drainage areas, and thereby a higher likelihood of PCB discharge to stormwater.

[9] E.g. Zone 4 Line A FWMC = 14,500 pg/L: Gilbreath et al., 2012a; Ettie Street Pump Station mean = 59,000 pg/L; Pulgas Pump Station-North: 60,300 pg/L: McKee et al., 2012.

[10] Note, Pulgas Pump Station-South (8,222 ng/g), Santa Fe Channel (1,295 ng/g), Pulgas Pump Station-North (893 ng/g), Ettie St. Pump Station (759 ng/g). Inconsistencies between the EPCs reported herein and those reported in McKee et al. (2012) stem from the slightly different method of computing the central tendency of the data (see the methods section of this report above) and, in the case of Pulgas Pump Station – South, because of the extensive additional sampling that has occurred since McKee et al. (2012) reported the reconnaissance results from the WY 2011 field season.

Table 5. Concentrations of total mercury, sum of PCBs and ancillary constituents measured at each of the sites during winter storms of water years 2015, 2016, and 2017. The sum of PCBs and total mercury are also expressed as an estimated particle concentration (mass of pollutant divided by mass of suspended sediment). The table is sorted from high to low PCB estimated particle concentrations.

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Industrial Rd Ditch	San Mateo	San Carlos	3/11/16	4	26			160,000	1	6,140	1	13.9	40	0.535	18
Line 12H at Coliseum Way	Alameda	Oakland	12/15/16	3	60			156,000	2	2601	2	36.1	24	0.602	12
Gull Dr SD	San Mateo	South San Francisco	3/5/16	5	10			8,590	30	859	3	5.62	55	0.562	15
Outfall at Gilman St.	Alameda	Berkeley	12/21/15	9	83			65,700	3	794	4	439	1	5.31	1
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	San Mateo	South San Francisco	2/7/17	2	43	1.7	1.4	33,900	9	788	5	9.05	51	0.210	48
Outfall to Lower Silver Ck	Santa Clara	San Jose	2/6/15	5	57	8.6	8.3	44,600	5	783	6	24.1	33	0.423	26
S Linden Ave SD (291)	San Mateo	South San Francisco	1/8/17	7	16			11,800	22	736	7	12.4	46	0.775	6
Austin Ck at Hwy 37	Solano	Vallejo	3/24/17	6	20		6.3	11,500	23	573	8	12.8	45	0.640	10
Ridder Park Dr SD	Santa Clara	San Jose	12/15/14	5	114	7.7	8.8	55,500	4	488	9	37.1	23	0.326	37
Line 12I at Coliseum Way	Alameda	Oakland	12/15/16	3	93			37,000	7	398	10	12.0	48	0.129	52
Line 3A-M at 3A-D	Alameda	Union City	12/11/14	5	74	9.5	7.3	24,800	13	337	11	85.9	6	1.17	3
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	Contra Costa	Pittsburg	1/8/17	4	23			6,530	34	284	12	5.98	53	0.260	44

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Seabord Ave SD SC-050GAC580	Santa Clara	Santa Clara	12/11/14	5	85	9.5	10	19,900	16	236	13	46.7	15	0.553	17
Line 12M at Coliseum Way	Alameda	Oakland	2/9/17	4	109			24,100	14	222	14	39.6	19	0.365	30
Line 4-E	Alameda	Hayward	12/16/14	6	170	2.8	3.6	37,400	6	219	15	59.0	12	0.346	33
Seabord Ave SD SC-050GAC600	Santa Clara	Santa Clara	12/11/14	5	73	7.9	8.6	13,472	21	186	16	38.3	21	0.528	19
Line 12F below PG&E station	Alameda	Oakland	12/15/16	3	114			21,000	15	184	17	42.5	17	0.373	28
South Linden PS	San Mateo	South San Francisco	2/6/15	5	43	7.4	7.4	7,810	32	182	18	29.2	28	0.679	9
Gull Dr Outfall	San Mateo	South San Francisco	3/5/16	5	33			5,760	37	174	19	10.4	50	0.315	38
Taylor Way SD	San Mateo	San Carlos	3/11/16	5	25	4.5	9.1	4,230	41	169	20	28.9	30	1.16	4
Line 9-D	Alameda	San Leandro	4/7/15	8	69	5	4.6	10,500	25	153	21	16.6	36	0.242	45
Meeker Slough	Contra Costa	Richmond	12/3/14	6	60	4.4	5.3	8,560	31	142	22	76.4	8	1.27	2
Rock Springs Dr SD	Santa Clara	San Jose	2/6/15	5	41	11	11	5,250	38	128	23	38	22	0.927	5
Charcot Ave SD	Santa Clara	San Jose	4/7/15	6	121	20	20	14,900	18	123	24	67.4	11	0.557	16
Veterans PS	San Mateo	Redwood City	12/15/14	5	29	5.9	6.3	3,520	44	121	25	13.7	41	0.469	22
Gateway Ave SD	San Mateo	South San Francisco	2/6/15	6	45	9.9	10	5,240	39	117	26	19.6	35	0.436	23

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Line 9-D-1 PS at outfall to Line 9-D	Alameda	San Leandro	1/5/16	8	164			18,100	17	110	27	118	4.5	0.720	8
Tunnel Ave Ditch	San Mateo	Brisbane	3/5/16	6	96	5.8	11.3	10,500	24	109	28	73.0	10	0.760	7
Valley Dr SD	San Mateo	Brisbane	3/5/16	6	96			10,400	26	109	29	26.5	32	0.276	42
Runnymede Ditch	San Mateo	East Palo Alto	2/6/15	6	265	16	16	28,500	12	108	30	51.5	14	0.194	51
E. Gish Rd SD	Santa Clara	San Jose	12/11/14	5	145	12	13	14,400	19	99.2	31	84.7	7	0.585	14
Line 13-A at end of slough	Alameda	San Leandro	3/10/16	7	357			34,300	8	96.0	32	118	4.5	0.331	35
Line 3A-M-1 at Industrial PS	Alameda	Union City	12/11/14	6	93	4.2	4.5	8,920	28	95.8	33	31.2	26	0.335	34
Rosemary St SD 066GAC550C	Santa Clara	San Jose	1/8/17	5	46			4,110	43	89.4	34	27.2	31	0.591	13
North Fourth St SD 066GAC550B	Santa Clara	San Jose	1/8/17	5	48			4,170	42	87.0	35	22.9	34	0.477	21
Forbes Blvd Outfall	San Mateo	South San Francisco	3/5/16	5	23	3.4	7.9	1,840	52	80.0	36	14.7	39	0.637	11
SD near Cooley Landing	San Mateo	East Palo Alto	2/6/15	6	82	13	13	6,470	36	78.9	37	35.0	25	0.427	25
Lawrence & Central Expwys SD	Santa Clara	Santa Clara	1/6/16	3	58			4,510	40	77.7	38	13.1	42.5	0.226	46
Condensa St SD	Santa Clara	Santa Clara	1/19/16	6	35			2,600	48	74.4	39	11.5	49	0.329	36
Oddstad PS	San Mateo	Redwood City	12/2/14	6	148	8	7.5	9,200	27	62.4	40	54.8	13	0.372	29

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Guadalupe River at Hwy 101	Santa Clara	San Jose	1/8/17	7	560			32,700	10	58.4	41	NR		NR	
Line 4-B-1	Alameda	Hayward	12/16/14	5	152	2.8	3.1	8,670	29	57	42	43.0	16	0.282	41
Zone 12 Line A under Temescal Ck Park	Alameda	Emeryville	1/6/16	8	143			7,800	33	54.4	43	41.5	18	0.290	40
Victor Nelo PS Outfall	Santa Clara	San Jose	1/19/16	9	45	4.0	11	2,290	49	50.9	44	15.8	37	0.351	31
Line 12K at Coliseum Entrance	Alameda	Oakland	2/9/17	4	671			32,000	11	47.6	45	288	2	0.429	24
Haig St SD	Santa Clara	San Jose	3/6/16	6	34			1,450	53	42.8	46	6.61	52	0.194	50
Colma Ck at S. Linden Blvd	San Mateo	South San Francisco	2/7/17	5	71			2,650	47	37.3	47	15.3	38	0.215	47
Line 12J at mouth to 12K	Alameda	Oakland	12/15/16	3	183			6,480	35	35.4	48	73.4	9	0.401	27
S Spruce Ave SD at Mayfair Ave (296)	San Mateo	South San Francisco	1/8/17	8	111			3,360	45	30.3	49	38.9	20	0.350	32
E Outfall to San Tomas at Scott Blvd	Santa Clara	Santa Clara	3/6/16	6	103			2,800	46	27.2	50	13.1	42.5	0.127	53
Duane Ct and Ave Triangle SD	Santa Clara	Santa Clara	12/13/15 and 1/6/2016	5	79			1,950	51	24.6	51	5.91	54	0.0748	54
Duane Ct and Ave Triangle SD	Santa Clara	Santa Clara	12/13/15 and 1/6/2016	3	48	4.2	12	832	54	17.3	52	12.9	44	0.268	43
Lower Penitencia Ck	Santa Clara	Milpitas	12/11/14	7	144	5.9	6.1	2,030	50	14.1	53	29.0	29	0.202	49
Refugio Ck at Tsushima St	Contra Costa	Hercules	1/18/17	6	59	5.5		533	55	9.04	54	30.0	27	0.509	20

Watershed/Catchment	County	City	Sample Date	Number of Aliquots Collected	SSC	DOC	TOC	PCBs				Total Hg			
					(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Contra Costa	Rodeo	1/18/17	7	2630		11	13,900	20	5.28	55	119	3	0.0453	55
East Antioch nr Trembath	Contra Costa	Antioch	1/8/17	6	39			<MDL		NA		12.2	47	0.313	39
Minimum				2	10	1.7	1.4	533		5.28		5.62		0.0453	
Median				5	73.1	5.90	8.45	8923		109		29.2		0.373	
Maximum				9	2630	20	20	160,000		6140		439		5.31	

Mercury stormwater concentrations and estimated particle concentrations

Total mercury concentrations in composite water samples ranged from 5.62 to 439 ng/L, a variation of 78-fold, among the 55 catchment sampling sites sampled so far (Table 5). This relatively large range among sites is similar to that from a previous reconnaissance effort in WY 2011, when mean HgT concentrations ranged from 13.9 to 503 ng/L among sites (McKee et al., 2012). The highest HgT concentration measured was at the Outfall at Gilman Street (439 ng/L), which has 32% old industrial upstream from the sampling point. Other sites with high HgT concentrations were Line 12K at the Coliseum Entrance in Oakland (0.9% old industrial), Rodeo Creek at Seacliff Ct. Pedestrian Br. in Rodeo (2.6% old industrial), Line 9-D-1 PS at outfall to Line 9-D, and Line 13-A at end of the slough, both in San Leandro (62% and 68% old industrial respectively). These results suggest that there is no direct or strong relationship between mercury concentrations and old industrial land use, in contrast to the weak and positive relationship between concentrations measured in water and industrial land use for PCBs, after the addition of WY 2017 data to the dataset.

Based on estimated particle concentrations, the highest site was the same but the rest of the high-ranking sites were different than the ranking based on water concentration. The five most highly ranked sites were Outfall at Gilman Street (32% old industrial), Meeker Slough in Richmond (6% old industrial), Line-3A-M at 3A-D in Hayward (12% old industrial), Taylor Way Storm Drain in San Carlos (11% Old Industrial), and Rock Springs Dr. Storm Drain in San Jose (10% old industrial). Estimated particle concentrations at these sites were 5.3, 1.3, 1.2, 1.2, and 1.0 µg/g, respectively, exceeding the upper range of those measured during the WY 2011 sampling campaign[11] (McKee et al., 2012). On a regional basis, there is no discernible relationship between old industrial land use and HgT EPCs.

Co-occurrence of elevated PCBs and total mercury at the same locations

Another important issue during the ranking process is to consider the combined ranks of PCBs and HgT to determine whether management effort might address both pollutants together. There are few areas where both pollutants are elevated, notably the Gilman Street site in Berkeley and the area around the Coliseum in Oakland. However, in general, only a weak positive relationship exists between PCB and HgT concentrations. The six highest ranking sites for PCBs based on EPCs ranked 14th, 11th, 1st, 19th, 26th, and 3rd for HgT. There is one obvious location where both HgT and PCBs are high: Gilman Street. It shows up in the top five for both pollutants in stormwater and EPCs. The other area (not a site) that shows up high for both is around the Coliseum in Oakland. Line 12H is high for PCBs EPC. Line 12K is high for HgT in stormwater. They are not the same site but they are the same area. This observation contrasts with the conclusions drawn from the WY 2011 dataset, where there appeared to be more of a general correlation between the two contaminants (McKee et al., 2012). This difference might reflect a stronger focus on PCBs during the WY 2015-2017 sampling drainage-line outfalls to creeks with higher imperviousness and old industrial land use, or perhaps it might still be an artifact of small datasets without sample representation along all environmental gradients. This observation is explored further in later sections.

[11] Pulgas Pump Station-South: 0.83 µg/g, San Leandro Creek: 0.80 µg/g, Ettie Street Pump Station: 0.78 µg/g, and Santa Fe Channel: 0.68 µg/g (McKee et al., 2012).

Trace metal (As, Cd, Cu, Mg, Pb, Se and Zn) concentrations

Trace metal concentrations (for As, Cd, Cu, Pb and Zn) measured in select watersheds during WYs 2015, 2016, and 2017 were all similar in range to those previously measured in the Bay Area.

- Arsenic (As): Measured As concentrations ranged from less than the reporting limit (RL)-2.66 µg/L (Table 6). Total As concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) but are much lower than what was measured at the North Richmond Pump Station (mean=11 µg/L) (Appendix A3 in McKee et al., 2015).
- Cadmium (Cd): Cadmium concentrations were 0.023-0.55 µg/L (Table 6). These Cd concentrations are similar to mean concentrations measured at Guadalupe River at Hwy 101 (0.23 µg/L), North Richmond Pump Station (0.32 µg/L), and Zone 4 Line A (0.25 µg/L) (Appendix A3 in McKee et al., 2015).
- Copper (Cu): Concentrations for Cu ranged from 3.63-52.7 µg/L (Table 6). These concentrations are typical of those measured in other Bay Area watersheds (Guadalupe River at Hwy 101: 19 µg/L; Lower Marsh Creek: 14 µg/L; North Richmond Pump Station: Cu 16 µg/L; Pulgas Pump Station-South: Cu 44 µg/L; San Leandro Creek: Cu 16 µg/L; Sunnyvale East Channel: Cu 18 µg/L; and Zone 4 Line A: Cu 16 µg/L) (Appendix A3 in McKee et al., 2015).
- Lead (Pb): Measured Pb concentrations ranged from 0.910-21.3 µg/L (Table 6). Total Pb concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: 14 µg/L; North Richmond Pump Station: Pb 1.8 µg/L; and Zone 4 Line A: 12 µg/L) (Appendix A3 in McKee et al., 2015).
- Zinc (Zn): Zinc concentrations measured 39.4-337 µg/L (Table 6). Zinc measurements at 26 of the sites sampled during WYs 2015, 2016, and 2017 were comparable to the mean concentrations measured in the Bay Area previously (Zone 4 Line A: 105 µg/L; Guadalupe River at Hwy 101: 72 µg/L) (see Appendix A3 in McKee et al., 2015).

In WY 2016, measurements of Mg (528-7350 µg/L) and Se (<RL-0.39 µg/L) were added to the analytical list. Both of these analytes largely reflect geologic sources in watersheds. No measurements of Mg have been previously reported in the Bay Area. The measured concentrations of Se are on the lower side of previously reported values (North Richmond Pump Station: 2.7 µg/L; Walnut Creek: 2.7 µg/L; Lower Marsh Creek: 1.5 µg/L; Guadalupe River at Hwy 101: 1.3 µg/L; Pulgas Creek Pump Station - South: 0.93 µg/L; Sunnyvale East Channel: 0.62 µg/L; Zone 4 Line A: 0.48 µg/L; Mallard Island: 0.46 µg/L; Santa Fe Channel - Richmond: 0.28 µg/L; San Leandro Creek: 0.22 µg/L) (Table A3: McKee et al., 2015). Given the high proportion of Se transported in the dissolved phase and inversely correlated with flow (David et al., 2012; Gilbreath et al., 2012a), it is reasonable that the current sampling design, with a focus on high flow, most likely measured lower concentrations than those measured with sampling designs that included low flow and baseflow samples (North Richmond Pump Station: 2.7 µg/L; Guadalupe River at Hwy 101: 1.3 µg/L; Zone 4 Line A: 0.48 µg/L; Mallard Island: 0.46 µg/). Therefore, Se concentrations reported from this study should not be used to estimate regional loads due to this sampling bias.

Table 6. Concentrations of selected trace elements measured during winter storms of water years 2015, 2016, and 2017. The highest and lowest concentration for each trace element is bolded.

Watershed/Catchment	Sample Date	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Charcot Ave SD	4/7/2015	0.623	0.0825	16.1	2.02			115
Condensa St SD	1/19/2016	1.07	0.055	6.66	3.37	3,650	0.39	54.3
E. Gish Rd SD	12/11/2014	1.52	**0.552**	23.3	19.4			152
East Antioch nr Trembath	1/8/2017	1.57	0.119	**3.53**	1.68	5,363	0.53	**36.3**
Forbes Blvd Outfall	3/5/2016	1.5	0.093	31.7	3.22	7,350	**0**	246
Gateway Ave SD	2/6/2015	1.18	0.053	24.3	1.04			78.8
Gull Dr SD	3/5/2016	**0**	**0.023**	3.63	1.18	**528**	**0**	39.4
Line 9-D-1 PS at outfall to Line 9-D	1/5/2016	1.07	0.524	22.5	20.9	2,822	0.2	217
Line 3A-M at 3A-D	12/11/2014	2.08	0.423	19.9	17.3			118
Line 3A-M-1 at Industrial PS	12/11/2014	1.07	0.176	14.8	7.78			105
Line 4-B-1	12/16/2014	1.46	0.225	17.7	8.95			108
Line 4-E	12/16/2014	2.12	0.246	20.6	13.3			144
Line 9-D	4/7/2015	0.47	0.053	6.24	**0.91**			67
Lower Penitencia Ck	12/11/2014	2.39	0.113	16.4	4.71			64.6
Meeker Slough	12/3/2014	1.75	0.152	13.6	14.0			85.1
North Fourth St SD 066GAC550B	1/8/2017	1.15	0.125	14.0	5.70	**11,100**	**0.67**	75.7
Oddstad PS	12/2/2014	2.45	0.205	23.8	5.65			117
Outfall to Lower Silver Ck	2/6/2015	2.11	0.267	21.8	5.43			**337**
Ridder Park Dr SD	12/15/2014	**2.66**	0.335	19.6	11.0			116
Rock Springs Dr SD	2/6/2015	0.749	0.096	20.4	2.14			99.2
Runnymede Ditch	2/6/2015	1.84	0.202	**52.7**	**21.3**			128
S Spruce Ave SD at Mayfair Ave (296)	1/8/2017	2.2	0.079	9.87	5.31	3,850	0.13	54.8
SD near Cooley Landing	2/6/2015	1.74	0.100	9.66	1.94			48.4
Seabord Ave SD SC-050GAC580	12/11/2014	1.29	0.295	27.6	10.2			168
Seabord Ave SD SC-050GAC600	12/11/2014	1.11	0.187	21	8.76			132
South Linden PS	2/6/2015	0.792	0.145	16.7	3.98			141
Taylor Way SD	3/11/2016	1.47	0.0955	10.0	4.19	5,482	**0**	61.6
Veterans PS	12/15/2014	1.32	0.093	8.83	3.86			41.7
Victor Nelo PS Outfall	1/19/2016	0.83	0.140	16.3	3.63	1,110	0.04	118
Minimum		0	0.0233	3.53	0.91	528	0	36.3
Maximum		2.66	0.552	52.7	21.3	11,100	0.67	337

Comparison between composite and remote sampling methods

The results from remote suspended-sediment samplers were compared to those from the water composite samples collected in parallel (Table 7a and Table 7b).

Grain sizes were analyzed for a select number of sites and the results show that the grain size distribution for the Hamlin samplers was typically coarser than for the Walling tube samples, and the grain size distribution for the Walling tube samples better approximated the grain size distribution for the manual water composite samples (Figure 3).

The EPCs for the samples from the remote samplers and manual water composites were evaluated to compare the measurement techniques. Following the Bland-Altman approach (Bland and Altman, 1986; and explained in Dallal, 2012), results were first plotted against one another for a basic visual inspection of scatter about the 1:1 line, and then the differences between the methods were plotted against the mean of the two measurements to evaluate symmetric grouping around zero and systematic variation of the differences with the mean.

Results for Hg showed that much of the remote sampler data had lower EPCs than those obtained from the composited stormwater samples (Figure 4A, B). However, the Walling tube samples are much closer to the 1:1 line than the Hamlin samples, and have no obvious bias (four samples are lower than the 1:1 line and two are higher). The mean and standard deviation of the paired sample differences (remote samples minus the water composite samples) for the Hamlin sampler were -240 ng/g (mean) and 292 (standard deviation), whereas the mean for the Walling tube sampler was -77 ng/g with a standard deviation of 148. The smallest difference in Hg EPCs between the remote samplers and the composite water samples was at Rodeo Creek at Seacliff Ct. Pedestrian Br (RPD 10%), which could be a result of subsampling and analytical variation. However, at other sites the differences could be up to 5-fold and cannot be easily explained by subsampling or analytical variation, as both the composite sample (time paced with just 2 to 9 sub-samples) and remote sampler methods collect time-integrated samples which reduce the influence of momentary spikes in concentrations. That the Hg EPCs from the remote sampler are typically lower than those from the manual composites is conceptually in concordance with the findings in Yee and McKee (2010). This study found that composited samples often have lower sediment content and thus a greater proportion of Hg in the dissolved phase or on fine particles and, hence, a higher EPC.

For PCBs, there is better agreement between the remote and manual sampling methods (Figure 4C,D). For sites with high EPCs from composite samples, consistently high EPCs were measured from remote samples. The EPCs from remote samples were higher than those from the manual samples, a result that is conceptually reasonable but somewhat surprising, since the manual composite EPCs also included a dissolved proportion (mean 15%, median 12%; Table 7) that would elevate the manual composite EPC versus a remote sample that has an insignificant dissolved phase contribution. Additional sampling in future years is expected to allow for more definitive interpretation. There was one interesting outlier from the Hamlin remote sampler with EPC (1767 ng/g) elevated well above the manual water composite EPC (783 ng/g). A Walling tube was also deployed at this location during the same storm and resulted with an EPC (956 ng/g) much closer to the manual water composite EPC (783 ng/g). One hypothesis is

Table 7a. Remote suspended-sediment sampler PCB data and comparison with manually collected composite water data. Note: EPC = estimated particle concentration.

Site	Remote Sampler Used	Manual Water Composite Data								Remote Sampler Data	
		SSC (manual composite) (mg/L)	PCBs Total (pg/L)	PCBs Particulate (pg/L)	PCBs Dissolved (pg/L)	% Dissolved	PCB particle concentration (lab measured on filter) (ng/g)	PCB EPC (ng/g)	Bias (EPC: lab measured)	PCB EPC (remote) (ng/g)	Comparative Ratio between Remote Sampler and Manual Water Composites
Duane Ct and Ave Triangle SD (Jan 6)	Hamlin	48	832	550	282	34%	11	17	151%	43	246%
Victor Nelo PS Outfall	Hamlin	45	2,289	2,007	283	12%	45	51	114%	70	137%
Taylor Way SD	Hamlin	25	4,227	3,463	764	18%	139	169	122%	237	140%
Tunnel Ave Ditch	Hamlin	96	10,491	9,889	602	6%	103	109	106%	150	137%
Forbes Blvd Outfall	Hamlin	23	1,840	1,794	47	3%	78	80	103%	42	53%
Charcot Ave SD	Hamlin	121	14,927					123		142	115%
Outfall to Lower Silver Ck	Hamlin	57	44,643					783		1767	226%
SD near Cooley Landing	Hamlin	82	6,473					79		68	87%
Austin Ck at Hwy 37	Hamlin	20	11,450					573		700	122%
Outfall to Lower Silver Ck	Walling	57	44,643	No data				783	No data	956	122%
Austin Ck at Hwy 37	Walling	20	11,450					573		362	63%
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Walling	2626	13,863					5		10	195%
Victor Nelo PS Outfall	Walling	45	2,289	2,007	283	12%	45	50.9	114%	100	197%
Tunnel Ave Ditch	Walling	96	10,491	9,889	602	6%	103	109	106%	96	88%
Refugio Ck at Tsushima St	Walling	59	533	533	<MDL	0%	9	9	100%	8	86%
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	Walling	43	33,875	37,461	1045	3%	871	788	90%	1172	149%
Median						6%			106%		130%
Mean						11%			112%		135%

Table 7b. Remote suspended-sediment sampler Hg data and comparison with manually collected composite water data. Note: EPC = estimated particle concentration.

Site	Remote Sampler Used	Manual Water Composite Data								Remote Sampler Data	
		SSC (manual composite)	Hg Total (ng/L)	Hg Particulate (ng/L)	Hg Dissolved (ng/L)	% Dissolved	Hg particle concentration (lab measured on filter) (ng/g)	Hg EPC (ng/g)	Bias (EPC: lab measured)	Hg EPC (remote) (ng/g)	Comparative Ratio between Remote Sampler and Manual Water Composites
Duane Ct and Ave Triangle SD (Jan 6)	Hamlin	48	13	11	1.88	15%	229	268	117%	99	37%
Victor Nelo PS Outfall	Hamlin	45	16	12.1	3.71	23%	269	351	131%	447	127%
Taylor Way SD	Hamlin	25	29	17.9	11	38%	716	1156	161%	386	33%
Tunnel Ave Ditch	Hamlin	96	73	65.8	7.23	10%	685	760	111%	530	70%
Forbes Blvd Outfall	Hamlin	23	15	12.2	2.45	17%	530	637	120%	125	20%
Charcot Ave SD	Hamlin	121	67	No data				557	No data	761	137%
Outfall to Lower Silver Ck	Hamlin	57	24					423		150	36%
SD near Cooley Landing	Hamlin	82	35					427		101	24%
Austin Ck at Hwy 37	Hamlin	20	13					640		459	72%
Outfall to Lower Silver Ck	Walling	57	24					423		255	60%
Austin Ck at Hwy 37	Walling	20	13					640		548	86%
Rodeo Creek at Seacliff Ct. Pedestrian	Walling	2626	119					45		50	110%
Victor Nelo PS Outfall	Walling	45	16	12.1	3.71	23%	269	351	131%	483	138%
Tunnel Ave Ditch	Walling	96	73	65.8	7.23	10%	685	760	111%	577	76%
Refugio Ck at Tsushima St	Walling	59	30	21.6	8.44	28%	366	509	139%	223	44%
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	Walling	43	9	9.7	4.9	54%	225	210	93%	264	125%
Median						23%			120%		71%
Mean						26%			125%		75%

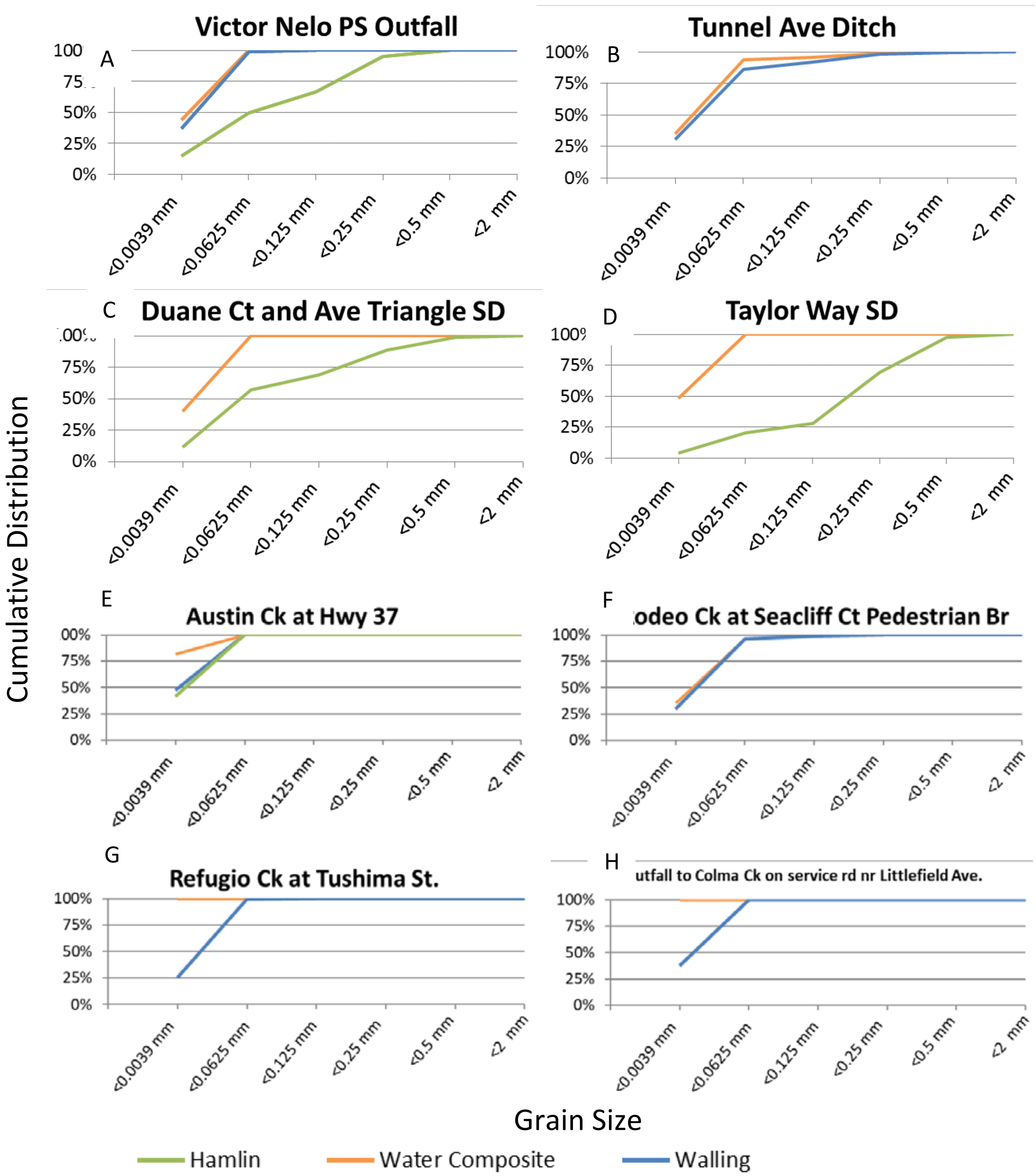

Figure 3. Cumulative grain size distribution in the Hamlin suspended-sediment sampler, Walling tube suspended-sediment sampler, and water composite samples at eight of the sampling locations. Note that both samplers were only used at two of these eight sites.

that the remote samplers captured a time-limited pulse of PCBs during the storm but the manual composite subsampling missed the pulse. This hypothesis may not entirely explain the high concentration in the Hamlin, however, since the EPC from the Walling tube sampler was only slightly elevated above the manual composite EPC. A key difference between the Hamlin sampler and the other two methods is that it disproportionately captures heavier and larger particles. These two ideas, taken together, may explain the very high Hamlin concentration – there may have been a time-limited pulse between manual samples causing both remote samplers to have relatively elevated concentrations, and a substantial portion of the PCBs flowing through this catchment may have been associated with larger particles, which the Hamlin is more likely to capture than the Walling tube.

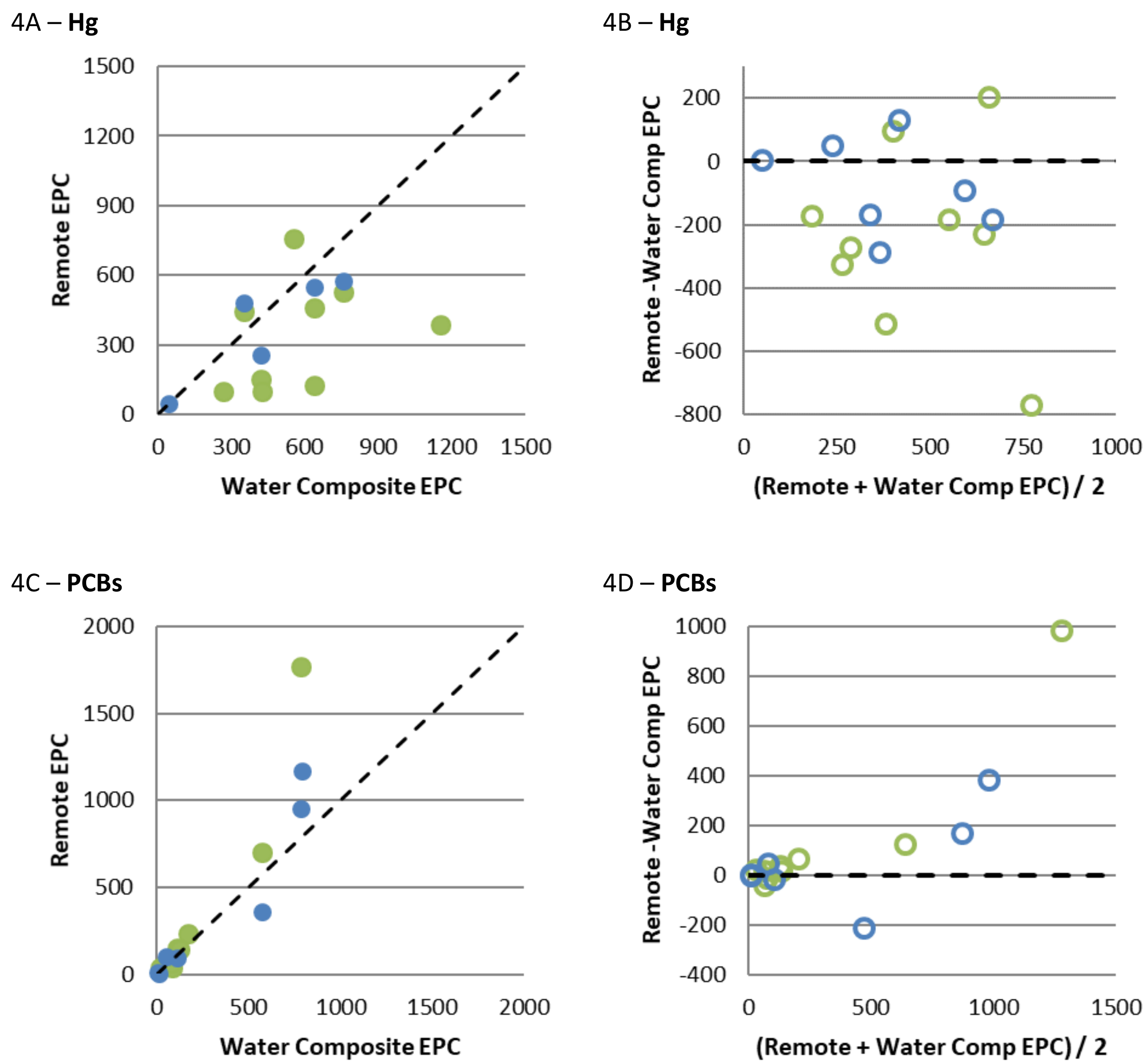

Figure 4. Estimated particle concentration comparisons between remote suspended-sediment samples versus manually collected composite samples, and comparisons of the differences between the methods against their means. Figures 4A and 4C show the 1:1 line (dashed black line), and Figures 4B and 4D show the zero line as dashed. Data for samples collected with the Hamlin sampler are green, and data for samples collected using the Walling tube are blue.

While remote sampling methods could be used as an alternative for cost saving and in places where manual sampling is not feasible, interpreting the data from remote samples and comparing them to the composite samples remains challenging. Whereas the remote methods collect primarily a concentrated, whole storm integrated suspended sediment sample, the manually composited water samples include some proportion of dissolved concentration, which conflates the metric of comparison (EPC) between the methods. In addition, the data collected thus far from the Hamlin sampler has a largely different grain size distribution than collected by the manual water composite method. Another challenge with these remote sampling data is that they cannot be used to estimate loads without corresponding sediment load estimates, which are not readily available at this point.

In summary, remote samplers show some promise as a relative ranking or prioritization tool based on the data collected to date. This pilot study will continue into WY 2018 and possibly beyond. The additional data being collected should help confirm whether these samplers have value as a reconnaissance tool. If that proves to be the case, they can be used as a low-cost screening and ranking tool to identify watersheds where greater investment in manual sampling and other methods of investigation may be needed.

Pros and cons of the remote sampling method

The pilot study to assess effectiveness of remote samplers is still in progress. The samplers have been successfully deployed at 12 locations, with the Hamlin sampler tested at nine and the Walling tube sampler tested at seven locations. A preliminary comparison between remote sampling and manual sampling methods is presented in Table 8a and 8b. Generally speaking, it is anticipated that remote sampling methods will be more cost-effective because they allow for multiple sites to be monitored during a single storm event. There would be initial costs to purchase the equipment, and labor would be required to deploy and process samples. In addition, there will always be logistical constraints (such as turbulence, tidal influences or securing the samplers in hardened channels) that complicate use of the remote devices and require manual monitoring at a particular site. The data collected from the remote sampling methodologies is generally less straightforward to interpret than water grab or composite samples, and overall would be mostly useful for ranking sites for different pollutants but not for load calculations. Therefore, the remote sampling method may best be used as a companion to manual monitoring methods to reduce costs and collect data for other purposes, providing some value as a cost-effective reconnaissance and prioritization tool.

With these concerns raised, the sampling program for WY 2018 will continue to build out the dataset for comparing samples derived from composite and remote sampling methods. The future testing of the remote samplers will need to include more side-by-side Hamlin and Walling tube sites to better compare them and confirm whether the Walling tubes indeed perform well even in circumstances when the Hamlin sampler may not. An articulated versions of the Walling tube also needs to be tested in a stormdrain setting. The additional data from this pilot effort should provide more confidence in the importance of bias and the range of differences among methods. They may also shed light on the causes of bias and differences, either broad ones across the region or specific to a site (e.g., land use) or event (e.g., storm intensity, duration, sample grain size, organic carbon).

Table 8a. Preliminary comparison of the advantages and disadvantages of the remote sampling method versus the manual sampling method for the screening of sites.

Category	Remote Sampling Relative to Manual Sampling	Notes
Cost	Less	Both manual and remote sampling include many of the same costs, though manual sampling generally requires more staff labor related to tracking the storm carefully in order to deploy field staff at just the right time. The actual sampling also requires more labor for manual sampling, especially during long storms. There are some greater costs for remote sampling related to having to drive to the site twice (to deploy and then to retrieve) and then slightly more for post-sample processing, but these additional costs are minimal relative to the amount of time required to track storms and sample on site during the storm. See additional details in Table 8b below.
Sampling Feasibility	Some advantages, some disadvantages	Remote sampling has a number of feasibility advantages over manual sampling. With remote sampling, manpower is less of a constraint; there is no need to wait on equipment (tubing, Teflon bottle, graduated cylinder) cleaning at the lab; the samplers can be deployed for longer than a single storm event, if desired; the samplers composite more evenly over the entire hydrograph; and conceivably, with the help of municipalities, remote samplers may be deployed in storm drains in the middle of streets. On the contrary, at this time there is no advantage to deploy remote samplers (and perhaps it is easier to just manually sample) in tidal locations since they must be deployed and retrieved within the same tidal cycle, although we are beginning to think of solutions to this challenge.
Data Quality	Assessment incomplete	Comparison between the remote sampler and manual sampling results are being assessed in this study. Through WY 2017 sampling, the 16 results for PCBs (using either sampler) have a range in relative percent differences (RPDs)[12] between water manual composite and remote sample of -62 – 84%, and a mean of 21%. For Hg, the range in RPD is -134 to 32%, with a mean of -42%. If remote samplers can be used consistently over multiple storm events, it is reasonable to think that the extended sample collection would improve the representativeness of the sample.
Data Uses	Equivalent or slightly lower	At this time, both the remote and manual sampling collect data for a single storm composite which is then used for screening purposes. The water concentration data from the manual water composites may also be used to estimate loads if the volume is known or can be estimated (e.g., using the RWSM). Water concentration data from remote samplers cannot be used for this purpose.
Human stresses and risks associated with sampling program	Much less	Manual sampling involves a great deal of stressful planning and logistical coordination to sample storms successfully; these stresses include irregular schedules and having to cancel other plans; often working late and unpredictable hours; working in wet and often dark conditions after irregular or insufficient sleep and added risks under these cumulative stresses. Some approaches to remote sampling (e.g., not requiring exact coincidence with storm timing) could greatly reduce many of these stresses (and attendant risks).

[12] RPD is the relative percent difference, calculated as: $\text{RPD} = \frac{\text{Difference (between replicate samples)}}{\text{Average (replicate samples)}} \times 100\%$

Table 8b. Detailed preliminary labor and cost comparison between the remote sampling method versus the manual composite sampling method for the screening of sites.

Task	Remote Sampling Labor Hours Relative to Manual Sampling	Manual Composite Sampling Task Description	Remote Sampling Task Description
Sampling Preparation in Office	Equivalent	Cleaning tubing/bottles; preparing bottles, field sampling basic materials	Cleaning sampler; preparing bottles, field sampling basic materials
Watching Storms	Much less	Many hours spent storm watching and deciding if/when to deploy	Storm watching is minimized to only identifying appropriate events with less/little concern about exact timing
Sampling Preparation at Site	Equivalent	Set up field equipment	Deploy sampler
Driving	More (2x)	Drive to and from site	Drive to and from site 2x
Waiting on Site for Rainfall to Start	Less	Up to a few hours	No time since field crew can deploy equipment prior to rain arrival
On Site Sampling	Much less	10-20 person hours for sampling and field equipment clean up	2 person hours to collect sampler after storm
Sample Post-Processing	Slightly more (~2 person hours)	NA	Distribute composited sample into separate bottles; takes two people about 1 hour per sample
Data Management and Analysis	Equivalent	Same analytes and sample count (and usually same matrices)	Same analytes and sample count (and usually same matrices)

Preliminary site rankings based on all available data (including previous studies)

A relative ranking was generated for PCBs and Hg based on both water concentrations and EPCs for all the available data. This analysis differs from the rankings reported in Table 5 in that all available data were considered, not just the data collected for this study. The additional data included in this section primarily is comprised of data collected in intensive loadings studies from 2003-2010 and 2012-2014, a similar reconnaissance study implemented in WY 2011, and studies of green infrastructure conducted between 2010 and the present.

While there are always challenges associated with interpreting data in relation to highly variable factors, including antecedent conditions, storm specific rainfall intensity, and watershed specific source-release-transport processes, the objective here is to provide evidence to help identify watersheds that might have disproportionately elevated PCB or Hg concentrations or EPCs. Given the nature of the reconnaissance sampling design, the absolute rank is much less certain but it is unlikely that the highest ranked locations would drop in ranking much if more sampling was conducted.

PCBs

Based on water composite concentrations for all available data, the 10 highest ranking sites for PCBs are (in order from higher to lower): Pulgas Pump Station-South, Santa Fe Channel, Industrial Rd Ditch, Line

12H at Coliseum Way, Sunnyvale East Channel, Outfall at Gilman St., Pulgas Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain, and Outfall to Lower Silver Creek (Table 9, Figure 6). The old industrial land use for these sites ranges from 3-79%, highlighting the challenge of using land use alone as a guide to identify high leverage areas. Using PCB EPCs, the ten most polluted sites are: Pulgas Pump Station-South, Industrial Rd Ditch, Line 12H at Coliseum Way, Santa Fe Channel, Pulgas Pump Station-North, Gull Dr SD, Outfall at Gilman St., Outfall to Colma Ck on service road near Littlefield Ave., Outfall to Lower Silver Creek, and Ettie Street Pump Station. Eight sampling sites made both of the top 10 lists; one site (Gull Dr SD) was ranked high in EPCs but very low on water concentration because of very low suspended sediment mass, and Sunnyvale East Channel exhibited elevated water concentrations but low EPC.

To a large degree, sites that rank high for PCB water concentrations also rank high for EPCs (Figure 7). Watersheds that rank high in water concentration but low in EPC suggest that there are sources present but the EPC is diluted by relatively higher rates of clean sediment. Examples include Line 13A at end of slough and Line 12K at Coliseum Entrance. Conversely, those watersheds that rank high in EPC but not high in water concentration suggest that PCB mobilization is high relative to sediment mobilization, often with samples having a relatively low SSC. Examples of this include Gull Dr. SD and Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Circle. This latter scenario is more likely to occur in watersheds that are highly impervious with little input of clean sediment.

The data collected in WY 2017 added new information to the regional dataset. In addition to identifying two new top-10 ranked PCB EPC sites, the WY 2017 stormwater sampling efforts also identified several more sites with moderately high EPCs (Figure 6). This additional large cohort of sites with moderately elevated EPCs was likely a result of a site selection process that targeted watershed areas with greater older industrial influences.

Most of the sites measured have PCB EPCs that are higher than average conditions needed for attainment of the TMDL. The PCB load allocation of 2 kg from the TMDL (SFBRWQCB 2008) translates to a mean water concentration of 1.33 ng/L and a mean particle concentration of 1.4 ng/g. These calculations assume an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012) and an average annual suspended sediment load of 1.4 million metric tons (McKee et al., 2013). Keeping in mind that the estimates of regional flow and regional sediment loads are subject to change as further interpretations are completed, only five sampling locations observed to date (Gellert Park bioretention influent stormwater, Duane Ct. and Triangle Ave., East Antioch nr Trembath, Refugio Ck at Tsushima St. and Haig St. SD) have a composite averaged PCB water concentration of < 1.33 ng/L (Table 9) and none of 78 sampling locations have composite averaged PCB EPCs <1.4 ng/g (Table 9; Figure 6 and 7). The lowest PCB EPC measured to date is for Marsh Creek (2.9 ng/g).

Table 9. PCB and total mercury (HgT) water concentrations and estimated particle concentrations (EPCs) measured in the Bay area based on all data collected in stormwater since water year 2003 and that focused on urban sources (79 sites in total for PCBs and HgT). This dataset is sorted high-to-low for PCB EPC to provide preliminary information on potential leverage. Note: Ranks with a half number are the result of two watersheds with the same rank.

Watershed/Catchment	County	Water Year Sampled	Area (km^2)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Pulgas Pump Station-South	San Mateo	2011-2014	0.58	87%	54%	8222	1	447,984	1	0.35	42.5	19	56
Industrial Rd Ditch	San Mateo	2016	0.23	85%	79%	6139	2	159,606	3	0.53	26	14	63
Line 12H at Coliseum Way	Alameda	2017	0.97	71%	10%	2601	3	156,060	4	0.60	18	36	42
Santa Fe Channel	Contra Costa	2011	3.3	69%	3%	1295	4	197,923	2	0.57	21.5	86	12.5
Pulgas Pump Station-North	San Mateo	2011	0.55	84%	52%	893	5	60,320	7	0.40	36	24	52.5
Gull Dr SD	San Mateo	2016	0.30	78%	54%	859	6	8,592	43	0.56	23	6	76
Outfall at Gilman St.	Alameda	2016	0.84	76%	32%	794	7	65,670	6	5.31	1	439	4
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	San Mateo	2017	0.09	88%	87%	788	8	33,875	14	0.21	62	9	73
Outfall to Lower Silver Creek	Santa Clara	2015	0.17	79%	78%	783	9	44,643	10	0.42	34	24	52.5
Ettie Street Pump Station	Alameda	2011	4.0	75%	22%	759	10	58,951	8	0.69	14	55	25.5
S Linden Ave SD (291)	San Mateo	2017	0.78	88%	57%	736	11	11,781	32	0.78	11	12	68
Austin Ck at Hwy 37	Solano	2017	4.9	61%	2%	573	12	11,450	34	0.64	16	13	67
Ridder Park Dr Storm Drain	Santa Clara	2015	0.50	72%	57%	488	13	55,503	9	0.33	46	37	41
Line 12I at Coliseum Way	Alameda	2017	3.4	63%	9%	398	14	36,974	12	0.13	72	12	70
Sunnyvale East Channel	Santa Clara	2011	15	59%	4%	343	15	96,572	5	0.20	64	50	29
Line-3A-M at 3A-D	Alameda	2015	0.88	73%	12%	337	16	24,791	18	1.17	5	86	12.5
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	Contra Costa	2017	37	18%	5%	284	17	6,528	48	0.26	55	6	75
North Richmond Pump Station	Contra Costa	2011-2014	2.0	62%	18%	241	18	13,226	30	0.81	10	47	30.5
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.4	81%	68%	236	19	19,915	23	0.55	25	47	30.5

Watershed/Catchment	County	Water Year Sampled	Area (km²)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Line 12M at Coliseum Way	Alameda	2017	5.3	69%	22%	222	20	24,090	19	0.36	39	40	37
Line 4-E	Alameda	2015	2.0	81%	27%	219	21	37,350	11	0.35	42.5	59	22
Glen Echo Creek	Alameda	2011	5.5	39%	0%	191	22	31,078	16	0.21	63	73	18
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.8	62%	18%	186	23	13,472	29	0.53	27	38	39.5
Line 12F below PG&E station	Alameda	2017	10	56%	3%	184	24	21,000	22	0.37	37	43	34
South Linden Pump Station	San Mateo	2015	0.14	83%	22%	182	25	7,814	46	0.68	15	29	48
Gull Dr Outfall	San Mateo	2016	0.43	75%	42%	174	26	5,758	52	0.32	48	10	72
Taylor Way SD	San Mateo	2016	0.27	67%	11%	169	27	4,227	57	1.16	6	29	49
Line 9-D	Alameda	2015	3.6	78%	46%	153	28	10,451	36	0.24	56.5	17	57.5
Meeker Slough	Contra Costa	2015	7.3	64%	6%	142	29	8,560	44	1.27	4	76	16
Rock Springs Dr Storm Drain	Santa Clara	2015	0.83	80%	10%	128	30	5,252	53	0.93	8	38	39.5
Charcot Ave Storm Drain	Santa Clara	2015	1.8	79%	24%	123	31	14,927	26	0.56	24	67	20
Veterans Pump Station	San Mateo	2015	0.52	67%	7%	121	32	3,520	61	0.47	30	14	62
Gateway Ave Storm Drain	San Mateo	2015	0.36	69%	52%	117	33	5,244	54	0.44	31	20	55
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014	233	39%	3%	115	34	23,736	20	3.60	3	603	1
Line 9D1 PS at outfall to Line 9D	Alameda	2016	0.48	88%	62%	110	35	18,086	25	0.72	13	118	8.5
Tunnel Ave Ditch	San Mateo	2016	3.0	47%	8%	109	36	10,491	35	0.76	12	73	19
Valley Dr SD	San Mateo	2016	5.2	21%	7%	109	37	10,442	37	0.28	53	27	51
Runnymede Ditch	San Mateo	2015	2.1	53%	2%	108	38	28,549	17	0.19	66	52	28
E. Gish Rd Storm Drain	Santa Clara	2015	0.45	84%	70%	99	39	14,365	27	0.59	20	85	14
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.4	78%	26%	96	40	8,923	39	0.34	44	31	45
Line 13A at end of slough	Alameda	2016	0.83	84%	68%	96	41	34,256	13	0.33	45	118	8.5
Rosemary St SD 066GAC550C	Santa Clara	2017	3.7	64%	11%	89	42	4,112	59	0.59	19	27	50
North Fourth St SD 066GAC550B	Santa Clara	2017	1.0	68%	27%	87	43	4,174	58	0.48	29	23	54

Watershed/Catchment	County	Water Year Sampled	Area (km²)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Zone 4 Line A	Alameda	2007- 2010	4.2	68%	12%	82	44	18,442	24	0.17	68	30	47
Forbes Blvd Outfall	San Mateo	2016	0.40	79%	0%	80	45	1,840	69	0.64	17	15	61
Storm Drain near Cooley Landing	San Mateo	2015	0.11	73%	39%	79	46	6,473	50	0.43	32	35	43
Lawrence & Central Expwys SD	Santa Clara	2016	1.2	66%	1%	78	47	4,506	56	0.23	58	13	64.5
Condensa St SD	Santa Clara	2016	0.24	70%	32%	74	48	2,602	67	0.33	47	12	71
San Leandro Creek	Alameda	2011-2014	8.9	38%	0%	66	49	8,614	42	0.86	9	117	10
Oddstad Pump Station	San Mateo	2015	0.28	74%	11%	62	50	9,204	38	0.37	38	55	25.5
Line 4-B-1	Alameda	2015	1.0	85%	28%	57	51	8,674	41	0.28	51.5	43	33
Zone 12 Line A under Temescal Ck Park	Alameda	2016	17	30%	4%	54	52	7,804	47	0.29	50	42	35
Victor Nelo PS Outfall	Santa Clara	2016	0.58	87%	4%	51	53	2,289	68	0.35	40	16	59
Line 12K at Coliseum Entrance	Alameda	2017	16	31%	1%	48	54	31,958	15	0.43	33	288	5
Haig St SD	Santa Clara	2016	2.1	72%	10%	43	55	1,454	71	0.19	65	7	74
Colma Ck at S. Linden Blvd	San Mateo	2017	35	41%	3%	37	56	2,645	66	0.22	61	15	60
Line 12J at mouth to 12K	Alameda	2017	8.8	30%	2%	35	57	6,483	49	0.40	35	73	17
S Spruce Ave SD at Mayfair Ave (296)	San Mateo	2017	5.1	39%	1%	30	58	3,359	62	0.35	41	39	38
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	59	4,576	55	0.24	56.5	34	44
Calabazas Creek	Santa Clara	2011	50	44%	3%	29	60	11,493	33	0.15	71	59	22
E Outfall to San Tomas at Scott Blvd	Santa Clara	2016	0.67	66%	31%	27	61	2,799	65	0.13	73	13	64.5
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	62	12,870	31	0.18	67	41	36
Stevens Creek	Santa Clara	2011	26	38%	1%	23	63	8,160	45	0.22	59.5	77	15
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	64	3,120	63	4.09	2	529	2
Duane Ct and Ave Triangle SD	Santa Clara	2016	1.0	79%	23%	17	65	832	73	0.27	54	13	66
Lower Penitencia Creek	Santa Clara	2011, 2015	12	65%	2%	16	66	1,588	70	0.16	69.5	17	57.5

Watershed/Catchment	County	Water Year Sampled	Area (km²)	Impervious Cover (%)	Old Industrial Land Use (%)	Polychlorinated Biphenyls (PCBs)				Total Mercury (HgT)			
						Estimated Particle Concentration		Composite/Mean Water Concentration		Estimated Particle Concentration		Composite/Mean Water Concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Borel Creek	San Mateo	2011	3.2	31%	0%	15	67	6,129	51	0.16	69.5	58	24
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	68	2,825	64	0.28	51.5	59	22
Zone 5 Line M	Alameda	2011	8.1	34%	5%	13	69.5	21,120	21	0.57	21.5	505	3
Belmont Creek	San Mateo	2011	7.2	27%	0%	13	69.5	3,599	60	0.22	59.5	53	27
Refugio Ck at Tsushima St	Contra Costa	2017	11	23%	0%	9	71	533	74	0.51	28	30	46
Walnut Creek	Contra Costa	2011	232	15%	0%	7	72	8,830	40	0.07	75	94	11
Rodeo Creek at Seacliff Ct. Pedestrian Br.	Contra Costa	2017	23	2%	3%	5	73	13,863	28	0.05	76	119	7
Lower Marsh Creek	Contra Costa	2011-2014	84	10%	0%	3	74	1,445	72	0.11	74	44	32
East Antioch nr Trembath	Contra Costa	2017	5.3	26%	3%	NR[a]	NR[a]	<MDL	NR[a]	0.31	49	12	69
San Pedro Storm Drain	Santa Clara	2006	1.3	72%	16%	No data				1.12	7	160	6
El Cerrito Bioretention Influent	Contra Costa	2011	0.00	74%	0%	442	NR[a]	37690	NR[a]	0.19	NR[a]	16	NR[a]
Fremont Osgood Road Bioretention Influent	Alameda	2012, 2013	0.00	76%	0%	45	NR[a]	2906	NR[a]	0.12	NR[a]	10	NR[a]
Gellert Park Daly City Library Bioretention Influent	San Mateo	2009	0.02	40%	0%	36	NR[a]	725	NR[a]	1.01	NR[a]	22	NR[a]

[a]NR = site not included in ranking. All sites that are not included in the ranking are very small catchments with unique sampling designs for evaluation of green infrastructure.

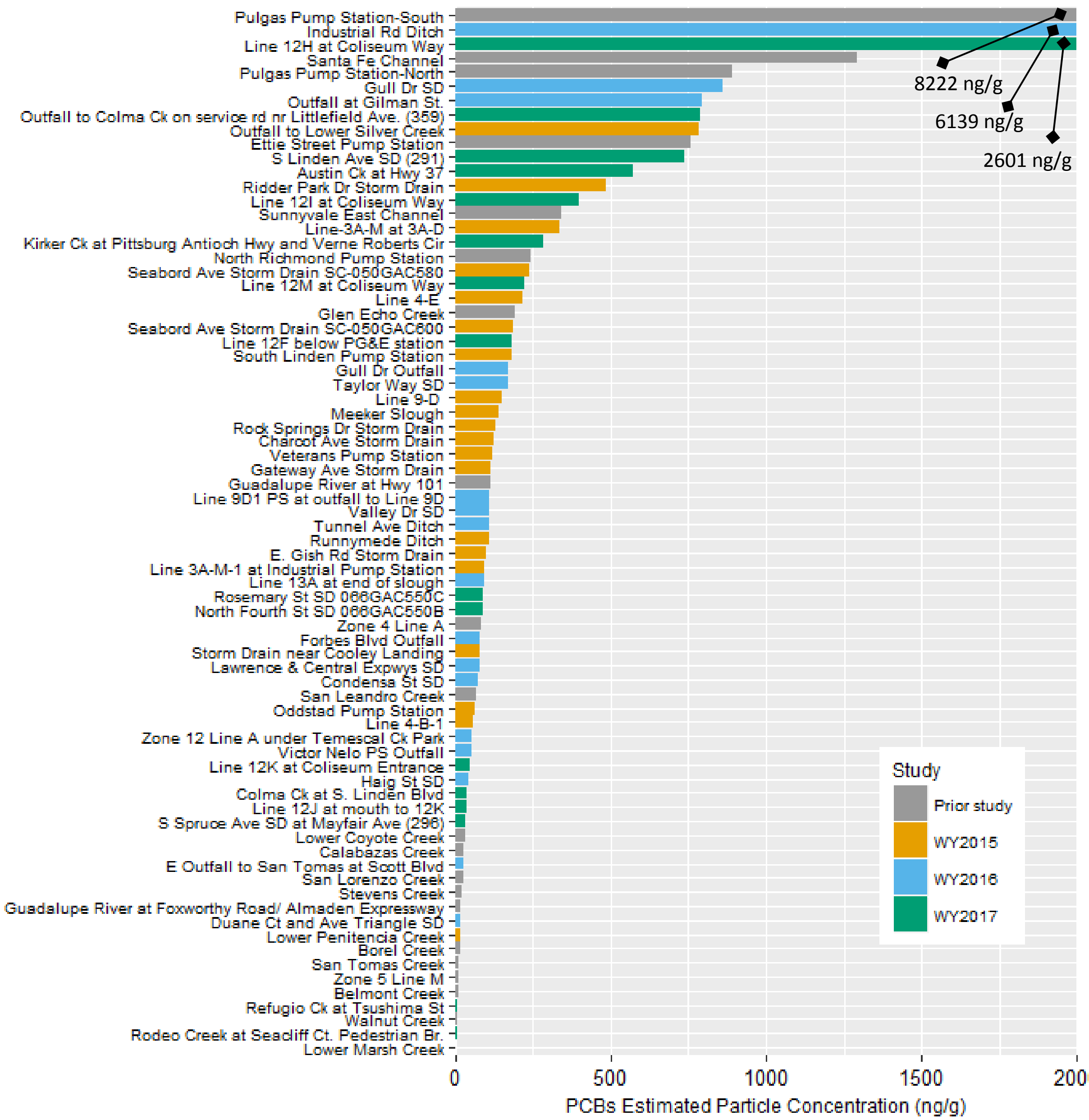

Figure 6. PCB estimated particle concentrations for watershed sampling sites measured to date (water years 2003-2017; where more than one storm is sampled at a site, the reported value is the average of the storm composite samples). Note that PCB EPCs for Pulgas Pump Station-South (8,222 ng/g), Industrial Road Ditch (6,139 ng/g) and for Line 12H at Coliseum Way (2,601 ng/g) are beyond the extent of this graph. The sample count represented by each bar in the graph is provided in Appendix B.

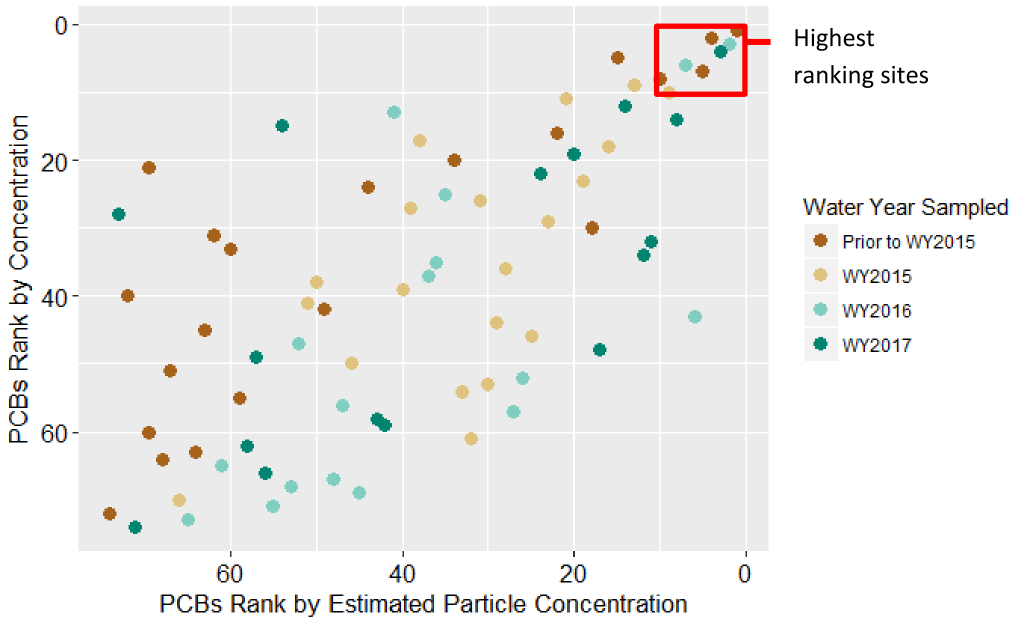

Figure 7. Comparison of site rankings for PCBs based on estimated particle concentrations versus water concentrations. 1 = highest rank; 75 = lowest rank.

Mercury

Based on composite water concentrations, the 10 highest ranking sites for HgT are the Guadalupe River at Hwy 101, Guadalupe River at Foxworthy Road/ Almaden Expressway, Zone 5 Line M, Outfall at Gilman St., Line 12K at the Coliseum Entrance, San Pedro Storm Drain, Rodeo Creek at Seacliff Ct. Pedestrian Br., Line 13-A at end of slough, Line 9-D-1 PS at outfall to Line 9-D and San Leandro Creek (Table 9). Just one of these (Outfall at Gilman St.) also ranked in the top 10 for PCBs.

In addition to the two Guadalupe River mainstem sites, the 10 most polluted sites based on EPCs are Outfall at Gilman St., Meeker Slough, Line 3A-M at 3A-D, Taylor Way SD, San Pedro Storm Drain, Rock Springs Dr. Storm Drain, San Leandro Creek and North Richmond Pump Station (Table 9; Figure 8). Management action in these watersheds might be most cost effective for reducing HgT loads. Only one of these top 10 sites was also identified as elevated for PCBs (Outfall at Gilman St.), but eight additional watersheds rank in the top 20 for both pollutants (Figure 9), providing the opportunity for treating both pollutants. Twenty-one sites measured to date have EPCs <0.25 µg/g, which, given a reasonable expectation of error bars of 25% around the measurements, could be considered equivalent to or less than 0.2 µg/g of Hg on suspended solids (the particulate Hg concentration that was specified in the Bay and Guadalupe River TMDLs (SFBRWQCB, 2006; 2008)).

Site ranking for HgT presented a different picture from PCBs. Sites ranking high based on water concentration are not necessarily ranked high for EPC with the exception of a few sites (Figure 10). Given the atmospheric deposition of Hg across the landscape (McKee et al., 2012), and the highly variable sediment erosion in Bay Area watersheds, it is possible that a watershed could have very elevated HgT stormwater concentrations but very low EPCs. The best example of this is Walnut Creek, which was ranked 11th highest for stormwater composite concentrations but 75th for EPCs. Therefore, HgT sites need to be ranked more carefully than PCBs.

Another important point is that there are a number of watersheds that have relatively low Hg concentrations. The HgT load allocation of 80 kg from the TMDL (add citation for TMDL) translates to a mean water concentration of 53 ng/L. These calculations assume an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012). Forty-nine of 79 sampling locations tested have composite HgT water concentrations below this concentration (Table 9). The impervious cover from these low-ranking sites ranges from 10 to 88%, and there are likely very few Hg sources in these watersheds besides atmospheric deposition[13].

Relationships between PCBs and Hg and other trace substances and land-cover attributes

Beginning in WY 2003, many sites have been evaluated for a range of trace elements in addition to PCBs and HgT. These sites include the fixed station loads monitoring sites on Guadalupe River at Hwy 101 (McKee et al., 2006), Zone 4 Line A (Gilbreath et al., 2012a), North Richmond Pump Station (Hunt et al., 2012) and at four sites for which only Cu was measured (Lower Marsh Creek, San Leandro Creek, Pulgas Pump Station-South, and Sunnyvale East Channel) (Gilbreath et al., 2015a). Copper data were also collected at the inlets to several pilot performance studies for bioretention (El Cerrito: Gilbreath et al., 2012b; Fremont: Gilbreath et al., 2015b), and Cu, Cd, Pb, and Zn data were collected at the Daly City Library Gellert Park demonstration bioretention site (David et al., 2015). During WYs 2015, 2016, and 2017, trace element data were collected at an additional 29 locations (Table 6). When all these data are pooled, the resulting dataset has samples sizes of: n=39 sites for Cu; n=33 for Cd, Pb, and Zn; and n=32 for As. Data for Mg and Se were not included due to small sample size. Organic carbon has been more widely collected, including at 28 locations in this study and an additional 21 locations in previous studies.

A Spearman rank correlation analysis was conducted to investigate relationships between EPCs of PCBs and HgT, trace elements, and impervious land cover and old industrial land use (Table 10). In the case of Guadalupe River, the HgT data were removed from the analysis because of historic mining influence in the watershed[14]. Estimated particle concentrations were chosen for this analysis for the same reasons as

[13] Multiple studies in the Bay Area on atmospheric deposition rates for HgT reported very similar wet deposition rates of 4.2 $\mu g/m^2/y$ (Tsai and Hoenicke, 2001) and 4.4 $\mu g/m^2/y$ (Steding and Flegal, 2002), and Tsai and Hoenicke reported a total (wet + dry) deposition rate of 18-21 $\mu g/m^2/y$. Tsai and Hoenicke computed volume-weighted mean mercury concentrations in precipitation based on 59 samples collected across the Bay Area of 8.0 ng/L. They reported that wet deposition contributed 18% of total annual deposition; scaled to volume of runoff, an equivalent stormwater concentration is 44 ng/L (8 ng/L/0.18 = 44 ng/L).

[14] Historic mining in the Guadalupe River watershed caused a unique positive relationship between Hg, Cr, and Ni, and there are unique inverse correlations between Hg and other typically urban metals such as Cu and Pb (McKee et al., 2005).

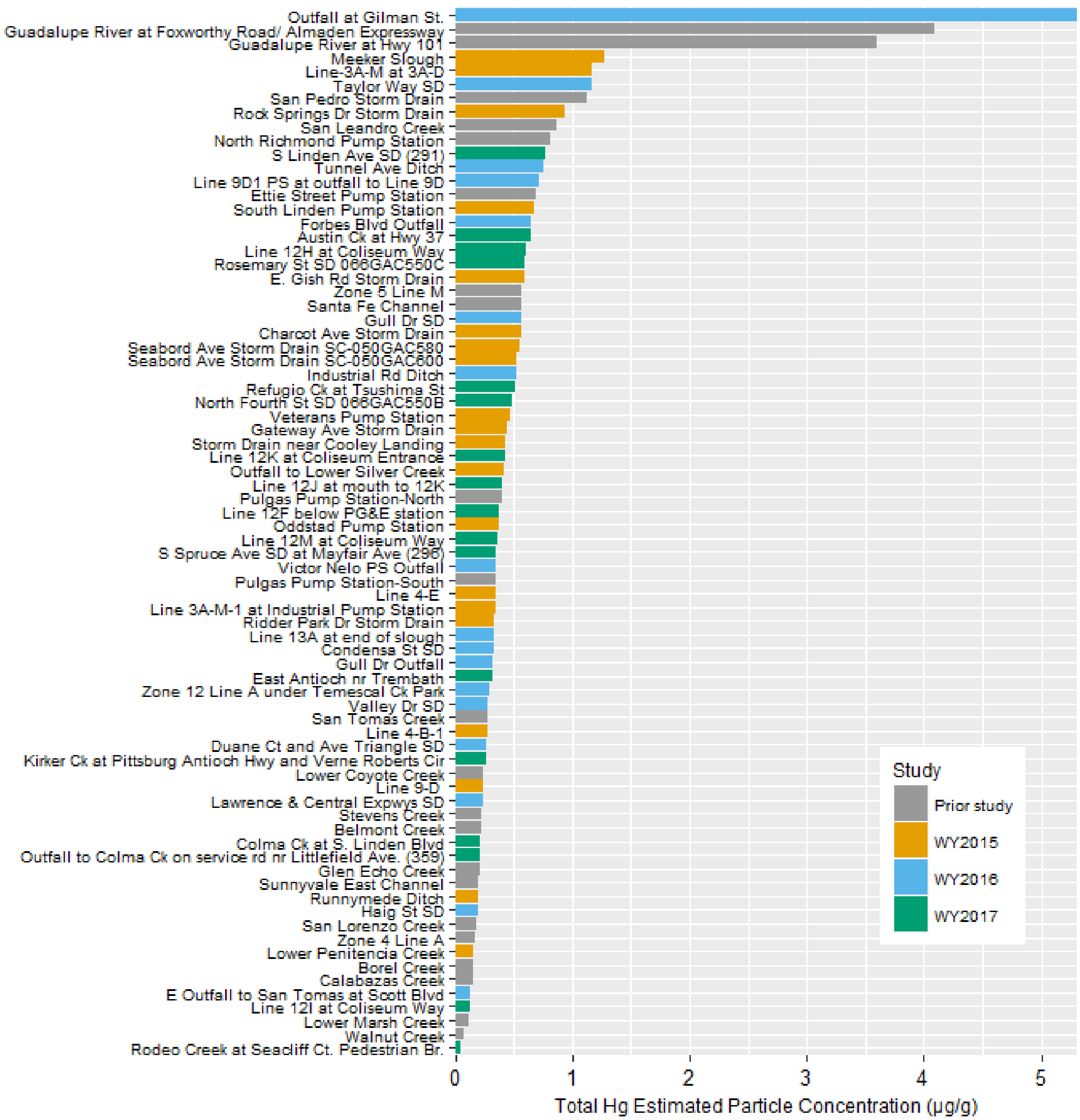

Figure 8. All watershed sampling locations measured to date (water years 2003-2017) ranked by total mercury (HgT) estimated particle concentrations. The sample count represented by each bar in the graph is provided in Appendix B.

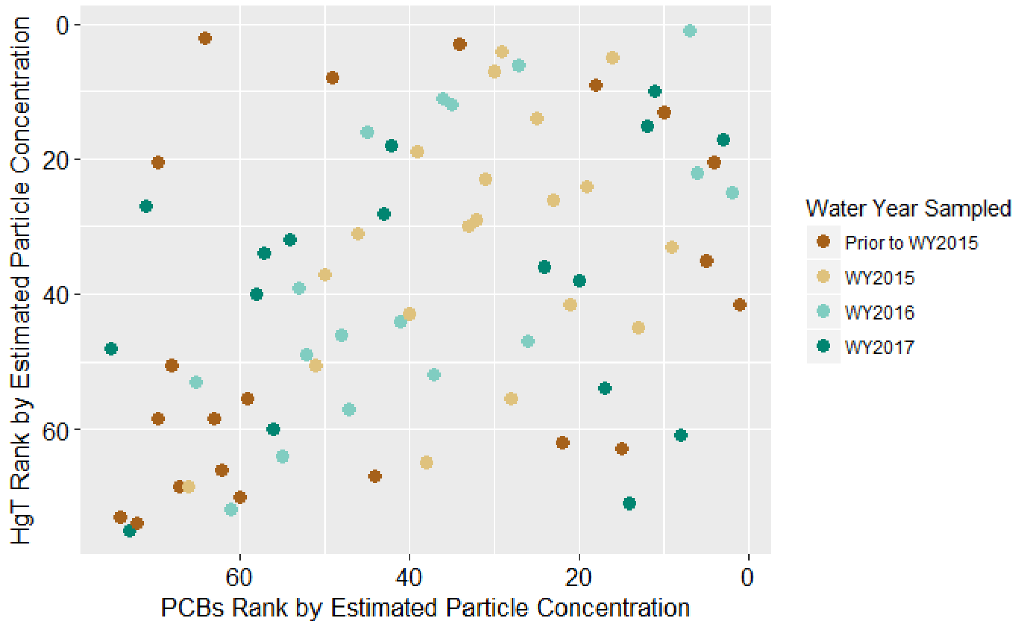

Figure 9. Comparison of site rankings for PCB and total mercury (HgT) estimated particle concentrations. 1 = highest rank; 75 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT, and nine watersheds rank in the top 20 for both pollutants.

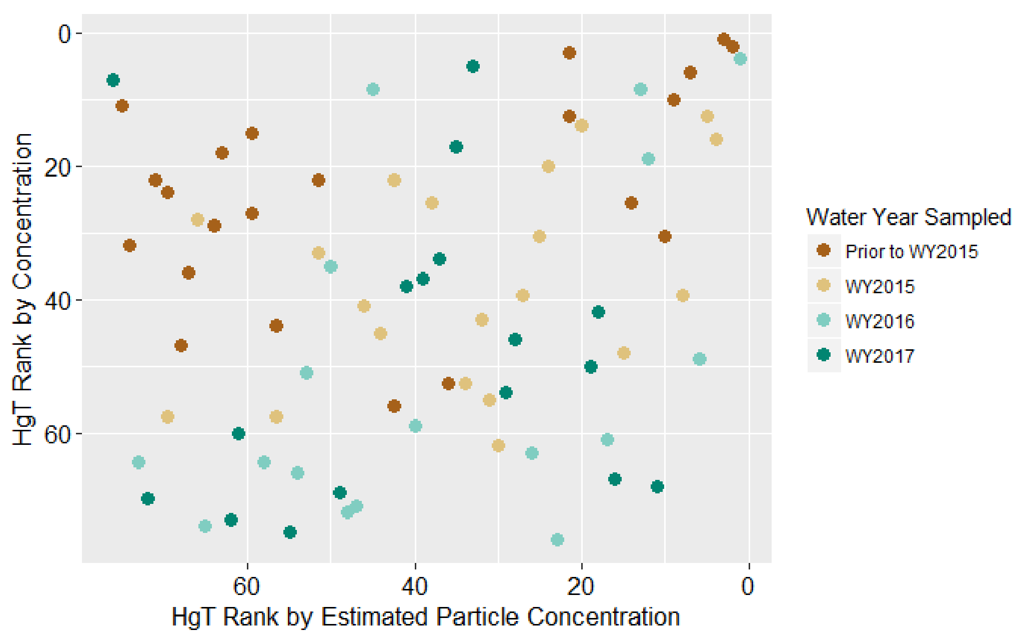

Figure 10. Comparison of site rankings for total mercury (HgT) estimated particle concentrations and water concentrations. 1 = highest rank; 76 = lowest rank.

described above and in McKee et al. (2012): the influence of variable sediment production across Bay Area watersheds is best normalized out so that variations in the influence of pollutant sources and mobilization can be more easily observed between sites.

PCBs correlate positively with impervious cover, old industrial land use and HgT, and inversely correlate with watershed area (Table 10). These observations are consistent with previous analysis (McKee et al., 2012), and make conceptual sense given that larger watersheds tend to have mixed land use and thus a lower proportional amount of PCB source areas.

There was also a positive but relatively weak correlation between PCBs and HgT which makes sense given the general relationships between impervious cover and old industrial land use and both PCBs and HgT. However, the weakness of the relationship is probably associated with the larger role of atmospheric recirculation in the mercury cycle and large differences between the use history of each pollutant. PCBs is a legacy contaminant that was used as dielectrics, plasticizers, and oils. Mercury was used in electronic devices, pressure and heat sensors, pigments, mildewcides, and dentistry and has a strong contemporary signal in addition to legacy usage.

Total Hg also has relationships to impervious cover, old industrial land use, and watershed area that are similar to but weaker than those for PCBs and these geospatial variables.

Neither PCBs nor Hg have strong correlations with other trace metals. Based on this analysis using the available pooled data, there is no support for the use of trace metals as a surrogate investigative tool for either PCB or HgT pollution sources.

To further explore these relationships, the PCB data were examined graphically (Figure 11). The graphs show that the three highest PCB concentrations are in small watersheds that have a high proportion of impervious cover and old industrial area. But the lack of a strong correlation between these metrics indicates that not all small, highly impervious watersheds have high PCB concentrations. The data also indicate the presence of outliers that may be worth exploring with additional data.

Table 10. Spearman Rank correlation matrix based on estimated particle concentrations of stormwater samples collected in the Bay Area since water year 2003 (see text for data sources and exclusions). Sample size in correlations ranged from 28 to 79. Values shaded in light blue have a *p* <0.05.

	PCBs (pg/mg)	HgT (ng/mg)	Arsenic (ug/mg)	Cadmium (ug/mg)	Copper (ug/mg)	Lead (ug/mg)	Zinc (ug/mg)	Area (sq km)	% Imperviousness	% Old Industrial	% Clay (<0.0039 mm)	% Silt (0.0039 to <0.0625 mm)	% Sands (0.0625 to <2.0 mm)
HgT (ng/mg)	0.43												
Arsenic (ug/mg)	-0.61	-0.06											
Cadmium (ug/mg)	-0.27	0.23	0.67										
Copper (ug/mg)	-0.07	0.16	0.56	0.74									
Lead (ug/mg)	-0.25	0.18	0.58	0.86	0.71								
Zinc (ug/mg)	-0.24	0.27	0.50	0.80	0.89	0.69							
Area (sq km)	-0.45	-0.34	0.01	-0.24	-0.43	-0.09	-0.41						
% Imperviousness	0.56	0.33	-0.35	0.02	0.20	-0.08	0.18	-0.77					
% Old Industrial	0.58	0.31	-0.47	-0.20	-0.22	-0.25	-0.14	-0.55	0.74				
% Clay (<0.0039 mm)	0.26	0.15	-0.12	0.04	-0.22	-0.04	-0.15	-0.23	0.04	0.10			
% Silt (0.0039 to <0.0625 mm)	-0.13	0.06	-0.14	-0.19	0.27	0.00	0.16	0.21	-0.05	-0.04	-0.35		
% Sands (0.0625 to <2.0 mm)	-0.21	-0.23	0.09	-0.01	0.02	0.07	0.00	0.24	-0.08	-0.04	-0.90	0.15	
TOC (mg/mg)	0.27	0.43	0.70	0.60	0.87	0.47	0.76	-0.49	0.45	0.17	-0.13	0.11	-0.04

p value <0.05

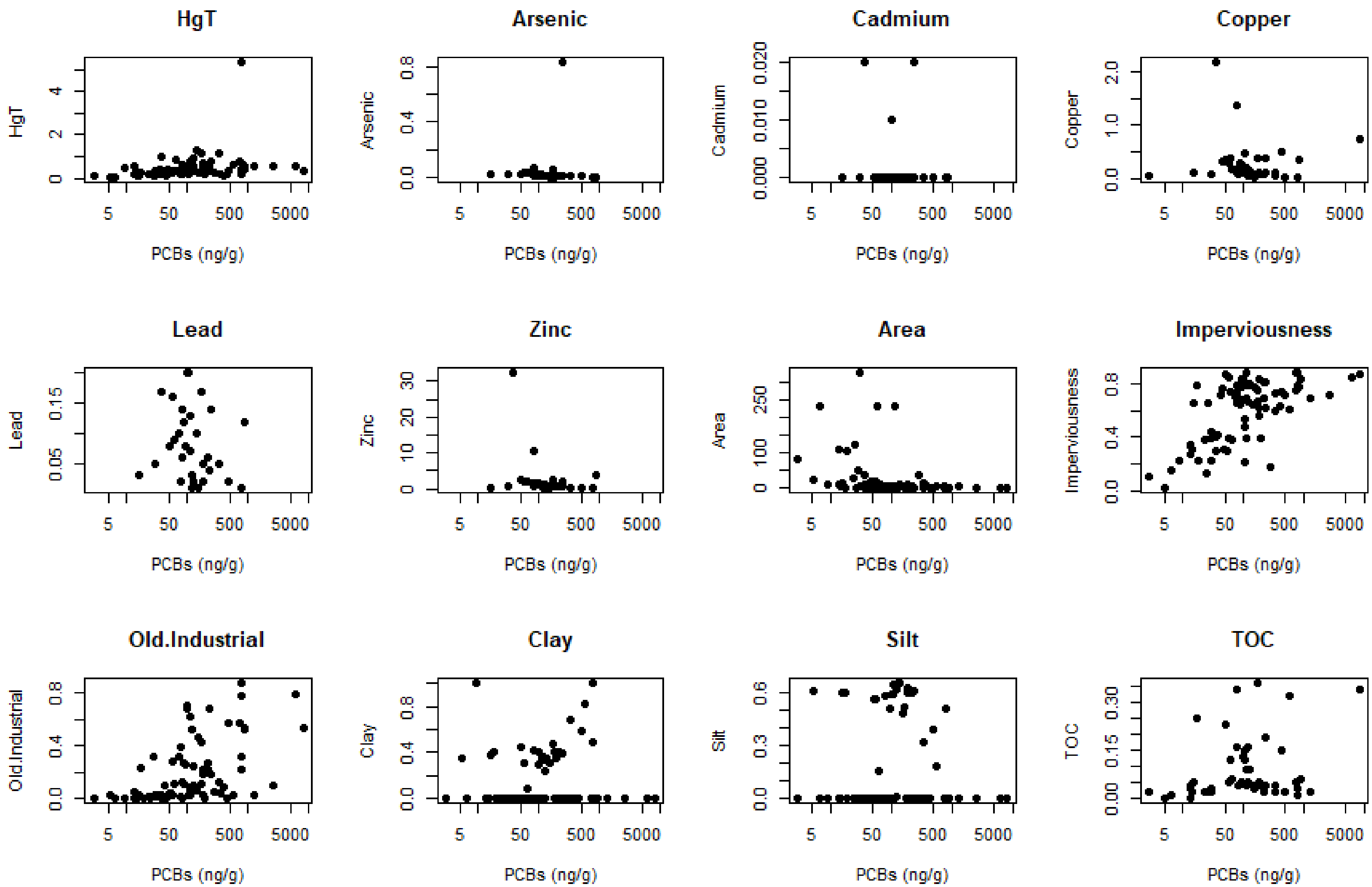

Figure 11. Relationships between observed estimated particle concentrations of PCBs and total mercury (HgT), trace elements, and impervious land cover and old industrial land use.

Sampling progress in relation to data uses

Sampling completed in older industrial areas can be used as an indicator of progress towards identifying areas for potential management. It has been argued previously that old industrial land use and the specific source areas found within or in association with older industrial areas are likely to have higher concentrations and loads of PCBs and HgT (McKee et al., 2012; McKee et al., 2015).

RMP sampling for PCBs and HgT since WY 2003 has included 34% of the old industrial land use in the region. The best effort so far has occurred in Santa Clara County (96% of this land use is in watersheds that have been sampled), followed by San Mateo County (51%) and Alameda County (41%). In Contra Costa County, only 11% of old industrial land use is in watersheds that have been sampled, and just 1% in Solano County. The disproportional coverage in Santa Clara County is due to sampling several large watersheds (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek and San Tomas Creek) that have older industrial land use upstream from their sampling points. Of the remaining older industrial land use yet to be sampled, 46% of it lies within 1 km and 67% within 2 km of the Bay. These areas are more likely to be tidal, likely to include heavy industrial areas that were historically serviced by rail and ship based transport and military areas, but are often very difficult to sample due to a lack of public rights of way and tidal conditions. A different sampling strategy may be needed to effectively assess what pollution might be associated with these areas to better identify areas for potential management.

Summary and Recommendations

During WYs 2015-2017, composite water samples were collected at 55 sites during at least one storm event and analyzed for PCBs, HgT and SSC, as well as trace metals, organic carbon, and grain size for a select subset. Sampling efficiency was increased by sampling two nearby sites during a single storm. In parallel, a second sample was collected at nine of the sampling sites using a Hamlin remote suspended sediment sampler, and at seven sites using a Walling tube sampler. From this dataset, a number of sites with elevated PCB and HgT concentrations and EPCs were identified, in part because of an improved site selection process that focused on older industrial landscapes. The testing of the remote samplers showed mixed results and further testing is needed. Based on the WY 2015-2017 results, the following recommendations are made.

- Continue to select sites based on the four main selection objectives (Section 2.2). The majority of the sampling effort should be devoted to identify potential high leverage areas with high unit area loads or EPCs/concentrations. Selecting sites by focusing on older industrial and highly impervious landscapes appears successful in identifying high leverage areas and should continue.
- Continue to use the composite sampling design as developed and applied during WYs 2015-2017 with no further modifications. In the event of a higher-rainfall wet season, it may be possible to sample tidally influenced sites when there is a greater likelihood that more storm events will fall within the required tidal windows.

- If WY 2018 sampling includes resampling a site previously sampled, present an improved analysis of the potential for composite, single-storm sampling design to return false negative results (low or moderate concentrations when high concentrations are possible) (see Appendix A for discussion of the possibility for false negatives). Develop a procedure for selecting and resampling sites that return lower than expected concentrations or EPCs.
- Preliminary results from the remote sampler study indicate that the samplers show promise as a screening tool for PCBs, but less so for Hg. More Hamlin samples have been collected than Walling tube samples, and few side-by-side deployments have been made. It is therefore recommended that the testing should continue, with a focus on using the Walling tube sampler, and where the Hamlin is deployed a Walling tube should especially be deployed for comparison between the two remote samplers.
- Develop an improved (advanced) data analysis method for identifying and ranking watersheds of management interest for further characterization or investigation. This recommendation will be carried out in the 2018 calendar year.

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Appendices

Appendix A – Sampling Method Development

The monitoring program implemented in WYs 2015, 2016, and 2017 was based on a previous monitoring design that was trialed in WY 2011 when multiple sites were visited during one or two storm events. In that study, multiple discrete stormwater samples were collected at each site and analyzed for a number of POCs (McKee et al., 2012). At the 2014 SPLWG meeting, an analysis of previously collected stormwater sample data from both reconnaissance and fixed station monitoring was presented (SPLWG et al. 2014). A comparison of three sampling designs for Guadalupe River at Hwy 101 (sampling 1, 2, or 4 storms, respectively: functionally 4, 8, and 16 discrete samples) showed that PCB estimated particle concentrations (EPC) at this site can vary from 45-287 ng/g (1 storm design), 59-257 ng/g (2 storm design), and 74-183 ng/g (4 storm design) between designs, suggesting that the number of storms sampled for a given watershed has big impacts on the EPCs and therefore the potential relative ranking among sites. A similar analysis that explores the relative ranking based on a random 1-storm composite or 2-storm composite design was also presented for other monitoring sites (Pulgas Pump Station-South, Sunnyvale East Channel, North Richmond Pump Station, San Leandro Creek, Zone 4 Line A, and Lower Marsh Creek). This analysis showed that the potential for a false negative could occur due to a low number of sampled storms, especially in smaller and more urbanized watersheds where transport events can be more acute due to lack of channel storage. The analysis further highlighted the trade-off between gathering information at fewer sites with more certainty versus at more sites with less certainty. Based on these analyses, the SPLWG recommended a 1-storm composite per site design with allowances that a site could be revisited if the measured concentrations were lower than expected, either because a low-intensity storm was sampled or other information suggested that potential sources exist.

In addition to composite sampling, a pilot study was designed and implemented to test remote suspended sediment samplers based on enhanced water column settling. Four sampler types were considered: the single-stage siphon sampler, the CLAM sampler, the Hamlin sampler, and the Walling tube. The SPLWG recommended the single-stage siphon sampler be dropped because it allowed for collection of only a single stormwater sample at a single time point, and therefore offers no advantage over manual sampling but requires more effort and expense to deploy. The CLAM sampler was also dropped as it had limitations affecting the interpretation of the data; primarily its inability to estimate the volume of water passing through the filters and the lack of performance tests in high turbidity environments. As a result, the remaining two samplers (Hamlin sampler and Walling tube) were selected for the pilot study as previous studies showed the promise of using these devices in similar systems (Phillips et al., 2000; Lubliner, 2012). The SPLWG recommended piloting these samplers at 12 locations[15] where manual water composites would be collected in parallel to test the comparability between sampling methods.

[15] Note that so far due to climatic constraints, only 9 and 7 locations have been sampled with the Hamlin and Walling samplers, respectively. Additional samples using the Walling sampler are planned for WY 2018.

Appendix B – Quality assurance

The sections below report quality assurance reviews on WYs 2015, 2016, and 2017 data only. The data were reviewed using the quality assurance program plan (QAPP) developed for the San Francisco Bay Regional Monitoring Program for Water Quality (Yee et al., 2017). That QAPP describes how RMP data are reviewed for possible issues with hold times, sensitivity, blank contamination, precision, accuracy, comparison of dissolved and total phases, magnitude of concentrations versus concentrations from previous years, other similar local studies or studies described from elsewhere in peer-reviewed literature and PCB (or other organics) fingerprinting. Data handling procedures and acceptance criteria can differ among programs, however, for the RMP the underlying data were never discarded. Because the results for "censored" data were maintained, the effects of applying different QA protocols can be assessed by a future analyst if desired.

Suspended Sediment Concentration and Particle Size Distribution

In WY 2015, the SSC and particle size distribution (PSD)[16] data from USGS-PCMSC were acceptable, aside from failing hold-time targets. SSC samples were all analyzed outside of hold time (between 9 and 93 days after collection, exceeding the 7-day hold time specified in the RMP QAPP); hold times are not specified in the RMP QAPP for PSD. Minimum detection limits (MDLs) were generally sufficient, with <20% non-detects (NDs) reported for SSC and the more abundant Clay and Silt fractions. Extensive NDs (>50%) were generally reported for the sand fractions starting as fine as 0.125 mm and larger, with 100% NDs for the coarsest (Granule + Pebble/2.0 to <64 mm) fraction. Method blanks and spiked samples are not typically reported for SSC and PSD. Blind field replicates were used to evaluate precision in the absence of any other replicates. The relative standard deviation (RSD) for two field blind replicates of SSC were well below the 10% target. Particle size fractions had average RSDs ranging from 12% for Silt to 62% for Fine Sand. Although some individual fractions had average relative percent difference (RPD) or RSDs >40%, suspended sediments in runoff (and particle size distributions within that SSC) can be highly variable, even when collected by minutes, so results were flagged as estimated values rather than rejected. Fines (clay and silt) represented the largest proportion (~89% average) of the mass.

In 2016 samples, SSC and PSD was analyzed beyond the specified 7-day hold time (between 20 and 93 days after collection) and qualified for holding-time violation but not censored. No hold time is specified for grain-size analysis. Method detection limits were sufficient to have some reportable results for nearly all the finer fractions, with extensive NDs (> 50%) for many of the coarser fractions. No method blanks or spiked samples were analyzed/reported, common with SSC and PSD. Precision for PSD could not be evaluated as no replicates were analyzed for 2016. Precision of the SSC analysis was evaluated using the field blind replicates and the average RSD of 2.12% was well within the 10% target Method Quality Objective (MQO). PSD results were similar to other years, dominated by around 80% Fines.

[16] Particle size data were captured for % Clay (<0.0039 mm), % Silt (0.0039 to <0.0625 mm), % V. Fine Sand (0.0625 to <0.125 mm), % Fine Sand (0.125 to <0.25 mm), % Medium Sand (0.25 to <0.5 mm), % Coarse Sand (0.5 to <1.0 mm), % V. Coarse Sand (1.0 to <2.0 mm), and % Granule + Pebble (>2.0 mm). The raw data can be found in appendix B.

Average SSC for whole-water samples (excluding those from passive samplers) was in a reasonable range of a few hundred mg/L.

In 2017, method detection limits were sufficient to have at least one reportable result for all analyte/fraction combinations. Extensive non-detects (NDs > 50%) were reported for only Granule + Pebble/2.0 to <64 mm (90%). The analyte/fraction combinations Silt/0.0039 to <0.0625 mm; Sand/Medium 0.25 to <0.5 mm; Sand/Coarse 0.5 to <1.0 mm; Sand/V. Coarse 1.0 to <2.0 mm all had 20% (2 out of 10) non-detects. No method blanks were analyzed for grain size analysis. SSC was found in one of the five method blanks at a concentration of 1 mg/L. The average SSC concentration for the 3 method blanks in that batch was 0.33 mg/L < than the average method blank method detection limit of 0.5 mg/L. No blank contamination qualifiers were added. No spiked samples were analyzed/reported. Precision for grain size could not be evaluated as there was insufficient amount of sample for analysis of the field blind replicate. Precision of the SSC analysis was examined using the field blind replicates with the average RSD of 29.24% being well above the 10% target MQO, therefore they were flagged with the non-censoring qualifier "VIL" as an indication of possible uncertainty in precision.

Organic Carbon in Water

Reported TOC and DOC data from EBMUD and ALS were acceptable. In 2015, TOC samples were field acidified on collection, DOC samples were field or lab filtered as soon as practical (usually within a day) and acidified after, so were generally within the recommended 24-hour holding time. MDLs were sufficient with no NDs reported for any field samples. TOC was detected in only one method blank (0.026 mg/L), just above the MDL (0.024 mg/L), but the average blank concentration (0.013 mg/L) was still below the MDL, so results were not flagged. Matrix spike samples were used to evaluate accuracy, although many samples were not spiked high enough for adequate evaluation (must be at least two times the parent sample concentration). Recovery errors in the remaining DOC matrix spikes were all below the 10% target MQO. TOC errors in WY 2015 averaged 14%, above the 10% MQO, and TOC was therefore qualified but not censored. Laboratory replicate samples evaluated for precision had an average RSD of <2% for DOC and TOC, and 5.5% for POC, within the 10% target MQO. RSDs for field replicates were also within the target MQO of 10% (3% for DOC and 9% for TOC), so no precision qualifiers were needed.

POC and DOC were also analyzed by ALS in 2016. One POC sample was flagged for a holding time of 104 days (past the specified 100 days). All OC analytes were detected in all field samples and were not detected in method blanks, but DOC was detected in filter blanks at 1.6% of the average field sample and 5% of the lowest field sample. The average recovery error was 4% for POC evaluated in LCS samples, and 2% for DOC and TOC in matrix spikes, within the target MQO of 10%. Precision on POC LCS replicates averaged 5.5% RSD, and 2% for DOC and TOC field sample lab replicates, well within the 10% target MQO. No recovery or precision qualifiers were needed. The average 2016 POC was about three times higher than 2014 results. DOC and TOC were 55% and 117% of 2016 results, respectively.

In 2017, method detection limits were sufficient with no non-detects (NDs) reported except for method blanks. DOC and TOC were found in one method blank in one lab batch for both analytes. Four DOC and 8 TOC results were flagged with the non-censoring qualifier "VIP". TOC was found in the field blank and it's three lab replicates at an average concentration of 0.5375 mg/L which is 8.6% of the average concentration found in the field and lab replicate samples (6.24 mg/L). Accuracy was evaluated using the matrix spikes except for POC which was evaluated using the laboratory control samples. The average %error was less than the target MQO of 10% for all three analytes; DOC (5.2%), POC (1.96%), and TOC (6.5%). The laboratory control samples were also examined for DOC and TOC and the average %error was once again less than the 10% target MQO. No qualifying flags were needed. Precision was evaluated using the lab replicates with the average RSD being well below the 10% target MQO for all three analytes; DOC (1.85%), POC (0.97%), and TOC (1.89%). The average RSD for TOC including the blind field replicate and its lab replicates was 2.32% less than the target MQO of 10%. The laboratory control sample replicates were examined and the average RSD was once again well below the 10% target MQO. No qualifying flags were added.

PCBs in Water and Sediment

PCBs samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203). Water (whole water and dissolved) and sediment (separately analyzed particulate) PCB data from AXYS were acceptable. EPA 1668 methods for PCBs recommend analysis within a year, and all samples were analyzed well within that time (maximum 64 days). MDLs were sufficient with no NDs reported for any of the PCB congeners measured. Some blank contamination was detected in method blanks for about 20 of the more abundant congeners, with only two PCB 008 field sample results censored for blank contamination exceeding one-third the concentration of PCB 008 in those field samples. Many of the same congeners detected in the method blank also were detected in the field blank, but at concentrations <1% the average measured in the field samples and (per RMP data quality guidelines) always less than one-third the lowest measured field concentration in the batch. Three target analytes (part of the "RMP 40 congeners"), PCBs 105, 118, and 156, and numerous other congeners were reported in laboratory control samples (LCS) to evaluate accuracy, with good recovery (average error on target compounds always <16%, well within the target MQO of 35%). A laboratory control material (modified NIST 1493) was also reported, with average error 22% or better for all congeners. Average RSDs for congeners in the field replicate were all <18%, within the MQO target of 35%, and LCS RSDs were ~2% or better. PCB concentrations have not been analyzed in remote sediment sampler sediments for previous POC studies, so no inter-annual comparisons could be made. PCBs in water samples were similar to those measured in previous years (2012-2014), ranging from 0.25 to 3 times previous averages, depending on the congener. Ratios of congeners generally followed expected abundances in the environment.

AXYS analyzed PCBs in dissolved, particulate, and total fraction water samples for 2016. Numerous congeners had several NDs, but extensive NDs (>50%) were reported for only PCBs 099 and 201 (both 60% NDs). Some blank contamination was detected in method blanks, with results for some congeners in field samples censored due to concentrations that were less than 3 times higher than the highest concentration measured in a blank. This was especially true for dissolved-fraction field samples with low concentrations. Accuracy was evaluated using the laboratory control samples. Again, only three of the PCBs (PCB 105, PCB 118, and PCB 156) reported in the field samples were included in LCS samples (most being non-target congeners), with average recovery errors for those of <10%, well below the target MQO of 35%. Precision on LCS and blind field replicates was also good, with average RSDs <5% and <15%, respectively, well below the 35% target MQO. Average PCB concentrations in total fraction water samples were similar to those measured to previous years, but total fraction samples were around 1% of those measured in 2015, possibly due to differences in the stations sampled.

AXYS also analyzed PCBs in dissolved, particulate, and total fraction water samples for 2017. Numerous congeners had several NDs but none extensively. Some blank contamination was detected in method blanks, with results for some congeners in field samples censored due to concentrations that were less than 3 times higher than the highest concentration measured in a blank. This was especially true for dissolved-fraction field samples with low concentrations. Accuracy was evaluated using the laboratory control samples. Again, only three of the PCBs (PCB 105, PCB 118, and PCB 156) reported in the field samples were included in LCS samples (most being non-target congeners), with average recovery errors for those of <10%, well below the target MQO of 35%. Precision on LCS replicates was also good, with average RSDs <5%, well below the 35% target MQO.

Trace Elements in Water

Overall the 2015 water trace elements (As, Cd, Pb, Cu, Zn, Hg) data from Brooks Rand Labs (BRL) were acceptable. MDLs were sufficient with no NDs reported for any field samples. Arsenic was detected in one method blank, and mercury in four method blanks; the results were blank corrected, and blank variation was <MDL. No analytes were detected in the field blank. Recoveries in certified reference materials (CRMs) were good, averaging 2% error for mercury to 5% for zinc, all well below the target MQOs (35% for arsenic and mercury; 25% for all others). Matrix spike and LCS recovery errors all averaged below 10%, well within the accuracy MQOs. Precision was evaluated in laboratory replicates, except for mercury, which was evaluated in certified reference material replicates (no mercury lab replicates were analyzed). RSDs on lab replicates ranged from <1% for zinc to 4% for arsenic, well within target MQOs (35% for arsenic and mercury; 25% for all the other analytes). Mercury CRM replicate RSD was 1%, also well within the target MQO. Matrix spike and laboratory control sample replicates similarly had average RSDs well within their respective target MQOs. Even including the field heterogeneity from blind field replicates, precision MQOs were easily met. Average concentrations were up to 12 times higher than the average concentrations of 2012-2014 POC water samples, but whole water composite samples were in a similar range those measured in as previous years.

For 2016 the quality assurance for trace elements in water reported by Brooks Applied Lab (BRL's name post-merger) was good. Blank corrected results were reported for all elements (As, Cd, Ca, Cu, Hardness (as $CaCO_3$), Pb, Mg, Hg, Se, and Zn). MDLs were sufficient for the water samples with no NDs reported for Cd, Cu, Pb, Hg, and Zn. Around 20% NDs were reported for As, Ca, Hardness, and Mg, and 56% for Se. Mercury was detected in a filter blank, and in one of the three field blanks, but at concentrations <4% of the average in field samples and (per RMP data quality guidelines) always less than one-third the lowest measured field concentration in the batch. Accuracy on certified reference materials was good, with average %error for the CRMs ranging from 2 to 18%, well within target MQOs (25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Recovery errors on matrix spike and LCS results on these compounds was also good, with the average errors all below 9%, well within target MQOs. The average error of 4.8% on a Hardness LCS was within the target MQO of 5%. Precision was evaluated for field sample replicates, except for Hg, where matrix spike replicates were used. Average RSDs were all < 8%, and all below their relevant target MQOs (5% for Hardness; 25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Blind field replicates were also consistent, with average RSDs ranging from 1% to 17%, all within target MQOs. Precision on matrix spike and LCS replicates was also good. No qualifiers were added. Average concentrations in the 2016 water samples were in a similar range of POC samples from previous years (2003-2015), with averages ranging 0.1x to 2x previous years' averages.

In 2017, the data was overall good and all field samples were usable. Blank corrected results were reported for all elements (As, Cd, Ca, Cu, Hardness (as $CaCO_3$), Pb, Mg, Hg, Se, and Zn). MDLs were sufficient for the water samples with no NDs reported. The Hg was also not detected. Accuracy on certified reference materials was good, with average %error for the CRMs within 12%, well within target MQOs (25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se). Recovery errors on matrix spike and LCS results on these compounds were also all within target MQOs. Precision was evaluated for field sample replicates. Average RSDs were all < 8%, and all below their relevant target MQOs (5% for Hardness; 25% for Cd, Ca, Cu, Pb, Mg, Zn; 35% for As, Hg, and Se).

Trace Elements in Sediment

A single sediment sample was obtained in 2015 from fractionating one Hamlin sampler and analyzing for As, Cd, Pb, Cu, Zn, and Hg concentration on sediment. Overall the data were acceptable. MDLs were sufficient with no NDs for any analytes in field samples. Arsenic was detected in one method blank (0.08 mg/kg dw) just above the MDL (0.06 mg/kg dw), but results were blank corrected and the blank standard deviation was less than the MDL so results were not blank flagged. All other analytes were not detected in method blanks. CRM recoveries showed average errors ranging from 1% for copper to 24% for mercury, all within their target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike and LCS average recoveries were also within target MQOs when spiked at least 2 times the native concentrations. Laboratory replicate RSDs were good, averaging from <1% for zinc to 5% for arsenic, all well within the target MQOs (35% for arsenic and mercury; 25% for others). Matrix spike RSDs were all 5% or less, also well within target MQOs. Average results ranged from 1 to 14 times higher than the average concentrations for the RMP Status and Trend sediment samples (2009-2014). Results were reported for Mercury and Total Solids in one sediment sample analyzed in two laboratory batches. Other client samples (including lab replicates and Matrix Spike/Matrix Spike replicates), a certified reference material (CRM), and method blanks were also analyzed. Mercury results were reported blank corrected.

In 2016, a single sediment sample was obtained from a Hamlin sampler, which was analyzed for total Hg by BAL. MDLs were sufficient with no NDs reported, and no target analytes were detected in the method blanks. Accuracy for mercury was evaluated in a CRM sample (NRC MESS-4). The average recovery error for mercury was 13%, well within the target MQO of 35%. Precision was evaluated using the laboratory replicates of the other client samples concurrently analyzed by BAL. Average RSDs for Hg and Total

Solids were 3% and 0.14%, respectively, well below the 35% target MQO. Other client sample matrix spike replicates also had RSDs well below the target MQO, so no qualifiers were needed for recovery or precision issues. The Hg concentration was 30% lower than the 2015 POC sediment sample.

Appendix C – Figures 7 and 10 Supplementary Info

Table 11: Sample counts for data displayed in Figures 7 and 10 bar graphs. For samples with a count of 2 or more, the central tendency was used which was calculated as the sum of the pollutant water concentrations divided by the sum of the SSC data.

Catchment	Year Sampled	PCB Sample Count	HgT Sample Count
Belmont Creek	Prior to WY2015	3	4
Borel Creek	Prior to WY2015	3	5
Calabazas Creek	Prior to WY2015	5	5
Charcot Ave Storm Drain	WY2015	1	1
Condensa St SD	WY2016	1	1
Duane Ct and Ave Triangle SD	WY2016	1	1
E Outfall to San Tomas at Scott Blvd	WY2016	1	1
E. Gish Rd Storm Drain	WY2015	1	1
Ettie Street Pump Station	Prior to WY2015	4	4
Forbes Blvd Outfall	WY2016	1	1
Gateway Ave Storm Drain	WY2015	1	1
Glen Echo Creek	Prior to WY2015	4	4
Guadalupe River at Foxworthy Road/ Almaden Expressway	Prior to WY2015	14	46
Guadalupe River at Hwy 101	Prior to WY2015	119	261
Gull Dr Outfall	WY2016	1	1
Gull Dr SD	WY2016	1	1
Haig St SD	WY2016	1	1
Industrial Rd Ditch	WY2016	1	1
Lawrence & Central Expwys SD	WY2016	1	1
Line 13A at end of slough	WY2016	1	1
Line 3A-M-1 at Industrial Pump Station	WY2015	1	1
Line 4-B-1	WY2015	1	1
Line 9-D	WY2015	1	1
Line 9D1 PS at outfall to Line 9D	WY2016	1	1
Line-3A-M at 3A-D	WY2015	1	1
Line4-E	WY2015	1	1
Lower Coyote Creek	Prior to WY2015	5	6
Lower Marsh Creek	Prior to WY2015	28	31
Lower Penitencia Creek	WY2015	4	4
Meeker Slough	WY2015	1	1
North Richmond Pump Station	Prior to WY2015	38	38
Oddstad Pump Station	WY2015	1	1

Outfall at Gilman St.	WY2016	1	1
Outfall to Lower Silver Creek	WY2015	1	1
Pulgas Pump Station-North	Prior to WY2015	4	4
Pulgas Pump Station-South	Prior to WY2015	29	26
Ridder Park Dr Storm Drain	WY2015	1	1
Rock Springs Dr Storm Drain	WY2015	1	1
Runnymede Ditch	WY2015	1	1
San Leandro Creek	Prior to WY2015	39	38
San Lorenzo Creek	Prior to WY2015	5	6
San Pedro Storm Drain	Prior to WY2015		3
San Tomas Creek	Prior to WY2015	5	5
Santa Fe Channel	Prior to WY2015	5	5
Seabord Ave Storm Drain SC-050GAC580	WY2015	1	1
Seabord Ave Storm Drain SC-050GAC600	WY2015	1	1
South Linden Pump Station	WY2015	1	1
Stevens Creek	Prior to WY2015	6	6
Storm Drain near Cooley Landing	WY2015	1	1
Sunnyvale East Channel	Prior to WY2015	42	41
Taylor Way SD	WY2016	1	1
Tunnel Ave Ditch	WY2016	1	1
Valley Dr SD	WY2016	1	1
Veterans Pump Station	WY2015	1	1
Victor Nelo PS Outfall	WY2016	1	1
Walnut Creek	Prior to WY2015	6	5
Zone 12 Line A under Temescal Ck Park	WY2016	1	1
Zone 4 Line A	Prior to WY2015	69	94
Zone 5 Line M	Prior to WY2015	4	4
Line 12H at Coliseum Way	WY2017	1	1
Outfall to Colma Ck on service rd nr Littlefield Ave. (359)	WY2017	1	1
S Linden Ave SD (291)	WY2017	1	1
Austin Ck at Hwy 37	WY2017	1	1
Line 12I at Coliseum Way	WY2017	1	1
Kirker Ck at Pittsburg Antioch Hwy and Verne Roberts Cir	WY2017	1	1
Line 12M at Coliseum Way	WY2017	1	1
Line 12F below PG&E station	WY2017	1	1
Rosemary St SD 066GAC550C	WY2017	1	1
North Fourth St SD 066GAC550B	WY2017	1	1
Line 12K at Coliseum Entrance	WY2017	1	1

Colma Ck at S. Linden Blvd	WY2017	1	1
Line 12J at mouth to 12K	WY2017	1	1
S Spruce Ave SD at Mayfair Ave (296)	WY2017	1	1
Refugio Ck at Tsushima St	WY2017	1	1
Rodeo Creek at Seacliff Ct. Pedestrian Br.	WY2017	1	1
East Antioch nr Trembath	WY2017	1	1