Santa Clara Valley
Urban Runoff
Pollution Prevention Program

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March 31, 2017

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

Subject: SCVURPPP Urban Creeks Monitoring Report and Electronic Monitoring Data submittal for Water Year 2016

Dear Bruce:

On behalf of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), I am pleased to submit SCVURPPP's Urban Creeks Monitoring Report (UCMR) and Electronic Monitoring Data for water quality monitoring conducted in Water Year (WY) 2016 (October 1, 2014 through September 30, 2015).

The UCMR is submitted in compliance with provision C.8.h.iii of the 2015 Municipal Regional Stormwater Permit (MRP, NPDES # CAS612008, Order R2-2015-0049) and 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 several appendices.

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

Table 1. Project, date range, and applicable MRP provision for data included in the Electronic Status Monitoring Data Report.

Project	Date Range	MRP Provision
Creek Status Monitoring	April - September 2016	C.8.d
Stressor/Source Identification Study	April – September 2016	C.8.e
Pollutants of Concern Monitoring	February – June 2016	C.8.f
Pesticides and Toxicity Monitoring	July 2016	C.8.g

The quality of all Creek Status Monitoring (MRP provision C.8.d), Stressor/Source Investigation (MRP provision C.8.e), and Pesticides and Toxicity Monitoring (MRP provision C.8.g) data and the Pollutants of Concern (MRP provision C.8.f) nutrient data was evaluated consistent with the Bay Area Stormwater

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

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) QAPP. The quality of all data from the Pollutants of Concern Monitoring (MRP provision C.8.f) PCBs and mercury data was consistent with the Clean Watersheds for Clean Bay (CW4CB) QAPP.

In compliance with provision C.8.h.ii (Electronic Reporting) of the MRP, all CEDEN-acceptable data (i.e., data collected from receiving waters) were also 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.[2] 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 were not submitted to the Regional Data Center. For more details regarding the data types associated with CEDEN, see the BASMAA letter to the CEDEN Data Manager (dated March 20, 2017) which was cc’d to several of your staff.

Monitoring data included in this submittal suggest that ambient biological conditions in Santa Clara Basin 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 from stormwater agencies. A detailed analysis of the data is included in the UCMR.

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 SCVURPPP 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.”

Very truly yours,

Original signed by

Adam W. Olivieri, Dr. P.H., P.E.
Program Manager

CC: SCVURPPP Management Committee Members
Tom Mumley, Assistant Executive Officer, SF Bay Water Board
Chris Sommers, SCVURPPP Project Manager

Attachments: SCVURPPP UCMR Water 2016
Electronic Data Report (i.e., one compact disc) for Water Year 2016 Creek Status and Pesticides & Toxicity Monitoring Data (4 files), Stressor/Source Identification Data (3 files), and Pollutants of Concern Monitoring Data (2 files).

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[2] See footnote no. 1.

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 2016:

- The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) conducted a portion of the data collection in Water Year 2016 on behalf of Permittees, pursuant to MRP provision C.8.f – Pollutants of Concern Loads 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.

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Urban Creeks Monitoring Report

Water Quality Monitoring

Water Year 2016 (October 2015 – September 2016)

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

March 31, 2017

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 the MRP).[1] The RMC includes the following participants:

- Alameda Countywide Clean Water Program (ACCWP)
- Contra Costa Clean Water Program (CCCWP)
- San Mateo County Wide 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 Sanitation and Flood Control District (Vallejo)

This Urban Creeks Monitoring Report complies with MRP provision C.8.h.iii for reporting of all data in Water Year 2016 (October 1, 2015 through September 30, 2016). 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 Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) 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 Program 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) QAPP.[2] Data presented in this report were also submitted in electronic SWAMP-comparable formats by SCVURPPP to the Regional Water Board on behalf of SCVURPPP Co-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 QAPP 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
BASMAA	Bay Area Stormwater Management Agency Association
BASMAA BOD	BASMAA Board of Directors
BMP	Best Management Practice
CADDIS	Causal Analysis/Diagnosis Decision Information System
CCCWP	Contra Costa Clean Water Program
CEC	Chemicals of Emerging Concern
CEDEN	California Environmental Data Exchange Network
CFWG	Contaminant Fate Workgroup
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
ECWG	Emerging Contaminant Workgroup
EEWG	Exposure and Effects Workgroup
FSURMP	Fairfield Suisun Urban Runoff Management Program
FY	Fiscal Year
GIS	Geographic Information Systems
IBI	Index of Biological Integrity
IPM	Integrated Pest Management
IWRMP	Integrated Water Resources Master Plan
LID	Low Impact Development
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MWAT	Maximum Weekly Average Temperature
MYP	Multi-Year Monitoring Plan
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
PAHs	Polycyclic Aromatic Hydrocarbons
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PEC	Probable Effect Concentration
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFOS	Perfluorooctane Sulfonate
POC	Pollutant of Concern
POTW	Publicly Owned Treatment Works
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SFEI	San Francisco Estuary Institute
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Procedures
SPLWG	Sources, Pathways, and Loadings Workgroup
SPoT	Statewide Stream Pollutant Trend Monitoring
SSC	Suspended Sediment Concentration
SSID	Stressor/Source Identification
S&T	Status and Trends Monitoring Program
STLS	Small Tributary Loading Strategy

SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TMDL	Total Maximum Daily Load
TRC	Technical Review Committee
TU	Toxic Unit
UCMR	Urban Creeks Monitoring Report
USEPA	US Environmental Protection Agency
USGS	US Geological Survey
WMA	Watershed Management Area
WQ	Water Quality
WQO	Water Quality Objective
WY	Water Year

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TABLE E.1. WATER YEAR 2016 CREEK STATUS MONITORING STATIONS

In compliance with provision C.8.h.iii.(1), this table of all Creek Status Monitoring stations sampled by SCVURPPP in Water Year 2016 is provided immediately following the Table of Contents. See Section 3.0 for additional information on Creek Status Monitoring.

Map ID	Probabilistic Station Number	Targeted Station Number	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic Monitoring		Targeted Monitoring		
								Bioassessment, Nutrients, Chlorine, General WQ	Toxicity, Sediment Chemistry	Temp	Cont WQ	Pathogen Indicators
213	205R00213		Coyote Creek	Cow Creek	NU	37.264449	-121.650393	x				
305	205R00305		Coyote Creek	San Felipe Creek	NU	37.256256	-121.66266	x				
578	205R00578		Coyote Creek	Arroyo Aguague	NU	37.349247	-121.71812	x				
1114	205R01114		Guadalupe River	Guadalupe River	U	37.2845	-122.88231	x				
1731	205R01731	205COY117	Coyote Creek	Upper Penitencia Creek	U	37.392645	-121.834768	x		x	x	x
2330	205R02330		Guadalupe River	Ross Creek	U	37.2552	-121.90656	x				
2422	205R02422	205GUA329	Guadalupe River	Arroyo Calero	U	37.21059	-121.82717	x				x
2458	205R02458	205GUA262	Guadalupe River	Alamitos Creek	U	37.218965	-121.843211	x				x
2474	205R02474	205SAR075	San Tomas Aquino	Saratoga Creek	U	37.25819	-122.03437	x				x
2538	205R02538		San Tomas Aquino	Calabazas Creek	U	37.275375	-122.042246	x				
2547	205R02547		Stevens Creek	Stevens Creek	U	37.31243	-122.16309	x				
2563	205R02563		Guadalupe River	Los Gatos Creek	U	37.329237	-121.899601	x				
2602	205R02602		San Tomas Aquino	Tributary to San Tomas	U	37.23547	-122.00528	x				
2618	205R02618		Guadalupe River	Aldercroft Creek	U	37.17623	-121.98942	x				
2650	205R02650		Guadalupe River	Alamitos Creek	U	37.2215	-121.847003	x				
2659	205R02659		Stevens Creek	Stevens Creek	U	37.344735	-122.064166	x				
2730	205R02730		San Tomas Aquino	Saratoga Creek	U	37.28141	-122.00642	x				
2762	205R02762		Guadalupe River	Ross Creek	U	37.23593	-121.95184	x				
2771	205R02771		Coyote Creek	Lower Silver Creek	U	37.352282	-121.835429	x				
2835	205R02835	205COY135	Coyote Creek	Upper Penitencia Creek	U	37.396581	-121.803899	x		x		x
021		205STE021	Stevens Creek	Stevens Creek	U	37.41096	-122.06893		x			
010		205STQ010	San Tomas Aquino	San Thomas Aquino	U	37.38895	-121.96858		x			
025		205AAG025	Coyote Creek	Arroyo Aguague	NU	37.39711	-121.78570			x		
114		205COY114	Coyote Creek	Upper Penitencia Creek	U	37.39007	-121.84361			x	x	
121		205COY121	Coyote Creek	Upper Penitencia Creek	U	37.39530	-121.82668			x	x	
130		205COY130	Coyote Creek	Upper Penitencia Creek	U	37.39362	-121.81783			x	x	
140		205COY140	Coyote Creek	Upper Penitencia Creek	U	37.40113	-121.79541			x		
142		205COY142	Coyote Creek	Upper Penitencia Creek	U	37.40418	-121.79317			x		
145		205COY145	Coyote Creek	Upper Penitencia Creek	NU	37.40469	-121.79165			x		

U = Urban, NU = Non-urban

1.0 INTRODUCTION

This Urban Creeks Monitoring Report (UCMR) was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water 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 (i.e., Water Year 2016). 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 SCVURPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://water100.waterboards.ca.gov/ceden/sfei.shtml).

Chapters in this report are organized according to the following topics and MRP sub-provisions. Several of the topics are summarized briefly in this report but described fully in 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) (**Appendices 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 illustrates locations of monitoring stations associated with provision C.8 compliance in Water Year 2016 (WY 2016), including Creek Status Monitoring, the SSID project, Pesticides and Toxicity Monitoring, and POC Monitoring conducted by SCVURPPP and the Small Tributaries Loading Strategy (STLS). This figure illustrates the geographic extent of monitoring conducted in Santa Clara County in WY 2016.

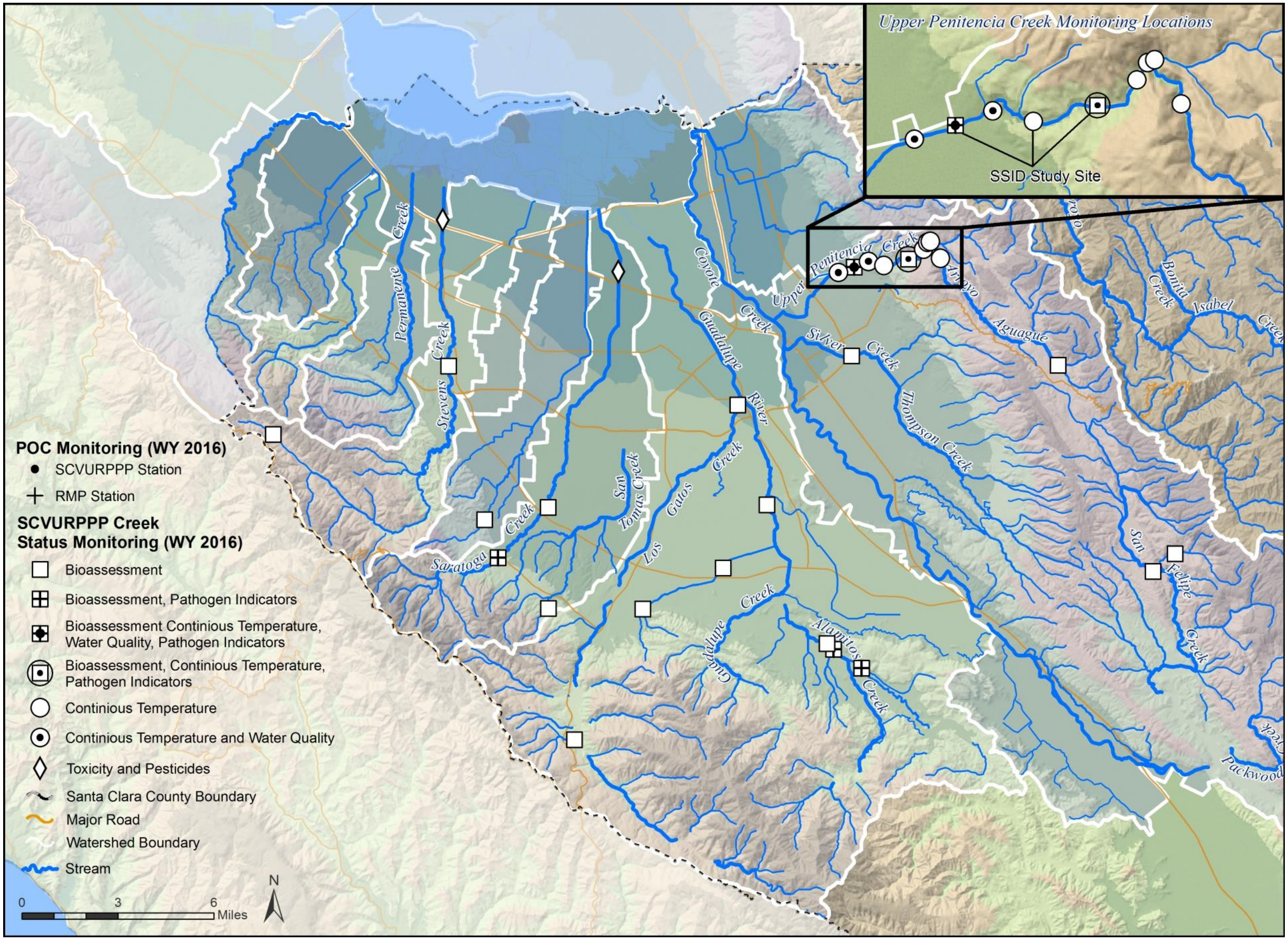

Figure 1.1. SCVURPPP Creek Status, Pollutant of Concern (POC), Pesticides and Toxicity, and Stressor/Source Identification (SSID) monitoring stations in WY 2016.

1.1 RMC Overview

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. In June 2010, Permittees notified the 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 Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). In a November 2, 2010 letter to the Permittees, the 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. 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 regional projects have already been identified and will be conducted in compliance with the 2015 MRP.

Regionally implemented activities are conducted under the auspices of BASMAA, a 501(c)(3) non-profit organization comprised of 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, approved by the BASMAA BOD. MRP Permittees, through their stormwater program representatives on the BASMAA BOD and its subcommittees, collaboratively authorize and participate in BASMAA regional projects or tasks. Regional project costs are 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 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 Sanitation and Flood Control District

1.2 Coordination with Third-party Monitoring Programs

SCVURPPP strives to work collaboratively with our 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 2016, SCVURPPP continued to coordinate with water quality monitoring programs conducted by third parties. These programs include the Regional Monitoring Program for Water Quality in San Francisco Bay's (RMP) 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 the STLS are reported in this document and were utilized to supplement SCVURPPP compliance with provision C.8 of the MRP, consistent with sub-provision C.8.a.iii.[3,4] Data are specifically referenced in section 5.0 (POC Monitoring) of this report.

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[3] Data reported by the RMP STLS are summarized in this report but were not included in the SCVURPPP electronic data submittal.

[4] In most years, the SPoT Program monitors two stations in Santa Clara County for constituents required by provision C.8.f of the MRP. In WY 2016, the stations were not sampled for those constituents.

2.0 SAN FRANCISCO ESTUARY RECEIVING WATER MONITORING (C.8.C)

As described in 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 the San Francisco Estuary (RMP). Since the adoption of the 2009 MRP, SCVURPPP has complied with this provision by making financial contributions to the RMP. Additionally, SCVURPPP staff actively participates 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 2016.

Now in its 24th year, the RMP is a long-term monitoring program that is discharger-funded and 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 stormwater (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 does not provide direct oversight of the RMP but does help identify stakeholder information needs, develop workplans that address these needs, and implement the workplans.

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 2016 Detailed Workplan and Budget*[5] 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. The *2016 RMP Update*[6] provides a concise overview of recent RMP activities and findings, and a look ahead to significant products anticipated in the next two years.

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 Technical Review Committee (TRC), in which SCVURPPP participates, continues to assess the efficacy and value of the various elements of the S&T Program and to recommend modifications to

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[5] http://www.sfei.org/sites/default/files/biblio_files/2016%20RMP%20Detailed%20Workplan%20and%20Budget%20FINAL.pdf

[6] http://www.sfei.org/sites/default/files/biblio_files/Update%202016_FINAL%20for%20web%20with%20covers.pdf

S&T Program activities based on ongoing findings. The current S&T sampling schedule is listed in Table 2.1.

Table 2.1. RMP Status and Trends Monitoring Schedule.

Program Element	Schedule	2016 Sampling
Water	Every two years	No
Bird Eggs	Every three years	Yes
Sediment	Every four years	No
Sport Fish	Every five years	No
Bivalves	Every two years	Yes
Support to the USGS for suspended sediment and nutrient monitoring	Every year	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 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 Steering Committee.

In 2016, Pilot and Special Studies focused on the following topics:

- Nutrients Management Strategy
    - Continuous monitoring of nutrients, phytoplankton biomass, and dissolved oxygen at moored sensors
    - Continuous monitoring of dissolved oxygen in shallow margin habitats
    - Nutrients monitoring program development
- Small Tributary Loadings Strategy (see below and Section 5.0 for more details)
- Chemicals of emerging concern (CEC) monitoring (perfluorochemicals, fipronil, and microplastics)
- Development of conceptual PCB models for prioritized Bay margin units
- Selenium in fish tissue monitoring
- Evaluation of toxicity testing protocols for marine sediments

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).

In WY 2016, a considerable amount of RMP and Stormwater Program staff time was spent 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 tributaries to the San Francisco Bay. Additional information on STLS-related studies is included in Section 5.0 (POC Loads Monitoring) of this report.

2.3 Participation in Committees, Workgroups and Strategy Teams

In WY 2016, SCVURPPP actively participated in the following RMP committees, workgroups, and strategy teams:

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

Committee, workgroup, and strategy team representation was provided by Permittee, Stormwater Program staff, and/or individuals designated by RMC participants and the BASMAA BOD. Representation included participating in meetings, reviewing technical reports and work products, co-authoring or reviewing articles included in the *2016 RMP Update*, 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 representatives (on behalf of Permittees) during BASMAA Monitoring and Pollutants of Concern Committee (MPC) and/or BASMAA BOD meetings to ensure that Permittees' interests were represented.

3.0 CREEK STATUS (C.8.D) AND PESTICIDES/TOXICITY MONITORING (C.8.G)

Creek status monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each 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 program to assess the status of beneficial uses in local creeks within its Program (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., SCVURPPP) 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. Twenty probabilistic sites were sampled by SCVURPPP in WY 2016.

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 eight sites using HOBO® temperature data loggers in the Upper Penitencia 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 three sites in the Upper Penitencia Creek watershed. Water samples for analysis of pathogen indicators (*E. coli* and enterococcus) were collected at five probabilistic sites that were located in parks.

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 MPR. In WY 2016, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two bottom-of-the-watershed stations. Consistent with provision C.8.g.iii, wet weather pesticides and toxicity monitoring will be conducted on a regional basis and will begin in WY 2018.

Creek Status and Pesticides and Toxicity monitoring stations are listed in Table E-1 and illustrated in Figure 1.1. Creek status monitoring data from WY 2016 were submitted to the Regional Water Board by SCVURPPP. The analyses of results from creek status monitoring conducted by SCVURPPP in WY 2016 are summarized below and presented in detail in **Appendix A**. The WY 2016 report includes stressor analysis of the five-year (i.e., WY 2012 – WY 2016) SCVURPPP dataset. Analysis of the five-year *regional* RMC dataset is anticipated to occur in Fiscal Year 2017/18.

3.1 Management Questions

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?*

The first MRP creek status management question 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 3.2. 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 ongoing and completed SSID projects).

The second MRP creek status 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 for the five-year (i.e., WY 2012 – WY 2016) SCVURPPP dataset were compared to physical habitat and water quality data collected synoptically with bioassessments to evaluate whether correlations exist that may explain the variation in biological condition scores.

3.2 Monitoring Results and Conclusions

3.2.1 Bioassessment Monitoring

Twenty sites were sampled for benthic macro-invertebrates (BMIs), benthic algae, physical habitat (PHab) observations, and nutrients. Stations were randomly selected using a probabilistic monitoring design. The following preliminary conclusions and recommendations are made based on these data.

Probabilistic Survey Design

- Site evaluations were conducted at a total of 76 potential probabilistic sites in Santa Clara County during WY 2016. Of these sites, a total of twenty were sampled in WY 2016 (rejection rate of 74%). Three of the twenty sites (15%) were classified as non-urban land use.
- Between WY 2012 and WY 2016, a total of 112 probabilistic sites were sampled by SCVURPPP (n=100) and SWAMP (n=12)[7] in Santa Clara County, including 87 urban and 25 non-urban sites.
- There is a sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for urban streams in Santa Clara County (in development). More samples are needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas).

Biological Condition Assessment (WY 2016)

- The California Stream Condition Index (CSCI) tool was used to assess the biological condition. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. Of the 20 sites monitored in WY 2016, five sites (25%) rated as likely intact or possibly intact (CSCI scores ≥ 0.795); five sites rated as likely altered condition (CSCI score 0.635 – 0.795), and ten sites rated as very likely altered condition (≤ 0.635).
- The 15 sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- Diatoms were relatively well represented across all sites ranging from 15 to 61 taxa. Soft algae taxa were less common across sites, ranging from 1 to 10 taxa. Seven of the sites (30%) had three or less soft algae taxa.
- Three algae IBI metrics were used to evaluate stream condition using benthic algae data collected synoptically with BMIs. These include D18 (diatoms), S2 (soft algae), and H20 (combination of diatoms and algae). Eight sites were ranked in good condition based on D18 scores (D18 ≥ 62). Two sites were ranked in good condition based on S2 scores (S2 ≥ 47) and one site was ranked in good condition based on H20 scores (H20 ≥ 63).

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[7] The data from three SWAMP samples collected in WY 2015 were not available for analyses in this report. Data results from nine probabilistic sites sampled by SWAMP are included in this report.

Biological Condition Assessment (WY 2012-WY 2016)

- CSCI scores were calculated for the five-year Santa Clara County probabilistic data set (n=112). Good biological condition scores (CSCI score > 0.795) occurred at 11% of the urban sites and 52% of non-urban sites.
- There was no significant difference in median CSCI scores between perennial (n=85) and non-perennial (n=27) sites. Median algal IBI scores were slightly higher at non-perennial sites.
- The CSCI and three algae IBI tools showed were relatively consistent in their response across an urban gradient, with generally lower median scores associated with higher percent imperviousness.
- CSCI scores were better correlated with site elevation ($r^2 = 0.34$) compared to D18 scores ($r^2 = 0.18$), suggesting that physical habitat variables associated with changing elevation (e.g., stream gradient, substrate size) have greater influence on the BMI community compared to diatom assemblages.
- It is unknown whether drought conditions that were present from WY 2012 through WY 2015 affected overall CSCI scores in Santa Clara County.

Stressor Assessment

- Potential stressors (nutrients, algal biomass indicators, conventional analytes) were measured in samples collected concurrently with bioassessments which are conducted in the spring season. Physical habitat parameters were also observed during bioassessments. Other potential stressors (e.g., percent urbanization/imperviousness in contributing catchments) were calculated in GIS.
- The association of potential stressors with biological condition scores collected over five years was assessed using the Spearman rank method and random forests. Land use variables (percent impervious and urban), chloride, temperature and specific conductivity showed significant negative correlations with CSCI scores. Two PHAB parameters (epifaunal substrate score and channel alteration score) were significantly positively correlated with CSCI scores.
- Water quality objectives were generally not exceeded in WY 2016.

Trend Assessment

- 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.

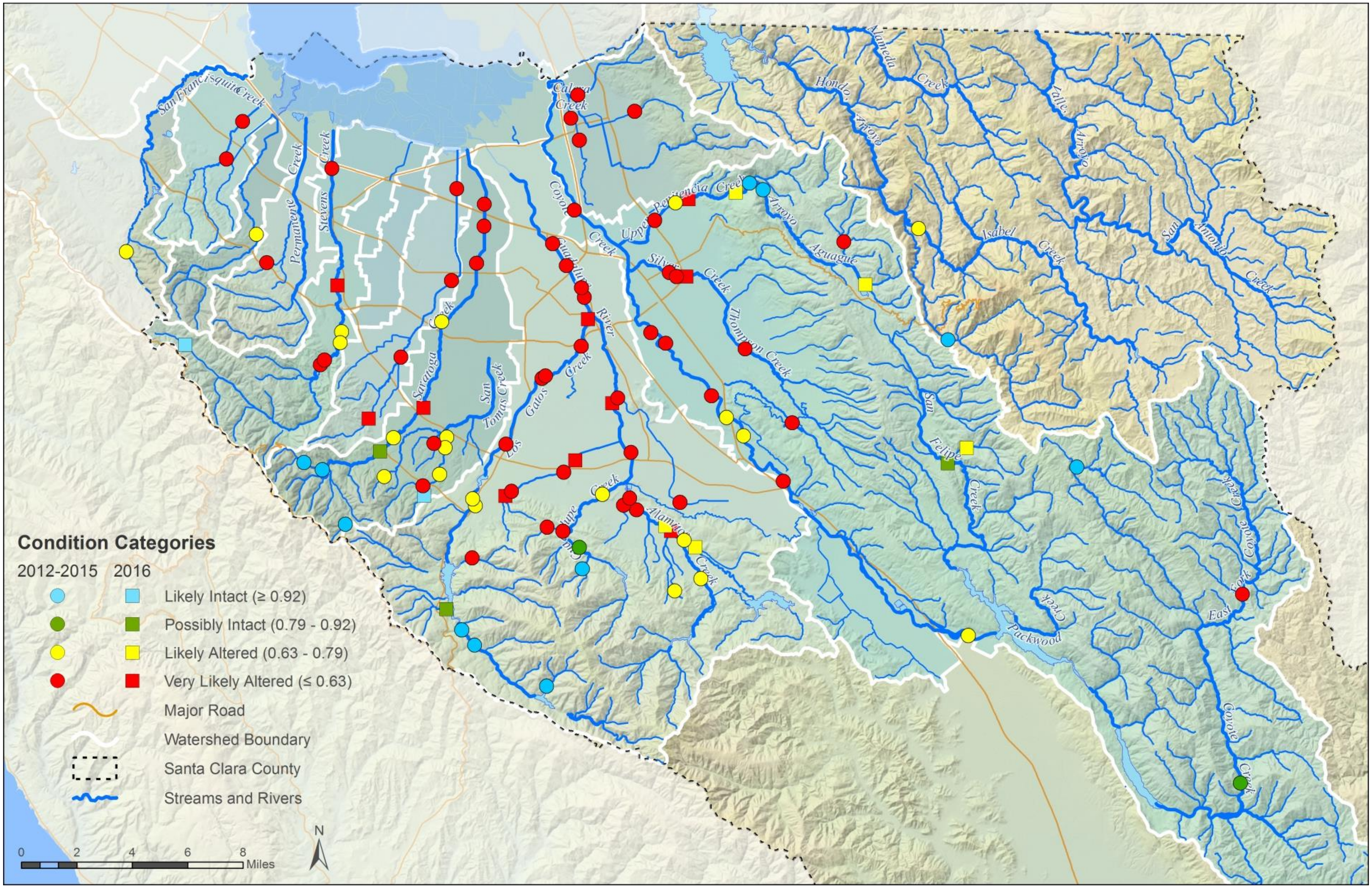

Figure 3.1. CSCI condition category for probabilistic sites sampled in Santa Clara County (n=112), WY 2012 – WY 2016.

3.2.2 Targeted Monitoring Results/Conclusions

Targeted monitoring in WY 2016 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at eight sites in the Upper Penitencia 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 Upper Penitencia Creek watershed during two 2-week periods in May (Event 1) and September (Event 2). Pathogen indicator grab samples were collected during a sampling event in June at five probabilistic sites throughout Santa Clara County that coincide with public parks. Stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2016 are listed below. The sections below are organized on the basis of three 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?*

Spatial and Temporal Variability in Water Quality

- Median water temperatures continuously measured in the Upper Penitencia Creek watershed were generally coolest at the four upper elevation sites in Alum Rock Park. Temperatures became elevated at the four lower elevation sites between May and September 2016. Water temperatures were highest at site 114 when it was influenced by discharge from upstream percolation ponds.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at eight targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, temperature) collected at three targeted stations.
- Five of the eight temperature stations in Upper Penitencia Creek exceeded the MRP trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of the ongoing drought and locally-derived temperature thresholds developed by NMFS suggests that temperature is not a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) beneficial uses (i.e., 7.0 mg/L) was met in all measurements recorded at the three water quality stations in Upper Penitencia Creek, with the exception of site 117, which had drops in DO that appeared to be related to significant drop in flow level during the dry season.
- Values for pH measured at the three sites in Upper Penitencia Creek during WY 2016 frequently exceeded the upper pH WQO of 8.5. As a result, all sites will be added to the list of potential SSID projects.
- Specific conductivity recorded at the three Upper Penitencia Creek sites in WY 2016 was consistently below the MRP trigger threshold of 2000 us/cm.

Potential Impacts to Water Contact Recreation

- Pathogen indicator densities were measured at five targeted sites during WY 2016. Although none of the stations could be considered “bathing beaches,” monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. MRP trigger thresholds for *E. coli* (410 cfu/100 ml) were not exceeded. MRP trigger thresholds for enterococcus (130 cfu/100 ml) were exceeded at two sites: one site on the Alamitos Creek at Leland High School and one on Upper Penitencia Creek at Alum Rock Park. These sites will be added to the list of candidate SSID projects.
- 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. Pathogen indicators observed at the WY 2016 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality objectives and criteria for full body contact recreation, may not be appropriate and should be interpreted cautiously.

3.2.3 Chlorine Monitoring Results/Conclusions

Monitoring of total and free chlorine residual at probabilistic stations was conducted in compliance with provision C.8.d.ii of the MRP. While chlorine residual is generally not a concern in Santa Clara Valley urban creeks, WY 2016 and prior monitoring results suggest there are occasional free chlorine and total chlorine exceedances in the County. The Program 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 2016, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two stations in compliance with provision C.8.g of the MRP. Statistically significant toxicity to *Chironomus dilutus* was observed either water or sediment samples collected from both sites during dry weather**;** however, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria. Although the midge, *Chironomus dilutus*, has been observed to be sensitive to fipronil, fipronil concentrations measured in sediment samples collected concurrently with the water and sediment toxicity samples were below the method detection limit.

Threshold effect concentration (TEC) and probable effect concentration (PEC) quotients were calculated for all metals and PAHs measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations 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 most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel.

SCVURPPP will continue to sample the same two stations for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SCVURPPP anticipates working with the BASMAA RMC partners on 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. 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 candidate SSID projects based on WY 2016 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 (including channel type and location with respect to reservoirs) 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 3.1. Summary of SCVURPPP trigger threshold exceedance analysis in WY 2016. “No” indicates samples were collected but did not exceed the MRP trigger; “Yes” indicates an exceedance of the MRP trigger.

Probabilistic Station Number	Targeted Station Number	Creek	Bioassessment [1]	Nutrients [2]	Chlorine	Water Toxicity	Sediment Toxicity	Sediment Chemistry	Continuous Temperature	Continuous WQ	Pathogen Indicators
205R00213		Cow Creek	Yes	No	No	--	--	--	--	--	--
205R00305		San Felipe Creek	No	No	No	--	--	--	--	--	--
205R00578		Arroyo Aguague	Yes	No	No	--	--	--	--	--	--
205R01114		Guadalupe River	Yes	No	No	--	--	--	--	--	--
205R01731	205COY117	Upper Penitencia Creek	Yes	No	No	--	--	--	--	Yes	No
205R02330		Ross Creek	Yes	No	No	--	--	--	--	--	--
205R02422	205GUA329	Arroyo Calero	Yes	No	No	--	--	--	--	--	No
205R02458	205GUA262	Alamitos Creek	Yes	No	No	--	--	--	--	--	Yes
205R02474	205SAR075	Saratoga Creek	No	No	No	--	--	--	--	--	No
205R02538		Calabazas Creek	Yes	No	No	--	--	--	--	--	--
205R02547		Stevens Creek	No	No	No	--	--	--	--	--	--
205R02563		Los Gatos Creek	Yes	No	No	--	--	--	--	--	--
205R02602		Tributary to San Tomas	No	No	No	--	--	--	--	--	--
205R02618		Aldercroft Creek	No	No	No	--	--	--	--	--	--
205R02650		Alamitos Creek	Yes	No	No	--	--	--	--	--	--
205R02659		Stevens Creek	Yes	No	No	--	--	--	--	--	--
205R02730		Saratoga Creek	Yes	No	No	--	--	--	--	--	--
205R02762		Ross Creek	Yes	No	No	--	--	--	--	--	--
205R02771		Lower Silver Creek	Yes	No	Yes	--	--	--	--	--	--
205R02835	205COY135	Upper Penitencia Creek	Yes	No	No	--	--	--	Yes	--	Yes
	205STE021	Stevens Creek	--	--	--	No	No	Yes	--	--	--
	205STQ010	San Thomas Aquino	--	--	--	No	No	Yes	--	--	--
	205AAG025	Arroyo Aguague	--	--	--	--	--	--	Yes	--	--
	205COY114	Upper Penitencia Creek	--	--	--	--	--	--	Yes	No	--
	205COY121	Upper Penitencia Creek	--	--	--	--	--	--	Yes	Yes	--
	205COY130	Upper Penitencia Creek	--	--	--	--	--	--	Yes	--	--
	205COY140	Upper Penitencia Creek	--	--	--	--	--	--	No	--	--
	205COY142	Upper Penitencia Creek	--	--	--	--	--	--	No	--	--
	205COY145	Upper Penitencia Creek	--	--	--	--	--	--	No	--	--

Notes:

1. CSCI score ≥ 0.795.
2. Unionized ammonia (as N) ≥ 0.025 mg/L, nitrate (as N) ≥ 10 mg/L, chloride > 250 mg/L.

3.4 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 the Santa Clara Valley and identifying stressors and sources of impacts observed. Although the sample size from WY 2016 (overall n=20; urban n=17) 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 2015 and is analyzed with the full five-year dataset (n=112). 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. Additionally, episodic or site specific increases temperature (particularly in lower creek reaches) may not be optimal for aquatic life in local creeks.

The Program and its Co-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, the Program and Co-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 Co-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) Co-permittees continue to implement programs 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 2016 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 2016 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, the Santa Clara Valley Water District's Integrated Water Resources Master Plan (IWRMP) or "One Water Plan" is an ongoing, multi-year process to develop a framework for long-term management of Santa Clara county water resources. The One Water Plan will identify, prioritize and implement activities at a watershed scale to meet flood protection, water supply, water quality and environmental stewardship goals and objectives. The Santa Clara Valley Water District was also recently awarded a Proposition 1 grant to develop a Storm Water Resource Plan for the Santa Clara Basin that will support the development and implementation of MRP-required Green Infrastructure Plans and produce a list of prioritized runoff capture and use projects eligible for future State implementation grant funds. Through the continued implementation of MRP-associated and other watershed stewardship programs, SCVURPPP 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.

In recognition of SCVURPPP's accomplishments, the Water Environment Federation (WEF) awarded SCVURPPP the Overall Highest Score for a Phase 1 Municipal Stormwater Program and Gold Level for Innovation and Program Management. The awards are part of the National Municipal Stormwater and Green Infrastructure Awards program, led by WEF through a cooperative agreement with the U.S. Environmental Protection Agency (USEPA). The awards program was established in 2015 to recognize high-performing regulated MS4s throughout the United States. The objective of the program is to inspire MS4 program leaders to seek new and innovative ways to meet and exceed regulatory requirements in a manner that is both technically effective as well as financially efficient.

4.0 STRESSOR/SOURCE IDENTIFICATION (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 2016 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 Stressor/Source Identification (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. SCVURPPP and its RMC partners must collectively initiate a region-wide minimum of eight new SSID Projects during the term of the current permit. All SSID project reports must be summarized in a unified, regional-level report. The regional SSID report is attached to this UCMR as **Appendix B.**

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 MRP describes the stepwise process for conducting SSID projects:

- 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. 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 (SCCWRP 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 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.

SCVURPPP has not yet initiated an SSID project during the current MRP, but due to delays associated with the 2012-16 drought is still implementing one SSID project that was initiated during the previous MRP term. The Upper Penitencia Creek SSID Project is described in the section below.

4.1 Upper Penitencia Creek SSID Project

In WY 2013, SCVURPPP initiated the Upper Penitencia Creek SSID Project by developing a work plan to investigate low creek condition scores (e.g., CSCI, SoCal B-IBI) and temperature trigger exceedances. Over the next two years, field work could not be conducted due to severe drought conditions resulting in a lack of flow in the study reach during the bioassessment index period. In WY 2016, biological assessments and water and sediment quality monitoring were conducted at two locations in Upper Penitencia Creek. The monitoring design followed the CADDIS framework developed by the USEPA (2010). Monitoring parameters were selected to evaluate range of potential stressors to biological condition at two locations. One site (the “test site”) is potentially affected by percolation ponds discharges and the second site (the “comparator site”) is located about one mile upstream test site above the discharge outfall. Results from the Upper Penitencia Creek SSID Study are presented in **Appendix C**.

Based on results of the WY 2016 monitoring, the reduced biological integrity observed in Upper Penitencia creek is believed to be associated with the lack of stream flow in the segment where the reduced condition was observed. This segment has historically dried up during the spring/summer season due to percolation of surface flow into the underlying groundwater basin. The biological conditions of this loss of flow are reflected in the aquatic biota that has adapted to abrupt, seasonal changes in flow and water quality conditions. The natural seasonal changes in habitat have further been magnified by anthropogenic activities associated with periodic water operations. However, the sources of stressors identified as causing poor biological condition in the study area cannot be mitigated through stormwater management.

Based on the conclusions drawn to-date, steps #1 and #2 of the SSID process outlined in the MRP are now complete. Although no enhanced or improved municipal stormwater management actions are warranted, in an effort to evaluate and inform future actions that may improve biological conditions in Upper Penitencia, SCVURPPP is moving forward with follow-up actions consistent with Step #3 (i.e., conduct follow-up actions based on SSID investigation findings) in the SSID process. The follow-up actions will include an evaluation of current management practices associated with water quality and water flows in Upper Penitencia creek and the development of recommendations that should be considered by partner regulatory agencies to protect the biological condition of the stream in the future. A control measure evaluation and recommendations report will be completed in FY 2017-18 and submitted with the SCVURPPP Water Year 2017 UCMR. Once this report is submitted, the Upper Penitenica SSID project will be complete.

5.0 POLLUTANTS OF CONCERN MONITORING

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 action plans (TMDLs) and other pollutant control strategies, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for these pollutants. 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.

Provision C.8.f of the MRP requires POC monitoring of polychlorinated biphenyls (PCBs), mercury, copper, emerging contaminants, and nutrients.[8] The MRP defines yearly and total (i.e., 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. Progress toward POC monitoring requirements accomplished in WY 2016 and the planned allocation of effort for WY 2017 is described in the SCVURPPP POC Monitoring Report (SCVURPPP 2016) that was submitted to the Regional Water Board on October 15, 2016 in compliance with provision C.8.h.iv of the MRP.

In WY 2016, SCVURPPP complied with Provision C.8.f of the MRP through the following activities:

- Implementation of a catchment-scale storm sampling program for PCBs, mercury, and copper analysis;
- Collection of dry weather samples for nutrients analysis; and
- Continued participation in the RMP Small Tributaries Loading Strategy Team (STLS).[9]

POC monitoring in WY 2016 focused primarily on identification of source areas of PCBs and mercury to the MS4 and San Francisco Bay. WY 2016 data continued to assist SCVURPPP implement a process to identify and prioritize watershed management areas (WMAs) in the Santa Clara Valley. This process is generally consistent with the efforts underway by other RMC partners. WMAs are priority watersheds or catchments in the urban landscape where control measures for PCBs and mercury are currently being implemented or will be implemented during the MRP permit term, to the extent that feasible and cost-effective controls can be identified.

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[8] Emerging contaminant monitoring requirements will be met through participation in RMP special studies. The special study 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.

[9] SCVURPPP strives to work collaboratively with our 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. Samples collected in Santa Clara County through the RMP are used to supplement the Program's efforts towards achieving provision C.8.f monitoring requirements.

A report describing the results of all POC monitoring conducted by SCVURPPP is included as **Appendix D** to this report and a report describing the results of POC monitoring conducted by the STLS is included as **Appendix E**.

5.1 SCVURPPP POC Monitoring

In compliance with provision C.8.f of the MRP, the Program conducted POC monitoring in WY 2016 for PCBs, mercury, copper, and nutrients. The MRP-required yearly minimum number of samples was met or exceeded for all POCs. Results are summarized in the sections below.

5.1.1 PCBs and Mercury

PCBs, mercury, and copper monitoring by the Program in WY 2016 was conducted in accordance with the Water Year 2016 Pollutant of Concern Monitoring - Sampling and Analysis Plan (SCVURPPP 2015). The primary goal of the monitoring, as described in the Sampling and Analysis Plan (SAP), is to provide information to identify WMAs where control measures could be implemented to comply with MRP requirements for load reductions of PCBs and mercury. WY 2016 PCBs and mercury monitoring was focused on collection of storm composite samples from high interest WMAs that may contain PCB and/or mercury source properties. High interest WMAs were identified and prioritized for sampling by evaluating several types of data, including: PCBs and mercury concentrations from prior sediment and water sampling efforts, land use data showing old industrial parcels, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), catchment areas delineated from municipal storm drain data, and logistical/safety considerations (SCVURPPP 2015).

During WY 2016, the Program collected nine[10] samples for PCBs and mercury analysis. 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 “RMP 40” PCB congeners (method EPA 1668C), total mercury (method EPA 1631E), and suspended sediment concentration (SSC; method ASTM D3977-97).

In summary, WY 2016 results included:

- Total PCB concentrations, calculated as the sum of the “RMP 40” congeners, ranged from 0.584 ng/L to 9.04 ng/L; and PCB particle ratios, calculated by dividing total PCB concentrations by SSC, ranged from 30.1 ng/g to 367 ng/g.
- Mercury concentrations ranged from 4.0 ng/L to 35.7 ng/L and mercury particle ratios ranged from 128 ng/g to 962 ng/g.

Results were relatively low compared to other samples collected throughout the region, including samples collected by the RMP STLS in WY 2015 and WY 2016. Because no samples were above preliminary thresholds set to identify catchments that likely have PCB sources, no WMAs were identified as “Known High Interest Source Areas” based on WY 2016 data. SCVURPPP plans to continue working with other Bay Area countywide stormwater programs (through the BASMAA MPC Committee) and the RMP STLS to evaluate the results of the ongoing efforts in the Bay Area to identify PCBs and mercury source areas and plan next steps in Santa Clara County. Figure 5.1 illustrated those WMAs (i.e., catchments) that have been identified as high interest source areas (9) or are confirmed to contain source properties (2).

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[10] The Program had planned to collect up to 25 samples in WY 2016; however, a lack of rainfall in the study area relative to the rest of the Bay Area limited monitoring opportunities. The industrial areas of Santa Clara County are located in the rain shadow of the Santa Cruz Mountains.

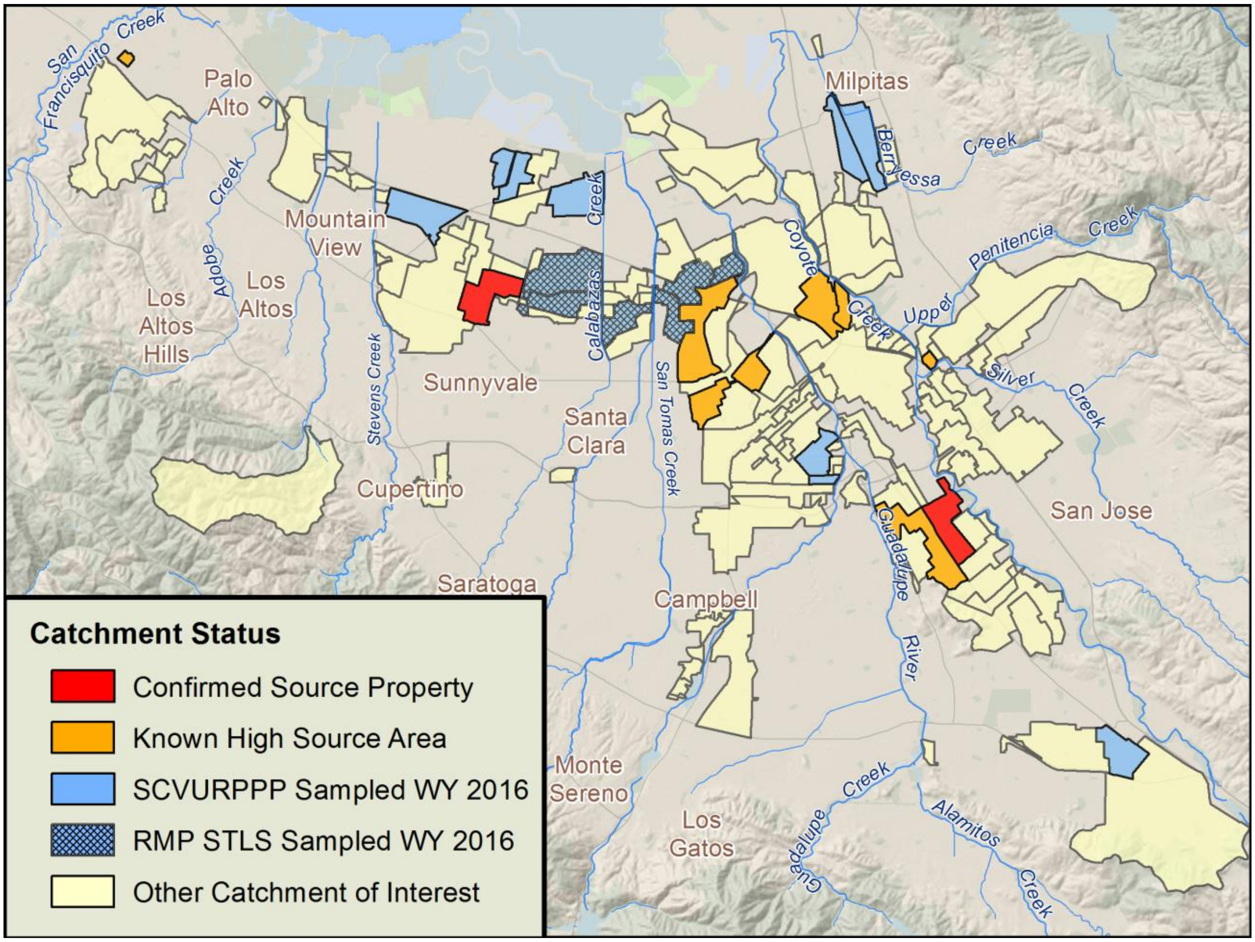

Figure 5.1. WMA map of Santa Clara County, showing catchments sampled in WY 2016.

5.1.2 Copper

A subset (four of nine) of the wet weather samples collected by SCVURPPP in WY 2016 were analyzed for total and dissolved copper and hardness to characterize copper concentrations in stormwater runoff from highly urban catchments. Two samples were collected in the MS4 and two in local small creeks. Dissolved copper concentrations in creek samples were compared to hardness-dependent acute water quality objectives (WQOs). Neither sample exceeded the copper WQO.

5.1.3 Nutrients

Two samples, collected synoptically with bioassessment monitoring in Upper Penitencia Creek as part of the SSID study were analyzed for the suite of nutrients required in the MRP (i.e., ammonium[11], nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus). No applicable WQOs were exceeded.

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[11] 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.

5.1.4 Recommendations for WY 2017 POC Monitoring

As described in **Appendix D**, the Program identified the following recommendations for POC monitoring in WY 2017 and beyond:

- SCVURPPP and the RMP's STLS will continue to conduct PCB and mercury monitoring with the goal of identifying WMAs and specific source properties where new PCB and mercury control measures can be implemented during the permit term.

- At least eight samples that address Management Question #3 (Management Action Effectiveness) must be collected by the end of year four of the permit. SCVURPPP is currently working with BASMAA to develop a regional project to design a Monitoring Plan for POC Management Action Effectiveness. The goal is to finalize the Monitoring Plan/study design in WY 2017 and implement the plan in WY 2018. A major consideration for the regional Management Action Effectiveness Monitoring Plan and other future monitoring efforts will be collection of data in support of conducting the Reasonable Assurance Analysis (RAA) that is required by Provision C.12.c.iii.(3) of the MRP and which must be submitted with the 2020 Annual Report (September 30, 2020).

- At least eight samples that address Management Question #5 (Trends) must be collected by the end of year four of the permit. SCVURPPP will continue to participate in the STLS Trends Strategy Team to 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. The preliminary design concept includes additional monitoring at one or two of the region-wide loadings stations to gain a better understanding of the variability in PCBs concentrations/loadings in the existing dataset. The variability of PCB concentrations in stormwater runoff will predict the number and frequency of samples needed to depict given load reductions over given periods of time. STLS Trends Strategy monitoring could begin as early as WY 2017 and will likely continue through the Permit term, however, the monitoring design is still being developed.

- SCVURPPP will continue to work with the SPoT Program to address Management Question #5 (Trends). The *SPoT Monitoring Program* conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Program is to investigate long-term trends in water quality (Management Question #5 – Trends). Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including two stations in Santa Clara County (Coyote Creek and Guadalupe River). In most years, sediments are analyzed for PCBs, mercury, toxicity, pesticides, and organic pollutants (Phillips et al. 2014). In WY 2016, SPoT monitoring in Santa Clara County did not include PCBs or mercury; however, those constituents are anticipated for WY 2017.

- A subset of the wet weather PCB and mercury samples collected in WMAs with suspected sources will continue to be analyzed for total and dissolved copper in WY 2017.

- Nutrient samples will be collected from mixed land use watersheds. Nutrient monitoring efforts should be increased above the minimum number of yearly samples in order to make more progress towards the total number of samples required by the end of year five of the MRP.

- SCVURPPP will continue to participate in the RMP and the RMP's CEC Strategy.

5.2 Small Tributaries Loading Strategy

The RMP Small Tributaries Loading Strategy was developed in 2009 by the STLS Team, which included 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 2011, with concurrence of participating Regional Water Board staff, a framework (i.e., the STLS Multi-Year Plan) was developed presenting an alternative approach to the POC loads monitoring requirements described in provision C.8.e.i of the 2009 MRP, as allowed by provision C.8.e. The most recent published version (Version 2013a) of the STLS Multi-Year Plan (MYP) was submitted with the Regional Urban Creeks Monitoring Report in March 2013 (BASMAA 2013). The STLS MYP is integrated with other RMP-funded activities (see Section 2.0) and is a major component of the RMP MYP. Version 2013a of the STLS MYP includes two main elements that collectively address the four priority management questions for POC monitoring described in the 2009 MRP:

- Development and improvement of the Regional Watershed Spreadsheet Model (RWSM) as a tool for estimating regional loads of POCs to the Bay, and
- Watershed monitoring at six fixed stations.

Based on the lessons learned through the implementation of the STLS MYP in WY 2012, WY 2013, and WY 2014, and the reprioritization of management information needs in the 2015 MRP, SCVURPPP and its RMC partners implemented a revised approach to POC Loads monitoring in WY 2015[12]. The revised monitoring approach was discussed at numerous STLS workgroup meetings during WY2014[13] and was agreed upon by STLS members, including Water Board staff, as the best approach to addressing near-term high priority information needs regarding PCB and mercury sources and loadings. The revised alternative approach initiated in WY 2015 discontinues most POC loads monitoring stations sampled in previous Water Years, adds wet weather characterization monitoring, and maintains support of the RWSM. The sections below describe the tasks implemented by the RMP STLS in WY 2016.

5.2.1 Wet Weather Characterization

With a goal of identifying watershed sources of PCBs and mercury, STLS field monitoring in WY 2016 continued to focus on collection of storm composite samples in the downstream reaches of catchments located throughout the region. In WY 2016, 17 catchments ranging in size from 0.23 km^2 to 17.47 km^2 and representing engineered MS4 drainage areas were sampled during storm events. The storm composite water samples were analyzed for concentrations of PCBs, total mercury, other metals (arsenic, cadmium, lead, copper, zinc), total organic carbon, dissolved organic carbon, suspended sediment concentration, and grain size distribution. 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 and WY 2016 monitoring is included in **Appendix E** (Pollutants of concern reconnaissance monitoring final progress report, water years 2015 and 2016).

In WY 2016 six catchments were targeted in Santa Clara County based on recommendations by Program staff evaluating land uses in the County that have the highest likelihood of generating PCBs in stormwater runoff. All of the six Santa Clara County sampling stations were located at manholes accessing the MS4 or MS4 outlets to receiving waters. One of the stations was sampled twice in WY 2016.

Wet weather characterization monitoring by the RMP STLS is planned to continue in WY 2017.

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[12] The BASMAA Phase I stormwater managers discussed the approach with the Assistant Executive Officer of the SF Bay Regional Water Quality Control Board at the August 28, 2014 monthly meeting and amended the RMC to reflect the modification.

[13] Discussions about revised POC loads monitoring approaches for FY 13-14 (Water Year 2015) were discussed and ultimately agreed upon by Water Board staff and other STLS and RMC partners at the following STLS meetings: October 13, 2013; March 19, 2014; April 1, 2014; April 16, 2014; May 15, 2014; and June 9, 2014.

Preliminary Findings

The RMP STLS now has a growing database of 62 stations that have been sampled during wet weather 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, WY 2015 and WY 2016 stations were primarily located in small catchments draining primarily old industrial land uses. Acknowledging that dynamic climatic conditions and individual storm characteristics may affect data interpretation, a number of conclusions have been identified:

- While PCB particle ratios appear to positively correlate with impervious cover and old industrial land use, they inversely correlate with watershed area and other trace metals analyzed (As, Cu, Cd, Pb, and Zn).

- Mercury concentrations have a positive but weaker relationship with impervious cover and old industrial land use. This is consistent with the understanding that atmospheric deposition plays a role in mercury source areas.

- Many areas of interest in terms of identifying PCBs and mercury source areas are located within close proximity to the Bay, in tidal zones that are often very difficult to sample due to lack of public right-of-way.

- The PCB and mercury load allocations from the TMDLs of 2 and 80 kg respectively translate to mean annual concentrations of 1.33 ng/L (PCBs) and 53 ng/L (mercury) and mean annual particle ratios of 1.4 ng/g (PCBs) and 0.058 ug/g (mercury) (assuming certain annual average flow and suspended sediment loads). None of the concentrations or particle ratios measured at the 62 stations sampled to date (including those in natural creeks) approach these estimated goals.

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 at the wet weather characterization monitoring stations in WY 2016 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 were not collected in receiving waters; instead, they 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 or not 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/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 at POC stations in WY 2016, WQOs or criteria have only been promulgated for total mercury and total cadmium. WQOs for other metals analyzed are expressed in terms of the dissolved fraction of the metal in the water column for which data are not available. Furthermore, the WQO for cadmium is based on hardness, which was not measured in the WY 2016 samples. Therefore, the comparison of data collected in WY 2016 to applicable numeric WQOs or criteria adopted by the Regional Water Board is limited to total mercury.

All samples collected in Santa Clara County in WY 2016 were well below the freshwater acute objective for mercury of 2.4 µg/L. Total mercury concentrations ranged from 0.06 µg/L to 0.016 µg/L. See **Appendix E** for a list of RMP STLS sampling results.

5.2.2 Regional Watershed Spreadsheet Model

The STLS Team and SPLWG continued to provide oversight in WY 2016 to the development and refinement 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. The RWSM is being developed by SFEI on behalf of the RMP, with funding from both the RMP and BASMAA regional projects.

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 cheap tool for 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, and also require large calibration datasets which take money and time to collect.

Development of a spreadsheet model to estimate POC loads from small tributaries to the Bay has been underway since 2010 when a water-based copper model was completed. Because PCBs and mercury are more closely related to sediments, a draft model for suspended sediments was developed. However, resulting loads estimates for PCBs and mercury appeared to be too high leading to the conclusion that accuracy and precision at small (e.g., watershed) scales is challenged by the regional nature of the calibration process and the simplicity of the model. In WY 2016, the water-based model for PCBs and mercury was improved with new approaches to calibration which reflect the growing wet weather characterization dataset and the greater understanding of regional hydrology. The improved RWSM can be used for estimating regional scale annual average loads and could be useful for comparing relative loading between sub-regions and more polluted versus less polluted watersheds.

During WY 2016, SCVURPPP reviewed and provided input on documents describing the RWSM and/or its loadings estimates (e.g., the annotated PowerPoint presentation). SCVURPPP also participated in the SPLWG which is the main venue for soliciting input from interested parties and technical advisors.

In WY 2017, the RWSM calibration will continue to be improved with data from the WY 2016 wet weather characterization monitoring and BASMAA studies. Improvements to the land use GIS layer will also help refine the model. 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 2016, the STLS Trends Strategy team continued to meet. The STLS Trends Strategy was developed based on recommendations from the SPLWG 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. Initially comprised of SFEI staff, RMC participants, and Regional Water Board staff, the STLS Trends Strategy team expanded in WY 2016 to include additional interested parties (e.g., EPA) and technical advisors (e.g., USGS).

In WY 2016, the STLS Trends Strategy team drafted the Trends Strategy document and Technical Appendix. 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., PCB concentrations and particle-ratios) 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 presents an evaluation of variability and statistical power for detecting trends based on POC loading station PCBs data. It recommends sample size and revisit frequency needed to detect declining trends in PCBs in 25 years with > 80% statistical power. Results of the statistical analyses were presented to USGS technical advisors with expertise in trends analysis of water data.

In WY 2017, the Trends Strategy team will continue to explore POC loading station data in an effort to model PCB concentrations and loads. Results of the analysis will inform the design of the long-term monitoring program for trends. It is likely that additional data will be collected from two POC loading stations (e.g., Guadalupe River in Santa Clara County and Zone 4 Line 7 in Alameda County) to fill data gaps the baseline dataset and increase understanding of variability.

5.2.4 Guadalupe River Loading Station Contingency Monitoring

POC loads monitoring activities have been conducted for nearly a decade on the Guadalupe River near the Highway 101 overpass. These efforts have 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. 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 did not occur in WY 2016, but the Program was prepared to institute contingency monitoring in WY 2016 to sample water at the Highway 101 station in the event of a qualifying storm. This same approach will be followed in WY 2017.

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 the 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 Co-permittees, SCVURPPP conducts creek water quality monitoring and monitoring projects in the Santa Clara Valley (Lower South Bay) in collaboration with the Regional Monitoring Coalition (RMC), and actively participates in the San Francisco Bay Regional Monitoring Program (RMP), which focuses on assessing Bay water quality and associated impacts.

In WY 2017, SCVURPPP will continue to comply with water quality monitoring requirements of the MRP. The following list of next steps will be implemented in WY 2017:

- SCVURPPP will continue to collaborate with the RMC (MRP provision C.8.a).
- Where applicable, monitoring data collected and reported by SCVURPPP will continue to be SWAMP comparable (MRP provision C.8.b).
- SCVURPPP will continue to provide financial contributions towards the RMP and to actively participate in the RMP committees and work groups described in Sections 2.0 and 5.0 (MRP provision C.8.c).
- SCVURPPP will continue to conduct probabilistic and targeted Creek Status Monitoring consistent with the specific requirements in the MRP (MRP provision C.8.d).
- SCVURPPP will continue to implement dry weather Pesticides and Toxicity Monitoring and will work with RMC partners to develop and begin implementation of a wet weather Pesticides and Toxicity Monitoring program consistent with MRP provision C.8.g.
- SCVURPPP will continue to review monitoring results and maintain a list of all results exceeding trigger thresholds (MRP provision C.8.e.i). SCVURPPP will coordinate with the RMC to initiate a region wide goal of four new SSID projects by the third year of the permit (MRP provision C.8.e.iii). This will include initiation (i.e., development of a work plan) of at least one new SSID project by SCVURPPP in calendar year 2017.
- SCVURPPP 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, advancement of the STLS Trends Strategy, and contingency monitoring at the Guadalupe River loading stations
- SCVURPPP will implement a POC monitoring framework to comply with provision C.8.f of the MRP. The monitoring framework will address 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 2017 monitoring will include collection of wet weather composite water samples from catchments and collection of dry weather sediment samples from the public right-of-way to identify areas where PCB and mercury control measures may be implemented. WY 2017 monitoring will also include sampling for nutrients and copper.
- WY 2017 POC monitoring accomplishments and allocation of sampling efforts for POC monitoring in WY 2018 will be submitted in the Pollutants of Concern Monitoring Report that is due to the Water Board by October 15, 2017 (MRP provision C.8.h.iv).
- Results of WY 2017 monitoring will be described in the Programs WY 2017 Urban Creeks Monitoring Report that is due to the Water Board by March 31, 2018 (MRP provision C.8.h.iii).

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Appendix A

SCVURPPP Creek Status Monitoring Report, Water Year 2016

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Creek Status Monitoring Report

Water Year 2016 (October 2015 – September 2016)

Submitted in compliance with Provision C.8.h.iii of NPDES Permit No. CAS612008,
Order No. R2-2015-049

March 31, 2017

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 the 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 Sanitation and Flood Control 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 2016 (October 1, 2015 through September 30, 2016). 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 Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) using probabilistic and targeted monitoring designs as described herein.

Consistent with the Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), monitoring data were collected in accordance with the most recent versions of the BASMAA RMC Quality Assurance Program 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) QAPP[2]. Data presented in this report were submitted in electronic SWAMP-comparable formats by SCVURPPP to the Regional Water Board on behalf of SCVURPPP Co-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 QAPP 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
CAP	Conservation Action Planning
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
COLD	Cold Freshwater Habitat
CSCI	California Stream Condition Index
DO	Dissolved Oxygen
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information Systems
GRTS	Generalized Random Tessellation Stratified
HDI	Human Disturbance Index
IBI	Indices of Biotic Integrity
IWRMP	Integrated Water Resources Management Plan
LID	Low Impact Development
MPC	Monitoring and Pollutants of Concern Committee
MRP	Municipal Regional Permit
MWAT	Maximum Weekly Average Temperature
MWMT	Maximum Weekly Maximum Temperature
NMFS	National Marine and Fisheries Services
NPDES	National Pollution Discharge Elimination System
O/E	Observed to Expected
PAH	Polycyclic Aromatic Hydrocarbons
PEC	Probable Effects Concentrations
PHAB	Physical habitat assessments
pMMI	Predictive Multi-Metric Index
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWB	Reachwide Benthos
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
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
TST	Test of Significant Toxicity
TU	Toxicity Unit
WARM	Warm Freshwater Habitat
USEPA	Environmental Protection Agency
WQ	Water Quality
WQO	Water Quality Objective
WY	Water Year

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1.0 INTRODUCTION

This Creek Status Monitoring Report was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program), on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water 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 Creek Status and Pesticides & Toxicity monitoring data collected during the foregoing October 1 – September 30 (i.e., Water Year 2016).[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 SCVURPPP and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) (http://water100.waterboards.ca.gov/ceden/sfei.shtml).

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?*

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 SCVURPPP between 2002 and 2009. 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 2015 were submitted in prior reports (SCVURPPP 2016, SCVURPPP 2015, SCVURPPP 2014, SCVURPPP 2013).

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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 SCVURPPP Urban Creeks Monitoring Report (UCMR) for WY 2016 to which this Creek Status Monitoring Report is appended.

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.[4] 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.

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 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 Sanitation and Flood Control District

The goals of the RMC are to:

1. Assist Permittees in complying with requirements in provision C.8 (Water Quality Monitoring) of the MRP;
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., Regional 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

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[4] 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.

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). Table 1.2 provides a list of which parameters are included in the probabilistic and targeted programs. This report includes data collected in Santa Clara 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 2.0 provision 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

1.3 Monitoring and Data Assessment Methods

1.3.1 Monitoring Methods

Water quality data were collected in accordance with 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 California Surface Water Ambient Monitoring Program (SWAMP) QAPP[5], 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.

1.3.2 Laboratory Analysis Methods

RMC participants, including SCVURPPP, agreed to use the same laboratories for individual parameters (excepting 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

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

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
- San Jose-Santa Clara Regional Wastewater Facility – Pathogen indicators

1.3.3 Data Analysis Methods

Water and sediment chemistry and toxicity data generated during WY 2016 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 and 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. Followup SSID projects will be selected from this list.

1.4 Setting

1.4.1 Watersheds Monitored by SCVURPPP

There are 13 major watersheds within the SCVURPPP jurisdictional boundaries and these watersheds comprise most of the Santa Clara Basin. The watersheds are mapped in Figure 1.1 and their major characteristics are listed in Table 1.3. The Santa Clara Basin, San Francisco Bay south of the Dumbarton Bridge, and the 840 square miles that drain to it, are bounded by the Diablo Mountains on the east and the Santa Cruz Mountains on the west and south. Elevations range from sea level at the Bay to almost 4,000 feet in the Santa Cruz Mountains. There is a distinct transition in geography and land use at elevations of 600 to 800 feet. Areas above this elevation generally have steeper slopes and are largely forest, rangeland, or open space; below this threshold, an urbanized landscape dominates. Most watersheds have their headwaters in the undeveloped mountains and drain north through urbanized areas to the Bay. Flows in the lower reaches of most watersheds are controlled by the presence of water supply reservoirs that are managed by the Santa Clara Valley Water District (SCVWD) and other agencies. Many of the reservoirs are constructed at the transition between the Santa Clara Valley and the surrounding foothills. Water is captured during the winter rainy season and released in the spring at managed rates to allow for percolation through the stream bed and to protect fish habitat downstream of the reservoirs. To varying degrees, portions of all watersheds within the urban zone have been engineered or placed within underground culverts. The Sunnyvale East and West Channel watersheds contain no natural creek bed at all; they were constructed in the 1960s to manage flooding.

Table 1.3. Characteristics of major watersheds within SCVURPPP boundary.

Watershed	Area (square miles)	Number of Tributary Creeks	Natural Creek Bed (Miles)	Engineered Channel (Miles)	Underground Culvert or Stormdrain (Miles)	Impervious Area	Land Use				
							Residential	Industrial/ Commercial	Forest	Rangeland	Other
Adobe	11.0	7	18.8	2.3	12.0	44.7%	46.5%	11.8%	36.3%	2.7%	2.7%
Barron	15.6	5	15.1	7.9	28.6	60.3%	60.5%	20.1%	7.3%	7.0%	5.1%
Calabazas	20.3	6	12.9	14.1	55.5	NA	54.5%	29.4%	8.8%	5.2%	2.1%
Coyote	321	53	670	36.4	146	11.1%	8.6%	3.7%	49.9%	29.6%	8.2%
Guadalupe	171	50	207	45.5	265	37.1%	29.6%	13.6%	34.7%	15.5%	6.6%
Lower Penitencia	28.6	13	29.2	20.8	61.6	42.9%	30.7%	19.0%	1.1%	38.7%	10.5%
Matadero	14.0	3	18	NA	NA	60.3%	57.1%	5.8%	8.9%	8.2%	20%
Permanente	17.3	7	NA	NA	NA	43.9%	46.3%	13.1%	35.0%	2.8%	2.8%
San Francisquito	42.8	25	90.6	4.8	15.3	20.8%	29.6%	5.2%	44.7%	15.0%	5.5%
San Tomas Aquino	44.8	15	50.5	15.5	79.3	60.1%	53.9%	18.8%	23.7%	0.8%	2.8%
Stevens	29.2	12	54.2	1.1	30.0	28.6%	24.5%	9.0%	49.2%	12.5%	4.8%
Sunnyvale East	7.1	0	0	6.2	26.6	82.2%	65.3%	31.8%	0%	0%	2.9%
Sunnyvale West	7.6	0	0	6.7	18.7	72.4%	20.9%	65.2%	0%	0%	13.9%

Source: http://www.scvurppp-w2k.com/watersheds.shtml
NA – not available

WY 2016 Creek Status and Pesticides and Toxicity Monitoring Stations

The complete list of probabilistic and targeted monitoring sites samples by SCVURPPP in WY 2016 in compliance with Provisions C.8.d (Creek Status Monitoring) and C.8.g (Pesticides and Toxicity Monitoring) is presented in Table 1.4. Monitoring locations with monitoring parameter(s) are mapped in Figure 1.2. Probabilistic station numbers, generated from the RMC Sample Frame, are provided for all bioassessment locations. Targeted stations numbers, based on SWAMP station numbering methods (BASMAA 2016b), are provided for all targeted monitoring sites. In some cases, targeted sites occurred within the probabilistic site (150 meter reach), and both station numbers are provided.

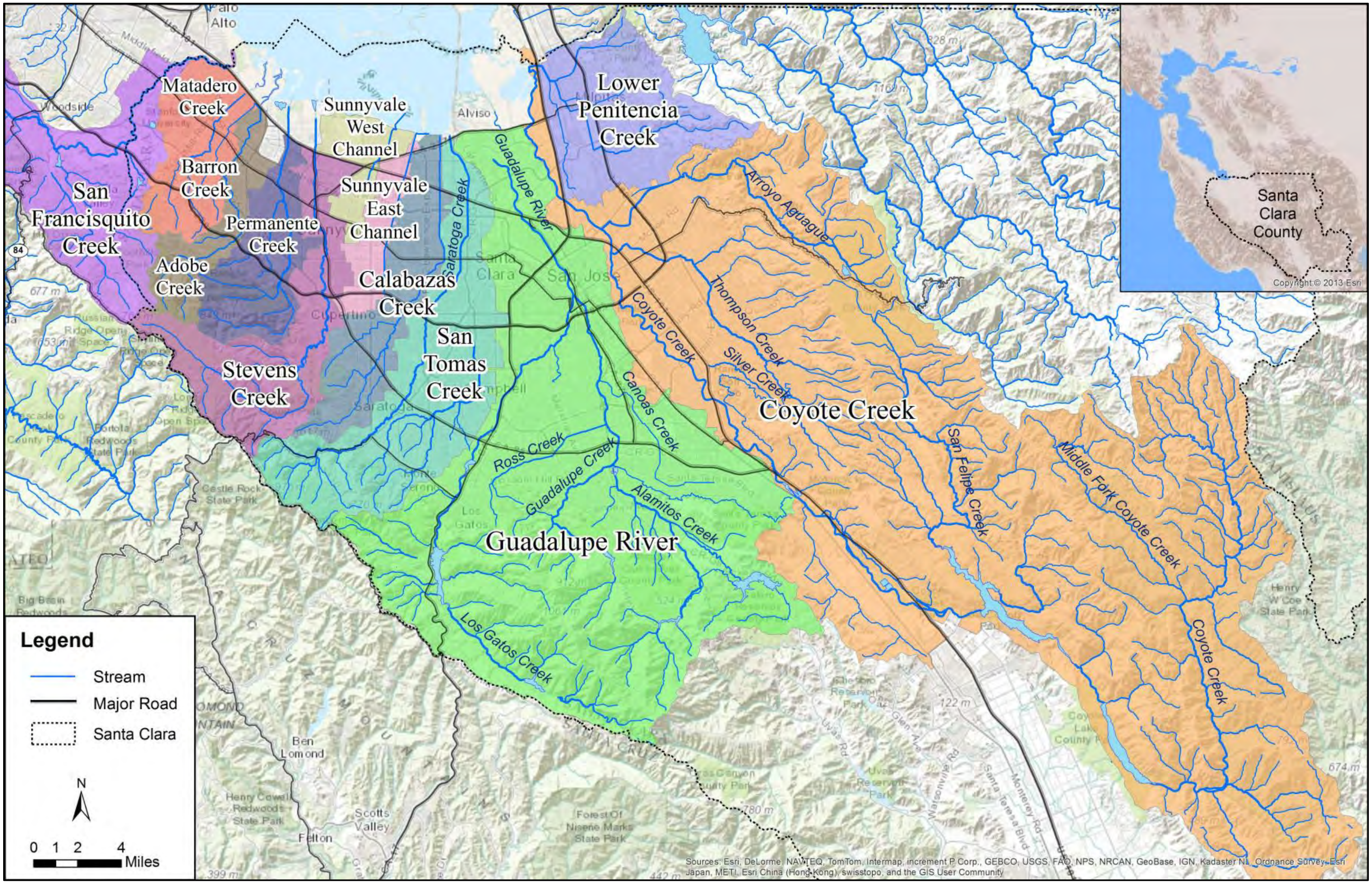

Figure 1.1. Watersheds within SCVURPPP jurisdictional boundaries.

Table 1.4. Sites and parameters monitored in WY 2016 in Santa Clara County. In cases where targeted sites occurred within a bioassessment sample reach, the geographic coordinates for the bioassessment site is indicated. Coordinates for all targeted sites are provided in method section for those parameters.

Map ID	Probabilistic Station Number	Targeted Station Number	Watershed	Creek Name	Land Use	Latitude	Longitude	Probabilistic Monitoring		Targeted Monitoring		
								Bioassess, Nutrients, Chlorine, General WQ	Toxicity, Sediment Chemistry	Temp	Cont WQ	Pathogen Indicators
213	205R00213		Coyote Creek	Cow Creek	NU	37.264449	-121.650393	x				
305	205R00305		Coyote Creek	San Felipe Creek	NU	37.256256	-121.66266	x				
578	205R00578		Coyote Creek	Arroyo Aguague	NU	37.349247	-121.71812	x				
1114	205R01114		Guadalupe River	Guadalupe River	U	37.2845	-122.88231	x				
1731	205R01731	205COY117	Coyote Creek	Upper Penitencia Creek	U	37.392645	-121.834768	x		x	x	x
2330	205R02330		Guadalupe River	Ross Creek	U	37.2552	-121.90656	x				
2422	205R02422	205GUA329	Guadalupe River	Arroyo Calero	U	37.21059	-121.82717	x				x
2458	205R02458	205GUA262	Guadalupe River	Alamitos Creek	U	37.218965	-121.843211	x				x
2474	205R02474	205SAR075	San Tomas Aquino	Saratoga Creek	U	37.25819	-122.03437	x				x
2538	205R02538		San Tomas Aquino	Calabazas Creek	U	37.275375	-122.042246	x				
2547	205R02547		Stevens Creek	Stevens Creek	U	37.31243	-122.16309	x				
2563	205R02563		Guadalupe River	Los Gatos Creek	U	37.329237	-121.899601	x				
2602	205R02602		San Tomas Aquino	Tributary to San Tomas	U	37.23547	-122.00528	x				
2618	205R02618		Guadalupe River	Aldercroft Creek	U	37.17623	-121.98942	x				
2650	205R02650		Guadalupe River	Alamitos Creek	U	37.2215	-121.847003	x				
2659	205R02659		Stevens Creek	Stevens Creek	U	37.344735	-122.064166	x				
2730	205R02730		San Tomas Aquino	Saratoga Creek	U	37.28141	-122.00642	x				
2762	205R02762		Guadalupe River	Ross Creek	U	37.23593	-121.95184	x				
2771	205R02771		Coyote Creek	Lower Silver Creek	U	37.352282	-121.835429	x				
2835	205R02835	205COY135	Coyote Creek	Upper Penitencia Creek	U	37.396581	-121.803899	x		x		x
021		205STE021	Stevens Creek	Stevens Creek	U	37.41096	-122.06893		x			
010		205STQ010	San Tomas Aquino	San Thomas Aquino	U	37.38895	-121.96858		x			
025		205AAG025	Coyote Creek	Arroyo Aguague	NU	37.39711	-121.78570			x		
114		205COY114	Coyote Creek	Upper Penitencia Creek	U	37.39007	-121.84361			x	x	
121		205COY121	Coyote Creek	Upper Penitencia Creek	U	37.39530	-121.82668			x	x	
130		205COY130	Coyote Creek	Upper Penitencia Creek	U	37.39362	-121.81783			x	x	
140		205COY140	Coyote Creek	Upper Penitencia Creek	U	37.40113	-121.79541			x		
142		205COY142	Coyote Creek	Upper Penitencia Creek	U	37.40418	-121.79317			x		
145		205COY145	Coyote Creek	Upper Penitencia Creek	NU	37.40469	-121.79165			x		

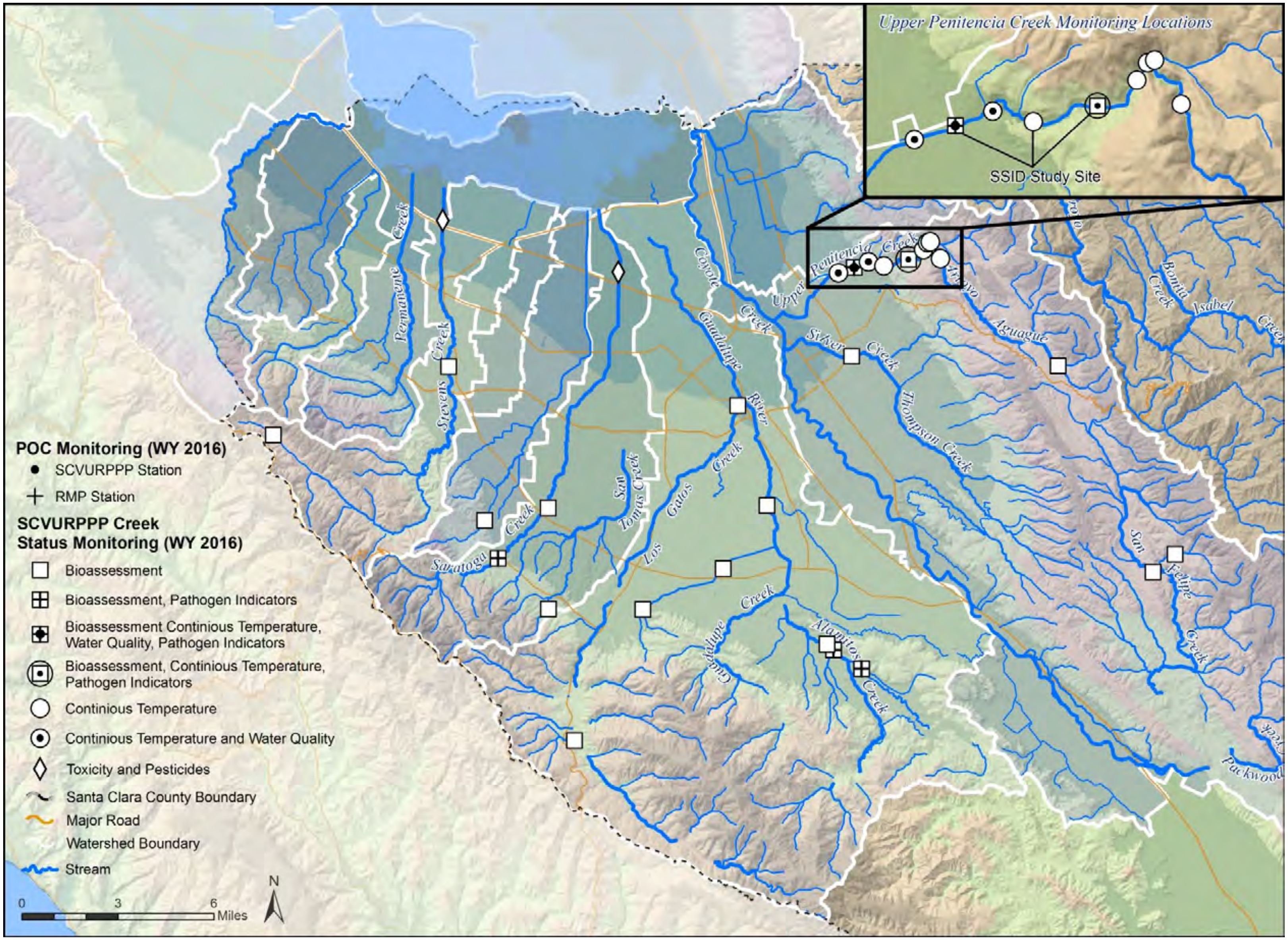

Figure 1.2. Map of SCVURPPP Program Area, major creeks, and sites monitored in WY 2016.

1.4.2 Designated Beneficial Uses

Beneficial Uses in Santa Clara Valley creeks are designated by the SFRWQCB for specific water bodies. Uses include aquatic life, recreation, human consumption, and habitat. Table 1.5 lists Beneficial Uses designated by the SFRWQCB (2013) for water bodies monitored by SCVURPPP in WY 2016.

Table 1.5. Creeks monitored by SCVURPPP in WY 2016 and their Beneficial Uses (SFRWQCB 2013).

Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
Alamitos Creek			E	E					E			E	E	E	E	E	E	E	
Aldercroft Creek[1]																			
Arroyo Aguague									E			E	E	E	E	E	E	E	
Arroyo Calero			E						E			E	E	E	E	E	E	E	
Calabazas Creek	E			E					E						E	E	E	E	
Cow Creek[1]																			
Guadalupe River				E					E			E	E	E	E	E	E	E	
Los Gatos Creek		E	E	E					E			E	E	E	E	E	E	E	
Lower Silver Creek															E	E	E	E	
Ross Creek				E											E	E	E	E	
San Felipe Creek			E						E					E	E	E	E	E	
San Tomas Aquino									E				E		E	E	E	E	
Saratoga Creek	E		E	E					E						E	E	E	E	
Stevens Creek			E	E					E			E	E	E	E	E	E	E	
Tributary to San Tomas Aquino Creek[1]									E				E		E	E	E	E	
Upper Penitencia Creek			E	E					E			E	E	E	E	E	E	E	

[1] No Beneficial Uses listed specifically for waterbody.

Notes:

COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water

EST = Estuarine (the Basin Plan assigns this beneficial use to slough portions of Plummer Creek; for this evaluation WARM is presumed applicable to freshwater portions)

NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
REC-2 = Non-contact Recreation

WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
P = Potential Use
E = Existing Use
L = Limited Use.
* = "Water quality objectives apply; water contact recreation is prohibited or limited to protect public health" (SFRWQCB 2013).

1.4.3 Climate

The Santa Clara Valley experiences a Mediterranean-type climate with cool, wet winters and hot, dry summers. The wet season typically extends from November through March with local long-term, mean annual precipitation ranging from 15 inches near the Bay to over 55 inches along the highest ridges in the Santa Cruz Mountains (PRISM Climate Group 30-year normals, 1981-2010[6]). Figure 1.3 illustrates the geographic variability of mean annual precipitation in the area. It is important to understand that mean annual precipitation depths are statistically calculated or modeled; actual measured precipitation in a given year rarely equals the statistical average. Extended periods of drought and wet conditions are

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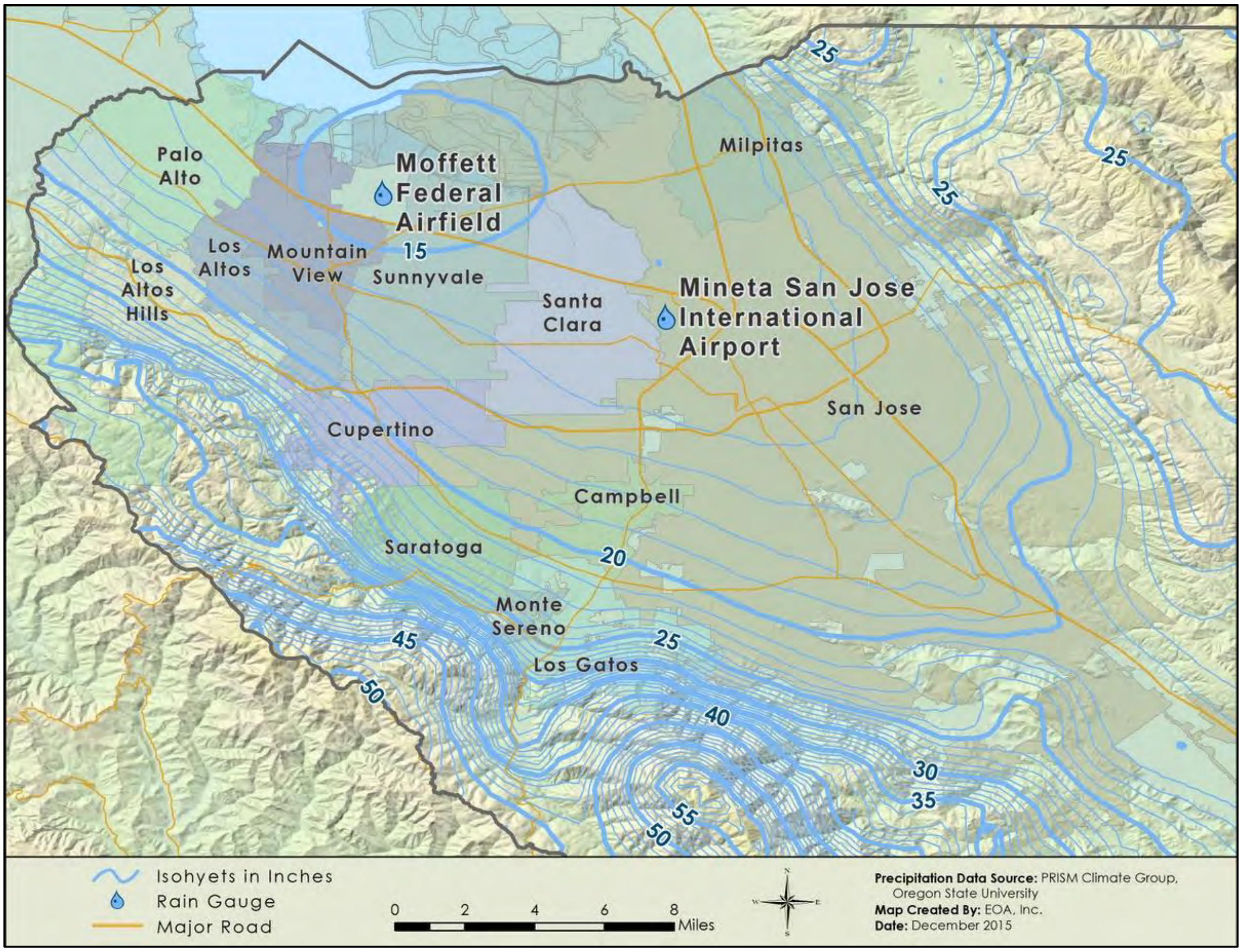
[6] http://www.prism.oregonstate.edu/normals/

common with episodic events exerting a great influence on hydrology and ecology. Figure 1.4 illustrates the temporal variability in annual precipitation measured at the Mineta San Jose International Airport. Creek Status Monitoring in compliance with the MRP began in WY 2012 which was the first year of an ongoing severe drought on a statewide and local basis. Some climate scientists suggest the current drought began as early as WY 2006, punctuated by two slightly above average years in WY 2009 and WY 2010 (UCLA Water Resources Group[7]). Although measured precipitation in WY 2015 and WY 2016 at the San Jose Airport was near or above average, it did not necessarily signal the end of the drought for the region.



Precipitation Data Source: PRISM Climate Group, Oregon State University
Map Created By: EOA, Inc.
Date: December 2015

Figure 1.3. Average annual precipitation in Santa Clara Valley, modeled by the PRISM Climate Group for the period of 1981-2010.

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[7] http://www.environment.ucla.edu/water/drought

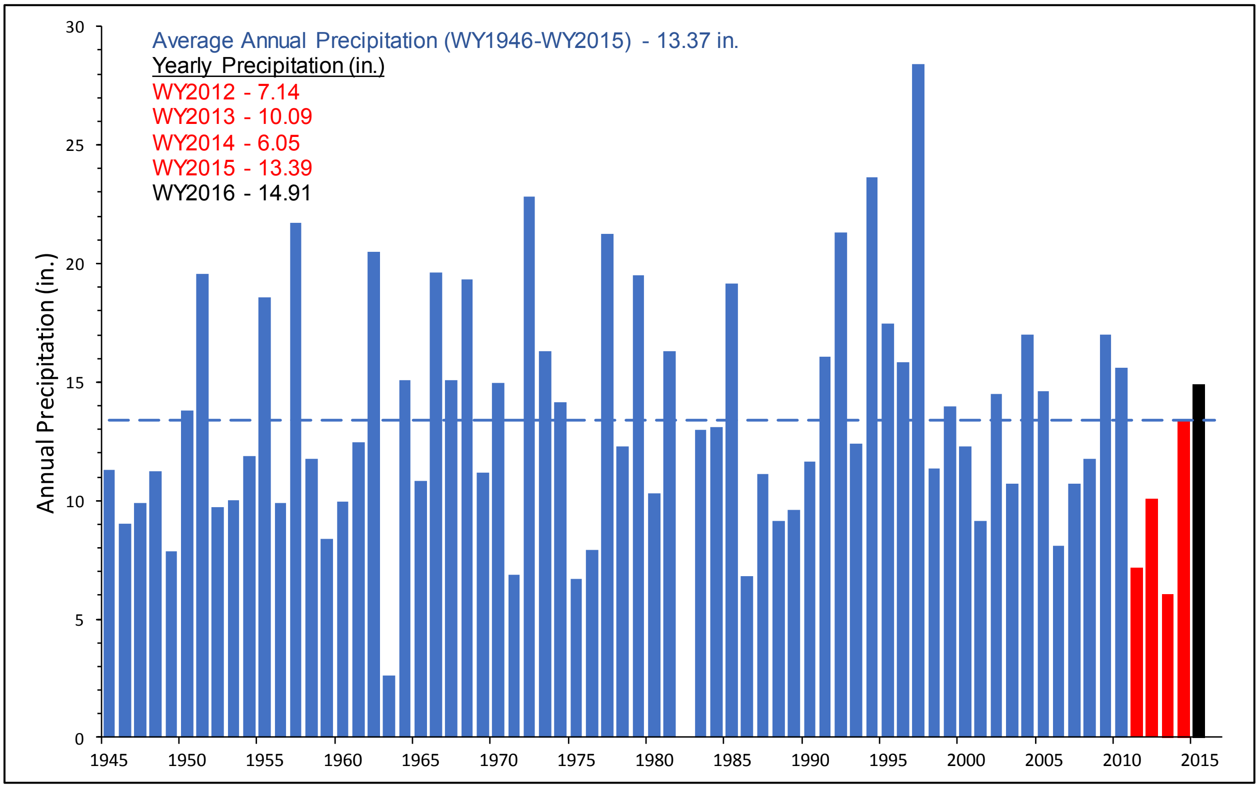

Figure 1.4. Annual rainfall recorded at the San Jose Airport, WY1946 – WY2016.

Individual dry years often result in decreased summer stream flows or earlier than normal desiccation. The cumulative effect of sustained dry conditions can exasperate low flow conditions as ground water tables begin to fall. During severe droughts, water management agencies (such as the Santa Clara Valley Water District) may also decrease the magnitude and duration of reservoir releases. For these reasons, climate should be considered when evaluating water temperature and general water quality data as these parameters are influenced by water depth and stream flows. Periods of drought (rather than individual dry years) can also result in changes in riparian and upland vegetation communities and 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. Therefore, periods of drought can influence the physical habitat parameters measured by the Creek Status Monitoring program.

There is still some uncertainty regarding the impact of periods of drought on overall stream condition as assessed through the calculation of stream condition indices based on benthic macroinvertebrate data (USEPA 2012a). 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, indices of biotic integrity (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 *periods* of extended drought 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.

1.5 Statement of Data Quality

A comprehensive Quality Assurance/Quality Control (QA/QC) program was implemented by SCVURPPP 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 QAPP[8]. A detailed QA/QC report is included as Attachment 1. Overall, the results of the QA/QC review suggest that the Creek Status Monitoring data generated during WY 2016 was of sufficient quality. Some data were flagged in the project database based on exceedances of measurement and/or data quality objectives; however, only a small percent of continuous dissolved oxygen data were rejected.

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[8] The current SWAMP QAPP 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, SCVURPPP conducted bioassessment monitoring in WY 2016. All bioassessment monitoring was performed at sites selected randomly using the probabilistic monitoring design. The probabilistic monitoring design allows each individual RMC participating program to objectively assess stream ecosystem conditions within its program area (e.g., 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 area?*) 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 five years, the SCVURPPP and Regional Water Board have sampled 112 probabilistic sites in Santa Clara 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, as well as all streams within smaller areas of interest (e.g., watershed or jurisdictional areas).[9]

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 collected at the probabilistic sites, as potential stressors to biological health. The extent and magnitude of these stressors above certain thresholds can also be assessed for streams in Santa Clara County. In addition, the stressor levels can be compared to biological indicator data through correlation and relative risk analysis. 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. Although, long-term trend analysis for the RMC probabilistic survey will require more than five years of data collection, preliminary trend analysis

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[9] 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).

of biological condition may be possible for some stream reaches using a combination of historical targeted data with the probabilistic data.

The sections below present bioassessment data collected at twenty sites in WY 2016. A preliminary analysis of biological indicator and stressor data collected in Santa Clara County over the past five years (WY 2012 – WY 2016) is also presented. It is anticipated that the BASMAA RMC will conduct a *regional* analysis of biological condition using the five-year data set (WY 2012 – WY 2016) in Fiscal Year 2017/18.

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 (SCCWRP 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 (listed in Table 1.1). 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 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 12 sites in Santa Clara County.[10] Bioassessment data collected by SWAMP from the Santa Clara County sites are included in this report.

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:

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[10] As of WY 2016, the SFRWQCB SWAMP is no longer conducting RMC-related bioassessment monitoring at probabilistic sites.

1. The location (latitude/longitude) provided for a site is located on or is within 300 meters of a non-impounded receiving water body;[11]
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;
7. Landowner(s) grant permission to access the site.[12]

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 2016, one storm occurred over April 8-9, 2016 (0.56 inches in 24-hour period). In WY 2016, due to antecedent dry conditions and concerns that many sites would desiccate before the end of the 30-day grace period, bioassessments were initiated on April 26th at sites exhibiting low flow conditions. Visual observations at these sites indicated that the April storm event did not generate high flows. Presumably, antecedent dry ground conditions absorbed much of the runoff from the precipitation event. Bioassessments were conducted at the more urbanized sites after the 30-day grace period.

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

[12] 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.

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 et al. 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).

Immediately prior to biological and physical habitat data collection, water samples were collected at 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^{TM} II and DPD Powder Pillows according to SOP FS-3 (BASMAAS 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. Taxa that were not on the SWAMP list were flagged and identified for future potential harmonization work.

2.2.4 Data Analysis

BMI and algae data were analyzed to assess the biological condition of the sampled reaches using condition index scores. The physical habitat and water chemistry data were evaluated as potential stressors to biological health using thresholds from published sources and regulatory criteria/guidance, as well as correlations with condition index scores. Data analysis methods are described below.

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. 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 a biological index that was developed by the State Water Resources Control Board (State Board) and is used to score the condition of BMI communities in perennial wadeable rivers and streams. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that is intended to represent the full range of natural conditions in California (Rehn et al. 2015). It 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 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.

Benthic Algae

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.

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 IBI is expected to be completed in 2017. The statewide algae index will build upon studies by Fetscher et al. (2014) that developed and tested algal indices of biological integrity (IBIs) for streams in Southern California (SoCal Algae IBI). 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 Santa Clara County were evaluated using the existing SWAMP Algae Reporting Module, (Algae RM) which was developed in 2012 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 Santa Clara 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 Santa Clara 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 identified by contracting labs for stormwater projects and, depending on available resources, may be "harmonized" with taxa on the SWAMP master list. Each year, SWAMP updates the taxa list used to calculate metrics in the Algae RM. The trait attributes table, used to associate taxa response to environmental stressors, has not been updated 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.

Biological Condition Thresholds

Existing thresholds for biological indicators defined in Mazor (2015) were used to evaluate the bioassessment data collected in Santa Clara 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).

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

Index	Likely Intact (>30th Percentile)	Possibly Intact (10th – 30th Percentile)	Likely Altered (1st – 10th Percentile)	Very Likely Altered (< 1st Percentile)
Benthic Macroinvertebrates (BMI)				
CSCI Score	≥ 0.92	0.79 – 0.92	0.63 – 0.79	< 0.63
Benthic Algae				
S2 Score	≥ 60	47 - 60	29 - 47	< 29
D18 Score	≥ 72	62 - 72	49 - 62	< 49
H20 Score	≥ 70	63 - 70	54 - 63	< 54

A CSCI score below 0.795 is referenced in the MRP as a threshold below which indicates 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). Further investigation is needed to evaluate the applicability of this threshold to sites in highly urban watersheds and/or modified channels.

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 standard provided in the San Francisco Basin Water Quality Control Plan (Basin Plan) (SFRWQCB 2013). The conversion was based on a formula provided by the American Fisheries Society (AFS, internet source). The calculation requires total ammonia and field-measured parameters of pH, temperature, and specific conductance.
- The 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 variables consisted of reachwide endpoints of quantitative and qualitative habitat measurements. Quantitative measurements included percent canopy cover, percent sands & fines and percent micro- and macro-algae cover (both derived from pebble count data). Qualitative measurements included human disturbance index and three physical habitat (PHAB) scores (epifaunal substrate complexity, sediment deposition and channel alteration). 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, and road density at three different spatial scales (1000 km^2, 5000 km^2 and entire watershed).

Another potential stressor is the lower than average precipitation and stream flow during the five years of probabilistic bioassessment sampling. In addition to low rainfall, low base flow conditions during the dry season were further impacted by minimal or complete absence of water releases from upstream reservoirs and diversion pipes bringing imported water from other parts of the State. Future sampling during wetter years will provide useful information to evaluate the impacts of drought on biological integrity of the streams.

Stressor Thresholds

In compliance with Provision C.8.h.iii.(4), water chemistry data collected at the bioassessment sites during WY 2016 were compared to stressor thresholds and applicable water quality standards (Table 2.2). 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 2013). 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). Los Gatos Creek is the only creek sampled in WY 2016 with MUN designated (see Table 1.4).

Table 2.2. 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 to 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 Use

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

Stressor Association with Biological Conditions

Statistical tests were conducted to evaluate which potential stressors (i.e., physical habitat measurements, water chemistry) have the most significant relationships with biological indicator data (i.e., CSCI scores, algae IBIs). The tests were conducted using all probabilistic data collected in Santa Clara County over the past 5 years (n=112) which is considered sufficient sample size to estimate ambient biological condition. Two statistical methods were used:

- Correlations between biological indicator data and potential stressors were evaluated using the Spearman rank method in Sigma Plot statistical software. The Spearman rank method was selected for its suitability of evaluating data that are not normally distributed. Coefficients values greater than ±0.5 indicate a strong relationship between variables. If the p-value is ≤0.05, the correlation is considered statistically significant.

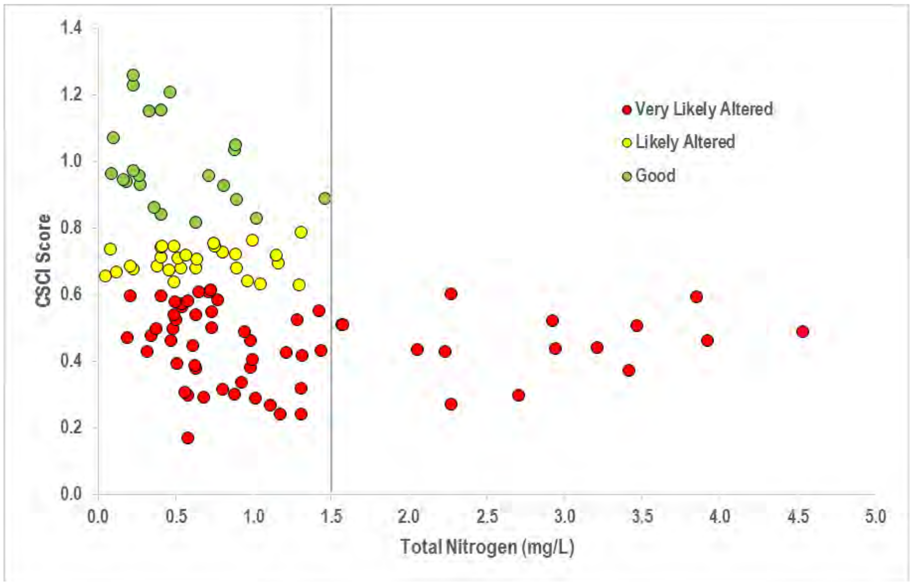
- The random forest method was applied to assess which potential stressors are most important in explaining variability in CSCI scores. Random forest is a bootstrap method that combines many regression trees. It is able to discover more complex dependencies and works well with non-linear data, many variables, outliers, and small datasets (Cutler et al. 2007). We used the randomForest package in R. The random forest script did not run with missing data; the five-year dataset was culled to remove sites with missing data. Many of the culled sites were those provided by SWAMP which generally did not include laboratory results.

The extent and relative risk of stressors at a regional scale can be assessed using probabilistic datasets. This is one of the benefits of the probabilistic component of the Creek Status Monitoring design that was initiated in WY 2012. Ode et al (2011) identifies several approaches for evaluating stressor and biological indicator data collected for probability surveys, including: 1) relative risk and attributable risk estimates; 2) continuous risk relationships; and 3) biology-based stressor thresholds. These approaches will be explored for regional analyses of probabilistic data for Santa Clara County and entire RMC area during FY 2017/18.

Establishing Stressor Thresholds

In general, stressor thresholds can be derived a number of ways

- One approach is to apply existing regulatory standards (e.g., Basin Plan Water Quality Objectives, TMDL targets); however, these thresholds may not have any association with biological condition.
- Another approach is to establish stressor thresholds using data collected at "reference sites." Reference sites are identified by evaluating environmental variables in a GIS to identify areas that have little or no human disturbance (e.g., road density, impervious area). Reference-based thresholds are based on a statistical function (e.g., 90th percentile) of the data collected at reference sites. Reference-based thresholds, however, may be too stringent to evaluate sites in more urban areas.
- A third approach to evaluate stressor data is to use biologically-based thresholds. Biological indicators (i.e., CSCI scores) can demonstrate thresholds of response to stressors, where sites in good biological condition are not observed to exceed a certain stressor concentrations. In the case below, total nitrogen concentration is plotted with CSCI scores for 112 sites sampled in Santa Clara County. All sites classified as "good" and "likely altered" CSCI scores plot below the "indicated threshold" for total nitrogen concentration of 1.5 mg/L.



2.3 Results and Discussion

2.3.1 Site Evaluations

During WY 2016, the SCVURPPP conducted site evaluations at a total of 76 potential probabilistic sites in Santa Clara County drawn from the Master List. Of these sites, a total of twenty were sampled in WY 2016 (rejection rate of 74%). Three of the twenty sites (15%) were classified as non-urban land use. Land use classification, sampling location, and date for each site sampled during WY 2016 are listed in Table 2.3.

Table 2.3. Bioassessment sampling date and locations in Santa Clara County in WY 2016.

Station Code	Creek	Program	Land Use	Sample Date	Latitude	Longitude
205R00213	Cow Creek	SCVURPPP	NU	4/27/2016	37.26445	-121.65039
205R00305	San Felipe Creek	SCVURPPP	NU	4/27/2016	37.25626	-121.66266
205R00578	Arroyo Aguague	SCVURPPP	NU	4/26/2016	37.34925	-121.71812
205R01114	Guadalupe River	SCVURPPP	U	5/3/2016	37.28450	-122.88231
205R01731	Upper Penitencia Creek	SCVURPPP	U	5/5/2016	37.39265	-121.83477
205R02330	Ross Creek	SCVURPPP	U	5/3/2016	37.25520	-121.90656
205R02422	Arroyo Calero	SCVURPPP	U	5/4/2016	37.21059	-121.82717
205R02458	Alamitos Creek	SCVURPPP	U	5/4/2016	37.21897	-121.84321
205R02474	Saratoga Creek	SCVURPPP	U	5/18/2016	37.25819	-122.03437
205R02538	Calabazas Creek	SCVURPPP	U	5/18/2016	37.27538	-122.04225
205R02547	Stevens Creek	SCVURPPP	U	6/1/2016	37.31243	-122.16309
205R02563	Los Gatos Creek	SCVURPPP	U	5/19/2016	37.32924	-121.89960
205R02602	Tributary to San Tomas	SCVURPPP	U	6/2/2016	37.23547	-122.00528
205R02618	Aldercroft Creek	SCVURPPP	U	5/2/2016	37.17623	-121.98942
205R02650	Alamitos Creek	SCVURPPP	U	5/31/2016	37.22150	-121.84700
205R02659	Stevens Creek	SCVURPPP	U	5/19/2016	37.34474	-122.06417
205R02730	Saratoga Creek	SCVURPPP	U	6/1/2016	37.28141	-122.00642
205R02762	Ross Creek	SCVURPPP	U	6/2/2016	37.23593	-121.95184
205R02771	Lower Silver Creek	SCVURPPP	U	6/3/2016	37.35228	-121.83543
205R02835	Upper Penitencia Creek	SCVURPPP	U	5/5/2016	37.39658	-121.80390

NU = non-urban, U = urban

Since WY 2012, a total of 112 probabilistic sites were sampled by SCVURPPP (n=100) and SWAMP (n=12) in Santa Clara County. During the five-year sampling period, SCVURPPP sampled 87 urban and 13 non-urban sites and SWAMP sampled 12 non-urban sites. A total of 403 total sites were evaluated to obtain the 112 samples, an overall rejection rate of 73%[13]. Refer to Section 2.2.2 for list of criteria used to reject sites. The number of sites (and percentage of total evaluated sites) rejected for each criterion are presented in Table 2.4. The location and site evaluation results for all sites evaluated are shown in Figure 2.1.

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[13] The rejection rate is an important factor in defining the confidence level of statistical data interpretations at countywide and regional scales.

Table 2.4. Probabilistic site evaluation results in Santa Clara County, WY 2012 – WY 2016.

Subpopulation	Target Sampled Sites	Potential Target Not sampled due to access issues	Non-Target Rejected due to low or no flow	Non-Target Rejected for other reasons	Total Sites Evaluated
Urban	87 (32%)	22 (8%)	101 (37%)	62 (23%)	272
Non-Urban	25 (19%)	35 (27%)	67 (51%)	4 (3%)	131
Total	112 (28%)	57 (14%)	168 (42%)	66 (16%)	403

Low or no flow conditions were the most common reason for site rejection (42% of all sites). Low flow conditions were documented at more than half the non-urban sites evaluated. The inclusion of first order streams in the upper watershed areas in the Master List increases the potential for low flow conditions during the sample index period. In addition, the extended period of drought conditions during the five years of Creek Status Monitoring likely resulted in low flow conditions in reaches that would be perennial during normal years of rainfall.

Access issues (e.g., physical barriers, permission not granted) were another common reason for not sampling a site (14% of total sites). Access issues were more frequently encountered for non-urban sites due to high proportion of privately owned land, lack of road access to remote sites, and densely vegetated hill slopes adjacent to sites. The remaining sites (16% of total sites) were rejected for a variety of reasons, including site location not on a creek, site was tidally influenced, or site was not wadeable (e.g., too deep).

There are sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for urban streams in Santa Clara County (in development). More samples are needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas).

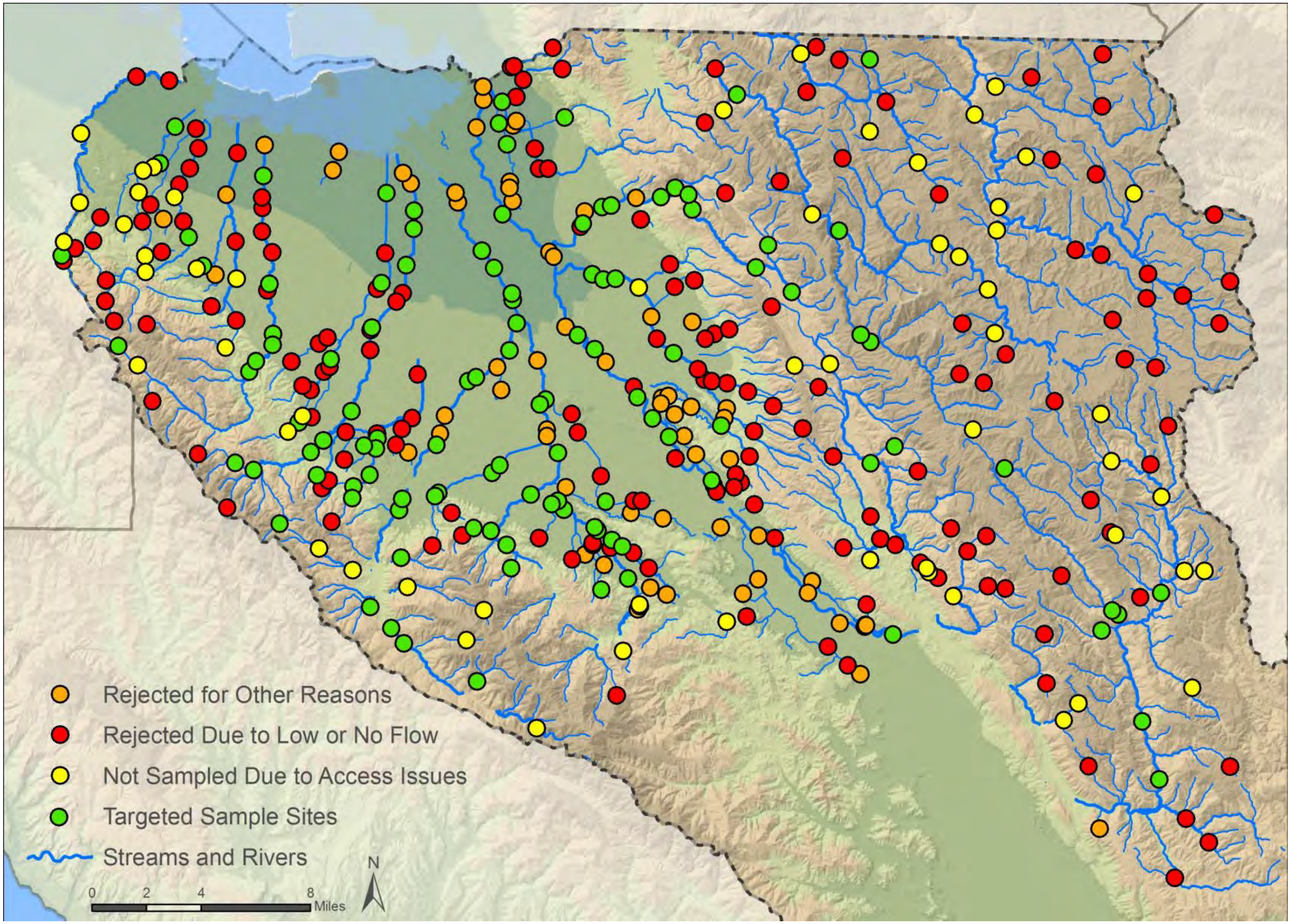


Figure 2.1. Site evaluation results for probabilistic sites (n=347) in Santa Clara County, WY 2012 – WY 2016.

2.3.2 Biological Condition Assessment

This section presents the results of the biological condition assessment conducted in WY 2016 and compiles those data with results from water years 2012 through 2015.

WY 2016 Results

A total of 152 unique BMI taxa were identified in samples collected at 20 bioassessment sites in Santa Clara County during WY 2016. A total of 244 benthic algae taxa were identified in samples collected at the same sites, including 205 diatom and 39 soft algae taxa. The total number of 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 11 to 51 taxa, and diatoms ranging from 15 to 61 taxa. Soft algae taxa were less common across sites, ranging from 1 to 10 taxa. Seven of the sites (30%) had three or less soft algae taxa.

Table 2.5. The total number of unique BMI, diatom and soft algae taxa identified in samples collected at 20 bioassessment sites in Santa Clara County during WY 2016.

Station	Creek	Land Use	BMIs	Diatoms	Soft Algae
205R00213	Cow Creek	NU	25	16	5
205R00305	San Felipe Creek	NU	41	22	9
205R00578	Arroyo Aguague	NU	21	33	2
205R01114	Guadalupe River	U	11	48	8
205R01731	Upper Penitencia Creek	U	16	31	8
205R02330	Ross Creek	U	16	25	10
205R02422	Arroyo Calero	U	36	61	7
205R02458	Alamitos Creek	U	40	36	7
205R02474	Saratoga Creek	U	31	21	1
205R02538	Calabazas Creek	U	26	22	5
205R02547	Stevens Creek	U	51	22	4
205R02563	Los Gatos Creek	U	14	30	3
205R02602	Tributary to San Tomas	U	36	15	2
205R02618	Aldercroft Creek	U	30	34	3
205R02650	Alamitos Creek	U	32	53	7
205R02659	Stevens Creek	U	18	45	1
205R02730	Saratoga Creek	U	24	42	7
205R02762	Ross Creek	U	19	28	4
205R02771	Lower Silver Creek	U	18	46	5
205R02835	Upper Penitencia Creek	U	27	43	3

NU = non-urban, U = urban

Biological condition, as represented by CSCI scores and algae IBI scores (S2, D18 and H20), for the 20 probabilistic sites sampled by SCVURPPP during WY 2016 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 in Figure 2.2 for the 20 sites sampled in WY 2016.

The CSCI scores ranged from 0.29 to 0.96 across the 20 bioassessment sites sampled in WY 2016. The two main components of the CSCI score, O over E and MMI scores, are listed for each site in Attachment 2. Five of the 20 bioassessment sites (25%) had CSCI scores in the two higher condition categories - “possibly intact” and “likely intact” condition. The combined classifications are above the MRP trigger threshold value of 0.795 and are herein referred to as “good” biological condition in this report. All but one of these sites were classified as urban (Table 2.6). Five sites ranked “likely altered”; two of these sites were classified as non-urban land use. Ten of the urban sites were ranked “very likely altered” (CSCI < 0.63), indicating highly degraded condition. Four of these sites had non-perennial flow status and two were in modified channels. Sites with CSCI scores below 0.795 will be considered as candidates for SSID projects.

Benthic algae taxa identified in the twenty samples collected in Santa Clara County were used to calculate scores for three SoCal Algae IBIs (S2, D18 and H20) (Table 2.6). Of the 244 total taxa identified in samples collected in WY 2016, six taxa (all diatoms) that did not match the SWAMP master taxa list. These were excluded from the IBI calculations. The individual metrics and scores for all three algae IBIs are presented in Attachment 2.

- **S2.** There were insufficient algae data to calculate a S2 IBI score at site 205R02618. For the remaining sites, the S2 IBI scores were relatively low, with 17 sites receiving scores equal to or below 47, corresponding to “likely altered” or “very likely altered” biological condition category.
- **D18.** Eight of the twenty bioassessment sites (40%) had D18 scores that were classified as “possibly intact” or “likely intact” condition.
- **H20.** Only one site of the twenty sites (5%) had H20 scores that would rank in good condition.

Total PHAB scores at twenty bioassessment sites ranged from 21 to 53 (Table 2.6). Total PHAB scores were slightly better correlated with CSCI scores (r^2=0.26, p value = 0.008) compared to H20 scores (r^2=0.16, p value = 0.08).
The CSCI and SoCal Algae IBI scores were generally not well correlated at either urban or nonurban sites (Table 2.6). One explanation is that BMIs are responding to different stressors compared to algae. BMIs typically have much longer life cycles compared to algae and thus, may respond more to habitat fluctuations that may occur at different points over time. In contrast, algae have much shorter life cycles and would be expected to show response to more recent changes in flow or water quality (e.g., peak flow events, drops in dissolved oxygen). As discussed above, BMIs generally show negative correlation with stressors associated with physical habitat, whereas algae can produce high biological condition scores in poor habitats (e.g., concrete channels) (Rafael Mazor, SCCWRP, personal communication).

In summary, CSCI and Algae IBI scores should be evaluated using a weight-of-evidence approach, to determine if potential stressors may be impacting biological condition at a site. Individual metric scores for each index or trait based responses from individual taxa can also be evaluated to determine if stressors may be affecting biological integrity.

Table 2.6. Biological condition scores, presented as CSCI and SoCal Algae IBIs (S2, D18 and H20) for 20 probabilistic sites sampled in WY 2016. Total PHAB scores for each site are also presented. Site characteristics related to channel **modification and flow condition are also presented. Bold values indicate "good" condition.**

Station Code	Creek	Elevation (ft)	Land Use	Modified Channel^2	Flow^3	CSCI Score	Soft Algae **"S2" IBI** Score	Diatom **"D18" IBI** Score	Hybrid **"H20" IBI** Score	Total PHAB Score
205R00213	Cow Creek	1135	NU	N	NP	0.66	80	80	80	53
205R00305	San Felipe Creek	1022	NU	N	P	0.89	45	56	56	28
205R00578	Arroyo Aguague	1564	NU	N	NP	0.74	90	40	62	37
205R01114	Guadalupe River	523	U	N	P	0.39	7	48	31	33
205R01731	Upper Penitencia Cr	151	U	N	NP	0.63	23	20	20	36
205R02330	Ross Creek	202	U	Y	NP	0.49	3	16	11	21
205R02422	Arroyo Calero	311	U	N	P	0.72	25	54	41	36
205R02458	Alamitos Creek	267	U	N	P	0.61	22	64	51	31
205R02474	Saratoga Creek	474	U	N	P	0.82	0	24	15	45
205R02538	Calabazas Creek	401	U	N	P	0.57	13	56	42	28
205R02547	Stevens Creek	1651	U	N	P	0.96	12	68	48	43
205R02563	Los Gatos Creek	87	U	N	NP	0.52	3	70	44	34
205R02602	Unnamed Tributary	634	U	N	NP	0.93	17	82	51	39
205R02618	Aldercroft Creek	660	U	N	P	0.83	NR	24	15	42
205R02650	Alamitos Creek	277	U	N	P	0.73	25	74	55	42
205R02659	Stevens Creek	230	U	N	P	0.62	0	70	44	31
205R02730	Saratoga Creek	306	U	N	NP	0.29	47	22	25	32
205R02762	Ross Creek	329	U	N	P	0.30	20	68	51	30
205R02771	Lower Silver Creek	111	U	Y	P	0.49	15	4	8	24
205R02835	Upper Penitencia Cr	521	U	N	P	0.79	17	46	38	37

WY 2012 through WY 2016 Results

Biological indicator data were compiled for all probabilistic sites sampled by SCVURPPP (n=100) and the Regional Water Board (n=12) over the past five years. Biological condition based on CSCI scores for the five-year dataset are illustrated in Figure 2.3. The proportion of urban and non-urban sites for each of the biological condition classes based on CSCI scores are shown in Figure 2.4. Good biological condition scores occurred at 11% of the urban sites and 52% of non-urban sites.

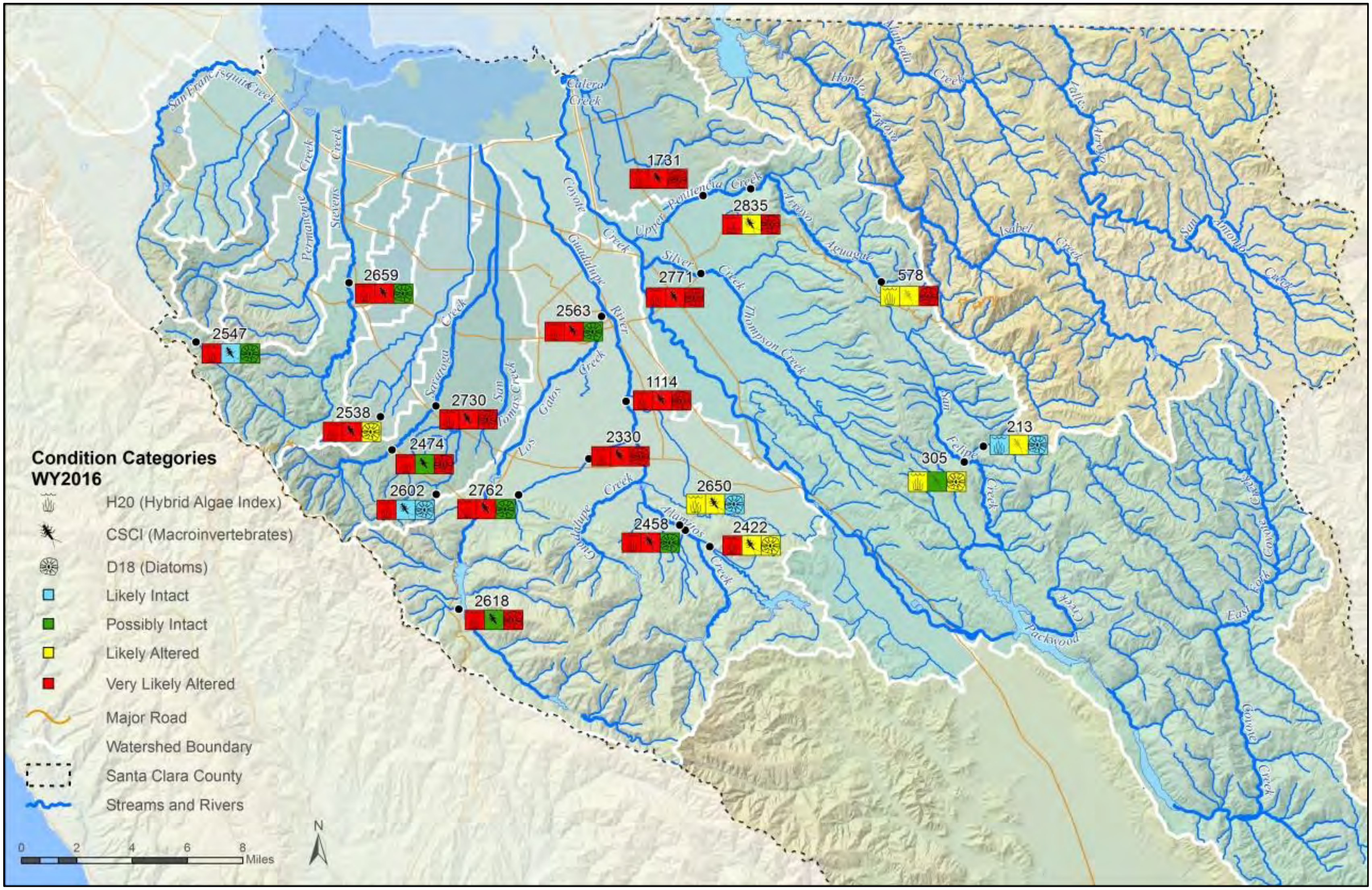


Figure 2.2. Condition category as represented by CSCI, D18 and H20 scores for 20 probabilistic sites sampled in Santa Clara County during WY 2016.

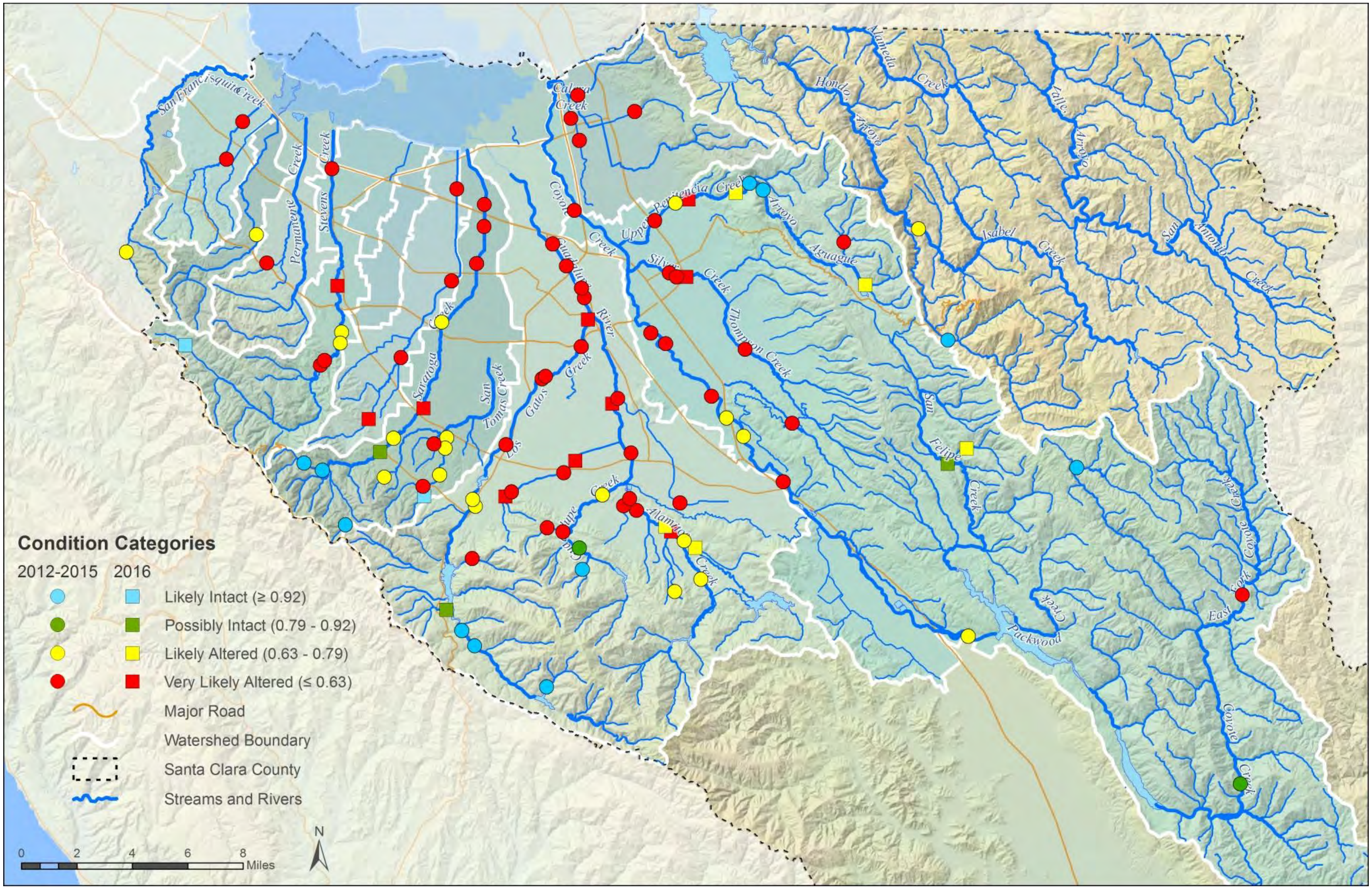


Figure 2.3. Biological condition based on CSCI scores for 112 sites sampled in Santa Clara County by SCVURPPP and SWAMP between WY 2012 and WY 2016.

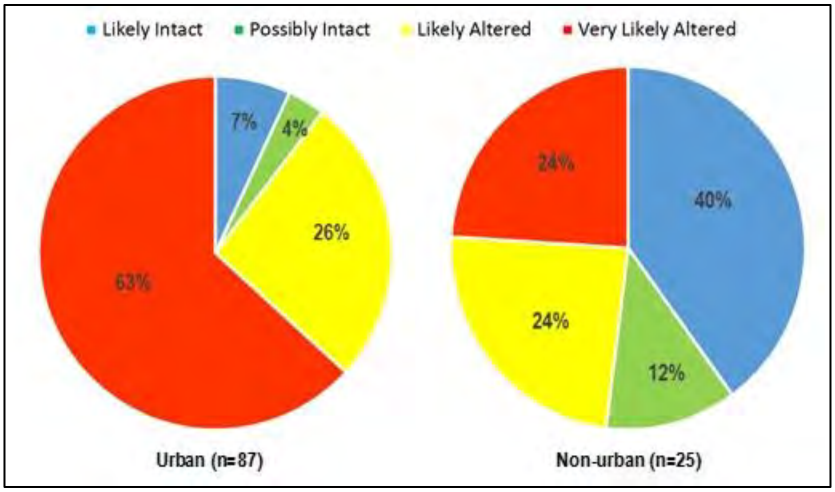


Figure 2.4. Proportion of bioassessment sites sampled over five years (WY 2012-WY 2016), grouped by land use classification, for each of the CSCI biological condition category.

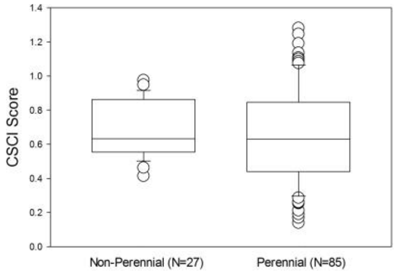
Assessing Flow at Bioassessment Sites

The State Board's Perennial Stream Assessment (PSA) Program only assesses wadeable, perennial streams in California. In contrast, the RMC Creek Status Monitoring Program conducts bioassessments at both perennial and non-perennial sites. Perennial flow status is determined by visiting sampling locations during the fall season and assessing flow conditions using definitions for five potential flow scenarios.

Flow status at potential sites can be highly variable due to natural (e.g., low rainfall, ground water levels) and human factors (e.g., water diversions, reservoir releases). Drought conditions over the past five years in the San Francisco Bay Area have generally resulted in low flow conditions in creeks throughout Santa Clara Valley watersheds. Thus, many sites that were not sampled due to low or no flow, could potentially be sampled in subsequent, wetter years.

Although the CSCI tool was originally developed to assess biological condition for perennial creeks, CSCI scores for both perennial and non-perennial sites in Santa Clara County over five-year period (WY 2012-WY 2016) have similar central tendencies (median score = 0.63).

Perennial	Wet Flowing: Continuously wet or nearly so, flowing water.
	Wet Trickle: Continuously wet or nearly so, very low flow (trickle, <0.1 L/sec.).
	Majority Wet: Discontinuously wet, >25% (by length) of stream bed covered with water (isolated pools).
Non Perennial	Minority Wet: Discontinuously wet, <25% of stream bed (by length) covered with water (isolated pools).
	No Water: No surface water present.



Biological condition scores, based on CSCI and three SoCal Algal IBI scores, for perennial (n=85) and non-perennial (n=27) sites sampled over the past five years in Santa Clara County are shown in Figure 2.5. Approximately 25% of the bioassessment sampling locations were non-perennial. There was no difference in median CSCI scores for perennial and non-perennial sites (0.63). The median algae IBI scores were consistently higher at non-perennial sites. Non-perennial sites tended to be either small non-urban creeks in the upper watershed area or sections of urban creeks in the Santa Clara Valley that stop flowing during the dry season.

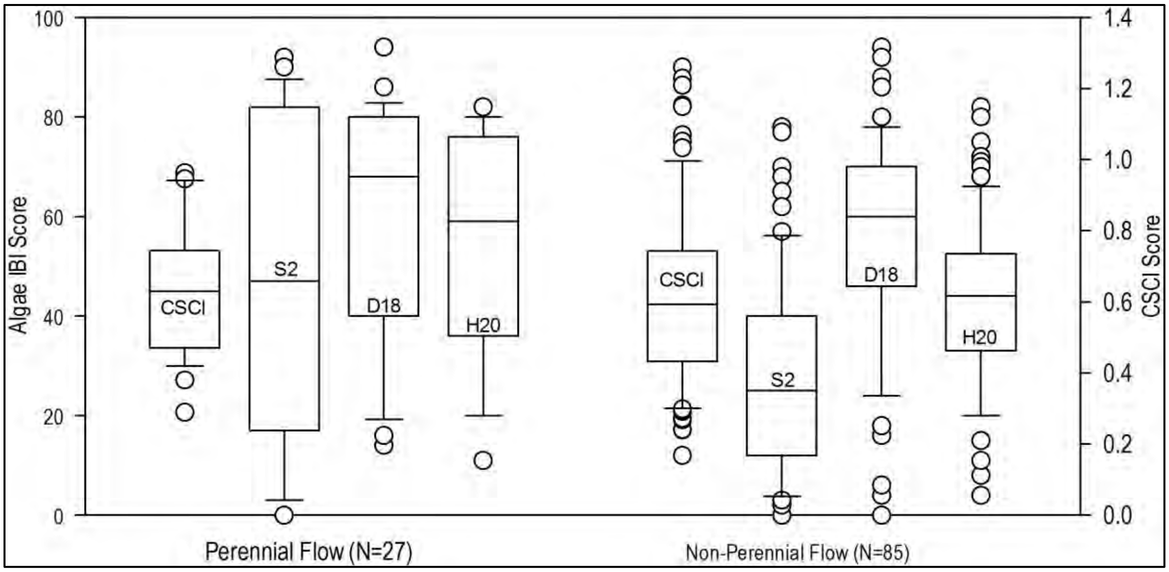


Figure 2.5. Box plots showing CSCI and algae IBI scores, grouped by flow classification, for 112 bioassessment sites sampled in Santa Clara County over the past 5 years (WY 2012 – WY 2016).

A beanplot is a variation of a box plot that shows the variable density of data and highlights the mean result, rather than the median shown in box plots. Figure 2.6 shows beanplot distributions of CSCI scores for perennial and non-perennial sites. The beanplots illustrate that, although mean values are similar, non-perennial sites have a somewhat bi-modal distribution of CSCI scores.

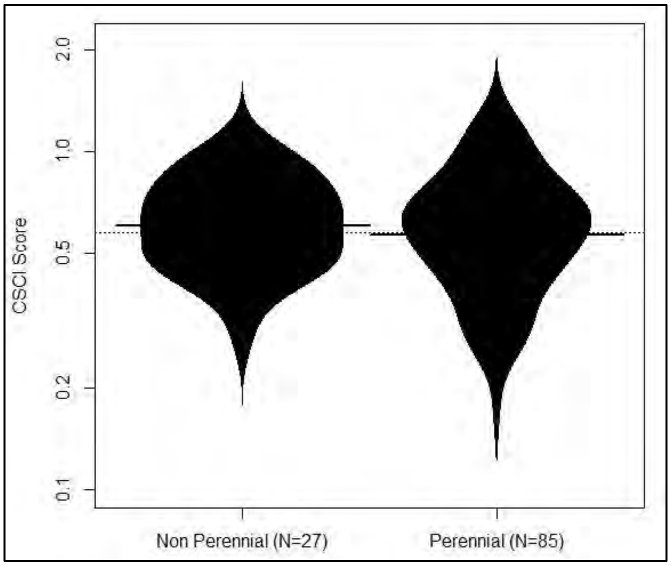


Figure 2.6. Beanplots showing CSCI, grouped by flow classification, for 112 bioassessment sites sampled in Santa Clara County over the past 5 years (WY 2012 – WY 2016). The cross bars are equal to the mean value.

The CSCI and three algae IBI tools showed relative consistency in their response across an urban gradient, with generally lower median scores associated with increasing urbanization (i.e., percent imperviousness) (Figure 2.7). The S2 IBI scores were especially variable at sites with low percent impervious area (< 3%), while the D18 IBI scores had more variability for sites with higher amount of impervious area. Beanplots of CSCI scores for the three different imperviousness groupings are shown in Figure 2.8.

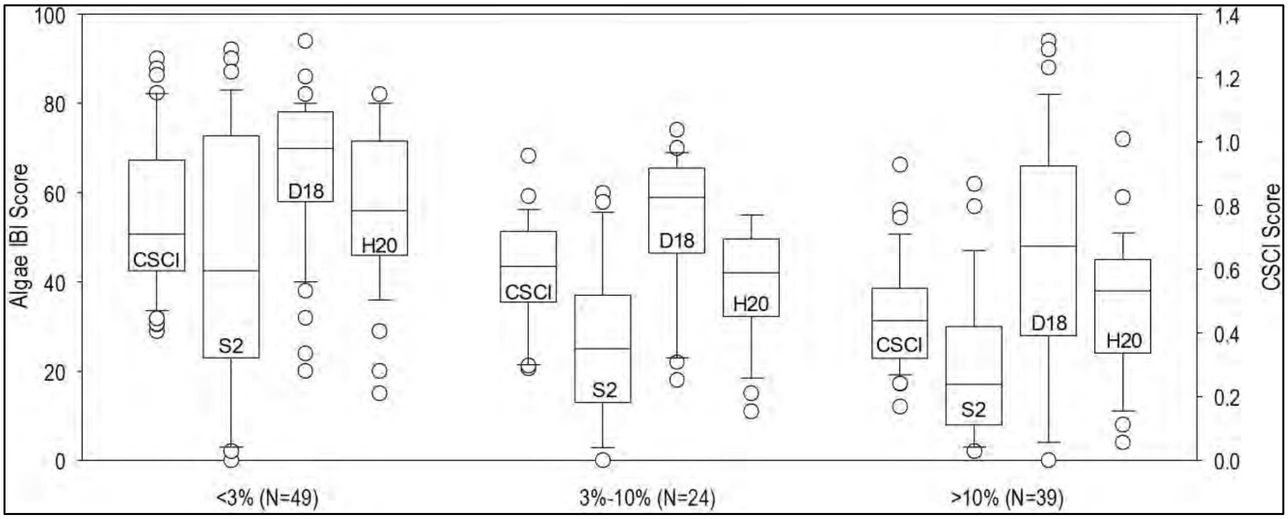


Figure 2.7. Box plots showing CSCI and algae IBI scores, grouped by percent impervious area, for 112 bioassessment sites sampled in Santa Clara County over the past 5 years (WY 2012 – WY 2016).

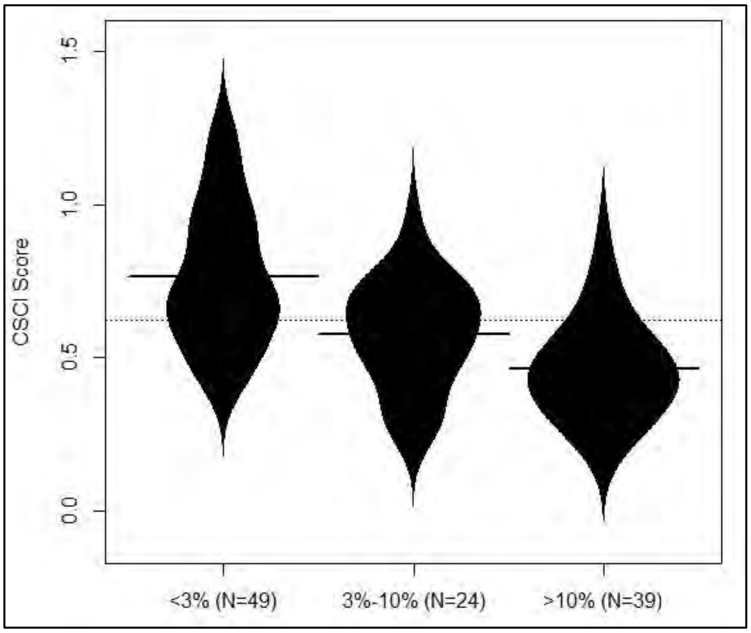


Figure 2.8. Beanplots showing CSCI scores, grouped by percent impervious area, for 112 bioassessment sites sampled in Santa Clara County over the past 5 years (WY 2012 – WY 2016).

CSCI scores were better correlated with site elevation ($r^2 = 0.34$, p value <0.001) compared to D18 scores ($r^2 = 0.18$, p value <0.001), suggesting that physical habitat variables associated with changing elevation (e.g., stream gradient, substrate size) have greater influence on the BMI community compared to diatom assemblages (Figure 2.9). For this reason, algae may provide useful data to assess water quality issues at urban sites with poor habitat.

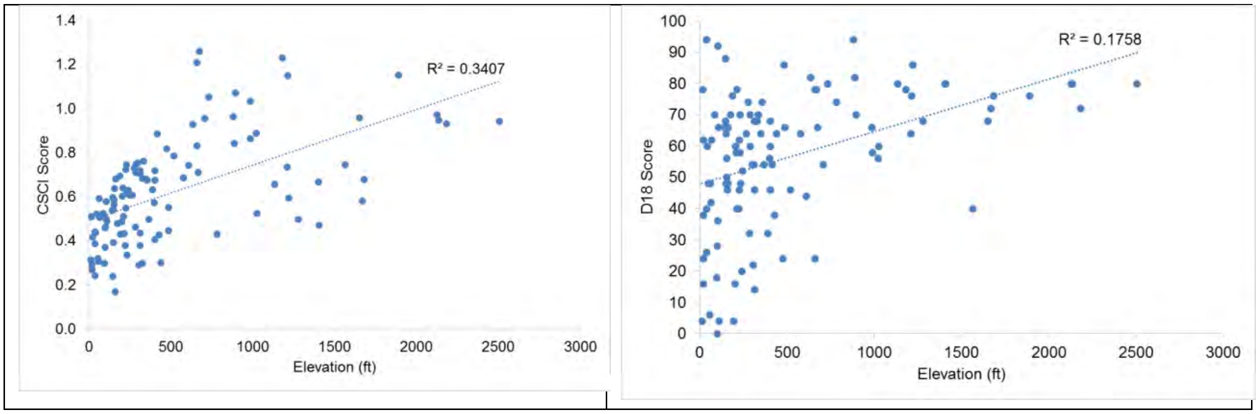


Figure 2.9. CSCI and D18 scores plotted with elevation for 112 bioassessment sites sampled in Santa Clara County over five-year period (WY 2012 – WY 2016).

Similar to site elevation, total PHAB scores had better correlation with CSCI scores (r^2=0.37, p value <0.001) compared to D18 scores (r^2=0.19, p value <0.001) (Figure 2.10)

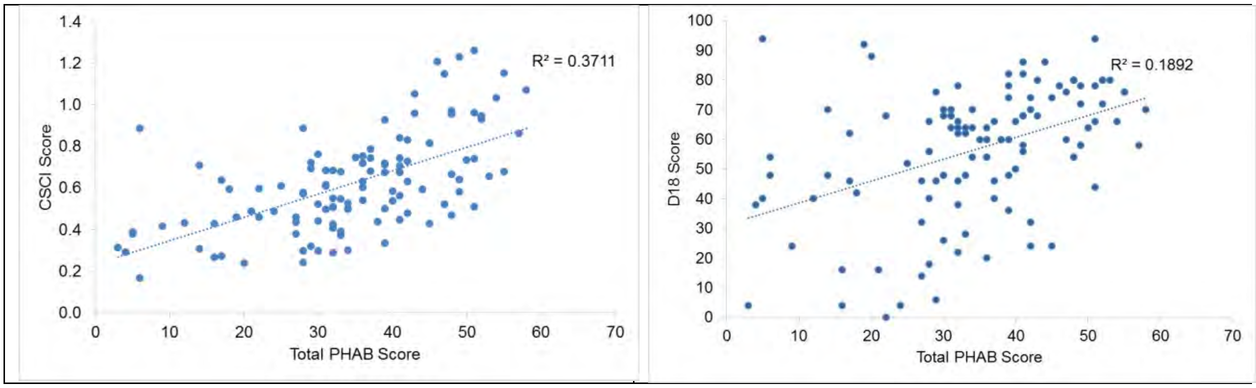


Figure 2.10. CSCI and D18 scores plotted with total PHAB scores for 112 bioassessment sites sampled in Santa Clara County over five-year period (WY 2012 – WY 2016).

Analyses of physical habitat related stressor data was limited to the data collected at each probabilistic site and environmental variables that were generated in GIS. Additional stressor data, not collected during the study that may also have important impacts to biological condition, include impacts from reservoirs (e.g., modified peaks flows and sediment transport processes), variability in channel form and flood plain access (e.g., channel incision), modifications to stream channel (e.g., hardened banks, earthen levees), and riparian habitat condition. These stressor data types however typically require detailed measurements that are not practical to collect during bioassessment sampling.

Are Good Condition Sites Protected?

Many of the RMC Creek Status Monitoring sites sampled by SCVURPPP and SWAMP are located in publicly protected lands that have limited urban development. These lands include State Parks, County Parks, Municipal Parks, Midpeninsula Open Space Regional District Preserves, and watersheds protected by public utility agencies that provide water supply (e.g., San Jose Water Company).

A majority of the bioassessment sites sampled in Santa Clara County that received the highest biological condition scores, based on BMI data, were in publicly protected lands. Sixteen of the 112 bioassessment sites sampled over the past 5 years had CSCI scores ≥ 92. Twelve of these sites were in publicly owned land with minimal urban development. The other four sites were in either privately owned land or within an urban municipal park. Three of the "unprotected" sites were located on Saratoga Creek.

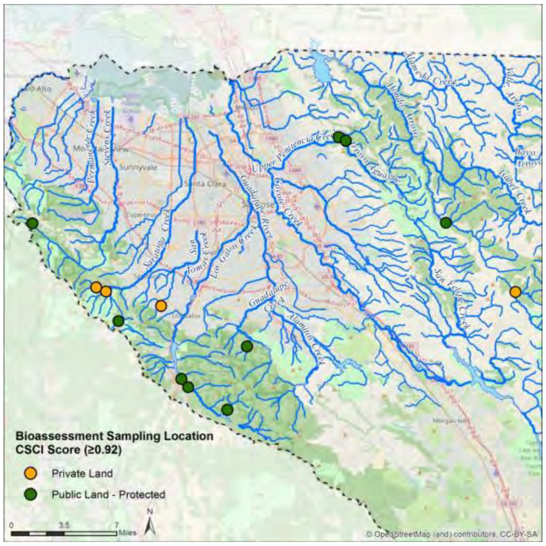


Table 2.7. Nutrient and conventional constituent concentrations in water samples collected at 20 sites in Santa Clara County during WY 2016. Analyte concentrations that exceed water quality objectives are indicated in bold.

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	250 [a]	NA	NA	10 [a]	NA	NA	NA	NA	NA	NA	NA
205R00213	Cow Creek	0.01	0.000	13	13.9	1.24	0.01	0.0005	0.035	0.046	0.006	0.018	0.024	16
205R00305	San Felipe Creek	0.01	0.000	16	83.5	87.1	1.2	0.002	0.26	1.462	0.024	0.04	0.064	14
205R00578	Arroyo Aguague	0.01	0.000	18	72.4	8.89	0.01	0.0005	0.4	0.411	0.03	0.044	0.074	13
205R01114	Guadalupe River	0.02	0.000	15	304	64.3	0.025	0.002	0.48	0.507	0.016	0.086	0.102	8.8
205R01731	Upper Penitencia Cr	0.03	0.001	41	55.2	2.02	0.19	0.004	1.1	1.294	0.02	0.026	0.046	15
205R02330	Ross Creek [b]	0.03	0.009	670	22.2	66.2	0.15	0.001	0.79	0.941	0.06	0.084	0.144	16
205R02422	Arroyo Calero	0.02	0.000	37	421	75.4	0.26	0.004	0.88	1.144	0.039	0.049	0.088	17
205R02458	Alamitos Creek	0.03	0.001	28	34.4	34.6	0.14	0.003	0.57	0.713	0.03	0.037	0.067	18
205R02474	Saratoga Creek	0.01	0.003	50	30.0	14.2	0.059	0.0019	0.57	0.631	0.042	0.044	0.086	20
205R02538	Calabazas Creek	0.01	0.006	37	62.8	13.4	0.01	0.0014	0.53	0.541	0.032	0.019	0.051	16
205R02547	Stevens Creek	0.03	0.000	20	13.6	14.9	0.01	0.0005	0.7	0.711	0.025	0.024	0.049	18
205R02563	Los Gatos Creek	0.01	0.000	96	39.5	145	0.66	0.0031	0.62	1.283	0.021	0.033	0.054	10
205R02602	Unnamed Trib	0.03	0.001	43	195	11.7	0.41	0.0005	0.4	0.811	0.2	0.017	0.217	23
205R02618	Aldercroft Creek	0.02	0.022	17	9.89	3.80	0.54	0.001	0.48	1.021	0.081	0.087	0.168	23
205R02650	Alamitos Creek	0.02	0.000	38	186	71.0	0.18	0.002	0.62	0.802	0.034	0.037	0.071	18
205R02659	Stevens Creek	0.39	0.001	12	71.6	10.2	0.089	0.014	0.62	0.723	0.028	0.072	0.100	18
205R02730	Saratoga Creek	0.07	0.005	71	158	96.1	0.22	0.0005	0.79	1.011	0.098	0.11	0.208	10
205R02762	Ross Creek	0.04	0.000	18	62.5	223	1.6	0.009	1.1	2.709	0.036	0.2	0.236	35
205R02771	Lower Silver Creek	0.10	0.002	96	736	123	3.4	0.031	1.1	4.531	0.2	0.082	0.282	24
205R02835	Upper Penitencia Cr	0.17	0.004	120	248	74.3	0.3	0.035	0.97	1.305	0.03	0.042	0.072	15
Number of exceedances		NA	0	0	NA	NA	0	NA	NA	NA	NA	NA	NA	NA

NA = not applicable

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

[b] Ross Creek is not designated for MUN Use.

Table 2.8. Selected physical habitat variables and general water quality measurements collected at 20 bioassessment sites in Santa Clara County during WY2016. Land use data calculated in GIS, is also provided. Measurements that exceed objectives or MRP thresholds are indicated in bold.

Station Code	Creek	% Micro Algae Cover	% Macro Algae Cover	% Canopy Cover	% Sands+ Fines	HDI Score	% Urban (watershed)	% Imperv (watershed)	Temp (C) Instan Maximum	DO (mg/L)	pH	Specific Cond (uS/cm)
Water Quality Objective/Threshold		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*24*	*5 or 7*	*6.5 to 8.5*	*2000*
205R00213	Cow Creek	0.00	0.95	85.70	5.71	0.00	0%	1%	10.7	10.49	8.2	492
205R00305	San Felipe Creek	2.86	8.57	90.37	18.10	0.09	0%	1%	13.4	10.67	8.4	555
205R00578	Arroyo Aguague	0.00	7.62	58.42	17.14	0.86	0%	1%	13.9	7.94	7.6	305
205R01114	Guadalupe River	0.00	20.95	1.07	28.57	1.72	38%	17%	18.9	9.41	8.3	547
205R01731	Upper Penitencia Cr	1.90	19.05	70.15	16.19	2.95	4%	2%	15.7	10.26	8.7	876
205R02330	Ross Creek	14.29	43.81	20.45	2.86	3.91	86%	37%	25.2	16	9.1	2848
205R02422	Arroyo Calero	8.57	13.33	93.16	51.43	1.98	37%	6%	15.8	8.77	7.7	489
205R02458	Alamitos Creek	0.95	27.62	82.35	37.14	2.15	9%	2%	16.7	10.36	8.1	4712
205R02474	Saratoga Creek	9.52	4.76	89.19	15.24	2.21	10%	3%	14.6	9.92	8	526
205R02538	Calabazas Creek	0.00	37.14	87.17	19.05	1.63	12%	4%	20.1	8.68	8	1108
205R02547	Stevens Creek	0.00	3.81	87.97	6.67	0.05	37%	6%	12.6	10.22	8.2	534
205R02563	Los Gatos Creek	12.38	71.43	64.04	25.71	2.85	2%	2%	21.4	12.13	8.8	498
205R02602	Unnamed Trib	2.86	0.95	94.25	7.62	2.40	32%	18%	15.8	8.86	7.6	468
205R02618	Aldercroft Creek	3.81	3.81	86.10	15.24	0.61	21%	4%	11.7	10.85	8	575
205R02650	Alamitos Creek	0.96	26.67	79.55	34.29	1.82	13%	4%	16.4	8.99	7.9	492
205R02659	Stevens Creek	0.95	5.71	78.74	21.90	1.12	13%	5%	15.7	9.6	8.4	467
205R02730	Saratoga Creek	0.00	0.00	82.35	22.86	1.97	16%	8%	20.1	10.3	8.4	501
205R02762	Ross Creek	6.67	54.29	89.97	32.38	3.01	80%	13%	18.7	11.65	8.3	1013
205R02771	Lower Silver Creek	0.00	34.29	5.08	39.05	3.07	24%	10%	20.9	8.95	8.1	1364
205R02835	Upper Penitencia Cr	7.62	10.48	85.83	27.62	2.01	76%	23%	13.8	9.95	8.2	794
Number of exceedances		NA	NA	NA	NA	NA	NA	NA	1	NA	3	1

Stressor Data (WY 2012 - 2016)

Nutrient data were compiled for all bioassessment sites sampled during the past five years (WY 2012 – WY 2016) in Santa Clara County. Total nitrogen and phosphorus concentrations, grouped by three classes of percent imperviousness of the area draining to monitoring site, are presented as box plots in Figure 2.11. In general, urban sites had slightly higher concentrations compared to less urban sites for both total nitrogen and total phosphorus.

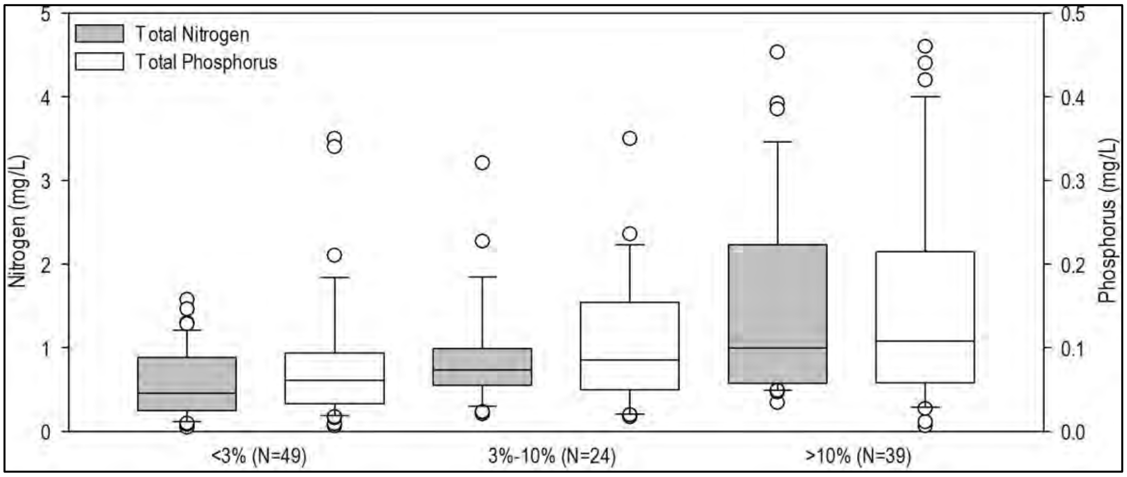


Figure 2.11. Total nitrogen and total phosphorus concentrations measured in water samples collected at bioassessment sites (n=112) by SCVURPPP and SWAMP between WY 2012 and WY 2016.

Box plots for total nitrogen and total phosphorus, grouped by subwatershed, are presented in Figures 2.12 through 2.14. See Figure 1.1 for a map of watersheds within SCVURPPP jurisdictional boundaries. In the Coyote Creek watershed, elevated[14] total nitrogen concentrations were measured at all sites in Lower Silver/Thompson Creek and at the lowest elevation site in Coyote Creek (Figure 2.12). Elevated concentrations for total phosphorus were also observed at two sites in Lower Silver/Thompson Creek, one site in Upper Silver Creek and one site in Los Coches Creek (tributary to Lower Penitencia Creek).

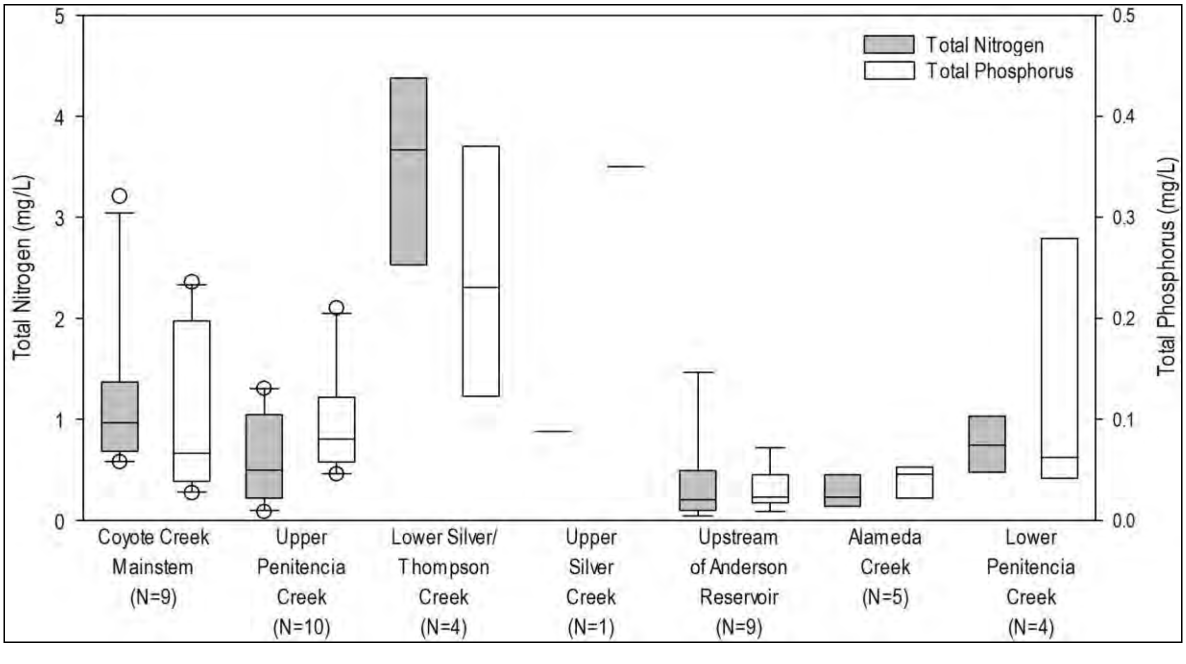


Figure 2.12. Total nitrogen and total phosphorus concentrations measured in water samples collected in Coyote Creek, Lower Penitencia Creek and Alameda Creek watersheds between WY 2012 and WY 2016.

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[14] In this analysis, samples are considered elevated if nutrient concentrations exceed the 90th percentile of all data collected in Santa Clara and San Mateo Counties in the past five years.

In the Guadalupe River watershed, elevated total nitrogen concentrations occurred at three sites in Guadalupe River, two sites in Ross Creek and one site in Alamitos Creek (Figure 2.13). The highest concentration of total phosphorus (0.46 mg/L) for all stations sampled over the past five years occurred in water sample collected in 2015 at site 205R01738 in Ross Creek. In the western Santa Clara Valley watersheds, elevated total nitrogen concentrations occurred at two sites in Matadero Creek (Figure 2.14).

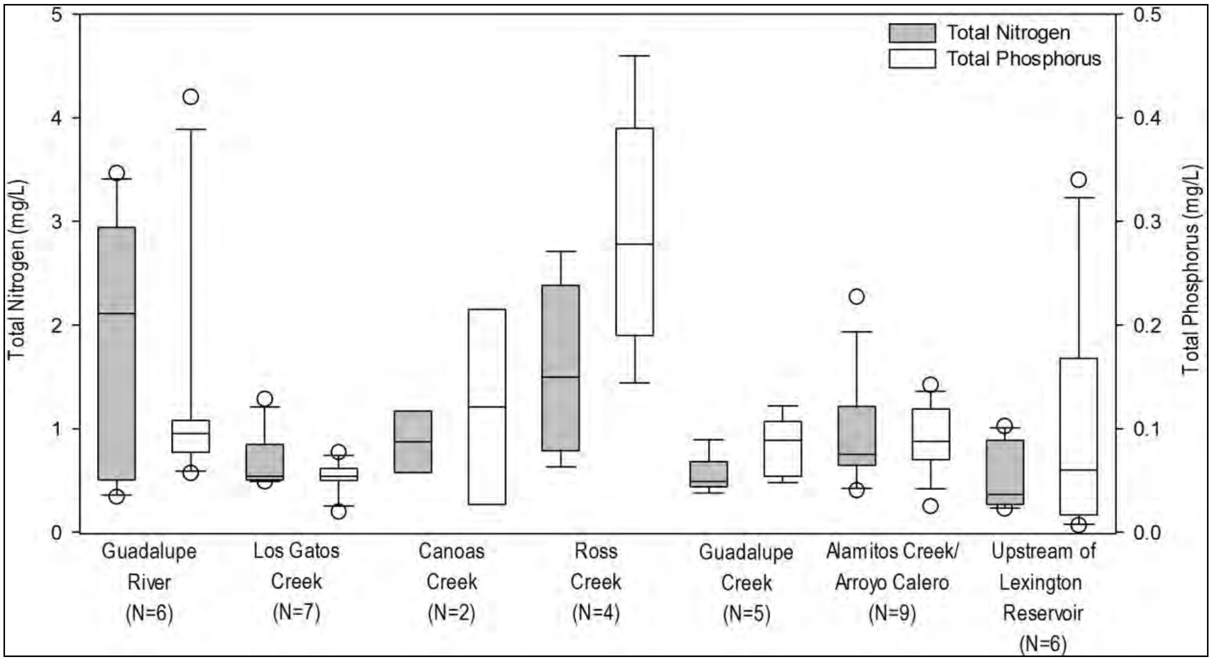

Figure 2.13. Total nitrogen and total phosphorus concentrations measured in water samples collected in the Guadalupe River watershed between WY 2012 and WY 2016.

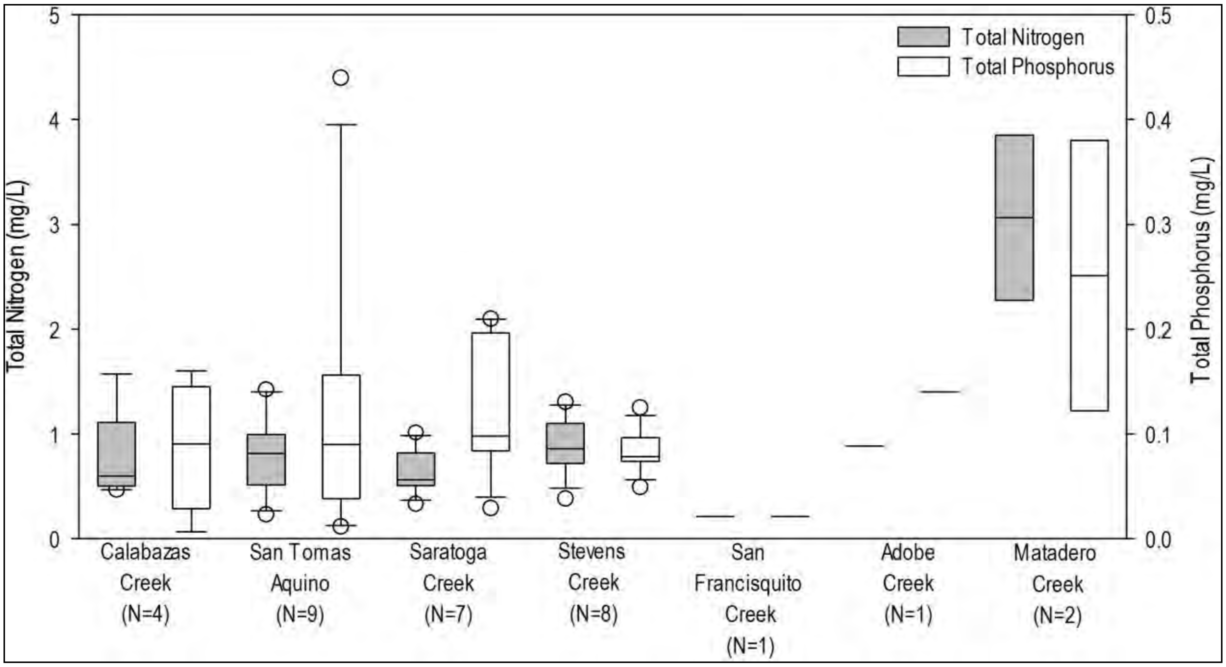

Figure 2.14. Total nitrogen and total phosphorus concentrations measured in water samples collected in Western Santa Clara Valley watersheds between WY 2012 and WY 2016.

In an effort to assess whether total nitrogen concentrations (measured during bioassessments) are affecting indicators of biomass (i.e., chlorophyll a, ash free dry mass, percent macro-algae cover), simple regression models were run. There was no correlation between total nitrogen concentration and chlorophyll a, ash free dry mass, or percent macro-algae cover in the Santa Clara County dataset (n=112). However, chlorophyll a and macro-algae cover were moderately correlated (r2 = 0.27, p value <0.05) (Figure 2.15) indicating that estimating algae cover during pebble counts may provide a reasonable estimate for algae biomass at bioassessment sites.

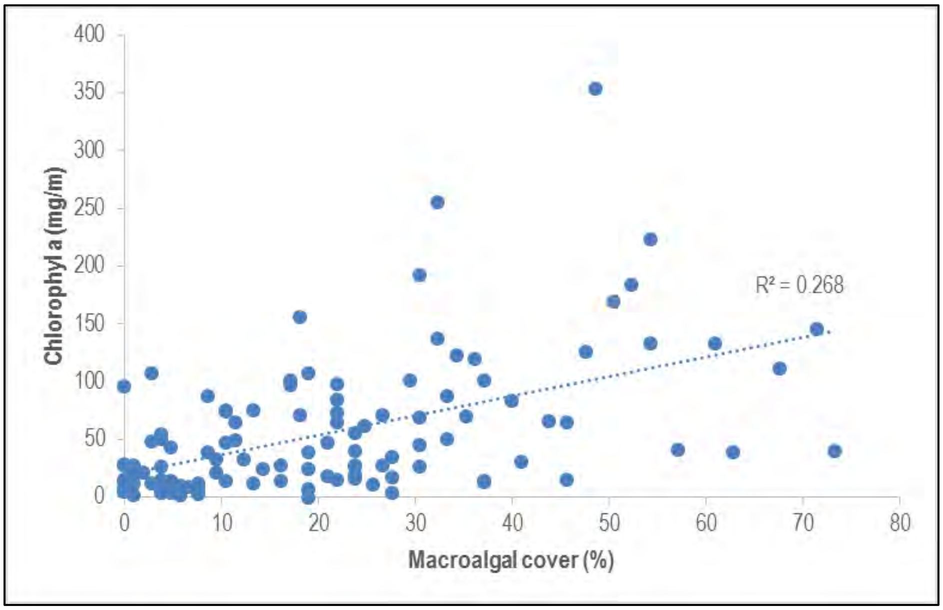

Figure 2.15. Plot of chlorophyll a concentrations with percent macro-algae cover measured at 112 bioassessments conducted WY 2012 through WY 2016 in Santa Clara County.

Stressor Association with Biological Condition

Spearman Correlations

Spearman Rank Correlations for environmental variables associated with CSCI and D18 scores are presented in Figures 2.16 and 2.17, respectively. Statistically significant variables (i.e., p <0.05) are indicated as shaded columns. Coefficients values greater than ±0.5 indicate a stronger relationship between the variable and the CSCI/D18 score.

- CSCI scores are negatively correlated with land use variables (percent impervious, percent urban), chloride, temperature, and specific conductivity. CSCI scores are positively correlated with two PHAB parameters (epifaunal substrate score and channel alteration score).
- D18 scores are negatively correlated with chloride and total nitrogen but are not well correlated with any other of the measured stressors.

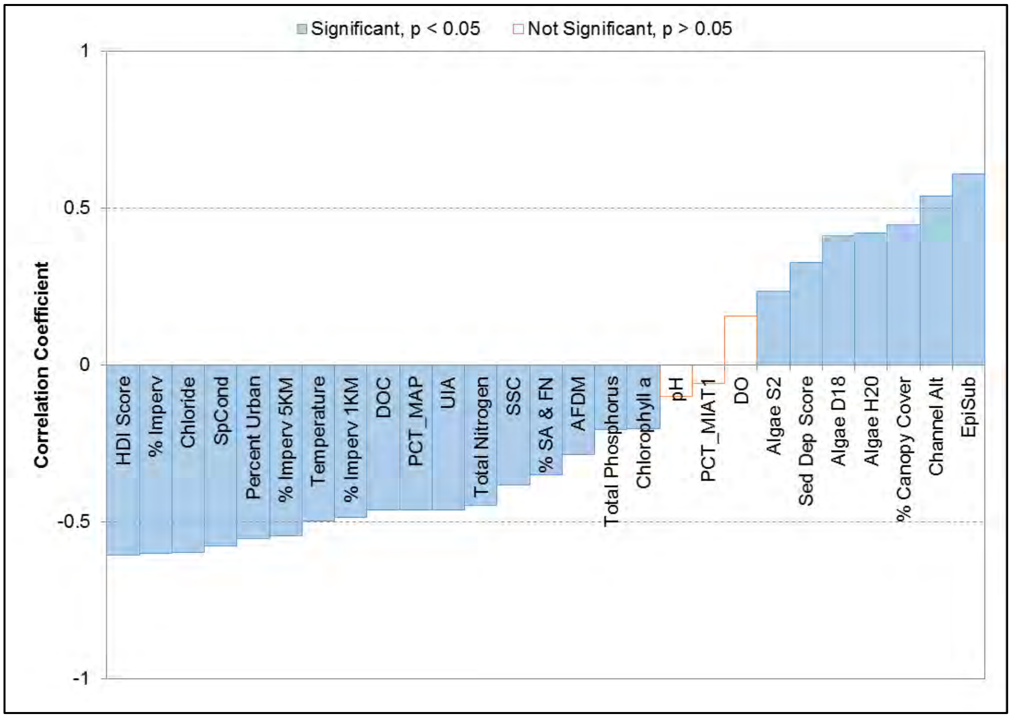

Figure 2.16. Spearman Rank Correlation for CSCI scores and stressor variable data collected at 20 bioassessment sites in Santa Clara County in WY2016.

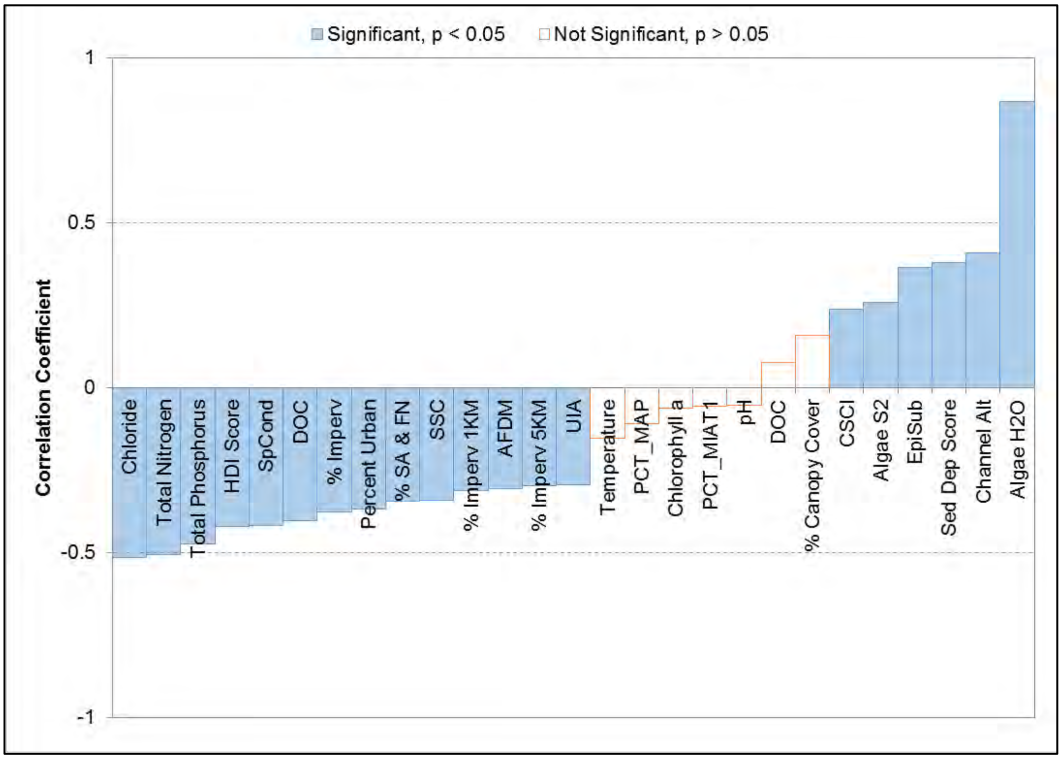

Figure 2.17. Spearman Rank Correlation for D18 scores and stressor variable data collected at 20 bioassessment sites in Santa Clara County in WY 2016

Random Forests

Figure 2.18 shows variable importance plots for potential stressors from the random forest analysis. Stressors with mean square error (%IncMSE) values are more important in explaining variability in CSCI scores. In this analysis, the five most important stressors are: elevation, specific conductance, epifaunal substrate, dissolved oxygen, and temperature. All of the stressors, except dissolved oxygen, were also identified through the Spearman Rank Correlation as statistically significant; albeit not as important as other variables. Dissolved oxygen was not found to be statistically significant though the Spearman Rank Correlation. The node purity (IncNodePurity) value relates to the loss function in the regression tree and is not as robust a measure of importance as %IncMSE. The random forest analysis was able to explain 59 percent of the variance in CSCI scores.

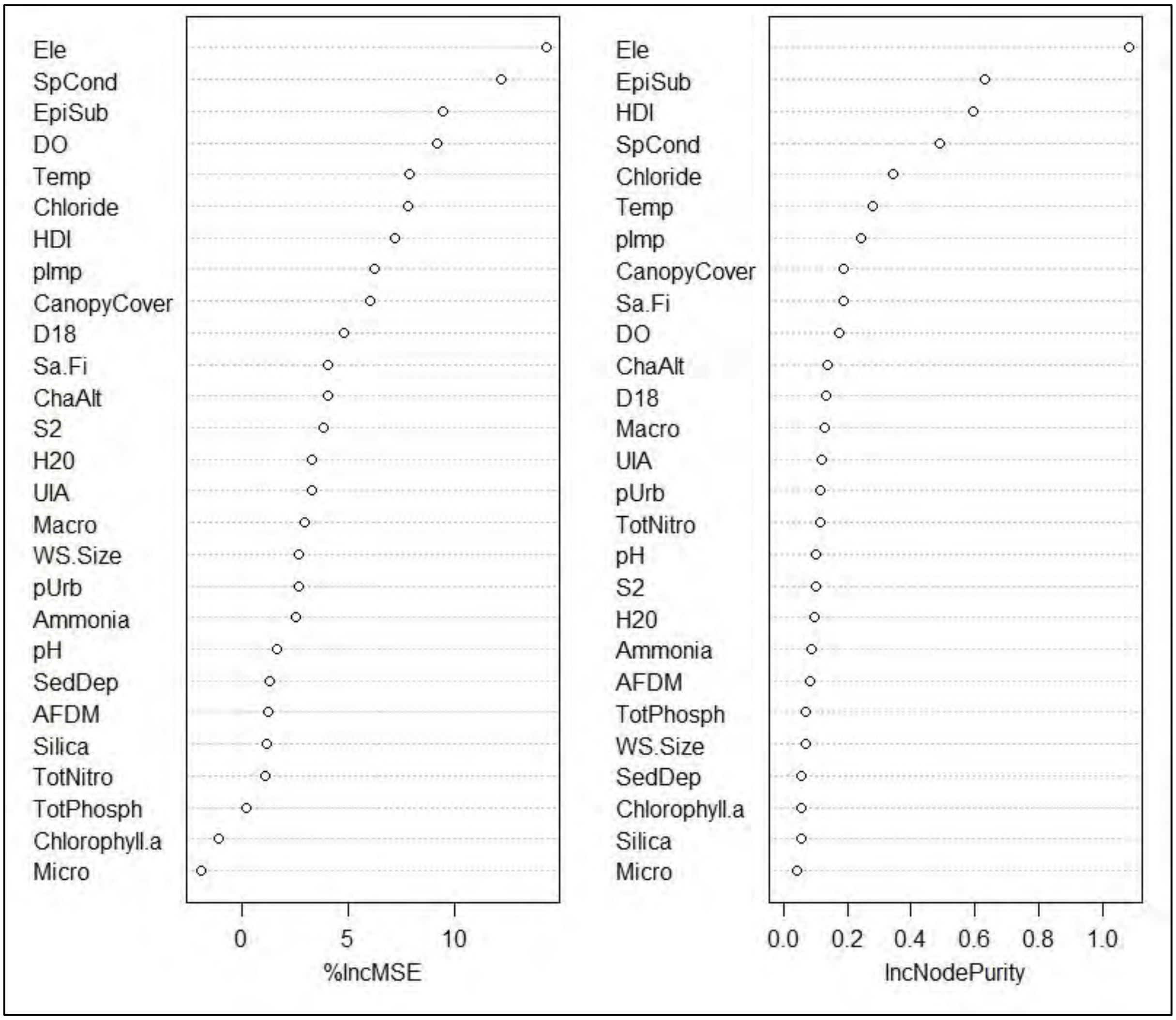

Figure 2.18. Variable importance for CSCI scores in Santa Clara County, WY 2012 – WY 2016.

2.4 Conclusions

Bioassessment monitoring in WY 2016 was conducted in compliance with provision C.8.d.i of the MRP. Twenty sites were sampled for BMIs, benthic algae, PHab observations, and nutrients. Stations were randomly selected using a probabilistic monitoring design. The following preliminary conclusions and recommendations are made based on these data.

Probabilistic Survey Design

- Site evaluations were conducted at a total of 76 potential probabilistic sites in Santa Clara County during WY 2016. Of these sites, a total of twenty were sampled in WY 2016 (rejection rate of 74%). Three of the twenty sites (15%) were classified as non-urban land use.
- Between WY 2012 and WY 2016, a total of 112 probabilistic sites were sampled by SCVURPPP (n=100) and SWAMP (n=12) in Santa Clara County, including 87 urban and 25 non-urban sites.
- There is a sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for urban streams in Santa Clara County (in development). More samples are needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas).

Biological Condition Assessment (WY 2016)

- The California Stream Condition Index (CSCI) tool was used to assess the biological condition. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. Of the 20 sites monitored in WY 2016, five sites (25%) were rated in good condition (CSCI scores ≥ 0.795); five sites rated as likely altered condition (CSCI score 0.635 – 0.795), and ten sites rated as very likely altered condition (≤ 0.635).
- The 15 sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- Diatoms were relatively well represented across all sites ranging from 15 to 61 taxa. Soft algae taxa were less common across sites, ranging from 1 to 10 taxa. Seven of the sites (30%) had three or less soft algae taxa.
- Three algae IBI metrics were used to evaluate stream condition using benthic algae data collected synoptically with BMIs. These include D18 (diatoms), S2 (soft algae), and H20 (combination of diatoms and algae). Eight sites were ranked in good condition based on D18 scores (D18 ≥ 62). Two sites were ranked in good condition based on S2 scores (S2 $\geq$ 47) and one site was ranked in good condition based on H20 scores (H20 ≥ 63).

Biological Condition Assessment (WY 2012-WY 2016)

- CSCI scores were calculated for the five-year Santa Clara County probabilistic data set (n=112). Good biological condition scores (CSCI score > 0.795) occurred at 11% of the urban sites and 52% of non-urban sites.
- There was no significant difference in median CSCI scores between perennial (n=85) and non-perennial (n=27) sites. Median algal IBI scores were slightly higher at non-perennial sites.
- The CSCI and three algae IBI tools showed were relatively consistent in their response across an urban gradient, with generally lower median scores associated with higher percent imperviousness.
- CSCI scores were better correlated with site elevation (r^2 = 0.34) compared to D18 scores (r^2 = 0.18), suggesting that physical habitat variables associated with changing elevation (e.g., stream gradient, substrate size) have greater influence on the BMI community compared to diatom assemblages.

Stressor Assessment

- Potential stressors (nutrients, algal biomass indicators, and conventional analytes) were measured in samples collected concurrently with bioassessments which are conducted in the spring season. Physical habitat parameters were also observed during bioassessments. Other potential stressors (e.g., percent urbanization/imperviousness in contributing catchments) were calculated in GIS.
- The association of potential stressors with biological condition scores collected over five years was assessed using the Spearman rank method and random forests. Land use variables (percent impervious and urban), chloride, temperature and specific conductivity showed significant negative correlations with CSCI scores. Two PHAB parameters (epifaunal substrate score and channel alteration score) were significantly positively correlated with CSCI scores.
- Water quality objectives were generally not exceeded in WY 2016.

Trend Assessment

- 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.

3.0 TARGETED MONITORING

3.1 Introduction

During WY 2016 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[15] 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 for future evaluation of Stressor Source Identification projects.

3.2 Study Area

In compliance with MRP, temperature was monitored at a minimum of eight sites, general water quality was monitored at three 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

From April through September 2016, Continuous (hourly) water temperature measurements were recorded at eight stations in the Upper Penitencia Creek watershed[16] ranging from 200 to 900 feet in elevation (Figure 3.1). Eight of the nine locations were on Upper Penitencia Creek and one site was in Arroyo Aguague, approximately 0.75 mile upstream of its confluence with Upper Penitencia Creek. The highest elevation site in both creeks were just downstream of waterfalls that are migration barriers for anadromous fishes. Six of the upper elevation sites are in Alum Rock Park, which supports both rearing and spawning habitat for steelhead, as well as other native fishes. All six sites had flowing water throughout the study period.

The two lowest elevation sites were located on the eastern edge of the Santa Clara Valley (sites 121 and 114). Only one of these “valley reach” sites had flow throughout the study period. This was the uppermost site (site 121), located just upstream of the stream gage at Dorel Drive. The lowest elevation site in the valley reach (site 114) continued to flow through late July as the result of discharges from the Robert Gross Percolation Ponds near Piedmont Avenue. Releases from the ponds stopped during the month of

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[15] 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."

[16] SCVURPPP typically monitors water temperature at more stations than the MRP required minimum to mitigate for potential equipment loss.

August and resumed in early September. The majority of the water that is stored in the ponds is imported from the Central Valley for the purposes of groundwater recharge.

During WY 2016, the Program conducted a Stressor Source Identification (SSID) project in Upper Penitencia Creek, evaluating a range of potential stressors that may cause reduced biological condition previously observed at site 114. Water temperature data collected at sites 114 and 121 for Creek Status Monitoring were also used to evaluate potential effects of temperature on biological condition at the same sites. Results from this SSID study are presented in Appendix B of the UCMR.

3.2.2 General Water Quality

Continuous (15-minute) general water quality measurements (dissolved oxygen, specific conductance, pH, and temperature) were recorded at three locations (sites 114, 117 and 121) in the Upper Penitencia Creek watershed during two sampling events in WY 2016 (Figure 3.1). The first event was in April and the second event was in June. The middle elevation site (117) went dry soon after the June event. The lowest elevation site (114) had flowing conditions through late July due to augmented water supply from percolation ponds. Water quality data collected for at these sites were used to evaluate potential impacts to biological condition as part of the Upper Penitencia Creek SSID Project (Appendix X of the UCMR).

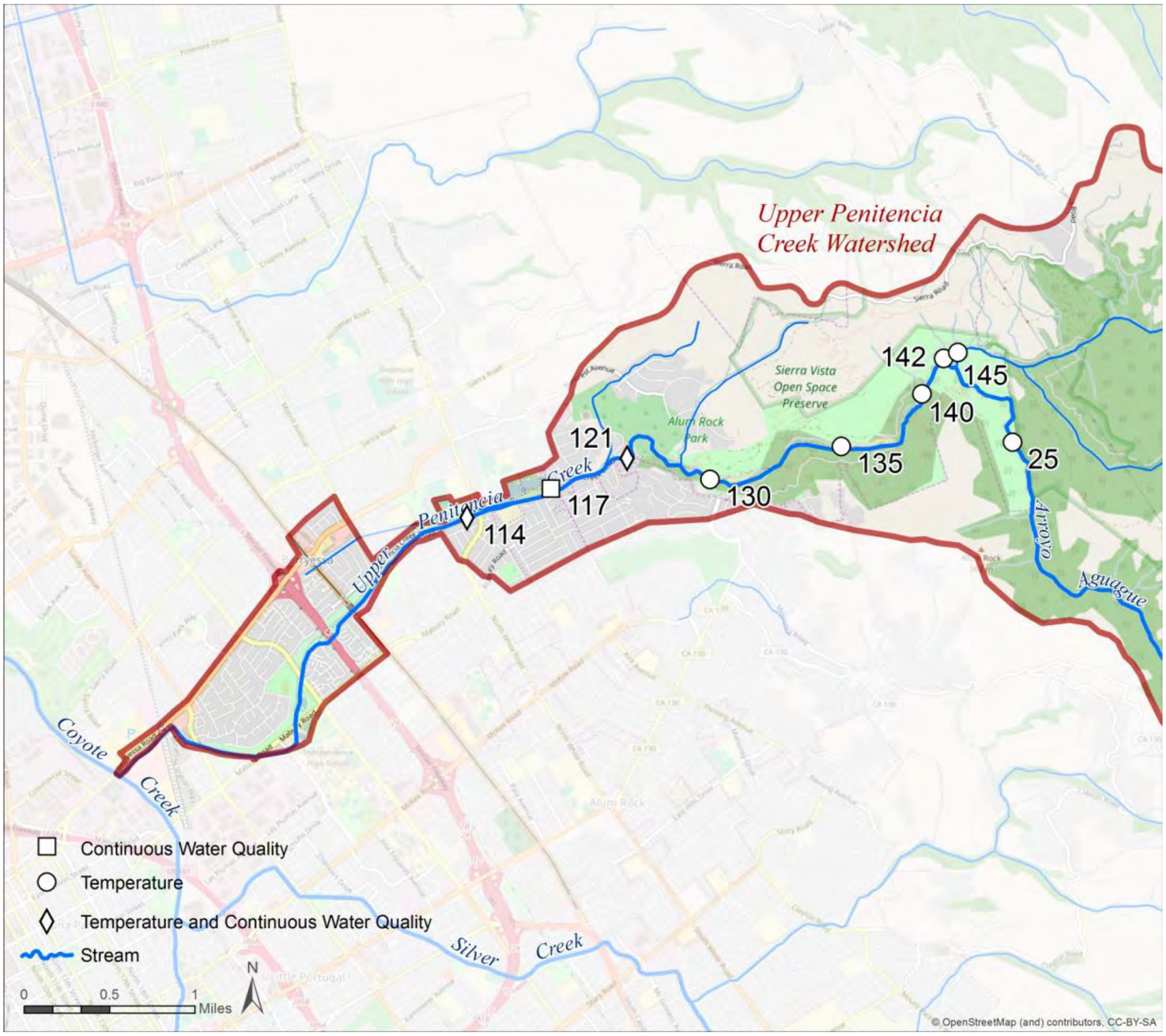

Figure 3.1. Continuous temperature and water quality monitoring stations deployed in Upper Penitencia Creek during WY 2016.

3.2.3 Pathogen Indicators

Pathogen indicator samples were collected at five sites located in municipal or county owned/operated parks in areas with good public access to creeks and potential for recreational water contact (Figure 3.2). Two of the five sites were in Upper Penitencia Creek; one site in Alum Rock Park (site 132) and one site adjacent to the Penitencia Creek Trail (site 117) at Noble Ave. One site was in Alamitos Creek adjacent to the Alamitos Creek Trail and another site was in Arroyo Calera Creek adjacent to the Calera Creek Trail. The last site was in Saratoga Creek at Wildwood Park, located in the Town of Saratoga. The five pathogen indicator sampling locations were also bioassessment monitoring sites in WY 2016.

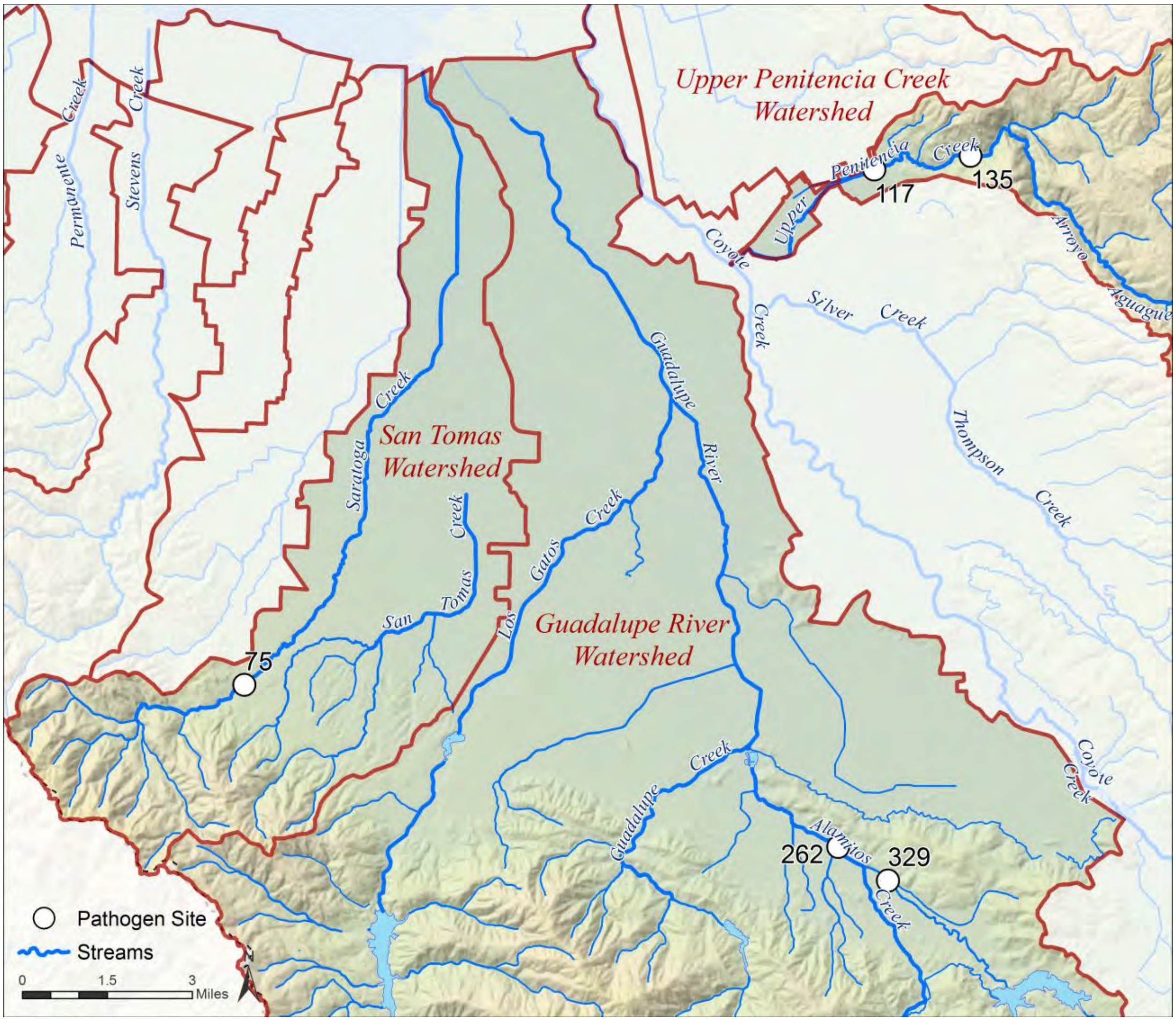

Figure 3.2. Pathogen indicator monitoring sites sampled in Santa Clara County during WY 2016.

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) were programmed to record data at 60-minute intervals and were deployed at targeted sites from April through September 2016. 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 Measurements

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 and once during summer season in 2016. Procedures for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016b).

3.3.3 Pathogen Indicators Sampling

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

3.3.4 Data Evaluation

Trigger Comparison

Continuous temperature, water quality, and pathogen indicator data generated during WY 2016 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). Provision C.8.d of the MRP (SFRWQCB 2015), 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 2.0 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	MRP 2.0 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			
Enteroccocus	≥ 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.

Temperature Trigger Considerations

Sullivan et al. (2000) is referenced in MRP Provision C.8.iii.(4) as the published source for the given trigger threshold(s) to use for evaluating water temperature data, specifically for creeks that have salmonid fish communities. The report summarizes results from previous field and laboratory studies investigating the effects of water temperature on salmonids of the Pacific Northwest and lists acute and chronic thresholds that can potentially be used to define temperature criteria. The authors identified annual maximum temperature (acute) and maximum 7-day weekly average temperature (MWAT) chronic indices as biologically meaningful thresholds. They found the MWAT index to be most correlated with growth loss estimates for juvenile salmonids, which can be used as a threshold for evaluating the chronic effects of temperature on summer rearing life stage.

Previous studies conducted by EPA (1977) identified a MWAT of 19°C for steelhead and 18°C for coho salmon. Using risk assessment methods, Sullivan et al (2000) identified lower thresholds of 17°C and 14.8°C for steelhead and coho respectively. The risk assessment method applied growth curves for salmonids over a temperature gradient and calculated the percentage in growth reduction compared to the growth achieved at the optimum temperature. The risk assessment analysis estimated that temperatures exceeding a threshold of 17°C would potentially cause 10% reduction in average salmonid growth compared to optimal conditions. In contrast, exceedances of the 19°C threshold derived by EPA (1977) would result in a 20% reduction in average fish growth compared to optimal conditions.

The lower MWAT thresholds presented in Sullivan et al. (2000) are based on data collected from creeks in the Pacific Northwest region, which exhibits different patterns of temperature associated with climate, geography and watershed characteristics compared to creeks supporting steelhead and salmon in Central California. Furthermore, a single temperature threshold may not apply to all creeks in the San Francisco Bay Area due to high variability in climate and watershed characteristics within the region.

In October 2016, the National Marine Fisheries Service (NMFS) released the Coastal Multispecies Final Recovery Plan for California Coastal Chinook, Northern California Steelhead and Central California Coast Steelhead. The Recovery Plan addresses the Central California Coast Steelhead Distinct Population Unit, which includes steelhead populations in the Santa Clara Valley watersheds. The plan includes an assessment of physical habitat and water quality as well as natural and anthropogenic threats to their habitat and survival. The NMFS developed a Conservation Action Planning (CAP) Analysis for the major watersheds supporting salmonid populations (e.g., Coyote Creek). Water temperature was one of the factors used to evaluate existing conditions for steelhead. The CAP utilized a threshold of 20°C for maximum weekly maximum temperature (MWMT), or 7-day maximum, to protect summer juvenile steelhead populations.

Previous studies evaluating the differences between MWMT and MWAT, have shown that MWMT better reflects transient water temperature peaks (Welsh et al. 2001) and any acute effects of the single point maximum temperature. The MWMT is suggested to be a more biologically meaningful parameter that can better predict the ability of a given waterbody to support cold-water adapted species. It is important to note however, that stream temperature affects rearing salmonids in interaction with many other factors, all of which vary with species and location. In cases where low flow conditions in concert with high temperatures during summer season are impacting steelhead populations, management actions that improve food availability (e.g., increase summer flow) may better address factors that are more critically limiting steelhead production. For monitoring, fish size thresholds at critical life stages such as smolting may be a much better indicator for understanding viability of steelhead populations (Atkinson et al. 2011).

In compliance with MRP Provision C.8.d, sites with temperature data exceeding the 17°C MWAT trigger threshold are added to the list of candidate SSID project. However, in an effort to develop a more meaningful understanding of the temperature data within the local context, SCVURPPP also compared the results to the 20°C MWMT threshold proposed by NMFS (2016) CAP.

3.4 Results and Discussion

3.4.1 Continuous Temperature

Summary statistics for continuous water temperature data collected at eight[17] sites in Upper Penitencia Creek during WY 2016 are listed in Table 3.2. Hourly temperature data was collected at six of the eight sites from March/April through September 2016. At the lowest elevation site (114), no water temperature data was collected in September due to dry channel conditions beginning in late August (note: water releases from percolation ponds was re-initiated in mid-September). One hobo device was not recovered at site 135 during a field check in June. A new device was re-deployed and data was collected from June through September.

Table 3.2. Descriptive statistics for continuous water temperature measured in Upper Penitencia Creek at eight sites during WY2016.

	Site	205COY114	205COY121	205COY130	205COY135	205COY140	205COY142	205COY145	205AAG025
	Start Date	3/24/2016	3/24/2016	4/5/2016	6/10/2016	4/5/2016	4/5/2016	4/5/2016	4/5/2016
	End Date	8/20/2016	9/20/2016	9/20/2016	9/20/2016	9/20/2016	9/20/2016	9/20/2016	9/20/2016
Temperature (ºC)	Min	8.2	8.2	9.9	13.5	9.6	9.2	8.9	9.0
	Median	19.5	17.2	17.3	18.2	15.3	15.0	14.8	15.6
	Mean	19.1	17.2	17.2	18.4	15.1	15.0	14.5	15.1
	Max	27.1	24.5	25.3	24.1	24.8	26.7	26.7	26.8
	Max 7-day mean	24.7	20.3	20.2	20.0	16.9	16.8	17.4	18.1
	N	3574	4321	4033	2450	4033	4033	4033	4033

Consistent with MRP requirements, MWAT was calculated for non-overlapping, 7-day periods. The number of 7-day periods ranged from 17 to 26. The total number and percent of weeks when the MWAT exceeded the 17°C trigger threshold are presented in Table 3.3. Five of the eight stations exceeded the MRP trigger threshold of having two or more 7 days periods where MWATs exceeded 17°C.

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[17] Hobos were originally deployed at nine sites, however, the hobo device at site 117 was not recovered. A new device was re-deployed in early June, but the creek went dry less than two weeks later. Thus, data collected at site 117 is too limited to compare with data collected at remaining sites for entire sampling period.

The MWAT values calculated from temperatures recorded at the four lowest elevation sites in Upper Penitencia Creek (sites 114, 121, 130, and 135) are plotted in Figure 3.3 (see Figure 3.1 for a map of their locations). MWAT values exceeded the MRP threshold at all four sites from the beginning of June to the end of August. The MWAT values were consistently higher at the lowermost site (114), with temperatures 3 to 4°C higher compared to site 121 during the months of June and July. Beginning in May, releases from the percolation ponds were augmenting flow at site 114 and are likely responsible for the relatively high temperatures.

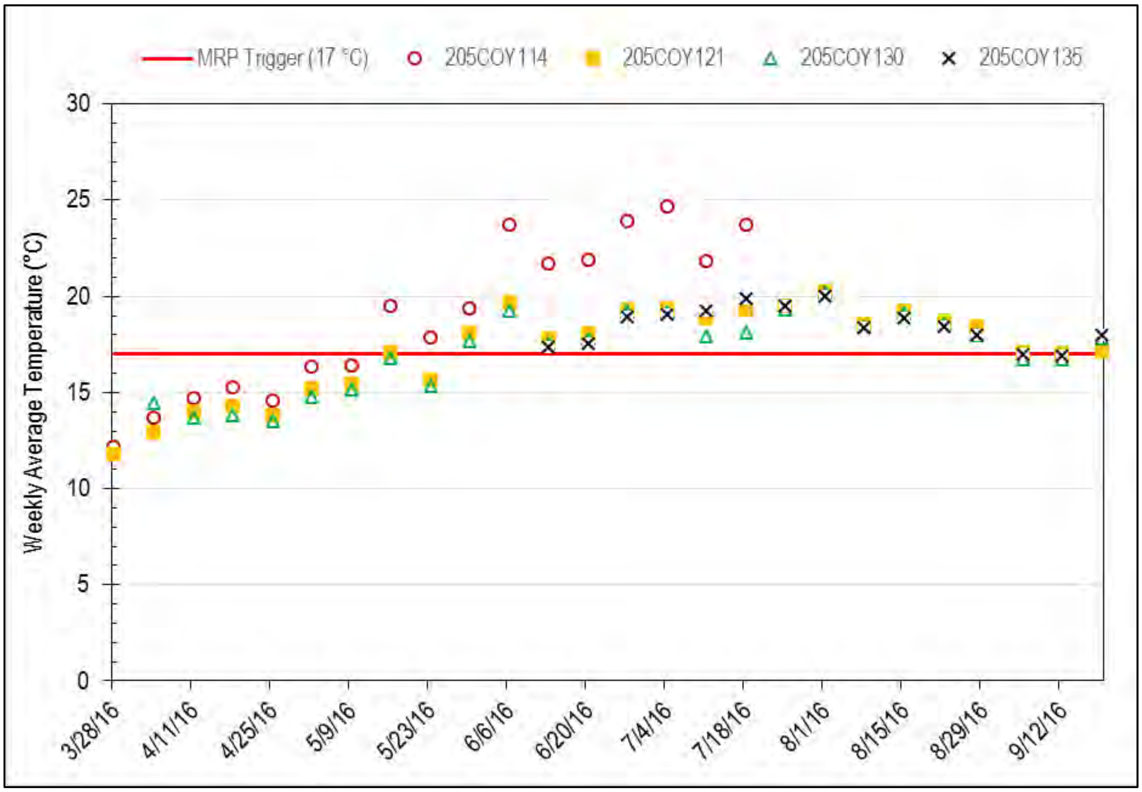

Figure 3.3. Plot of MWAT values calculated from temperatures collected at four lower elevation sites in Upper Penitencia Creek over 26 weeks of temperature monitoring. The MRP trigger (17°C) is shown for comparison.

The MWMT was calculated for each site by breaking the measurements into non-overlapping, 7-day periods. A threshold of 20°C for the MWMT was used to evaluate the data, similar to the temperature threshold for this criterion that was used by NMFS to evaluate the level of protection for summer juvenile steelhead populations in the Central Coastal Steelhead Recovery Plan. The total number and percent of weeks when the MWMT exceeded the 20°C threshold are presented in Table 3.3.

The MWAT threshold (17.0 °C) was exceeded more than three times more often compared to the MWMT temperature threshold (20.0 °C) at the four lower elevation sites, with the exception of site 114, which had the same number of exceedances. The four upper elevation sites had similar pattern for the two criteria (i.e., little or no exceedances occurred).

Table 3.3. MWAT and MWMT values for water temperature data collected at eight sites monitored in Upper Penitencia Creek in Santa Clara County, WY 2016. MWAT values that exceed MRP trigger (17°C) and MWMT values that exceed threshold (20°C) are indicated in bold. Data were not collected due to dry **channel "a" or device not recovered "b".**

Station	114		121		130		135		140		142		145		25	
Date	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT	MWAT	MWMT
3/28/2016	12.2	13.6	11.8	13.2	--	--	--	--	--	--	--	--	--	--	--	--
4/4/2016	13.7	15.8	13.0	14.7	14.5	14.8	b	b	12.8	12.9	12.7	12.7	12.2	12.3	12.7	12.7
4/11/2016	14.7	16.5	14.0	15.5	13.7	15.0	b	b	12.8	13.4	12.5	13.2	12.6	13.3	12.8	13.5
4/18/2016	15.3	16.8	14.3	15.6	13.9	15.2	b	b	12.4	13.4	12.0	13.0	11.9	13.2	12.2	13.4
4/25/2016	14.6	16.7	13.8	15.4	13.5	15.0	b	b	12.3	13.4	11.7	13.2	11.8	13.1	12.0	13.4
5/2/2016	16.4	17.3	15.2	16.1	14.8	15.7	b	b	13.0	13.9	12.4	13.5	12.5	13.8	12.8	13.9
5/9/2016	16.4	17.6	15.5	16.6	15.1	16.3	b	b	13.5	14.3	13.0	13.8	13.3	14.1	13.4	14.3
5/16/2016	19.5	21.0	17.1	18.9	16.8	18.5	b	b	14.4	15.2	13.9	15.0	14.2	15.1	14.4	15.5
5/23/2016	17.9	20.8	15.6	17.8	15.4	17.5	b	b	13.5	14.8	12.7	14.2	12.9	14.7	13.1	14.7
5/30/2016	19.4	21.5	18.1	19.6	17.7	19.1	b	b	14.8	15.7	14.3	15.5	14.6	16.0	14.9	16.1
6/6/2016	23.7	24.3	19.7	20.3	19.2	19.8	b	b	15.9	16.1	15.7	16.3	16.4	16.7	16.1	16.7
6/13/2016	21.7	22.8	17.8	18.8	17.6	18.4	17.3	18.4	15.0	15.6	14.4	15.2	15.3	16.2	14.6	15.6
6/20/2016	21.9	23.4	18.1	18.7	17.8	18.5	17.6	18.3	15.1	15.4	14.4	14.8	14.8	15.5	14.7	15.1
6/27/2016	23.9	25.2	19.3	20.4	19.2	20.2	18.9	20.0	15.9	16.5	15.5	16.5	16.0	16.8	15.9	16.8
7/4/2016	24.7	25.1	19.4	19.7	19.2	19.5	19.0	19.3	16.2	16.3	16.0	16.2	17.0	17.1	16.3	16.5
7/11/2016	21.9	23.5	18.9	19.6	17.9	18.7	19.3	19.8	15.9	16.3	15.6	15.9	16.3	16.7	17.0	18.3
7/18/2016	23.7	24.7	19.3	20.4	18.1	18.7	19.9	21.0	16.5	17.1	15.6	15.9	16.3	16.4	18.1	20.4
7/25/2016	a	a	19.5	21.0	19.3	20.8	19.5	20.8	16.3	16.9	15.8	16.8	16.3	16.8	16.2	17.2
8/1/2016	a	a	20.3	21.1	20.2	21.0	20.0	20.8	16.8	17.1	16.8	17.2	17.4	17.5	17.1	17.6
8/8/2016	a	a	18.5	19.0	18.4	18.9	18.4	18.8	16.2	16.4	15.6	16.0	16.9	17.3	15.9	16.2
8/15/2016	a	a	19.3	19.6	19.1	19.4	18.9	19.3	16.5	16.7	15.9	16.2	16.7	16.9	16.3	16.6
8/22/2016	a	a	18.8	19.3	18.5	19.1	18.5	18.9	16.4	16.6	15.9	16.2	16.9	17.0	16.2	16.5
8/28/2016	a	a	18.4	18.9	18.0	18.5	18.0	18.3	16.3	16.5	15.5	15.7	16.4	16.6	15.7	16.0
9/5/2016	a	a	17.1	17.9	16.7	17.5	17.0	17.7	15.8	16.1	14.7	15.3	15.5	16.0	14.9	15.5
9/12/2016	a	a	17.1	18.0	16.7	17.8	16.9	17.9	15.8	16.3	14.6	15.2	15.1	15.5	14.9	15.6
9/19/2016	a	a	17.2	18.6	17.8	18.2	18.0	18.2	16.9	16.3	16.2	15.4	16.3	15.1	16.5	15.9
Total Weeks	17		26		25		15		25		25		25		25	
MWMT >20	10	10	18	5	15	3	14	3	0	0	0	0	1	0	2	1
% Exceed	59	59	69	19	60	12	93	20	0	0	0	0	4	0	8	4
> MRP Trigger	Y	-	Y		Y		Y		N		N		N		Y	

The distribution of instantaneous temperature measured at the eight sites in Upper Penitencia Creek are shown in Figure 3.4. The acute temperature threshold (24.0 °C) is shown for comparison. Temperatures collected at all sites were generally below the acute threshold, with the exception site 114, which had approximately 12% of the data exceeding 24.0 °C. These exceedances coincided with period that discharge from percolation ponds were occurring during the months of June and July.

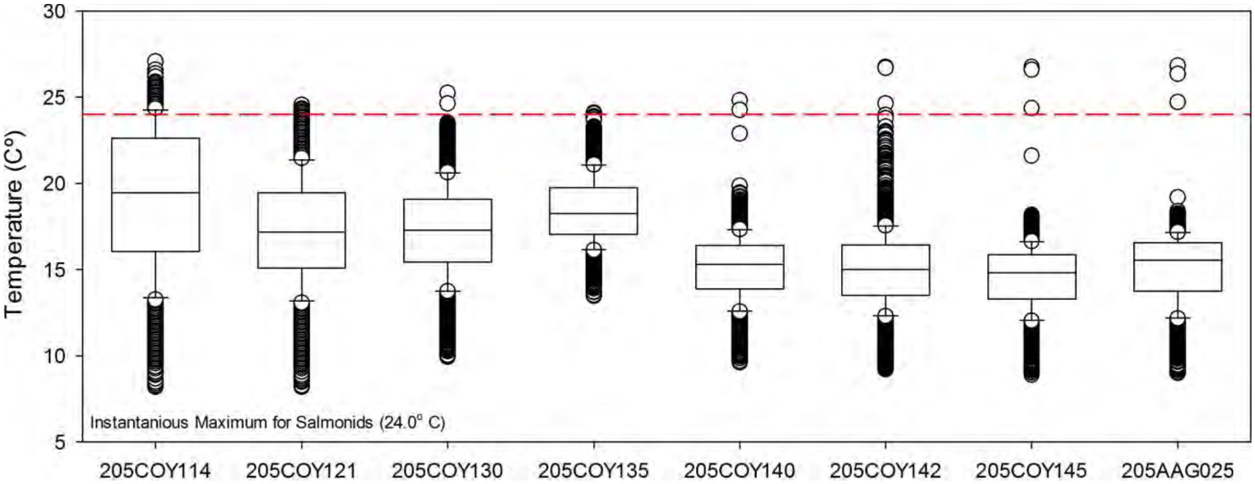

Figure 3.4. Box plots of water temperature data collected at eight stream locations in Upper Penitencia Creek, Santa Clara County, from April through September 2016.

The Basin Plan (SFRWQCB 2013) designates several Beneficial Uses for Upper Penitencia Creek that are associated with aquatic life uses, including COLD, WARM, MIGR, SPWN and RARE (Table 1.5). Furthermore, a limiting factors analysis study identified the reaches in Alum Rock Park as having the best quality steelhead spawning and juvenile rearing habitat within the Upper Penitencia Creek watershed (Stillwater 2006). The urban section of Upper Penitencia creek further downstream of Alum Rock Park is primarily a migrational corridor for steelhead. Stillwater (2006) identified potential low flow conditions reducing success of migrating steelhead smolts, especially in the urban reach, as the most important factor impacting success of migrating steelhead smolts.

Monitoring results from WY 2016 indicate that the upper reaches of Upper Penitencia Creek in Alum Rock Park have temperatures that support juvenile steelhead populations through the dry season. The MWAT (17 °C) threshold for steelhead was generally not exceeded at the four upper elevation sites (sites 140, 142, 145 and 25; Table 3.3). Site 25 exceeded the MWAT threshold for 2 of the 25 weeks of monitoring; however, one of those weeks was barely over the threshold (17.1 °C). The results were similar using the MWMT to evaluate temperature at the upper four sites; only one site (25) exceeded the MWMT threshold (20°C) for a single week.

Monitoring results indicate temperatures at the four lower elevation sites are not optimal for juvenile steelhead rearing habitat. However, with the exception of site 114, the remaining sites all had perennial flow that would allow juvenile steelhead to move further upstream in search of habitat with cooler temperatures. Longitudinal connectivity to areas where food is available can allow juvenile steelhead to increase feeding behavior and maintain optimal body weight to survive periods of warmer temperatures.

Site 114 is within an unconfined geological reach of Upper Penitencia Creek that contains alluvial deposits that percolates water into the underlying groundwater basin. As surface flows diminish during the late spring season, the creek typically dries up downstream Dorel Drive due to groundwater percolation. During WY 2016, stream flow at site 114 was present during spring and summer as the result of imported water getting released from the percolation ponds. The augmented water resulted in wetted channel for a short distance downstream (approximately Capital Expressway) until it percolated into the groundwater basin. Due to antecedent drought conditions, the groundwater level was relatively low during WY 2016, resulting in majority of surface water percolating into the groundwater basin.

3.4.2 General Water Quality

Summary statistics for general water quality measurements collected at the three sites in Upper Penitencia Creek during two sampling events in W Y2016 are listed in Table 3.4. Sample Events 1 and 2 were conducted in April and June, respectively. Sampling locations are mapped in Figure 3.1. Plots for all water quality parameters collected during Event 1 are shown in Figure 3.5 and for Event 2 in Figure 3.6.

Some of the water quality data were not included in the analyses due to malfunction of one or more sensors. At site 114, the dissolved oxygen sensor malfunctioned during the first half of deployment in April, presumably due to fine sediment clogging the probe. All parameters measured during the June sampling event at site 117 were flagged and not used in the analysis due to dry channel conditions.

Table 3.4. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at sites in Upper Penitencia Creek, Santa Clara County during WY2016. Data were collected every 15 minutes over a two two-week time periods during April (Event 1) and June (Event 2).

Parameter	Data Type	114	117	121	114	117[b]	121
		April WY2016			June WY2016		
Temperature (°C)	Min	10.3	9.9	9.9	19.2	11.9	13.3
	Median	14.5	14.0	13.6	21.6	16.8	17.5
	Mean	14.7	14.2	13.8	21.6	17.1	17.8
	Max	21.1	20.3	18.8	24.2	23.9	22.8
	% > 24 °C	0%	0%	0%	1%	0%	0%
Dissolved Oxygen (mg/L)	Min	8.0	8.9	9.0	8.0	0.5	7.2
	Median	9.9	10.4	10.4	8.8	9.8	8.8
	Mean	10.0	10.5	10.4	8.9	8.4	9.0
	Max	12.1	12.1	11.8	9.9	11.4	11.3
	% < 7 mg/L	0%	0%	0%	0%	0%	0%
pH	Min	7.9	8.4	8.2	7.7	7.3	8.2
	Median	8.1	8.5	8.5	8.0	8.2	8.3
	Mean	8.2	8.6	8.5	8.0	8.2	8.4
	Max	8.8	9.1	9.0	8.5	9.0	8.7
	% < 6.5 or 8.5	13%	50%	39%	0%	5%	28%
Specific Conductivity (uS/cm)	Min	240	65	507	286	485	977
	Median	722	630	721	305	583	1025
	Mean	705	626	699	305	600	1023
	Max	800	813	800	333	1028	1072
	% > 2000	0%	0%	0%	0%	0%	0%
Total number of data points (N)		1630[a]	1621	1623	1252	1262	1261

[a] Due to a sensor malfunction, the number of data points for dissolved oxygen was 1049.

[b] Data collected at site 117 during Event 2 was affected by no or low flow conditions and were not used to assess exceedance of MRP trigger.

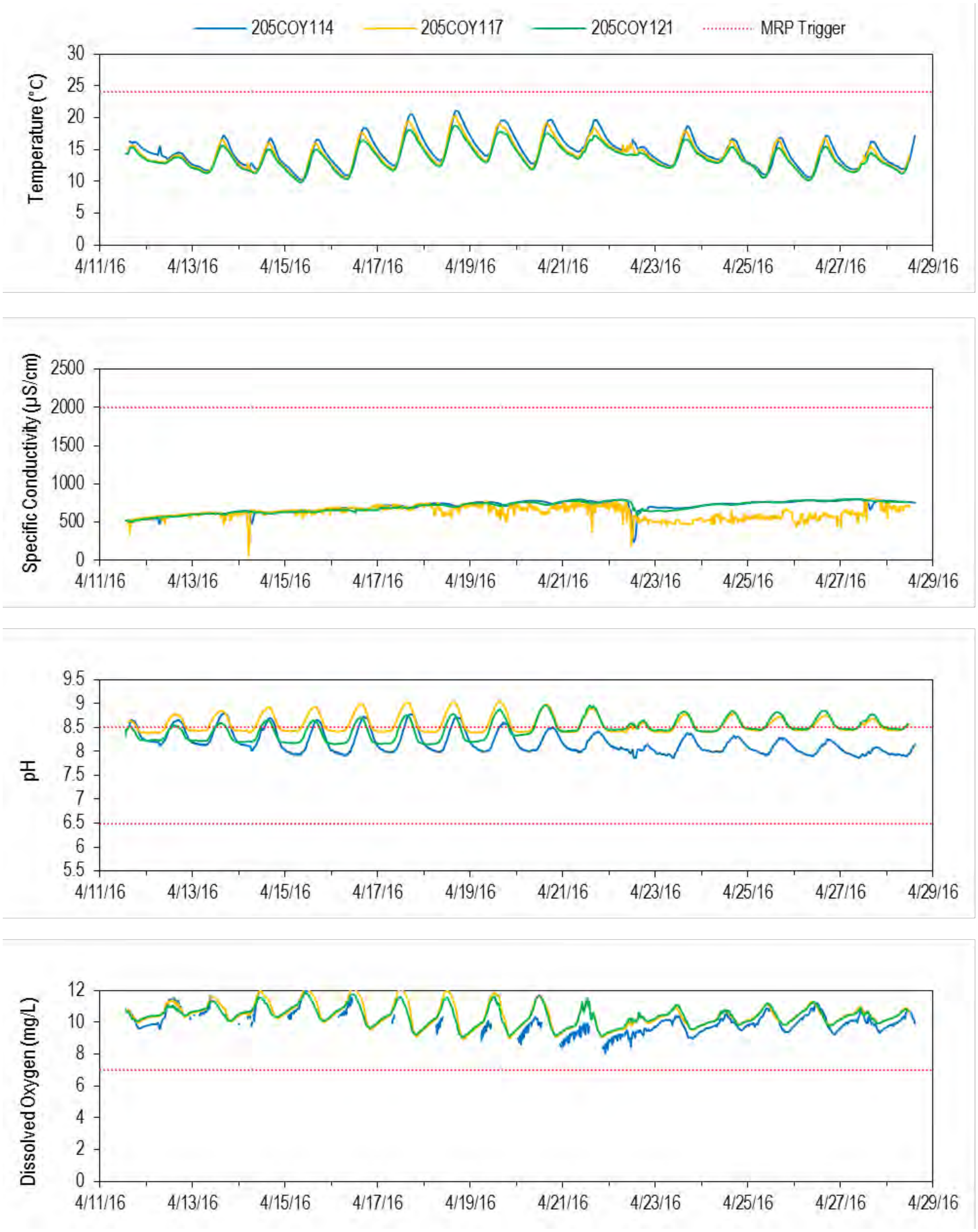

Figure 3.5 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at three sites in Upper Penitencia Creek in April, 2016.

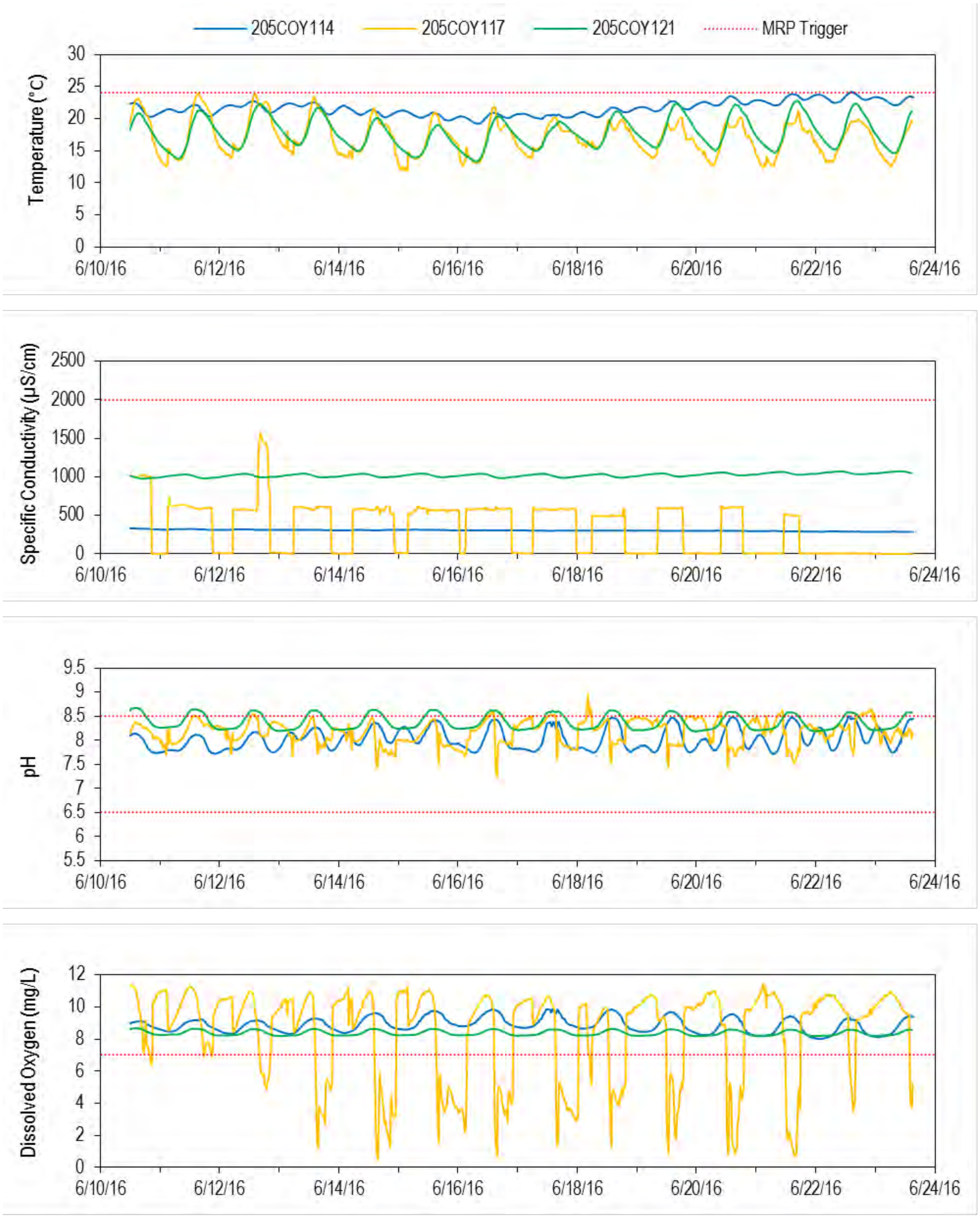

Figure 3.6 Continuous water quality data (temperature, specific conductance, pH, and dissolved oxygen) collected at three sites in Upper Penitencia Creek in June, 2016.

Temperature

Temperatures never exceeded the 24°C acute threshold for salmonids at any of the sites for either sampling event. MWAT was not calculated for temperature data collected by sondes due to limited number of data points (requires at least two 7 day periods to determine MRP trigger). However, MWAT was calculated for temperature data collected by hobos at sites 114 and 121 (see Section 3.4.1). The variability of temperatures at site 114 during Event 2 was much lower compared to other sites due to influence of water quality associated with the percolation pond discharge.

Dissolved Oxygen

Dissolved oxygen never dropped below WQOs for WARM or COLD Freshwater Habitat at any of the sites for both events, with the exception of site 117 in June. The DO sensor appeared to be affected by abrupt changes in flow and may have been periodically exposed to air and/or possible debris causing changes in flow. There was minimal flow at site 117 during sonde retrieval and the channel stopped flowing altogether by the end of June. As a result, this site will not be added to list of candidate SSID projects for DO.

pH

The MRP trigger for pH was exceeded at two monitoring locations. Site 121 (both events) and site 117 for April event had > 20% data greater than pH of 8.5. As a result, these two sites will be added to the list of candidate SSID projects. The pH was generally highest at the upper elevation site (121) for both events. The pH was reduced at site 114 midway through Event 1, possibly as a result of groundwater return flows associated with water diversion into the percolation ponds.

Specific Conductivity

Specific conductivity never exceeded the MRP trigger threshold (2000 µS) at the three sonde locations for either event.

Table 3.5. Exceedances of MRP water quality thresholds at three sites in Upper Penitencia Creek, Santa Clara County, WY 2016.

Site ID	Site Location	Monitoring Event	Temperature	Dissolved Oxygen	pH	Specific Conductivity
			Acute Trigger >20% results exceed 24˚C	< 7 mg/L or < 5 mg/L	> 8.5 or < 6.5	> 2000 µS
114	Piedmont Av	April	No	No	No	No
		June	No	No	No	No
117	Noble Av	April	No	No	Yes	No
		June[1]	No	No	No	No
121	Dorel Dr	April	No	No	Yes	No
		June	No	No	Yes	No

[1] Data were flagged due to sensor readings getting impacted by dry channel conditions. The data were not used in the analysis.

3.4.3 Pathogen Indicators

Pathogen indicator densities measured in water samples in WY 2016 are listed in Table 3.6. Stations are mapped in Figure 3.3.

Table 3.6. Enterococcus and *E. coli* levels measured in Santa Clara County during WY 2016.

Site ID	Creek Name	Site Name	*Enterococcus (cfu/100ml) (MPN/100ml)*[1]	*E. Coli (cfu/100ml) (MPN/100ml)* [1]	Sample Date
		MRP Trigger Threshold (USEPA 2012b)	*130*	*410*	
205R01731	Upper Penitencia Creek	Percolation Ponds	13	11	6/22/2016
205R02422	Arroyo Calero	Below Santa Therese Creek Confluence	110	340	6/22/2016
205R02458	Alamitos Creek	At Leland High School	140	280	6/22/2016
205R02474	Saratoga Creek	Wildwood Park	130	220	6/22/2016
205R02835	Upper Penitencia Creek	Alum Rock Park	140	110	6/22/2016

[1] USEPA 2012b 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.

All five creeks monitored for pathogen indicators are designated for both contact (REC-1) and non-contact (REC-2) recreation Beneficial Uses. Although none of the stations could be considered “bathing beaches,” monitoring locations at each creek were selected at city parks or trails that were considered to exhibit high potential for public access. The MRP threshold for *E. coli* was not exceeded at any of the sites. The MRP threshold for enterococcus was exceeded at two sites. These will be added to the list of candidate SSID projects.

3.5 Conclusions and Recommendations

Targeted monitoring in WY 2016 was conducted in compliance with Provisions C.8.d.iii – v of the MRP. Hourly temperature measurements were recorded at eight sites in the Upper Penitencia 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 Upper Penitencia Creek watershed during two 2-week periods in May (Event 1) and September (Event 2). Pathogen indicator grab samples were collected during a sampling event in June at five probabilistic sites throughout Santa Clara County that coincide with public parks. Stations were deliberatively selected using the Directed Monitoring Design Principle.

Conclusions and recommendations from targeted monitoring in WY 2016 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 in Water Quality

- Median water temperatures continuously measured in the Upper Penitencia Creek watershed were generally coolest at the four upper elevation sites in Alum Rock Park. Temperatures became elevated at the four lower elevation sites between May and September 2016. Water temperatures were highest at site 114 when it was influenced by discharge from upstream percolation ponds.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at eight targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, temperature) collected at three targeted stations.
- Five of the eight temperature stations in Upper Penitencia Creek exceeded the MRP trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of the ongoing drought and locally-derived temperature thresholds developed by NMFS suggests that temperature is not a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) beneficial uses (i.e., 7.0 mg/L) was met in all measurements recorded at the three water quality stations in Upper Penitencia Creek, with the exception of site 117, which had drops in DO that appeared to be related to significant drop in flow level during the dry season.
- Values for pH measured at the three sites in Upper Penitencia Creek during WY 2016 frequently exceeded the upper pH WQO of 8.5. As a result, all sites will be added to the list of potential SSID projects.
- Specific conductivity recorded at the three Upper Penitencia Creek sites in WY 2016 was consistently below the MRP trigger threshold of 2000 us/cm.

Potential Impacts to Water Contact Recreation

- Pathogen indicator densities were measured at five targeted sites during WY 2016. Although none of the stations could be considered “bathing beaches,” monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. MRP trigger thresholds for *E. coli* (410 cfu/100 ml) were not exceeded. MRP trigger thresholds for enterococcus (130 cfu/100 ml) were exceeded at two sites: one site on the Alamitos Creek at Leland High School and one on Upper Penitencia Creek at Alum Rock Park. These sites will be added to the list of candidate SSID projects.
- 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. Pathogen indicators observed at the WY 2016 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality objectives and criteria for full body contact recreation, may not be appropriate and should be interpreted cautiously.

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 MS4s 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 Creek Status Monitoring Provision C.8.d.ii and to assess whether the chlorine in receiving waters is potentially toxic to the aquatic life living there, SCVURPPP measured total and free chlorine residual in urban creeks. Total chlorine residual is comprised of combined and free chlorine, and is always greater than or equal to the free chlorine residual. Combined chlorine is the chlorine that has reacted with ammonia or organic nitrogen to form chloramines, while free chlorine is the chlorine that is remains unbound.

4.2 Methods

In accordance with the MRP and the BASMAA RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2012), WY 2016 field testing for free chlorine and total chlorine residual was conducted at all 20 probabilistic sites concurrent with spring bioassessment sampling (April-May). 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 (BASMAAS 2016b), water samples were collected and analyzed for free and total chlorine using a Pocket Colorimeter^{TM} 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 to 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 2016, SCVURPPP monitored the 20 probabilistic sties for free chlorine and total chlorine residual. These measurements were compared to the MRP trigger threshold of 0.1 mg/L.[18] Results are listed in Table 4.1.

The Lower Silver Creek sample (and the resample) on June 3, 2016 exceeded the threshold of 0.1 mg/L for free chlorine and total chlorine residual. The field crew noted nearby active construction activities which may have been related to the chlorine observations. SCVURPPP staff immediately informed City of San Jose Watershed Protection Division staff and the Senior Environmental Inspector. City staff indicated that the report would be logged and an environmental inspector would be sent out to inspect the construction site. City staff reported that follow-up measurements were at or below the MRP trigger and determined that either the source of the higher readings had stopped, or that the original results were in error.

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[18] For reference, 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 residual chlorine.

Table 4.1. Summary of SCVURPPP chlorine testing results compared to MRP trigger of 0.1 mg/L, WY 2016.

Station Code	Date	Creek	Free Chlorine (mg/L)[1, 2]	Total Chlorine Residual (mg/L)[1, 2]	Exceeds Trigger Threshold? [3] (0.1 mg/L)
205R00213	4/27/2016	Cow Creek	< 0.02	0.03	No
205R00305	4/27/2016	San Felipe Creek	< 0.02	0.05	No
205R00578	4/26/2016	Arroyo Aguague	0.09 / 0.07	0.05	No
205R01114	5/3/2016	Guadalupe River	0.02	0.05	No
205R01731	5/5/2016	Upper Penitencia Creek	0.03	0.03	No
205R02330	5/3/2016	Ross Creek	0.02	0.06	No
205R02422	5/4/2016	Arroyo Calero	0.02	0.02	No
205R02458	5/4/2016	Alamitos Creek	0.03	0.04	No
205R02474	5/18/2016	Saratoga Creek	0.03	0.05	No
205R02538	5/18/2016	Calabazas Creek	0.03	0.03	No
205R02547	6/1/2016	Stevens Creek	< 0.02	0.02	No
205R02563	5/19/2016	Los Gatos Creek	< 0.02	-	No
205R02602	6/2/2016	Unnamed Trib	0.02	0.02	No
205R02618	5/2/2016	Aldercroft Creek	< 0.02	0.04	No
205R02650	5/31/2016	Alamitos Creek	0.02	0.04	No
205R02659	5/19/2016	Stevens Creek	< 0.02	0.02	No
205R02730	6/1/2016	Saratoga Creek	0.06	0.05	No
205R02762	6/2/2016	Ross Creek	0.04	< 0.02	No
205R02771	6/3/2016	Lower Silver Creek	0.26 / 0.25	0.40 / 0.91	Yes
205R02835	5/5/2016	Upper Penitencia Creek	< 0.02	< 0.02	No

[1] The method detection limit is 0.02 mg/L.

[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 Santa Clara Valley urban creeks, WY 2016 and prior monitoring results suggest there are occasional free chlorine and total chlorine exceedances in the County. Exceedances are likely 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. The Program 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 toxic effects (acute and chronic) of all the chemicals in samples of receiving waters or sediments and allows the cumulative effect of the pollutants present in the sample to be evaluated. 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 is conducted synoptically with toxicity monitoring to provide 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

The Program is required to conduct water toxicity and sediment chemistry and toxicity monitoring at two locations during the dry season, 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 dilutus* (survival).
- Toxicity testing in sediment is required using two species: *Hyella azteca* (survival) and *Chironomus dilutus* (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 for toxicity testing and analysis of pyrethroids, fipronil, imidacloprid and indoxacarb. The permit states that sample event(s) must occur during wet weather, but does not specify whether a “storm event” must be sampled. The permit states that monitoring locations should be representative of urban watersheds (i.e., bottom of watersheds).

The permit states that if the wet season monitoring is conducted by the RMC on behalf of all Permittees, a total of ten 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. The RMC is still in the process of allocating sample sites and developing a monitoring approach. The assumption is that SCVURPPP will be responsible for collecting three wet weather samples during the permit term.

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

5.2 Methods

5.2.1 Site Selection

In WY 2016, in compliance with MRP Provision C.8.g.i, water and sediment toxicity and sediment chemistry samples were collected from two sites during dry weather: Stevens Creek and San Thomas

Aquino (see Figure 1.2). Sites were selected to represent urban watersheds that are not already being monitored for toxicity or pesticides by other programs, such as the SWAMP Stream Pollution Trends (SPoT) program or the California Department of Pesticide Regulation (DPR) Surface Water Protection Program Monitoring (SWPP). Specific stations within the watersheds were identified based on the likelihood that they would contain fine depositional sediments during dry season sampling and would be safe to access during future wet weather sampling. It is anticipated that SCVURPPP will continue to sample the same two stations throughout the permit term with the goal of building a long-term dataset that compliments data being gathered through SWAMP SPoT and DPR SWPP.

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.

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. Therefore, some of the calculated numbers for TEC and PEC quotients may be artificially elevated (and contribute to trigger exceedances) due to the method used to account for filling in 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 Santa Clara Valley. All sites in Santa Clara 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 they pyrethroids are ubiquitous in the urban environment and little is known about fipronil and carbaryl distribution. However, SCVURPPP computed toxicity unit (TU) equivalents for individual pyrethroid and fipronil results, based on available literature values for pyrethroids in sediment LC50 values.[19,20] Because organic carbon mitigates the toxicity of pyrethroid and fipronil 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 2016 dry weather water and sediment samples. Based on the results, it is not necessary to add the sites to the list of potential SSID projects.

- **San Tomas Aquino (205STQ010).** The water sample collected from San Tomas Aquino was not significantly toxic to any of the test organisms. The sediment sample was found to be significantly toxic to *Chironomus dilutus* (survival); however, the Percent Effect did not exceed the 50% threshold for follow-up.
- **Stevens Creek (205STE021).** The water sample collected from Stevens Creek was found to be significantly toxic to *Chironomus dilutus* (survival) and *Pinephales promelas* (survival); however, the Percent Effect of both tests was less than the 50% threshold for follow-up. The sediment sample was not significantly toxic to any of the test organisms.

The cause of the water and sediment toxicity is unknown; however, the midge, *Chironomus dilutus*, has been shown to be the most sensitive species to newer classes of pesticides such as imidacloprid (a neonicotinoid) and fipronil and its degradates (SWAMP 2016). Imidacloprid is not included in the list of required dry weather analytical constituents but will be required in water samples collected during wet weather. Fipronil was analyzed in WY 2016 dry weather sediment samples. The concentration of fipronil was below the method detection limit in both the San Tomas Aquino and Stevens Creek samples.

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

[20] No LC50 is published for carbaryl.

Table 5.1. Summary of SCVURPPP toxicity results for WY 2016.

Site	Organism	Test Type	Unit	Results		TST Result	% Effect	Follow up needed (TST "Fail" and **≥50%)**
				Lab Control	Organism Test			
205STQ010 San Tomas Aquino	Water							
	Ceriodaphnia dubia	Survival	%	90	100	Pass[1]	-11.1%	No
		Reproduction	Num/Rep	34.7	32.1	Pass	7.49%	No
	Pimephales promelas	Survival	%	92.5	91.9	Pass	0.68%	No
		Growth	mg/ind	0.626	0.677	Pass	-8.12%	No
	Chironomus dilutus	Survival	%	100	95	Pass	5%	No
	Hyalella azteca	Survival	%	98	98	Pass	0%	No
	Selenastrum capricornutum	Growth	cells/ml	1620000	2700000	Pass	-66.7%	No
	Sediment							
	Chironomus dilutus	Survival	%	92.5	76.3	Fail	17.6%	No
	Hyalella azteca	Survival	%	100	96.3	Pass	3.75%	No
205STE021 Stevens Creek	Water							
	Ceriodaphnia dubia	Survival	%	90	100	Pass[1]	-11.1%	No
		Reproduction	Num/Rep	34.7	32.4	Pass	6.50%	No
	Pimephales promelas	Survival	%	92.5	67.5	Fail	27%	No
		Growth	mg/ind	0.626	0.605	Pass	3.35%	No
	Chironomus dilutus	Survival	%	100	70	Fail	30%	No
	Hyalella azteca	Survival	%	98	100	Pass	-2.04%	No
	Selenastrum capricornutum	Growth	cells/ml	1620000	3120000	Pass	-92.3%	No
	Sediment							
	Chironomus dilutus	Survival	%	92.5	81.3	Pass	12.2%	No
	Hyalella azteca	Survival	%	100	98.8	Pass	1.25%	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. SCVURPPP also evaluated TU equivalents of pyrethroids.

Table 5.2 lists TEC quotients for all non-pyrethroid, fipronil, and carbaryl sediment chemistry constituents, calculated as the measured concentration divided by the highly conservative TEC value, per MacDonald et al. (2000)[21]. TECs are extremely conservative and are intended to identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. Both of the sites 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. In both creeks, there were TEC exceedances of chromium and nickel as expected in watersheds draining hillsides underlain by serpentinite formations. In Stevens Creek (205STE021), the TEC for copper was also exceeded.

Table 5.3 provides PEC quotients for all non-pyrethroid, fipronil, and carbaryl sediment chemistry constituents, and calculated mean values of the PEC quotients for each site. PECs are intended to identify concentrations above which toxicity to benthic-dwelling organisms are predicted to be probable. Neither of the sites had any PEC quotient equal to or greater than 1.0.

Table 5.4 provides a summary of the calculated TU equivalents for the pesticides for which there are published LC50 values in the literature[22]. 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 at each site, and the TOC-normalized concentrations were used to compute TU equivalents. Although no TU equivalents exceeded 1.0, the highest TU equivalent in both samples was calculated for bifenthrin (0.78). Bifenthrin is considered to be the leading cause of pyrethroid-related toxicity in urban areas (Ruby 2013).

In compliance with the MRP, a grain size analysis was conducted on both of the sediment samples (Table 5.5). The Stevens Creek (205STE021) sample was 8% fines (i.e., 4% clay and 4% silt); whereas the San Tomas Aquino (205STQ010) sample was 15% fines (i.e., 6% clay and 9% silt). It unknown whether these differences in percent fines influenced the toxicity tests or sediment chemistry analysis and evaluation.

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[21] 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.

[22] Although an LC50 value has not been published for carbaryl, the carbaryl concentration is included in Table 5.4.

Table 5.2. Threshold Effect Concentration (TEC) quotients for WY 2016 sediment chemistry constituents. Bolded and shaded values indicate TEC quotient ≥ 1.0.

		WY 2016	
Site ID		205STE021	205STQ010
Creek	TEC	Stevens Creek	San Tomas Aquino
Metals (mg/kg DW)			
Arsenic	9.79	0.30	0.26
Cadmium	0.99	0.21	0.14
Chromium	43.4	1.7	1.1
Copper	31.6	1.23	0.8
Lead	35.8	0.39	0.28
Nickel	22.7	3	2.1
Zinc	121	0.81	0.58
PAHs (ug/kg DW)			
Anthracene	57.2	0.09	0.03 [a]
Fluorene	77.4	0.04 [b]	0.02 [a]
Naphthalene	176	0.01 [a]	0.01 [a]
Phenanthrene	204	0.20	0.10
Benz(a)anthracene	108	0.09	0.04 [b]
Benzo(a)pyrene	150	0.05	0.01 [a]
Chrysene	166	0.31	0.12
Dibenz[a,h]anthracene	33.0	0.05 [a]	0.05 [a]
Fluoranthene	423	0.19	0.05
Pyrene	195	0.37	0.10
Total PAHs	1,610	0.21 [c]	0.08 [c]

a. Concentration was below the method detection limit (MDL). TEC quotient calculated using 1/2 MDL.
b. TEC quotient calculated from concentration below the reporting limit (DNQ-flagged).
c. Total calculated using 1/2 MDLs.

Table 5.3. Probable Effect Concentration (PEC) quotients for WY 2016 sediment chemistry constituents. No PEC quotients exceeded 1.0.

Site ID		205STE021	205STQ010
Creek	PEC	Stevens Creek	San Tomas Aquino
Metals (mg/kg DW)			
Arsenic	33.0	0.09	0.08
Cadmium	4.98	0.04	0.03
Chromium	111	0.6	0.41
Copper	149	0.26	0.17
Lead	128	0.11	0.08
Nickel	48.6	1.3	1.0
Zinc	459	0.21	0.15
PAHs (ug/kg DW)			
Anthracene	845	0.01	0.00 [a]
Fluorene	536	0.01 [b]	0.00 [a]
Naphthalene	561	0.00 [a]	0.00 [a]
Phenanthrene	1170	0.04	0.02
Benz(a)anthracene	1050	0.01	0.00 [b]
Benzo(a)pyrene	1450	0.01	0.00 [a]
Chrysene	1290	0.04	0.02
Fluoranthene	2230	0.04	0.01
Pyrene	1520	0.05	0.01
Total PAHs	22,800	0.01 [c]	0.01 [c]

a. Concentration was below the method detection limit (MDL). PEC quotient calculated using 1/2 MDL.

b. PEC quotient calculated from concentration below the reporting limit (DNQ-flagged).

c. Total calculated using 1/2 MDLs.

Table 5.4. Calculated pyrethroid toxic unit (TU) equivalents for WY 2016 pesticide concentrations.

			WY 2016	
			205STE021	205STQ010
Pyrethroid	Units	LC50	Stevens Creek	San Tomas Aquino
Bifenthrin	µg/g dw	0.52	0.78	0.39
Cyfluthrin	µg/g dw	1.08	0.13	0.15
Cypermethrin	µg/g dw	0.38	0.03 [b]	0.15 [b]
Deltamethrin	µg/g dw	0.79	0.19	0.11 [b]
Esfenvalerate	µg/g dw	1.54	0.02 [b]	0.02 [a]
Lambda-Cyhalothrin	µg/g dw	0.45	0.03 [b]	0.03 [a]
Permethrin	µg/g dw	10.83	0.03	0.03
Other MRP Pesticides of Concern				
Carbaryl	mg/Kg dw	NA[c]	NA [c]	NA [c]
Fipronil	ng/g dw	410	0.01 [b]	0.01 [b]

[a] Concentration was below the method detection limit (MDL). TU equivalents calculated using 1/2 MDL.
[b] TU equivalents calculated from concentration below the reporting limit (DNQ-flagged).
[c] Currently there is no available LC50 value for Carbaryl, however the observed concentration was below the detection limit.

Table 5.5. Summary of grain size for the two locations sampled in Santa Clara during WY 2016.

Grain Size (%)		205STE021	205STQ010
		Stevens Creek	San Tomas Aquino
Clay	<0.0039 mm	4%	6%
Silt	0.0039 to <0.0625 mm	4%	9%
Sand	V. Fine 0.0625 to <0.125 mm	29%	20%
	Fine 0.125 to <0.25 mm	27%	25%
	Medium 0.25 to <0.5 mm	6%	13%
	Coarse 0.5 to <1.0 mm	11%	13%
	V. Coarse 1.0 to <2.0 mm	19%	15%
Granule	2.0 to <4.0 mm	13%	12%
Pebble	Small 4 to <8 mm	2%	0%
	Medium 8 to <16 mm	0%	4%
	Large 16 to <32 mm	0%	0%
	V. Large 32 to <64 mm	0%	25%

5.4 Conclusions and Recommendations

Statistically significant toxicity to *Chironomus dilutus* was observed either water or sediment samples collected from both sites during dry weather**;** however, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria. Although the midge, *Chironomus dilutus*, has been observed to be sensitive to fipronil, fipronil concentrations measured in sediment samples collected concurrently with the water and sediment toxicity samples were below the method detection limit.

TEC and PEC quotients were calculated for all metals and PAHs measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations 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 most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel.

6.0 CONCLUSIONS AND RECOMMENDATIONS

In WY 2016, 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), SCVURPPP 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 2016 in Santa Clara 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.

6.1 Conclusions

6.1.1 Bioassessment Monitoring

Probabilistic Survey Design

- Site evaluations were conducted at a total of 76 potential probabilistic sites in Santa Clara County during WY 2016. Of these sites, a total of twenty were sampled in WY 2016 (rejection rate of 74%). Three of the twenty sites (15%) were classified as non-urban land use.
- Between WY 2012 and WY 2016, a total of 112 probabilistic sites were sampled by SCVURPPP (n=100) and SWAMP (n=12)[23] in Santa Clara County, including 87 urban and 25 non-urban sites.
- There is a sufficient number of samples from probabilistic sites to develop estimates of biological condition and stressor assessment for urban streams in Santa Clara County (in development). More samples are needed to estimate biological condition at more local scales (e.g., watershed and jurisdictional areas).

Biological Condition Assessment (WY 2016)

- The California Stream Condition Index (CSCI) tool was used to assess the biological condition. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. Of

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[23] The data from three SWAMP samples collected in WY 2015 were not available for analyses in this report. Data results from nine probabilistic sites sampled by SWAMP are included in this report.

the 20 sites monitored in WY 2016, five sites (25%) were rated likely intact or possibly intact (CSCI scores ≥ 0.795); five sites rated as likely altered condition (CSCI score 0.635 – 0.795), and ten sites rated as very likely altered condition (≤ 0.635).

- The 15 sites with CSCI scores less than the trigger threshold of 0.795 will be added to the list of candidate SSID projects.
- Diatoms were relatively well represented across all sites ranging from 15 to 61 taxa. Soft algae taxa were less common across sites, ranging from 1 to 10 taxa. Seven of the sites (30%) had three or less soft algae taxa.
- Three algae IBI metrics were used to evaluate stream condition using benthic algae data collected synoptically with BMIs. These include D18 (diatoms), S2 (soft algae), and H20 (combination of diatoms and algae). Eight sites were ranked likely intact or possibly intact based on D18 scores (D18 ≥ 62). Two sites were ranked likely intact or possibly intact based on S2 scores (S2 ≥ 47) and one site was ranked likely intact or possibly intact based on H20 scores (H20 ≥ 63).

Biological Condition Assessment (WY 2012-WY 2016)

- CSCI scores were calculated for the five-year Santa Clara County probabilistic data set (n=112). Condition ranking of likely intact or possibly intact (CSCI score > 0.795) occurred at 11% of the urban sites and 52% of non-urban sites.
- There was no significant difference in median CSCI scores between perennial (n=85) and non-perennial (n=27) sites. Median algal IBI scores were slightly higher at non-perennial sites.
- The CSCI and three algae IBI tools were relatively consistent in their response across an urban gradient, with generally lower median scores associated with higher percent imperviousness.
- CSCI scores were better correlated with site elevation ($r^2 = 0.34$) compared to D18 scores ($r^2 = 0.18$), suggesting that physical habitat variables associated with changing elevation (e.g., stream gradient, substrate size) have greater influence on the BMI community compared to diatom assemblages.

Stressor Assessment

- Potential stressors (nutrients, algal biomass indicators, conventional analytes) were measured in samples collected concurrently with bioassessments which are conducted in the spring season. Physical habitat parameters were also observed during bioassessments. Other potential stressors (e.g., percent urbanization/imperviousness in contributing catchments) were calculated in GIS.
- The association of potential stressors with biological condition scores collected over five years was assessed using the Spearman rank method and random forests. Land use variables (percent impervious and urban), chloride, temperature and specific conductivity showed significant negative correlations with CSCI scores. Two PHAB parameters (epifaunal substrate score and channel alteration score) were significantly positively correlated with CSCI scores.
- Water quality objectives were generally not exceeded in WY 2016.

Trend Assessment

- 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.

6.1.2 Targeted Monitoring for Temperature and General Water Quality

Spatial and Temporal Variability in Water Quality

- Median water temperatures continuously measured in the Upper Penitencia Creek watershed were generally coolest at the four upper elevation sites in Alum Rock Park. Temperatures became elevated at the four lower elevation sites between May and September 2016. Water temperatures were highest at site 114 when it was influenced by discharge from upstream percolation ponds.

Potential Impacts to Aquatic Life

- Potential impacts to aquatic life were assessed through analysis of continuous temperature data collected at eight targeted stations and continuous general water quality data (pH, dissolved oxygen, specific conductance, temperature) collected at three targeted stations.
- Five of the eight temperature stations in Upper Penitencia Creek exceeded the MRP trigger threshold of having two or more weeks where the maximum weekly average temperature (MWAT) exceeded 17°C. None of the stations exceeded the maximum instantaneous trigger threshold of 24°C.
- All stations with MWAT trigger exceedances will be added to the list of candidate SSID projects; however, review of the monitoring data in the context of the ongoing drought and locally-derived temperature thresholds developed by NMFS suggests that temperature is not a limiting factor for salmonid habitat (i.e., summer rearing juveniles) in the study reaches.
- The WQO for DO in waters designated as having cold freshwater habitat (COLD) beneficial uses (i.e., 7.0 mg/L) was met in all measurements recorded at the three water quality stations in Upper Penitencia Creek, with the exception of site 117, which had drops in DO that appeared to be related to significant drop in flow level during the dry season.
- Values for pH measured at the three sites in Upper Penitencia Creek during WY 2016 frequently exceeded the upper pH WQO of 8.5. As a result, all sites will be added to the list of potential SSID projects.
- Specific conductivity recorded at the three Upper Penitencia Creek sites in WY 2016 was consistently below the MRP trigger threshold of 2000 us/cm.

Potential Impacts to Water Contact Recreation

- Pathogen indicator densities were measured at five targeted sites during WY 2016. Although none of the stations could be considered “bathing beaches,” monitoring locations were selected at city parks or trails that were considered to have a relatively high potential for public access. MRP trigger thresholds for *E. coli* (410 cfu/100 ml) were not exceeded. MRP trigger thresholds for enterococcus (130 cfu/100 ml) were exceeded at two sites: one site on the Alamitos Creek at Leland High School and one on Upper Penitencia Creek at Alum Rock Park. These sites will be added to the list of candidate SSID projects.
- 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. Pathogen indicators observed at the WY 2016 stations may not be associated with human sources and therefore may not pose a threat to human health. As a result, the comparison of pathogen indicator results to water quality objectives and criteria for full body contact recreation, may not be appropriate and should be interpreted cautiously.

6.1.3 Chlorine Monitoring

Monitoring of total and free chlorine residual at probabilistic stations was conducted in compliance with provision C.8.d.ii of the MRP.

While chlorine residual is generally not a concern in Santa Clara Valley urban creeks, WY 2016 and prior monitoring results suggest there are occasional free chlorine and total chlorine exceedances in the County. The Program 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 2016, SCVURPPP conducted dry weather pesticides and toxicity monitoring at two stations in compliance with provision C.8.g of the MRP.

Statistically significant toxicity to *Chironomus dilutus* was observed either water or sediment samples collected from both sites during dry weather; however, the magnitude of the toxic effects in the samples compared to laboratory controls were not great and did not exceed MRP trigger criteria. Although the midge, *Chironomus dilutus*, has been observed to be sensitive to fipronil, fipronil concentrations measured in sediment samples collected concurrently with the water and sediment toxicity samples were below the method detection limit.

TEC and PEC quotients were calculated for all metals and PAHs measured in sediment samples. Both sites had at least one TEC or PEC quotient exceeding 1.0. In compliance with the MRP, both stations 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 most of the TEC and PEC quotient exceedances are related to naturally occurring chromium and nickel.

SCVURPPP will continue to sample the same two stations for dry weather pesticides and toxicity throughout the permit term. In WY 2018, SCVURPPP anticipates working with the BASMAA RMC partners on 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. 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 will be selected from this list. Table 6.1 lists candidate SSID projects based on WY 2016 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 SCVURPPP Trigger Threshold Exceedance Analysis, WY 2016**. “No” indicates samples were collected but did not exceed the MRP trigger; “Yes” indicates an exceeda**nce of the MRP trigger.

Probabilistic Station Number	Targeted Station Number	Creek	Bioassessment [1]	Nutrients [2]	Chlorine	Water Toxicity	Sediment Toxicity	Sediment Chemistry	Continuous Temperature	Continuous WQ	Pathogen Indicators
205R00213		Cow Creek	Yes	No	No	--	--	--	--	--	--
205R00305		San Felipe Creek	No	No	No	--	--	--	--	--	--
205R00578		Arroyo Aguague	Yes	No	No	--	--	--	--	--	--
205R01114		Guadalupe River	Yes	No	No	--	--	--	--	--	--
205R01731	205COY117	Upper Penitencia Creek	Yes	No	No	--	--	--	--	Yes	No
205R02330		Ross Creek	Yes	No	No	--	--	--	--	--	--
205R02422	205GUA329	Arroyo Calero	Yes	No	No	--	--	--	--	--	No
205R02458	205GUA262	Alamitos Creek	Yes	No	No	--	--	--	--	--	Yes
205R02474	205SAR075	Saratoga Creek	No	No	No	--	--	--	--	--	No
205R02538		Calabazas Creek	Yes	No	No	--	--	--	--	--	--
205R02547		Stevens Creek	No	No	No	--	--	--	--	--	--
205R02563		Los Gatos Creek	Yes	No	No	--	--	--	--	--	--
205R02602		Tributary to San Tomas	No	No	No	--	--	--	--	--	--
205R02618		Aldercroft Creek	No	No	No	--	--	--	--	--	--
205R02650		Alamitos Creek	Yes	No	No	--	--	--	--	--	--
205R02659		Stevens Creek	Yes	No	No	--	--	--	--	--	--
205R02730		Saratoga Creek	Yes	No	No	--	--	--	--	--	--
205R02762		Ross Creek	Yes	No	No	--	--	--	--	--	--
205R02771		Lower Silver Creek	Yes	No	Yes	--	--	--	--	--	--
205R02835	205COY135	Upper Penitencia Creek	Yes	No	No	--	--	--	Yes	--	Yes
	205STE021	Stevens Creek	--	--	--	No	No	Yes	--	--	--
	205STQ010	San Thomas Aquino	--	--	--	No	No	Yes	--	--	--
	205AAG025	Arroyo Aguague	--	--	--	--	--	--	Yes	--	--
	205COY114	Upper Penitencia Creek	--	--	--	--	--	--	Yes	No	--
	205COY121	Upper Penitencia Creek	--	--	--	--	--	--	Yes	Yes	--
	205COY130	Upper Penitencia Creek	--	--	--	--	--	--	Yes	--	--
	205COY140	Upper Penitencia Creek	--	--	--	--	--	--	No	--	--
	205COY142	Upper Penitencia Creek	--	--	--	--	--	--	No	--	--
	205COY145	Upper Penitencia Creek	--	--	--	--	--	--	No	--	--

Notes:
1. CSCI score ≥ 0.795.
2. Unionized ammonia (as N) ≥ 0.025 mg/L, nitrate (as N) ≥ 10 mg/L, chloride > 250 mg/L.

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 the Santa Clara Valley and identifying stressors and sources of impacts observed. Although the sample size from WY 2016 (overall n=20; urban n=17) 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 2015 and is analyzed with the full five-year dataset (n=112). 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. Additionally, episodic or site specific increases temperature (particularly in lower creek reaches) may not be optimal for aquatic life in local creeks.

The Program and its Co-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, the Program and Co-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 Co-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) Co-permittees continue to implement programs 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 2016 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 2016 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, the Santa Clara Valley Water District's Integrated Water Resources Master Plan (IWRMP) or "One Water Plan" is an ongoing, multi-year process to develop a framework for long-term management of Santa Clara county water resources. The One Water Plan will identify, prioritize and implement activities at a watershed scale to meet flood protection, water supply, water quality and environmental stewardship goals and objectives. The Santa Clara Valley Water District was also recently awarded a Proposition 1 grant to develop a Storm Water Resource Plan for the Santa Clara Basin that will support the development and implementation of MRP-required Green Infrastructure Plans and produce a list of prioritized runoff capture and use projects eligible for future State implementation grant funds. Through the continued implementation of MRP-associated and other watershed stewardship programs, SCVURPPP 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.

In recognition of SCVURPPP's accomplishments, the Water Environment Federation (WEF) awarded SCVURPPP the Overall Highest Score for a Phase 1 Municipal Stormwater Program and Gold Level for Innovation and Program Management. The awards are part of the National Municipal Stormwater and Green Infrastructure Awards program, led by WEF through a cooperative agreement with the U.S. Environmental Protection Agency (USEPA). The awards program was established in 2015 to recognize high-performing regulated MS4s throughout the United States. The objective of the program is to inspire MS4 program leaders to seek new and innovative ways to meet and exceed regulatory requirements in a manner that is both technically effective as well as financially efficient.

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ATTACHMENTS

Attachment 1

QA/QC Report

Quality Assurance/Quality Control Report

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Prepared for:

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

March 31, 2017

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ACRONYMS

BASMAA	Bay Area Stormwater Management Agencies Association
BMI	Benthic Macroinvertebrates
DQO	Data Quality Objective
EDDs	Electronic data deliverables
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PAH	Polycyclic Aromatic Hydrocarbon
PR	Percent Recovery
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RPD	Relative Percent Difference
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCVURPPP	Santa Clara Valley Urban Pollution Prevention Program
SFRWQCB	San Francisco Regional Water Quality Control Board
SOP	Standard Operating Procedures
STE	Standard Taxonomic Effort
SWAMP	Surface Water Ambient Monitoring Program

1. INTRODUCTION

In Water Year 2016 (WY 2016; October 1, 2015 through September 30, 2016), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) 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). SCVURPPP 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, some WY 2016 data were rejected (continuous dissolved oxygen results) and some data were flagged. However, overall, WY 2016 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 SCVURPPP 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)

- City of San Jose, Environmental Services Department Laboratory (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 SCVURPPP 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 Santa Clara Valley urban creeks.

2.2. COMPARABILITY

In addition to the bioassessment and field sampling training, SCVURPPP 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 SCVURPPP 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, SCVURPPP 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.

For bioassessments, the SCVURPPP 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.

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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

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 SCVURPPP staff member reviewed the field sheets again, and noted any missing data.

2.3.3. Laboratory Results

SCVURPPP 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 SCVURPPP, 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
EV = 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 °C, it is replaced.

2.6. PRECISION

2.6.1. Field Duplicates

For creek status monitoring, duplicate biological samples were collected at 10% (two) of the 20 probabilistic sites and duplicate water chemistry samples were collected at 5% (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. SCVURPPP collected one field duplicate 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 2016. 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

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. In addition to a laboratory blank that was run with each batch, the RMC QAPP requires the collection and analysis of field blank samples at a rate of 5% for orthophosphate. This equates to a total of one samples for the 20 samples collected in Santa Clara County.

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 SCVURPPP 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 Santa Clara Valley Creeks.

3.2. OVERALL PROJECT COMPARABILITY

SCVURPPP 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

The BMI taxonomic laboratory, BioAssessment Services, received the RMC QAPP, and 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

SCVURPPP completed bioassessments and physical habitat assessments for all 11 transects at 20 of 20 planned/required sites for a 100% sampling completion rate. However, the analytical laboratory lost the chlorophyll a sample filter collected for site 205R01731 and could not analyze the sample[4]. The loss of one sample is acceptable as SCVURPPP met the QAPP target completion rate of 95% for chlorophyll a, and exceeded the target with a 100% completion rate for all other parameters.

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.

The reporting limits for ash free dry mass analysis (8-13 mg/L) were 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 two BMI samples submitted to a separate QC taxonomic laboratory had no major taxonomic discrepancies. 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 metrics met their respective MQOs. 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 no protocol for evaluating the accuracy of algae taxonomic identification.

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[4] The sample was assigned a “LST” QA code to indicate that the sample was lost.

Table 1. Quality control metrics for taxonomic identification of benthic macroinvertebrates collected in Santa Clara County in WY 2016 compared to measurement quality objectives.

Quality Control Metric	Error Rate	MQO	Exceeds MQO?
Absolute Recount	2.37%	< 5% [a]	No
Taxa ID	4.92%	≤ 10%	No
Individual ID	0.95%	≤ 10%	No
Lower Taxonomic Resolution Individual	0%	≤ 10%	No
Lower Taxonomic Resolution Count	0%	≤ 10%	No

[a] the RMC QAPP MQO for recount accuracy is ≥ 95%

3.3.4. Precision

Duplicate algae and BMI samples were collected at two sites in WY 2016 and were sent to the taxonomic laboratories for identification. However, only one duplicate sample was collected for chlorophyll a and ash free dry mass, due to a staff mistaking those analytes for water chemistry parameters and not biological parameters.

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 greatly exceeded the MQO. 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 site 205R02618, collected on May 20, 2016.

Analyte Name	Fraction Name	Unit	Original Result	Duplicate Result	RPD	Exceeds MQO (>25%)[a]
Chlorophyll a	Particulate	mg/m^2	3.8	6.37	51%	Yes
Ash Free Dry Mass	Fixed	g/m^2	9.89	107.24	166%	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 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 20 bioassessment sites for a 100% completeness rate.

3.4.2. Sensitivity

Free and total chlorine residual were measured using a HACH Pocket Colorimeter^{TM} 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 does not need to be calibrated.

3.4.4. Precision

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

3.5. WATER CHEMISTRY

Water chemistry samples were collected by SCVURPPP 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

SCVURPPP collected 100% of planned/required water chemistry samples at the 20 bioassessment sites including one duplicate sample (5% of total project sample count). 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 and method detection limit for all nitrate samples were higher than the target reporting limit, but one sample, collected at 205R01114, was affected and flagged as “detected, not quantified” when it would have been quantified at the lower reporting limit. SCVURPPP will discuss the nitrate reporting limit with Caltest for future analysis. Target and actual reporting limits are shown in Table 3.

Table 3. Target and actual reporting limits for nutrients analyzed in SCVURPPP creek status monitoring.

Analyte	Target RL mg/L	Actual RL mg/L
Ammonia	0.02	0.02
Chloride	0.25	1-100
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
Ash Free Dry Mass	2	2
Chlorophyll a	N/A	50

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. Seven MS/MSD percent recoveries exceeded the MQO range listed in the RMC QAPP for various conventional analytes, including ammonia, phosphorus, total Kjeldahl nitrogen (TKN), and silica. The affected samples 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 7%, well below the MQO target of < 25%.

The field duplicate samples exceeded the RPD MQO for total Kjeldahl nitrogen. 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 Table 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 205R02618, collected on May 20, 2016. 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	0.015	< 0.015	NA	No
Chloride	None	mg/L	15	16	6%	No
Nitrate as N	None	mg/L	0.54	< 0.02	NA	No
Nitrite as N	None	mg/L	0.001	0.001	0%	No
Nitrogen, Total Kjeldahl	None	mg/L	0.48	0.35	31%	Yes
Orthophosphate as P	Dissolved	mg/L	0.081	0.065	22%	No
Phosphorus as P	Total	mg/L	0.087	0.084	4%	No
Silica as SiO2	Total	mg/L	23	23	0%	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. Phosphorus was detected but not quantified in one laboratory blank, and silica was also detected but not quantified in another blank sample. However, both analytes were detected at concentrations below the reporting limit, and thus no data were flagged due to these results.

SCVURPPP did not collect an orthophosphate field blank sample (5% of total project samples) as required by the RMC QAPP for the 20 samples collected in Santa Clara County in WY 2016. However, the field crew took precautions to prevent contamination during sample collection by following RMC SOP protocols, including but not limited to wearing gloves during sample collection and rinsing bottles with stream water prior to collection. In future years, SCVURPPP QA staff will work closer with field staff to avoid QA oversights.

3.6. PATHOGEN INDICATORS

Pathogen indicator samples were collected by SCVURPPP staff at WY 2016 bioassessment sites and were analyzed by the City of San Jose's Environmental Services Department Laboratory. Samples were collected on the morning of June 22, 2016 and were analyzed later that day for *E. coli* and enterococcus.

3.6.1. Completeness

All five required/planned pathogen indicator samples were collected for a 100% completeness rate. However, two samples exceeded the eight-hour hold time. Culturing began at 5:09 PM for *E.coli* and 5:36 PM for enterococcus, but the samples collected at 205R02835 and 205R01731 were collected at 8:30 AM and 8:55 AM, respectively. As a result, these samples exceeded the target hold time by 14-66 minutes. Due to the well persevered nature of the samples and minimal time exceedance, data were flagged but not rejected.

3.6.2. Sensitivity

The reporting limits for *E. coli* and enterococcus (1 MPN/100mL for both indicators) were below the target RL of 2 MPN/100mL listed in the project QAPP.

3.6.3. Accuracy

No certified reference material (CRM) was run for pathogen indicators. As a result, accuracy could not be calculated for pathogen indicators.

3.6.4. Precision

Due to the number of samples collected and the laboratory methodology, it was not possible to run a laboratory duplicate and evaluate the pathogen samples could not be evaluated for precision

3.6.5. Contamination

One method blank 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 three sites during the spring (April 2016), concurrent with bioassessment sampling, and again in the summer (June 2016) in compliance with the MRP. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes over two-week deployments using a multi-parameter water quality sonde (YSI 6600-V2).

3.7.1. Completeness

During the spring deployment, the sonde located at 205COY114 recorded erroneous dissolved oxygen concentrations for 36% of the deployment. However, more than one week of data (the MRP minimum) were unaffected, so the deployment was kept and erroneous data points were flagged and rejected. No data from the other deployments 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

A summary of the drift measurements is shown in Table 5. During the first event, the pH 10 drift for the sensor installed at 205COY114 exceeded the measurement quality objective for pH 10. This sensor also failed in the field for dissolved oxygen. All measurements for that site have been flagged for the pH drift exceedance, but not rejected, and dissolved oxygen measurements that were affected by the sensor malfunction were rejected for that site during the first event. The multi-parameter sonde was serviced immediately following the first event, but the problem could not be identified as the sensors passed all diagnostic tests.

The same sonde was installed at 205RCOY114 during the second event, and did not meet the measurement quality objects for the pH 10 drift check once again. The pH 10 data were again flagged at that site, but not rejected due to percolation pond releases upstream of the site, which confounded known conditions. The pH sensor for the errant sonde will be replaced prior to the next field season, and diagnostic tests will be run to prevent questionable data during future deployments.

Table 5. Drift measurements for two continuous water quality monitoring events in Santa Clara Valley urban creeks during WY 2016. Bold and highlighted values exceeded measurement quality objectives.

Parameter	Measurement Quality Objectives	205COY114		205COY117		205COY121	
		Event 1	Event 2	Event 1	Event 2	Event 1	Event 2
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	0.1	-0.24	-0.01	0	0.23	0.07
pH 7.0	± 0.2	-0.07	0.16	0.02	-0.03	-0.06	-0.03
pH 10.0	± 0.2	0.35	0	-0.04	0.44	0.01	0.06
Specific Conductance (uS/cm)	± 10%	-0.1%	-0.1%	-0.2%	0.1%	0.2%	-0.1%

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 eight sites in Santa Clara. Onset HOBO Water Temperature Data loggers recorded one measurement per hour.

3.8.1. Completeness

The MRP requires SCVURPPP to monitor eight stream reaches for temperature each year, but in past years one to two loggers have been lost during the deployment. Anticipating a lost HOBO temperature logger, SCVURPPP deployed one extra temperature loggers, for a total of nine loggers. Additionally, SCVURPPP staff periodically checked the loggers to ensure that they were still recording. During the June field check, staff discovered that two temperature loggers were missing at sites 205COY117 and 205COY135. New loggers were redeployed at that time, but the reach at 205COY117 went dry by the next field check in July. Similarly, the most downstream reach at site 205COY114 was also dry by July. The temperature loggers at 205COY114, 205COY135, and 205COY117 recorded 70%, 61%, and 8% of the deployment period, respectively, while the loggers at the other six reaches recorded 100% of the deployment period. Since data collected at site 205COY117 is too limited to compare with data collected at the other eight sites, data for this site were excluded from reporting and analysis.

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 2016. None of the loggers exceeded the 0.2 °C mean difference for the room temperature bath (<0.25 °C) or for the ice bath (0.27 °C). 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

Dry season sediment chemistry samples were collected by Kinnetic Laboratories, Inc (KLI) concurrently with dry season toxicity samples on July 11, 2016. Inorganic and synthetic organic compounds were analyzed by Caltest and grain size distribution was analyzed by Soil Control Laboratories, a subcontractor laboratory. All samples were 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.

3.9.1. Completeness

Both planned/required samples were collected and analyzed for all requested analytes, and 100% of results were reported.

3.9.2. Sensitivity

Laboratory reporting limits generally met or were lower than RMC QAPP target reporting limits, except for metals, one bifenthrin sample, and one permethrin sample. A comparison of target and actual reporting limits for those parameters is shown in Table 6. For all samples where the reporting limit was higher than the target limits, concentrations were measured at concentrations above the RLs; therefore, the method provided adequate sensitivity.

Table 6. Comparison of target and actual reporting limits for sediment analytes where reporting limits exceeded target limits. Sediment samples were collected in Santa Clara County creeks in WY 2016.

Analyte	Target RL mg/kg	Actual RL mg/kg
Arsenic	0.3	1
Cadmium	0.01	0.08
Chromium	0.1	0.2-0.21
Copper	0.01	0.41
Lead	0.01	0.2-0.21
Nickel	0.02	0.2-0.21
Zinc	0.1	4.1
Bifenthrin	0.33	0.33-0.51
Permethrin	0.03	0.33-0.51

3.9.3. Accuracy

Inorganic Analytes

No QA samples exceeded the QAPPP MQO for LCS or MS percent recovery (PR) for metals (75-125%).

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 were much larger than PR ranges listed in the QAPP. The MQOs ranged from 1 to 275% in certain cases. 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. The MS/MSD percent recoveries exceeded the RMC MQO range for carbaryl, 12 PAHs, and three surrogates. The PAHs MS/MSD samples that exceeded the PR MQO include benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene. biphenyl, dibenz(a,h)anthracene, dimethylnaphthalene, 2,6-indeno(1,2,3-c,d)pyrene, methylnaphthalene, 2-perylene. Sediment chemistry data were flagged when necessary, but none were rejected.

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. None of the duplicates for metals exceeded the RMC RPD MQO.

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 all synthetic organics excepting pyrethroids, and as <35% for pyrethroids. The RPD for duplicates was evaluated using the RMC MQOs, and as a result, three analytes that were not flagged by the laboratory were flagged by the local QA officer; the MS/MSD RPDs for benz(a)anthracene, phenanthrene, and 2-methylnaphthalene were all slightly over the MQO of < 25%.

Field Duplicates
A sediment sample field duplicate was collected in Santa Clara County on July 11, 2016, 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 small pebbles (4 to <8 mm), benz(a)anthracene, 2-methylnaphthalene, and phenanthrene. Given the inherent variability associated with field duplicates, the low number of analytes with RPDs outside of the MQO limits is remarkable. 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 7. Sediment chemistry duplicate field results for site 205STE021, collected on July 11, 2016 in Santa Clara 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	%	4.44	4.51	2%	No
	Silt: 0.0039 to <0.0625 mm	%	4.49	4.42	2%	No
	Sand: V. Fine 0.0625 to <0.125 mm	%	5.77	5.69	1%	No
	Sand: Fine 0.125 to <0.25 mm	%	10.61	11	4%	No
	Sand: Medium 0.25 to <0.5 mm	%	18.59	19.24	3%	No
	Sand: Coarse 0.5 to <1.0 mm	%	28.68	28.88	1%	No
	Sand: V. Coarse 1.0 to <2.0 mm	%	27.42	26.25	4%	No
	Granule: 2.0 to <4.0 mm	%	12.85	10.83	17%	No
	Pebble: Small 4 to <8 mm	%	2.05	2.93	35%	Yes
	Pebble: Medium 8 to <16 mm	%	-0.01	2.64	N/A	N/A
	Pebble: Large 16 to <32 mm	%	-0.01	-0.01	N/A	N/A
	Pebble: V. Large 32 to <64 mm	%	-0.01	-0.01	N/A	N/A
Metals	Arsenic	mg/Kg dw	2.9	3	3%	No
	Cadmium	mg/Kg dw	0.21	0.21	0%	No
	Chromium	mg/Kg dw	72	65	10%	No
	Copper	mg/Kg dw	39	32	20%	No
	Lead	mg/Kg dw	14	14	0%	No
	Nickel	mg/Kg dw	63	63	0%	No
	Zinc	mg/Kg dw	98	93	5%	No
Pyrethroids (MQO <35%)	Bifenthrin	ng/g dw	1.1	0.8	32%	No
	Cyfluthrin, total	ng/g dw	0.39	0.32	20%	No
	Cyhalothrin, Total lambda-	ng/g dw	-0.06	0.072	N/A	N/A
	Cypermethrin, total	ng/g dw	0.14	0.14	0%	No
	Deltamethrin/Tralomethrin	ng/g dw	0.41	0.17	83%	Yes
	Esfenvalerate/Fenvalerate, total	ng/g dw	-0.13	-0.13	N/A	N/A
	Permethrin, Total	ng/g dw	0.92	0.88	4%	No
	Total Organic Carbon	%	0.27	0.26	4%	No
	Carbaryl	mg/Kg dw	-0.021	-0.021	N/A	N/A
	Fipronil	ng/g dw	-0.1	-0.1	N/A	N/A
Polycyclic Aromatic Hydrocarbons	Acenaphthene	ng/g dw	-3.1	-3.1	N/A	N/A
	Acenaphthylene	ng/g dw	-3.1	-3.1	N/A	N/A
	Anthracene	ng/g dw	5.1	4.1	22%	No
	Benz(a)anthracene	ng/g dw	10	21	71%	Yes
	Benzo(a)pyrene	ng/g dw	8.2	9.2	11%	No
	Benzo(b)fluoranthene	ng/g dw	21	21	0%	No
	Benzo(e)pyrene	ng/g dw	8.2	8.2	0%	No
	Benzo(g,h,i)perylene	ng/g dw	-3.1	10	N/A	N/A
	Benzo(k)fluoranthene	ng/g dw	7.2	7.2	0%	No
	Biphenyl	ng/g dw	-3.4	-3.4	N/A	N/A
	Chrysene	ng/g dw	51	51	0%	No
	Dibenz(a,h)anthracene	ng/g dw	-3.1	-3.1	N/A	N/A
	Dibenzothiophene	ng/g dw	-3.4	-3.4	N/A	N/A
	Dimethylnaphthalene, 2,6-	ng/g dw	6.2	5.1	19%	No
	Fluoranthene	ng/g dw	82	72	13%	No

Table 7. Sediment chemistry duplicate field results for site 205STE021, collected on July 11, 2016 in Santa Clara County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Analyte		Unit	Original	Duplicate	RPD	Exceeds MQO? (<25%)[a]
	Fluorene	ng/g dw	3.1	-3.1	N/A	N/A
	Indeno(1,2,3-c,d)pyrene	ng/g dw	-3.1	8.2	N/A	N/A
	Methylnaphthalene, 1-	ng/g dw	-3.1	-3.1	N/A	N/A
	Methylnaphthalene, 2-	ng/g dw	4.1	3.1	28%	Yes
	Methylphenanthrene, 1-	ng/g dw	-3.1	-3.1	N/A	N/A
	Naphthalene	ng/g dw	-3.1	-3.1	N/A	N/A
	Perylene	ng/g dw	-3.1	-3.1	N/A	N/A
	Phenanthrene	ng/g dw	41	31	28%	Yes
	Pyrene	ng/g dw	72	72	0%	No
Surrogates	Chloroxuron(Surrogate)	%	101	96	5%	No
	Esfenvalerate-d6-1(Surrogate)	%	78	74	5%	No
	Esfenvalerate-d6-2(Surrogate)	%	88	84	5%	No
	Fluorobiphenyl, 2-(Surrogate)	%	60	50	18%	No
	Nitrobenzene-d5(Surrogate)	%	57	45	24%	No
	Tebuthiuron(Surrogate)	%	104	100	4%	No
	Terphenyl-d14(Surrogate)	%	94	91	3%	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

Copper was detected in one blank at a concentration above the method detection limit, but not above the reporting limit. The RMC QAPP for blank samples is < RL, so the same was not 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 two Santa Clara County sites on July 11, 2016. 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 two sites per year in Santa Clara County. All planned/required dry season water and sediment toxicity samples were collected in WY 2016. 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 SCVURPPP. 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 Santa Clara County and tested 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 duplicates listed in the RMC QAPP, but sediment duplicates met the MQO for water toxicity testing with the exception of the *Ceriodaphnia dubia* growth endpoint (see Table 8).

Table 8. Water and sediment toxicity duplicate results for site 205STE021, collected on July 11, 2016 in Santa Clara County. Data in highlighted rows exceed monitoring quality objectives in RMC QAPP.

Matrix	Organism	Endpoint	Original Sample Mean	Duplicate Sample Mean	RPD	Exceeds MQO (<20%)?
Water	Pimephales promelas	% Survival	67.5	72.5	7%	No
Water	Pimephales promelas	Biomass (mg/individual)	0.605	0.612	1%	No
Water	Ceriodaphnia dubia	% Survival	100	100	0%	No
Water	Ceriodaphnia dubia	Young per female	32.4	24.9	26%	Yes
Water	Selenastrum capricornutum	Total Cell Count (cells/mL)	3120000	3340000	7%	No
Water	Hyalella azteca	% Survival	100	100	0%	No
Water	Chironomus dilutus	% Survival	70	80	13%	No
Sediment	Hyalella azteca	% Survival	98.8	98.8	0%	No
Sediment	Chironomus dilutus	% Survival	76.3	72.5	5%	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 generally followed MRP and RMC QAPP requirements, with the following exception:

- No orthophosphate field blank collected
- One chlorophyll a sample misplaced by the laboratory
- Two pathogen samples exceeded the 8-hour hold time between collection and analysis.

Data that exceeded measurement quality objectives were flagged, and no data were rejected with the following exception:

- 36% of dissolved oxygen field measurements for the April continuous water quality monitoring event at site 205COY114

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.

Attachment 2

Biological Indicator Metric Scores

Table 1. Output for calculation of CSCI score, including O/E and MMI components of CSCI, for 20 bioassessment sites sampled in WY2016 in Santa Clara County.

Station Code	E	Mean_O	O/E	MMI	CSCI
205R00213	10.8	9.0	0.83	0.75	0.79
205R00305	10.9	9.0	0.82	1.01	0.92
205R00578	10.5	8.9	0.85	0.72	0.78
205R01114	8.5	5.9	0.69	0.27	0.48
205R01731	8.5	6.5	0.76	0.66	0.71
205R02330	9.1	6.4	0.70	0.37	0.54
205R02422	9.5	9.2	0.96	0.74	0.85
205R02458	9.5	7.7	0.81	0.70	0.75
205R02474	11.2	12.5	1.12	0.79	0.95
205R02538	9.3	7.5	0.80	0.50	0.65
205R02547	12.5	12.8	1.02	1.10	1.06
205R02563	10.1	6.5	0.65	0.51	0.58
205R02602	9.1	9.0	0.98	0.78	0.88
205R02618	13.1	11.6	0.88	0.82	0.85
205R02650	9.5	9.8	1.02	0.73	0.88
205R02659	9.5	8.9	0.93	0.53	0.73
205R02730	9.4	4.3	0.45	0.38	0.41
205R02762	8.5	4.9	0.57	0.31	0.44
205R02771	10.0	7.0	0.70	0.51	0.60
205R02835	11.3	10.1	0.89	0.84	0.87

Table 2. SoCal “D18” (diatom only) IBI scores for 20 bioassessment sites sampled in WY2016 in Santa Clara County. Individual metric values and scores are also shown. Each IBI score is scaled to 100 based on the number of metrics involved. For D18, the total sum of scores is multiplied by 100/50 to obtain the total score.

StationCode	Proportion halobiontic	Proportion low TP indicators	Proportion N heterotrophs	Proportion requiring >50% DO saturation	Proportion sediment tolerant (highly motile)	Proportion halobiontic Score	Proportion low TP indicators Score	Proportion N heterotrophs Score	Proportion requiring >50% DO saturation Score	Proportion sediment tolerant (highly motile) Score	Total MMI Score
205R00213	0.023	0.208	0.04	0.986	0.013	9	3	9	9	10	80
205R00305	0.062	0.023	0.147	0.875	0.257	9	1	7	6	5	56
205R00578	0.219	0.189	0.454	0.731	0.162	6	3	1	3	7	40
205R01114	0.151	0.084	0.233	0.876	0.319	7	1	5	7	4	48
205R01731	0.478	0.167	0.575	0.85	0.447	1	2	0	6	1	20
205R02330	0.791	0.01	0.86	0.91	0.622	0	1	0	7	0	16
205R02422	0.153	0.052	0.12	0.891	0.232	7	1	7	7	5	54
205R02458	0.149	0.03	0.145	0.972	0.117	7	1	7	9	8	64
205R02474	0.556	0.017	0.574	0.998	0.473	0	1	0	10	1	24
205R02538	0.288	0.017	0.208	0.92	0.114	5	1	6	8	8	56
205R02547	0.166	0.079	0.096	0.99	0.065	7	1	8	9	9	68
205R02563	0.096	0.065	0.059	0.99	0.041	8	1	8	9	9	70
205R02602	0	0.015	0	1	0.005	10	1	10	10	10	82
205R02618	0.497	0.013	0.546	0.944	0.413	1	1	0	8	2	24
205R02650	0.059	0.024	0.042	0.985	0.04	9	1	9	9	9	74
205R02659	0.105	0.03	0.041	0.973	0.11	8	1	9	9	8	70
205R02730	0.502	0.007	0.56	0.952	0.419	1	0	0	8	2	22
205R02762	0.101	0.013	0.105	0.946	0.062	8	1	8	8	9	68
205R02771	0.589	0.023	0.463	0.608	0.503	0	1	1	0	0	4
205R02835	0.253	0.145	0.26	0.875	0.244	5	2	5	6	5	46

Table 3. SoCal “S2” (soft algae only) IBI scores for 20 bioassessment sites sampled in WY2016 in Santa Clara County. Individual metric values and scores are also shown. Each IBI score is scaled to 100 based on the number of metrics involved. For S2, the total sum of scores is multiplied by 100/60 to obtain the total score. “NR” refers to values and scores that were not reported due to insufficient data.

Station Code	Prop high Cu (s, sp)	Prop high DOC (s, sp)	Prop low TP (s, sp)	Prop non-ref (s, sp)	Prop green algae in CRUS (s, b)	Prop ZHR (s, m)	Prop high Cu (s, sp) Score	Prop high DOC (s, sp) Score	Prop low TP (s, sp) Score	Prop non-ref (s, sp) Score	Prop green algae in CRUS (s, b) Score	Prop ZHR (s, m) Score	S2 Score
205R00213	0.00	0.50	0.50	0.00	0.00	0.25	10	4	10	10	10	4	80
205R00305	0.17	0.33	0.17	0.17	1.00	0.14	5	6	6	7	0	3	45
205R00578	0.00	0.00	0.50	0.00	0.00	0.25	10	10	10	10	10	4	90
205R01114	0.40	0.80	0.00	0.40	0.83	0.00	0	0	0	2	2	0	7
205R01731	0.33	0.50	0.00	0.17	1.00	0.07	1	4	0	7	0	2	23
205R02330	0.40	0.60	0.00	0.60	1.00	0.00	0	2	0	0	0	0	3
205R02422	0.20	0.60	0.00	0.20	1.00	0.08	4	2	0	7	0	2	25
205R02458	0.20	0.40	0.00	0.40	1.00	0.08	4	5	0	2	0	2	22
205R02474	1.00	1.00	0.00	1.00	1.00	0.00	0	0	0	0	0	0	0
205R02538	0.20	0.60	0.00	0.40	1.00	0.00	4	2	0	2	0	0	13
205R02547	0.50	0.50	0.00	0.50	1.00	0.17	0	4	0	0	0	3	12
205R02563	1.00	1.00	0.00	1.00	0.80	0.00	0	0	0	0	2	0	3
205R02602	1.00	1.00	0.00	1.00	0.00	0.00	0	0	0	0	10	0	17
205R02618[a]	0.50	1.00	0.00	0.50	NR	0.00	0	0	0	0	NR	0	NR
205R02650	0.25	0.50	0.00	0.25	1.00	0.20	3	4	0	5	0	3	25
205R02659	1.00	1.00	0.00	1.00	1.00	0.00	0	0	0	0	0	0	0
205R02730	0.20	0.50	0.00	0.00	0.00	0.00	4	4	0	10	10	0	47
205R02762	0.33	0.33	0.00	0.33	1.00	0.13	1	6	0	3	0	2	20
205R02771	0.50	0.50	0.00	0.50	1.00	0.28	0	4	0	0	0	5	15
205R02835	0.33	0.33	0.00	0.33	1.00	0.00	1	6	0	3	0	0	17

[a] Unable to calculate S2 score due to insufficient data causing null value for submetric.

Table 4. SoCal “H20” (hybrid) IBI scores for 20 bioassessment sites sampled in WY2016 in Santa Clara County. Individual metric values and scores are also shown. Each IBI score is scaled to 100 based on the number of metrics involved. For H20, the total sum of scores is multiplied by 100/80 to obtain the total score. “d’ represents metrics based on diatoms, “s” represents metrics based on soft algae, “sp” is species richness metric.

Station Code	Prop halo-biontic (d)	Prop high Cu (s, sp)	Prop high DOC (s, sp)	Prop low TN (d)	Prop low TP (s, sp)	Prop N hetero-trophs (d)	Prop require >50% DO sat (d)	Prop sed tol (highly motile) (d)	Prop halo-biontic Score	Prop high Cu Score	Prop high DOC Score	Prop low TN Score	Prop low TP Score	Prop N hetero-trophs Score	Prop require >50% DO sat Score	Prop sed tol (highly motile) Score	Total MMI Score
205R00213	0.023	0.000	0.500	0.208	0.500	0.040	0.986	0.013	9	10	4	3	10	9	9	10	80
205R00305	0.062	0.167	0.333	0.021	0.167	0.147	0.875	0.257	9	5	6	1	6	7	6	5	56
205R00578	0.219	0.000	0.000	0.227	0.500	0.454	0.731	0.162	6	10	10	3	10	1	3	7	62
205R01114	0.151	0.400	0.800	0.128	0.000	0.233	0.876	0.319	7	0	0	2	0	5	7	4	31
205R01731	0.478	0.333	0.500	0.196	0.000	0.575	0.850	0.447	1	1	4	3	0	0	6	1	20
205R02330	0.791	0.400	0.600	0.009	0.000	0.860	0.910	0.622	0	0	2	0	0	0	7	0	11
205R02422	0.153	0.200	0.600	0.052	0.000	0.120	0.891	0.232	7	4	2	1	0	7	7	5	41
205R02458	0.149	0.200	0.400	0.029	0.000	0.145	0.972	0.117	7	4	5	1	0	7	9	8	51
205R02474	0.556	1.000	1.000	0.017	0.000	0.574	0.998	0.473	0	0	0	1	0	0	10	1	15
205R02538	0.288	0.200	0.600	0.016	0.000	0.208	0.920	0.114	5	4	2	1	0	6	8	8	42
205R02547	0.166	0.500	0.500	0.073	0.000	0.096	0.990	0.065	7	0	4	1	0	8	9	9	48
205R02563	0.096	1.000	1.000	0.053	0.000	0.059	0.990	0.041	8	0	0	1	0	8	9	9	44
205R02602	0.000	1.000	1.000	0.015	0.000	0.000	1.000	0.005	10	0	0	1	0	10	10	10	51
205R02618	0.497	0.500	1.000	0.013	0.000	0.546	0.944	0.413	1	0	0	1	0	0	8	2	15
205R02650	0.059	0.250	0.500	0.027	0.000	0.042	0.985	0.040	9	3	4	1	0	9	9	9	55
205R02659	0.105	1.000	1.000	0.033	0.000	0.041	0.973	0.110	8	0	0	1	0	9	9	8	44
205R02730	0.502	0.200	0.500	0.042	0.000	0.560	0.952	0.419	1	4	4	1	0	0	8	2	25
205R02762	0.101	0.333	0.333	0.012	0.000	0.105	0.946	0.062	8	1	6	1	0	8	8	9	51
205R02771	0.589	0.500	0.500	0.015	0.000	0.463	0.608	0.503	0	0	4	1	0	1	0	0	8
205R02835	0.253	0.333	0.333	0.139	0.000	0.260	0.875	0.244	5	1	6	2	0	5	6	5	38

Appendix B

Regional SSID Project Status Table

BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects Updated February 2017
For Projects Initiated Under MRP 1 (Municipal Regional Stormwater NPDES Permit, Order No. R2-2009-0074, Prov. C.8.d.i)

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or alternative site ID	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project	Complete?
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
AL-1	1/23/17	Alameda/ ACCWP	Castro Valley Creek	204R00047	X						X			IBI Score = 24 (Poor); Relatively high bifenthrin (pyrethroid) in sediment; >3 chemicals exceed TECs	Triad triggers were accompanied by *Hyalella azteca* water toxicity that did not reach trigger on retest. Potential sources for investigation in small watershed include freeway and urban land use areas.	SSID Project began in 2013 with sediment sampling and watershed records review; No specific sources to local MS4 identified during 2014. Pesticides as the primary stressor are supported by additional WY 2015 sediment chemistry/toxicity results from another site higher in this watershed that also showed high Hyalella mortality in wet season water toxicity. March 2016 UCMR included Appendix 4A summary report describing BMPs implemented and completion of the site-specific elements of this project, March 2017 UCMR includes commentary on additional WY 2016 results from nearby sites in the same creek .	
AL-2	1/23/17	Alameda/ ACCWP	Dublin Creek	204R00084	X		X				X			IBI Score = 17 (Very Poor); Relatively high bifenthrin (pyrethroid) in sediment; >3 chemicals exceed TECs	Potential sources for different triad triggers may be separable by monitoring between freeway and urban land use areas, altered vs. natural channels.	SSID Project began in 2013 with sediment sampling, watershed records review and bioassessment sampling at RMC plus a supplemental site. Bioassessment impacts were strongly associated with channel alteration and habitat quality. Review of inspection information identified no specific sources of pesticides or metals to sediment. March 2017 UCMR provides update on review of land use inputs and freeway runoff, for final monitoring report to be submitted in September 2017.	
AL-3	1/23/17	Alameda/ ACCWP	Crow Creek	204CRW030		X								67% of DO results < 7 mg/L in September	Potentially significant stressor on COLD beneficial use; Potential source for investigation from lake discharge or nutrient sources.	SSID Project began in 2013 with DO and water sampling; initial hypothesis regarding reservoir runoff not supported by first year's special study. Further monitoring in WY 2014 and 2015 indicated there may have been episodic contributions from urban runoff to low DO incidents observed in WY2014 but not during WY2015. March 2017 UCMR includes Appendix 4C progress report with WY2016 monitoring evaluation of summer inflows using continuous monitoring of conductivity as well as temperature.	

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or alternative site ID	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project	Complete?
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
CC-1	1/23/17	Contra Costa/ CCCWP	Grayson Creek	207R00011	X				X	X	X			32% survival of *Hyalella azteca* in water during spring of 2012; 43.8% survival of *Hyalella azteca* in sediment during summer 2012; relatively high bifenthrin in sediment; IBI Score = 13 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, with testing of water and sediments from sites upstream and downstream of original Grayson Creek site. Only water samples were toxic to *Hyalella*. Water TIE and concurrent chemistry point to pyrethroid pesticides as likely causes of *Hyalella* toxicity in waters of Grayson Creek. SSID Project Part B completed, WY 2015, computing urban use amounts for six pyrethroid pesticides detected in Part A monitoring. Based on County pesticide use data from 2009-2013, uses of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) have increased in urban areas in Contra Costa County in recent years. Urban uses account for most of the annual use amounts for those six pyrethroids in CC County. CCCWP is implementing Study Part C (pesticide/toxicity controls) via compliance with MRP Provision C.9 (Pesticides Toxicity Control).	
CC-2	1/23/17	Contra Costa/ CCCWP	Dry Creek	544R00025	X		X		X	X	X			60% survival of *Hyalella azteca* in sediment during summer, 2012; 0% survival of *Hyalella azteca* in water during spring of 2012; relatively high bifenthrin in sediment; IBI Score = 3 (Very Poor). Water toxicity confirmed by retest, 2013.	Evidence of water and sediment toxicity to *Hyalella azteca*, with concurrent high concentration of bifenthrin in sediment. Recent publications by CASQA and others indicate pyrethroid pesticide-caused toxicity is a pervasive problem in urban areas of CA. Investigation of sources and solutions could be widely beneficial.	SSID Project Part A completed, WY 2014, with testing of water and sediments from sites upstream and downstream of original Dry Creek site. All samples were toxic to *Hyalella*. Water and sediment TIEs and concurrent chemistry point to pyrethroid pesticides as likely causes of *Hyalella* toxicity in water and sediments of Dry Creek. SSID Project Part B completed, WY 2015, computing urban use amounts for six pyrethroid pesticides detected in Part A monitoring. Based on County pesticide use data from 2009-2013, uses of the most toxic and impactful pyrethroids (bifenthrin and cyfluthrin) have increased in urban areas in Contra Costa County in recent years. Urban uses account for most of the annual use amounts for those six pyrethroids in CC County. CCCWP is implementing Study Part C (pesticide/toxicity controls) via compliance with MRP Provision C.9 (Pesticides Toxicity Control).	
SC-1	5/11/15	Santa Clara/ SCVURPPP	Coyote Creek	205COY235 (Coyote Cr. - Watson Park to Julian St.)		X								100% < 5mg/L D.O. in spring and summer periods 2012; and Pre-MRP Data	Coyote Creek supports a productive fish community and the project reach exhibits depressed dissolved oxygen that could cause biological impacts.	Project began in 2011 and was completed in 2013. Summary report was submitted in March 2014 as Appendix B1 in Part A of the Integrated Monitoring Report.	Yes

SSID Project ID	Date Updated	County/ Program	Creek/Channel Name	Site Code(s) or alternative site ID	Primary Indicator(s) Triggering Stressor/Source ID Project									Indicator Result Summary	Rationale for Proposing/Selecting Project	Current Status of SSID Project	Complete?
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
SC-2	5/11/15	Santa Clara/ SCVURPPP	Guadalupe River (and Alviso Slough)										X	Fish kills observed in 2008, 2009 & 2010.	The Guadalupe River supports a productive fish community and the project reaches exhibited fish kills that are a concern to local agencies.	Project began in 2011 and was completed in 2013. Summary report was submitted in March 2014 as Appendix B2 in Part A of the Integrated Monitoring Report.	Yes
SC-3	2/23/17	Santa Clara/ SCVURPPP	Upper Penitencia Creek	205R00035	X									IBI Score = 23 (Poor)	Upper Penitencia Creeks supports one of the most productive steelhead communities in the Santa Clara Valley. Poor biological integrity scores may indicate impacts to steelhead and other biological communities.	SCVURPPP submitted a Work Plan with their WY 2015 UCMR that follows Step 5 of the USEPA Causal Analysis/Diagnosis Decision Information System (CADDIS). Implementation of the Work Plan was delayed two years due to drought conditions. In WY 2016, in compliance with the Work Plan, SCVURPPP conducted bioassessments at two stations (case and comparator sites) twice during the spring index period – before and after initiation of stream augmentation from a nearby SCVWD-operated pond. Stressor data collected at the sites included continuous temperature and water quality, nutrients, sediment chemistry and toxicity. A Technical Report submitted in March 2017 with the WY 2016 UCMR suggests that low bioassessment scores are the result of natural hydrologic conditions rather than MS4 or pond discharges. Potential management options will be evaluated in WY 2017.	No - In Process
SM-1	2/10/16	San Mateo/ SMCWPPP	San Mateo Creek	204SMA059		X								Pre-MRP data demonstrating temperatures > 19°C and DO < 7mg/L. WY2013 creek status data confirmed DO < 7 mg/L at 204SMA059 but not at 204SMA122 located approximately 4 miles upstream. Temperatures in WY2013 rarely exceeded the 19°C threshold.	San Mateo Creek is one of two creeks on the Bay-side of San Mateo County that supports a productive coldwater community. Warm temperatures and/or low DO levels may impact this valuable community.	WY2014 monitoring was conducted to investigate spatial and temporal extent of low DO. Monitoring consisted of sonde installments and a creek walk. Low DO was not observed in WY2014. Review of flow data at USGS gage below Crystal Springs Reservoir confirmed higher dry season flows in WY2014 compared to WY2013. The higher flows were the result of a new SFPUC release schedule following dam improvements that will continue into perpetuity. It appears that higher dry season flows result in reduced water temperatures and higher DO levels. Confirmation monitoring conducted in WY2015 supported the findings. Final Project Report was submitted to RWQCB staff on 7/9/15 and with the WY2015 UCMR.	Yes

SSID Project ID	**Date Updated**	**County/ Program**	**Creek/Channel Name**	**Site Code(s) or alternative site ID**	**Primary Indicator(s) Triggering Stressor/Source ID Project**									**Indicator Result Summary**	**Rationale for Proposing/Selecting Project**	**Current Status of SSID Project**	**Complete?**
					Bioassess	General WQ	Chlorine	Temp	Water Tox	Sed Tox	Sed Chem	Pathogen Indicators	Other				
SM-2	2/10/16	San Mateo/ SMCWPPP	San Mateo Creek	204SMA060								X		Pre-MRP data and WY2012 creek status grab samples had pathogen indicator (fecal coliform) densities exceeding the REC-1 WQO.	San Mateo Creek is a perennial creek with two Creekside parks. It flows through residential and commercial areas and discharges to San Francisco Bay just north of Marina Lagoon which is 303(d)-listed for bacteria.	WY2014 monitoring was conducted to investigate the magnitude and seasonal variability pathogen indicator densities. Microbial source tracking methodologies (i.e., Bacteroidales) were employed to investigate whether human and/or dog markers were present in the samples. Final Project Report submitted with the WY2015 UCMR.	Yes

Appendix C

SCVURPPP Upper Penitencia Creek Stressor/Source Identification Project Report

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Upper Penitencia Creek
Stressor/Source Identification Project
Water Year 2016

March 31, 2017

Executive Summary

The purpose of this report is to summarize monitoring activities conducted during Water Year (WY) 2016 to meet requirements listed under Provision C.8.d.i of the San Francisco Bay Region Municipal Regional Stormwater NPDES Permit ("MRP 1.0"; Order No. R2-2009-0074). This MRP 1.0 provision requires Permittees to conduct monitoring projects to identify and isolate potential stressors and/or sources associated with observed potential water quality impacts.

The Upper Penitencia Creek SSID Project was triggered by Creek Status Monitoring data collected by the Program during WY 2013 and WY 2014. Bioassessment data collected at two monitoring stations in an urban segment of Upper Penitencia Creek had poor biological condition, based on the California Stream Condition Index (CSCI) score for benthic macroinvertebrate (BMI) data.

The Causal Analysis/Diagnosis Decision Information System (CADDIS) was applied to evaluate potential biological impacts observed in Upper Penitencia Creek. The study approach focused on evaluating the differences in biological, physical, chemical and toxicological indicators between a case site (114) located within the segment of interest and a comparator site (121) located directly upstream of the segment. Because the biological condition, as measured by CSCI scores, at the case site was consistently lower than the comparator site, the CADDIS process was focused on identifying indicators of biological condition stress that may indicate the cause of decreased CSCI scores.

Two sample events were conducted at sites 114 and 121 in WY 2016 to evaluate biological conditions and stressor levels during different flow conditions. Sampling event 1 was conducted on April 28 following a series of storms that resulted in perennial flow throughout the urban reach of Upper Penitencia Creek. Event 2 was conducted on June 9 when the source of flow at site 114 was primarily from percolation pond releases; no flow was observed in the upstream reach between the outfall from the ponds and a short distance downstream of Dorel Drive. Site 121 had perennial flow during both sampling events.

Biological conditions, based on CSCI scores, at the case site (114) were consistently lower than the comparator site (121). The BMIs collected at the case site were predominantly short-lived taxa and absence of organisms that require perennial flow. It appears that biological condition at the case site may be impacted by intermittent flow conditions. The case site (114) used in this study is located within a segment of Upper Penitencia Creek that historically dried up during the spring/summer season due to the percolation of surface flow into the underlying groundwater basin.

The stressor (physical, chemical and toxicological) data available for evaluation during the study do not show a clear linkage to the biological condition observed at the case site. In general, the physical habitat at the case and comparator sites were very similar and not likely the cause of reduced biological condition at the case site. Similarly, water and sediment chemistry at the two sites are very similar, with the exception of temperature and nutrient concentrations, which increased with the increase in water diverted from the percolation ponds into the stream channel during the summer months.

Based on the best available information, sources of stress on biological communities in the Upper Penitencia Creek segment of interest, whether natural (e.g., lack of stream flow) or anthropogenic (e.g., nutrients or temperature), are not associated with discharges from the

municipal separate storm sewer system (MS4). Rather, if reduced biological conditions in this segment are partially caused by anthropogenic inputs, they are likely associated with diversions from the percolation ponds to the channel, which are intended to sustain water flows for groundwater percolation to satisfy downstream well users/water rights.

Although municipal stormwater discharges do not appear to be the probable causes of reduced biological conditions in the Upper Penitencia Creek segment of interest, SCVURPPP recognizes the importance of freshwater habitat in this creek that currently supports freshwater organisms, including a viable steelhead community. SCVURPPP plans to complete a brief *Upper Penitencia Creek Watershed Management Practices Summary* by September 30, 2017 to assist in the continued management of this important natural resource. The management practices summary will include a compilation of watershed management activities that are currently in place or planned in the watershed, an evaluation of practices that could be implemented or enhanced to improve biological conditions in the creek, and recommendations of actions (monitoring or management) that would support the management of the freshwater habitat beneficial use in Upper Penitencia Creek.

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1.0 Introduction

The purpose of this report is to summarize monitoring activities conducted during Water Year (WY) 2016 to meet requirements listed under Provision C.8.d.i of the San Francisco Bay Region Municipal Regional Stormwater NPDES Permit ("MRP 1.0"; Order No. R2-2009-0074).[1] This MRP 1.0 provision requires Permittees to conduct monitoring projects to identify and isolate potential stressors and/or sources associated with observed potential water quality impacts. In FY 2013-14, the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) successfully completed two stressor/source identification projects (i.e., Guadalupe River and Coyote Creek) (SCVURPPP 2014). The Upper Penitencia Creek Stressor/Source Identification (SSID) Project, described in this report, is the third and final project to be completed consistent with MRP 1.0 requirements.

The Upper Penitencia Creek SSID Project was triggered by Creek Status Monitoring data collected by the Program during WY 2013 and WY 2014. Bioassessment data collected at two monitoring stations in an urban segment of Upper Penitencia Creek had poor biological condition, based on the California Stream Condition Index (CSCI) score for benthic macroinvertebrate (BMI) data.

In March 2015, the Program submitted a Work Plan (SCVURPPP 2015) to the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) that outlined the data collection efforts and analysis procedures that SCVURPPP would take to evaluate factors potentially impacting biological condition in the creek segment of interest. The Causal Analysis/Diagnosis Decision Information System (CADDIS) framework (USEPA 2010) was selected by SCVURPPP to identify and evaluate potential stressors and sources affecting biological condition. The Work Plan assessed existing available data, identified information gaps, and included a monitoring plan to investigate the linkage between probable stressors and biological condition.

The Program was unable to implement monitoring activities identified in the Work Plan in WY 2014 or WY 2015 due to an extended drought and dry channel conditions within the study area. A wetter winter season during WY 2016 provided suitable sampling conditions to conduct the monitoring activities for the SSID project. This report presents results and conclusions from monitoring conducted in WY 2016.

2.0 Background

2.1 Biological Condition Assessments

The Program has conducted biological condition assessments at multiple locations along Upper Penitencia Creek on several occasions since 2008. The Program conducted bioassessments using benthic macroinvertebrates at six sites in Upper Penitencia Creek in 2008 as part of its Annual Monitoring Program (SCVURPPP 2008). Sampling locations were selected in 2008 using a targeted design to conduct monitoring across a wide range of stream conditions in the watershed (Figure 1). The BMI results were interpreted using two existing tools: the Southern California Index of Biological Integrity (SoCal IBI) (Ode et al. 2005) and the California Stream Condition Index (CSCI) (Mazor et al. 2015). SoCal IBI and CSCI scores are listed in Table 1.

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[1] The San Francisco Bay Regional Water Quality Control Board (Regional Water Board) issued MRP 1.0 to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (Regional Water Board 2009). In 2015, the Regional Water Board revised and reissued the MRP (Order No. R2-2015-2049). The 2015 permit is referred to as "MRP 2.0."

During WYs 2012 and 2013, the Program conducted bioassessments at three locations in Upper Penitencia Creek to meet requirements for Creek Status Monitoring under the MRP. Sampling locations were selected using a probabilistic monitoring design (SCVURPPP 2014). Two of the sampling locations (sites 105 and 114), located between Interstate 680 and Piedmont Road, had CSCI scores of 0.59 and 0.64, respectively (Table 1). The CSCI scores for both sites are classified as "very likely altered" biological condition and are below the MRP 2.0 trigger (<0.795) for sites to be considered for potential SSID projects. The third monitoring location (site 140), located about 3 miles upstream of Piedmont Road in Alum Rock Park, received a CSCI score of 1.26.

Table 1. Location and date of bioassessments conducted by SCVURPPP in 2008 through 2013. Biological condition scores and condition categories using CSCI are also presented.

Site ID[2]	Elevation (ft)	Sample Date	Monitoring Design	SoCal IBI		CSCI	
				Score	Condition	Score	Condition
90	74	4/30/2008	Targeted	7	Very Poor	0.52	Very Likely Altered
100	123	4/30/2008	Targeted	4	Very Poor	0.43	Very Likely Altered
105	145	5/24/2012	Probabilistic	21	Poor	0.59	Very Likely Altered
114	194	6/5/2013	Probabilistic	30	Poor	0.64	Likely Altered
115	206	5/1/2008	Targeted	29	Poor	0.66	Likely Altered
120	256	5/1/2008	Targeted	52	Fair	0.86	Likely Intact
130	431	5/2/2008	Targeted	54	Fair	0.93	Likely Intact
140	597	5/2/2008	Targeted	90	Very Good	1.23	Likely Intact
140	607	6/12/2013	Probabilistic	99	Very Good	1.26	Likely Intact

The biological condition scores decreased in an upstream to downstream direction (Table 1). A relatively large decrease in CSCI score was observed in 2008 between sites 120 and 115, with scores of 0.86 and 0.66, respectively. These sites are approximately 1 mile apart. Subsequent bioassessment monitoring in 2013 at site 114, had a similar CSCI score (0.64) as site 115. These sites are only 100 meters apart. The purpose of this SSID study is to understand why there was such a dramatic decrease in CSCI scores downstream of site 120.

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[2] Site IDs are based on the last three numbers of the station codes used by SCVURPPP for identifying monitoring stations (e.g., 90 represents monitoring station 205COY090).

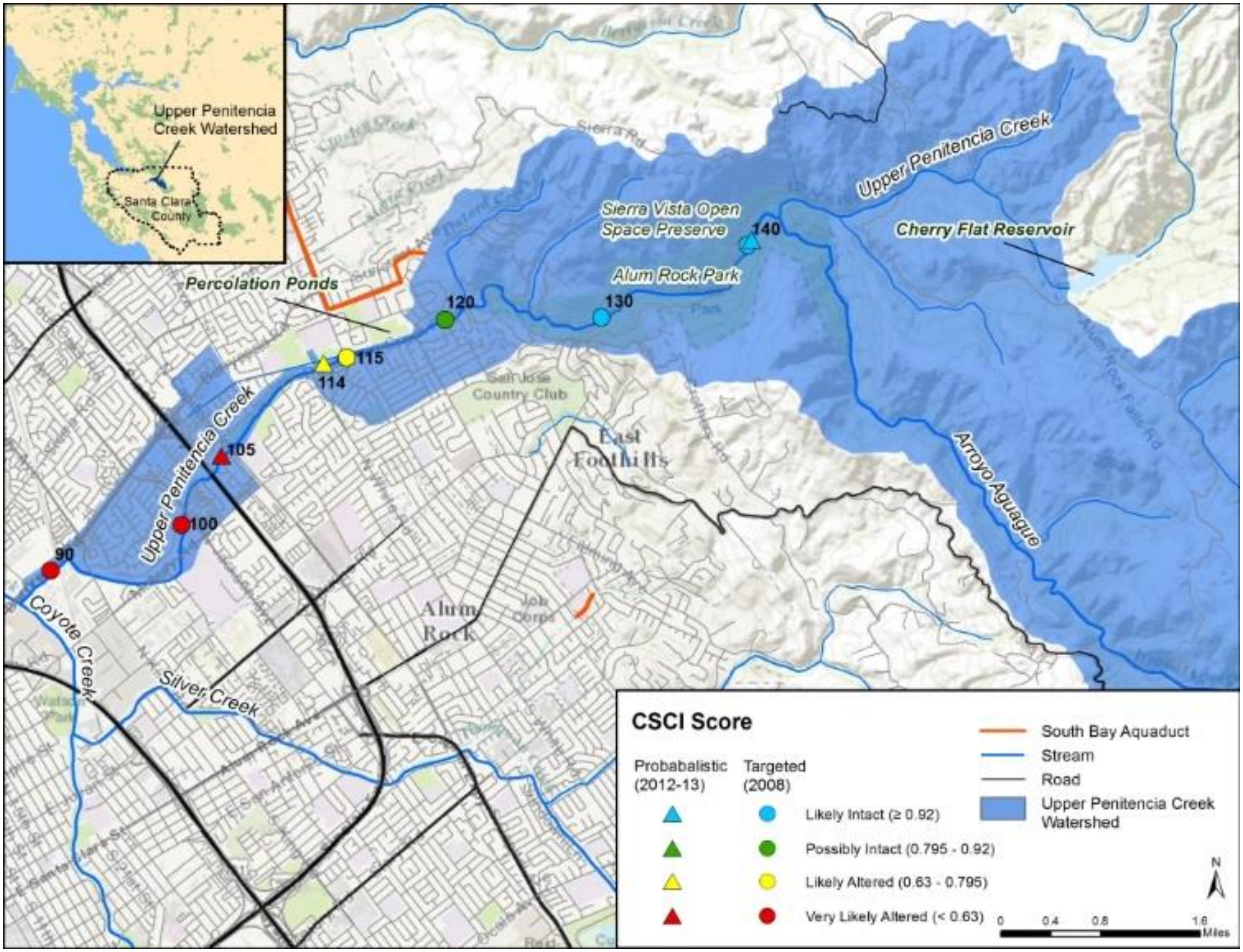

Figure 1. Nine bioassessment locations in Upper Penitencia Creek sampled between 2008 and 2013.

2.2 Causal Assessment Approach

The Causal Analysis/Diagnosis Decision Information System (CADDIS) was applied to evaluate potential biological impacts observed in Upper Penitencia Creek. CADDIS was developed by the US EPA as an online guidance application for users to conduct causal assessments (US EPA 2010). The online tool provides a logical, step-by-step framework for Stressor Identification (SI) for biologically impacted aquatic ecosystems. CADDIS identifies a five-step process for conducting a causal assessment:

- Step 1: Define the Case
- Step 2: List Candidate Causes
- Step 3: Evaluate Data from the Case
- Step 4: Evaluate Data from Elsewhere (e.g., comparator site)
- Step 5: Identify Probable Causes

The five-step process is illustrated in Figure 2.

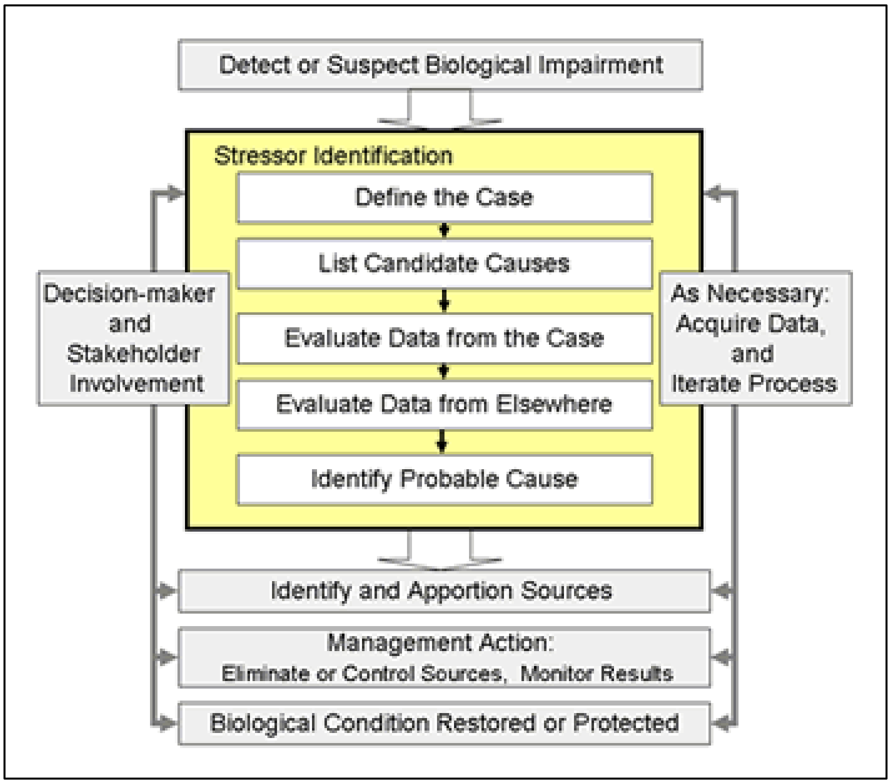

Figure 2. Causal assessment process defined in CADDIS (US EPA 2010).

The first step (Step 1) of the Stressor Identification process is to define the subject of the analysis (i.e., the case), by determining the geographic area of the investigation and the effects to be analyzed. The case definition sets the stage for the rest of the causal analysis in terms of the information that will be assembled, the causes to be evaluated, and how conclusions will be presented.

The next step (Step 2) is to develop a comprehensive list of candidate causes, or stressors, to be evaluated for potential impacts to biological conditions observed at the case site. Identification of the stressors further refines the scope of the causal analysis, and provides a framework for assembling available data and determining what data are needed for the causal analysis.

In Step 3, existing data are analyzed to compare measures of the biological response (e.g., BMI taxonomic richness) with direct measures of proximate stressors (e.g., toxicant concentrations or percent embeddedness values), or intermediate measures that link sources, stressors, and biological effects. Data are analyzed with two goals in mind:

- To develop consistent and credible evidence that allows one to confidently eliminate very improbable stressors, or to use symptoms to refute or diagnose a stressor, and
- To begin building the body of evidence for those candidate stressors that cannot be eliminated or diagnosed, which will be used in Step 5 to identify the most probable stressor.

In Step 4, the candidate stressors that remain are evaluated further by bringing in data from studies conducted outside of the case. The evidence developed from this exercise completes the body of evidence used to identify the most probable stressors of the observed biological effects. *The key distinction between data from elsewhere and data from the case is location: data from elsewhere are assumed to be independent of what is observed at the case sites.*

The last step (Step 5) in the stressor identification process is to distinguish the most probable stressor(s). Each candidate stressor must be compared to every other candidate stressor to evaluate which stressor led to the specific observed effects. The rationale for identifying one stressor relative to the others needs to be clear, reasonable, and convincing if management action is to be motivated and effectively directed.

Steps 1-4 of the CADDIS process for the Upper Penitencia Creek SSID Project were summarized in the Work Plan (SCVURPPP 2015). The majority of the data available were suitable to evaluate most of the candidate stressors that directly impacted the case site. Thus, there was limited application of *Step 4 (Evaluate Data from Elsewhere)*. In some cases, however, existing data did not consistently provide both spatial and temporal co-occurrence to evaluate all stressors. As a result, additional monitoring activities were identified in the Work Plan to address the data gaps. The results of these monitoring activities and the application of *Step 5 (Identify Probable Cause)* are presented in this report.

2.3 Study Area

The Upper Penitencia Creek subwatershed drains approximately 24 square miles area within the larger Coyote Creek watershed in Santa Clara County (Figure 1). The creek flows approximately eleven miles from its headwaters in the Diablo Range to its confluence with Coyote Creek approximately 10 miles upstream of the San Francisco Bay. The upper reach of the creek flows into Cherry Flat Reservoir, a small reservoir (500 acre-feet) that was constructed in 1932 for water supply. The creek continues to flow through Alum Rock Park (ARP), managed by the City of San Jose, where it exits the foothills onto the valley floor. The creek continues west for approximately four miles through an urbanized section of eastern Santa Clara Valley.

Historical flow conditions in the upper reaches of the creek are typically perennial with the majority of flow derived from springs and tributary inputs from Arroyo Aguague (Stillwater Sciences 2006). In the lower reaches of the valley floor, the creek was historically intermittent, with the majority of dry season flow permeating into the alluvial fan deposits of the valley floor and recharging the groundwater aquifer. Transition from perennial to intermittent flow regime is supported by historical observations of the change in the riparian vegetation from a mixed riparian forest in the foothill region to a more sycamore-dominated riparian canopy in the valley floor (Beller et al 2012).

A number of hydromodifications in the Upper Penitencia Creek subwatershed have altered the dry season hydrology of the creek.

- Periodic flow augmentation downstream of the Cherry Flat Reservoir dam is believed to have increased the extent and duration of the wetted channel in Alum Rock Park (SCVURPPP 2003).
- There is a diversion structure located upstream of Noble Ave that diverts water to off-channel percolation ponds for groundwater percolation (Figure 3). Diversions from the Upper Penitencia Creek typically occur during spring season when surface flows are still present. The Robert Gross Percolation Ponds are owned and operated by the Santa Clara Valley Water District (SCVWD or District).
- When creek flows begin to decrease during the declining hydrograph of spring season, additional water from the South Bay Aqueduct is diverted directly into the percolation ponds, which are located just upstream of Piedmont Ave. Water imports to percolation ponds may continue through the summer season.
- A portion of the water from the percolation pond is typically released back into the main channel of Upper Penitencia Creek during the dry season for groundwater percolation to satisfy downstream well users/water rights (Figure 3). There are two locations that water is released back into the channel[3]: 1) Gross Pond 1 via turnout near Toyon Ave; and Gross Pond 3 via overflow structure, just upstream of Piedmont Rd.
- Typically, the augmented water extends downstream to Jackson Road, where the water is then diverted to another off-channel percolation pond at Mabury Road. In 2016, the water did not extend to the diversion at Mabury, presumably due to high percolation rates caused by low elevation of the groundwater basin.

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[3] In 2016, a preliminary estimate of 1890 acre feet was released from Robert Gross Percolation Ponds into Upper Penitencia Creek between May 12 – July 22 and September 1 – October 6 (Carole Foster, SCVWD, personal communication). Over 90% of water released came from the Pond 1 turnout.

- There are 8 storm drain outfalls along reach of Upper Penitencia Creek between White Road and Dorel Drive. These outfalls drain approximately 375 acres of area that is comprised of predominantly single family homes. A majority of the urban area along the north side of Upper Penitencia Creek, between Piedmont and Noble Ave, drains north into the Berryessa Creek watershed. Upstream of Dorel Drive there are 43 storm drain outfalls within Alum Rock Park that drain approximately 585 acres of the park area that is used for parking, picnicking, hiking etc.

Percolation pond operations described above were drastically changed during WY 2014 and WY 2015 due to extended period of drought. During this time, no water was imported from the State Water Project to the percolation ponds. As a result, the reach of Upper Penitencia Creek below Dorel Drive remained dry during the dry season. Following the return of imported water to percolation ponds in 2016, the extent of the wetted channel below the ponds appeared to be limited, presumably due to low elevation of the groundwater table following the drought.

There are two stream gages in Upper Penitencia Creek that are within the study area, one at Piedmont Road and one at Dorel Drive (gaging low flow only). The drainage area upstream of the lower gage (Piedmont Road) is primarily comprised of open space, urban park and residential land uses.

Throughout much of Alum Rock Park, Upper Penitencia Creek provides cool temperatures and physical habitat conditions that support rearing and spawning lifestages for *Oncorhynchus mykiss* (steelhead). This reach also supports a predominately native fish community of Pacific lamprey, hitch, California roach, stickleback, Sacramento pikeminnow, Sacramento sucker and sculpin species. Lower reaches may support native warm water fishes when flow is available, but more importantly, are important for upstream and downstream passage for migratory fishes. Insufficient flow in the lower urban reaches was identified as an important factor limiting the juvenile steelhead populations. (Stillwater Sciences 2006)

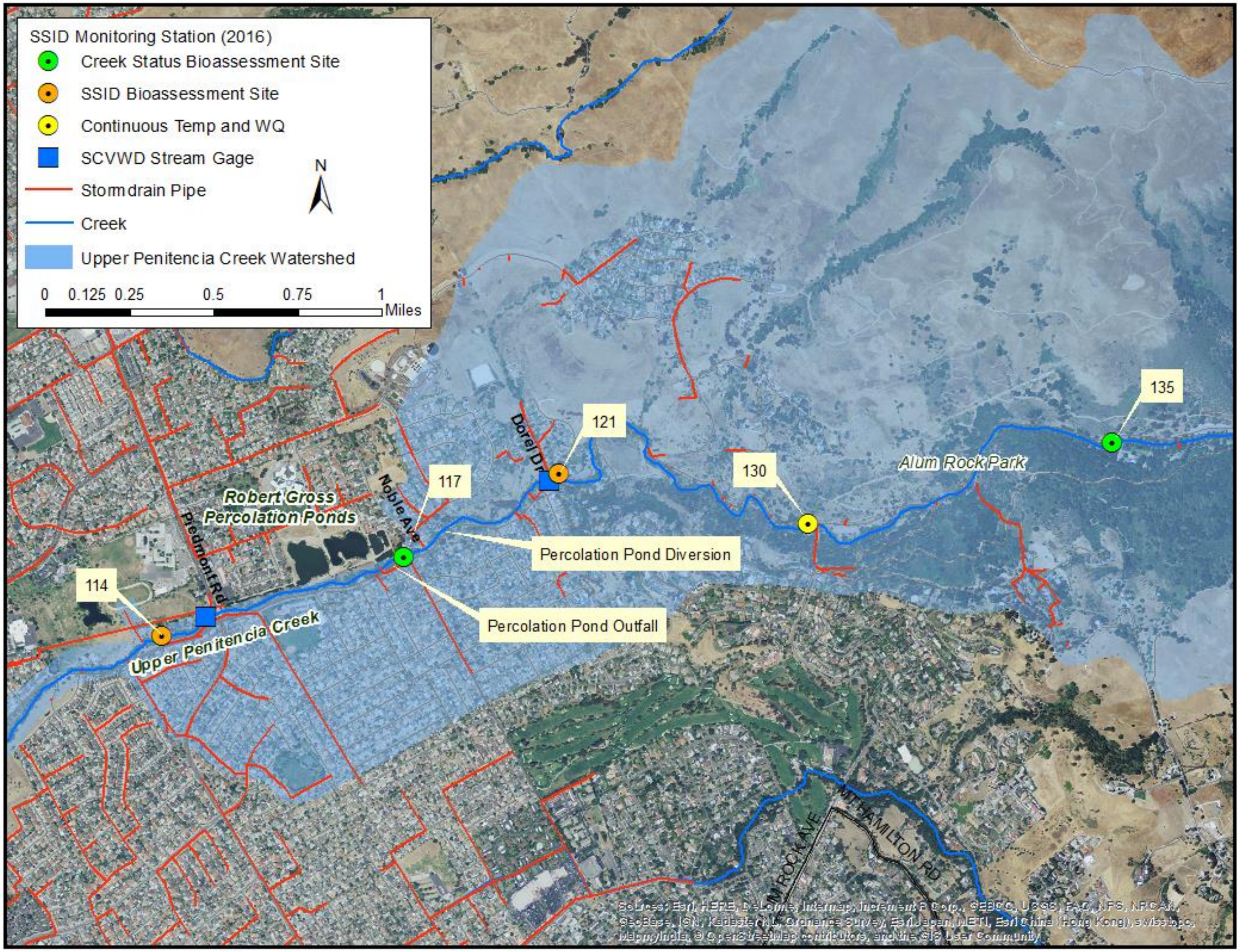

Figure 3. Study reach for the Upper Penitencia Creek showing monitoring locations used for SSID Project during WY 2016.

3.0 Methods

3.1 Sampling Design

The Upper Penitencia SSID project focused on a causal analysis of stressors that may impact the biological condition at site 114, herein referred to as the case site. Biological indicator and potential stressor data were collected at site 114, as well as site 121, located about one mile upstream near Dorel Drive (Figure 3). Site 121, herein referred to as the comparator site, is located near the upper boundary of urban/residential area and just downstream of Alum Rock Park. Site 121 is perennial year-round, but the channel typically dries up a short distance downstream of Dorel Drive. Site 114 is typically non-perennial, although may have stream flow during portions of the dry season due to releases from the off-channel percolation ponds. The SCVWD operates stream gages near each of the bioassessment locations - Piedmont Road (site 114) and Dorel Drive (site 121).

Bioassessments were also conducted at two additional stations in Upper Penitencia Creek as part of Creek Status Monitoring activities during WY 2016. Site 117 (RMC Site 205R01731), located immediately upstream of the percolation pond outfall and just downstream of Dorel Drive, is approximately half-way between sites 114 and 121 (Figure 3). Site 135 (RMC site 205R02853) is located farther upstream, in Alum Rock Park. Both of the Creek Status Monitoring sites were sampled on May 5, 2016.

Two sample events were conducted at sites 114 and 121 in WY 2016 to evaluate biological conditions and stressor levels during different flow conditions. Sampling event 1 was conducted on April 28 following a series of storms that resulted in perennial flow throughout the urban reach of Upper Penitencia Creek. Event 2 was conducted on June 9 when the source of flow at site 114 was primarily from percolation pond releases; no flow was observed in the upstream reach between the outfall from the ponds and a short distance downstream of Dorel Drive (Figure 4). Site 121 had perennial flow during both sampling events.

A summary of parameters, sampling locations and frequencies for 2016 monitoring is shown in Table 2. Sampling locations are illustrated in Figure 3. Sampling methods are described in the next section.

Figure 4. Upper photo: Water release from Robert Gross Percolation Ponds on June 9, 2016. The channel directly upstream the outfall is nearly dry. Lower photo: Site 114, approx. 0.5 mile downstream of outfall. (Site 117, where bioassessment was conducted on May 5, 2016, is located in the dry reach above the outfall.)

Table 2. Parameter type and data collection period at five stations in the Upper Penitencia Creek that were monitored during 2016 for the SSID project.

Sampling Site ID	Location	Latitude	Longitude	Bioassessment (BMI, algae), Physical Habitat	Nutrients, Chlorine, General WQ	Water Temp	Water Quality	Sediment Chemistry & Toxicity
114	Piedmont Ave	37.39007	-121.84361	4/28/16	4/28/16	3/24/16-8/20/16	4/11/16-4/28/16	5/5/16
				6/9/16	6/9/16		6/16/16-6/23/16	
117	Nobel Ave	37.39264	-121.83477	5/5/16	5/5/16	--	4/11/16-4/28/16	--
							6/16/16-6/23/16	
121	Dorel Drive	37.39530	-121.82668	4/28/16	4/28/16	3/24/16-8/20/16	4/11/16-4/28/16	5/5/16
				6/9/16	6/9/16		6/16/16-6/23/16	
							9/7/16-9/20/16	
130	Quail Hollow	37.39362	-121.81783	--	--	4/5/16-8/20/16	9/7/16-9/20/16	--
135	Log Cabin	37.39658	-121.80390	5/5/16	5/5/16	6/5/16-8/20/16	9/7/16-9/20/16	--

Data types associated with potential stressors of biological condition that were evaluated in the Work Plan (SCVURPPP 2015) are shown in Table 3. The expected biological response to each stressor is also indicated in the table. Each of the data types was collected at the case and comparator sites for the SSID project (sites 114 and 121). In addition, some of the data types were collected at the bioassessment (sites 117 and 135) or targeted temperature monitoring (site 130) sites for the Creek Status Monitoring activities for WY 2016.

Table 3. Potential stressors and associated data type collected to evaluate biological condition response.

Potential Stressor	Data Type	Biological Condition Response
Flow alteration, dry channel conditions	Stream discharge	BMI community change (e.g., taxa with short life cycles)
Increase in water temperature	Water Temperature	Reduced cold water biota (e.g., EPT[1] taxa)
Decrease in dissolved oxygen, high/low pH, elevated conductivity	Water Quality	Reduced oxygen dependent taxa (e.g., EPT taxa)
Increase sands + fine substrate, increase algal cover	Physical Habitat	BMI community change (e.g., increased sediment tolerant organisms)
Increase of total nitrogen, total phosphorus, ammonia	Nutrients	Toxic response; response to low Dissolved Oxygen related to eutrophication
Chronic and/or acute toxicity; toxic Pesticides and Toxicity	Pesticide concentrations and toxicity	Low BMI andr algae diversity, abundance

[1] EPT: Ephmeroptera, Trichoptera, Plecoptera- biological metric that indicates group of taxa that prefer good habitat and water quality conditions

3.2 Field Sampling

Stream Flow and Precipitation

Real-time stream flow data[4] recorded at two gaging stations in Upper Penitencia Creek, both operated by the SCVWD, were downloaded from the SCVWD website[5]. Hourly stream discharge (cfs) data were obtained for the period between October 2015 and September 2016. The stream gage at Dorel Drive (alert ID 1548), located at the eastern edge of the Santa Clara Valley near the Alum Rock Park boundary, drains approximately 21.5 square miles. The stream gage at Piedmont Ave (alert ID 1489), located just downstream of the percolation ponds, drains approximately 22.6 square miles. The flow at the Piedmont Ave gage includes releases from the percolation ponds in addition to natural stream flow.

Precipitation data recorded at a station in San Jose, operated by National Oceanic and Atmospheric Administration (NOAA), were downloaded from NOAA website[6]. The daily record of precipitation was obtained for the period between October 2015 and September 2016. The precipitation gaging station (San Jose 5.8 NNE) is located approximately 0.5 mile south of the study reach on Upper Penitencia Creek.

Biological Indicators

Benthic macroinvertebrates and algae were collected using protocols described by Ode et al. (2016). 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. Physical habitat data were collected within the sample reach using methods for the California Surface Water Ambient Monitoring Program (SWAMP) “Full” level of effort. The presence of micro- and macroalgae was assessed during the pebble counts.

Biological samples were sent to laboratories for analysis. The laboratory analytical methods used for BMIs followed Woodward et al. (2012), using 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 and revised when necessary to match the SWAMP master taxonomic list.

Water Chemistry

Immediately prior to biological and physical habitat data collection, water samples were collected for nutrients and conventional analytes 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). In addition, general water quality parameters (dissolved oxygen, pH, specific conductivity and temperature) were measured at or near the centroid of the stream flow using pre-calibrated multi-parameter probes. Benthic algae composite samples were filtered to obtain ash free dry mass and chlorophyll a samples using procedures described by Ode et al. (2016). Water samples and filters were sent to a laboratory for analysis.

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[4] These data have not been through a quality review check; final data review was not completed in time for this report.

[5] http://alert.valleywater.org/

[6] https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:US1CASC0027/detail.

Continuous Water Temperature

Digital temperature loggers (Onset HOBO Water Temp Pro V2) were programmed to record data at 60-minute intervals and were deployed at both SSID bioassessment locations for approximately six months (April – September). At site 114, the device was removed in August due to dry channel conditions. Temperature devices were also deployed at six[7] other stations in Upper Penitencia Creek for the Creek Status Monitoring project for six months, with the exception of site COY135 where the device was lost and data was only collected over a four-month timer period. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-5 (BASMAA 2016b).

Continuous Water Quality

Water quality monitoring equipment recording dissolved oxygen, temperature, conductivity, and pH at 15-minute intervals (YSI 6600 data sondes) were deployed at five[8] monitoring sites for three 2-week periods in April, June and September 2017. In September, sondes were deployed for two-week period at site COY121 and two new sites (COY130 and COY135) in Alum Rock Park. Sondes could not be deployed in September at COY114 or COY117 due to dry channel conditions. Procedures used for calibrating, deploying, programming and downloading data are described in RMC SOP FS-4 (BASMAA 2016b).

Sediment Chemistry and Toxicity

Sediment samples were collected at the case and comparator sites (sites 114 and 121) and tested for sediment toxicity and pyrethroid pesticides. Sediment samples were collected from the top 2 cm at each sub-site beginning at the downstream-most location and continuing upstream. 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 jars were sent to respective laboratories for analyses. Sediment toxicity testing was performed on two species, *Hyalella azteca* and *Chironomus dilutus* using acute endpoints (i.e., survival).

3.3 Data Analyses

Benthic Macroinvertebrates

Two existing tools were used to interpret the benthic macroinvertebrate data: the Southern California Index of Biological Integrity (SoCal IBI) (Ode et al. 2005) and the California Stream Condition Index (CSCI). The SoCal IBI was initially used to evaluate the BMI data collected in 2008 and 2013, was therefore used to interpret the data collected in 2016. The California Stream Condition Index (CSCI), developed by the State Water Resources Control Board (State Board), is an index used to score the condition of BMI communities in perennial wadeable rivers and streams in California. The CSCI is calculated using a combination of biological and environmental data following methods described in Rehn et al. (2015). It 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 based on reference conditions. The CSCI score is computed as the average of

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[7] Water temperature device was also deployed at site 117, however the first device was not recovered and the channel dried up soon after a second device was deployed. Thus, data from that site are not presented in this report.

[8] The first two sampling events were conducted at same three sites. The two lower elevation sites had no flowing water during September sampling event. As a result, sondes were deployed at two new sites further upstream.

the sum of O/E and pMMI. Detailed information related to methods for calculating CSCI are in the Creek Status Monitoring Report (SCVURPPP 2017)

Benthic Algae

The State Water Resources Control 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 IBI is expected to be completed in 2017. The statewide algae index will build upon studies by Fetscher et al. (2014) that developed and tested algal indices of biological integrity (IBIs) for streams in Southern California (SoCal Algae IBI). 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 Upper Penitencia Creek were evaluated using the existing SWAMP Algae Reporting Module, (Algae RM) which was developed in 2012 using the SoCal Algae IBI as the basis for metric and IBI calculations (Marco Sigala, SWAMP, personal communication). A soft algae-diatom hybrid index (H20) was used as an interpretive tool for algae data collected for the SSID project. Detailed information related to methods for calculating H20 are in the Creek Status Monitoring Report (SCVURPPP 2017)

Biological Condition Thresholds

SoCal IBI scoring thresholds were used to interpret BMI data: Very Good (80-100), Good (60-79), Fair (40-49), Poor (20-39) and Very Poor (0-19). Existing thresholds for biological indicators defined in Mazor (2015) were used to evaluate the bioassessment data collected for the SSID Project (Table 4). 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 MRP 2.0 as a threshold below which indicates a potentially degraded biological community, and thus should be considered for a SSID Project.

Table 4. Condition categories used to evaluate CSCI and Algae IBI scores.

Index	Likely Intact (>30th)	Possibly Intact (10th – 30th)	Likely Altered (1st – 10th)	Very Likely Altered (< 1st)
CSCI - Benthic Macroinvertebrates	≥ 0.92	0.79 – 0.92	0.63 – 0.79	< 0.63
H20 Index – Benthic Algae	≥ 70	63 - 70	54 - 63	< 54

4.0 Results

4.1 Stream Flow

For over two years (WY 2014 and WY 2015) an extended drought in California resulted in extremely low flow conditions in the Santa Clara Valley. Stream flow was further reduced at some locations, including Upper Penitencia Creek, with cessation of water imports from the State Water Project (i.e., South Bay Aqueduct). Due to absence of water imports, there were no water releases from the percolation ponds in Upper Penitencia Creek in 2014 or 2015. The lack of water during bioassessment index period (April 15 – June 30) resulted in a delay for the Upper Penitencia Creek SSID Project. Summary statistics of water discharge between beginning of April and end of June for the past five years is shown in Table 5.

Table 5. Summary statistics of stream flow discharge recorded at SCVWD gaging station at Piedmont Avenue during April 1 – June 30 for the past five years (2012 – 2016).

Flow Discharge (cfs)	2012	2013	2014	2015	2016
Minimum	2.5	3.8	0	0	0.0
Maximum	98.1	12.9	0	0	12.6
Median	4.3	4.5	0	0	5.2
Average	5.7	4.6	0	0	5.6

Stream flow discharge data (cfs) recorded at the two gages (Dorel and Piedmont) in Upper Penitencia Creek and precipitation data recorded near the study area during WY 2016 are plotted in Figure 5. Precipitation data is also plotted for the same time period. Winter peak flows measured at the Piedmont gage occurred in mid-December (346 cfs) and mid-January (487 cfs). (Note: Stream gage at Dorel is only accurate for low flow conditions). A period of dry weather in February was followed by a series of storms in March that resulted in flow conditions at both case and comparator sites.

Stream flow at the Dorel and Piedmont stream gages during the spring and summer seasons and bioassessment timing are detailed in Figure 6. The increase in stream flow at the Piedmont stream gage during this timeframe is associated with percolation pond releases. Flow levels at the Piedmont gage increased up to a maximum of 12 cfs between May and July, while flow at Dorel gage was relatively consistent at less than 1 cfs. The June 9 sampling event occurred during these flow conditions (Figure 5). Once the pond releases were stopped on July 20, the channel at Piedmont became dry again. Percolation pond discharges were re-initiated on September 1 and continued through the end of the study.

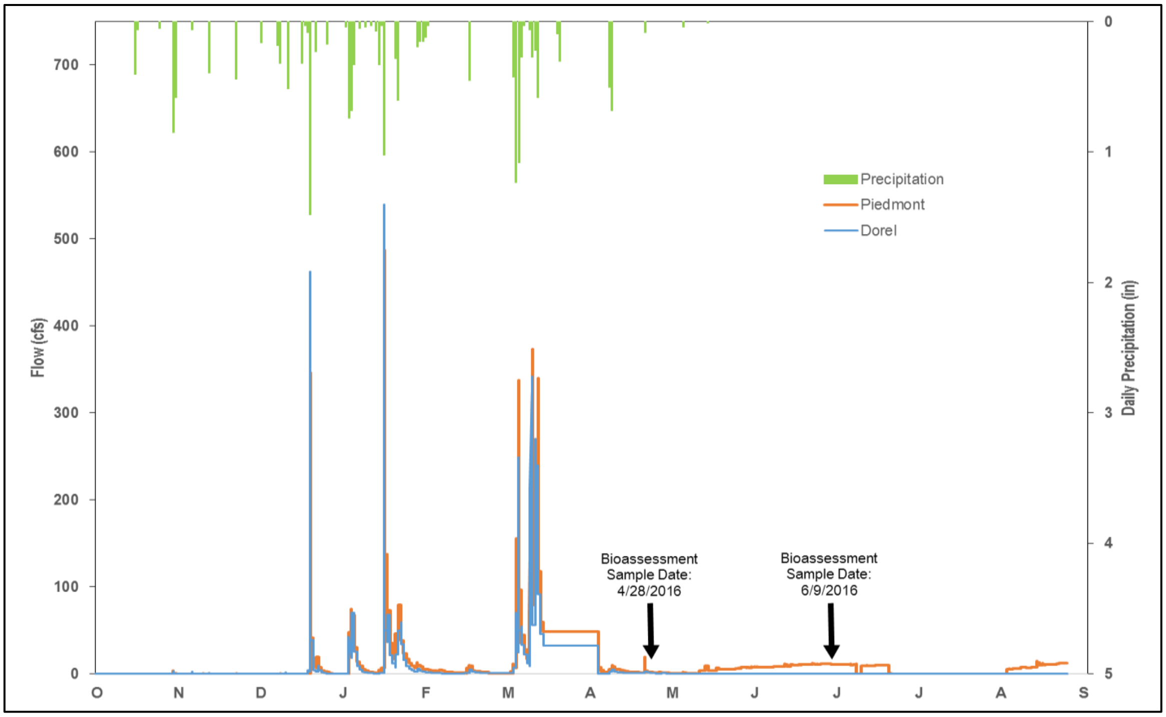

Figure 5. Stream flow discharge recorded at SCVWD Alert Gage at Dorel and Piedmont during WY 2016. Precipitation records, recorded at NOAA rain gage, are also presented.

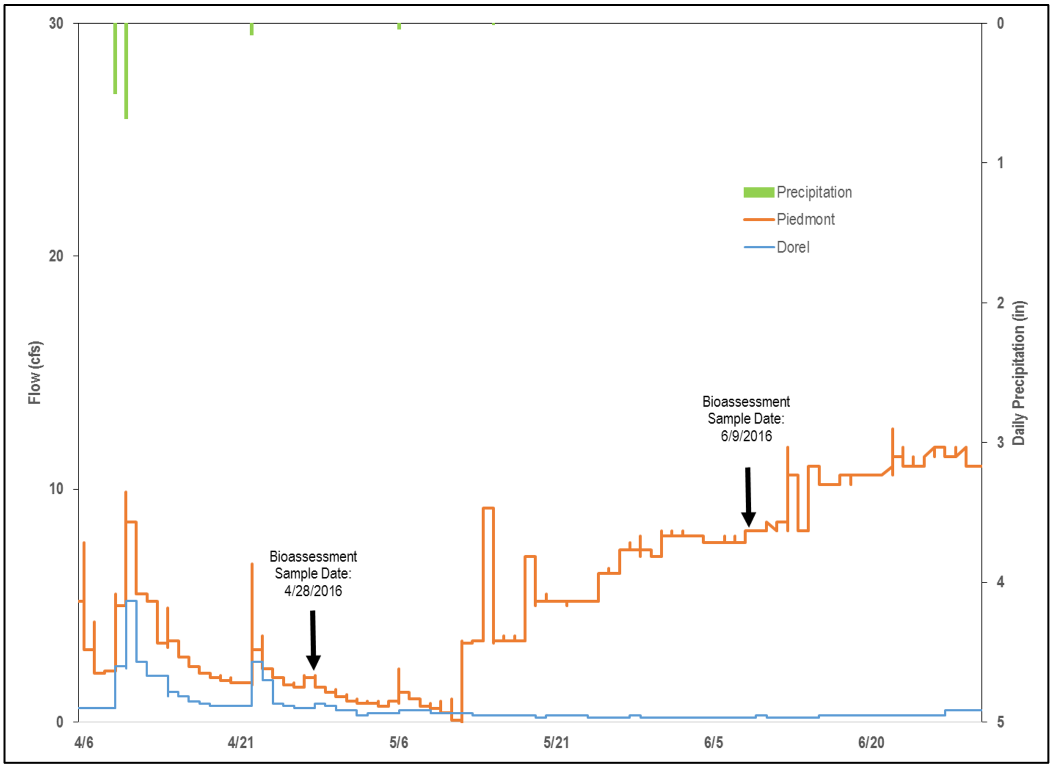

Figure 6. Stream flow discharge recorded at SCVWD Alert Gage at Dorel and Piedmont between April 15 and September 27, 2016.

4.2 Biological Condition

Biological condition scores, based on indices for benthic macroinvertebrate (CSCI and SoCal IBI) and algae (SoCal Algae H20 IBI) data, for the four sites in Upper Penitencia Creek where bioassessments were conducted during WY 2016 are shown in Table 6. Site elevation and flow status for each site are also shown. Biological condition scores are shown for both sampling events (April 28 and June 9, 2016) conducted at the case site (114) and comparator site (121) for SSID Project and assessments conducted at the two probabilistic sites (117 and 135) for the Creek Status Monitoring Project are shown.

Table 6. Biological condition, based on CSCI and SoCal IBI scores for benthic macroinvertebrates and SoCal Algae H20 IBI scores for algae data, for four bioassessment sites in Upper Penitencia Creek in 2016.

Station Code	Project	Sampling Date	Elevation (ft)	Flow Status	Benthic Macroinvertebrates			Benthic Algae
					CSCI Score	CSCI Condition	SoCal IBI Score	Hybrid "H20" IBI Score
114	SSID	4/28/2016	209	NP	0.65	Likely Altered	26	11
		6/9/2016	209	NP	0.66	Likely Altered	29	19
117	Creek Status	5/5/2016	239	NP	0.63	Likely Altered	36	20
121	SSID	4/28/2016	270	P	0.78	Possibly Intact	39	20
		6/9/2016	270	P	0.97	Likely Intact	59	32
135	Creek Status	5/5/2016	521	P	0.79	Possibly Intact	53	38

Benthic Macroinvertebrates

CSCI scores were similar for both sampling events at site 114 and at site 117, ranging 0.63 to 0.65. The highest CSCI score (0.97) occurred at site 121 during the June sampling event[9]. The CSCI scores were always higher at the site 121 compared to site 114, however the difference in score was greater for June event compared to the April event. The CSCI scores were relatively similar at sites 121 and 132 during the April/May sampling event, 0.78 and 0.79, respectively. The SoCal IBI scores show similar pattern to the CSCI, with scores higher at site 121 compared to site 114 during both sampling events.

Individual metric scores for the BMI data collected during six sampling events are shown in Table 7. Biological metric scores associated with richness, composition, tolerance and functional feeding group measures were calculated for each sampling event. The metric scores results indicate the following characteristics for the case and comparator sites:

- Fluctuating habitat conditions at case site (114) – The BMI assemblages at the case site for both sampling events were predominantly taxa with short life cycles (i.e., Chironomids and black flies comprised over 90% of the taxa). These metrics suggest that biological condition may be impacted by changes in habitat, magnitude of flow and/or water quality.
- Habitat/water quality conditions improved over time at comparator site (121). The BMI assemblage transitioned from short-lived taxa during April sampling event to long-lived, and more diverse taxa during the June event. Biological condition at site 121 appears to have increased following onset of summer base flow conditions.

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[9] CSCI scores at reference sites are typically at or above 1.0

- Non-perennial flow status at case site; absence of both larval and adult life stages of Coleoptera taxa (beetles).
- Perennial flow status at comparator site; presence of long-lived, predator and intolerant taxa.

Benthic Algae

The Algae H20 IBI scores were generally very low across all sites and sampling events (Table 6). The H20 scores ranged from 11 to 38 (highest possible score is 100). All of the sampling events had algae IBI scores that fell into the “very likely altered” condition category (Mazor et al. 2015). Algae IBI scores were higher for the June sampling event compared to the April sampling event for both case (114) and comparator (121) sites.

Individual metric scores used to generate the H20 IBI score for algae data are shown in Table 8. The metric scores were relatively similar between sites 114 and 121, with the exception of the following:

- Evidence of more stressors at site 114 (both events); greater proportion of taxa tolerant of fine sediment and dissolved salts (halobiontic).
- Response to nutrients at site 114 (June event); greater proportion of diatom taxa that utilize organic bound nitrogen (heterotrophic). These taxa may have been dispersed into the case sites from percolation ponds.

Table 7. Biological metric scores for BMI data collected at four sites on Upper Penitencia Creek during WY 2016. Sampling station number for SSID sites are in bold.

Biological Metrics	April/May 2016				June 2016	
	114	117	**121**	135	**114**	**121**
Richness:						
Taxonomic	19	16	27	27	26	40
EPT	6	7	12	14	8	14
Ephemeroptera	3	4	4	4	2	6
Plecoptera	0	1	3	3	0	1
Trichoptera	3	2	5	7	6	7
Coleoptera	0	1	1	1	0	3
Predator	5	3	9	10	10	13
Diptera	7	7	7	8	8	12
Composition:						
EPT Index (%)	2.8	7.1	5.8	6.2	10	32
Sensitive EPT Index (%)	0.5	0.5	2.6	2.1	0.9	5.1
Shannon Diversity	1.3	1.66	1.6	1.37	1.8	2.8
Dominant Taxon (%)	54	33	39	62	54	18
Non-insect Taxa (%)	26	6.3	22	15	35	23
Tolerance:						
Tolerance Value	5.4	5.7	5.5	5.6	5.9	5.7
Intolerant Organisms (%)	0.3	0.5	2.3	1.8	0.9	5.4
Intolerant Taxa (%)	5.3	19	22	19	7.7	18
Tolerant Organisms (%)	0.6	0.5	1.6	0.2	10	14
Tolerant Taxa (%)	11	13	22	4	31	23
Functional Feeding Groups:						
Collector-Gatherers (%)	68	83	55	30	28	52
Collector-Filterers (%)	29	16	40	63	56	19
Collectors (%)	98	99	95	92	85	71
Scrapers (%)	0.3	0.2	1.4	3.1	8.5	2.5
Predators (%)	1.6	1.3	3.4	3.8	6.5	19
Shredders (%)	0.3	0.0	0.5	0.5	0.0	1.3
Other (%)	0.0	0.0	0.0	0.2	0.3	6.4
Taxa characteristics:						
Chironomids + blackflies (%)	93	92	91	90	76	46
Sensitive Taxa (TV < 3)	1	3	6	5	2	7
Estimated Abundance	20,000	29,000	7,000	19,000	12,000	10,000
Biological Condition Score:						
SoCal IBI Score (0-100)	26	36	39	53	29	59
CSCI Score (1 – 1.0)	0.65	0.63	0.78	0.79	0.66	0.97

Table 8. Scores for biological metrics used to calculate H20 IBI for sites in Upper Penitencia Creek sampled during WY 2016. SSID station numbers are in bold.

Biological Metrics	April/May 2016				June 2016	
	114	117	**121**	135	**114**	**121**
Proportion halobiontic Score	0	1	3	5	1	3
Proportion high copper indicators Score	0	1	0	1	0	0
Proportion high DOC[1] indicators Score	0	4	0	6	0	0
Proportion low TN[2] indicators Score	2	3	2	2	3	2
Proportion low TP[3] indicators Score	0	0	0	0	0	0
Proportion Nitrogen heterotrophs Score	0	0	1	5	1	6
Proportion requiring >50% DO[4] saturation Score	7	6	7	6	8	8
Proportion sediment tolerant (highly motile) Score	0	1	3	5	2	7
Total H20 Score	**11**	**20**	**20**	**38**	**19**	**32**

[1] DOC: Dissolved Organic Carbon
[2] TN: Total Nitrogen
[3] Total Phosphorus
[4] DO: Dissolved Oxygen

4.3 Physical Habitat

The physical habitat assessment collected during each bioassessment sampling event are shown in Table 9. The amount of fine substrate and percentage of canopy cover were similar across sites. The percent riffle habitat was highly correlated with flow rates; higher at site 114 during June event and higher at site 121 at April event. The percent macroalgae cover was much higher during the June sampling event at both sites.

Table 9. Selected physical habitat variables collected at 4 bioassessment sites in Upper Penitencia Creek, Santa Clara County during WY2016.

Station Code	Sampling Date	% Micro Algae Cover	% Macro Algae Cover	% Canopy Cover	% Sands+ Fines	% Riffle Habitat
114	4/28/2016	0	4.8	74.7	23.8	28
	6/9/2016	1.0	47.6	83.7	27.6	58
117	5/5/2016	1.9	19.1	70.2	16.2	NR
121	4/28/2016	5.7	22.9	79.6	24.8	61
	6/9/2016	1.9	59.1	81.0	25.7	36
135	5/5/2016	7.6	10.5	85.8	27.6	NR

4.4 Water Temperature

Plots showing temperature data collected at the four monitoring sites in Upper Penitencia Creek in WY 2016 are presented in Figure 7. The temperature plot for site 114 indicates period of higher temperatures and reduced diurnal variability between June and the end of the deployment in July (when percolation pond releases were stopped). Temperatures during this period appear to show influence of warmer water from the percolation ponds coupled with reduced (or absent) surface flow from the upstream channel reach.

The maximum weekly average temperatures (MWAT) were calculated for non-overlapping, 7-day periods for all sites. The MWAT values calculated from temperatures recorded at the four lowest elevation sites in Upper Penitencia Creek (sites 114, 121, 130, and 135) are plotted in Figure 8. The case site (114) had MWAT values that were 2 to 6 °C higher than other sites during months of June - July.

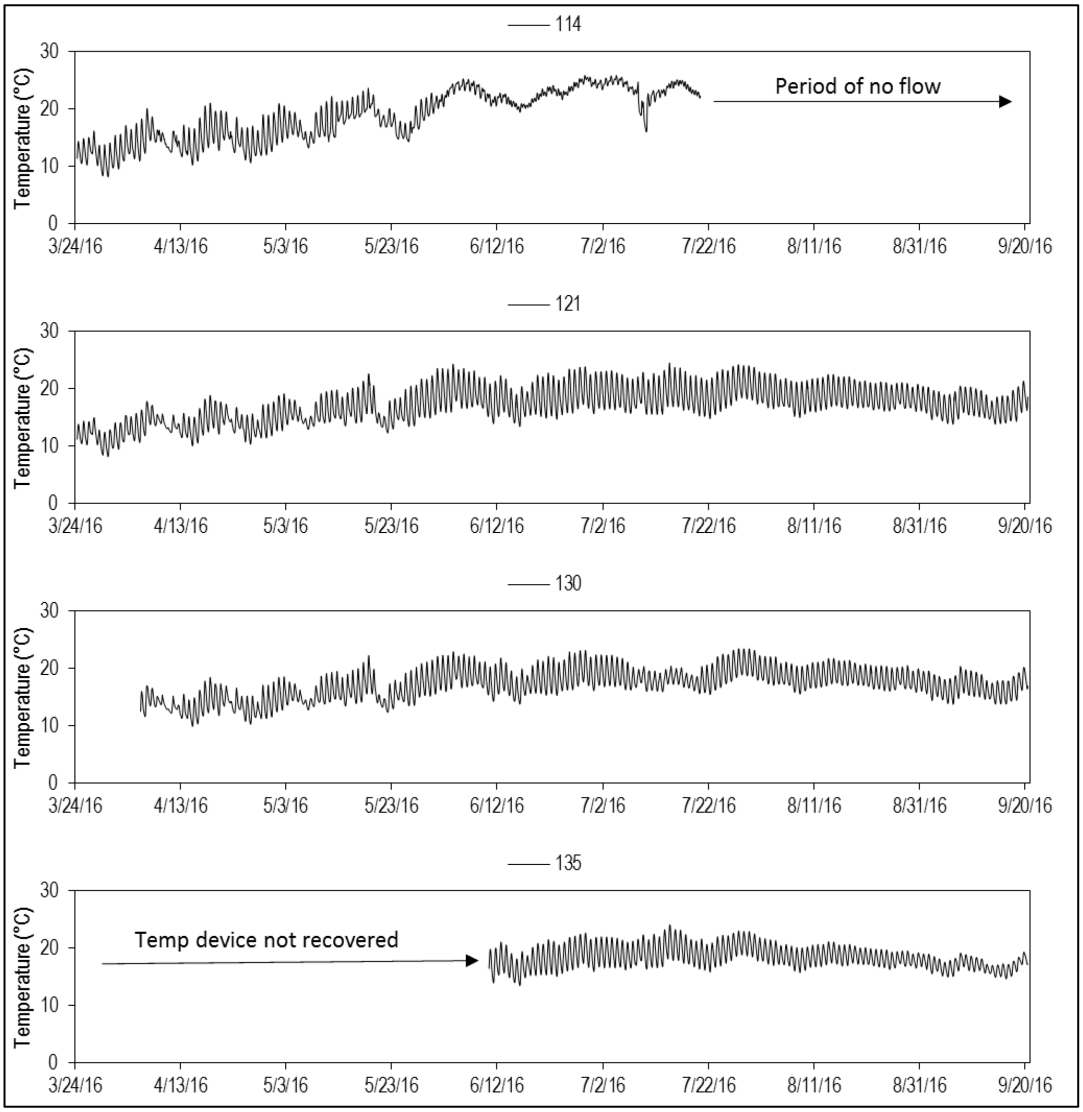

Figure 7. Plot of hourly temperature data collected at four monitoring sites in Upper Penitencia Creek during WY 2016.

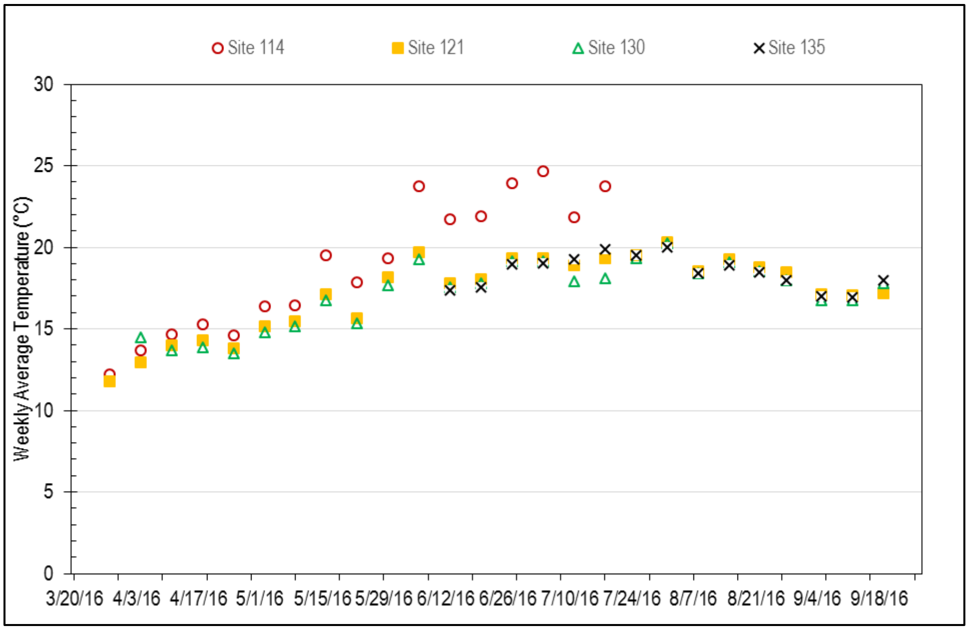

Figure 8. MWAT values for temperature data collected at four monitoring locations in Upper Penitencia Creek during WY 2016.

4.5 General Water Quality

Summary statistics for general water quality measurements collected at the five sites in Upper Penitencia Creek during three sampling events occurring in April, June and September 2016 are listed in Table 10. Continuous water quality monitoring during Event 1 and Event 2 occurred directly before and after, respectively, the two bioassessment sampling events conducted at sites 114 and 121. Summary of the results for each of the water quality parameters are provided below:

- Temperature: Median temperature measured during Event 1 was about 1°C warmer at site 114 compared to site 121. During Event 2, median temperature was 4°C warmer at site 114 compared to site 121. The higher temperatures coincide with period of discharges from the percolation ponds.

- Dissolved Oxygen: Median DO measured at sites 114 and 121 ranged from 8.8 to 10.4 mg/L for both sampling events. There was very little difference between sites.

- pH: Median pH measured at sites 114 and 121 ranged from 8.0 to 8.5 for both events. The maximum values of pH ranged from 8.5 to 9.0, with the highest value measured at site 121 during Event 1.

- Specific Conductance: The median specific conductance measured during Event 1 was 722 uS/cm for both sites. The specific conductance measured during Event 2 was much lower at site 114 (305 uS/cm) compared to site 121 (1025 uS/cm). The lower conductivity measurement for Event 2 is likely influenced from imported water originating from percolation ponds.

Table 10. Descriptive statistics for continuous water temperature, dissolved oxygen, pH, and specific conductance measured at five sites in Upper Penitencia Creek, Santa Clara County during WY2016. Data were collected every 15 minutes over a two two-week time periods during April (Event 1), June (Event 2) and September (Event 3).

Sample Month		**Event 1 (April 14-28)**			**Event 2 (June 10-23)**		**Event 3 (Sept 7-20)**		
Station Code		**114**	**117**	**121**	**114**	**121**	**121**	**130**	**135**
Temperature (°C)	Min	10.3	9.9	9.9	19.2	13.3	20.4	13.6	13.8
	Median	14.5	14.0	13.6	21.6	17.5	22.1	16.5	16.8
	Mean	14.7	14.2	13.8	21.6	17.8	22.1	16.5	16.9
	Max	21.1	20.3	18.8	24.2	22.8	23.8	19.8	20.6
Dissolved Oxygen (mg/L)	Min	8.0	8.9	9.0	8.0	7.2	7.8	6.8	7.8
	Median	9.9	10.4	10.4	8.8	8.8	8.4	8.9	9.3
	Mean	10.0	10.5	10.4	8.9	9.0	8.5	8.9	9.5
	Max	12.1	12.1	11.8	9.9	11.3	9.6	10.5	11.1
pH	Min	7.9	8.4	8.2	7.7	8.2	7.8	8.0	8.2
	Median	8.1	8.5	8.5	8.0	8.3	8.1	8.2	8.3
	Mean	8.2	8.6	8.5	8.0	8.4	8.2	8.2	8.4
	Max	8.8	9.1	9.0	8.5	8.7	8.9	8.4	8.6
Specific Conductivity (uS/cm)	Min	240	65	507	286	977	427	1185	1196
	Median	722	630	721	305	1025	475	1245	1246
	Mean	705	626	699	305	1023	481	1238	1240
	Max	800	813	800	333	1072	547	1289	1275
Total number of data points (N)		*1632*	*1621*	*1623*	*1262*	*1260*	*1252*	*1252*	*1253*

4.6 Water Chemistry

Concentrations of nutrients and conventional analytes measured in water samples collected at the four bioassessment sites in Upper Penitencia Creek during WY 2016 are shown in Table 11.

Table 11. Nutrient and conventional constituent concentrations in water samples collected at four sites in Upper Penitencia Creek during WY 2016.

Parameter	Units	Water Quality Objective[1]	114		117	121		135
			4/28/16	6/9/16	5/5/16	4/28/16	6/9/16	5/5/16
Ammonia as N	mg/L	NA	0.025	0.11	0.03	0.043	0.043	0.17
Unionized Ammonia (as N)	mg/L	0.025	NR	0.01	0.001	0.002	0.003	0.004
Chloride	mg/L	250	43	42	41	42	78	120
AFDM	g/m2	NA	52.4	47.9	55.2	60.9	29.3	247.7
Chlorophyll a	mg/m2	NA	23.4	31.7	2	31.2	110.4	74.3
Nitrate as N	mg/L	0.42	0.13	0.3	0.19	0.24	0.04	0.3
Nitrite as N	mg/L	NA	0.008	0.008	0.004	0.011	0.001	0.035
Total Kjeldahl	mg/L	NA	0.57	1.1	1.1	0.48	0.88	0.97
Total Nitrogen	mg/L	NA	0.71	1.41	1.29	0.73	0.92	1.31
Ortho-Phosphate as P	mg/L	NA	0.02	0.14	0.02	0.02	0.01	0.03
Phosphorus as P	mg/L	NA	0.03	0.28	0.03	0.03	0.09	0.04
Total Phosphorus	mg/L	NA	0.057	0.42	0.046	0.055	0.095	0.072
Silica as SiO2	mg/L	NA	12	10	15	12	9.4	15

[1] Nitrate and chloride water quality objectives only apply to waters with MUN designated Beneficial Uses (BU) SFRWQCB (2013). MUN is not a designated BU for Upper Penitencia Creek.

The highest concentrations for nitrate (0.3 mg/L), total nitrogen (1.41 mg/L), total phosphorus (0.42 mg/L) and unionized ammonia (0.01) occurred at the case site 114 during the June event. The concentrations for the same analytes at site 121 during the June event were much lower, suggesting that augmented water from the percolation ponds are likely a source of additional nutrients to site 114. In contrast, similar nutrient levels occurred at sites 114 and 121 during the April sampling event and sites 117 and 135 during the May sampling event.

There are no established nutrient thresholds for Santa Clara County that are associated with biological condition. An evaluation of CSCI scores in relation to nutrient concentrations was conducted for 112 bioassessment sites sampled between 2012 and 2016 for Creek Status Monitoring. The results indicated that all sites with “likely intact” and “possibly intact” and the majority of sites with “likely altered” CSCI scores had total nitrogen concentrations that were ≤1.5 mg/L. All of the samples collected at sites 114 and 121 were below this threshold.

4.7 Sediment Chemistry and Toxicity

To evaluate sediment chemistry impacts to biological condition, sediment samples were analyzed for pyrethroid pesticide concentrations. Toxicity unit (TU) equivalents were computed for individual pyrethroid and fipronil results, based on available literature values for pyrethroids in sediment LC50 values.[10,11] (Table 12). 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 at each site, and the TOC-normalized concentrations were used to compute TU equivalents. None of the pesticide constituents had TU equivalents that exceeded 1.0 for either site.

Table 12. Calculated pyrethroid toxic unit (TU) equivalents for sediment samples collected at two sites in Upper Penitencia Creek in 2016.

Pyrethroid	**Units**	**LC50**	**Sampling Location**			
			114		**121**	
Bifenthrin	µg/g dw	0.52	0.19		0.14	a
Cyfluthrin	µg/g dw	1.08	0.03	b	0.07	a
Cypermethrin	µg/g dw	0.38	0.08	b	0.19	a
Deltamethrin	µg/g dw	0.79	0.02	a	0.11	a
Esfenvalerate	µg/g dw	1.54	0.01	a	0.06	a
Lambda-Cyhalothrin	µg/g dw	0.45	0.04	b	0.16	a
Permethrin	µg/g dw	10.83	0.00	b	0.01	a
Other MRP Pesticides of Concern						
Carbaryl	µg/g dw	NA[c]	NA	c	NA	c
Fipronil	µg/g dw	0.41	0.03	a	0.17	a

[a] Concentration was below the method detection limit (MDL). TU equivalents calculated using 1/2 MDL.
[b] TU equivalents calculated from concentration below the reporting limit (DNQ-flagged).
[c] Currently there is no available LC50 value for Carbaryl, however the observed concentration was below the detection limit.

A summary of toxicity testing results for two stations on Upper Penitencia Creek during WY 2016 is presented in Table 13. The toxicity of sediment samples to the test organisms are 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. Both the TST result and the Percent Effect are determined by the analytical laboratory.

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[10] The LC50 is the concentration of a given chemical that is lethal on average to 50% of test organisms.
[11] No LC50 is published for carbaryl.

Table 13. Summary of SCVURPPP toxicity results for sediment samples collected at two sites in Upper Penitencia Creek in 2016.

Site ID	Organism	Test Type	Unit	Results		TST Result	% Effect
				Lab Control	Organism Test		
114	*Chironomus dilutus*	Survival	%	86.3	93.8	Pass	-8.7%
	Hyalella azteca	Survival	%	100	97.5	Pass	2.5%
121	*Chironomus dilutus*	Survival	%	86.3	96.3	Pass	-11.6%
	Hyalella azteca	Survival	%	100	100	Pass	0%

5.0 Discussion

Using the CADDIS process outlined in section 3.0, existing information and new data collected as part of this project was analyzed to distinguish the most probable stressor(s) causing decreased biological condition in a segment of Upper Penitencia Creek roughly defined by the outfall of the Robert Gross Percolation Ponds to the stream crossing of Piedmont Avenue. The study approach focused on evaluating the differences in biological, physical, chemical and toxicological indicators between a case site (114) located within the segment of interest and a comparator site (121) located directly upstream of the segment. Because the biological condition, as measured by CSCI scores, at the case site was consistently lower than the comparator site, the CADDIS process was focused on identifying indicators of biological condition stress that may indicate the cause of decreased CSCI scores. A comparison of indicator values observed at the case and comparator sites during April and June 2016 is provided as Table 14.

5.1 Spatial and Temporal Differences in Macroinvertebrate and Algal Communities

The combined bioassessment results from 2008, 2013 and 2016 at sites within urban reach of Upper Penitencia Creek show a distinct biological gradient, with CSCI scores decreasing from upstream to downstream direction (Figure 9). The change between “intact” and “altered” biological condition categories (as defined by MRP trigger of 0.795) is located at approximately the 250-foot elevation mark, just downstream of the Dorel Drive bridge and the SCVWD stream gage. This location is approximately the downstream extent of perennial flow in Upper Penitencia Creek and the upstream extent of the Santa Clara Valley groundwater basin.

Benthic macroinvertebrate communities and CSCI scores varied between April 2016 and June 2016 at the comparator site (121). CSCI scores ranged from 0.78 in April to 0.97 in June. In April, the macroinvertebrate community was dominated by short-lived taxa, indicating a recent change in the extent of wetted channel that was likely related to spring pulse flows (i.e., newly wetted stream margins are first colonized by taxa with short life cycles). Following a period of consistent baseflows, a more diverse benthic macroinverterate community including the presence of long-lived taxa (e.g., water beetles) was observed in samples collected in June.

In contrast, CSCI scores calculated for the three bioassessments conducted in 2013 (n=1) and 2016 (n=2) at the case site (114) were relatively consistent, ranging from 0.64 to 0.66) and the biological community was dominated by short-lived taxa. Benthic macroinvertebrate taxa that typically indicate the presence of perennial flows were noticeably absent from the communities observed at the case site. Although CSCI scores remained stable at the case site, variations in water quality conditions were observed between April and June 2016. Percolation pond discharges directly upstream of the case site resulted in higher flow rates and warmer temperatures during the June 2016 bioassessent event. It is likely that very few or no BMIs would historically be present at the case site during the bioassessment index period without imported water getting released from the percolation ponds.

Table 14. Summary of the biological indicator and physical and chemical stressor data collected at the case site (114) and the comparator site (121) during the April and June 2016 events.

Indicator or Potential Stressor	April 2016			June 2016		
	114	121	% Difference[a]	114	121	% Difference[a]
Biological Indicators						
Benthic Macroinvertebrates						
CSCI Score	0.65	0.75	**-13%**	0.66	0.97	**-32%**
CSCI Condition Category	Likely Altered	Possibly Intact	**One Category**	Likely Altered	Likely Intact	**Two Categories**
Benthic Algae						
H20 Score	11	20	**-45%**	19	32	**-41%**
H20 Condition Category	Very Likely Altered	Very Likely Altered	None	Very Likely Altered	Very Likely Altered	None
Potential Stressors						
Stream Discharge (cfs)	2.3	0.9	**156%**	7.7	0.2	**3750%**
Release from Percolation Ponds	No	No	-	Yes	No	-
Flow Regime	NP	P	-	NP	P	-
Continuous WQ (mean values)[b]						
Temperature (C)	14.7	13.8	7%	21.6	17.8	**21%**
DO (mg/L)	10	10.4	-4%	8.9	9	-1%
pH	8.2	8.5	-4%	8	8.4	-5%
Specific conductivity (uS/cm)	705	699	1%	305	1023	**-70%**
% sand and fines	23.8	24.8	-4%	27.6	25.7	7%
% riffle habitat	28	61	**-54%**	58	36	**61%**
% Macroalgae cover	4.8	22.9	**-79%**	47.6	59.1	**-19%**
Ammonia as N (mg/L)	0.025	0.043	**-42%**	0.11	0.043	**156%**
Total nitrogen (mg/L)	0.71	0.73	-3%	1.41	0.92	**53%**
Total phosphorus (mg/L)	0.057	0.055	4%	0.42	0.1	**320%**
Chlorophyll a (mg/m2)	23.4	31.2	**-25%**	31.7	110.4	**-71%**
Ash Free Dry Mass (AFDM)	52.4	60.9	**-14%**	47.9	29.3	**64%**

[a] % Difference = ((value at case site-value at comparator site)/value at comparator site*100%).

[b] Represents data collected for period of two weeks prior (Event 1) and following (Event 2) bioassessment sample event.

Values over 10% are indicated in bold.

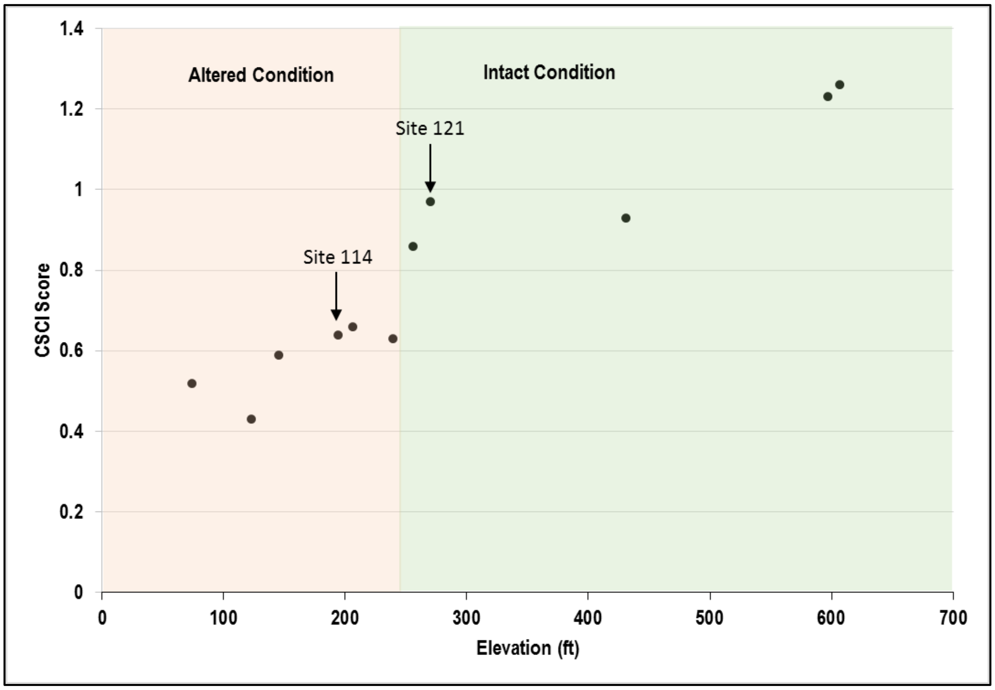

Figure 9. CSCI scores at bioassessment sites sampled in Upper Penitencia Creek between 2008 and 2016 across the elevation gradient.

5.2 Differences in Physical Habitat Indicators between Sites

Physical habitat conditions at a site can significantly affect the biological condition measured via CSCI or H20 indices. Based on the results of the physical habitat assessments conducted during each bioassessment event at the comparator and case sites, the overall condition of the habitat at each site is similar. The amount of fine substrate, percentage of canopy cover, and other variables observed at both sites were nearly identical during both the April and June events.

One indicator of the physical condition of the stream segments that differed between the two sites was the percent riffle habitat present. This indicator measures the extent of riffle habitat present to support benthic macroinvertebrate communities and it is highly correlated with the stream flow at the site. Stream flow was greater at the comparator site during the April event and greater at the case site during the June event, presumably due to water inputs from the percolation ponds during the summer, which creates a greater extent of wetted stream channel at the case site than likely occurs during natural conditions.

5.3 Differences in Chemical and Toxicological Indicators between Sites

Water and sediment chemistry and toxicity can also affect the biological condition observed in stream segments. Based on the analysis of available data, water and sediment chemistry and toxicity do not appear to be the likely causes of reduced biological condition at the case site. With the exception of water temperature and possibly nutrients, differences in water and sediment chemistry between case and comparator sites were not observed during the study.

Temperature and nutrient increases were observed during the June event, and are assumed to be associated with percolation pond releases. Although nutrient concentrations increased, concentrations are within the average range observed in Santa Clara Valley streams. Average weekly maximum water temperatures during the summer are bordering levels of concern (i.e., 24 °C). Sediment toxicity was not observed at either site and therefore is not considered to be a stressor of interest.

6.0 Conclusions and Next Steps

A summary of the analysis conducted on the available physical, chemical and toxicological data from both the case and comparator sites is presented in Table 15. Summary conclusions drawn using the CADDIS process outlined in section 3.0 are also presented in Table 15 and below:

- Biological Condition Affected by Natural Stream Drying - The case site (114) used in this study is located within a segment of Upper Penitencia Creek that historically dried up during the spring/summer season due to the percolation of surface flow into the underlying groundwater basin (Beller et al 2012). Biological conditions, based on CSCI scores, at the case site are consistently lower than the comparator site (121) at least partially due to the lack of perennial flow in this segment. This conclusion is supported by the abundance of short-live taxa at the case site and lack of organisms that prefer perennial flow.

- Water Inputs from Percolation Ponds Improve Flows and Affect Water Quality - The stressor (physical, chemical and toxicological) data available for evaluation during the study do not show a clear linkage to the biological condition observed at the case site. With exception of the extent of riffle habitat, the physical habitat at the case and comparator sites is very similar and not likely the cause of reduced biological condition at the case site. Similarly, water and sediment chemistry at the two sites are very similar, with the exception of temperature and nutrient concentrations, which increased with the increase in water diverted from the percolation ponds into the stream channel during the summer months.

- Municipal Stormwater Unlikely Source of Stressors - Based on the best available information, sources of stress on biological communities in the Upper Penitencia Creek segment of interest, whether natural (e.g., lack of stream flow) or anthropogenic (e.g., nutrients or temperature), are not associated with discharges from the municipal separate storm sewer system (MS4). Rather, if reduced biological conditions in this segment are partially caused by anthropogenic inputs, they are likely associated with diversions from the percolation ponds to the channel, which are intended to sustain water flows for groundwater percolation to satisfy downstream well users/water rights.

Although municipal stormwater discharges do not appear to be the probable causes of reduced biological conditions in the Upper Penitencia Creek segment of interest, SCVURPPP recognizes the importance of freshwater habitat in this creek that currently supports freshwater organisms, including a viable steelhead community. SCVURPPP plans to complete a brief *Upper Penitencia Creek Watershed Management Practices Summary* by September 30, 2017 to assist in the continued management of this important natural resource. The management practices summary will include a compilation of watershed management activities that are currently in place or planned in the watershed, an evaluation of practices that could be implemented or enhanced to improve biological conditions in the creek, and recommendations of actions (monitoring or management) that would support the management of the freshwater habitat beneficial use in Upper Penitencia Creek. The management practices summary will be included in the Program’s FY 16-17 Annual Report, which will be submitted to the Regional Water Board in September 2017.

Table 15. Summary results and conclusions of the Upper Penitencia Creek SSID project.

Potential Cause of Reduced Biological Condition	Summary Results of Data Analysis	Likelihood that Stressor is Cause of Reduce Biological Condition	Likely Source of Stressor
Stream Flow	Natural non-perennial flow due to natural percolation of water into streambed reduces the CSCI score at the case site.	Probable Cause	NA (Naturally Occurring)
	Although increases in stream flow during summer months due to diversions into the channel from percolation ponds may exacerbate unstable habitat conditions for benthic macroinverebrate communities, resulting in lower CSCI scores.	Possibly (Partial) Cause	Water Inputs from Percolation Ponds
Water Temperature	Water temperatures during the summer months greater (2 to 4 ^{o}C) than temperatures directly upstream and nearing weekly maximum thresholds (24 ^{o}C).	Possibly (Partial) Cause	Water Inputs from Percolation Ponds
General Water Quality	General water quality conditions in good ranges and similar between case and comparator sites.	Unlikely	NA
Physical Habitat	No significant differences in habitat quality between case and comparator sites.	Unlikely	NA
Nutrients	Higher nutrient concentrations observed during at the case site during summer.	Unlikely but Possible (Partial) Cause	Water Inputs from Percolation Ponds
Pesticides/Toxicity	Pesticide concentrations not observed at adverse concentrations. No differences in pesticide concentrations observed between the sites. No toxicity observed.	Unlikely	NA

7.0 References

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Appendix A

Quality Assurance/Quality Control Report

INTRODUCTION

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) conducted a Stressor/Source Identification (SSID) Project in Upper Penitencia Creek during Water Year (WY) 2016 to comply with Provision C.8.e (Stressor/Source Identification (SSID) Projects) of the National Pollutant Discharge Elimination Program (NPDES) Municipal Regional Permit for the San Francisco Bay Area (i.e., MRP). Data collected during monitoring conducted for Creek Status Monitoring (CSM; MRP Provision C.8.d) and Pollutants of Concern Monitoring (POC; MRP Provision C.8.f) were used for this project in addition to supplemental data collected solely for this project. Monitoring for this SSID project (hereinafter Project) was performed according to the Upper Penitencia Creek SSID Project Final Work Plan (SCVURPPP 2015).

In WY 2016, SCVURPPP implemented a comprehensive data quality assurance and quality control (QA/QC) program for all three projects. Data 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).

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 and are data type dependent. Specific DQOs are based on Measurement Quality Objectives (MQOs) for each data type and analyte. Detailed methodology for evaluating the data quality attributes is included in the SCVURPPP Creek Status Monitoring QA/QC report for WY 2016.

DATA TYPES

This QA/QC report only addresses data quality for those parameters conducted solely for this project, including biological, chemical, and toxicological analysis. Data QA/QC for parameters collected for the other projects is included in the QA/QC for their respective report. See Table 1 for the monitored parameters, sites, dates and to which project each corresponds.

Table 1. Distribution of sites, dates, and parameters monitored for the Upper Penitencia Creek Stressor/Source Identification Project in WY 2016 and projects/QA reports associated with those parameters. Project codes include Stressor Source Identification Project (SSID), Pollutants of Concern (POC) and Creek Status Monitoring (CSM).

Site	Dates	Parameters Monitored					
		Bioassessment[1], Physical Habitat, Field Measurements	**Ammonia, Phosphorus, Nitrogen[2]**	**Chloride, Silica**	**Sediment Toxicity & Chemistry**	**Continuous Water Temperature[3]**	**Continuous Water Quality**
205COY114	3/28/16-8/20/16					CSM	
	4/11/16-4/28/16						CSM
	4/28/16	SSID	POC	SSID			
	6/9/16	SSID	POC	SSID	SSID		
	6/10/16-6/23/16						CSM
	9/7/16-9/20/16						
205COY121	3/28/16-8/20/16					CSM	
	4/11/16-4/28/16						CSM
	4/28/16	SSID	POC	SSID			
	6/9/16	SSID	POC	SSID	SSID		
	6/10/16-6/23/16						CSM
	9/7/16-9/20/16						SSID
205COY117	3/28/16-8/20/16					CSM	
	6/10/16-6/23/16						CSM
205COY130	9/7/16-9/20/16						SSID
205COY135	9/7/16-9/20/16						SSID

[1] Includes benthic macroinvertebrates (BMI) and algae taxonomy plus chlorophyll a and ash free dry mass analysis.
[2] Phosphorus includes orthophosphate and phosphorus as P. Nitrogen includes nitrate, nitrite, and total Kjeldahl nitrogen.
[3] Includes temperature, pH, specific conductivity, and dissolved oxygen.

PROJECT REPRESENTATIVENESS

The Project Work Plan staff and field crew members are trained in SWAMP and RMC protocols, and receive significant supervision from the local monitoring coordinator and QA officer. As a result, each field crew member is knowledgeable of, and performs data collection according to the protocols in the RMC QAPP and SOP, ensuring that all samples and field measurements are representative of conditions in Santa Clara Valley urban creeks.

PROJECT COMPARABILITY

Data for this SSID project, creek status monitoring and POC monitoring were collected by the same field crew and monitoring for all three projects was conducted in accordance with the RMC QAPP. As a result, any data collected for this SSID project is considered comparable to both monitoring projects and with other RMC monitoring. Additionally, electronic data deliverables (EDDs) for all three projects are submitted to the San Francisco Regional Water Quality Control Board (SFRWQCB) in Microsoft Excel templates developed by SWAMP, to ensure data comparability with the California Surface Water Ambient Monitoring Program (SWAMP). 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[12]. Completed templates are reviewed using SWAMP's online data checker[13], further ensuring SWAMP-comparability.

BIOASSESSMENTS AND PHYSICAL HABITAT ASSESSMENTS

Supplemental bioassessments conducted for the SSID Project were included in the same batch as bioassessments conducted for creek status monitoring, for a total of 24 sites. The RMC QAPP requires field duplicates be collected at 2 sites (10% of total sites) and benthic macroinvertebrates (BMI) at two sites be submitted to a second taxonomic laboratory for quality control. These QA samples and their results were collected and analyzed during creek status monitoring and apply to this project as well. Refer to the creek status monitoring QA/QC report for more information.

COMPLETENESS

The Project Work Plan identified three sites/reaches in Upper Penitencia Creek for bioassessments and physical habitat assessments. However, the reach for the middle site, 205COY117, overlapped with the reach of a probabilistic site selected for creek status monitoring and it was determined that the probabilistic site would be representative of that middle reach and could replace 205COY117. Consequently, only two of the three planned sites were monitored for the Project, but they were both assessed twice as planned by the Work Plan. During all four assessments, SCVURPPP completed bioassessments and physical habitat assessments for all 11 transects at each site.

SENSITIVITY

Taxonomic Results

The benthic macroinvertebrate taxonomic identification met sensitivity objectives; the taxonomy laboratory that organisms were identified to SAFIT STE Level I.

Analytical Results

Due to high concentrations requiring large dilutions, the reporting limits for ash free dry mass analysis (8 mg/L) and the chlorophyll a (50 mg/L) were much higher than the RMC QAPP target reporting limits (2 mg/L and 5 mg/L, respectively). As concentrations were several orders of magnitude higher than either reporting limit, results were not affected by the higher 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.

ACCURACY

Two BMI samples collected during creek status monitoring were submitted to a separate QC taxonomic laboratory. Refer to the creek status monitoring QA/QC report for accuracy results.

PRECISION

Duplicate algae and BMI samples were collected at two sites during creek status monitoring in WY 2016. Refer to the creek status monitoring QA/QC report for precision results.

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[12] Look up lists available online at http://swamp.waterboards.ca.gov/swamp_checker/LookUpLists.php.

[13] Checker available online at http://swamp.waterboards.ca.gov/swamp_checker/SWAMPUpload.php

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.

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^{TM} II, which uses the DPD method. All other parameters were measured with a YSI Professional Plus multi-parameter instrument. All data collection was performed according to RMC SOP FS-3 (Performing Manual Field Measurements).

COMPLETENESS

Temperature, dissolved oxygen, pH, specific conductivity, total chlorine residual, and free chlorine residual were collected at three of the four bioassessment sites. Only pH was collected at 205COY114 during the April event. The error was not noticed until after the field crew had left the site, but staff were alerted to the error prior to any future assessments. Changes in internal field crew protocols were implemented to prevent future oversights in subsequent field seasons. Field crew will now send a photo of the field measurements to the local QA officer prior to leaving the site to allow for resampling if the QA officer deems it necessary.

SENSITIVITY

Free and total chlorine residual are measured using a HACH Pocket Colorimeter^{TM} II, which uses the DPD method. For this method, the estimated detection limit for the low range measurements (0.02-2.00 mg/L) is 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.

ACCURACY

Data collection for the Project was intermixed with creek status monitoring and was conducted Monday through Thursday. 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 does not need to be calibrated.

PRECISION

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

WATER CHEMISTRY

Four water chemistry samples were collected by SCVURPPP staff concurrently with the four bioassessment samples, and analyzed by Caltest Analytical Laboratory (Caltest). Caltest analyzed samples within their respective holding times and 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.

Ammonia, phosphorus, orthophosphate, nitrate, nitrite, and total Kjeldahl nitrogen samples were collected to comply with POC monitoring requirements, but results were also used for the SSID project. QA results for those analytes is included in the POC QA/QC report. Supplemental water chemistry samples collected for the SSID Project include silica and chloride. All water chemistry samples collected for the three projects (creek status, POC, and SSID) were included in the same batch, and all QA samples collected apply to all three project, including one field duplicate (5% of 24 total sites) that was collected during creek status monitoring.

COMPLETENESS

The Project Work Plan originally planned for the collection of water chemistry/nutrient samples at sites 205COY114 and 205COY121 once during the summer for a total of two planned samples. However, SCVURPPP collected water chemistry samples at the two sites twice, for a total of four samples instead. Samples were analyzed for all requested analytes, and 100% of results were reported. Water chemistry data were flagged when necessary, but none were rejected.

SENSITIVITY

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. Laboratory reporting limits for silica met the target reporting limits, while reporting limits for chloride exceeded the target reporting limit. Concentrations were much higher than reporting limits, and the elevated reporting limits do not decrease confidence in the measurements. Target and actual reporting limits are shown in Table 3. Results with reporting limits that exceeded the target reporting limit were flagged.

Table 3. Target and actual reporting limits for chloride and silica samples collected for stressor/source identification in Upper Penitencia Creek in WY 2016.

Analyte	Target RL mg/L	Actual RL mg/L
Chloride	0.25	1-20
Silica	1	1

ACCURACY

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. Recoveries on all laboratory control samples (LCS), matrix spikes (MS), and matrix spike duplicates (MSD) were within the MQO target range of 80-120% recovery.

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. Caltest routinely analyzes matrix spike duplicate samples for target analytes. The relative percent differences (RPD) for all chloride and silica matrix spike duplicate pairs were well below the MQO target of < 25%.

One water chemistry field duplicate sample (5% of 24 samples) was collected during creek status monitoring. Precision of the duplicates is included in the creek status monitoring QA/QC report

CONTAMINATION

For chemical data, contamination is assessed as the presence of analytical constituents in blank samples. Neither of the target analytes were detected in any of the laboratory blanks.

CONTINUOUS WATER QUALITY

Continuous water quality measurements were recorded to supplement the two events conducted for creek status monitoring. Supplemental measurements were collected at one site 205COY121 in September 2016. Temperature, pH, dissolved oxygen, and specific conductivity were recorded once every 15 minutes over two-week deployments using a multi-parameter water quality sonde (YSI 6600-V2).

COMPLETENESS

Sondes were to be deployed at the same sites as creek status monitoring, but the two downstream sites were dry in September. Only the most upstream site, 205COY121, had enough flow for measurements to be collected. Consequently, two new upstream sites were added for September monitoring.

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.

ACCURACY

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.

A summary of the drift measurements is shown in Table 5. All drift measurements met measurement quality objectives.

Table 5. Drift measurements for continuous water quality monitoring events in Upper Penitencia Creek in WY 2016

Parameter	Measurement Quality Objectives	205COY121	205COY130	205COY135
Dissolved Oxygen (mg/l)	± 0.5 mg/L or 10%	0.24	0.1	0.13
pH 7.0	± 0.2	-0.03	0.11	0
pH 10.0	± 0.2	0.13	-0.05	0.02
Specific Conductance (uS/cm)	± 10%	0.3%	0.1%	0.2%

PRECISION

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

SEDIMENT CHEMISTRY

Sediment chemistry samples were collected by SCVURPPP staff concurrently with dry season toxicity samples on May 5, 2016 and analyzed for pesticides (pyrethroids, carbaryl, and fipronil) by Caltest All samples were analyzed their holding time. 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.

COMPLETENESS

Both planned/required samples were collected and analyzed for all requested analytes, and all results were reported.

SENSITIVITY

Laboratory reporting limits exceeded RMC QAPP target reporting limits for all analytes, except for one carbaryl sample. A comparison of target and actual reporting limits for those parameters is shown in Table 6. This discrepancy affected four analytes collected at 205COY114 that were detected but not quantified, whose concentrations were between the method detection limit and the reporting limit.

Table 6. Comparison of target and actual reporting limits for sediment analytes where reporting limits exceeded target limits. Sediment samples were collected in Santa Clara County creeks in WY 2016.

Analyte	Target RL mg/kg	Actual RL mg/kg
Bifenthrin	0.33	0.51
Cyfluthrin	0.33	0.51
Lambda-Cyhalothrin	0.33	0.51
Cypermethrin	0.33	0.51
Deltamethrin/Tralomethrin	0.33	0.51
Esfenvalerate/Fenvalerate	0.33	0.51
Permethrin	0.03	0.51
Carbaryl	30	30-41
Fipronil	0.33	0.51

ACCURACY

All laboratory control samples and matrix spike samples met the percent recovery MQO for pyrethroids in sediment (50-150%) listed in the RMC QAPP. None of the sediment chemistry data was flagged or rejected.

PRECISION

All the matrix spike duplicates met the RPD MQO for pyrethroids listed in the RMC QAPP (<35%).   In addition, a sediment sample field duplicate was collected during creek status monitoring. See the creek status monitoring QA/QC report for precision results.

CONTAMINATION

None of the other target analytes were detected in any of the blanks.

TOXICITY TESTING

Sediment toxicity samples were collected by SCVRUPPP staff concurrently with sediment chemistry samples at the two supplemental bioassessment sites on May 5, 2016. 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.*

COMPLETENESS

Both planned sediment toxicity samples were collected in Upper Penitencia Creek in WY 2016. Pacific EcoRisk tested required organisms for toxicity, and 100% of results were reported.

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 SCVURPPP. The laboratory data QC checks found that all conditions and responses were acceptable. A copy of the laboratory QC report is available upon request.

PRECISION

One field duplicate was collected during creek status monitoring. See the creek status monitoring QA/QC report for precision results.

CONTAMINATION

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

CONCLUSIONS

All planned data were collected with the exception of field measurements at 205COY114 in April. No issues with precision, accuracy, or contamination were encountered, but sensitivity exceedances (reporting limits) were noted in for ash free dry mass, chlorophyll a, silica and chloride in water, and pesticides in sediment. No data were rejected.

REFERENCES

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.

Santa Clara Urban Runoff Pollution Prevention Program (SCVURPPP). (2015). Upper Penitencia Creek Stressor Source Identification Project: Final Work Plan – Water Year 2015 (FY 14-15) Prepared by EOA, Inc., Oakland, CA. March 15.

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 D

SCVURPPP POC Monitoring Data Report, Water Year 2016

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Pollutants of Concern Monitoring - Data Report

Water Year 2016

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

March 31, 2017

This report is submitted by the agencies participating in the

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

City of Campbell
City of Cupertino
City of Los Altos
Town of Los Altos Hills
Town of Los Gatos

City of Milpitas
City of Monte Sereno
City of Mountain View
City of Palo Alto
City of San Jose

City of Santa Clara
City of Saratoga
City of Sunnyvale
County of Santa Clara
Santa Clara Valley Water District

Prepared for:

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)

Prepared by:

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LIST OF ACRONYMS

BASMAA	Bay Area Stormwater Management Agency Association
BMP	Best Management Practice
CADDIS	Causal Analysis/Diagnosis Decision Information System
CEC	Contaminants of Emerging Concern
CEDEN	California Environmental Data Exchange Network
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
RMP	Regional Monitoring Program
RWSM	Regional Watershed Spreadsheet Model
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SPoT	Statewide Stream Pollutant Trend Monitoring
SSC	Suspended Sediment Concentration
SSID	Stressor/Source Identification
STLS	Small Tributary Loading Strategy
SWAMP	Surface Water Ambient Monitoring Program
TOC	Total Organic Carbon
USEPA	US Environmental Protection Agency
WY	Water Year

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1.0 INTRODUCTION

This Pollutants of Concern Monitoring - Data Report (POC Data Report) was prepared by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Program) on behalf of its 15 member agencies (13 cities/towns, the County of Santa Clara, and the Santa Clara Valley Water 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 issued by the San Francisco Regional Water Quality Control Board (Regional Water Board) on November 19, 2015 as Order R2-2015-0049. This report fulfills the requirements of Provision C.8.h.iii of the MRP for reporting a summary of MRP provision C.8.f POC Monitoring conducted during Water Year (WY) 2016.[1]

This POC Data Report builds on the POC Monitoring Report that was submitted to the Regional Water Board on October 15, 2016. In accordance with 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 (SCVURPPP 2016a). The October 15, 2016 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 2016 Urban Creeks Monitoring Report (UCMR) which was submitted to the Regional Water Board on March 31, 2017. 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;

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[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 names year. For example, water year 2016 (WY 2016) began on October 1, 2015 and concluded on September 30, 2016.

[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, there is still some uncertainty and until the changes are clarified, SCVURPPP 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 Contaminants 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 of 80 PCBs samples must be collected and analyzed. At least eight PCB samples must be collected each year. By the end of Year 4[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.

Other MRP provisions require studies or have information needs that could be addressed through Provision C.8.f (POC Monitoring) and for which related samples will count towards POC monitoring requirements. These other Permit provisions and their associated timelines are listed below.

- Provisions C.11.a.iii and C.12.a.iii require that Permittees provide a list of management areas (referred to in this report as Watershed Management Areas, or WMAs) in which new mercury and PCB control measures will be implemented during the permit term. Progress toward developing the list was reported on April 1, 2016 (SCVURPPP 2016b). A more complete list with identified control measures was provided with the 2016 Annual Report (SCVURPPP 2016c) on September 30, 2016 and will be updated with each subsequent Annual Report per Provision C.11.a.iii(3). Provision C.8.f (POCs Monitoring) supports C.11.a/12.a requirements by requiring monitoring directed toward source identification (i.e., identifying which WMAs provide the greatest opportunities for implementing controls to reduce loads of POCs in urban stormwater runoff and source areas within the WMAs).

- 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. SCVURPPP 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.

1.2 Third-Party Data

SCVURPPP strives to work collaboratively with our 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. For example, samples collected in Santa Clara County through the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) and the State's Stream Pollution Trends (SPoT) Monitoring Program may supplement the Program's efforts towards achieving Provision C.8.f monitoring requirements. Third party monitoring conducted by the RMP and SPoT also provide context for reviewing and interpreting SCVURPPP monitoring results.

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[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).

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 # 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 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 (NH3) and ionized ammonia (ammonium, NH4+). 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 Program conducted POC monitoring in WY 2016 for PCBs, mercury, copper, and nutrients. Monitoring for PCBs, mercury, and copper was conducted in accordance with the SCVURPPP WY 2016 POC Sampling and Analysis Plan (SAP; SCVURPPP 2015a) which describes monitoring goals, methods, and quality assurance/quality control (QA/QC) procedures. 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 listed in Table 2. Specific monitoring stations are listed in Table 3 and illustrated in Figure 1. The sections below describe the results of the monitoring accomplished in WY 2016. Compliance with applicable water quality standards is described in Section 3.0.

2.1 Statement of Data Quality

A comprehensive QA/QC program was implemented by SCVURPPP covering all aspects of POC monitoring. Monitoring for PCBs, mercury, copper, and nutrients was performed according to protocols specified or referenced in the WY 2016 POC SAP (SCVURPPP 2015a). The Monitoring Plan references the CW4CB Quality Assurance Project Plan (QAPP; AMS 2012) as the basis for (QA/QC) procedures.

Overall, the results of the QA/QC review suggest that the POC monitoring data generated during WY 2016 were of sufficient quality. Although, some data were flagged in the project database, none were rejected. Details of the QA/QC review are provided in Attachment 1.

Table 2. SCVURPPP and Third-Party POC Monitoring Accomplishments in WY 2016.

Pollutant of Concern/ Agency	Number of Samples (WY 2016)	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							
SCVURPPP	9	9	9	--	9	--	Stormwater runoff samples to characterize high interest catchments
RMP STLS	6	6	6	--	6	--	Stormwater runoff samples to characterize high interest catchments
Copper							
SCVURPPP	4	--	--	--	4	--	Copper analyzed on a subset of PCBs/Hg stormwater runoff samples
Nutrients							
SCVURPPP	2	--	--	--	2	--	Water samples collected from SSID study stations

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

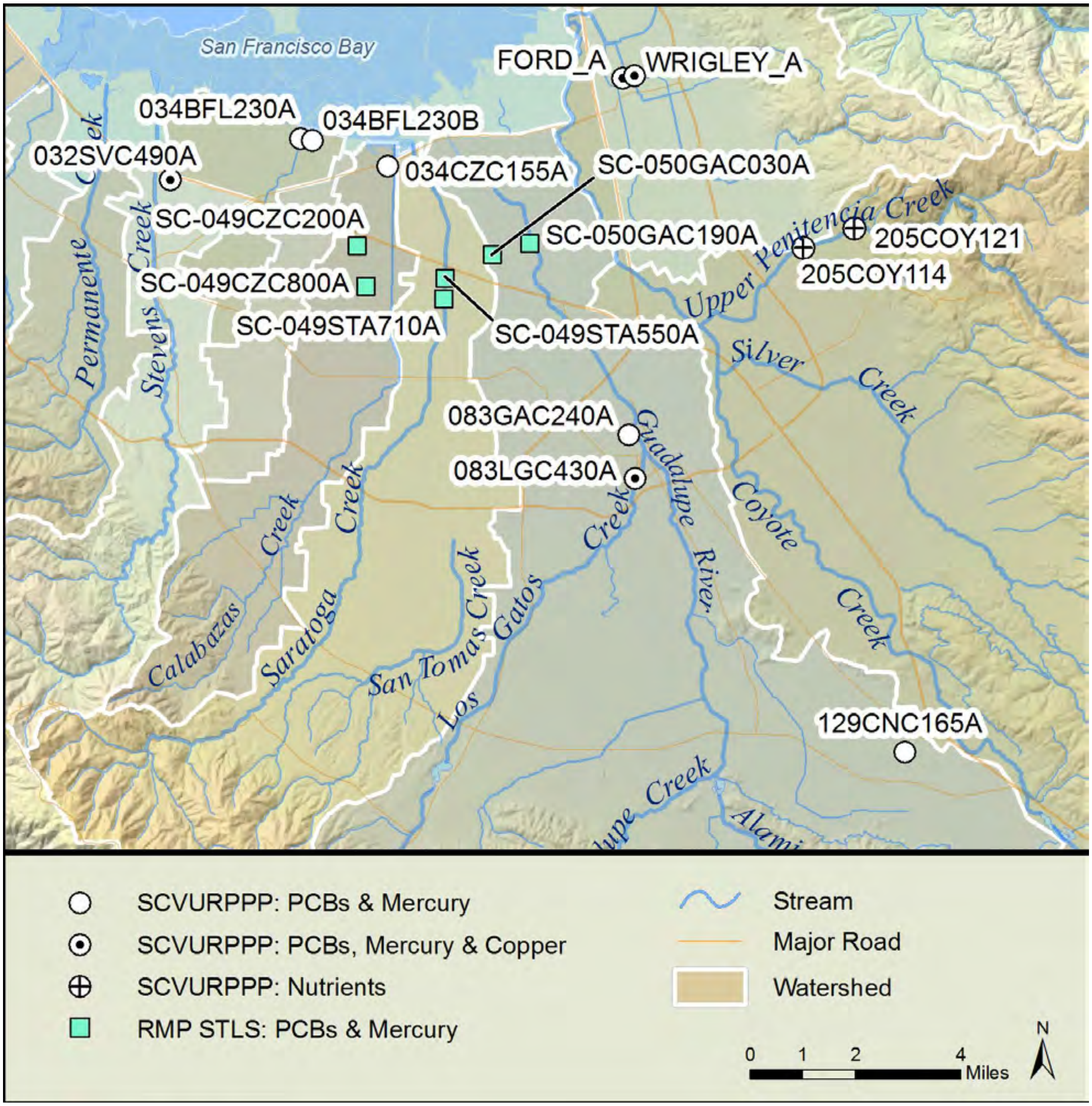

Figure 1. SCVURPPP and Third-Party POC Monitoring Stations in WY 2016.

Table 3. POC monitoring stations in Santa Clara County, WY 2016.

Agency	Station Code	Sample Date	Latitude	Longitude	Matrix	PCBs	Mercury	Suspended Sediment Concentration	Total Copper	Dissolved Copper	Hardness as CaCO3	Nutrients[b]
SCVURPPP	032SVC490A	1/5/2016	37.4058	-122.0639	water	x	x	x	x	x	x	
SCVURPPP	083LGC430A	1/19/2016	37.3257	-121.9019	water	x	x	x	x	x	x	
SCVURPPP	FORD_A	1/17/2016	37.4358	-121.9066	water	x	x	x	x	x	x	
SCVURPPP	WRIGLEY_A	1/17/2016	37.4358	-121.9065	water	x	x	x	x	x	x	
SCVURPPP	034BFL230A	3/5/2016	37.4177	-122.0191	water	x	x	x				
SCVURPPP	034BFL230B	3/5/2016	37.4172	-122.0163	water	x	x	x				
SCVURPPP	034CZC155A	1/17/2016	37.4106	-121.989	water	x	x	x				
SCVURPPP	083GAC240A	3/11/2016	37.3376	-121.9042	water	x	x	x				
SCVURPPP	129CNC165A	1/6/2016	37.2514	-121.8075	water	x	x	x				
RMP STLS	SC-049CZC800 (049CZC800A)	(a)	37.3774	-121.9957	water	x	x	x				
RMP STLS	SC-049STA550 (049STA550A)	(a)	37.3799	-121.9684	water	x	x	x				
RMP STLS	SC-049CZC200 (049CZC200A)	(a)	37.3885	-121.999	water	x	x	x				
RMP STLS	SC-050GAC030 (050GAC030A)	(a)	37.3866	-121.9522	water	x	x	x				
RMP STLS	SC-049STA710 (049STA710A)	(a)	37.3742	-121.9687	water	x	x	x				
RMP STLS	SC-050GAC190 (050GAC19A)	(a)	37.3899	-121.9395	water	x	x	x				
SCVURPPP	205COY114	6/9/2016	37.3898	-121.8449	water							x
SCVURPPP	205COY121	6/9/2016	37.3953	-121.8275	water							x

a. Specific sample dates have not yet been provided by the RMP STLS.

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

2.2 PCBs and Mercury

During WY 2016, the Program collected nine[6] samples for PCBs and mercury analysis. An additional six samples were collected in Santa Clara County through the RMP's Small Tributary Loading Strategy (STLS). These combined 15 samples address POC Management Questions #1 (Source Identification) and #2 (Contributions to Bay Impairment). Data will also be used 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.,

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[6] The Program had planned to collect up to 25 samples in WY 2016; however, a lack of rainfall in the study area relative to the rest of the Bay Area limited monitoring opportunities. The industrial areas of Santa Clara County are located in the rain shadow of the Santa Cruz Mountains.

Management Question #4 – Loads and Status).

PCBs and mercury monitoring by the Program in WY 2016 was conducted in accordance with the *Water Year 2016 Pollutant of Concern Monitoring - Sampling and Analysis Plan* (SCVURPPP 2015a). The primary goal of the monitoring, as described in the SAP, is to provide information to identify Watershed Management Areas (WMAs) where control measures could be implemented to comply with MRP requirements for load reductions of PCBs and mercury. WY 2016 PCBs and mercury monitoring was focused on collection of storm composite samples from high interest WMAs that may contain PCB and/or mercury source properties. High interest WMAs were identified and prioritized for sampling by evaluating several types of data, including: PCBs and mercury concentrations from prior sediment and water sampling efforts, land use data showing old industrial parcels, municipal storm drain data showing pipelines and access points (e.g., manholes, outfalls, pump stations), catchment areas delineated from municipal storm drain data, and logistical/safety considerations (SCVURPPP 2015b).

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 “RMP 40” PCB congeners (method EPA 1668C), total mercury (method EPA 1631E), and SSC (method ASTM D3977-97). A subset of the 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 copper results.

Table 4 lists PCBs, mercury, and SSC monitoring results collected by SCVURPPP in WY 2016[7]. “Total PCBs” were calculated as the sum of the RMP 40 congeners. The “PCB Particle Ratio” and “Hg Particle Ratio” is calculated by dividing Total PCBs and Total Mercury by SSC. The PCB Particle Ratio and Hg Particle Ratio addresses the fact that PCBs are generally bound to sediment and is used to compare and rank monitoring stations. A sample that has a relatively low concentration but a high particle ratio may be because the storm that was sampled was relatively small, and the rainfall was not enough to mobilize much sediment. A larger storm may mobilize more sediment and PCBs, so catchments with an elevated concentration or particle ratio may be considered for a source investigation.

For the nine samples that were collected by SCVURPPPP in WY 2016, mercury concentrations ranged from 4.0 ng/L to 35.7 ng/L and Hg Particle Ratios ranged from 128 ng/g to 962 ng/g. Total PCB concentrations ranged from 0.584 ng/L to 9.04 ng/L and PCB Particle Ratios ranged from 30.1 ng/g to 367 ng/g. Section 2.2.2 describes PCB monitoring results within the context of other water samples analyzed for PCBs in Santa Clara County and region-wide.

Table 4. PCB, mercury, and suspended sediment concentrations in water samples collected by SCVURPPP, WY 2016.

Station Code	Sample Date	SSC (mg/L)	Total PCBs (ng/L) [a]	PCB Particle Ratio (ng/g) [b]	Hg (ng/L)	Hg Particle Ratio (ng/g) [b]
032SVC490A	1/5/2016	38.4	1.75	45.6	7.7	201
034BFL230A	3/5/2016	19.4	0.584	30.1	4.0	206
034BFL230B	3/5/2016	24.6	9.04	367	8.0	325
034CZC155A	1/17/2016	25.3	2.76	109	3.9	154
083GAC240A	3/11/2016	70.2	2.72	38.7	20	286
083LGC430A	1/19/2016	37.1	5.38	145	36	962
129CNC165A	1/6/2016	57.9	2.14	37.0	20	342
FORD_A	1/17/2016	43.8	1.92	43.8	5.6	128
WRIGLEY_A	1/17/2016	26.1	2.63	101	5.0	192

[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.

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[7] RMP STLS results are reported separately by the San Francisco Estuary Institute (SFEI).

2.2.1 Third Party POC Monitoring in WY 2016

The RMP's STLS Team typically conducts annual monitoring for POCs on a region-wide basis. SCVURPPP 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 two stations in Santa Clara County. In WY 2015, the loading stations were discontinued and STLS monitoring shifted to wet weather characterization in catchments of interest. In WY 2016, the STLS Team continued wet weather characterization sampling using a similar approach to the PCBs and mercury sampling that was implemented by the Program. Six catchments (i.e., six storm composite samples) were sampled for PCBs and mercury by the RMP's STLS in Santa Clara County in WY 2016 and eight catchments were sampled in WY 2015.

2.2.2 Comparison with Region-wide Storm Sampling Results

Previous reports prepared by SCVURPPP and other BASMAA RMC partners describe PCB concentrations in *sediment* from samples collected throughout the region (SCVURPPP 2016d). There are over 1,200 region-wide sediment samples that have been analyzed for PCBs. The large sediment dataset was evaluated by the BASMAA RMC to develop the sediment concentration thresholds that have been used to identify WMAs and/or PCB source areas where new PCBs and mercury control measures will be implemented. Although sediment sampling efforts have been and will continue to be very informative in this process, there are some limitations to sediment sampling that can be resolved by collecting storm composite water samples. For example, sediment is not always found at the identified sampling stations. Furthermore, storm composite water samples can integrate POC sources over time and space within a catchment. For these reasons, WY 2016 monitoring focused on storm composite water samples.

Storm composite water sampling presents many source identification opportunities. However, the dataset for water samples is not as large or robust as the sediment sample dataset. Therefore, the BASMAA RMC has not established water concentration or PCB Particle Ratio thresholds for evaluating and categorizing catchments. As a preliminary step towards developing thresholds for water samples, SCVURPPP worked with the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) to review the PCBs monitoring data collected by SCVURPPP and SMCWPPP in WY 2016 with data from water samples collected throughout the region. The analysis includes data from RMP STLS monitoring (Gilbreath et al. 2017).

The storm sample dataset includes samples collected from 61 MS4 catchments and 15 natural waterways throughout the Bay Area. The MS4 catchment sites include storm drain manholes, outfalls, pump stations, and artificial channels.[8] The 15 sites in natural waterways have watersheds ranging in size from less than 3,000 acres (i.e., Lower Penitencia Creek) to the entire Sacramento–San Joaquin River Delta watershed (i.e., Mallard Island). Many of the sites have been sampled more than once and/or have multiple sample results reported for individual storm events. Eight of the 61 MS4 sites have multiple sample results (4 to 80). All the natural waterway sites have multiple sample results (3 to 125). For sites with more than one sample, the particle ratio is calculated by dividing the sum of PCB concentrations by the sum of suspended sediment concentrations. Performing the calculation in this way is effectively the equivalent of compositing 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. 2017).

PCB concentrations in water samples for the Bay Area dataset (n=76) is plotted in Figure 2. PCB particle ratios 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 30 sites in Santa Clara County. Nine of the sites were sampled by SCVURPPP in WY 2016, thirteen sites were sampled by the RMP STLS in WY 2015 and WY 2016, and eight sites were sampled multiple times by the RMP in prior water years.

Overall, Santa Clara County has relatively low PCB concentrations and PCB particle ratios compared to the other three counties. The highest PCB concentrations in Santa Clara County have been measured at

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[8] Stormwater samples have also been collected from inlets and/or LID systems as part of special studies. However, those were not included in this analysis.

Sunnyvale East Channel (96.6 ng/L), 051CTC400A (55.5 ng/L; Ridder Park Dr SD), 067SCL080A (44.6 ng/L; Outfall to Lower Silver Ck), and the Guadalupe River (23.7 ng/L). The sites with the highest PCB particle ratios are 067SCL080A (783 ng/g), 051CTC400A (488 ng/g), 034BFL230B (366 ng/g), and Sunnyvale East Channel (343 ng/g).

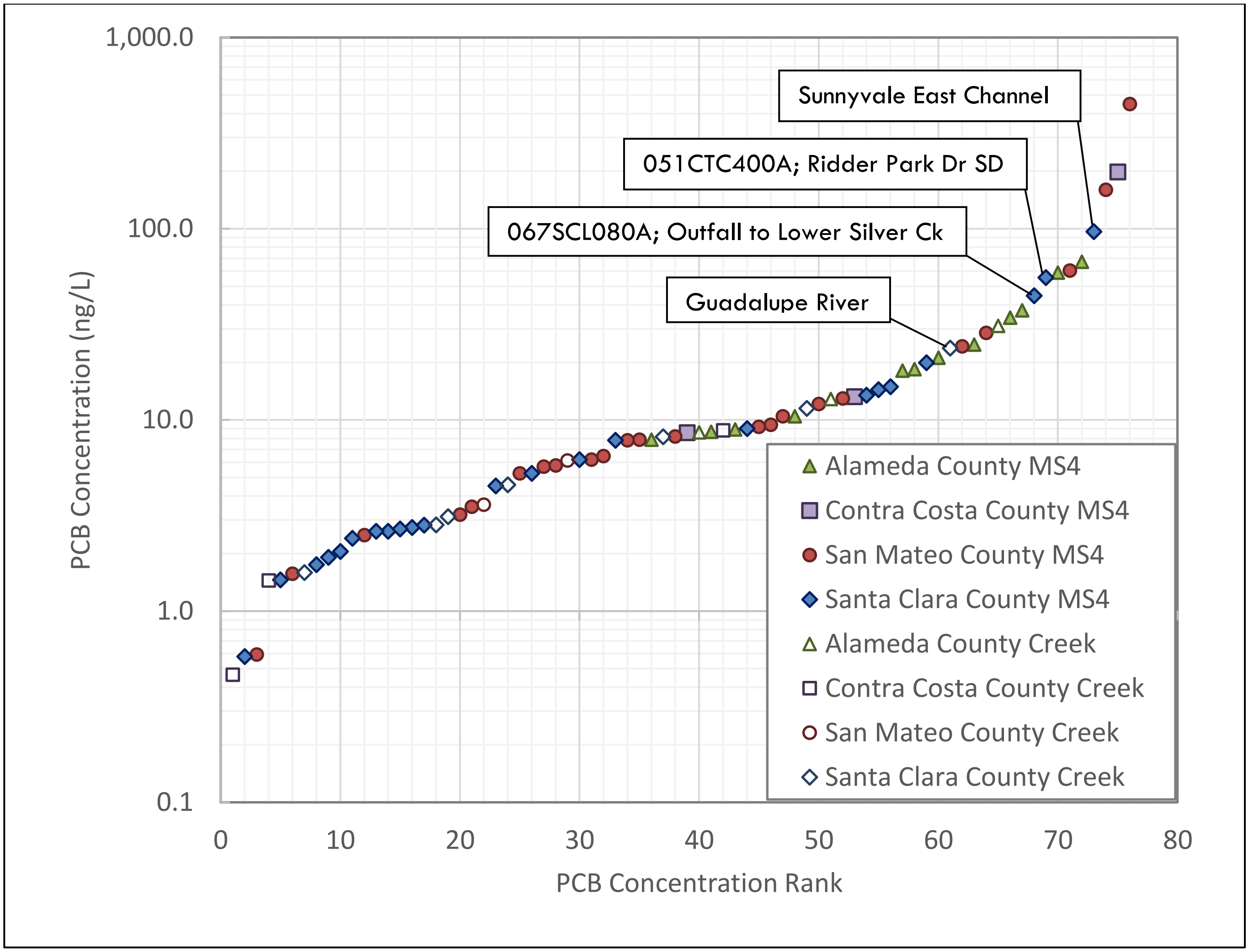

Figure 2. PCB concentrations for water samples collected in large MS4s in the Bay Area

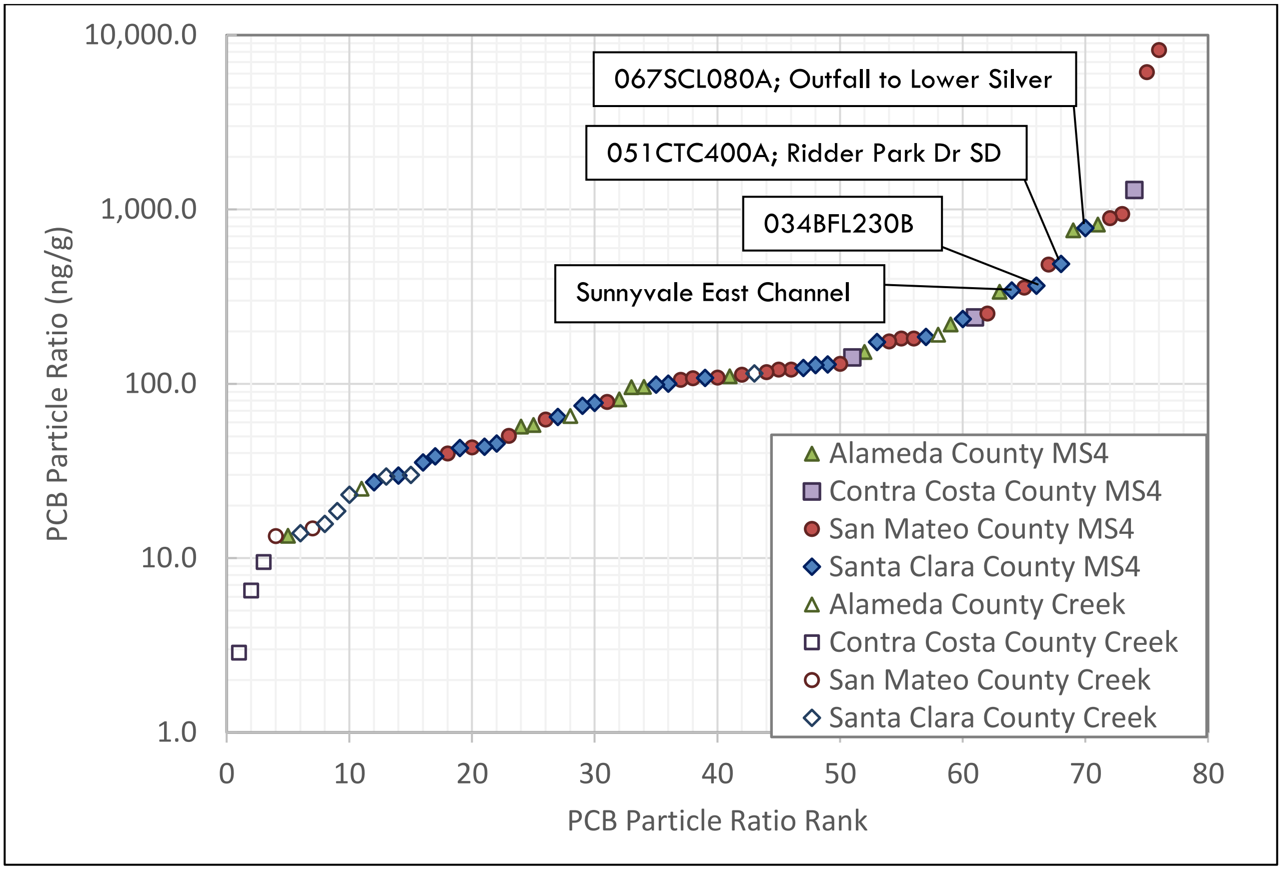

Figure 3. PCB particle ratios for water samples collected in MS4s and small tributaries (i.e., creeks/rivers) draining to the Bay.

Table 5 lists descriptive statistics on PCB and mercury concentrations for the Bay Area stormwater dataset (n=76). The median concentration of PCBs in water is 8.37 ng/L, and the mean is 23.9 ng/L. The median PCB particle ratio is 108 ng/g, and the mean is 366 ng/g. As can be seen in Figures 2 and 3, there are a few catchments with highly elevated samples that increase the average concentration statistic over the median (i.e., 50th percentile). Both SCVURPPP and the RMP are collecting additional stormwater composite samples in WY 2017 in an effort to grow 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 of PCB and mercury concentrations in water and particle ratios.

	PCBs (ng/L) [a]	Hg (ng/L)	SSC (mg/L)	PCB Particle Ratio (ng/g) [b]	Hg Particle Ratio (ng/mg) [b]
N	76	53	76	76	53
Min	0.464	3.9	10.0	2.88	0.13
10th Percentile	1.70	6.0	25.2	15.4	0.16
25th Percentile	3.14	11	43.4	42.9	0.25
50th Percentile	8.37	20	75.7	108	0.34
75th Percentile	18.4	41	153	190	0.55
90th Percentile	56.5	81	355	766	0.95
Max	448	440	1570	8220	5.3
Mean	23.9	38	151	366	0.53

[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 WMA Update

PCB and mercury sampling data are used to identify specific source properties and/or WMAs where control measures will be implemented. There are currently no thresholds established for classifying or prioritizing PCB or mercury concentrations in stormwater.[9] Therefore, the Program is applying the BASMAA RMC sediment concentration thresholds to PCB particle ratio data which can be expressed in the same units (mg/kg). A PCB particle ratio greater than 0.5 mg/kg (or 500 ng/g) is used as a preliminary threshold for classifying water samples as high, 0.2 – 0.5 mg/kg (200 – 500 ng/g) is moderate, and less than 0.2 mg/kg (200 ng/g) is low.

Based on WY 2016 sampling, no additional WMAs were identified as high priority catchments where source investigations should be considered. Sample 034BFL230B was the only sample collected in WY 2016 (out of a total 15 samples) that had a PCB particle ratio over 0.2 mg/kg, a threshold used to determine catchments that have *moderately elevated* levels of PCB. The current WMA map is illustrated in Figure 4, where the15 catchments that were sampled in WY 2016 and the status of other WMAs is presented.

WY 2017 POC sampling will include the collection of sediment samples within nine WMAs to investigate suspected PCBs and mercury source properties. If WY 2017 sediment sampling results in the identification of source properties, the Program will work with local municipalities to cleanup and abate the properties, and/or refer these properties to Regional Water Board for follow up action.

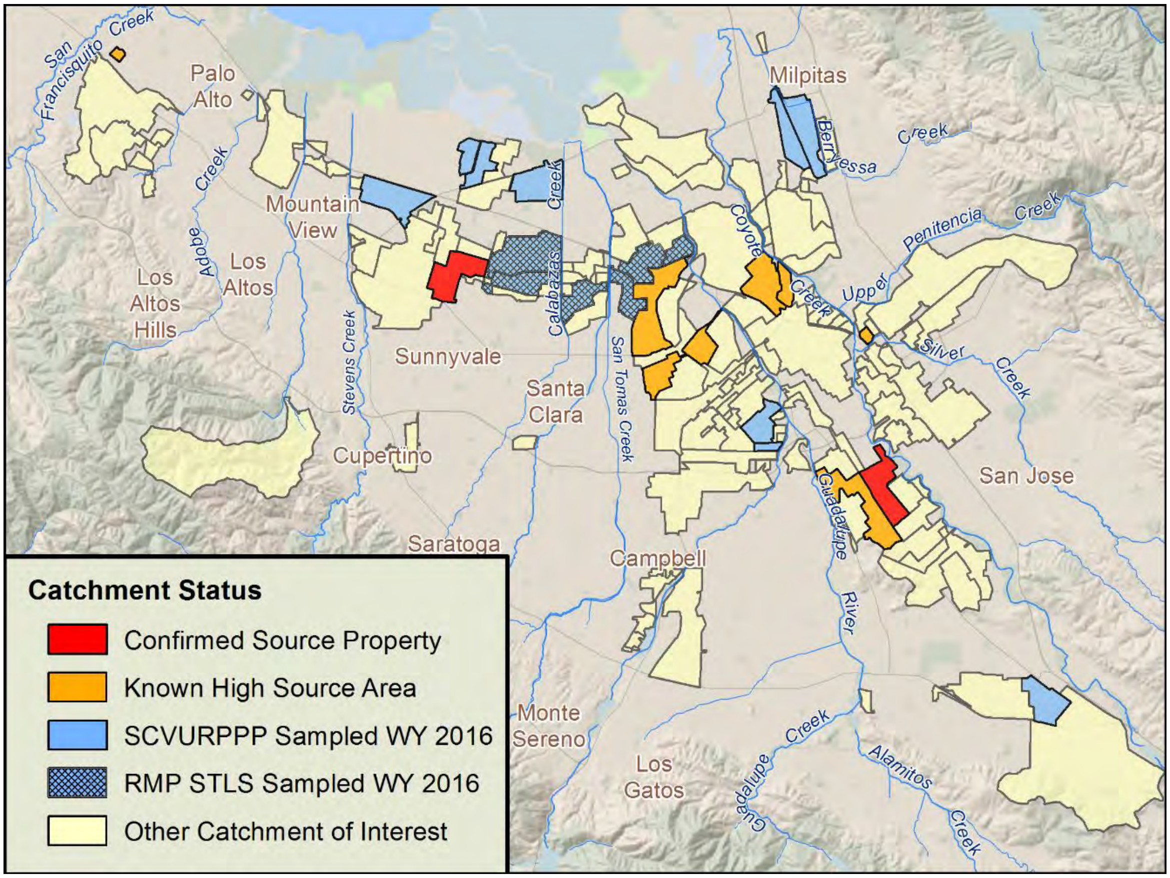

Figure 4. SCVURPPP current Watershed Management Area (WMA) map showing catchments sampled in WY 2016.

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[9] SFEI has suggested that sites be ranked region-wide based on a combination of concentration and particle ratios. See Appendix E to the WY 2016 UCRM for additional information.

2.3 Copper

In WY 2016, SCVURPPP collected copper samples concurrently within a subset (four) of the PCBs and mercury storm composite samples.[10] This approach provides a relatively efficient means of collecting copper samples during wet weather when copper is most likely to be discharged from the urban landscape. The goal of this approach is to address Management Question #4 (Loads and Status) by characterizing copper concentrations in stormwater runoff from highly urban catchments. Samples were analyzed for total copper, dissolved copper, and hardness. Results are listed 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 SCVURPPP, WY 2016.

Station Code	Sample Date	Total Copper (µg/L)	Dissolved Copper (µg/L)	Hardness as $CaCO_3$ (mg/L)
032SVC490	1/5/2016	10.5	4.32	30
083LGC430	1/19/2016	11.8	4.4	20
Ford Creek	1/17/2016	7.17	2.4	172
Wrigley Creek	1/17/2016	7.38	2.94	164

2.4 Nutrients

Nutrient monitoring addresses Management Question #4 (Loads and Status). 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 “Nutrient Management Strategy for San Francisco Bay” is part of a statewide initiative to address nutrient over-enrichment in State waters (Regional Water Board 2012). The suite of nutrients required in the MRP (i.e., ammonium, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorus) closely reflects the list of analytes measured by the RMP and BASMAA partners at the six regional loading stations monitored in WY 2012 and WY 2013. The prior data were used by the Nutrient Strategy Technical Team to develop and calibrate nutrient loading models.

In WY 2016, POC monitoring for nutrients in Santa Clara County was conducted synoptically with bioassessment monitoring in Upper Penitencia Creek as part of a Stressor/Source Identification (SSID) study. The SSID Work Plan was submitted to the Regional Water Board with the WY 2014 Urban Creeks Monitoring Report (SCVURPPP 2015b). The Upper Penitencia Creek SSID Project is investigating low creek status condition scores (i.e., California Stream Condition Index) and high temperatures following the Causal Analysis/Diagnosis Decision Information System (CADDIS) framework developed by the USEPA. The SSID Project Report is included with the SCVURPPP WY 2016 UCMR to which this POC Data Report is also appended.

Results of nutrient monitoring are listed in Table 7. The downstream station (205COY114) had higher concentrations of all nutrient species compared to the upstream station (205COY121). More information about the differences between the two stations is provided in the SSID Project Report. Comparisons to applicable freshwater water quality objectives are described in Section 3.0.

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[10] In order to simplify the field effort and reduce the risk of sample contamination, SCVURPPP requested that the analytical laboratory conduct the sample filtration required for dissolved copper analysis. The hold time for sample filtration is 24 hours and the laboratory is not staffed for this work on weekends. Therefore, only samples collected Monday through Thursday could be submitted for copper analysis. This constraint limited copper monitoring efforts to four samples.

Table 7. Nutrient concentrations in POC water samples collected by SCVURPPP, WY 2016.

Constituent	Units	205COY114	205COY121
Nitrate as N	(mg/L)	0.30	0.042
Nitrite as N	(mg/L)	0.008	0.001
Total Kjeldahl Nitrogen (TKN)	(mg/L)	1.1	0.88
Ammonia as N	(mg/L)	0.11	0.043
Un-ionized Ammonia as N [a]	(mg/L)	0.010	0.003
Ammonium [b]	(mg/L)	0.10	0.04
Total Nitrogen [c]	(mg/L)	1.41	0.92
Dissolved Orthophosphate as P	(mg/L)	0.14	0.006
Phosphorus as P	(mg/L)	0.28	0.089

[a] Un-ionized ammonia calculated using formula provided by the American Fisheries Society Online Resources.

[b] Ammonium = ammonia – un-ionized ammonia.

[c] Total nitrogen = TKN + nitrate + nitrite. Non-detects valued at ½ method detection limit in calculation.

2.5 Emerging Contaminants

Emerging contaminant monitoring is being addressed through Program participation in the RMP. The RMP investigated Contaminants of Emerging Concern (CECs) since 2001 and established the RMP Emerging Contaminants Work Group (ECWG) in 2006 to provide direction and oversight of these efforts. 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, and minimize impacts. The RMP published a CEC Strategy "living" document in 2013 (Sutton et al. 2013; Sutton and Sedlak 2015) which is scheduled for a full revision in the near future. The CEC Strategy document guides RMP special studies on CECs using a tiered risk and management action framework.

3.0 COMPARISON TO 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 data collected in WY2016 by SCVURPPP were compared to applicable numeric water quality objectives (WQOs) included in the SF Bay Water Quality Control Plan.

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. The majority of the PCB and mercury samples were collected within the engineered storm drain network, not receiving waters. 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/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 for PCBs, mercury, and copper 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 at POC stations in WY 2016, WQOs or criteria for the protection of aquatic life have only been promulgated for total mercury, dissolved copper, and unionized ammonia. In Water Year 2016, there were no exceedances of applicable water quality standards for these analytes in samples collected in receiving waters. Details of the analysis are provided below.

- **Total Mercury**. All mercury concentrations measured in SCVURPPP samples in Water Year 2016 were well below the freshwater acute objective for mercury of 2.4 ug/L (see Table 4).
- **Nutrients**. All un-ionized ammonia concentrations measured in SCVURPPP samples were below the annual median objective for un-ionized ammonia of 0.025 mg/L (see Table 7).
- **Dissolved Copper.** Acute (1-hour average) WQOs for copper are expressed in terms of the dissolved fraction of the metal in the water column and are hardness dependent. The acute copper WQO was calculated using the hardness values measured at the sample station and the dissolved copper concentrations measured at those stations were compared to the calculated WQO. Neither receiving water station exceeded the calculated WQO for copper.

Table 8. Comparison of WY 2016 Monitoring Data to the Copper WQO.

Station Code	Sample Date	Hardness as $CaCO_3$ (mg/L)	Acute WQO for Dissolved Copper at Measured Hardness (µg/L)	Dissolved Copper (µg/L)
Ford Creek	1/17/2016	172	23.3	2.4
Wrigley Creek	1/17/2016	164	22.3	2.94

4.0 CONCLUSIONS AND RECOMMENDATIONS

In WY 2016, SCVURPPP 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, SCVURPPP worked with the RMP's STLS to supplement WY 2016 monitoring accomplishments.

Conclusions from WY 2016 POC monitoring include the following:

- SCVURPPP collected nine wet weather samples from high interest catchments for PCBs and mercury analysis. Results from SCVURPPP monitoring were compiled with results from RMP STLS monitoring to potentially identify new high interest WMAs in which new PCB or mercury source investigations should be considered. The preliminary PCB particle ratio threshold for *high source areas* (0.5 mg/kg) was not exceeded and therefore no new WMAs were added to the list of high interest catchments at this time.

- A subset (four of nine) of the wet weather samples were analyzed for total and dissolved copper. Two of these samples were collected in the MS4 and two in small creeks/channels. The receiving water samples did not exceed applicable water quality standards.

- Two samples were collected in Upper Penitencia Creek during the dry season for nutrient analysis. Results of the analysis supported the Upper Penitencia SSID Project that investigated low ecological integrity at a specific segment of the creek. The SSID Project Report is included as Appendix C to the SCVURPPP WY 2016 UCMR.

Recommendations for WY 2017 POC monitoring include the following:

- SCVURPPP and the RMP's STLS will continue to conduct PCB and mercury monitoring with the goal of identifying WMAs and specific source properties where new PCB and mercury control measures can be implemented during the permit term.

- At least eight samples that address Management Question #3 (Management Action Effectiveness) must be collected by the end of year four of the permit. SCVURPPP is currently working with BASMAA to develop a regional project to design a Monitoring Plan for POC Management Action Effectiveness. The goal is to finalize the Monitoring Plan/study design in WY 2017 and implement the plan in WY 2018. A major consideration for the regional Management Action Effectiveness Monitoring Plan and other future monitoring efforts will be collection of data in support of conducting the Reasonable Assurance Analysis (RAA) that is required by Provision C.12.c.iii.(3) of the MRP and which must be submitted with the 2020 Annual Report (September 30, 2020).

- At least eight samples that address Management Question #5 (Trends) must be collected by the end of year four of the permit. SCVURPPP will continue to participate in the STLS Trends Strategy Team to 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. The preliminary design concept includes additional monitoring at one or two of the region-wide loadings stations to gain a better understanding of the variability in PCBs concentrations/loadings in the existing dataset. The variability of PCB concentrations in stormwater runoff will predict the number and frequency of samples needed to depict given load reductions over given periods of time. STLS Trends Strategy monitoring could begin as early as WY 2017 and will likely continue through the Permit term, however, the monitoring design is still being developed.

- SCVURPPP will continue to work with work with the SPoT Program to address Management Question #5 (Trends). The *SPoT Monitoring Program* conducts annual dry season monitoring (subject to funding constraints) of sediments collected from a statewide network of large rivers. The goal of the SPoT Program is to investigate long-term trends in water quality (Management Question #5 – Trends). Sites are targeted in bottom-of-the-watershed locations with slow water flow and appropriate micromorphology to allow deposition and accumulation of sediments, including two stations in Santa Clara County (Coyote Creek and Guadalupe River). In most years, sediments are analyzed for PCBs, mercury, toxicity, pesticides, and organic pollutants (Phillips et al. 2014). In WY 2016, SPoT monitoring in Santa Clara County did not include PCBs or mercury; however, those constituents are anticipated for WY 2017.

- A subset of the wet weather PCB and mercury samples collected in WMAs with suspected sources will continue to be analyzed for total and dissolved copper in WY 2017.
- Nutrient samples will be collected from mixed land use watersheds. Nutrient monitoring efforts should be increased above the minimum number of yearly samples in order to make more progress towards the total number of samples required by the end of year five of the MRP.
- SCVURPPP will continue to participate in the RMP and the RMP's CEC Strategy.

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Attachment 1

Quality Assurance/Quality Control Report

Pollutants of Concern Monitoring - Quality Assurance/Quality Control Report, WY 2016

1.0 INTRODUCTION

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) conducted Pollutants of Concern (POC) Monitoring in Water Year (WY) 2016 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). Monitoring was performed according to the project Sampling and Analysis Plan (SAP; SCVURPPP 2015).

This project utilized the Clean Watersheds for Clean Bay Project (CW4CB) Quality Assurance Project Plan (QAPP; AMS 2012) 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), specifically for nutrient samples. 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 data types are summarized in Table 1. 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. While some data were flagged in the project database, none of the data were rejected. Further details regarding the QA/QC review are provided in the sections below.

Table 1. Measurement quality objectives from the Clean Watersheds for a Clean Bay (CW4CB) Quality Assurance Project Plan (AMS 2012) and BASMAA RMC Quality Assurance Project Plan (BASMAA 2016)

Sample	PCBs[1]	Mercury[2]	Copper and Hardness[2]	SSC[3]	Nutrients[4]
Laboratory Blank	< Reporting Limit	< Reporting Limit	< Reporting Limit	< Reporting Limit	< Reporting Limit
Reference Material (Laboratory Control Sample)	50-150% recovery	75-125% recovery	75-125% recovery	80-120% recovery	80-120% recovery

Matrix Spike	50-150% recovery	75-125% recovery	75-125% recovery	NA	80-120% recovery
Matrix Spike, Field, and Laboratory Duplicate[4]	Relative Percent Difference < 25%	Relative Percent Difference < 25%	Relative Percent Difference < 25%	Lab Dup Relative Percent Difference < 25%	Relative Percent Difference < 25%
Reporting Limit	0.002 µg/L (2000 pg/L)	0.0002 µg/L (0.2 ng/L)	0.10 µg/L[5]	0.5 mg/L	None Listed

[1] Synthetic Analytes in Water (CW4CB)

[2] Inorganic Analytes in Water (CW4CB)

[3] Conventional Analytes – Solids (CW4CB)

Conventional Analytes in Water (BASMAA)

[4] NA if native concentration for either sample is less than the reporting limit

[5] No copper RL listed in CW4CQ QAPP. 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)

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 performed according to protocols specified in the Project SAP, CW4CB QAPP, and RMC QAPP. All field and laboratory personnel received and reviewed the SAP and QAPPs, and followed prescribed protocols including laboratory methods prescribed by the project SAP (SMCWPPP 2015). There was one minor deviation from the QAPP MQO for representativeness - the mercury analysis of one sample (station 032SVC490) was initially performed within the recommended holding time. However, analysis of the undiluted samples produced unacceptable MS/MSD results, and reanalysis at a dilution was required. The reanalysis was performed one day past the recommended holding time. The results from this second analysis were reported.

3.0 COMPARABILITY

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 the California Surface Water Ambient Monitoring Program (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.

4.0 COMPLETENESS

The project SAP (SCVURPPP 2016) specifies a goal of eight (8) PCB and mercury samples and four (4) copper and nutrients be collected during WY 2016. However, the SAP notes that these numerical targets are goals and allows for unforeseen field conditions which may hinder efforts.

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[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

During WY 2016, SCVURPPP achieved 100% completeness by collecting and analyzing the number of samples specified by the SAP, including one field duplicate.

5.0 SENSITIVITY

The project QAPP identified a reporting limit of 0.0002 ug/L or 0.2 ng/L for mercury, but the actual reporting limit was much higher at 5 ng/L. This elevated reporting limit was due to a high dilution factor (10), which was necessary to conduct the analysis. Copper samples met the SWAMP-recommended reporting limit of 0.1 µg/L for freshwater samples and PCB samples exceeded the reporting limit of 0.002 µg/L (2000 pg/L).

Nutrient analysis met the reporting limits listed in the RMC QAPP, except for nitrate whose target reporting limit 0.01 mg/L is slightly lower than the laboratory's reporting limit (0.05mg/L).

6.0 CONTAMINATION

The project SAP (SCVURPPP 2016) requires one field blank be analyzed for PCB and mercury, but due to staff oversight, no field blank was collected in WY 2016. However, the laboratory did analyze several laboratory blanks. All blank samples were analyzed for contamination, and results were compared to MQOs in Table 1 and the CW4CB QAPP, which require blanks to be less than the reporting limit.

Laboratory method blanks were less than reporting limits for most analytes with the exception of the following, which were flagged as "VIPRL" by the QA officer[3]:

- PCB 8
- PCB 18/30
- PCB 20/28
- PCB 31
- PCB 44/47/65
- PCB 52

Laboratory blanks that were run during nutrient analysis and all results were non-detect.

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), which were recalculated and compared to the target range in the CW4CB QAPP. If a QA sample did not meet MQOs, all samples in that batch for that particular analyte were flagged. For PCB, the CW4CB QAPP specifies a MQO of 50-150% recovery for both LCS and MS/MSD. For mercury and copper the MQO for recovery is 75-125% for both accuracy measurements.

None of the LCS or MS/MSD samples for mercury, copper, or PCBs exceeded their respective MQO ranges specified by the CW4CB QAPP. All nutrient laboratory LCS and MS/MSD samples were

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[3] None of the analytes detected in the laboratory method blanks above the reporting limit were flagged by the laboratory.

within the MQO specified by the BASMAA QAPP. Though the laboratory MQO ranges for copper, mercury, and PCBs were slightly different than the CW4CB MQO, all of the LCS results were within both MQO ranges and no data were qualified by either the laboratory or the QA officer for accuracy issues. See Table 2 for a comparison of QAPP and laboratory MQOs with the actual LCS range and Table 3 for the actual MS/MSD ranges.

Table 2. Laboratory control sample results compared to quality assurance project protocol and laboratory measurement quality objectives.

Analyte	QAPP MQO	Laboratory MQO	Results Range
Copper	75-125%	85-115	92-105%
Mercury	75-125%	77-123%	98-114%
PCBs	50-150%	60-135%	73-131%
Nutrients	80-120%	80-120% 90-110%[a]	90-110%

[a] Total Kjeldahl nitrogen, orthophosphate, phosphorus, nitrate

Table 3. Matrix spike and matrix spike duplicate results compared to quality assurance project protocol and laboratory measurement quality objectives.

Analyte	QAPP MQO	Laboratory MQO	Results Range
Copper	75-125%	70-130	97-99%
Mercury	75-125%	71-125	85-97%
PCBs	50-150%	50-150	91-119%
Nutrients	80-120%	80-120% 90-110%[b]	88-110%

[b] Phosphorus, orthophosphate

8.0 PRECISION

Precision is the repeatability of a measurement and is quantified by the relative percent different (RPD) of two duplicates samples. Three measures of precision were used for this project – matrix spikes duplicates (MSD), laboratory duplicates, and field duplicates. The MQO for RPD specified by both the CW4CB QAPP and the BASMAA QAPP is <25%.

8.1. Matrix Spike Duplicates

Matrix spike duplicates were analyzed for mercury, PCBs, and nutrients. The RPDs for all duplicate samples were well below the targeted range of < 25%.

8.2. Field Duplicates

One field duplicate was collected during this project at site 083LGC430 (labelled as 043CGL830). The duplicate sample was run as a blind duplicate by the laboratory. The RPD for copper and mercury met the CW4CB MQO (< 25%), but all the PCB RPDs were greater than the MQO (>25%).

A nutrient field duplicate was collected during creek status monitoring that is 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. Refer to the SCVURPPP Creek Status Monitoring QA/QC Report for more information.

8.3. Lab duplicates

Laboratory duplicates were analyzed for copper and PCBs. All the copper duplicates (RPDs 1-5%) were well below the CW4CB MQO and the laboratory's internal RPD limit of 20%. Most of the PCB duplicates were less than 25% except for the following:

- PCB 30/18 (27%)
- PCB 20/28 (25%)
- PCB 49/69 (33%)
- PCB 83/99 (26%)
- PCB 90/101/113 (32%)
- PCB 195 (33%)

The laboratory RPD for PCBs was 50% and several samples were not flagged by the laboratory that exceeded the CW4CB MQO (< 25%). The PCB samples associated with these QA samples were flagged by the QA officer with "VIL".

All laboratory duplicates for nutrients were below the RPD MQO (< 25%).

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Appendix E

Regional Monitoring Program for the SF Bay
Pollutants of Concern (POC) Reconnaissance Monitoring (Draft Final) Progress Report
Water Years (WYs) 2015 and 2016

Pollutants of concern (POC) reconnaissance monitoring draft final progress report, water years (WYs) 2015 and 2016

Prepared by

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On

February 24, 2017

For

Regional Monitoring Program for Water Quality in San Francisco Bay (RMP)
Sources Pathways and Loadings Workgroup (SPLWG)
Small Tributaries Loading Strategy (STLS)

Preface

WYs 2015 and 2016 reconnaissance monitoring 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 (WY 2017) is planned for this study. This initial full draft report was submitted to BASMAA in February 2017 in support of materials being submitted on or before March 31st 2017 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049. Minor additional changes will likely be made in response to SPLWG and TRC review comments before the report is lodged on the RMP website.

Acknowledgements

We appreciate the support and guidance from members of the Sources, Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality in San Francisco Bay. The detailed work plan behind this work was developed through 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 and 2016. Local members on the STLS Team at that time were Arleen Feng (for the Alameda Countywide Clean Water Program), Bonnie de Berry (for the San Mateo Countywide Water Pollution Prevention Program), Lucile Paquette (for the Contra Costa Clean Water Program) and Chris Sommers (for the Santa Clara Valley Urban Runoff Pollution Prevention Program); and Richard Looker, and Jan O'Hara (for the 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, and in the second year of the project by Patrick Kim, Amy Richie, and Jennifer Sun. SFEI's data management team is acknowledged for their diligent delivery of quality assured well-managed data. Over both years of this project, this team included: Cristina Grosso, Amy Franz, John Ross, Adam Wong, and Michael Weaver. Helpful written reviews of this report were provided by Arleen Feng (ACCWP), Lisa Sabin (EOA/ SCVURPPP), and Bonnie de Berry (EOA/ SMCWPPP).

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Executive Summary

The San Francisco Bay mercury and PCB TMDLs called for implementation of control measures to reduce PCB and mercury loads entering the Bay via stormwater. Subsequently, 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 entering the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). In November 2015, the Regional Water Board issued the second MRP. "MRP 2.0" places an increased focus on finding watersheds, source areas, and source properties that are potentially more polluted and are therefore more likely to be cost effective areas for addressing load reduction requirements through implementation of control measures.

To support this increased focus, a stormwater characterization monitoring program was developed and implemented in Water Year (WY) 2015 and 2016. Most of the sites monitored in WY 2015 and 2016 were located within Alameda, Contra Costa, and San Mateo Counties with just a few sites so far located in Contra Costa County. In addition, and with funding independent of the RMP efforts, this same design is being implemented in the winter of WY 2017 by the RMP, the San Mateo Countywide Water Pollution Prevention Program and the Santa Clara Valley Urban Runoff Pollution Prevention Program. In addition, the RMP is piloting a project to explore the use of alternative un-manned "remote" suspended sediment samplers (the Hamlin and Walling Tube samplers). During WYs 2015 and 2016, composite stormwater samples were collected from 37 watershed locations. At eight of these locations, data were also collected using one or, in three examples, two remote suspended sediment sampler devices, both of which are designed to enhance settling and capture of suspended sediment particles from the water column. This report summarizes and provides a preliminary interpretation of data collected during WY 2015 and 2016. The data collected is contributing to a broader effort to identify potential management areas. The report is designed to be updated in subsequent years as more data are collected.

Despite climatically challenging conditions resulting in a limited number of storms of appropriate magnitude for sample capture, a total of 20 additional sites were sampled during WY 2015 and an additional 17 sites were sampled and characterized for concentrations during WY 2016. At these sites, composite water samples collected during one storm event were analyzed for PCBs, HgT, SSC, selected trace metals, organic carbon, and grain size. Sampling efficiency was increased by sampling two sites during a single storm that had similar runoff characteristics and were near enough to each other to allow safe and rapid transport and reoccupation repeatedly during a rain event. At eight of these locations, simultaneous samples were also collected using a Hamlin remote suspended sediment sampler and at three sites a third method (the Walling tube remote suspended sediment sampler) was also trialed successfully. Based on this dataset, a number of sites with elevated PCB and Hg concentrations and particle ratios were successfully identified, in part based on an improved effort of site selection focusing on older industrial and highly impervious landscapes. With careful selection of sample timing, some success even occurred at tidal sites, but overall, tidal sites remain the most challenging to sample. Although optimism remains about future applications, the remote sampler trial showed mixed results and need further testing.

Total PCB concentrations measured in the composite water samples collected from the 37 sites varied 192-fold between 832 and 159,606 pg/L. The four highest ranking sites for PCB whole water concentrations were Industrial Rd Ditch in San Carlos, Outfall at Gilman St. in Berkeley, Ridder Park Dr SD in San Jose, and Outfall to Lower Silver Ck in San Jose. When normalized by suspended sediment concentrations (SSC) to generate particle ratios, the four sites with highest particle ratios were Industrial Rd Ditch in San Carlos (6,139 ng/g), Gull Dr SD in South San Francisco (859 ng/g), Outfall at Gilman St. in Berkeley (794 ng/g), and Outfall to Lower Silver Ck in San Jose (783 ng/g). Particle ratios of this magnitude are among the most extreme examples in the Bay Area (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): McKee et al., 2012; Gilbreath et al., 2016)[1]

Total Hg (HgT) concentrations in composite water samples collected during WY 2015 and 2016 ranged over 78-fold between 5.6 and 439 ng/L. The greatest HgT concentrations were observed in four Alameda County sites, the Outfall at Gilman St. in Berkeley, Line 9-D-1 PS at outfall to Line 9-D in San Leandro, Line 13-A at end of slough in San Leandro, and Line 3A-M at 3A-D in Union City. When the data were normalized by SSC, the four most highly ranked sites were Outfall at Gilman St. in Berkeley (5.3), Meeker Slough in Richmond (1.3), Line 3A-M at 3A-D in Union City (1.2), and Taylor Way SD in San Carlos (1.2). Particle ratios of this magnitude are similar to the upper range of those observed previously (mainly in WY 2011). The ten highest ranking sites for PCBs based on particle ratios only ranked 14th, 11th, 1st, 19th, 26th, 3rd, 13th, 22nd, 15th, and 8th respectively in relation to HgT particle ratios.

Both of the remote suspended sediment sampler types that were used (Walling sampler and Hamlin sampler) generally characterized sites similarly to the composite stormwater sampling methods (higher concentrations matching higher and lower matching lower), but results appear to be better for PCBs relative to Hg and there is a hint, based on just three samples, that the Walling sampler performs better than the Hamlin. Given that the data that result from remote samplers are less versatile (cannot be used for estimating loads without estimates of sediment load and are trickier to use in model calibration applications), one option is to consider using remote 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. 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.

Based on data collated from all sampling programs completed by SFEI since WY 2003 on stormwater in the Bay Area and the use of a Spearman Rank correlation analysis, PCB particle ratios appear to positively correlate with impervious cover, old industrial land use, and HgT. PCBs inversely correlate with watershed area and the other trace metals analyzed (As, Cu, Cd, Pb, and Zn). Total mercury does not appear to 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

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[1] Note, these particle ratios 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.

metals all appear to correlate with each other 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.

Climatic conditions may affect the interpretations of relative ranking between watersheds. WY 2015 was a drier than average year and WY 2016 was about average in San Francisco and San Jose. A total of 62 sites have so far been sampled for PCBs and HgT in stormwater by SFEI during various field sampling efforts since WY 2003. About 29% of the old industrial land use in the region has been sampled to date. The largest sample size so far has occurred in Santa Clara County (96% of this land use has been sampled), followed by San Mateo County (43%), Alameda County (33%), and Contra Costa County (4%). The disproportional coverage in Santa Clara County is due to a number of larger watersheds being sampled and because there were older industrial areas of land use further upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining older industrial land use yet to be sampled (~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, likely to 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 right of ways. A different sampling strategy may be needed to effectively determine what pollution might be associated with these areas.

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Introduction

The San Francisco Bay mercury and polychlorinated biphenyl (PCB) total maximum daily load plans (TMDLs) (SFBRWQCB, 2006; 2007) called for implementation of control measures to reduce stormwater PCB loads from about 20 kg to 2 kg by 2030 and to reduce stormwater total mercury (HgT) loads from about 160 kg down to 80 kg by 2028 with an interim milestone of 120 kg of Hg by 2018. Subsequently, 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(update)). MRP 1.0, as it came to be known, contained a provision that aimed to improve information on stormwater loads for a number of pollutants in selected watersheds (Provision C.8.) and additional provisions specific to Hg and PCBs (Provisions C.11. and C.12.) that called for piloting a number of management techniques to reduce PCB and Hg loads entering the Bay from smaller urbanized tributaries. To help address these information needs, a Small Tributaries Loading Strategy (STLS) was developed that outlined four key management questions (MQs) about loadings and a general plan to address these questions (SFEI, 2009). These questions were developed to be consistent with Provision C.8.e of MRP 1.0 and to link with the Hg and PCB specific provisions.

> MQ1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from pollutants of concern (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; and,
>
> 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 term of the MRP (2009-15) for MS4 Phase I stormwater permittees[2], the STLS Team focused the majority of the STLS-budgeted portion of RMP funds on refining pollutant loadings (Provision C.8.e) with some additional but more minor effort on finding and prioritizing potential "high leverage" watersheds and subwatersheds (those with disproportionately high concentrations or loads with connections to sensitive Bay margins). These RMP efforts with additional contract funds from Bay Area Stormwater Management Agencies Association (BASMAA)[3] resulted in the completion of a number of technical products that were consistent with the implementation plans outlined in the PCBs and Hg policy documents. These technical products in rough order of completion included the

1. 2009/2010 study to explore relationships between watershed characteristics (Greenfield et al., 2010) (RMP funds),

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[2] For a full list of permittees, the reader is referred to the individual countywide program websites or the reissued MRP (SFBRWQCB, 2015).

[3] BASMAA is made up of a number of programs which represent Permittees and other local agencies

2. 2009/2010 study to explore optimal sampling design for loads and trends (Melwani et al., 2010) (RMP funds),
3. reconnaissance study in water year 2011 to characterize concentrations during winter storms at 17 locations (McKee et al., 2012) (RMP funds),
4. completion of a number of “pollutant profiles” describing what is known about the sources and release processes for each pollutant (McKee et al., 2014) (BASMAA funds),
5. the development and operation of a loads monitoring program at six fixed station locations for water years 2012-2014 (Gilbreath et al., 2015a) (BASMAA and RMP funds),
6. completion of a loads monitoring synthesis report (McKee et al., 2015) (RMP funds), and
7. further refinement of geographic information about land uses and source areas of PCBs and Hg and the development of a regional watershed spreadsheet model (2010-present) (Wu et al., 2016; Wu et al., 2017) (BASMAA and RMP funds).

As a result of all this effort (several million dollars of funding spread over six years and a huge number of people and team members), sufficient pollutant data have been collected at sites with discharge measurements to make computations of pollutant loads of varying degrees of certainty at Mallard Island on the Sacramento River and 11 urban sites (McKee et al. 2015), and a reasonable calibration of the regional watershed spreadsheet model (RWSM) has been achieved for water, Cu, Hg, and PCBs (Wu et al., 2016; Wu et al., 2017), although we anticipate further improvements with the inclusion of WY 2016 data and further calibration and testing using 2017 RMP funding.

Discussions between BASMAA and the SFBRWQCB regarding the second term of the MRP, and parallel discussions at the October 2013 and May 2014 Sources Pathways and Loadings Workgroup (SPLWG) meetings, highlighted the need for an increasing focus on finding watersheds and land areas within watersheds that have relatively higher unit area load production or higher particle ratios or sediment pollutant concentrations at scales paralleling management practices (areas as small as subwatersheds, areas of old industrial land use, or source properties). This changed focus was consistent with the management trajectory outlined in the Fact Sheet (MRP Appendix I) issued with the November 2011 revision of the October 2009 MRP (SFBRWQCB, 2009; 2011). The Fact Sheet described a transition from pilot-testing in a few specific locations during the first MRP term to a greater amount of focused implementation in areas where benefits would be most likely to accrue in the second MRP term.

During 2014 and early 2015, the SPLWG and Small Tributaries Loadings Strategy (STLS) Team discussed alternative monitoring designs that could address this focus and settled upon the “reconnaissance design” described in this report. In November 2015, the Regional Water Board issued the second MRP (SFBRWQCB, 2015). “MRP 2.0” places an increased focus on finding high leverage watersheds, source areas, and source properties that are more polluted and located upstream from sensitive Bay margin areas. Specifically the permit retains the four Management Questions from MRP 1.0 but adds a new one stating that effort should be made to identify which sources or watershed source areas provide the greatest opportunities for reductions of mercury and PCBs in urban stormwater runoff. To help support this focus and also refine information addressing other Management Questions, the SPLWG and the STLS local team developed and implemented a stormwater reconnaissance characterization monitoring program in Water Year (WY) 2015 and 2016. The methods employed were modified from those first proposed at the October 2004 SPLWG meeting (study proposal #2), discussed again by the workgroup in 2005/06 as an alternative option to a loading study at Zone 4 Line A in Hayward, Alameda County, and implemented for the first time in WY 2011 (McKee et al., 2012). The nimble design implemented during the winter of WY 2015 and 2016 benefited from lessons learned during the WY 2011 effort and provides data primarily to support identification of potential high leverage areas as part of multiple lines of evidence being considered by the stormwater programs. The data also support improved calibration of the RWSM being developed to estimate regional scale watershed loads. This same design was implemented in the winter of WY 2016 by the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program. It is possible that this highly comparable data will be made available in time for the next calibrations of the RWSM planned for early 2017.

In parallel, the STLS team is designing a sampling program for monitoring stormwater loading trends in response to management efforts. Data collected using the reconnaissance characterization sampling design implemented in WYs 2011, 2015, 2016, and 2017 may also help to provide baseline data for observing concentration or particle ratio trends through time if the trends monitoring design effort provides evidence of suitability for that purpose.

This report summarizes and provides a preliminary interpretation of data collected during WY 2015 and 2016. The data collected and presented here is contributing to a broader based effort to identify potential management areas. The report was designed to be updated annually and will be updated again in approximately 12 months to include data from WY 2017 that is presently being collected.

Sampling methods

Methods selection

Water Year 2014 saw the conclusion of three years of pollutant loads monitoring at six fixed locations near the Bay margins for suspended sediment, total organic carbon (TOC), PCBs, HgT, total methylmercury (MeHgT), nitrate (NO_3), phosphate (PO_4)[4], and total phosphorus (TP). In addition, a fewer number of samples were gathered at the loading sites to characterize polybrominated diphenyl ether (PBDEs), polyaromatic hydrocarbons (PAHs), toxicity, pyrethroid pesticides, copper (Cu), and selenium (Se) (Gilbreath et al., 2015a). With the increasing focus of management efforts to identify areas of elevated PCBs (and mercury), a new monitoring design was needed to broaden the spatial coverage of information gathering and allow for relative comparisons of PCB and mercury concentrations across the region. In order to collect this information, a reconnaissance design was selected. This type of design is efficient, cost-effective, allows for a larger number of sites monitored,

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[4] Is also often referred to as dissolved orthophosphate or dissolved reactive phosphorous (DRP) or dissolved inorganic phosphorous (DIP). All these terms are functionally equivalent and refer to a sample that is filtered before analysis and analyzed using the ascorbic acid + molybdate blue reagents.

and can be used on a relative scale for identifying drainages with high PCB and mercury concentrations (McKee et al., 2012; SPLWG, May 2014; McKee et al., 2015).

The design implemented in WYs 2015 and 2016 was based on a previous monitoring design (WY 2011) in which multiple sites were visited during 1-2 storm events and stormwater samples were collected for a number of POCs. Based on discussions at the May 2014, SPLWG meeting, modifications were made to the WY 2011 design to increase cost-effectiveness. At the SPLWG meeting an analysis of previously collected stormwater sample data from both reconnaissance and fixed station monitoring was presented. An analysis of three sampling designs (sampling just 1, 2, or 4 storms, respectively: functionally 4, 8, and 16 discrete samples) showed that, for Guadalupe River at Hwy 101, PCB particle ratios could vary from 45-287 ng/g (1 storm design), 59-257 ng/g (2 storm design), and 74-183 ng/g (4 storm design). Although the Guadalupe River at Hwy 101 represents a more extreme example of variability due to smaller storms favoring runoff from just the lower and more urbanized part of the watershed versus larger storms causing runoff from the upper cleaner areas of the watershed, this analysis was used to imply that the number of storms sampled for a given system would have had quite a large influence on the resulting particle ratio and the potential relative ranking among sites. A similar analysis was then presented for the other fixed loads monitoring sites (Pulgas Pump Station-South, Sunnyvale East Channel, North Richmond Pump Station, San Leandro Creek, Zone 4 Line A, and Lower Marsh Creek) to explore the relative ranking based on a random 1-storm composite or 2-storm composite design. This analysis highlighted the potential for a false negative that could occur due to a lower number of sampled storms in Sunnyvale East Channel (3 of the 8 storms represented were < 200 ng/g which would have ranked it only slightly more polluted than San Leandro Creek, Zone 4 Line A or Guadalupe River at Hwy 101). This further highlighted the trade-off between generating information about water quality at fewer sites with more certainty or more sites with less certainty. The SPLWG agreed that a 1-storm composite per site design was preferable since the design has the flexibility to return to a site if the initial results did not make sense (either because the storm intensity was low or other information suggested potential sources).

In addition to collection of stormwater composites, a pilot study exploring in-line suspended sediment samplers based on enhanced water column settling was designed and implemented. Four sampler types were initially considered (single-stage siphon sampler, the CLAM sampler, the Hamlin sampler, and the Walling tube). After SPLWG discussion, the single-stage siphon sampler was dropped from consideration because it allowed for collection of only a single stormwater sample at a single time point, which offers no advantage over collecting a single manual stormwater sample, yet would require more effort and expense to set up. The CLAM sampler also has some limitations that affect interpretation of the data, primarily the lack of ability to estimate the volumes of water passing through the filters and the lack of performance tests in high turbidity environments. The remaining two sampler types (the Hamlin sampler and the Walling tube) were selected for the pilot study based on previous studies showing use of these devices in similar systems (velocities and analytes). However, there was a lot of discussion about how to analyze the samples and how to ensure their comparability to the composite water sample design. To test the comparability of sampling methods, the SPLWG Science Advisors recommended piloting the samplers at 12 locations[5] where manual water composites would be collected in parallel.

Watershed physiography and sampling locations

In the May 2014 SPLWG meeting, sample site selection rationale was discussed. The potential site selection rationales fall into four basic categories.

1. Identifying potential high leverage watersheds and subwatersheds (distributed across Phase I permittees)
    a. Watersheds with suspected high pollution
    b. Sites with ongoing or planned management actions
    c. Identifying sources 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 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)

It was agreed that the majority of samples each year (60-70% of the effort) would be dedicated to identifying potential high leverage watersheds and subwatersheds. The remaining resources would be allocated to addressing the other three rationales. In order to address this focus, SFEI worked with the respective Countywide Clean Water Programs to identify priority drainages including storm drains, ditches/culverts, tidally influenced areas, and natural areas for monitoring. A large pool of sites was visited during the summers of 2014 and 2015. We surveyed each for safety, logistical constraints, and to identify feasible drainage line entry points. From this larger set, a final set of ~25 sites were identified for monitoring during each WY (2015 and 2016). Due to drought conditions and challenges with sampling sites with tidal influence, of these 25 sites, 20 and 17 sites were sampled in WY 2015 and 2016 respectively (Figure 1; Table 1). The remaining unsampled sites were carried over for possible sampling in WY 2017.

It is seen, from Figure 1 and Table 1, that watershed sites with a wide variety of characteristics were sampled in WYs 2015 and 2016. In total, 14 sites were sampled in Santa Clara County, 13 sites in San Mateo County, nine sites in Alameda County, and just one site in Contra Costa County[6]. To-date, there has only been one watershed sampled in Contra Costa County (CCC) (Table 1). This represents a large data gap given the long history of industrial zoning along much of the CCC waterfront. Areas upstream

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[5] Note that in WYs 2015 and 2016 combined, only 8 and 3 locations could be sampled with the Hamlin and Walling samplers, respectively, due to climatic constraints. Five samples using the Walling sampler samples are planned for WY 2017.

[6] Two additional sites in Contra Costa County had been identified for WY 2015 but were not sampled because they are tidally influenced with only short sampling windows. Storms in WY 2015 did not align with these short windows.

from sample locations ranged between 0.11 km^2 and 17.5 km^2 and were characterized by a high degree of imperviousness (21%-88%: mean = 72%). The percentage of the watersheds designated as old industrial[7] ranged between 0% and 79% and averaged 29%. Although the sites were mainly selected to address site selection rationale number one (identifying potential high leverage watersheds and subwatersheds), Lower Penitencia Creek represents an example of a site that was previously sampled yet the resulting concentrations were surprisingly low, and therefore warranted re-sampling. The wide variety of imperviousness and industrial characteristics of these watersheds will help to broaden the environmental gradient of watershed characteristics that will potentially support an improved calibration of the RWSM (Wu et al., 2016). Although a matrix of site characteristics for sampling strategic larger watersheds was also developed (Table 2), none of these could be sampled during WY 2015 or 2016 because climatic conditions for rainfall and flow were not met.

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[7] 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).

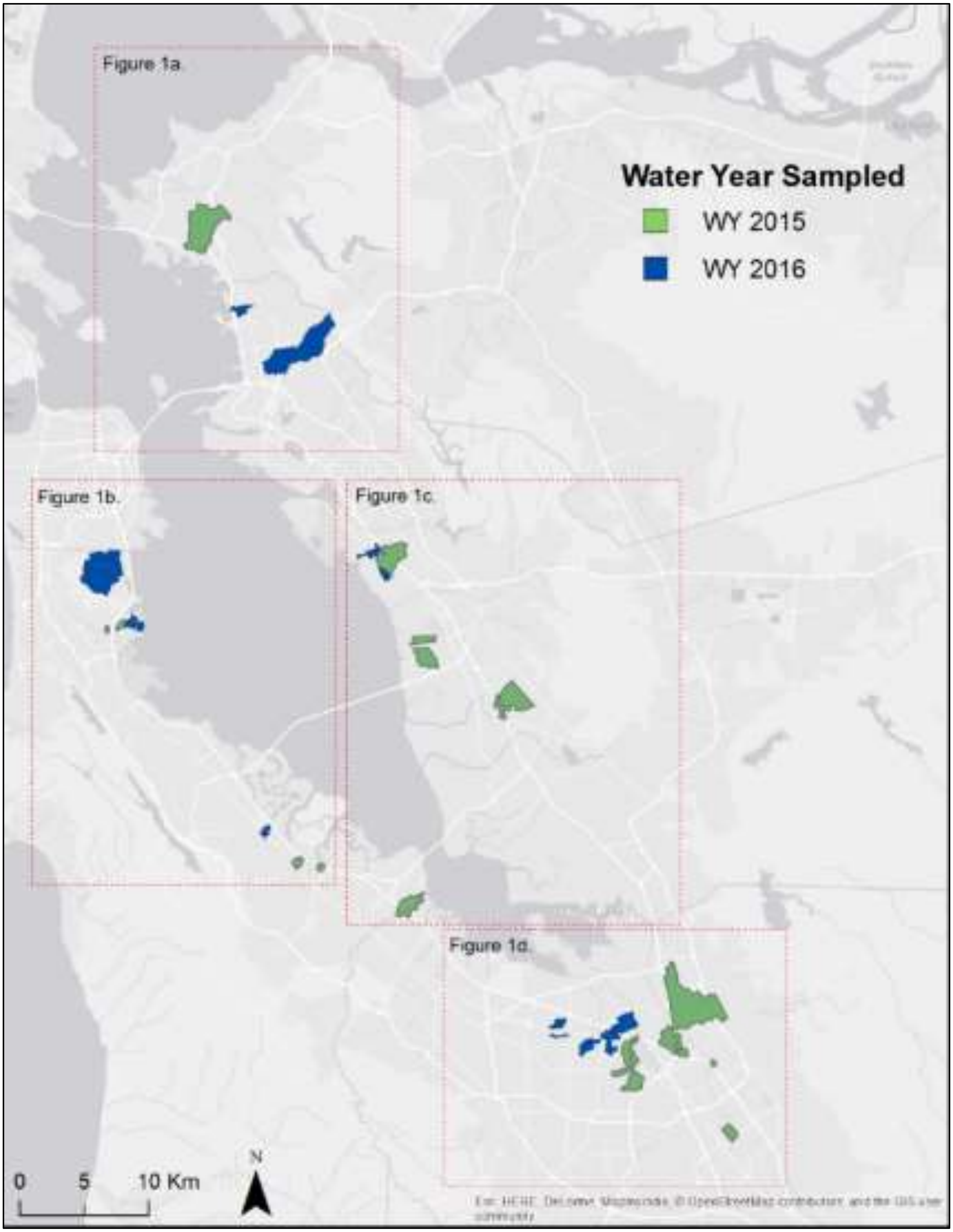

Figure 1. Sampling locations (marked by the dots) and watershed boundaries (shown in green and blue).

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Figure 1a. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in northern Alameda and Contra Costa counties.

Figure 1b. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in central and northern San Mateo County.

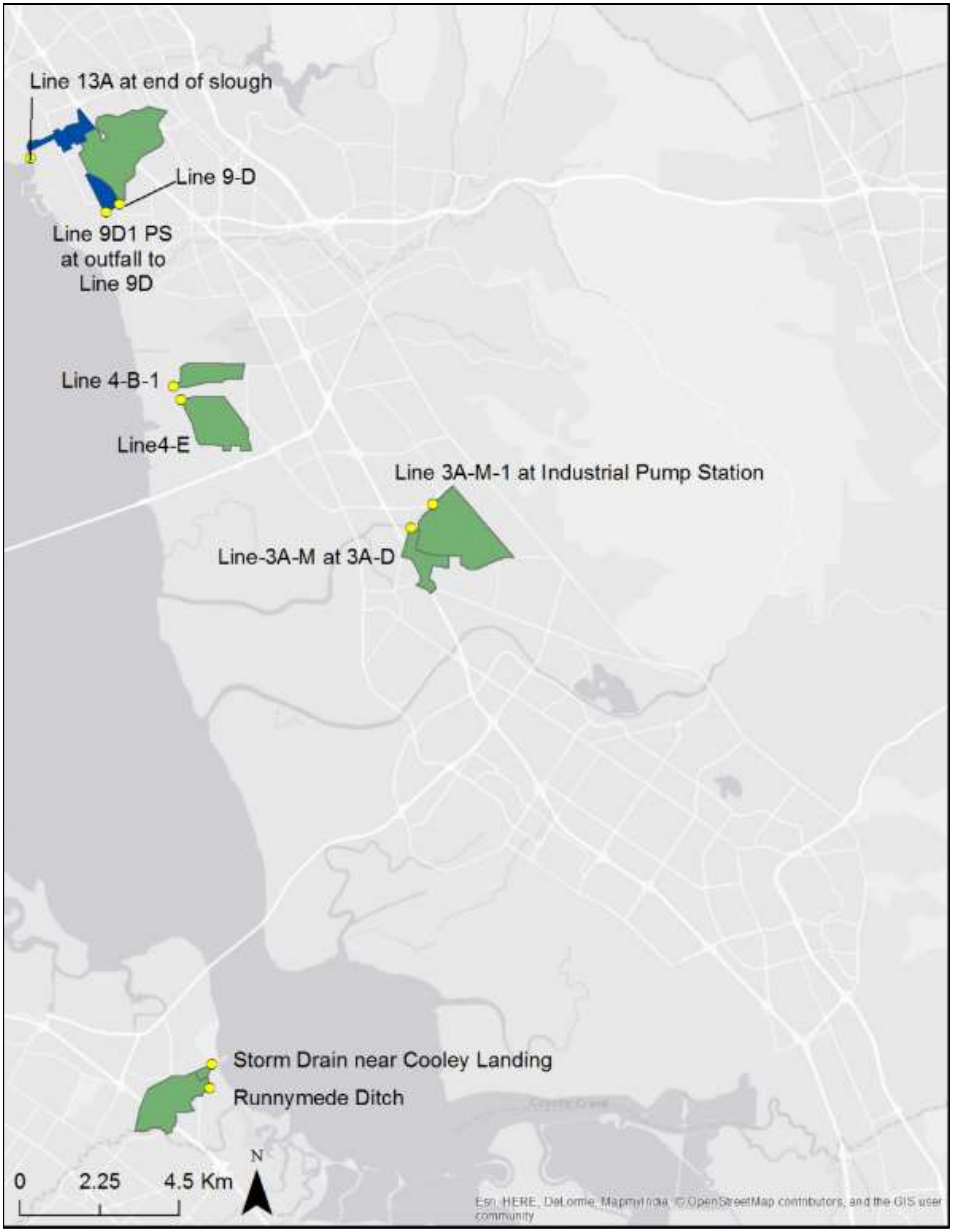

Figure 1c. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in southern Alameda and San Mateo counties.

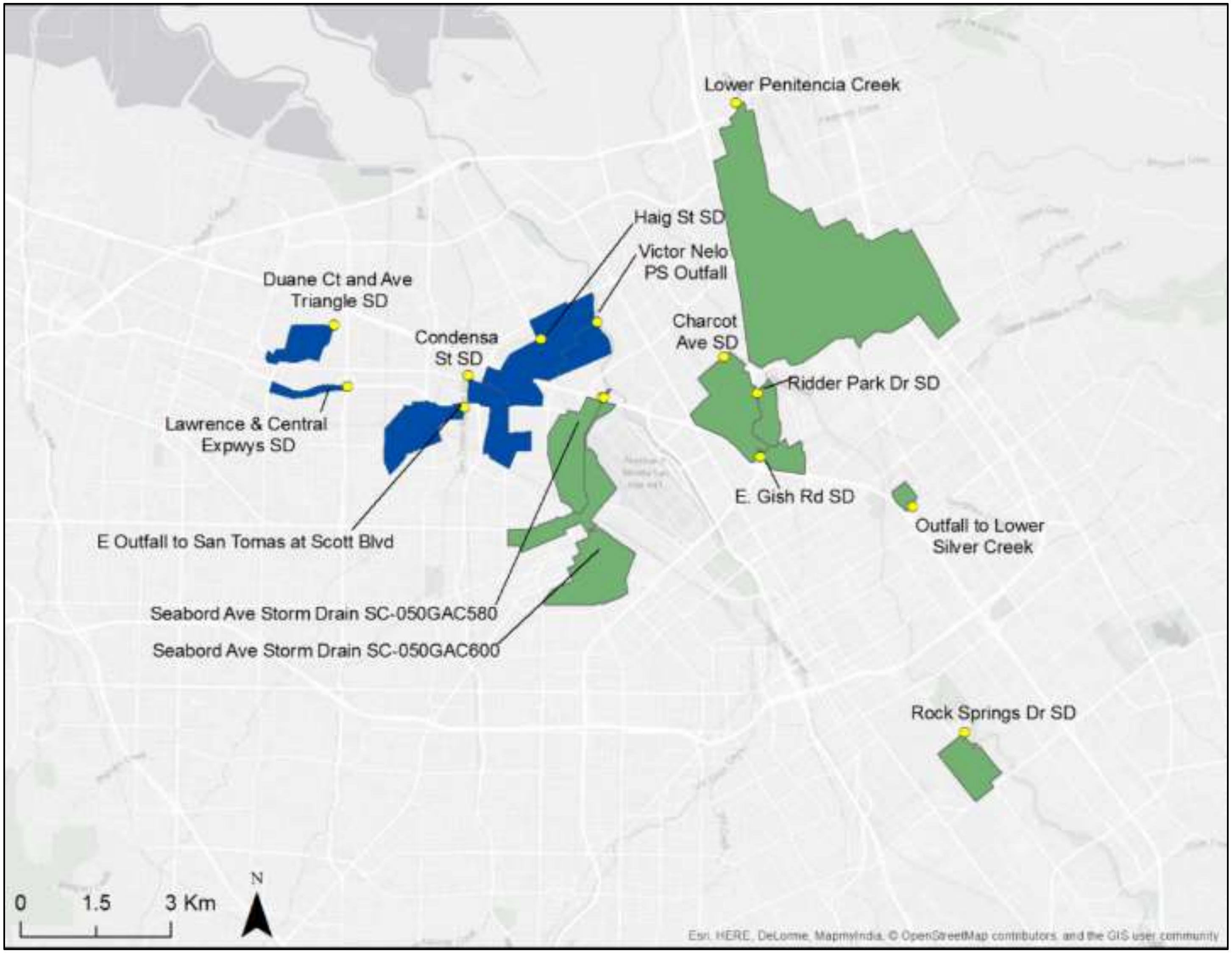

Figure 1d. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in Santa Clara County.

Table 1. Key characteristics of WY 2015 and 2016 sampling locations.

County	City	Watershed name	Catchment Code	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	37.61893	-122.05949	12/11/14	3.44	78%	26%
Alameda	Union City	Line 3A-M at 3A-D	AC-Line 3A-M	37.61285	-122.06629	12/11/14	0.88	73%	12%
Alameda	Hayward	Line 4-B-1	AC-Line 4-B-1	37.64752	-122.14362	12/16/14	0.96	85%	28%
Alameda	Hayward	Line 4-E	AC-Line 4-E	37.64415	-122.14127	12/16/14	2.00	81%	27%
Alameda	San Leandro	Line 9-D	AC-Line 9-D	37.69383	-122.16248	4/7/15	3.59	78%	46%
Alameda	San Leandro	Line 9-D-1 PS at outfall to Line 9-D	AC-2016-15	37.69168	-122.16679	1/5/16	0.48	88%	62%
Alameda	Berkeley	Outfall at Gilman St.	AC-2016-1	37.87761	-122.30984	12/21/15	0.84	76%	32%
Alameda	Emeryville	Zone 12 Line A under Temescal Ck Park	AC-2016-3	37.83450	-122.29159	1/6/16	17.47	30%	4%
Alameda	San Leandro	Line 13-A at end of slough	AC-2016-14	37.70497	-122.19137	3/10/16	0.83	84%	68%
Contra Costa	Richmond	Meeker Slough	Meeker Slough	37.91786	-122.33838	12/3/14	7.34	64%	6%
San Mateo	Redwood City	Oddstad PS	SM-267	37.49172	-122.21886	12/2/14	0.28	74%	11%
San Mateo	Redwood City	Veterans PS	SM-337	37.49723	-122.23693	12/15/14	0.52	67%	7%
San Mateo	South San Francisco	Gateway Ave SD	SM-293	37.65244	-122.40257	2/6/15	0.36	69%	52%
San Mateo	South San Francisco	South Linden PS	SM-306	37.65018	-122.41127	2/6/15	0.14	83%	22%
San Mateo	East Palo Alto	Runnymede Ditch	SM-70	37.46883	-122.12701	2/6/15	2.05	53%	2%
San Mateo	East Palo Alto	SD near Cooley Landing	SM-72	37.47492	-122.12640	2/6/15	0.11	73%	39%
San Mateo	South San Francisco	Forbes Blvd Outfall	SM-319	37.65889	-122.37996	3/5/16	0.40	79%	0%
San Mateo	South San Francisco	Gull Dr Outfall	SM-315	37.66033	-122.38502	3/5/16	0.43	75%	42%
San Mateo	South San Francisco	Gull Dr SD	SM-314	37.66033	-122.38510	3/5/16	0.30	78%	54%
San Mateo	Brisbane	Tunnel Ave Ditch	SM-350/ 368/more	37.69490	-122.39946	3/5/16	3.02	47%	8%
San Mateo	Brisbane	Valley Dr SD	SM-17	37.68694	-122.40215	3/5/16	5.22	21%	7%
San Mateo	San Carlos	Industrial Rd Ditch	SM-75	37.51831	-122.26371	3/11/16	0.23	85%	79%
San Mateo	San Carlos	Taylor Way SD	SM-32	37.51320	-122.26466	3/11/16	0.27	67%	11%
Santa Clara	Milpitas	Lower Penitencia Ck	Lower Penitencia	37.42985	-121.90913	12/11/14	11.50	65%	2%
Santa	Santa	Seabord Ave SD	SC-	37.37637	-121.93793	12/11/14	1.35	81%	68%

County	City	Watershed name	Catchment Code	Latitude	Longitude	Sample Date	Area (sq km)	Impervious cover (%)	Old industrial (%)
Clara	Clara	SC-050GAC580	050GAC580						
Santa Clara	Santa Clara	Seabord Ave SD SC-050GAC600	SC-050GAC600	37.37636	-121.93767	12/11/14	2.80	62%	18%
Santa Clara	San Jose	E. Gish Rd SD	SC-066GAC550	37.36632	-121.90203	12/11/14	0.44	84%	71%
Santa Clara	San Jose	Ridder Park Dr SD	SC-051CTC400	37.37784	-121.90302	12/15/14	0.50	72%	57%
Santa Clara	San Jose	Outfall to Lower Silver Ck	SC-067SCL080	37.35789	-121.86741	2/6/15	0.17	79%	78%
Santa Clara	San Jose	Rock Springs Dr SD	SC-084CTC625	37.31751	-121.85459	2/6/15	0.83	80%	10%
Santa Clara	San Jose	Charcot Ave SD	SC-051CTC275	37.38413	-121.91076	4/7/15	1.79	79%	25%
Santa Clara	Santa Clara	Duane Ct and Ave Triangle SD	SC-049CZC200	37.38852	-121.99901	12/13/15 and 1/6/16	1.00	79%	23%
Santa Clara	Santa Clara	Lawrence & Central Expwys SD	SC-049CZC800	37.37742	-121.99566	1/6/16	1.20	66%	1%
Santa Clara	Santa Clara	Condensa St SD	SC-049STA710	37.37426	-121.96918	1/19/16	0.24	70%	32%
Santa Clara	San Jose	Victor Nelo PS Outfall	SC-050GAC190	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	37.37991	-121.96842	3/6/16	0.67	66%	31%
Santa Clara	San Jose	Haig St SD	SC-050GAC030	37.38664	-121.95223	3/6/16	2.12	72%	10%

Table 2. Characteristics of larger watersheds to be monitored, proposed sampling location, and proposed sampling trigger. None of these watersheds could be sampled during WY 2015 or 2016 because climatic conditions for flow and rainfall were not met.

Proposed sampling location							**Relevant USGS gauge for 1st order loads computations**	
Watershed system	**Watershed area (sq km)**	**Impervious surface (%)**	**Industrial (%)**	**Sampling objective**	**Commentary**	**Proposed sampling triggers**	**Gauge number**	**Area at USGS gauge (sq km)**
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 decent forecast for the East Bay interior valley's (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 decent forecast for the East Bay Hills (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 decent forecast for the Peninsula Hills (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 decent forecast for the Peninsula Hills (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 decent forecast (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

Based on a minimum rainfall weather forecast for at least a quarter inch[8] over six hours, sampling teams were deployed to each of the sampling sites, ideally reaching the sampling site about one hour before the onset of rainfall[9]. When possible, one team sampled two sites in close proximity to one another to increase sample capture efficiency and decrease staffing costs to the program. Once arriving on site, the team worked together to assemble the equipment and carry out final safety checks. Sampling equipment varied between sites depending on the characteristics of the access point to the drainage line. Some sites were sampled by attaching laboratory prepared trace metal clean Teflon sampling tubing to a painters pole and a peristaltic pump (also installed with lab cleaned silicone pump roller tubing) (Figure 2a). During sampling, the tube was dipped into the channel or drainage line aiming for mid-channel mid-depth (if shallow) or depth integrating if the depth was more than about 0.5 m. In other cases, a DH 84 (Teflon) sampler was used that had also been cleaned prior to sampling, also aiming for mid-channel, mid-depth, or depth integrated depending on channel conditions.

Manual time-paced composite stormwater sampling procedures

At each site, a time-paced composite sample was collected comprising a variable number of sub-samples, or aliquots. Depending on the weather forecast, the prevailing on site conditions, and radar imagery, staff estimated the duration of the storm and selected the aliquot size and number to ensure that the minimum volume requirements for each analyte would be reached before the storm's end (Table 3). Because the minimum volume requirements were less than the size of the sample bottle, there was flexibility built into the sub-sampling program to add aliquots in the event that the storm ended up longer than predicted (e.g., minimally 5 aliquots but up to 10 aliquots could be collected; Table 3). The final decision on the aliquot volume was made just before the first aliquot was taken and remained fixed for the rest of the event. The ultimate number of aliquots, as long as the minimum volume was reached, was usually adjusted depending upon how rainfall progressed. All aliquots for the sample were collected into the same bottle throughout the storm, which was kept in a cooler on ice.

Remote suspended sediment sampling procedures

The Hamlin and Walling tube remote suspended sediment samplers were deployed approximately mid-channel/ storm drain. The Hamlin sampler sat flush, or nearly flush, with the bed of either the stormdrain or concrete channel[10], and was weighted down to the bed either by itself (the sampler weighs approximately 25 lbs) or additionally using barbell weight plates attached to the bottom of the sampler (see Figure 2b). The Walling tube could not be deployed in storm drains due to its size and

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[8] Note, this was relaxed due to a lack of larger storms. Ideally, mobilization would only proceed with a 0.5" forecast.

[9] Antecedent dry-weather was not considered prior to deployment. Although this would likely have a bearing on the concentration of certain build-up/wash-off pollutants like metals and perhaps even mercury. For PCBs, antecedent dry-weather is less important than the mobilization of in-situ legacy sources.

[10] In future years, if the Hamlin is deployed within a natural bed channel, elevating the sampler more off the bed may be necessary but was not the case in WY 2015.

requirement for staying horizontal, but was secured in open channels either by being weighted down to a concrete bed using hose clamps to secure to barbell weights, or secured to a natural bed using hose clamps attached to temporarily installed rebar. To minimize the chances of sampler loss, both samplers were additionally secured via a stainless steel cable attached on one end to the sampler and on the other end to a temporary rebar anchor or another object such as a tree or fence post.

The remote suspended sediment samplers were deployed for the duration of the manual water quality sampling (Table 4 for site list and success rate). At the end of sample collection with a remote sampler, the device was removed from the channel bed /storm drain bottom shortly after the last water quality sample aliquot. Water and sediments collected into the sediment sampler were decanted into one or two large glass bottles. Staff flushed all sediments into the collection bottles. When additional water was needed to flush the settled sediments from the remote samplers into the collection bottles, site water from the sampled channel was used. The samples were taken back to SFEI and refrigerated upon arrival until processing. Samples were split and placed into laboratory containers and then shipped to the laboratory for analysis. Samples collected by remote samplers from seven locations were analyzed as whole water samples (due to insufficient solid mass to analyze as a sediment sample), and one was analyzed as a sediment sample.

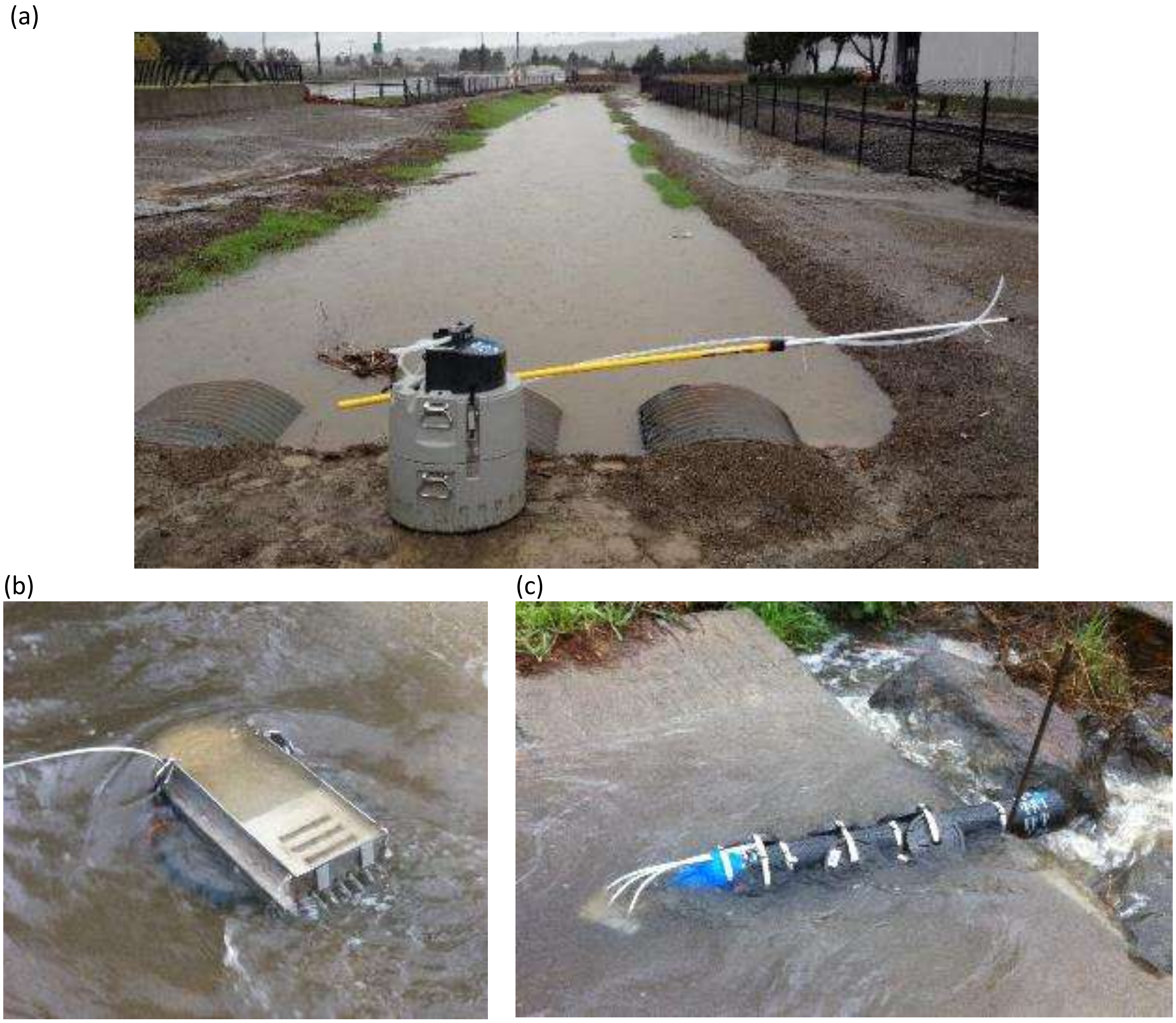

Figure 2. Sampling equipment used in the field. (a) Painters pole, Teflon tubing and an ISCO used as a slave pump; alternatively a Teflon bottle is attached to the end of a painters pole (DH84) and used for sample water collection as opposed to using an ISCO as a pump (b) Hamlin suspended sediment sampler; and (c) the Walling tube suspended sediment sampler.

Table 3. Sub-sample sizes in relation to analytes and sample container volumes.

Analyte	**Bottle size (L)**	**Minimum volume (L)**	**Aliquots (sub-samples) (minimum to maximum number, and required volumes (L)**			
			3 to 6	**4 to 8**	**5 to 10**	**6 to 12**
HgT/ trace metals	2	0.25	0.33	0.25	0.2	0.17
SSC	1	0.3	0.17	0.13	0.1	0.08
PCBs	2.5	1	0.33	0.25	0.2	0.17
Grain size	2	1	0.33	0.25	0.2	0.17
TOC	1	0.25	0.17	0.13	0.1	0.08

Table 4. 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.

Laboratory analytical methods

All samples were labeled, placed on ice, transferred back to SFEI, and refrigerated at 4 °C until transport to the laboratory for analysis, except for TOC/DOC. DOC has a 24-hour hold time for filtration. Samples were mostly dropped to the analytical laboratory within the 24-hour filtration hold time. In those cases where the laboratory was not open during the 24-hour hold time window, SFEI staff filtered DOC samples using a Hamilton 50 mm glass syringe with a 25 mm, 0.45 um filter. Laboratory methods shown in Table 5 were used to ensure the optimal combination of method detection limits, accuracy and precision, and costs (BASMAA, 2011; 2012) (Table 5). As seen in the table, Hg, PCBs and OC were analyzed for both particulate and dissolved phases. However, this was only completed for a small subset of samples that were gathered from sites where the remote samplers were being deployed and trialed (please see the remote sampler section for more details).

Table 5. Laboratory analysis methods.

Analysis	Matrix	Analytical Method	Lab	Filtered	Field preservation	Contract Lab / Preservation hold time
PCBs (40)-Dissolved	Water	EPA 1668	AXYS	Yes	NA	NA
PCBs (40)-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)	Water	EPA 9060A	ALS	No	HCL	NA
Organic carbon-Dissolved (WY 2016)	Water	EPA 9060A	ALS	Yes	HCL	NA
Mercury	Particulate	EPA 1631E, Appendix	BRL	NA	NA	
PCBs (40)	Particulate	EPA 1668	AXYS	NA	NA	NA
Organic carbon (WY 2016)	Particulate	EPA 440.0	ALS	NA	NA	NA

Interpretive methods

Particle normalized concentrations

Each site was only monitored at the characterization level, so there was no averaging of data for a site across multiple storm events. In the Bay Area, erosion of sediment varied greatly between watersheds (McKee et al., 2003). Given, PCBs and Hg are dominantly transported in particulate form and that erosion of contaminated particulate from sources and source areas is likely the main process of release and transport (McKee et al., 2015), it is reasoned that the ratio of concentrations of PCBs or Hg measured in stormwater to the suspended sediment concentration in stormwater is likely a better summary of water quality of a site than a single water concentration (McKee et al., 2012; Rügner et al., 2013; McKee et al., 2015). Although normalizing for SSC helps increase our ability to compare relative contamination between sites, the effects of climate cannot be as easily removed. Climatic conditions can influence the interpretations of relative ranking between watersheds although the absolute nature of that influence may differ between watershed locations depending on source characteristics. For example, for some watersheds, dry years or lower storm intensity might cause a greater particle ratio if transport of the sources of polluted sediments are activated and entrained into runoff but overall less diluted by lower erosion rates of cleaner particles from other parts of the watershed (this would be likely in mixed land use watersheds with larger proportions 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 could such processes be teased out. For example, WY 2015 in particular was drier than average and in WY 2016, about half of the Bay Area was approximately normal (San Francisco was 102% of the 40 year normal) and the other half slightly drier than average. The San Francisco gauge (047772) recorded 18.2 in or 80% of the 40 year (1977-2016) normal in WY 2015. While this was not greatly below average, most of this rainfall (11.7 in) fell in a single month (December), resulting in a rainfall year of one wet month and otherwise mostly dry conditions. In contrast, WY 2011 (when the last spatially intensive sampling occurred) was a wetter year with 128% of the 40 year San Francisco normal. These climatic challenges acknowledged, the particle ratio (PR) (mass of a given pollutant of concern in relation to mass of suspended sediment) was computed for each composite water sample collected for each analyte at each site by taking the water concentration (mass per unit volume) and dividing it by its suspended sediment concentration pair (mass of suspended sediment per unit volume) (Equation 1).

Equation 1 (example PCBs): $PR\ (ng/mg) = \ (PCB\ (ng/L))/(SSC\ (mg/L)\ )$

These ratios were then used as the primary comparison method between sites without regard to climate or rainfall intensity. 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. However, to generate information on the absolute relative ranking between individual sites, a much more rigorous sampling campaign sampling 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).

Derivations of central tendency for comparisons with past data

As commonly discussed in water quality literature, mean, median, geomean, or flow-weighted mean can be used as measures of central tendency of a dataset. In the Bay Area, the average or median of water concentrations at a site has sometimes been used, or the average or median of the particle ratios (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016). To best compare WY 2015 and 2016 composite results with past data that was previously collected as discrete stormwater samples rather than as composites, a different technique was used to estimate the central tendency than has been used in the past. A timed interval water composite collected over a single storm is similar to giving equal weight to discrete samples over a storm and mixing them all into a single bottle for analysis. Although variation across storms might be expected to bigger than within a single storm for any given site, for previously collected discrete grab data, the sum all of the water concentration samples divided by the sum of all the suspended sediment concentrations for each site (note: this method is mathematically not equivalent to averaging together the particle ratios of each discrete sample paired with its SSC) would be the best represented estimate of a site's central tendency.

Equation 2 (example PCBs): $PR\ (ng/mg) = \ (\Sigma PCB\ (ng/L))/(\Sigma SSC\ (mg/L))$

Due to the use of this alternate method for estimating the central tendency, particle ratios reported here in the current report differ slightly from those reported previously for the same site (e.g. McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

Results and Discussion

This section presents the data in the context of two key questions.

a) What are the concentrations and particle ratios observed at each of the sites based on the composite water samples?
b) How do the particle ratios observed at each of the sites based on the composite water samples compare to particle ratios derived from the remote sedimentation based samplers?

The reader is reminded that the data collected and presented here is contributing to a broader based effort to identify potential management areas. The rankings provided here based on either stormwater concentration or particle ratios are part of a weight of evidence approach being used for locating, prioritizing and managing areas in the landscape that may be disproportionately impacting downstream water quality.

PCBs Concentrations and Particle Ratios

Total PCB concentrations measured in the composite water samples across the 37 watershed sampling sites ranged almost 200-fold from 832-159,606 pg/L (Table 6) (Note that the Duane Ct and Ave Triangle SD site was sampled twice because the first storm sampled was very low intensity and we wanted to avoid the potential for a false negative result). The highest concentration was observed in Industrial Rd Ditch in San Carlos, a site downstream from Delta Star, a known PCB contamination site, and with 79% of its estimated drainage area in old industrial land use. This concentration was relatively high in relation to previous observations in the Bay Area (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). When normalized to SSC to generate particle ratios, the three highest ranking sites were the Industrial Rd Ditch in San Carlos (6,139 ng/g) (79% old industrial), Gull Dr Storm Drain in South San Francisco (859 ng/g) (54% old industrial), and the Outfall at Gilman St. in Berkeley (794 ng/g) (32% old industrial). Particle ratios of this magnitude are among the most extreme examples in the Bay Area (Pulgas Pump Station-South (8,222 ng/g) (54% old industrial), Santa Fe Channel (1,295 ng/g) (3% old industrial), Pulgas Pump Station-North (893 ng/g) (52% old industrial), Ettie St. Pump Station (759 ng/g) (22% old industrial): McKee et al., 2012; Gilbreath et al., 2016)[11]. The sample taken in Lower Penitencia Creek corroborates a similar finding that was previously reported (McKee et al., 2012). Similarly, two samples taken at the Duane Ct and Ave Triangle SD site during separate storm events on December 13, 2015 and January 6, 2016 indicate relatively consistent and low particle ratios (Table 6). In general, on average, the particle ratios for the WY 2015 and 2016 sampling effort were greater than those from WY 2011 (McKee et al., 2012). This likely resulted from a much greater average imperviousness and proportion of old industrial land use in the catchment areas of the WY 2015 and 2016 sites and other stakeholder knowledge that contributed to selection of sites with a higher likelihood of PCB discharge to stormwater.

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[11] Note, these particle ratios 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.

Table 6. Concentrations of total mercury, sum of PCBs (RMP 40), and ancillary constituents measured at each of the sites during winter storms of water years 2015 and 2016. Both the sum of PCBs and total mercury are also expressed at a particle ratio (mass of pollutant divided by mass of suspended sediment). The table was sorted from high to low based on PCB particle ratios.

Watershed/Catchment	County	City	Sample Date	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	26			159,606	1	6,140	1	13.9	29	0.535	14
Gull Dr SD	San Mateo	South San Francisco	3/5/16	10			8,592	20	859	2	5.62	38	0.562	11
Outfall at Gilman St.	Alameda	Berkeley	12/21/15	83			65,670	2	794	3	439	1	5.31	1
Outfall to Lower Silver Ck	Santa Clara	San Jose	2/6/15	57	8.6	8.3	44,643	4	783	4	24.1	24	0.423	19
Ridder Park Dr SD	Santa Clara	San Jose	12/15/14	114	7.7	8.8	55,503	3	488	5	37.1	17	0.326	26
Line 3A-M at 3A-D	Alameda	Union City	12/11/14	74	9.5	7.3	24,791	8	337	6	85.9	4	1.17	3
Seabord Ave SD SC-050GAC580	Santa Clara	Santa Clara	12/11/14	85	9.5	10	19,915	9	236	7	46.7	12	0.553	13
Line 4-E	Alameda	Hayward	12/16/14	170	2.8	3.6	37,350	5	219	8	59.0	9	0.346	22
Seabord Ave SD SC-050GAC600	Santa Clara	Santa Clara	12/11/14	73	7.9	8.6	13,472	13	186	9	38.3	15	0.528	15
South Linden PS	San Mateo	South San Francisco	2/6/15	43	7.4	7.4	7,814	22	182	10	29.2	20	0.679	8
Gull Dr Outfall	San Mateo	South San Francisco	3/5/16	33			5,758	25	174	11	10.4	35	0.315	27
Taylor Way SD	San Mateo	San Carlos	3/11/16	25	4.5	9.1	4,227	29	169	12	28.9	22	1.16	4
Line 9-D	Alameda	San Leandro	4/7/15	69	5	4.6	10,451	15	153	13	16.6	26	0.242	32
Meeker Slough	Contra Costa	Richmond	12/3/14	60	4.4	5.3	8,560	21	142	14	76.4	6	1.27	2
Rock Springs Dr SD	Santa Clara	San Jose	2/6/15	41	11	11	5,252	26	128	15	38	16	0.927	5
Charcot Ave SD	Santa Clara	San Jose	4/7/15	121	20	20	14,927	11	123	16	67.4	8	0.557	12
Veterans PS	San Mateo	Redwood City	12/15/14	29	5.9	6.3	3,520	30	121	17	13.7	30	0.469	16
Gateway Ave SD	San Mateo	South San Francisco	2/6/15	45	9.9	10	5,244	27	117	18	19.6	25	0.436	17
Line 9-D-1 PS at outfall to Line 9-D	Alameda	San Leandro	1/5/16	164			18,086	10	110	19	118	2.5	0.720	7

Watershed/Catchment	County	City	Sample Date	SSC	DOC	TOC	PCBs				Total Hg			
				(mg/L)	(mg/L)	(mg/L)	(pg/L)	Rank	(ng/g)	Rank	(ng/L)	Rank	(µg/g)	Rank
Tunnel Ave Ditch	San Mateo	Brisbane	3/5/16	96	5.8	11.3	10,491	14	109	20	73.0	7	0.760	6
Valley Dr SD	San Mateo	Brisbane	3/5/16	96			10,442	16	109	21	26.5	23	0.276	30
Runnymede Ditch	San Mateo	East Palo Alto	2/6/15	265	16	16	28,549	7	108	22	51.5	11	0.194	36
E. Gish Rd SD	Santa Clara	San Jose	12/11/14	145	12	13	14,365	12	99.2	23	84.7	5	0.585	10
Line 13-A at end of slough	Alameda	San Leandro	3/10/16	357			34,256	6	96.0	24	118	2.5	0.331	24
Line 3A-M-1 at Industrial PS	Alameda	Union City	12/11/14	93	4.2	4.5	8,923	18	95.8	25	31.2	19	0.335	23
Forbes Blvd Outfall	San Mateo	South San Francisco	3/5/16	23	3.4	7.9	1,840	36	80.0	26	14.7	28	0.637	9
SD near Cooley Landing	San Mateo	East Palo Alto	2/6/15	82	13	13	6,473	24	78.9	27	35.0	18	0.427	18
Lawrence & Central Expwys SD	Santa Clara	Santa Clara	1/6/16	58			4,506	28	77.7	28	13.1	31.5	0.226	33
Condensa St SD	Santa Clara	Santa Clara	1/19/16	35			2,602	32	74.4	29	11.5	34	0.329	25
Oddstad PS	San Mateo	Redwood City	12/2/14	148	8	7.5	9,204	17	62.4	30	54.8	10	0.372	20
Line 4-B-1	Alameda	Union City	12/16/14	152	2.8	3.1	8,674	19	57	31	43.0	13	0.282	29
Zone 12 Line A under Temescal Ck Park	Alameda	Emeryville	1/6/16	143			7,804	23	54.4	32	41.5	14	0.290	28
Victor Nelo PS Outfall	Santa Clara	San Jose	1/19/16	45	4.0	10.5	2,289	33	50.9	33	15.8	27	0.351	21
Haig St SD	Santa Clara	San Jose	3/6/16	34			1,454	37	42.8	34	6.61	36	0.194	35
E Outfall to San Tomas at Scott Blvd	Santa Clara	Santa Clara	3/6/16	103			2,799	31	27.2	35	13.1	31.5	0.127	37
Duane Ct and Ave Triangle SD (Dec 13)*	Santa Clara	Santa Clara	12/13/15	79			1,947	35	24.6	36	5.91	37	0.0748	38
Duane Ct and Ave Triangle SD (Jan 6)*	Santa Clara	Santa Clara	1/06/16	48	4.2	12	832	38	17.3	37	12.9	33	0.268	31
Lower Penitencia Ck	Santa Clara	Milpitas	12/11/14	144	5.9	6.1	2,033	34	14.1	38	29.0	21	0.202	34
Minimum				10	2.8	3.1	832		14.1		5.62		0.0748	
Maximum				357	20	20	159,606		6,140		439		5.31	

Mercury Concentrations and Particle Ratios

Total Hg concentrations in composite water samples varied 78-fold between the 37 watershed sampling sites from 5.62-439 ng/L (Table 6). This relatively large variation between sites is quite a change from that reported last year for WY 2015 alone (McKee et al., 2016) when concentrations were observed to vary from 14-86 ng/L (6.1-fold) and from previous reconnaissance effort in WY 2011 when mean HgT concentrations were observed to vary from 13.9-503 ng/L (36-fold) between sites (McKee et al., 2012). Since there was very similar variation between SSC during the 2011 study and the combined results from WYs 2015 and 2016 (both ~36-fold), this greater variation reflects the addition of a high sample concentration observed at the Outfall at Gilman Street (439 ng/L). Indeed, the greatest concentration of HgT now observed during the sampling in WYs 2015 and 2016 occurred at the that outfall, a site that is 32% old industrial upstream from the sampling point. Other sites with high HgT concentrations were 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% industrial respectively), Line 3A-M at 3A-D in Union City (12% industrial), Gish Rd Storm Drain in San Jose (71% old industrial), and Meeker Slough in Richmond now ranks number 6 with a land use of just 6% old industrial upstream from the sampling location. This helps to illustrate that mercury concentrations don't appear to follow a strong relationship with old industrial land use (in contrast to PCBs where there is a weak but positive relationship between concentrations measured in water and industrial land use). When the HgT data were normalized to SSC, 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). Particle ratios at these sites were 5.3, 1.3, 1.2, 1.2, and 1.0 µg/g, respectively. Particle ratios of this magnitude exceed the upper range of those observed during the WY 2011 sampling campaign (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).[see footnote 11 above] On a regional basis, there is no discernible relationship between old industrial land use and HgT particle ratios whereas, in contrast, there does appear to be a weak relationship between PCB particle ratios and old industrial land use.

When making comparisons between all the data collected in the Bay Area to date, the particle ratio method of normalization remains the most reliable tool for ranking sites in relation to potential management follow-up. It provides a mechanism for accounting for both flow of water and sediment erosion concurrently. Another important issue during the ranking process is to consider the combined ranks of PCBs and Hg together to get an idea about how management effort might address both pollutants together. However, in general there was only a weak but positive relationship between observed PCB and HgT concentrations. The six highest ranking sites for PCBs based on particle ratios ranked 14th, 11th, 1st, 19th, 26th, and 3rd, respectively, for HgT. This observation contrasts with the conclusions drawn from the WY 2011 dataset where there appeared to be more of a general correlation (McKee et al., 2012). This might reflect a stronger focus on PCBs during the WYs 2015 and 2016 site selection process and the resulting focus on smaller watersheds with higher imperviousness and old industrial land use, or perhaps it might still be an artifact of small datasets. This observation will be explored further below.

Trace metal (As, Cd, Cu, Pb, and Zn) Concentrations

Concentrations of As, Cd, Cu, Pb, and Zn were collected during both WY 2015 and 2016 and ranged between less than the reporting limit (RL)-2.66 µg/L, 0.023-0.55 µg/L, 3.63-52.7 µg/L, 0.910-21.3 µg/L, and 39.4-337 µg/L respectively (Table 7). 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 appear much lower than were observed in North Richmond Pump Station (mean=11 µg/L) (see Appendix A3 in McKee et al., 2015). The Cd concentrations observed at sites during the WY 2015 effort also appear similar to mean concentrations of Cd measured in 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) (see Appendix A3 in McKee et al., 2015). Similarly the Cu and Pb concentrations observed during the WYs 2015 and 2016 sampling effort also appear typical of other Bay Area watersheds (Guadalupe River at Hwy 101: Cu 19 µg/L, Pb 14 µg/L; Lower Marsh Creek: Cu 14 µg/L; North Richmond Pump Station: Cu 16 µg/L, Pb 1.8 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, Pb 12 µg/L) (see Appendix A3 in McKee et al., 2015). Similarly, Zn measurements at 26 of the sites measured during the WYs 2015 and 2016 sampling effort straddled the mean concentration observed in the Bay Area previously (Zone 4 Line A: 105 µg/L) (Gilbreath et al., 2012a; 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 picked up. Both of these two analytes are mostly indicative of geological sources in watersheds. No measurements of Mg have been reported before in the Bay Area but these concentrations of Se are on the lower side of mean concentrations reported previously in the Bay Area (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 dissolved phase (e.g. 81% in the Guadalupe River system) and the known inverse correlation with flow (David et al., 2012; Gilbreath et al., 2012a), it is reasonable that our sampling design that focused on high would have produced lower concentrations than observed when sampling designs have included low flow and base flow 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/). With Se data, extra care should be exercised when comparing data between sites; flow conditions matter.

Table 7. Concentrations of select trace elements measured at each of the sites during winter storms of water years 2015 and 2016.

Watershed/Catchment	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Outfall to Lower Silver Ck	2.11	0.267	21.8	5.43			**337**
Ridder Park Dr SD	**2.66**	0.335	19.6	11.0			116
Line 3A-M at 3A-D	2.08	0.423	19.9	17.3			118
Seabord Ave SD SC-050GAC580	1.29	0.295	27.6	10.2			168

Watershed/Catchment	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Pb (µg/L)	Mg (µg/L)	Se (µg/L)	Zn (µg/L)
Line 4-E	2.12	0.246	20.6	13.3			144
Seabord Ave SD SC-050GAC600	1.11	0.187	21	8.76			132
South Linden PS	0.792	0.145	16.7	3.98			141
Line 9-D	0.47	0.053	6.24	**0.91**			67
Meeker Slough	1.75	0.152	13.6	14.0			85.1
Rock Springs Dr SD	0.749	0.096	20.4	2.14			99.2
Charcot Ave SD	0.623	0.0825	16.1	2.02			115
Veterans PS	1.32	0.093	8.83	3.86			41.7
Gateway Ave SD	1.18	0.053	24.3	1.04			78.8
Runnymede Ditch	1.84	0.202	**52.7**	**21.3**			128
E. Gish Rd SD	1.52	**0.552**	23.3	19.4			152
Line 3A-M-1 at Industrial PS	1.07	0.176	14.8	7.78			105
SD near Cooley Landing	1.74	0.100	9.66	1.94			48.4
Oddstad PS	2.45	0.205	23.8	5.65			117
Line 4-B-1	1.46	0.225	17.7	8.95			108
Lower Penitencia Ck	2.39	0.113	16.4	4.71			64.6
Condensa St SD	1.07	0.055	6.66	3.37	3,650	**0.39**	54.3
Forbes Blvd Outfall	1.5	0.093	31.7	3.22	**7,350**	**0**	246
Gull Dr SD	**0**	**0.023**	**3.63**	1.18	**528**	**0**	**39.4**
Line 9-D-1 PS at outfall to Line 9-D	1.07	0.524	22.5	20.9	2,822	0.2	217
Taylor Way SD	1.47	0.0955	10.0	4.19	5,482	**0**	61.6
Victor Nelo PS Outfall	0.83	0.140	16.3	3.63	1,110	0.04	118
Minimum	0	0.023	3.63	0.91	528	0	39.4
Maximum	2.66	0.552	52.7	21.3	7,350	0.39	337

Comparisons between composite water and remote sampling methods

The 11 results from remote sedimentation samplers that were successfully gathered in WYs 2015 and 2016 were compared to the results from water composite samples collected in parallel at those sites for the same storm events (Table 8). Results for the remote samplers are all compared on a particle ratio basis.

Eight samples were collected using the Hamlin samplers, and a Walling Tube was simultaneously deployed at three of these sites. At the three locations with both samplers, the Hamlin sampler results observed SSC concentrations 1.1, 14 and 25 times greater than the Walling Tubes. These differences

Table 8. Remote sampler data and comparison with manual water composite data.

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 particle ratio (ng/g)	Bias (particle ratio: lab measured)	PCB particle ratio (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	Hamlin	121	14,927	No data				123	No data	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%
Outfall to Lower Silver Ck	Walling	57	44,643					783		956	122%
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%
Median						12%			114%		137%
Mean						15%			119%		141%

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 particle ratio (ng/g)	Bias (particle ratio: lab measured)	Hg particle ratio (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	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%
Outfall to Lower Silver Ck	Walling	57	24					423		255	60%
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%
Median						17%			120%		60%
Mean						21%			128%		69%

could be related to two physical factors that probably influenced capture performance. The Walling Tube can be positioned at any height in the water column and was set at approximately mid-depth position during each deployment. In contrast, the Hamlin samplers were positioned either on the bed or slightly elevated (~3 cm) above the bed when attached atop a weighted plate. It is likely that mountings that were closer to the bed helped to increase the capture of more sediment mass of a coarser sediment grain (Figure 3). In addition, the apparatus opening on each device differs. The Walling Tube has a single point opening with a 4 mm diameter while the Hamlin sampler has multiple rectangular openings 6.4 mm wide and 108 mm long. Perhaps the physics of the openings also helped to increase capture in the case of Hamlin sampler. In comparison, the composite samples that were collected from the water column by hand, whether collected via peristaltic pump or using a DH-81, were collected in a way that aimed for them to be representative of water column as a whole from about 5 cm through to near the surface rather than from a fixed point. As a result, relative to the other two sampling methods, the Hamlin sampler captures a portion of coarser grained near-bed or bedload sediment whereas the Walling Tube and composited stormwater samples were more representative of the mixed water column and were finer in texture.

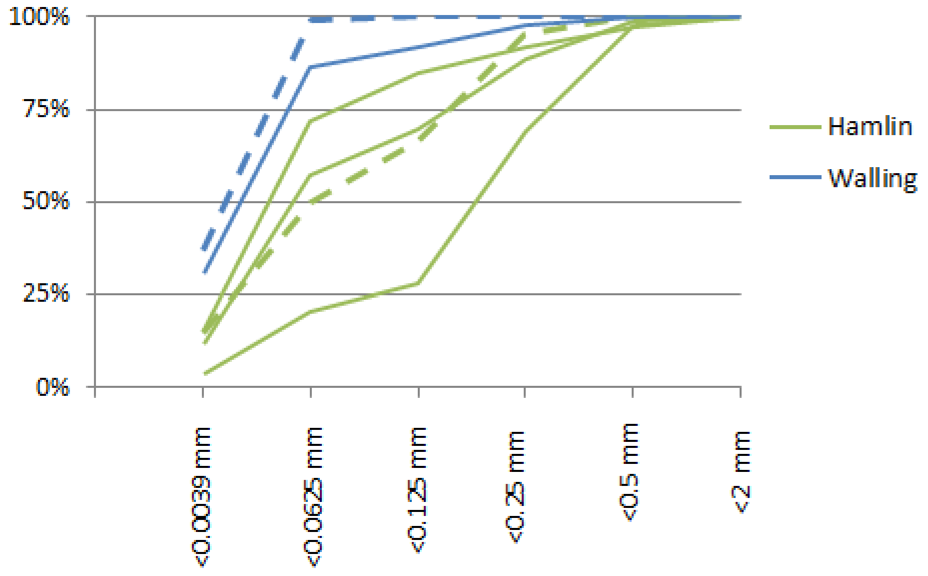

Figure 3. Cumulative grain size distribution in the Hamlin and Walling Tube samples. The dashed lined sample distributions were collected at the same site.

Figure 4 shows remote sampler particle ratio results for PCBs and Hg plotted versus particle ratios for composited stormwater samples. Both figures show a 1:1 line, which would occur if all the contaminant in composite water samples occurred in the sediment phase for those sites, and if the remote samplers collected contaminated sediments in equal proportions and grain sizes to those collected in the manual water composite method. For PCBs, the data generally show good correlation, i.e., higher remote sampler particle ratios occur for sites with higher particle ratios obtained from composite stormwater samples. The correlation for PCBs is significant ($p=1.74x10^{-5}$) at alpha=0.05. Most of the remote samples for PCBs had very comparable or slightly higher particle ratios than those obtained from the composited stormwater samples (Tables 8 and 9, and Figure 4A). These results are conceptually reasonable, though somewhat surprising. The remote samplers are affixed near the channel bed and therefore preferentially sample heavier and larger particles as compared to water-column integrated stormwater composite samples. A prior settling experiment using collected runoff (Yee and McKee, 2010) showed a majority of PCBs in a sediment phase settled out of a 30 cm water column within 20 minutes or less (in contrast to the results for HgT which showed generally lower settling rates). Therefore, conceptually it is reasonable that PCBs on sediment are settling out in the remote samplers at a rate efficient enough to accurately characterize the particle ratio for the site. The surprising aspect of these results is that by using the manual water composite particle ratio (total PCBs/SSC), the dissolved proportion is included in the ratio and therefore the particle ratio is biased high relative to the particulate concentration measured in the lab (mean bias=119%; Table 8). And yet, as compared to the remote samplers which include only particulates, the manual water composite particle ratios are still mostly lower (mean ratio of remote:manual water composites = 141%, Table 8). These preliminary interpretations are only initial hypotheses being used to help refine the sampling and analytical program. Care must be taken when interpreting general patterns with such a small number of samples.

In contrast, the results for Hg showed that most of the remote samples had lower particle ratios than those obtained from the composited stormwater samples (Table 10 and Figure 4B) and the overall correlation is poor, i.e., higher remote sampler particle ratios do not consistently occur for sites with higher particle ratios obtained from composite stormwater samples. That the remote sampler particle ratios are typically lower than the manual composites is conceptually in concordance with the findings in Yee and McKee, 2010, with Hg more in dissolved and slower settling fractions than PCBs. This is consistent with the data presented in Table 8 which indicates that on average 19% of the total Hg was in the dissolved form (range 10-38%). Thus, these composited stormwater samples would be expected to show higher particle ratios than from remote samplers, due to lower sediment content and thus a greater relative proportion of Hg in the dissolved phase or on fine particles biasing the calculated particle ratio higher. Although the Hg results for the Walling Tube samples may appear better correlated, this is merely coincidental; the Hamlin samples at the same sites performed almost as well as the Walling Tubes.

The differences in particle ratio for Hg were lowest for Victor Nelo PS Outfall (RPD 31%), which could plausibly be due in part to subsampling and analytical variation given the small difference. However, the particle ratios for Hg at other sites differed up to 5-fold (as noted previously, with the composited stormwater samples biased higher). This difference is not easily accounted for through sub-sampling or analytical variation, as both the composite sample (time paced with a limited number of sub-samples) and remote sampler methods collect time-integrated samples, which reduce the influence of momentary spikes in concentration. These larger differences, as noted before, with the Hg particle ratios from the remote samplers being lower than those in composites, might be a result of differences in the proportion of coarser sediment captured due to differences between the methods in their position within the water column.

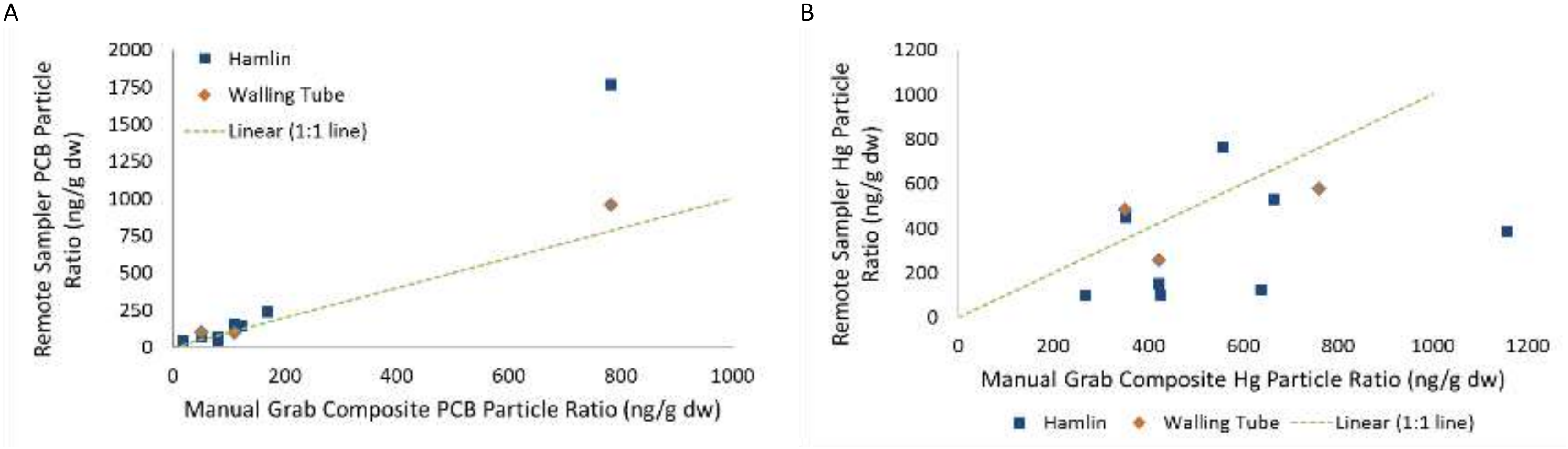

Figure 4. Particle Ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

Table 9. Summary statistics of the relative percent difference between remote and manual water composite samples for PCBs.

	N	Minimum	Maximum	Mean	Standard Deviation
Walling Tube	3	-13%	65%	24%	39%
Hamlin	8	-62%	84%	24%	47%
All	11	-62%	84%	24%	43%

Table 10. Summary statistics of the relative percent difference between remote and manual water composite samples for Hg.

	N	Minimum	Maximum	Mean	Standard Deviation
Walling Tube	3	-49%	32%	-15%	42%
Hamlin	8	-134%	31%	-66%	64%
All	11	-134%	32%	-52%	62%

When normalized to grain size, improvement was marginal and more promising for Hg than PCBs. Figure 5 shows the relationship between the manual water composites and the remote sample particle ratios, both when the ratios are not normalized and when the ratios are normalized to particles <0.25 mm and <0.125 mm. In particular, the Hg sample with the highest manual composite particle ratio, which had a correspondingly low remote sampler particle ratio (due to a high percentage of medium and coarse sands), benefited greatly by normalizing to particles <0.125 mm. On the other hand, the same sample for PCBs (also the highest manual composite particle ratio) correlated best when not normalized. Exploration into normalizing by grain size and TOC will continue in the next progress report with WY 2017 data (expected spring 2018).

The results obtained thus far show some promise as a qualitative site ranking tool especially for PCBs, but less so for Hg although additional data will be collected in WY 2017 to continue to assess this option. For PCBs, the samples with the highest particle ratios for composited stormwater samples were also the highest in the remote samplers while the sites with lower particle ratios for the composited stormwater sample also had lower concentrations in the remote sampler. The Hg results were more difficult to distinguish, with the remotely collected sample particle ratios differing from those of the composited stormwater samples by 1.3- to 5-fold.

These variable results indicate some challenges in interpretation of data collected by composite versus remote methods. The composited stormwater water samples conflate some dissolved load in the indicator (particle ratio) where concentrations based on whole water samples were normalized to suspended sediment. In addition, the composite water collection method likely either did not sample or at least under-sampled near-bed transport of sediment and pollutants. Although no samples were collected for different events at any site, the differences among sites for the composited and remote particle ratios suggest the potential for large differences among events even within a site, depending on storm event and site characteristics. These differences also present some challenges in applications beyond ranking and prioritization. Partly due to a small data set so far, there was no consistent direction of bias between the manual stormwater composite and remote methods, and even within PCBs (the more consistent analyte), for the Hamlin sampler, the particle ratio ranged from 27% to 190% of the composite sample result. The ability to find differences among sites or within a site with less than a two-fold difference would therefore seem unlikely at this point. This would be in addition to the between site differences caused by sampling non-representative storms that are present in the water composite methodology as well; there is always going to be more certainty than the sample for water composites which better represents transport through the majority of a sample site cross section. The other challenge with samples gathered using the remote samplers is that the data cannot be used to estimate loads without corresponding sediment load estimates. Since sediment loads are not readily available for individual watersheds and, after failures to calibrate the RWSM for suspended sediments, or for PCB and HgT using a sediment model as the basis (McKee et al., 2014), the RWSM is now being calibrated with some success using flow and water-based stormwater concentrations (Wu et al., 2016). Although perhaps cheaper to deploy or logistically possible to deploy in situations where staffing a site is not possible due to logistical constraints, the data derived from the sediment remote samplers are overall less versatile and more challenging to interpret.

With these concerns raised, the sampling program for WY 2017 will continue to build out the dataset for comparing samples derived from composite and remote suspended sediment sampling methods. Based on a full set of a further five planned sample pairs focusing on testing the Walling Tube, better confidence may be obtained about how to characterize the range of differences and biases among the methods, as well as to identify some causes of these artifacts, either generally or specific to certain site (land use) or/and event characteristics (storm intensity, duration, sample grain size, organic carbon). In the event that after the pilot study is completed and a total of eight samples have been collected for each sampler, and data still does not show reasonable comparability or explainable differences between the stormwater composite and suspended sediment remote sampler methods, future efforts to further improve these methods might need to consider additional factors such as inter-storm variation, site cross-sectional variation, and relative contributions of near-bed load to total pollutant discharge.

In summary, the data obtained to date from remote samplers show some promise as a relative ranking or prioritization tool; if the data from additional planned sample pairs continue to show similar relationships to stormwater composite samples, future monitoring strategies could be envisioned, first using remote samplers as a low-cost screening and ranking tool, to be followed up by site occupation and active water sampling for the highest priority locations.

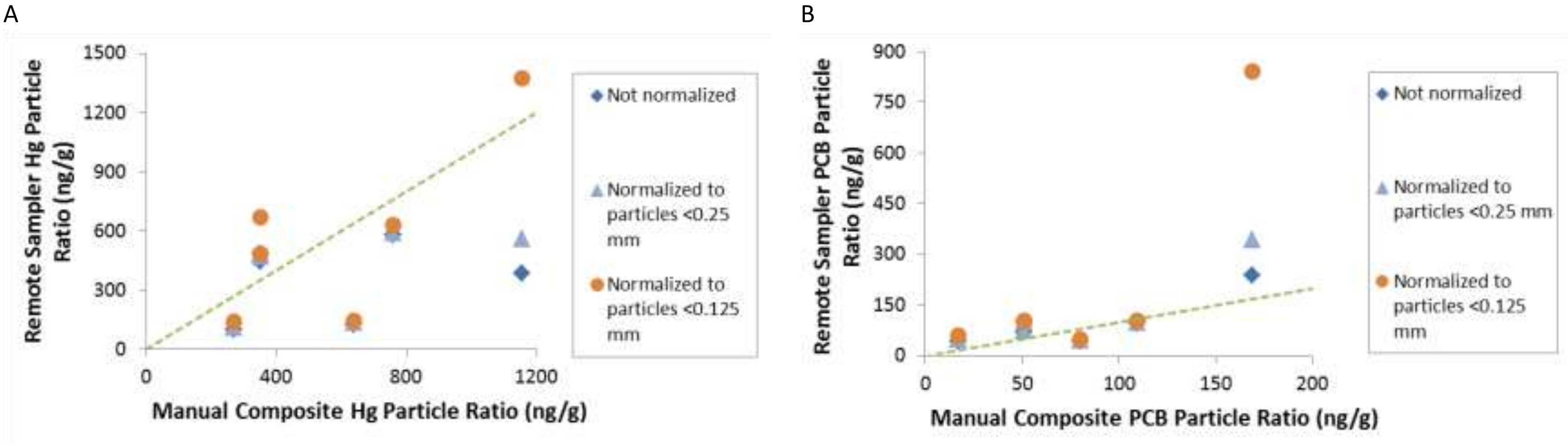

Figure 5. Grain size normalized particle ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

What are the 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 eight locations, in which the Hamlin sampler was tested at all eight and the Walling Tube sampler was tested at only three. During the winter of WY 2017 we intend to focus remote sampling using the Walling Tube and a more comprehensive analysis of effectiveness and cost versus benefit of this method will be completed after that sampling effort is completed. An early-phase comparison is presented in Table 11a and 11b below. Generally speaking, it is anticipated that non-manual sampling methods will be more cost-effective. Conceptually, this method would allow multiple sites to be monitored during a single storm event where devices are deployed prior to the storm and retrieved after the storm. There would be initial capital 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 or tidal influences) that complicate the use of the remote settling devices and cause the need for manual monitoring at a particular site. As mentioned above, the data derived from the remote sampling methodologies may be less straightforward to interpret (relative to previously collected water grab or composite samples) and overall would have somewhat less versatility or greater complications for other uses outside ranking sites for relative pollution, for example loadings estimates. But used as a companion to manual monitoring methods, costs would most likely be reduced and data suitable for other purposes would continue to be collected. Factoring in the more limited data uses in the cost-effectiveness analysis will be challenging.

Table 11a. Preliminary comparison of the pros and cons of the remote sampling method as compared to the manual sampling method for the characterization 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 11b 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,, though we are beginning to think of solutions to this challenge.
Data Quality	Unknown	Comparison between the remote sampler and manual sampling results are being assessed in this study. If remote samplers can be used consistently over multiple storm

		events, it is reasonable to say 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 collects data for a single storm composite which is then used for characterization purposes. Although not a high quality estimate, 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).
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 avoid making 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).

Table 11b. Detailed preliminary labor and cost comparison between the remote sampling method as compared to the manual composite sampling method for the characterization 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

The PCB and HgT load allocations of 2 and 80 kg respectively translate to a mean concentration of 1.33 ng/L (PCBs) and 53 ng/L (HgT) (assuming an annual average flow from small tributaries of 1.5 km^3 (Lent et al., 2012)) and mean annual particle ratio of 1.4 ng/g (PCBs) and 0.058 µg/g (HgT) (assuming 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 two sampling locations observed to date (Gellert Park bioretention influent stormwater and the storm drain at the corner of Duane Ct. and Triangle Ave.) have a composite averaged PCB concentration of < 1.33 ng/L (Table 12) and none out of 62 sampling locations have composite averaged PCB particle ratios <1.4 ng/g (Table 12; Figure 6 and 7). The lowest observed PCB particle ratio to date remains Marsh Creek (2.9 ng/g).

Although there are always challenges associated with interpreting data in relation to highly variable climate including antecedent conditions, storm specific rainfall intensity, and watershed specific source-release-transport processes, the objective here is to provide evidence to help differentiate watersheds that might be disproportionately elevated in PCB or Hg concentrations or particle ratios from those with lower pollutant signatures. Given the nature of the reconnaissance sampling design, the absolute rank is much less certain but it is unlikely that the highest rank locations would drop in ranking very much if more sampling was conducted. With these caveats in mind, the relative ranking was generated for PCBs and Hg based on both water concentrations and particle ratios for all the available data most of which was collected during WYs 2011 (a slightly wetter than average year), WY 2015 (a slightly drier than average year), and WY 2016 (about average).

Based on water composite concentrations for all available data, the ten most polluted sites for PCBs appear to be (in order from higher to lower): Pulgas Pump Station-South, Santa Fe Channel, Industrial Rd Ditch, Sunnyvale East Channel, Outfall at Gilman St., Pulgas Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain, Outfall to Lower Silver Creek, and Line 4-E (Figure 7). The locations span a range in land use from 3-79% old industrial illustrating some of the challenges in using land use alone as a tool for locating areas of high leverage. Using PCB particle ratios, the ten most polluted sites appear to be: Pulgas Pump Station-South, Industrial Rd Ditch, Santa Fe Channel, Pulgas Pump Station-North, Gull Dr SD, Outfall at Gilman St., Outfall to Lower Silver Creek, Ettie Street Pump Station, Ridder Park Dr Storm Drain and Sunnyvale East Channel. Nine of these locations were similarly selected based on water concentrations and particle ratios but one of the sites with elevated water concentrations (Line 4-E) dropped to lower rank for particle ratios due to high sediment production and one alternative site (Gull Dr SD) was ranked in the top ten based on the relative nature of PCB mass in the water and lower suspended sediment mass. In addition to identification of three new top-10 ranked PCB particle ratio sites, the WY 2015 and 2016 stormwater sampling efforts also identified a large number of sites with moderate particle ratios (Figure 7). This additional large cohort of sites with moderately elevated particle ratios was likely a result of the site selection process that targeted watershed areas with greater imperviousness and older industrial influences. This has also led to an improving relationship over time between PCB concentrations and PCB particle ratio (due to generally less variation in SSC between urban sites relative to sites representing larger watersheds with mixed land use).

Table 12. PCB and HgT concentrations and particle ratios observed in the Bay area based on all data collected in stormwater since WY 2003 that focused on urban sources (62 sites in total for PCBs and HgT). This dataset was sorted high to low based on PCBs particle ratio to provide preliminary information on potential leverage.

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		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	447984	1	0.35	31.5	19	46
Industrial Rd Ditch	San Mateo	2016	0.23	85%	79%	6139	2	159606	3	0.53	22	14	52
Santa Fe Channel	Contra Costa	2011	3.3	69%	3%	1295	3	197923	2	0.57	17.5	86	10.5
Pulgas Pump Station-North	San Mateo	2011	0.55	84%	52%	893	4	60320	6	0.4	28	24	43.5
Gull Dr SD	San Mateo	2016	0.30	78%	54%	859	5	8592	34	0.56	19	6	59
Outfall at Gilman St.	Alameda	2016	0.84	76%	32%	794	6	65670	5	5.31	1	439	4
Outfall to Lower Silver Creek	Santa Clara	2015	0.17	79%	78%	783	7	44643	9	0.42	27	24	43.5
Ettie Street Pump Station	Alameda	2011	4.0	75%	22%	759	8	58951	7	0.69	13	55	22.5
Ridder Park Dr Storm Drain	Santa Clara	2015	0.50	72%	57%	488	9	55503	8	0.33	35	37	35
Sunnyvale East Channel	Santa Clara	2011	15	59%	4%	343	10	96572	4	0.2	49	50	26
Line-3A-M at 3A-D	Alameda	2015	0.88	73%	12%	337	11	24791	14	1.17	5	86	10.5
North Richmond Pump	Contra	2011-	2.0	62%	18%	241	12	13226	23	0.81	10	47	27.5

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Station	Costa	2014											
Seabord Ave Storm Drain SC-050GAC580	Santa Clara	2015	1.4	81%	68%	236	13	19915	17	0.55	21	47	27.5
Line4-E	Alameda	2015	2.0	81%	27%	219	14	37350	10	0.35	31.5	59	19
Glen Echo Creek	Alameda	2011	5.5	39%	0%	191	15	31078	12	0.21	48	73	15
Seabord Ave Storm Drain SC-050GAC600	Santa Clara	2015	2.8	62%	18%	186	16	13472	22	0.53	23	38	33.5
South Linden Pump Station	San Mateo	2015	0.14	83%	22%	182	17	7814	37	0.68	14	29	40
Gull Dr Outfall	San Mateo	2016	0.43	75%	42%	174	18	5758	41	0.32	37	10	57
Taylor Way SD	San Mateo	2016	0.27	67%	11%	169	19	4227	46	1.16	6	29	41
Line 9-D	Alameda	2015	3.6	78%	46%	153	20	10451	27	0.24	43.5	17	47.5
Meeker Slough	Contra Costa	2015	7.3	64%	6%	142	21	8560	35	1.27	4	76	14
Rock Springs Dr Storm Drain	Santa Clara	2015	0.83	80%	10%	128	22	5252	42	0.93	8	38	33.5
Charcot Ave Storm Drain	Santa Clara	2015	1.8	79%	24%	123	23	14927	20	0.56	20	67	17
Veterans Pump Station	San Mateo	2015	0.52	67%	7%	121	24	3520	48	0.47	24	14	51
Gateway Ave Storm Drain	San Mateo	2015	0.36	69%	52%	117	25	5244	43	0.44	25	20	45

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Guadalupe River at Hwy 101	Santa Clara	2003-2006, 2010, 2012-2014	233	39%	3%	115	26	23736	15	3.6	3	603	1
Line 9-D-1 PS at outfall to Line 9-D	Alameda	2016	0.48	88%	62%	110	27	18086	19	0.72	12	118	6.5
Tunnel Ave Ditch	San Mateo	2016	3.0	47%	8%	109	28	10491	26	0.76	11	73	16
Valley Dr SD	San Mateo	2016	5.2	21%	7%	109	29	10442	28	0.28	41	27	42
Runnymede Ditch	San Mateo	2015	2.1	53%	2%	108	30	28549	13	0.19	51	52	25
E. Gish Rd Storm Drain	Santa Clara	2015	0.45	84%	70%	99	31	14365	21	0.59	16	85	12
Line 3A-M-1 at Industrial Pump Station	Alameda	2015	3.4	78%	26%	96	32	8923	30	0.34	33	31	38
Line 13-A at end of slough	Alameda	2016	0.83	84%	68%	96	33	34256	11	0.33	34	118	6.5
Zone 4 Line A	Alameda	2007-2010	4.2	68%	12%	82	34	18442	18	0.17	53	30	39
Forbes Blvd Outfall	San Mateo	2016	0.40	79%	0%	80	35	1840	54	0.64	15	15	50
Storm Drain near Cooley Landing	San Mateo	2015	0.11	73%	39%	79	36	6473	39	0.43	26	35	36
Lawrence & Central Expwys SD	Santa Clara	2016	1.2	66%	1%	78	37	4506	45	0.23	45	13	53.5

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Condensa St SD	Santa Clara	2016	0.24	70%	32%	74	38	2602	52	0.33	36	12	56
San Leandro Creek	Alameda	2011-2014	8.9	38%	0%	66	39	8614	33	0.86	9	117	8
Oddstad Pump Station	San Mateo	2015	0.28	74%	11%	62	40	9204	29	0.37	29	55	22.5
Line 4-B-1	Alameda	2015	0.96	85%	28%	57	41	8674	32	0.28	39.5	43	30
Zone 12 Line A under Temescal Ck Park	Alameda	2016	17	30%	4%	54	42	7804	38	0.29	38	42	31
Victor Nelo PS Outfall	Santa Clara	2016	0.58	87%	4%	51	43	2289	53	0.35	30	16	49
Haig St SD	Santa Clara	2016	2.12	72%	10%	43	44	1454	56	0.19	50	7	58
Lower Coyote Creek	Santa Clara	2005	327	22%	1%	30	45	4576	44	0.24	43.5	34	37
Calabazas Creek	Santa Clara	2011	50.1	44%	3%	29	46	11493	25	0.15	56	59	19
E Outfall to San Tomas at Scott Blvd	Santa Clara	2016	0.67	66%	31%	27	47	2799	51	0.13	57	13	53.5
San Lorenzo Creek	Alameda	2011	125	13%	0%	25	48	12870	24	0.18	52	41	32
Stevens Creek	Santa Clara	2011	26	38%	1%	23	49	8160	36	0.22	46.5	77	13
Guadalupe River at Foxworthy Road/ Almaden Expressway	Santa Clara	2010	107	22%	0%	19	50	3120	49	4.09	2	529	2
Duane Ct and Ave Triangle SD	Santa Clara	2016	1.0	79%	23%	17	51	832	58	0.27	42	13	55

Watershed/ Catchment	County	Water Year sampled	Area (km2)	Impervious cover (%)	Old Industrial land use (%)	Polychlorinated biphenyls (PCBs)				Total Mercury (HgT)			
						Particle Ratio		Composite /mean water concentration		Particle Ratio		Composite /mean water concentration	
						(ng/g)	Rank	(pg/L)	Rank	(µg/g)	Rank	(ng/L)	Rank
Lower Penitencia Creek	Santa Clara	2011, 2015	12	65%	2%	16	52	1588	55	0.16	54.5	17	47.5
Borel Creek	San Mateo	2011	3.2	31%	0%	15	53	6129	40	0.16	54.5	58	21
San Tomas Creek	Santa Clara	2011	108	33%	0%	14	54	2825	50	0.28	39.5	59	19
Zone 5 Line M	Alameda	2011	8.1	34%	5%	13	55.5	21120	16	0.57	17.5	505	3
Belmont Creek	San Mateo	2011	7.2	27%	0%	13	55.5	3599	47	0.22	46.5	53	24
Walnut Creek	Contra Costa	2011	232	15%	0%	7	57	8830	31	0.07	59	94	9
Lower Marsh Creek	Contra Costa	2011-2014	84	10%	0%	3	58	1445	57	0.11	58	44	29
San Pedro Storm Drain	Santa Clara	2006	1.3	72%	16%	No data				1.12	5	160	4
El Cerrito Bioretention Influent	Contra Costa	2011	0.004	74%	0%	442	NR[a]	37690	NR[a]	0.19	NR[a]	16	NR[a]
Fremont Osgood Road Bioretention Influent	Alameda	2012, 2013	0.0008	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	0.015	40%	0%	36	NR[a]	725	NR[a]	1.01	NR[a]	22	NR[a]

[a] NR = site not included in ranking. These are very small catchments with unique sampling designs for evaluation of green infrastructure.

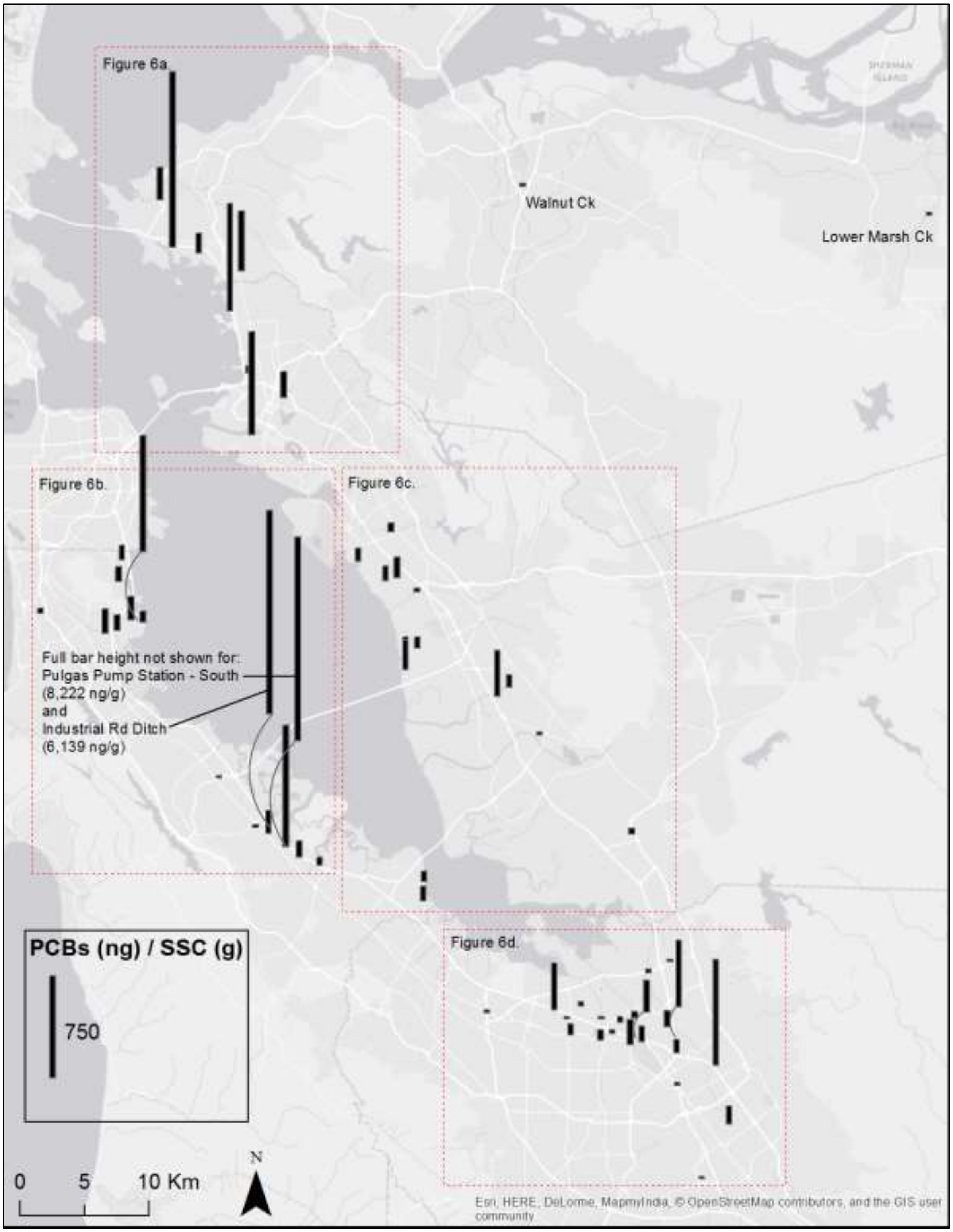

Figure 6. Regional distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date.

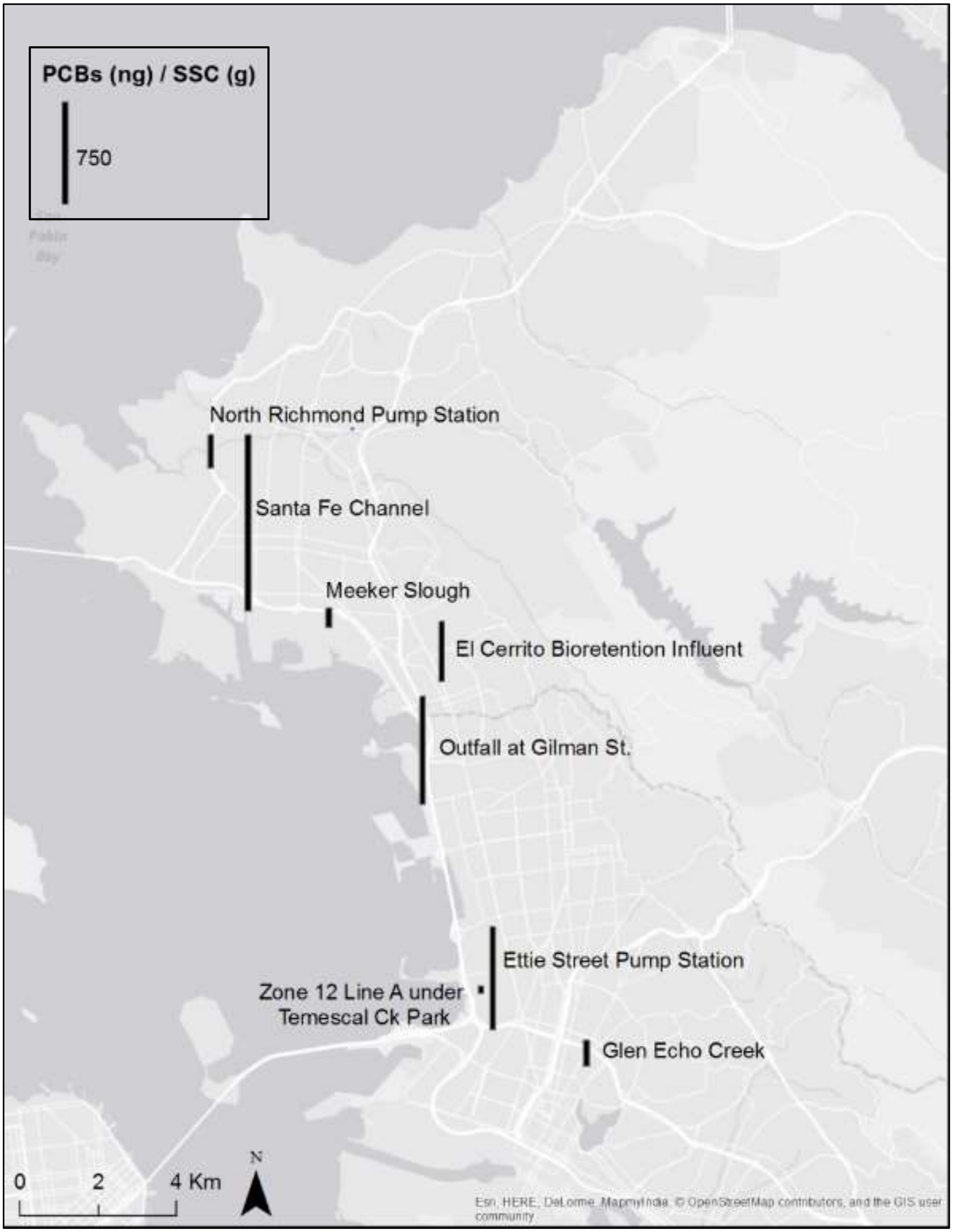

Figure 6a. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in northern Alameda and Contra Costa counties.

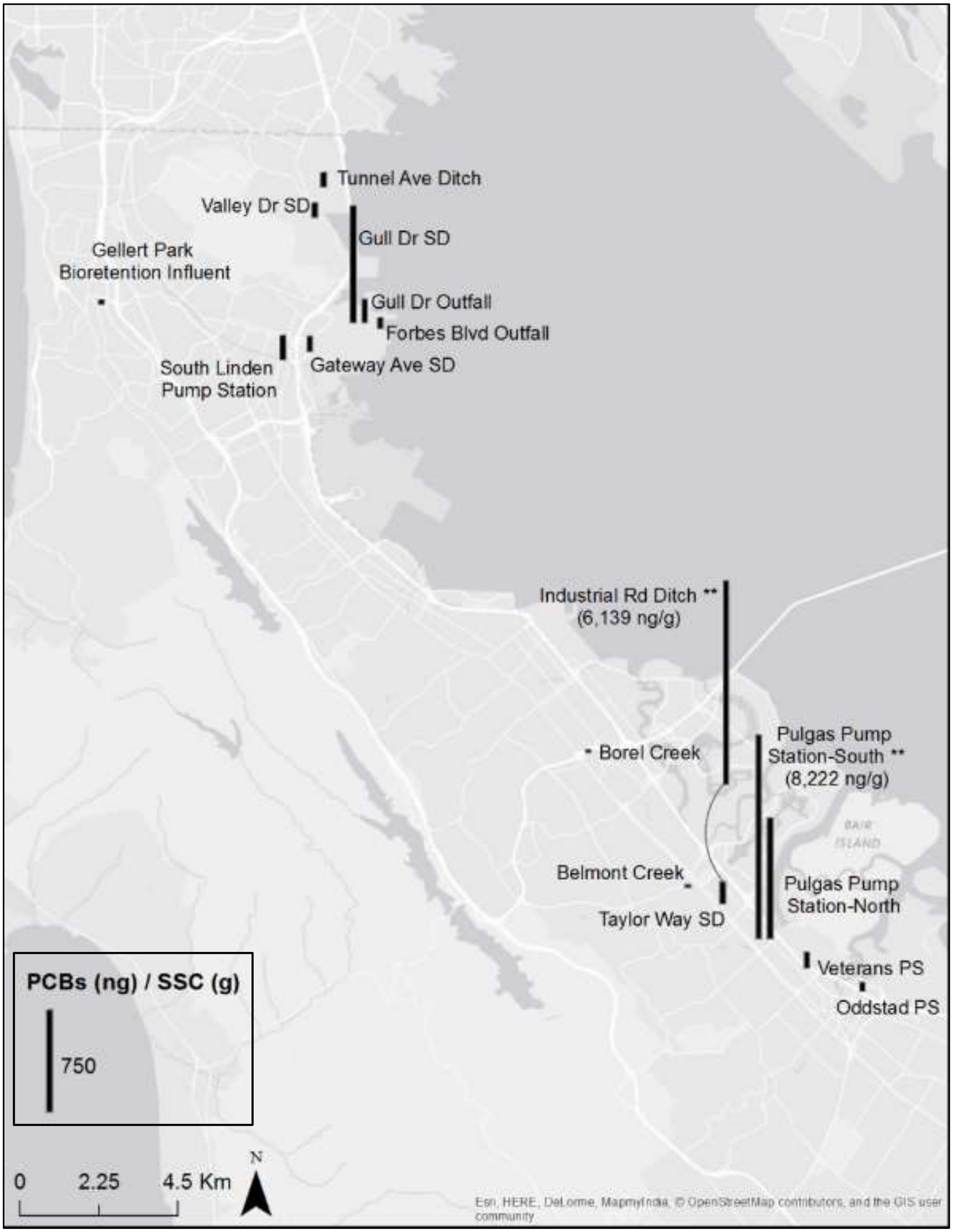

Figure 6b. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in central and northern San Mateo County.

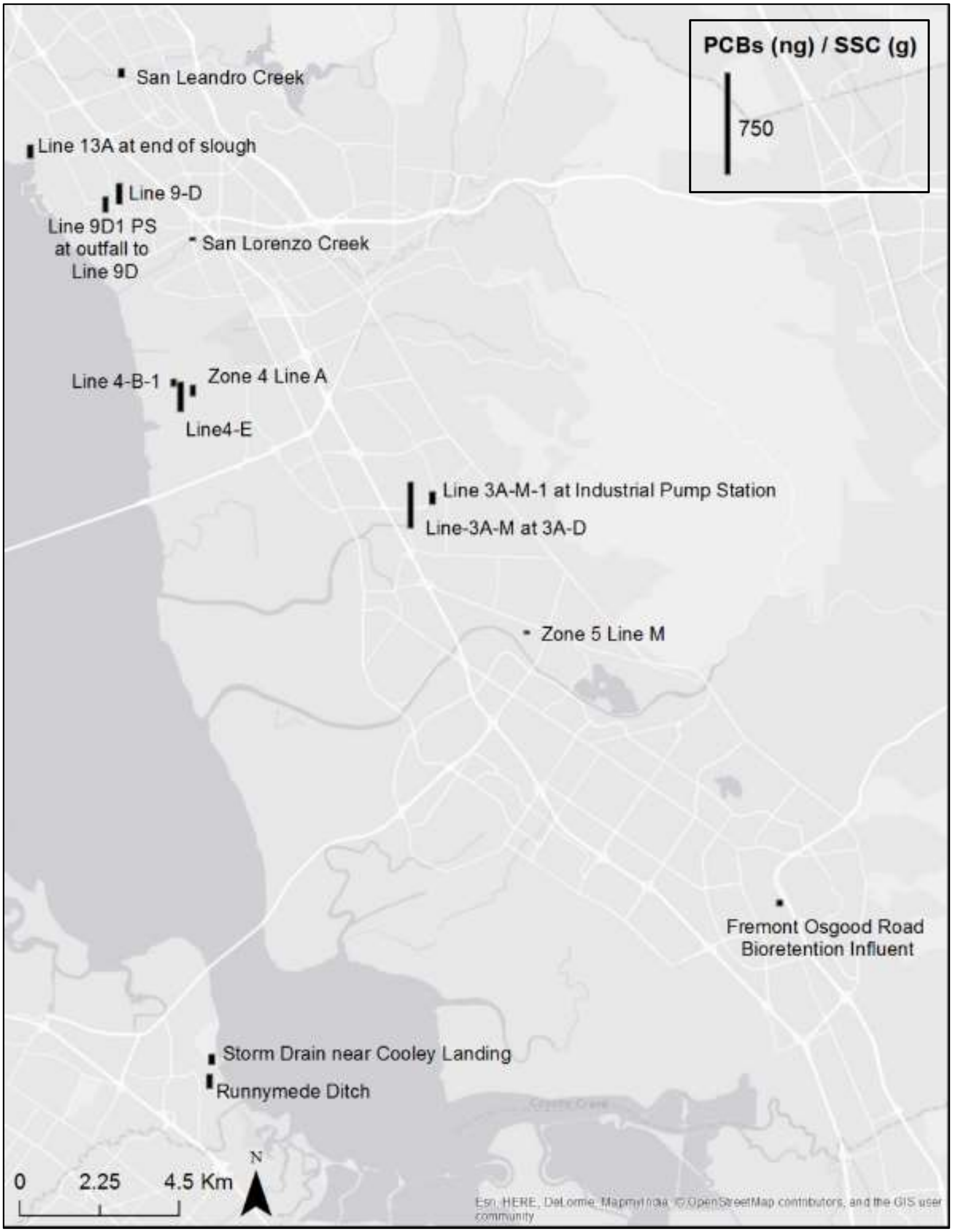

Figure 6c. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in southern Alameda and San Mateo counties.

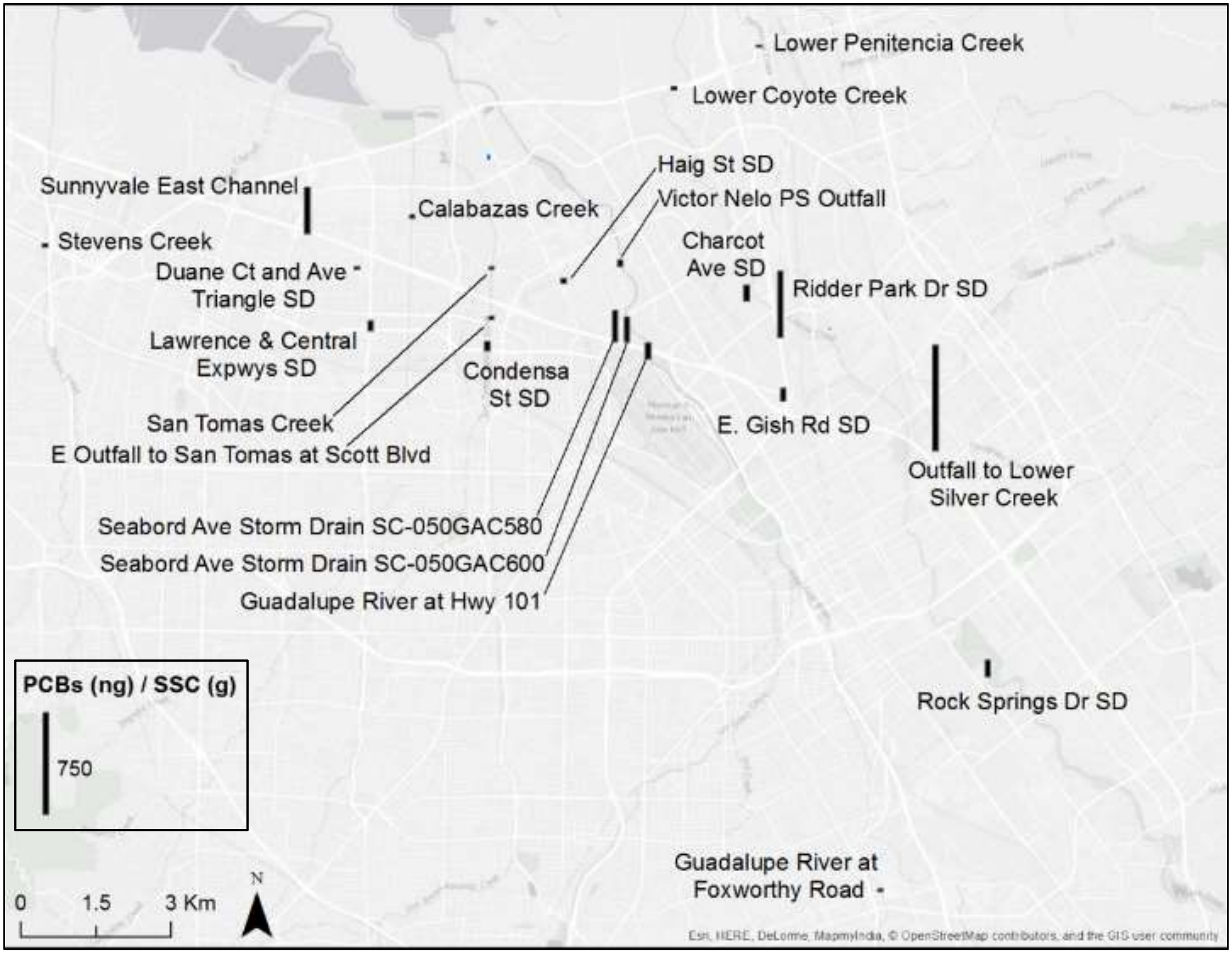

Figure 6d. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in Santa Clara County.

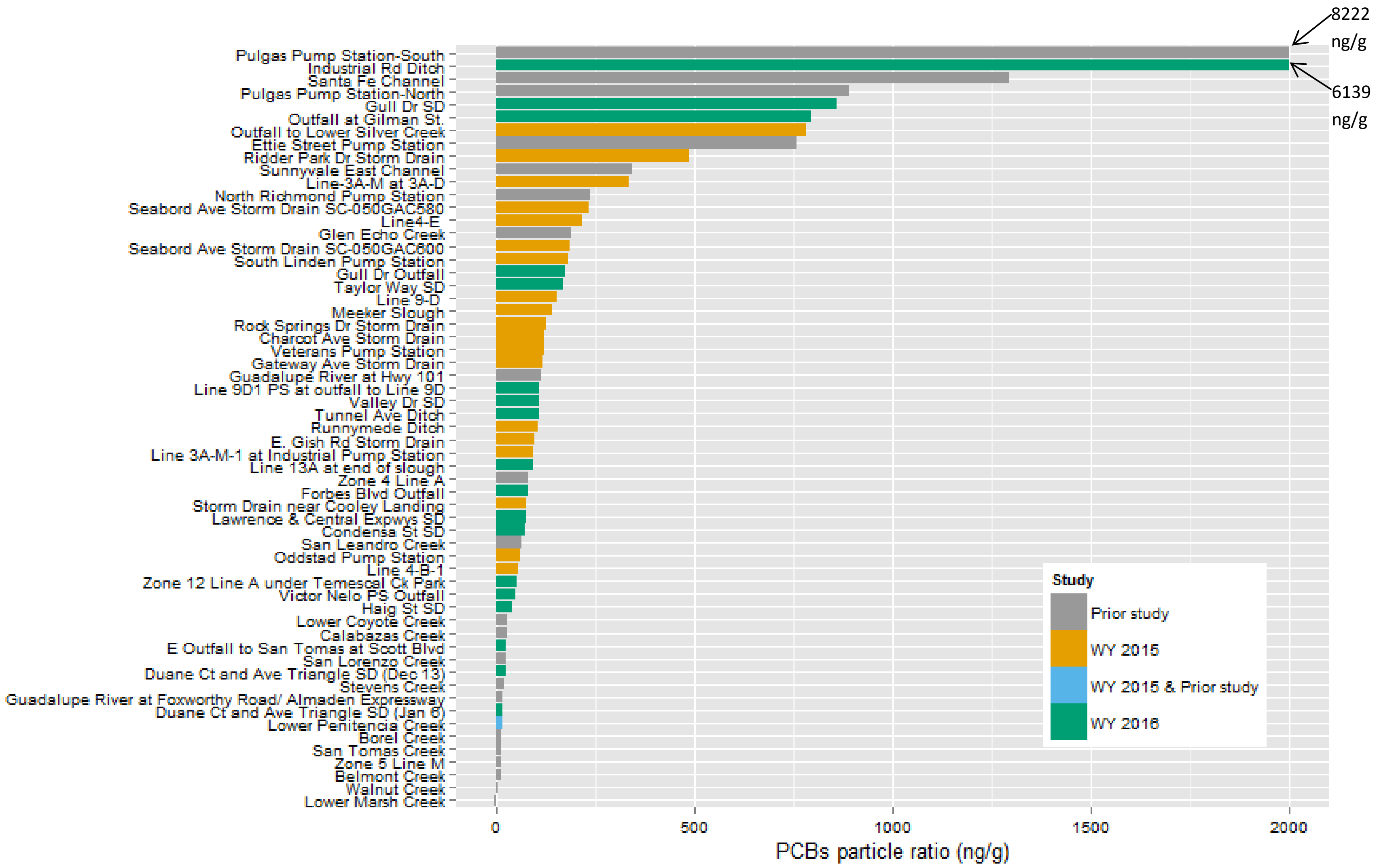

Figure 7. All watershed sampling locations measured to date ranked using PCB particle ratios. Note Pulgas Pump Station-South is beyond the extent of this graph at 8,222 ng/g as well as Industrial Road Ditch at 6139 ng/g.

To a large degree, sites that rank high for PCB water concentrations also rank high for particle ratios (Figure 8) however, comparisons between the ranking methodologies provide a hint as to the main vector for transport at each of the sites (contaminated soil erosion versus emulsion of liquid PCBs). For example, a high ranking for water concentration but low ranking for particle ratio can indicate high rates of erosion of relatively clean sediment, which is more typical of larger and less pervious watersheds. On the other hand, a high ranking for water concentrations and high ranking for particle ratio can indicate that sediment is not the dominant vector for transport and that PCB emulsions are possibly in transport, which is likely to be more typical of smaller and more impervious watersheds with a greater proportion of source areas. Conversely, a lower rank for concentration coupled with a higher ranking for particle ratio could possibly indicate erosion of highly contaminated particles. If this occurs in a smaller watershed, this would indicate sediment transport is the main vector. These hints can be instructive for helping to consider main source areas and release processes.

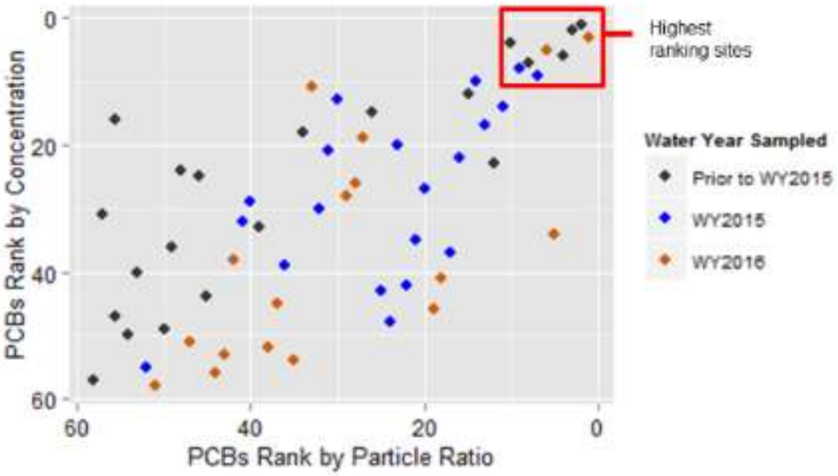

Figure 8. Correlation between site rankings for PCBs based on particle ratios versus water concentrations. 1 = highest rank; 58 = lowest rank.

There are a number of watersheds that appear to show relatively low Hg concentrations. In contrast to PCBs, 38 out of 62 sampling locations have composite averaged HgT water concentrations less than 53 ng/L (Table 12), the regionally averaged concentration derived from the TMDL target. These lower ranking sites based on water concentrations ranged in impervious cover between 10-87% with a median of 72%. However, none of the locations sampled to date have composite averaged HgT particle ratios <0.058 µg/g (the regionally averaged particle ratio based on the TMDL target combined with estimated average annual regional total suspended sediment loads[12]); the lowest observation so far has been Walnut Creek at 0.07 µg/g (0.07 mg/kg) (Table 12; Figure 9; Figure 10). But 17 sites measured to date (Walnut Creek, Lower Marsh Creek, E Outfall to San Tomas at Scott Blvd, Calabazas Creek, Lower Penitencia Creek, Borel Creek, Zone 4 Line A, San Lorenzo Creek, Runnymede Ditch, Haig St SD, Sunnyvale East Channel, Glen Echo Creek, Stevens Creek, Belmont Creek, Lawrence & Central Expressways SD, Lower Coyote Creek, and Line 9-D) do have particle ratios <0.25 µg/g that, given a reasonable expectation of error bars of 25% around our 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).

There have been several studies in the Bay Area on atmospheric deposition rates for HgT (Tsai and Hoenicke, 2001; Steding and Flegal, 2002). These studies measured 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) with Tsai and Hoenicke reporting a total (wet + dry) deposition rate of 18-21 $\mu g/m^2/y$. Tsai and Hoenicke observed volume-weighted average mercury concentrations in precipitation based on 59 samples collected across the Bay Area of 8.0 ng/L. They reported that wet deposition comprised 18% of total annual deposition; thus scaled to volume of runoff, an equivalent stormwater concentration of 44 ng/L can be derived. If a runoff coefficient (the proportion of rainfall that manifests as runoff) equivalent to the impervious cover of a watershed is assumed, it can be hypothesized that all of the runoff from the sites exhibiting composite averaged concentration of <53 ng/L could be accounted for by atmospheric deposition alone; indeed a high proportion of the runoff from any watershed exhibiting concentrations in stormwater of, for example, < 100 ng/L could also be atmospherically derived. This is not to say that there are no other sources in these watersheds, but rather that loads from any other sources are diluted out by cleaner runoff sustained by relatively low but relatively constant atmospheric deposition rates. Thus, a number of watersheds have been sampled for Hg that show relatively low concentrations and will likely continue to do so in alignment with atmospheric deposition. Given the data set now amassed, it is likely that many future sampling locations would show similar outcomes. However, this may not be the case for methylmercury, where in situ production in anoxic saturated zones may provide additional input not directly correlating to atmospheric loads.

On the other end of the spectrum, there are some watersheds that display elevated HgT concentrations that, if the sources could be found and treated, would help to reduce HgT loads entering the Bay (Table 12). Based on composite averaged HgT water concentrations, the 10 most polluted sites (ranked in order from high to lower) would include the Guadalupe River at Hwy 101, Guadalupe River at Foxworthy Road/ Almaden Expressway, Zone 5 Line M, Outfall at Gilman St., San Pedro Storm Drain, Line 13-A at end of slough, Line 9-D-1 PS at outfall to Line 9-D, San Leandro Creek, Walnut Creek, and Santa Fe Channel (Figure 10). Just two of these (Santa Fe Channel and the Outfall at Gilman St.) are also ranked in the top 10 for PCB concentrations in water, while 10 watersheds rank in the top 20 for both pollutants.

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[12] Again the reader is reminded that these regional estimates total suspended sediment loads are subject to change if future interpretations are completed.

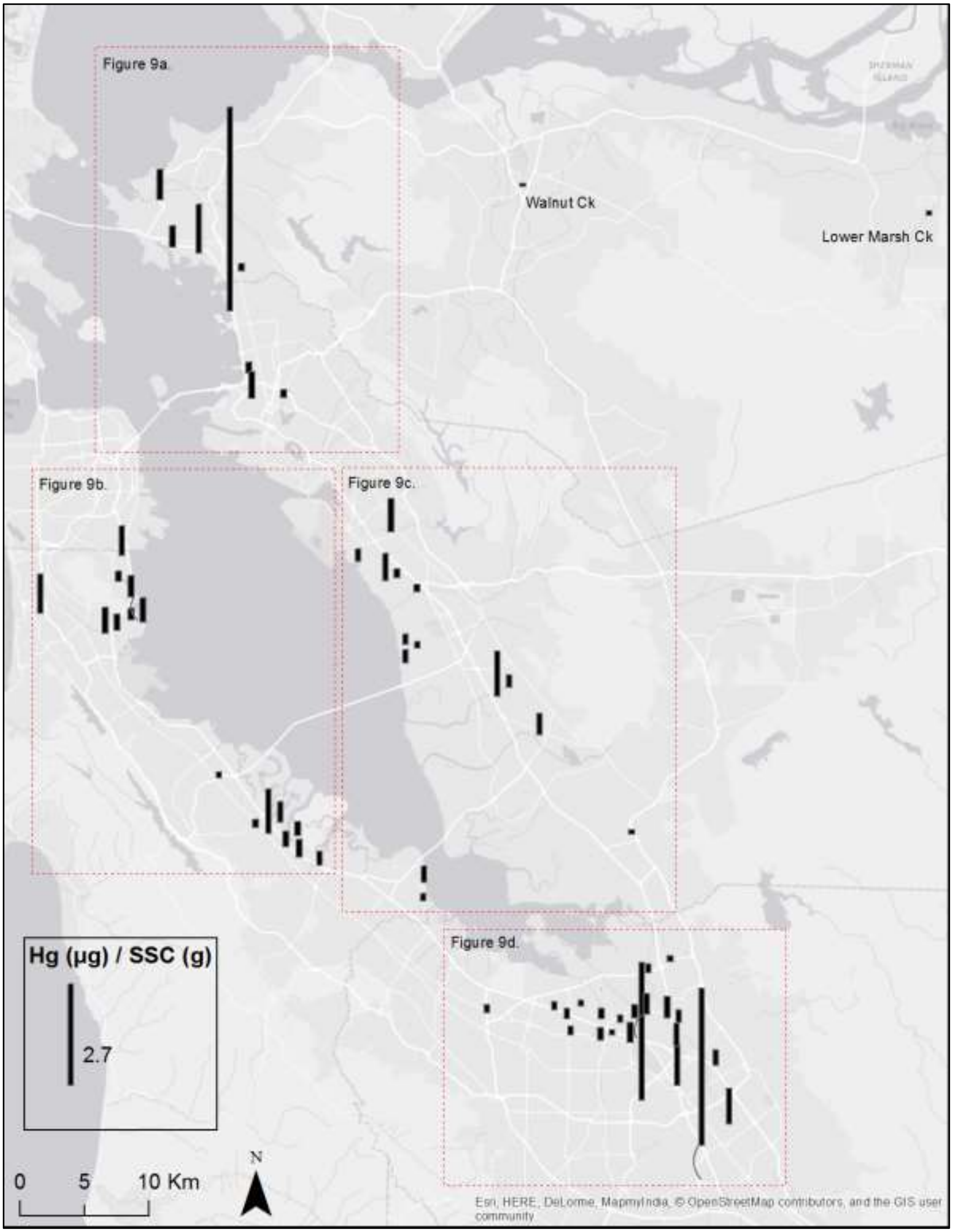

Figure 9. Regional distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date.

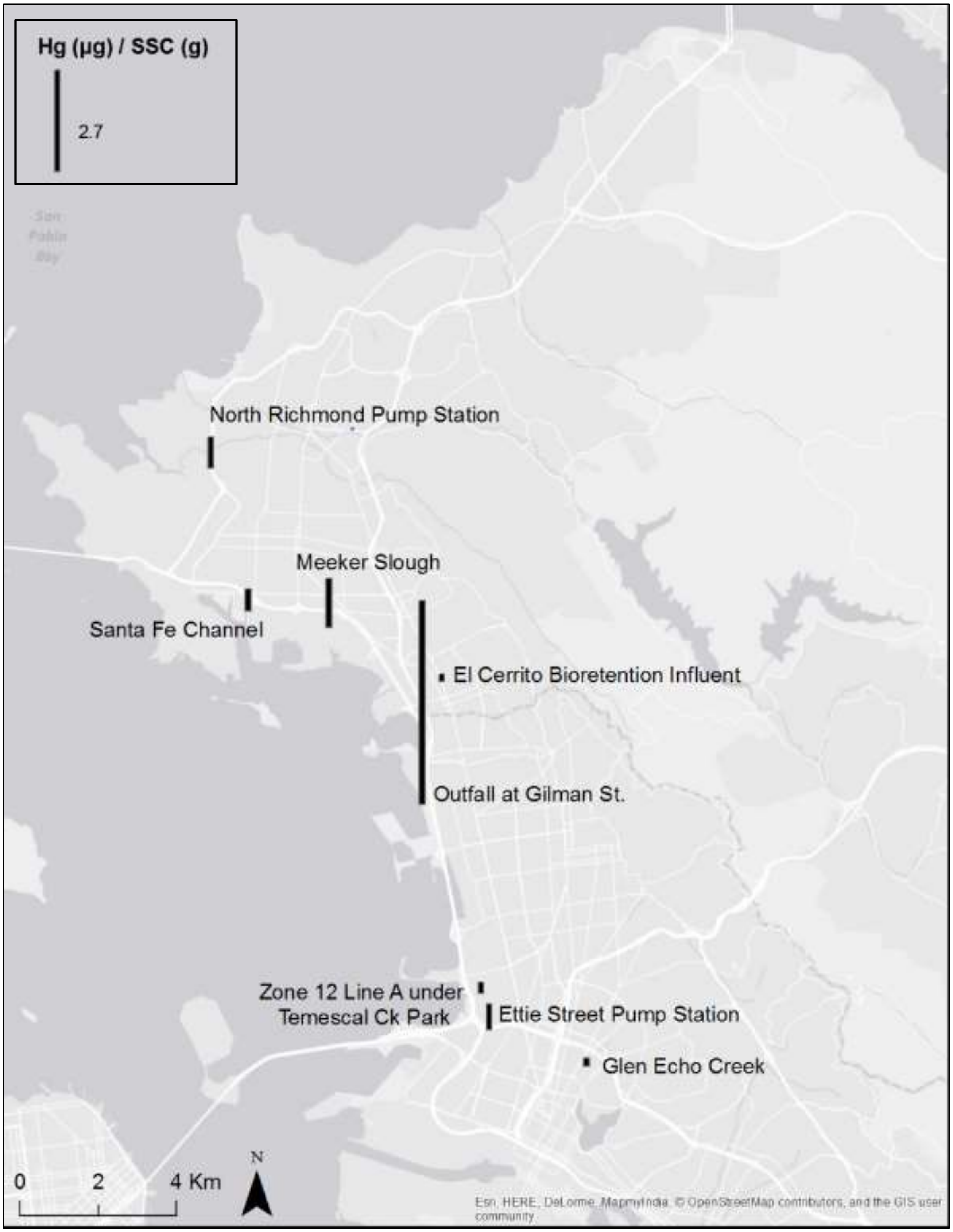

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Figure 9a. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in northern Alameda and Contra Costa counties.

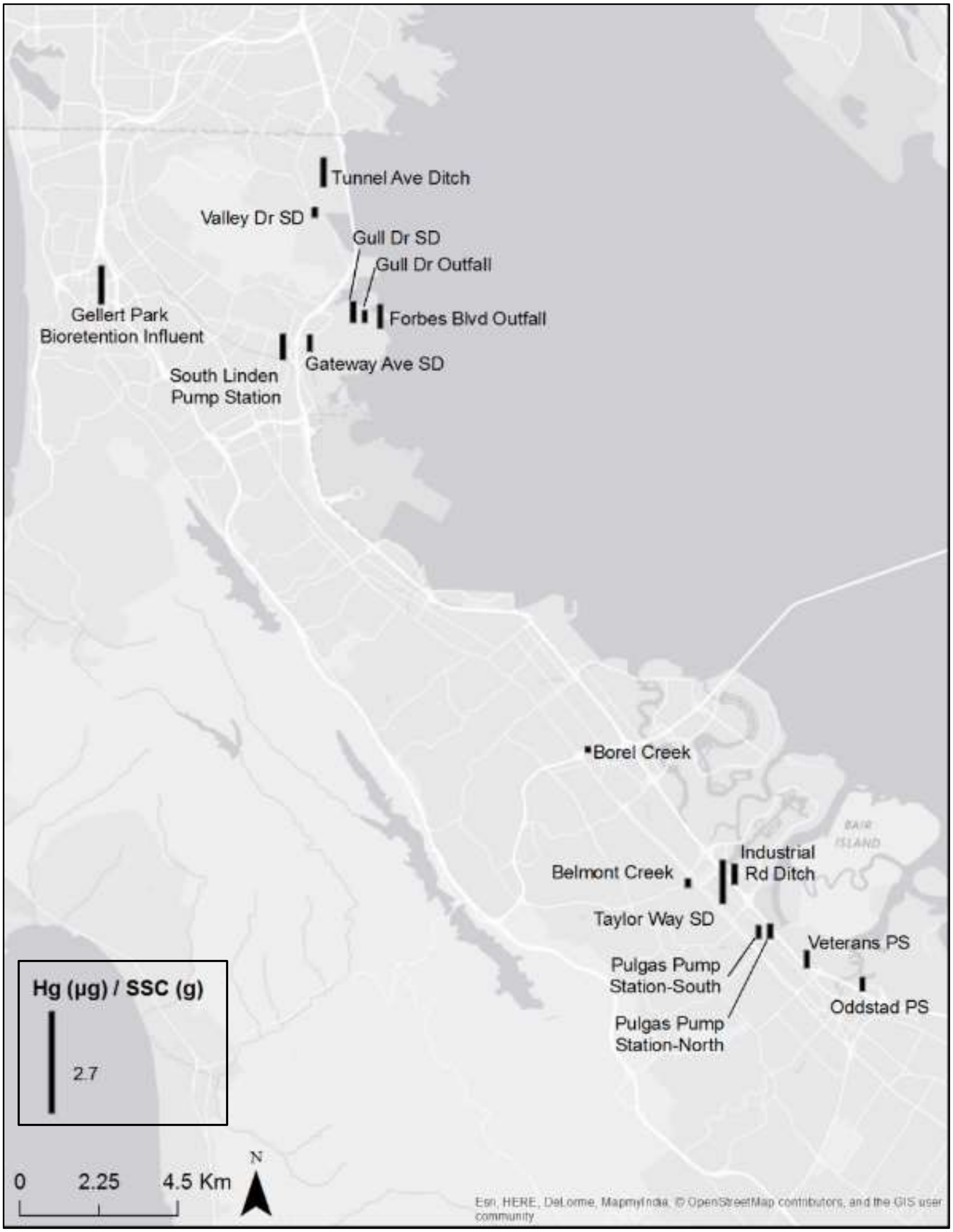

Figure 9b. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in central and northern San Mateo County.

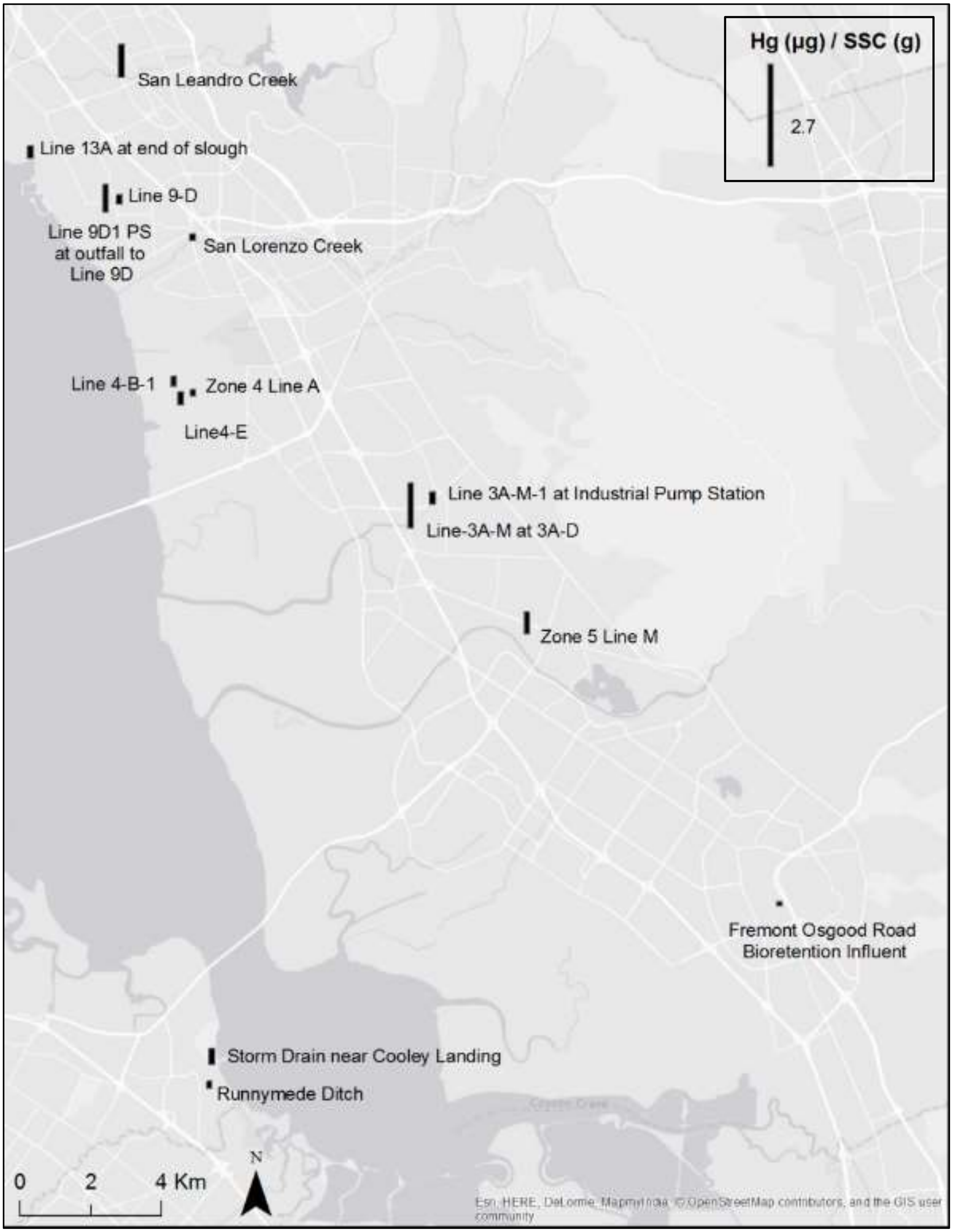

Figure 9c. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in southern Alameda and San Mateo counties.

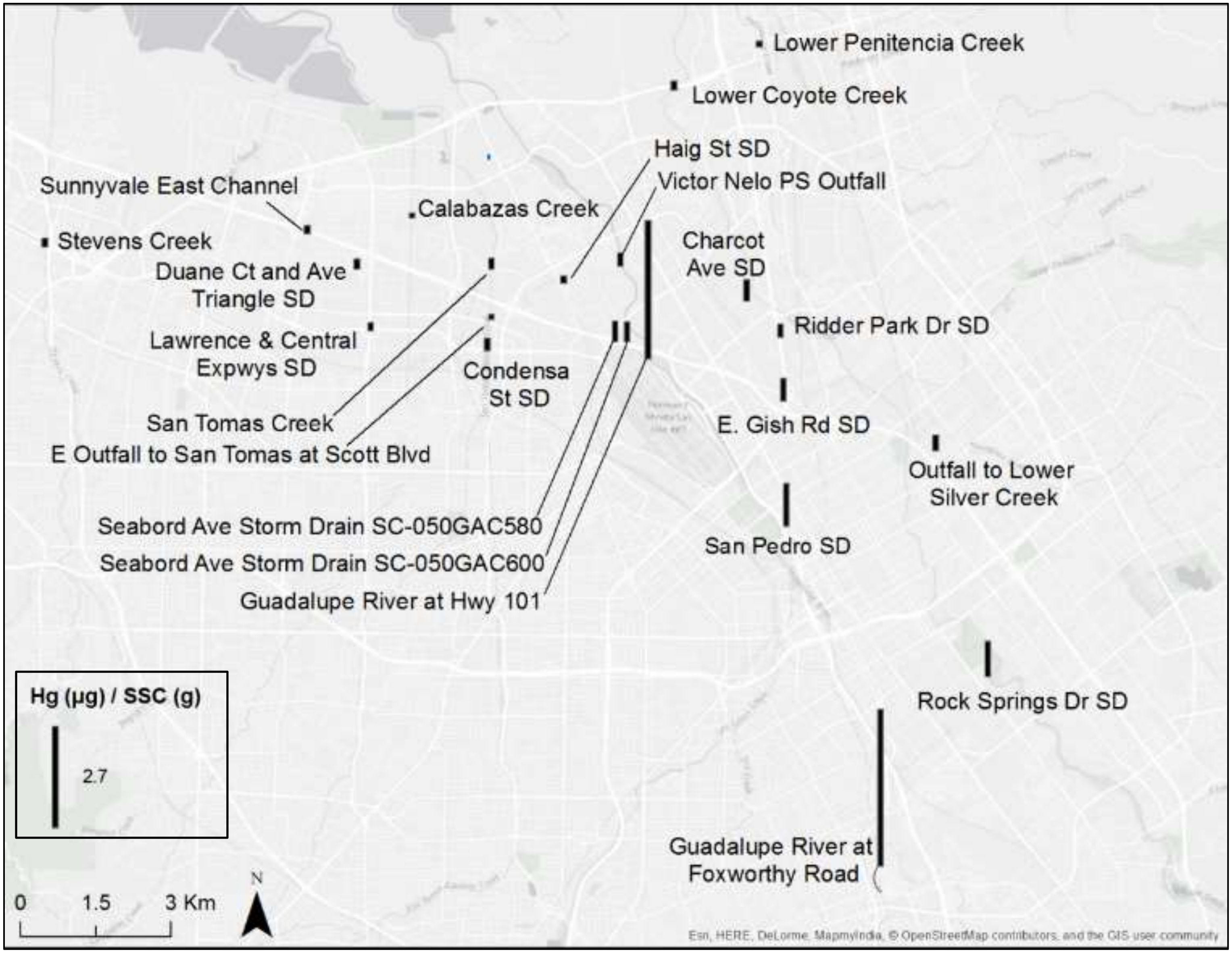

Figure 9d. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in Santa Clara County.

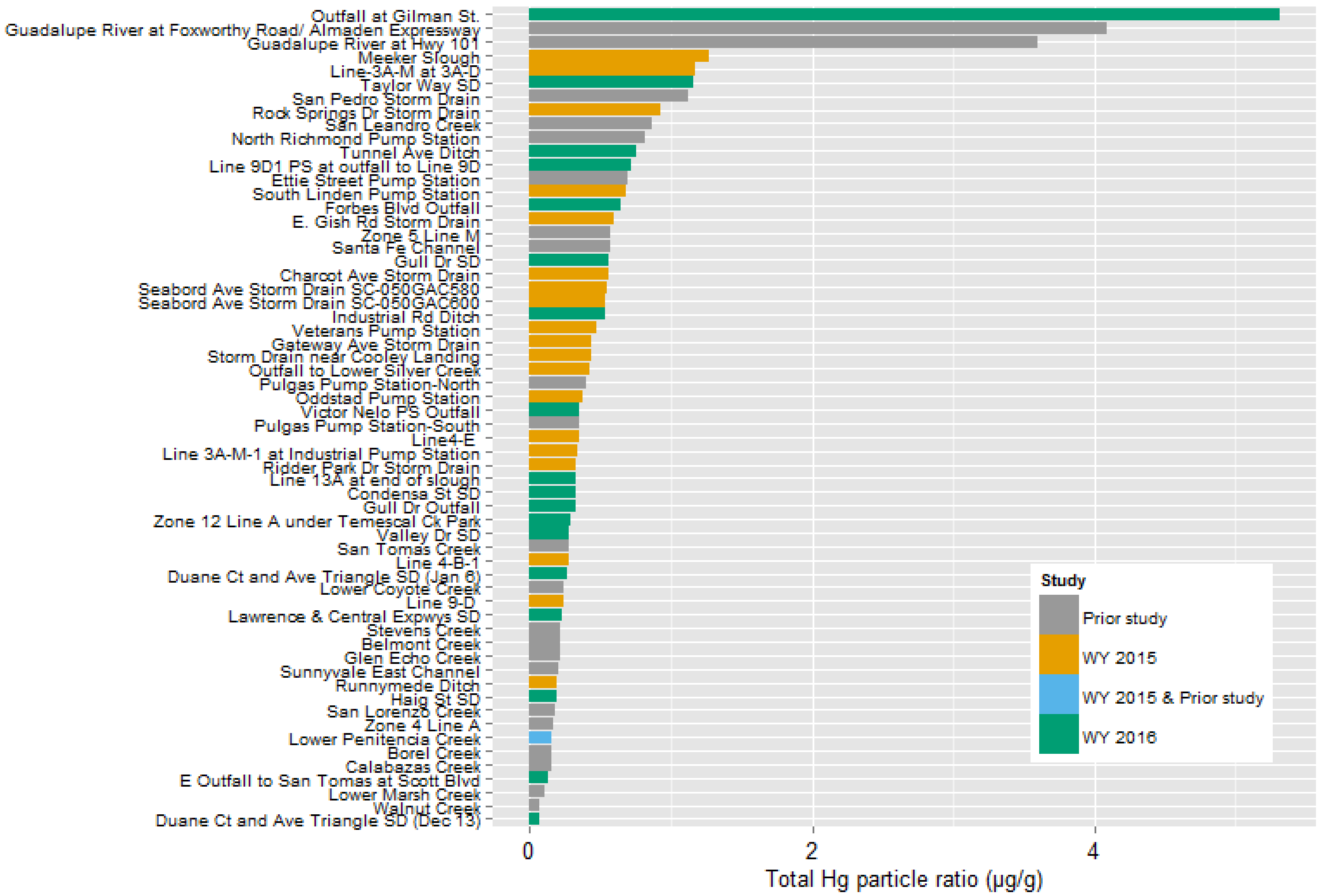

Figure 10. All watershed sampling locations measured to data ranked using total mercury (HgT) particle ratios.

Unlike for PCBs, sites ranking high for HgT concentration in water are not necessarily ranked high for particle ratio with the exception of a few very polluted cases (Guadalupe River at Hwy 101, Guadalupe River at Foxworthy Road/ Almaden Expressway, Outfall at Gilman St., San Pedro Storm Drain, and San Leandro Creek) (Figure 11). As discussed above and introduced by McKee et al. (2012), given the atmospheric sources of Hg and highly variable sediment erosion in Bay Area watersheds, it is possible to get very elevated HgT stormwater concentrations but very low particle ratios. The best example of this is Walnut Creek that was ranked 9th highest in terms of stormwater composite averaged concentrations but lowest (59th out of 62 ranked watershed locations) in terms of particle ratios (but other examples include Zone 5 Line M, Line 13-A at end of slough, Stevens Creek, Glen Echo Creek, Calabazas Creek, Guadalupe River at Hwy 101). Thus, much more care is needed when ranking the sites for HgT than for PCBs (for which the atmospheric pathway plays less of a role in dispersion). This is consistent with the relative results from the most recent calibrations of the RWSM based on the hydrology where better calibrations for PCBs than for Hg were achieved (Wu et al., 2016; Wu et al., 2017); a sediment model basis may be more appropriate for Hg.

Based on particle ratios (the preferred method), the 10 most polluted sites appear to be (in addition to the two Guadalupe River mainstem sites) 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, North Richmond Pump Station, Tunnel Ave Ditch, and Line 9-D-1 PS at outfall to Line 9-D (Table 12; Figure 10). Management in these watersheds might be most cost effective for HgT. The Daly City library bioretention demonstration project (at Gellert Park) with a particle ratio of 1.0 ug/g appears to have been placed (quite by accident) in a cost effective manner and appears to be functioning reasonably well for HgT removal, however, there were some concerns about methylmercury production (David et al., 2015). Just one of these top 10 locations were also identified as elevated for PCB particle ratios (Outfall at Gilman St.) while nine watersheds rank in the top 20 for both pollutants (Figure 12)) providing the opportunity for multiple benefits. Thus the reconnaissance sampling methods coupled with the use of particle ratio in the interpretative process has indicated a number of watersheds with elevated HgT. However, unlike concentrations in water, when normalized to SSC, there appears to be no useful relationship between HgT and PCB particle ratios; sites that are elevated for PCBs based on particle ratio may or may not be elevated for Hg. This fits our conceptual model for Hg where atmospheric deposition and soil erosion play a larger role in the transport of Hg relative to PCBs.

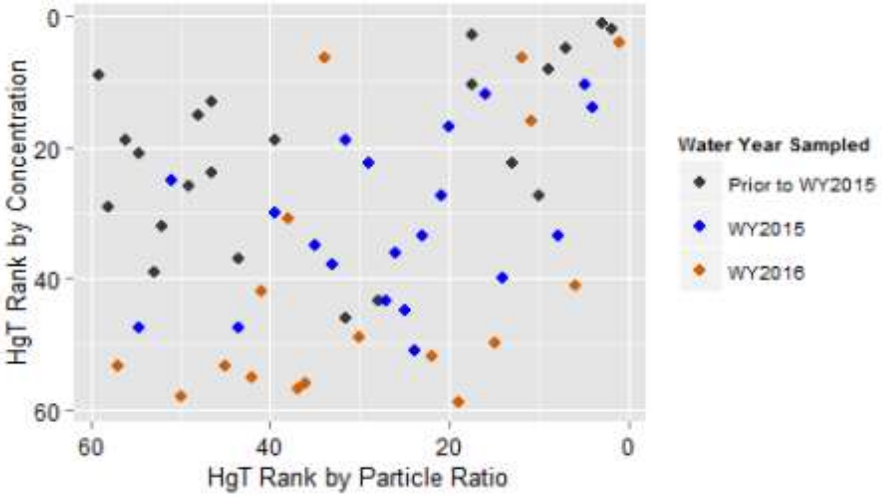

Figure 11. Relationship between site rankings for HgT based on particle ratios versus water concentrations. 1 = highest rank; 59 = lowest rank.

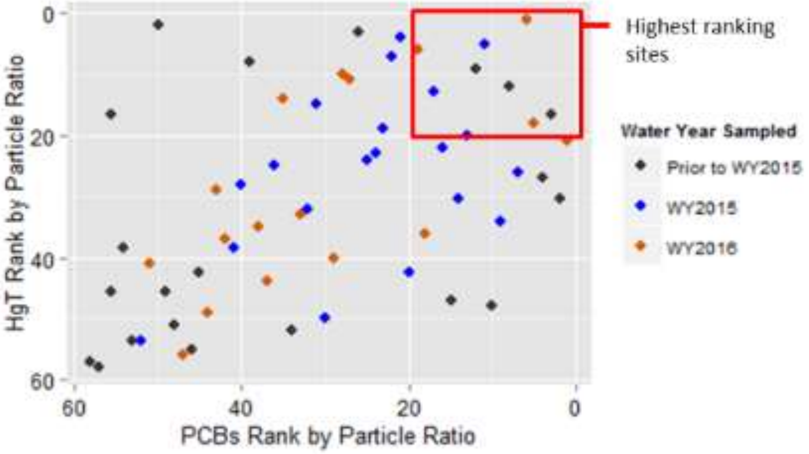

Figure 12. Relationship between site rankings for PCB particle ratios versus HgT particle ratios. 1 = highest rank; 58 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT, while nine watersheds rank in the top 20 for both pollutants.

Relationships between PCBs and Hg and other trace substances and land cover attributes

The data can be used to explore relationships between pollutants and with landscape attributes. Beginning in WY 2003, a number of sites have been evaluated for not only PCB and HgT concentrations in stormwater but also for a range of trace elements. These sites have included 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 for Cu only (Lower Marsh Creek, San

Leandro Creek, Pulgas Pump Station-South, and Sunnyvale East Channel) (Gilbreath et al., 2015a). Copper data have also been 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). In addition, during WYs 2015 and 2016, trace element data were collected at an additional 26 locations (See Table 6 earlier in this report). All these data (n=36 sites for Cu; n=30 for Cd, Pb, and Zn; n=28 for As; Mg and Se not included due to small sample size) were pooled to complete an analysis of relationships between observed particle ratios of PCBs and HgT, trace elements, and impervious land cover and old industrial land use using a Spearman Rank correlation analysis (Table 13). In the case of Guadalupe River, the HgT data were removed from the analysis due the historic mining influence in that watershed[13]. Particle ratios were chosen for this analysis for the same reasons as 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.

The relationships to trace metals are weak for both PCBs and Hg. Based on the available appropriate data and the particle ratio method, PCBs appear to positively correlate with impervious cover, old industrial land use and HgT. PCBs appear to inversely correlate with watershed area. These observations are consistent with previous analysis (McKee et al., 2012) and make conceptual sense given larger watersheds tend to have mixed land use and thus a lower proportional amount of PCB source areas. The positive but relatively weak correlation between PCBs and HgT also makes sense given the general relationships between impervious cover and old industrial land use and both PCBs and Hg. 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 was used as dielectrics, plasticizers, and oils whereas Hg was used in electronic devices, pressure and heat sensors, pigments, mildewcides, and dentistry). Correlations between PCBs and other trace metals are generally weak and not explained by these data. Total mercury does not appear to correlate with any of the other trace metals, and compared with PCBs, shows similar but weaker relationships to impervious cover, old industrial land use, and watershed area. To explore these relationships a little further, the PCB data were examined graphically (Figure 13). All relationships appear to be linear and there is no evidence that a log transformation would help explain the variances between PCBs and other potential indicators. The data do indicate the presence of outliers which may be worth exploring once additional data are obtained in WY 2017. Overall, based on this analysis using the available pooled data, there is no support for the use of these trace metals as a surrogate investigative tool for either PCB or HgT pollution sources.

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[13] Historic mining in the Guadalupe River watershed is known to cause a unique positive relationship between Hg, Cr, and Ni and it is known that there are unique inverse correlations between Hg and other typical urban metals such as Cu and Pb (McKee et al., 2005).

Table 13. Spearman Rank correlation matrix based on stormwater samples collected in the Bay Area since WY 2003 (see text for data sources and exclusions).

	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)	TOC (mg/mg)
PCBs (pg/mg)	1													
HgT (ng/mg)	0.51	1												
Arsenic (ug/mg)	-0.57	0.00	1											
Cadmium (ug/mg)	-0.35	0.24	0.77	1										
Copper (ug/mg)	-0.14	0.14	0.78	0.77	1									
Lead (ug/mg)	-0.29	0.17	0.73	0.90	0.71	1								
Zinc (ug/mg)	-0.32	0.27	0.63	0.78	0.90	0.68	1							
Area (sq km)	-0.41	-0.36	-0.14	-0.24	-0.40	-0.06	-0.41	1						
% Imperviousness	0.52	0.35	-0.23	0.03	0.13	-0.13	0.22	-0.68	1					
% Old Industrial	0.55	0.35	-0.44	-0.26	-0.29	-0.32	-0.21	-0.46	0.70	1				
% Clay (<0.0039 mm)	0.28	0.18	-0.12	0.06	-0.22	-0.04	-0.15	-0.41	0.15	0.30	1			
% Silt (0.0039 to <0.0625 mm)	-0.04	0.11	-0.11	-0.18	0.26	0.00	0.19	0.30	-0.07	-0.14	-0.11	1		
% Sands (0.0625 to <2.0 mm)	-0.26	-0.14	0.13	-0.07	0.12	0.01	0.04	0.25	-0.17	-0.33	-0.87	-0.50	1	
TOC (mg/mg)	0.20	0.37	0.69	0.59	0.88	0.47	0.76	-0.53	0.47	0.19	-0.24	0.24	0.20	1

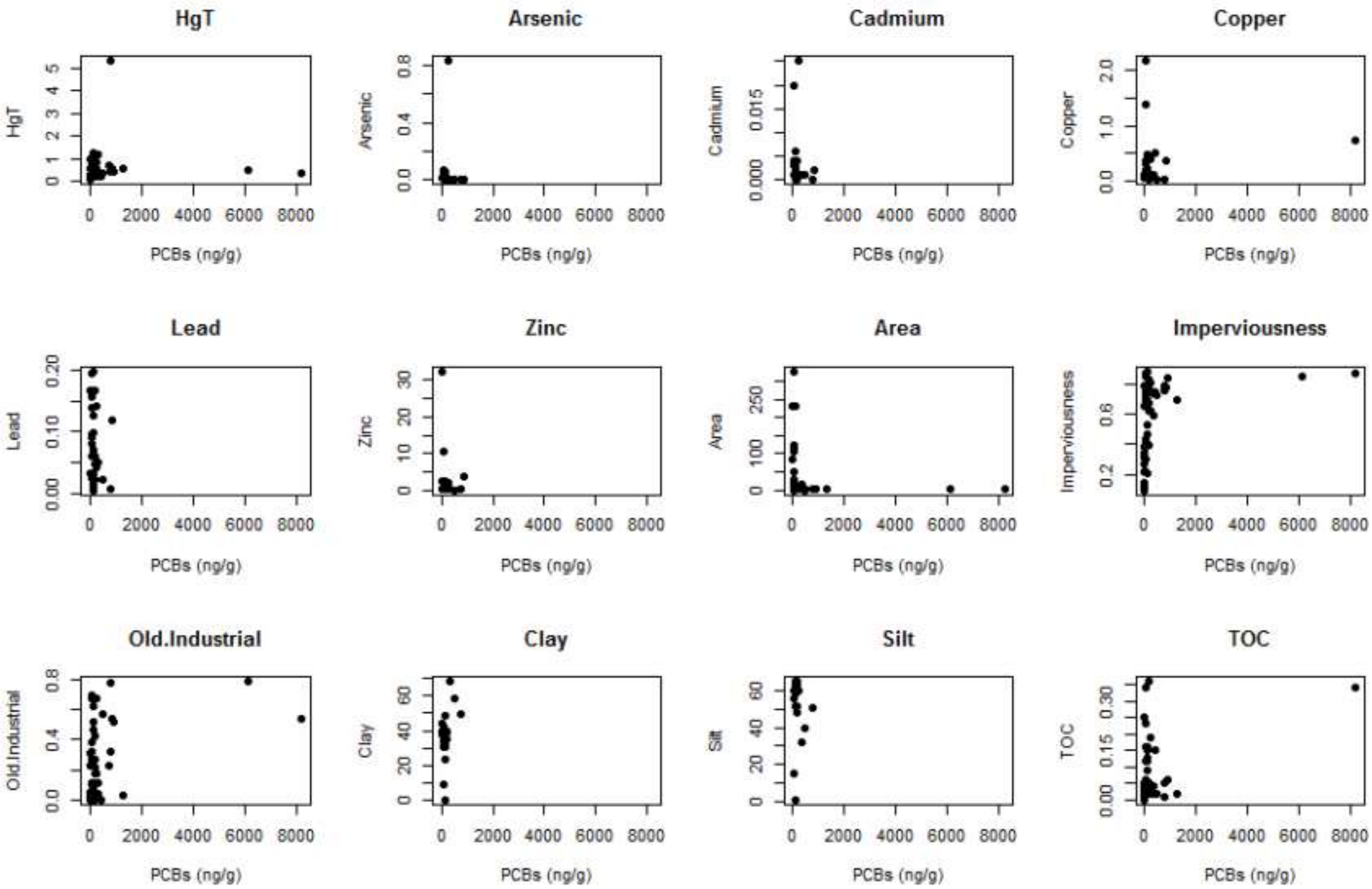

Figure 13. Relationships between observed particle ratios of PCBs and HgT, trace elements, and impervious land cover and old industrial land use.

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 (McKee et al., 2012; McKee et al., 2015) that old industrial land use and the specific source areas found within or in association with older industrial areas are likely to exhibit higher concentrations and loads with respect to PCBs and HgT. Although on a regional basis, this argument holds true (%old industrial land use describes in excess of 50% of the variability in PCB water concentrations and particle ratios), it is not reliable at the scale of individual sites; likely reasons include because the maps are out of date due to ongoing redevelopment and because of the nuanced nature of PCB sources and individual site characteristics such as differential soil erosion and runoff. A total of 62 sites have been sampled for PCBs and HgT during various field sampling efforts since WY 2003. The sampling locations have been selected to help answer a variety of questions, in some cases to make measurements of loads to the Bay from selected watersheds and in other cases to help characterize concentrations of PCBs, HgT and other trace pollutants in stormwater. Although land redevelopment is occurring at a rapid pace in some areas, the currently available old industrial land use layer that was based on the overlay of ABAG, 2005 industrial land use and an older urban land use coverage from 1968 (e.g. Wu et al., 2016) was used to evaluate the proportion of old industrial land use within each sampled watershed in relation to the regional and county based totals. In this way, progress towards characterizing concentrations in these areas was evaluated. This analysis (which excluded nested sampling sites) showed that about 29% of the so defined old industrial land use in the region has been sampled to date. The best effort so far has occurred in Santa Clara County (96% of this land use has been sampled), followed by San Mateo County (43%), Alameda County (33%), and Contra Costa County (4%). The disproportional coverage in Santa Clara County is due to a number of larger watersheds being sampled (Lower Penitencia Creek, Lower Coyote Creek, Guadalupe River at Hwy 101, Sunnyvale East Channel, Stevens Creek, and San Tomas Creek) and also because there were older industrial land use areas further upstream in the Coyote Creek and Guadalupe River watersheds. Of the remaining older industrial land use yet to be sampled, 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, likely to include heavy industrial areas that were historically serviced by rail and ship based transport, and military areas, and are often very difficult to sample due to a lack of public right of ways. A different sampling strategy may be needed to effectively determine what pollution might be associated with these areas to further progress towards identifying areas for potential management.

Data collected will also be used to calibrate the Regional Watershed Spreadsheet Model (RWSM) (Wu et al., 2016). The present version of the model was calibrated using data from 37 watershed areas. Parameterization of the model is currently limited because many of the key source areas are not present in sufficient amounts within the calibration watersheds to strongly influence the calibration procedures. For example, various forms of waste recycling (general waste, metals, auto, drum) only produce an estimated <1.5% of the runoff within the calibration watersheds and were present in <16 of the 37 watersheds (Wu et al., 2017). Based on the extended dataset (now 62 watersheds), the number of sampled watersheds where these types of source areas are present will likely increase. In addition, many of the new watersheds characterized in WY 2016 (described for the first time in this current report) are much smaller in size (0.23-17.5 km^2; mean = 2.1 km^2) compared to previous characterization or loading based sampling efforts (0.0008-327 km^2; mean = 31 km^2) and as such are less heterogeneous in relation to land uses and source areas. This may also help the model to calibrate better for ranking smaller watershed by placing stronger constraints on the calibration process for key source areas. The large variety of watershed sizes and land use characteristics also provides an opportunity to continue to question and evaluate the most appropriate choice of calibration watershed for estimating regional scale loads. Thus, apart from the use of the data to support watershed characterization in relation to pollution sources and higher potential leverage (along with other evidence being generated by the stormwater programs), another potential use of the data is for improving the calibration of the RWSM and by extension improved estimates of regional scale watershed loads.

Summary and Recommendations

Despite climatically challenging conditions resulting in a limited number of storms of appropriate magnitude for sample capture, a total of 20 additional sites were sampled during WY 2015 and an additional 17 sites were sampled and characterized for concentrations during WY 2016. At these sites, composite water samples collected during one storm event were analyzed for PCBs, HgT, SSC, selected trace metals, organic carbon, and grain size. Sampling efficiency was increased by sampling two sites during a single storm that had similar runoff characteristics and were near enough to each other to allow safe and rapid transport and reoccupation repeatedly during a rain event. At eight of these locations, simultaneous samples were also collected using a Hamlin remote suspended sediment sampler and at three sites a third method (the Walling tube remote suspended sediment sampler) was also trialed successfully. Based on this dataset, a number of sites with elevated PCB and Hg concentrations and particle ratios were successfully identified, in part based on an improved effort of site selection focusing on older industrial and highly impervious landscapes. With careful selection of sample timing, some success even occurred at tidal sites, but overall, tidal sites remain the most challenging to sample. Although optimism remains about future applications, the remote sampler trial showed mixed results and need further testing. Based on the WY 2015 and 2016 results, the following recommendations were made:

- Continue to select sites based on the four main selection rationales (Section 2.2). The majority of the samples should be devoted to identifying areas of potential high leverage (indicated by high unit area loads or particle ratios/ concentrations relative to other sites) with a smaller number of sites allocated to sampling potentially cleaner and variably-sized watersheds to help broaden the dataset for regional model calibration and to inform consideration of cleanup potential. The method of selection of sites of potentially higher leverage focusing on older industrial and highly impervious landscapes appears successful and should continue.
- Continue to use the composite water sampling design as developed and applied during WY 2015 and 2016 with no further modifications. In the event of a higher rainfall wet season, greater success may even occur at sites influenced by tidal processes since, with more storms to choose

from, there will be a greater likelihood that more storm events will fall within the needed tidal windows.

- In the next progress report, complete and present a final analysis of the statistical potential of the composite, single storm sampling design to return false negative (low or moderate) results. Make recommendations for a procedure to select and resample sites that return lower than expected concentrations or particle ratios.
- While conceivably cheaper and logistically easier to deploy, preliminary results from the remote sampler pilot study show promise as a characterization tool for PCBs, though maybe not for Hg. That said, we recommend continuation of the trial with a focus on collecting samples using the Walling Tube remote suspended sediment samplers to amass a full dataset of eight side-by-side sample pairs for comparison to the composite water column sampling design with the objective of evaluating usefulness and comparability of the data obtained in relation to the management questions.
- Although the Spearman rank analysis did not support the use of other trace metals as good indicators of PCB or Hg sources, the analysis revealed positive and negative correlations that were perplexing and encouraging of further investigation which could be completed in the next technical report.

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Appendices

Appendix A – Quality assurance

The sections below report quality assurance reviews on WY 2015 and 2016 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., 2015). 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. The results for "censored" data were maintained so the impacts of applying different QA protocols can be assessed by a future analyst if desired. Quality assurance (QA) summary tables can be found in this Appendix A in addition to the following narrative.

Suspended Sediment Concentration and Particle Size Distribution

The SSC and particle size distribution (PSD)[14] 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 particle size distribution. Minimum detection limits (MDLs) were generally sufficient, with <20% non-detects reported for SSC and the more abundant Clay and Silt fractions. Extensive non-detects (>50% NDs) 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, as would be expected. 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 RSD for two field blind replicates of SSC were well below the 10% target. Particle size fractions had average relative standard deviation (RSD) ranging from 12% for Silt to 62% for Fine Sand. Although some individual fractions had average percent difference (RPD) or RSDs >40%, suspended sediments in runoff (and particle size distributions within that SSC) can be highly variable even separated 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 non-detects (NDs > 50%) for many of the coarser fractions. No

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[14] Data of particle size was 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.

method blanks or spiked samples were analyzed/reported, common with SSC and PSD. Precision for PSD 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 MQO. PSD results were similar to other years, dominated by around 80% Fines. Average SSC for whole water samples (excluding those from passive samplers) was in a reasonable range of a few hundred mg/L.

Organic Carbon in Water

Reported TOC and DOC data from EBMUD and ALS were acceptable. 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 non-detects 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 were not spiked at high enough concentrations (at least 2x) the parent sample to evaluate. 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 was therefore qualified but not censored. Lab replicate samples evaluated for precision had 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 (past the specified 100 days). All OC analytes were detected in all field samples and were not detected in method blanks, but DOC was found in filter blanks at 3% the average in field samples. 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 3x higher than 2014 results. DOC and TOC were 55% and 117% of 2016 results, respectively.

PCBs in Water and Sediment

Overall the 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 non-detects reported for any of the PCB congeners measured. Some blank contamination was found in method blanks for about 20 of the more abundant congeners, with only two PCB 008 water results censored for blank contamination exceeding 1/3 the concentration in field samples. Many of the same congeners were detected in the field blank, but at concentrations <1% the average found in the field samples. Three target analytes, PCB 105, 118, and 156, and numerous non-RMP 40 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 getter. PCB concentrations have not been analyzed in remote sediment sampler sediments for previous POC studies, so no interannual comparisons could be made. PCBs in water samples were similar to previous years (2012-2014) ranging from 0.25x to 3x of 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 non-detects, but extensive non-detects (>50% NDs) were reported for only PCBs 099 and 201 (both 60% NDs). Some blank contamination was found in method blanks, with results for some congeners in field samples censored due to concentrations less than 3x higher than in blanks, especially in dissolved fraction 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 previous years, but total fraction samples were around 1% of those in 2015, possibly due to differences in the stations sampled.

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 non-detects reported for any field samples. Arsenic was detected in one method blank, and mercury in 4 method blanks, but 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 up 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 lab 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 up 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 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 non-detects (NDs) reported for Cd, Cu, Pb, Hg, and Zn. Around 20% non-detects were reported for As, Ca, Hardness, and Mg, and 56% for Se. Mercury was found in a filter blank, and in one of the three field blanks, but at concentrations <4% of the average in field samples. 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.

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 non-detects 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 2x the native concentrations. Lab 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), which might be expected Results were reported for Mercury and Total Solids in 1 sediment sample analyzed in 2 lab 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.

Similarly, 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 non-detects 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 lab replicates of the other client samples analyzed by BAL at the same time. 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 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.