cleanwater
PROGRAM

Protecting Alameda County Creeks, Wetlands & the Bay

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Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

March 31, 2017

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

SUBJECT: **SUBMITTAL OF THE ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM URBAN CREEKS MONITORING REPORT**

Dear Bruce:

As you know, various submission and reporting provisions of the Municipal Regional Stormwater Permit (MRP) authorize Permittee implementation and compliance though coordination of the countywide stormwater programs. The member agency Permittees of the Alameda Countywide Clean Water Program (ACCWP) through their Management Committee, and in conformance with the Memorandum of Agreement signed by their governing bodies, have authorized and directed me to prepare and submit certain reports as part of their compliance with submission of MRP-required reports.

Therefore, with this letter, I am submitting this ACCWP Urban Creeks Monitoring Report for Water Year 2016 on behalf of and for the benefit of the ACCWP member agency Permittees. By signing this letter on behalf of ACCWP, I certify under penalty of law that these documents 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. [40CFR 122.22(d)].

Sincerely,

James Scanlin
Program Manager

Attachments: Certification Statement (1 page)
ACCWP Urban Creeks Monitoring Report

Certification Statement

Report components

This submittal by the Alameda Countywide Clean Water Program includes the main body of the Urban Creeks Monitoring Report (UCMR) for October 2015 through September 2016 and the following appendices and attachments:

A.1 Creek Status Monitoring Report - Regional Parameters, Pesticides and Toxicity
A.2 Creek Status Monitoring Report -Targeted Parameters
A.3A ACCWP Pollutants of Concern Monitoring 2016 Sediment Sampling Report
A.3B Pollutants of concern (POC) reconnaissance monitoring draft final progress report, water years (WYs) 2015 and 2016
A.4A Castro Valley Creek Sediment Quality WY 2016 Progress Report
A.4B Dublin Creek Biological Community and Sediment Quality WY 2016 Progress Report
A.4C Crow Creek Low Dissolved Oxygen WY 2016 Progress Report
Attachment A: Electronic Data Submittal Transmittal Letter dated March 31, 2017 with attached file list
Attachment B: Attachment B. BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects, Updated February 2017

Third party monitoring

Please note that consistent with provision C.8.a.iii of the reissued MRP, portions of the Pollutants of Concern monitoring requirements were fulfilled or partially fulfilled by third party monitoring in Water Year 2016, as described in Section 6.2 of the attached UCMR and in the ACCWP Pollutants of Concern Monitoring Report for Water Year 2016 (submitted October 2016):

- The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) conducted a portion of the data collection in Water Year 2016 on behalf of Permittees, pursuant to provision C.8.f – Pollutants of Concern Monitoring. The results of that monitoring are reported in Appendix A.3B of the attached Urban Creeks Monitoring Report.
- Data addressing the Trends monitoring information need described in Provision C.8.f were collected by the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Stream Pollutant Trend (SPoT) Monitoring Program at two Alameda County locations in WY2016. As stated in provision C.8.a.iii, Permittees may use these data to comply with the monitoring requirements included in this provision, provided the data meet the data quality objectives described in C.8.b, i.e. SWAMP comparable. However, the schedule for SWAMP's review and reporting of data collected for the SPoT Program differs from the schedule described in the MRP.

Electronic Data Submittal

Under separate cover ACCWP is also submitting a CD-ROM containing the Program's monitoring data for Water Year 2016, as listed in Attachment A of the UCMR. Please note that in accordance with the comment letter of March 20, 2017 sent by Bay Area Stormwater Management Agencies Association to Jarma Bennett, manager of the state's California Environmental Data Exchange Network (CEDEN), due to lack of clarification regarding recently announced changes to CEDEN's scope ACCWP's concurrent Electronic Data Submittal to CEDEN does not include the portion of WY2016 Pollutants of Concern monitoring data that was not collected from receiving waters.

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

URBAN CREEKS MONITORING REPORT

OCTOBER 2015 THROUGH SEPTEMBER 2016

MEMBER AGENCIES:

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Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region

FINAL
March 31, 2017

ACKNOWLEDGEMENTS

ACCWP acknowledges the contributions of Mr. Paul Salop and other staff of Applied Marine Sciences in planning, implementation and reporting of Creek Status Monitoring, Pesticides and Toxicity Monitoring and Pollutants of Concern sediment sampling. Additional acknowledgements for preparation of specific Appendices are included in those documents.

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Attachment B.BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects, Updated February 2017

LIST OF APPENDICES

A.1 Creek Status Monitoring Report - Regional Parameters, Pesticides and Toxicity
A.2 Creek Status Monitoring Report -Targeted Parameters
A.3A ACCWP Pollutants of Concern (POC) Monitoring 2016Sediment Sampling Report
A.3B Pollutants of concern (POC) reconnaissance monitoring draft final progress report, water years (WYs) 2015 and 2016

STRESSOR-SOURCE IDENTIFICATION PROJECT REPORTS

A.4A Castro Valley Creek Sediment Quality WY2016 Progress Report
A.4B Dublin Creek Biological Community and Sediment Quality WY2016 Progress Report
A.4C Crow Creek Low Dissolved OxygenWY2016 Progress Report

LIST OF ACRONYMS

Acronym	Definition
ABL	Aquatic Bioassessment Laboratory
ACCWP	Alameda Countywide Clean Water Program
AMS	Applied Marine Sciences
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	Benthic Index of Biological Integrity
BMI	Benthic Macroinvertebrate
BOD	Board of Directors of BASMAA
CEC	Contaminants of Emerging Concern
CEDEN	California Environmental Data Exchange Network
CL	Control Limit
CSCI	California Stream Condition Index
DO	Dissolved oxygen
DOC	Dissolved Organic Carbon
E. coli	Escherichia coli
ECWG	Emerging Contaminant Workgroup of the RMP
EDD	Electronic Data Deliverable
EEWG	Exposure and Effects Workgroup of the RMP
LDM	Local Data Manager
LQAO	Local Quality Assurance Officer
MRP	Municipal Regional Stormwater Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MYP	Multi Year Plan
NPDES	National Pollutant Discharge Elimination System
POC	Pollutants of Concern
PSD	Particle Size Distribution
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in San Francisco Bay
RPD	Relative Percent Difference
RWQCB	Regional Water Quality Control Board
SC	Steering Committee of the RMP
SCL	Soil Control Lab
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board(California Regional Water Quality Control Board, San Francisco Bay Region)
SOP	Standard Operating Procedure
SSC	Suspended Sediment Concentration
SSID	Stressor/Source Identification
SPLWG	Sources, Pathways and Loadings Workgroup of the RMP

SPoT	Statewide Stream Pollutant Trend Monitoring
SWAMP	Surface Water Ambient Monitoring Program
TOC	Total Organic Carbon
TRC	Technical Review Committee of the RMP
USEPA	United States Environmental Protection Agency
WY	Water Year

WY 2016 Summary of Creek Status and Pesticides/Toxicity Monitoring Sites and Parameters Sampled (See Legend below for abbreviations, Section 3 of this Urban Creeks Monitoring Report and its Appendices A.1 and A.2 for definitions, monitoring results and discussion).

Site ID	Creek Name	Land Use	Latitude	Longitude	Creek Status Monitoring Parameter							
					BA	N	Cl	WQ Tox	SED	PATH	TEMP	GWQ
205R01902	Sabercat Creek	Urban	37.52703	-121.93739	X	X	X					
205R01582	Agua Caliente	Urban	37.50463	-121.90598	X	X	X					
205R02350	Agua Caliente	Urban	37.50578	-121.90118	X	X	X					
205R01838	Agua Fria	Urban	37.49337	-121.90866	X	X	X					
205R01070	Tributary to Agua Fria	Urban	37.49588	-121.90107	X	X	X					
204R01572	Gold Creek	Urban	37.68910	-121.92480	X	X	X					
205R03886	Zone 6 Line G	Urban	37.47742	-121.93189	X	X	X					
204R02015	Sulphur Creek	Urban	37.67451	-122.05757	X	X	X					
204R02175	San Lorenzo Creek	Urban	37.68454	-122.10825	X	X	X					
204R03783	Crandall Creek	Urban	37.56722	-122.05749	X	X	X					
205R03438	Zone 6 Line G	Urban	37.52406	-121.96912	X	X	X					
205R03694	Mission Creek	Urban	37.54533	-121.94308	X	X	X					
204R02183	Alameda Creek	Urban	37.56622	-121.99240	X	X	X					
204R02439	Alameda Creek	Urban	37.58765	-122.04057	X	X	X					
204R01863	Alameda Creek	Urban	37.57515	-122.01984	X	X	X					
204R02116	Arroyo Las Positas	Urban	37.69739	-121.81625	X	X	X					
204R03015	Zone 5 Line J-3	Urban	37.58821	-122.07665	X	X	X					
204R02287	Arroyo Viejo	Urban	37.75567	-122.15483	X	X	X					
204R02879	Estudillo Canal	Urban	37.69224	-122.14314	X	X	X					
204R02687	Arroyo del Valle	Urban	37.66101	-121.82442	X	X	X					

(continued on next page)

Site ID	Creek Name	Land Use	Latitude	Longitude	Creek Status Monitoring Parameter							
					BA	N	Cl	WQ Tox	SED	PATH	TEMP	GWQ
204CVY010	Castro Valley Creek	(Urban)	37.68159	-122.08070				X	X			
204SAU030	Sausal Creek	(Urban)	37.78592	-122.22455				X	X			
204CRW040	Crow Creek	(Urban)	37.70143	-122.05467							X	X
204CRW041A	Crow Creek	(Urban)	37.70150	-122.05451							X	
204CRW041B	Crow Creek	(Urban)	37.70204	-122.05398							X	
204CRW041C	Crow Creek	(Urban)	37.70272	-122.0501							X	
204CRW041D	Crow Creek	(Urban)	37.70265	-122.0501							X	
204CRW041E	Crow Creek	(Urban)	37.70189	-122.04912							X	X
204CRW042	Crow Creek	(Urban)	37.69996	-122.0492							X	
204CRW044	Crow Creek	(Urban)	37.70442	-122.04369							X	
204CRW045	Crow Creek	(Urban)	37.70681	-122.04188							X	X
204CVY020	Chabot Creek	(Urban)	37.68192	-122.08078						X		
204CVY080	Castro Valley Creek	(Urban)	37.68184	-122.08044						X		
204CVY084	Castro Valley Creek	(Urban)	37.68402	-122.07576						X		
204CVY090	Castro Valley Creek	(Urban)	37.68882	-122.07215						X		
204CVY125	Castro Valley Creek	(Urban)	37.69417	-122.07234						X		

Legend:
BA = Bioassessment (C.8.d.i); N = Nutrients (C.8.d.i); Cl = Chlorine (C.8.d.ii); WQ Tox = Water Column Toxicity (C.8.g.i&iii); SED = Sediment Toxicity and Chemistry (C.8.g.ii); PATH = Pathogen Indicators (C.8.d.v); TEMP = Continuous Temperature Monitoring (C.8.d.iii); GWQ = Continuous General Water Quality Monitoring (C.8.d.iv).
Note: Coordinates at first visit are reported where multiple sampling events were conducted at a particular site.

SECTION 1 - INTRODUCTION

This Urban Creeks Monitoring Report (UCMR) is submitted by the Alameda Countywide Clean Water Program (Program, ACCWP), on behalf of all towns, cities, counties and flood control agencies represented by the Program[1](i.e., Permittees) subject to the Municipal Regional Stormwater NPDES Permit (MRP, CAS612008) issued by the San Francisco Regional Water Quality Control Board (Water Board) on October 14, 2009 (Order R2009-0074)and reissued on November 19, 2015 (Order R2015-0049) with effective date January 1, 2016.The term "MRP" refers to the current, reissued MRP. Where it is necessary to distinguish between the 2009 MRP and reissued MRP, the former is referred to as "MRP1", and the latter as "MRP2".

This report (including all appendices and attachments) fulfills the requirements of MRP Provision C.8.h for interpreting and reporting monitoring data collected during Water Year 2016(WY 2016, October 1, 2015- September 30, 2016).Monitoring data presented in this report were submitted electronically to the Water Board by the Program on behalf of the represented Permittees and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) at http://www.ceden.org/, for those types of data accepted by CEDEN[2].

MRP1 was in effect during the first three months of WY 2016; MRP 2 was in effect during the remaining 9 months of WY 2016, and the Program's WY 2016 monitoring conforms to the MRP2 requirements except where otherwise noted. This report follows the organization of the C.8 requirements in MRP2, and is organized into two main parts – the main body and appendices. The main body provides brief summaries of accomplishments made in Water Year 2016 in compliance with MRP provision C.8. Summaries are organized by sub-provisions of the MRP and grouped into the sections listed in Table 1-1, which also shows the corresponding provision (as applicable) in MRP1.

Appendices include data analyses for interpretive reporting focused on specific types of water quality monitoring required by the MRP. Appendices are also grouped together by sub-provision as shown in Table 1-1and referenced within the applicable sections of the report's main body.

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[1] The 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 Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency).

[2] In September 2016 the Program and other MRP permittees became aware of a decision by the State Water Resources Control Board that in the future CEDEN will display certain types of non-receiving water data previously excluded from its scope. Due to uncertainties regarding implementation of this decision, The Program's submittal of WY 2016 data conforms to the definition of CEDEN in effect at the time the reissued MRP was adopted.

Table 1-1. UCMR Report Sections and Applicable MRP Provisions and Report Appendices

Urban Creeks Monitoring Report Section		MRP provision	UCMR Appendix with detailed reporting
1. Introduction		n/a	n/a
2. Monitoring Protocols and Data Quality		C.8.b	A.1- A.4 as applicable
3. San Francisco Estuary Receiving Water Monitoring		C.8.c	n/a
4. Creek Status Monitoring	Biological, Chlorine, Nutrients,	C.8.d	A.1
	General Water Quality, Temperature, Bacteria	C.8.d	A.2
5. Stressor/Source Identification Projects		C.8.e	A.4
6. Pollutants of Concern Monitoring		C.8.f	A.3
7. Pesticides and Toxicity Monitoring (including dry weather sediment chemistry)		C.8.g	A.1
8. Reporting		C.8.h	n/a

The main body of this report and associated appendices address the following reporting requirements for the annual Urban Creeks Monitoring Report (Provision C.8.h.iii) including as appropriate for each type of monitoring in Provision C.8:

- Descriptions of monitoring purpose and study design rationale
- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/long coordinates); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for Provision C.8.d.;
- Pollutant load and concentration at each mass emissions station;
- A listing of third party entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards; and,
- A signed certification statement.

Regional collaborative monitoring (BASMAA RMC)

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a Regional Collaboration, their countywide 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[3]. The regional monitoring collaborative is

[3] See Appendix A.1 for a list of all participants in the collaborative Regional Monitoring Coalition.

referred to as the Bay Area Stormwater Management Agencies (BASMAA) Regional Monitoring Coalition (RMC).The goals of the RMC are to:

1. Assist Permittees in complying with requirements in MRP Provision C.8 (Water Quality Monitoring);
2. Develop and implement regionally consistent creek monitoring approaches and designs in the Bay Area, through the improved coordination among RMC participants and other agencies such as the Regional Water Quality Control Board (RWQCB) that share common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining

In February 2011, the RMC developed a Multi-Year Work Plan (RMC Work Plan) to provide a framework for implementing regional monitoring and assessment activities required under MRP provision C.8. The RMC Work Plan summarized RMC-related 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 (BOD). A total of 27 regional projects were identified in the RMC Work Plan, based on the requirements described in provision C.8 of MRP1, most of which have continued with minor changes in MRP2.

Regionally-implemented activities to provide standardization and coordination for the RMC Work Plan were conducted under the auspices of the Bay Area Stormwater Management Agencies Association (BASMAA), a 501(c)(3) non-profit organization comprised of the municipal stormwater programs in the San Francisco Bay Area. Scopes, budgets, and contracting 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 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. ACCWP and other RMC participants coordinate their monitoring activities through meetings and communications of the RMC Work Group and the MPC.

SECTION 2 - MONITORING PROTOCOLS AND DATA QUALITY

Provision C.8.b requires monitoring data collected by Permittees in compliance with the MRP to be of a minimum data quality consistent with the applicable State of California's Surface Water Ambient Monitoring Program (SWAMP) standards, set forth in the SWAMP Quality Assurance Project Plan (QAPP). To assist Permittees in meeting SWAMP data quality standards and developing data management systems that allow

for easy access of water quality monitoring data by Permittees, the RMC coordinated guidance for SWAMP comparable data collection through several regional projects:

Standard Operating and Quality Assurance Procedures

For Creek Status Monitoring the RMC adapted existing creek status monitoring SOPs and QAPP developed by SWAMP to document the field procedures necessary to maintain comparable, high quality data among RMC participants. Version 1of these documents (BASMAA 2012a, 2012b) were completed in Water Year 2012 prior to field work. All interpretative issues or concerns raised during the initial two years of monitoring were resolved through the RMC Work Group and were documented in Version 2 (BASMAA 2014a, 2014b) along with minor revisions addressing lessons learned. The RMC produced Version 3 (BASMAA 2016a, 2016b)to reflect changes in the reissued MRP, which were finalized for use starting in WY2016.[4]

Information Management

For Creek Status and related Monitoring, the RMC participants developed an Information Management Systems (IMS) to provide SWAMP-compatible storage and import/export of data for all RMC programs. A data management subgroup of the RMC Work Group met periodically for training and review of data management issues, and to suggest enhancements for data checking and to increase efficiency,

For POC Loads Monitoring in MRP 1 BASMAA contracted with SFEI to design and maintain an IMS for management of data from stations operated by the RMC programs. During WY 2015 stormwater programs initiated upgrades to the Creek Status Monitoring IMS to accommodate new sample types for POC Monitoring begun in WY 2014 and receiving increased emphasis during MRP2.

The IMSs provide standardized data storage formats, thus providing a mechanism for sharing data among RMC participants and efficient submittal of data electronically to the Water Board per provision C.8.h, as described in Section 8, Reporting.

Monitoring Data Quality Review

All Creek Status findings and data reported during Water Year 2016 were reviewed against RMC measurement quality objectives (BASMAA, 2016a). Appendices A.1 and

[4] Available at
http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/SWAMP/BASMAA_RMC_QAPP_v3_final-2016-0331_r2_signed.pdf
http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/SWAMP/BASMAA_RMC_SOP_V3_Final%20March%202016.pdf

A.2 contain statements of data quality resulting from data quality review for Creek Status and Pesticides/Toxicity Monitoring data.

Additional evaluations of data quality for data collected pursuant to provision C.8.fare provided in Appendices A.3A and A.3B.

SECTION 3 - SAN FRANCISCO ESTUARY RECEIVING WATER MONITORING (C.8.c)

As described in MRP provision C.8.c, Permittees are required to provide financial contributions towards implementing an Estuary receiving water monitoring program on an annual basis that at a minimum is equivalent to the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Since the adoption of the MRP1, Permittees have complied with this provision by making financial contributions to the RMP directly or through stormwater programs (**Error! Reference source not found.**). Additionally, Permittees actively participated in RMP committees and work groups through Permittee and/or stormwater program staff as described in the following sections, which also provide a brief description of the RMP and associated monitoring activities conducted during this reporting period.

Table 3-1. . Stormwater Program annual contributions to the Regional Monitoring Program for Water Quality in the San Francisco Bay Estuary in 2017 by MRP-related Programs.

RMC Participant	2017 Contribution
Santa Clara Valley Urban Runoff Pollution Prevention Program	$196,851
Alameda Countywide Clean Water Program	$188,673
Contra Costa Clean Water Program	$153,776
San Mateo Countywide Water Pollution Prevention Program	$92,747
Vallejo Sanitation and Flood Control District	$13,844
Fairfield-Suisun Urban Runoff Management Program	$16,584
Total	$643,263

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.[5] The regulated community includes Permittees, publicly owned treatment works (POTWs), dredgers and industrial dischargers. The RMP is intended to answer the following core management questions:

- Are chemical concentrations in the Estuary potentially at levels of concern and are associated impacts likely?

[5] The RMP Annual Work Plans and other documents are available at http://www.sfei.org/programs/sf-bay-regional-monitoring-program

- What are the concentrations and masses of contaminants in the Estuary and its segments?
- What are the sources, pathways, loadings, and processes leading to contaminant related impacts in the Estuary?
- Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?
- 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 paragraphs provide a brief overview of these programs.

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 and redesigned in 2007 based on a more rigorous statistical design that enables the detection of trends. In Water Year 2016the S&T Program was comprised of the following program elements that collect data to address RMP management questions described above:

- Water/Sediment/Biota Chemistry and Toxicity Monitoring
- Sediment Benthos Monitoring
- Small and Large Tributary Loading Studies and Small Fish and Sport Fish Contamination Studies
- Studies to Determine the Causes of Sediment Toxicity
- Suspended Sediment, Hydrography and Phytoplankton Monitoring
- Bird Egg Monitoring

In fall 2011 the RMP Steering Committee, as part of a 5-year Master Planning process reviewed the S&T Program and agreed to reduce the frequency of some of the data collection activities or elements in future years so that more funding will be available for pilot and special studies. Beginning in 2015, a component was added to the S&T program to characterize surface sediments through monitoring in nearshore Bay margin areas that have been largely unsampled by the RMP and were excluded from the previous S&T redesign. Additional information on the S&T Program and associated monitoring data are available for downloading via the RMP website using the Contaminant Data Download and Display (CD3) at http://www.sfei.org/rmp/data.

RMP Pilot and Special Studies

The RMP also conducts Pilot and Special Studies (P/S Studies) on an annual basis. Studies usually are 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 and standing workgroups identify as priority for further study. These studies are developed through an open selection process at the workgroup level and selected for funding through RMP

committees. Results and summaries of the most pertinent P/S Studies can be found on the RMP website (www.sfei.org/rmp/).

In Water Year2016, a considerable amount of RMP and Stormwater Program staff time was spent in overseeing and implementing special studies associated with the RMP's Small Tributary Loading Strategy (STLS) intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small tributaries to the San Francisco Bay. Additional information is provided on STLS-related studies under Section 6.1 of this Report.

Participation in Committees, Workgroups and Strategy Teams

In Water Year2016, RMC Permittees actively participated in the following RMP Committees and work groups:

- Steering Committee (SC)
- Technical Review Committee (TRC)
- Sources, Pathways and Loadings Workgroup (SPLWG)
- Exposure and Effects Workgroup (EEWG)
- Strategy Teams for PCBs, Mercury, Small Tributaries, Sport Fish and Nutrients)

Committee and workgroup representation was provided by Permittee or stormwater program staff and/or individuals designated by RMC participants and the BASMAA BOD. During Water Year2016 ACCWP Program staff actively participated in the SPLWG, EEWG, Small Tributaries Loading Strategy Team (see Section 6, POC Monitoring, below) and the PCB Strategy Team. Representation included participating in meetings or conference calls, reviewing technical reports and work products, reviewing articles included in the RMP's annual update, and providing general program direction to RMP staff. RMC representatives to the RMP also provided timely summaries and updates to other stormwater program representatives (on behalf of Permittees) during MPC and/or BOD meetings and solicited timely input as needed to ensure Permittees' interests were adequately represented.

SECTION 4 - CREEK STATUS MONITORING (C.8.d)

Provision C.8.d requires Permittees to conduct Creek Status Monitoring that is intended to answer the following management questions:

- Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, river and tributaries?
- Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?

Creek Status Monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each stormwater program are described in Provision C.8.d of the MRP. Based on the implementation schedule described in Provision C.8.a.ii of MRP1, Creek Status Monitoring coordinated through the RMC began in October 2011.

While MRP2 designates a separate section for Pesticides and Toxicity Monitoring, these parameters were originally included in the design for Creek Status Monitoring as described below, and are reported together for purposes of this report.

Regional and Local Monitoring Designs

The RMC's regional monitoring strategy for complying with MRP provision C.8.d - Creek Status Monitoring is described in its *Creek Status and Long-Term Trends Monitoring Plan* (BASMAA 2011). 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)[6].

The Program submitted its Creek Status Monitoring data for Water Year 2015 to the Water Board by March 31, 2016. The analyses of results from Creek Status and Pesticides/Toxicity Monitoring conducted by the Program in Water Year2016are presented in Appendices A.1 and A.2 to this report. Table 4-1provides a list of which monitoring parameters are included in specific appendices.

Table 4-1. Location of result analyses for each monitored parameter in MRP Provisions C.8.d and C.8.g.

Biological Response and Stressor Indicators	Monitoring Design		Reporting
	Regional Ambient (Probabilistic)	Local (Targeted)	
Bioassessment & Physical Habitat Assessment	X		Appendix A.1
Chlorine	X		Appendix A.1
Nutrients (with Bioassessment)[a]	X		Appendix A.1
Water Toxicity	n/a		Appendix A.1
Sediment Toxicity	n/a		Appendix A.1
Sediment Chemistry	n/a		Appendix A.1
General Water Quality		X	Appendix A.2
Temperature		X	Appendix A.2
Bacteria		X	Appendix A.2

[a]Nutrients sampled for Pollutants of Concern Monitoring are reported in Section 6 below.

[6]Provision C.8.a.i of MRP1stated in reference to all subsections of C.8 that "provided these datatypes, quantities, and quality are obtained, a regional monitoring collaborative may develop its own sampling design" Provision C.8.a.i of MRP2 encourages Permittees to continue contributing to the RMC.

SECTION 5 - STRESSOR/SOURCE IDENTIFICATION PROJECTS (C.8.e)

As described in MRP Provision C.8.e, Permittees who conduct Creek Status monitoring through a regional collaborative are required to collectively initiate a minimum of eight new Stressor/Source Identification (SSID) projects (minimum one for toxicity) during the MRP 2 permit term. Potential SSID projects are identified when monitoring results reach criteria or thresholds for follow-up action as indicated for each data type in MRP provision C.8.d or C.8.g.

To ensure consistency in interpretation of the SSID requirements (C.8.e) and a coordinated approach to compliance with that provision, RMC Permittee efforts in the previous permit term included a collaborative evaluation of Water Year 2012 Creek Status monitoring results and joint decision-making process for selecting sites for SSID follow-up by individual programs. RMC Program representatives reviewed the list of candidate SSID projects with Water Board staff in the April 2013 meeting of the RMC Work Group. Attachment B is a summary table listing all RMC SSID projects initiated to date with their locations, rationales, and current status.

In consultation with Permittees, the Program developed workplans and initiated the first follow-up action for three Alameda County SSID projects in FY2013-14. As required by Provision C.8.d.i of MRP1 (Stressor/Source Identification), this first step was to conduct a site-specific study in a stepwise process to identify and isolate the cause(s) of the trigger stressor/source originally identified through Creek Status Monitoring results. Initial study design, data collection and results for the following stressor/source identification projects were provided in progress reports attached to the March 2014 Integrated Monitoring Report (IMR) for three studies. Current progress reports are provided in Appendix 4 as follows:

- Appendix A.4A for Castro Valley Creek WY2012 trigger results for sediment quality at probabilistic site 204R00047SSID.The site-specific study 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. The WY2016 progress report provides an update on WY2016 Pesticides and Toxicity monitoring at one site, describes BMPs implemented and a schedule for completion of the site-specific elements of this project.
- Appendix A.4B for Dublin Creek trigger results for biological community condition and sediment quality at probabilistic site 204R00084.The site-specific study began in 2013 with sediment sampling, watershed records review and bioassessment sampling at an additional RMC site plus a supplemental site along an urbanization gradient. Bioassessment impacts were strongly associated with channel alteration and habitat quality. Review of inspection information from the catchment area identified no specific sources of pesticides or metals to sediment. The progress report includes a schedule for completion of the site-specific elements of this project after further review of land use inputs and freeway runoff, and updating of biological community metrics.

- Appendix A.4C for Crow Creek trigger results for Low Dissolved Oxygen from General Water Quality measurements at targeted site 204CRW030. The site-specific Project began in 2013 with further DO and water sampling; the initial hypothesis regarding reservoir runoff was not supported by the first year's results. 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 WY 2015. The progress report reports results of WY2016 monitoring evaluate summer inflows from culvert outfalls using continuous monitoring of conductivity as well as temperature. In contrast to the previous drought years there were no DO problems at the downstream site, that originally triggered the SSID project, although anthropogenic influences from higher in the watershed were likely to have contributed to diurnal reductions of DO at the most upstream site monitored.

SECTION 6 - POLLUTANTS OF CONCERN MONITORING (C.8.f)

The POC Monitoring provision of the reissued MRP reflects the evolution of knowledge and data needs achieved during the first MRP term. The management questions for the next this new permit term have become more articulated and monitoring priorities are shifting towards increased support of management decisions relating to implementation of TMDL load reductions for PCBs and mercury. In October 2016, the Program submitted a separate Pollutants of Concern (POC) Monitoring Report describing accomplishments during Water Year 2016 and the allocation of POC monitoring sampling effort planned for WY 2017. As required in provision C.8.h.iv, the POC Monitoring Report included monitoring locations, number and types of samples collected for each purpose of sampling (management question addressed), and analytes measured. POC monitoring activities and data for WY 2016 are summarized below.

Provision C.8.f of the MRP lists five priority POC management information needs 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.

However, not all of the five information needs apply to all POCs. Table 8.2 of the MRP identifies the applicability of the five information needs to specific POC or POC groups. The Program's WY2016 POC Monitoring activities are described in Section 6.1 below and in Appendix A.3A to this report.

MRP Provision C.8.a.iii allows Permittees to use data collected by a third-party organization to fulfill a monitoring requirement, provided the data are demonstrated to meet data quality objectives comparable to those of the statewide Surface Water Ambient Monitoring Program (SWAMP) as described in Provision C.8.b. Section 6.2 summarizes third-party data collection activities by two programs that meet these criteria and are relevant to ACCWP's POC Monitoring objectives.

6.1 POC MONITORING BY ACCWP

The Program conducted POC Monitoring activities focused on the following POCs, for sample numbers and management information needs shown in Table 6-1:

- Polychlorinated Biphenyls (PCBs) and total mercury, for information needs 1-5;
- Copper and Nutrients (Ammonium, Nitrate, Nitrite, Total Kjeldahl Nitrogen, Orthophosphate and Total Phosphorus), for information needs 4 and 5.

Table 6-1. Types and Numbers of POC monitoring samples collected by ACCWP in WY 2016

Information Need	Sample Matrix	Type of Sampling Event/ Location	Target POCs	No. of WY 2016 Samples
1	Sediment, urban	Dry weather/ on or near ROW surface receiving runoff from potential/likely source	PCBs, mercury	8
1,2	Sediment, bedded	Dry weather/ in MS4 facilities or local channels	PCBs, mercury	0
4,5	Runoff	Dry weather grab sample/ lower watershed integrative site	Copper, nutrients	2
4,5	Sediment, bedded in channel	Dry weather/ fine grained at lower watershed integrative site	Copper	2 See Appendix A.1

As required by MRP Table 8.2, data on Ancillary Parameters such Total Organic Carbon, Suspended Sediment Concentration or hardness were collected as necessary for each sample to address management questions or information needs.

PCB Source Area Identification

In WY 2016 the Program continued sampling urban sediment in street right-of-ways for identification of potential source areas for TMDL pollutants to address Management Information Need 1), based on a multi-step PCB Implementation Planning process to identify watersheds or management areas for PCB load reduction activities. Background, goals and progress on this effort is described in separate reports submitted

by the Permittees in April 1, 2016 and in the 2016 Annual Report as required by Provision C.12.a of the MRP. Appendix A.3A reports the monitoring locations, numbers and types of samples collected by the Program during 2016 sediment s.

Copper and Nutrient POC monitoring -
Copper and nutrients were sampled in July 2016 at two creek sites in conjunction with dry weather sampling for Pesticides and Toxicity Monitoring. Locations of sites, methods of sampling and analysis and results of sediment sampling are reported in Appendix A.1. Table 6-2 shows the results for water column sampling on the same date.

Table 6-2. Results of copper and nutrients water column monitoring at sites 204CVY010 and 204SAU030 in Water Year 2016.

Analyte	Results		Units
	204CVY010	204SAU030	
Copper (dissolved)	1.7	1.3	ug/L
Hardness (as $CaCO_3$)	230	180	mg/L
Ammonia as N[a]	0.617*	0.083	mg/L
Nitrate	1.4	1.4	mg/L
Nitrite	0.19*	0.011	mg/L
Total Kjeldahl Nitrogen	0.47	0.35	mg/L
Orthophosphate	0.039	0.064	mg/L
Total Phosphorus	0.063	0.081	mg/L

[a] Unionized fraction calculated using field-measured pH per https://fisheries.org/wp-content/uploads/2016/03/Copy-of-pub_ammonia_fwc.xls

Comparisons to Numeric Water Quality Objectives/Criteria for Specific Analytes

Provision C.8.h.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, an assessment of data collected for ACCWP's POC monitoring of copper and nutrients in Water Year2016 is provided below.

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

Freshwater vs. Saltwater- POC monitoring data were collected in freshwater receiving water bodies above tidal influence and therefore comparisons were made to freshwater water quality objectives/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 creeks monitored.

Acute vs. Chronic Objectives/Criteria - For POC monitoring required by provision C.8.e, data were collected in an attempt to develop more robust loading estimates from small tributaries. Therefore, detecting the concentration of a constituent in any single sample was not the primary driver of POC monitoring. 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" water quality objectives/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. For analytes for which no water quality objectives/criteria have been adopted, comparisons were not made.

It is important to note that acute water quality objectives or criteria have only been promulgated for a small set of analytes collected in the POC monitoring station, including objectives for trace metals, i.e. copper.

Water samples collected in WY2016 were below applicable numeric water quality objectives (i.e., freshwater acute objective for aquatic life) for copper and ammonia. Nitrate as N and Nitrite as N were below water quality objectives for MUN supply although these objectives were not applicable to the sites sampled.

Data Quality - In general, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2016a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2016b), developed for C.8 monitoring and in conformity with SWAMP protocols as described in Section 2 above. No deviations were identified in regard to the water column POC monitoring.

6.2 POC MONITORING BY THIRD PARTIES

As discussed in the POC Monitoring Report, two third-party organizations met the criteria for their data to be used to partially fulfill POC monitoring requirements in WY2016, as described below:

Regional Monitoring Program (RMP)

As described in Section 3 above, the RMP conducts pilot and special studies to support water quality management in the Bay and its tributary watersheds. These studies are overseen by different RMP work Groups or teams as described below:

Small Tributaries Loading Strategy (STLS): To assist participants in effectively and efficiently conducting POC monitoring required by the MRP and answer POC loads

management questions listed in MRP1, an RMP Small Tributaries Loading Strategy (STLS) was developed in 2009 by the STLS Team, which included representatives from BASMAA, Water Board staff, RMP/SFEI and technical advisors. The objective of the STLS is to develop a comprehensive planning framework to coordinate POC loads monitoring and modeling (Management Information Needs 2, 4 and 5) between the RMP and RMC participants. This framework and a summary of activities and products to date were provided in an initial STLS Multi-Year Plan (STLS-MYP) under oversight of the STLS Team and the associated RMP Sources Pathways Loadings Work Group (SPLWG). Active elements of the STLS Work Plan and during the period from October 2015 through September 2016 included.

- Watershed Modeling –In WY 2016 the Permittees continued oversight of refinements to Regional Watershed Spreadsheet Model for estimating regional-scale pollutant loads to the Bay, through participation in the STLS Team and SPLWG. Monitoring data used to calibrate the model support potential future use in analyzing for information needs 2, 4 and 5
- Watershed Characterization "Reconnaissance" Monitoring is based on collaboration with stormwater programs to identify and rank catchments with possible PCB and/or mercury sources, to address management information need 1. Results to date are summarized in Appendix A.3B.

RMP PCB Strategy is engaged in a multi-year effort to develop Conceptual Models of PCB fate and transport in selected nearshore portions of SF Bay called Priority Margin Units (PMUs), in order to clarify contributions from adjacent watersheds to Bay impairment, inform future management decisions and tracking of trends in PCB loads from those watersheds. The first Conceptual Model report for the Emeryville Crescent was drafted in early 2016 using available data from the RMP and other sources. TThe mouths of several creeks around the second PMU in San Leandro Bay were included in RMP WY2016 data collection for a Conceptual Model report to be drafted by mid-2017.

Emerging Contaminants Special Study - Provision C.8.e.vii of MRP1required Permittees to develop a work plan and schedule for initial loading estimates and source analyses for contaminants of emerging concern (CECs). Contaminants that were mentioned in MRP1include: endocrine-disrupting compounds, PFOS/PFAS (Perfluorooctanesulfonates (PFOS), Perfluoroalkylsulfonates (PFAS), and NP/NPEs (nonylphenols/nonylphenol esters - estrogen-like compounds). The Permittees addressed this requirement through the CECs Strategy developed by the Emerging Contaminants Work Group (ECWG) of the RMP. For MRP 2, Table 8.2 of the MRP requires one or more special studies that address relevant management information needs for emerging contaminants to include at least PFOs, PFAs, and alternative flame retardants being used to replace polybrominated diphenyl ethers (PBDEs). The Permittees will cause this study to be conducted through the SPLWG and the ECWG by the end of the permit.

SWAMP Stream Pollution Trends (SPoT) Monitoring Program

The SPoT element of the SWAMP program aims to determine long-term trends in stream contaminant concentrations and effects statewide. For this purpose the program has

established a network of approximately 100 sites throughout the state where it samples depositional stream sediments collected near the base of watersheds, including two sites in Alameda County that were sampled in WY 2016. Results of SPoT 2013 and 2014 monitoring will be included in a 7-year report to be released in late 2016, with a future 10-year synthesis report planned to include data collected through 2017.

SECTION 7 - PESTICIDES AND TOXICITY MONITORING (C.8.g)

Provision C.8.g, requires Permittees to conduct wet weather and dry weather monitoring of pesticides and toxicity in urban creeks. This includes monitoring of toxicity in the water column (dry weather), monitoring of toxicity and other pollutants in sediment (dry weather), and wet weather pesticides and toxicity monitoring. Appendix A.1 to this UCMR reports the results of ACCWP's dry weather monitoring under this provision In WY2016. Per Provision C.8.g.iii(3) wet weather pesticides and toxicity monitoring will be conducted by the RMC on behalf of all Permittees, with a minimum of 6 samples collected across the region in WY2018 (the third WY of the permit term). During WY2017 the RMC will select sites for collecting a total of 10 samples during the permit term, with concurrence of Water Board staff in the RMC Work Group.

Provision C.8.g describes pesticide and toxicity monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each stormwater program while recognizing a trend towards development of a coordinated statewide monitoring program. Due to previous inclusion of these parameters in the RMC's regional monitoring strategy as described in its *Creek Status and Long-Term Trends Monitoring Plan* (BASMAA 2011), the analyses of results from pesticide and toxicity monitoring conducted by the Program in Water Year 2016 are presented along with other regionally designed Creek Status Monitoring parameters in Appendix A.1.

SECTION 8 - REPORTING (C.8.h)

Provision C.8.h requires Permittees to report annually on water quality data collected in compliance with the MRP. Annual reporting requirements include: 1) water quality standard exceedances; 2) electronic reporting; 3) Urban Creeks Monitoring Reports; 4) Pollutants Of Concern Monitoring Reports, Integrated Monitoring Report; and 4) standard report content.

Data are submitted in SWAMP format, as described in more detail in Section 2, Monitoring Protocols and Data Quality. Data are submitted with quality controls required by CEDEN, in accordance with the electronic reporting requirements in MRP provision C.8.h.ii.

In accordance with the reporting schedule of the reissued MRP, the Program's WY 2016creek status monitoring electronic data are being submitted to the Water Board by March 31, 2017, concurrent with the UCMR. Additionally, a separate Pollutants of

Concern Monitoring Report was submitted to the Water Board by October 15, 2016. In the fifth year of the permit term, an Integrated Monitoring Report will be submitted in lieu of the annual Urban Creeks Monitoring Report.

This report includes the standard report content required in MRP provision C.8.h.vi.

SECTION 9 - REFERENCES

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BASMAA. 2012b. Creek Status Monitoring Program Standard Operating Procedures. 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. 196 pp.

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SECTION 10 - ATTACHMENTS

Attachment A. Electronic Data Submittal Transmittal Letter dated March 31, 2017with attached file list.

Attachment B.BASMAA Regional Monitoring Coalition: Status of Regional Stressor/Source Identification (SSID) Projects, Updated February 2017

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

CREEK STATUS MONITORING REPORT - REGIONAL PARAMETERS, PESTICIDES AND TOXICITY

APPENDIX A.1

URBAN CREEKS MONITORING REPORT

OCTOBER 2015 THROUGH SEPTEMBER 2016

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by

Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region

FINAL

March 31, 2017

Protecting Alameda County Creeks, Wetlands & the Bay

Acknowledgements

EOA, Inc. contributed substantially to this report in preparation of the data analysis and discussion for bioassessment data. Matthew R. Cover, working as a subconsultant to Horizon, Water and Environment, LLC, provided additional review of the bioassessment data and findings. Horizon Water and Environment, LLC contributed substantially to the preparation of this report in preparation of the data analysis and discussion for water quality, pesticides and sediment chemistry/toxicity. Applied Marine Sciences, Inc. contributed substantially to the site evaluation, implementation of monitoring and preparation of the data analysis and discussion for all other regionally designed parameters.

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) collaboratively developed a framework for preparation of the Urban Creeks Monitoring Report (UCMR) used by ACCWP and other stormwater programs to comply with the Municipal Regional Stormwater Permit (MRP)[1] requirements for reporting on monitoring data collected under the MRP Monitoring provision C.8.

The following participants make up the RMC and are responsible for preparing UCMR documents on behalf of their respective member agencies:

- 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 report was prepared by ACCWP to fulfill reporting requirements for a portion of the Creek Status Monitoring data collected in Water Year 2016 (October 1, 2015 through September 30, 2016) in accordance with the RMC's Monitoring Plan (BASMAA 2011) for certain "regionally designed" parameters required by the MRP and conducted using a probabilistic monitoring design. Results of Pesticide and Toxicity Monitoring are also reported here since the sampling design is still driven by regional considerations under the reissued "MRP2", although no longer associated with the probabilistic design. This report is an Appendix to the full UCMR submitted by ACCWP on behalf of the following Permittees:

[1] Unless otherwise noted references to the MRP are to the reissued "MRP2" (SFBRWQCB, 2015) which became effective January 1, 2016. Most of the monitoring requirements addressed in this Appendix have not changed substantially from the original "MRP1" (SFBRWQCB, 2009)

- The 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 of the Alameda County Flood Control and Water Conservation District.

Other data collected in Alameda County during this period pursuant to MRP provision C.8 are reported in the main body and other appendices of ACCWP's UCMR for Water Year (WY) 2016.

As described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011), RMC participants collected data by implementing BASMAA RMC Standard Operating Procedures (SOPs, BASMAA, 2012b, 2014b and 2016b) in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2012a, 2014a and 2016a). Analytical laboratory analyses were also coordinated among all RMC participants.

In accordance with the reissued MRP (SFBRWQCB, 2015) ACCWP will also submit the data included in this report by March 31, 2017 to the California Environmental Data Exchange Network and San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) in electronic SWAMP-comparable format.

In addition to the RMC participants, San Francisco Bay Regional Water Quality Control Board staff, Kevin Lunde and Jan O'Hara, also participated in RMC workgroup meetings that contributed to design and implementation of the RMC Monitoring Plan. Additionally, these staff also provided input regarding previous Urban Creeks Monitoring Reports and threshold "trigger" criteria for stressor analyses conducted therein.

List of Acronyms

Acronym	Definition
ABL	Aquatic Bioassessment Laboratory
AFDM	Ash Free Dry Mass
AMS	Applied Marine Sciences, Inc.
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	Benthic Index of Biological Integrity
BMI	Benthic Macroinvertebrate
CDFG	California Department of Fish and Game (now CDFW)
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
DO	Dissolved oxygen
GIS	Geographic Information System
GRTS	Generalized Random Tessellated Stratified
IBI	Index of Biological Integrity
MRP	Municipal Regional Stormwater Permit
MQO	Measurement Quality Objective
MWAT	Maximum Weekly Average Temperature
NorCal B-IBI	Northern California Benthic Index of Biological Integrity
NPDES	National Pollutant Discharge Elimination System
NT	Non-Target
PHab	(Bioassessment) Physical Habitat Assessment
PSA	Perennial Streams Assessment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
RMC	Regional Monitoring Coalition
RWQCB	Regional Water Quality Control Board
SCCWRP	Southern California Coastal Water Research Project
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board (California Regional Water Quality Control Board, San Francisco Bay Region)
SMC	Southern California Stormwater Monitoring Coalition
SoCal B-IBI	Southern California Benthic Index of Biological Integrity
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
TNS	Target Not Sampled
WY	Water Year

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Executive Summary

In 2010, the seventeen member agencies of the Alameda Countywide Clean Water Program (ACCWP) joined other members of the Bay Area Stormwater Agencies Association (BASMAA) to form the BASMAA Regional Monitoring Coalition (RMC), as a collaborative effort to coordinate and oversee water quality monitoring required by provision C.8 of the Municipal Regional Stormwater Permit (MRP). This report is an appendix to the Urban Creeks Monitoring Report (UCMR) prepared to assist ACCWP member agencies in complying with the MRP Reporting provision C.8.h, reporting the results of data collected by ACCWP during the Water Year (WY) 2016 extending from October 1, 2015 through September 30, 2016 pursuant to the following MRP provisions:

Creek Status Monitoring (C.8.d) parameters that were sampled according to a regional probabilistic design; and
Pesticides and Toxicity Monitoring (C.8.g) which also assesses problems widespread across the region.

Other Creek Status Monitoring parameters were addressed using a targeted design, with regional coordination and common methodologies and are reported in a separate Targeted Appendix A.2[2] to the UCMR.

During WY 2016, ACCWP monitored 20 sites under the regional probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. Another two sites were monitored for water and sediment toxicity and sediment chemistry, to fulfill the dry season monitoring requirements in MRP provision C.8.g.i and ii.

The bioassessment data were used to evaluate potential stressors that may affect aquatic habitat quality and beneficial uses through a preliminary condition assessment for the monitored sites. The probabilistic design requires at least three years to produce sufficient data to develop a statistically-robust characterization of regional creek conditions, so the analysis and interpretation that can be completed with the first three years of data are necessarily limited.

The reissued MRP contains a separate provision C.8.g to combine all pesticide and toxicity monitoring into one section, instead of being distributed between Creek Status and Pollutants of Concern Monitoring provisions. For WY2016 monitoring ACCWP selected two sites where toxicity had been observed in the past.

[2] Similar methods and QA/QC procedures are being implemented for Stressor-Source Identification (SSID) studies reported in Appendix A.4 to the UCMR.

The following MRP reporting requirements (per provision C.8.h.vi) are addressed within this report or other portions of the UCMR, as applicable:

- Descriptions of monitoring purpose and study design rationale
- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/long coordinates); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for provision C.8.c.;
- Pollutant load and concentration at each mass emissions station;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards; and
- A signed certification statement.

In this report, the results of the stressor assessments are used to determine whether potential follow-up actions may be warranted to address the management questions underlying the RMC design (BASMAA 2011).

Biological community conditions were evaluated using the California Stream Condition Index (CSCI) which considers watershed attributes to identify comparable reference sites, along with several new algae indices of biological integrity. The stressor analysis of bioassessment data revealed the following observations about ACCWP's WY 2016 sampling sites:

- Data from the sites show alteration of biological communities, and channel modification and other habitat changes associated with urbanization is a likely stressor for benthic macroinvertebrate communities. The two sites with the highest CSCI scores had 1-2% impervious area and non-heavily modified channels. The remainder of the sites had CSCI scores below the threshold of 0.795.

The stressor analysis for water quality, sediment chemistry and water and sediment toxicity data revealed the following indications of potential stressors for WY 2016 sites:

- **Water Quality –** Of 11 parameters[3] sampled in association with WY 2016 bioassessment monitoring, applicable water quality standards were only identified for ammonia, chloride, and nitrate + nitrite (for sites with MUN beneficial use only). Of the results generated at the 20 sites monitored by ACCWP reporting herein for those three parameters, one chloride and no un-ionized ammonia or nitrate + nitrite concentrations exceeded the applicable water quality standard or threshold.
- **Water Toxicity –** For WY 2016, 14 aquatic toxicity endpoints were derived through testing of 5 species at 2 sites county-wide during one dry season event. Of these endpoints, two sample / test combinations exhibited statistically-significant toxicity as reported by the analytical laboratory (*C. dubia* reproduction and *C. dilutus* survival at site 204SAU030 during wet season aquatic toxicity monitoring). Neither of these two samples exhibited toxicity with survival, growth, or reproduction beyond the threshold of >50% Effect.
- **Sediment Toxicity –** Of the bedded sediment collected from 2 sites, a toxic response for *C. dilutus* survival was observed at site 204SAU030, however it was below the threshold of >50% Effect.
- **Sediment Chemistry –** At each of the two sites, 1 constituent was present above the PEC threshold. Site 204SAU030 had 3 constituents above TEC thresholds and site 204CVY010 had 7.

The stressor analyses identified a number of sites that may deserve follow-up investigation to provide better understanding of the sources/stressors likely contributing to reduce ecological condition in Bay Area creeks.

[3] Algal mass (ash-free dry weight), Chlorophyll a, Ammonia, Nitrate, Nitrite, TKN, Total Nitrogen, OrthoPhosphate, Phosphorus, Silica and Chloride

1. Introduction

This report fulfills a portion of the reporting requirements of provision C.8.h.iii of the Bay Area Municipal Regional Stormwater Permit (MRP[4]) for monitoring data collected during Water Year (WY) 2016 (October 1, 2015 - September 30, 2016) pursuant to the following MRP provisions:

- Creek Status Monitoring (C.8.d) parameters that were sampled according to a regional probabilistic design; and
- Pesticides and Toxicity Monitoring (C.8.g).

The regional probabilistic design was developed and implemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). Additional data required by provision C.8.are reported in other appendices and portions of ACCWP's Urban Creeks Monitoring Report (UCMR), of which this is Appendix A.1.

The RMC was formed in early 2010 as a collaboration among several BASMAA members representing all MRP Permittees (Table 1-1) to focus on development and implementation of a regionally-coordinated water quality monitoring program. The intent of the regional monitoring effort is to improve stormwater management in the region and address water quality monitoring required by the MRP[5]. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan allowed Permittees and the Water Board to effectively modify their existing creek monitoring programs, and 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 Committee (MPC) and its associated RMC Work Group, a subgroup of the MPC that meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. This workgroup includes staff from the SF Bay RWQCB at two levels – those generally engaged with the MRP as well as those working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

[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) and reissued the permit on November 19, 2015 (SFRWQCB 2015) with an effective date of January 1, 2016. Unless otherwise noted references in this report to the MRP are to the reissued "MRP2"

5. The RMC includes 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. Note that the RMC regional monitoring design was expanded to include the portion of eastern Contra Costa County that drains to the San Francisco Bay in order to assist the CCCWP in fulfilling parallel provisions in their NPDES permit from the Region 5 Central Valley RWQCB.

Table 1-1. Regional Monitoring Coalition Participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
Contra Costa Clean Water Program (CCCWP)	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo Countywide Water Pollution Prevention Program (SMCWPPP)	Cities and towns 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

This report presents the results of the portions of Creek Status Monitoring that were conducted using a regional ambient (probabilistic) monitoring design to comply with portions of provision C.8.d, and the closely related Pesticides and Toxicity Monitoring required by provision C.8.g (Table 1-2). The list of parameters in Table 1-2 derive from the MRP provisions C.8.d and C.8.g (SFBRWQCB 2015) and BASMAA's Creek Status Monitoring Standard Operating Procedures (BASMAA 2016a, 2016b).

Table 1-2. Creek Status and Pesticide/Toxicity Monitoring Parameters sampled in compliance with MRP provisions C.8.d and g, and the associated design approach and Appendix of the ACCWP UCMR.

Biological Response and Stressor Indicators	MRP Provision	Monitoring Design		Reporting
		Regional Ambient (Probabilistic)	Local (Targeted)	
Bioassessment & Physical Habitat Assessment	C.8.d.i	X		Appendix A.1
Nutrients[6]	C.8.d.i	X		Appendix A.1
Chlorine	C.8.d.ii	X		Appendix A.1
Water Toxicity	C.8.g.i&iii	X		Appendix A.1
Sediment Toxicity	C.8.g.ii	X		Appendix A.1
Sediment Chemistry	C.8.g.ii	X		Appendix A.1
General Water Quality	C.8.d.iv		X	Appendix A.2
Temperature	C.8.d.iii		X	Appendix A.2
Bacteria	C.8.d.v		X	Appendix A.2

Prior to formation of the RMC, San Francisco Bay Area stormwater programs implemented monitoring designs that targeted creek reaches of interest to address site-specific management questions. Because the representativeness of such targeted data was unknown, the overall condition of all creek reaches in the Bay Area was also unknown. The RMC addressed this issue by augmenting targeted monitoring designs with an ambient (probabilistic) creek status design that integrates many elements of the individualized monitoring programs that currently exist in the region.

The probabilistic monitoring design described in subsequent sections of this report complies with MRP provision C.8.d[7] by addressing the core monitoring questions listed below, which are further elaborated upon later in this report and in the main UCMR. This monitoring design allow each individual RMC participating program to 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.

1. What is the condition of aquatic life in creeks in the San Francisco Bay Area; are water quality objectives met and are beneficial uses supported?

[6] Results of nutrient sampling conducted pursuant to provision C.8.f are reported in the main UCMR.

[7] The MRP states that provision C.8.d monitoring is intended to answer the following questions: “Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?”; “Are conditions in local receiving waters supportive of or likely to be supportive of beneficial uses?”.

2. What are the major stressors[8] to aquatic life?
3. What are the long-term trends in water quality in creeks over time?

The remainder of this report addresses Study Area and Monitoring Design (Section 2), data collection and analysis methods (Section 3), results and discussion including Stressor Assessment (Section 4), and Conclusions and Next Steps (Section 5). More specifically, this report includes the standard report content as required by MRP provision C.8.h.vi in the respective sections referenced in Table 1-3. Additional details or discussion may also be found in other Appendices or in the main UCMR.

Table 1-3. Index to Standard Report Content per MRP Provision C.8.h.vi.

Report Section	Standard Report Content
2.0	Monitoring purpose and study design rationale
3.0	Sampling protocols and analytical methods
4.1	QA/QC summaries for sample collection and analytical methods
2.1	Sample location descriptions, sample dates, IDs
4.0	Sample concentrations detected, measurement units, detection limits
4.0	Data assessment, analysis and interpretation
5.0	List of volunteer and other non-Permittee entities whose data are included in the report
6.0	Assessment of compliance with applicable water quality standards

2. Study Area & Monitoring Design

2.1 RMC Area

Creek Status and Pesticide and Toxicity monitoring was conducted in non-tidally influenced, flowing water bodies (i.e., creeks, streams and rivers) interspersed among 3,407 square miles of land in the RMC area. The water bodies monitored were drawn from a master list that included all perennial and non-perennial creeks and channels that run through urban and non-urban areas within the portions of the five participating counties that fall within the SF Bay RWQCB boundary, and the eastern portion of Contra Costa County that drains to the Central Valley Regional Board (Figure 2-1). This report presents data collected by ACCWP during WY 2016.

[8] Stressors are interpreted per MRP provision C.8.d (SFBRWQCB 2015) as results that "trigger" action based upon comparison with an identified threshold.

2.2 Regional Monitoring Design

In 2011, the RMC developed a regional probabilistic monitoring design to identify ambient conditions of creeks in the five main counties subject to the requirements of the MRP[9] (SFBRWQCB 2009). The regional 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 SWAMP (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's (SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SMC 2007). For the purpose of developing the RMC's probabilistic design, the RMC area is considered to represent the "sample universe".

2.2.1 Site Selection

Bioassessment 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 RMC boundary[10] (BASMAA 2011). This approach was agreed to by SF Bay RWQCB staff during RMC workgroup meetings although it differed from that specified in provision C.8.c.iv of MRP 1, e.g., sampling on the basis of individual watersheds in rotation and selecting sites to characterize segments of a waterbody(s).The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the storm water programs associated with the RMC. The sample frame was stratified by management unit to ensure that provision C.8.c of MRP1 sample size requirements (SFBRWQCB 2009) would be achieved.

The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for future data coordination with these programs. The RMC sample frame was classified by county and

[9] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) issued the first five-year MRP (MRP1) to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009) and reissued the permit on November 19, 2015 (MRP2, SFBRWQCB 2015) with an effective date of January 1, 2016. Unless otherwise noted references in this report to the MRP are to the reissued "MRP2"

[10]Based on discussion during RMC Workgroup meetings, with SF Bay RWQCB staff present, the sample frame was extended to include the portion of Eastern Contra Costa County that drains to the San Francisco Bay in order to address parallel provisions in CCCWP's Region 5 Permit for Eastern Contra Costa County. The rest of the sample frame is within the boundaries of SFBRWQCB jurisdiction.

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 sample universe (i.e., RMC area). Based on discussion during RMC Workgroup meetings, with SF Bay RWQCB staff present, RMC participants weighted their sampling efforts so that annual sampling efforts are approximately 80% in urban areas and 20% in non-urban areas for the purpose of comparison. During WYs 2012-2015 RMC participants coordinated with the SF Bay RWQCB by identifying additional non-urban sites from their respective counties for SWAMP sampling.

Bioassessment sites sampled by ACCWP during the reporting period are shown in Figure 2-1 and Table 2-1.

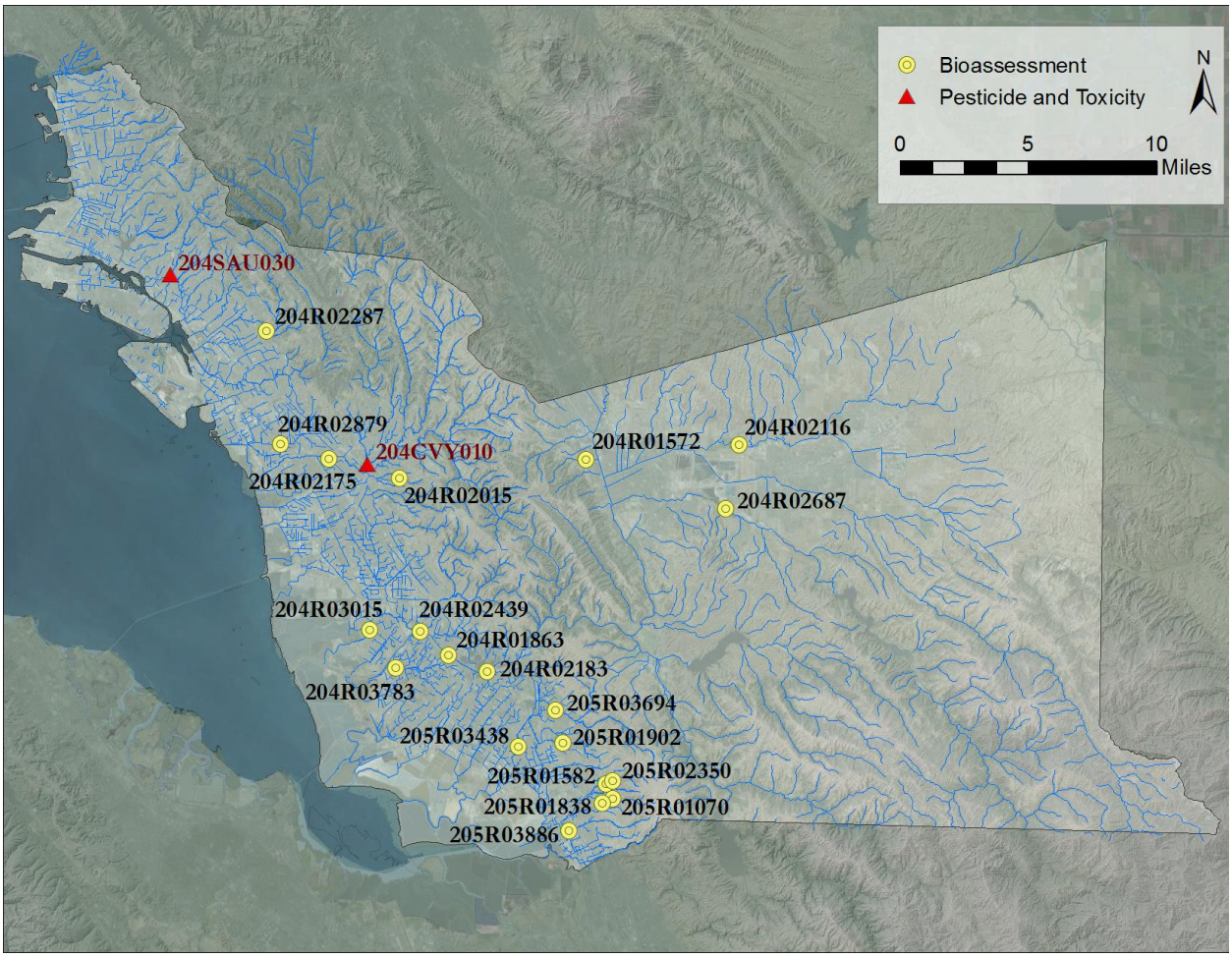

Figure 2-1. Alameda County sites sampled from the RMC probabilistic monitoring design and for Pesticides and Toxicity Monitoring in Water Year 2016.

Table 2-1. Alameda County Bioassessment Sites Sampled in Water Year 2016 by ACCWP.

Site ID	Creek Name	Land Use	Latitude	Longitude	Sampling Date
204R01572	Gold Creek	Urban	37.6891	-121.9248	5/5/2016
204R01863	Alameda Creek	Urban	37.57515	-122.01984	5/24/2016
204R02015	Sulphur Creek	Urban	37.67451	-122.05757	5/17/2016
204R02116	Arroyo Las Positas	Urban	37.69739	-121.81625	5/25/2016
204R02175	San Lorenzo Creek	Urban	37.68454	-122.10825	5/17/2016
204R02183	Alameda Creek	Urban	37.56622	-121.9924	5/23/2016
204R02287	Arroyo Viejo	Urban	37.75567	-122.15483	5/26/2016
204R02439	Alameda Creek	Urban	37.58765	-122.04057	5/24/2016
204R02687	Arroyo del Valle	Urban	37.66101	-121.82442	6/1/2016
204R02879	Estudillo Canal	Urban	37.69224	-122.14314	5/31/2016
204R03015	Zone 5 Line J-3	Urban	37.58821	-122.07665	5/25/2016
204R03783	Crandall Creek	Urban	37.56722	-122.05749	5/18/2016
205R01070	Tributary to Agua Fria	Urban	37.49588	-121.90107	5/4/2016
205R01582	Agua Caliente	Urban	37.50463	-121.90598	5/3/2016
205R01838	Agua Fria	Urban	37.49337	-121.90866	5/4/2016
205R01902	Sabercat Creek	Urban	37.52703	-121.93739	5/2/2016
205R02350	Agua Caliente	Urban	37.50578	-121.90118	5/3/2016
205R03438	Zone 6 Line G	Urban	37.52406	-121.96912	5/18/2016
205R03694	Mission Creek	Urban	37.54533	-121.94308	5/19/2016
205R03886	Zone 6 Line G	Urban	37.47742	-121.93189	5/16/2016

2.2.2 Management Questions

The RMC regional monitoring design was developed to address the management questions listed below. Those appearing in bolded font are addressed in this report in a preliminary manner. Those in normal font could not be addressed in this report due to the limited sample size from the Program's annual monitoring, but can be answered through collaborative review of cumulative data from all counties.

illustrates the length of time that would be required to establish statistically representative sample sizes for each of the classified strata in the regional monitoring design, estimated for continuation of the MRP-prescribed rate of annual bioassessment sampling.

1. **What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?**
    a. **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?**
    b. What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?
    c. **To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?**
    d. 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?**
    a. **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?

Table 2-2. Cumulative numbers of bioassessment samples per monitoring year according to RMC design; shaded cells indicate when a minimum sample size may be available to develop a statistically representative data set to address management questions related to condition of aquatic life.

Monitoring Year	RMC Area (Region-wide)		Santa Clara County		Alameda County		Contra Costa County		San Mateo County		Fairfield, Suisun City and Vallejo	
Land Use	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*
Year 1 (WY 2012)	**48**	22	16	6	16	6	8	4	8	4	0	2
Year 2 (WY 2013)	**100**	**44**	**32**	12	**32**	12	16	8	16	8	8	0
Year 3 (WY 2014)	**156**	**66**	**48**	18	**48**	18	24	12	24	12	12	6
Year 4 (WY 2015)	**204**	**88**	**64**	24	**64**	24	**32**	16	**32**	16	12	8
Year 5 (WY 2016)	**256**	**110**	**80**	**30**	**80**	**30**	**40**	20	**40**	20	16	10

Notes: 1. Non-Urban sample numbers assume that San Francisco Bay RWQCB would continue WY 2012-2013 sample effort of two non-urban sites annually in each RMC County

2. Assumes: FSURMP and Vallejo only monitor urban sites; FSURMP monitors 4 sites in Years 2, 3 and 5; and Vallejo monitors 4 sites in Year 3.

In Fiscal Year 2017/2018 BASMAA will conduct a regional project to analyze bioassessment monitoring data collected during five years (WY2012 – WY2016) by all participating RMC programs. The resulting integrative report will compile, analyze and map data and evaluate the usefulness of the data and may recommend changes to the probabilistic design of the RMC Multi-year Monitoring Plan and/or outline a redesign process that will address changes in other regional and state monitoring programs.

2.2.3 Pesticide and Toxicity Monitoring

The reissued MRP contains a separate provision C.8.g to combine all pesticide and toxicity monitoring into one section, instead of being distributed between Creek Status and Pollutants of Concern Monitoring provisions. This format is intended to provide for sampling designs that may provide more meaningful data for the region and potentially for statewide studies[11]. C.8.g requires Permittees to select monitoring sites where toxicity could be likely, so for WY2016 ACCWP selected the following two sites shown on Figure 2-1:

- 204CVY010, Castro Valley Creek at USGS gauge 11181008, is a location at the bottom of an urban subwatershed where water column toxicity was found in ACCWP monitoring during the 1990's (S.R. Hansen & Associates 1995).
- 204SAU030, Sausal Creek at East 22nd Street, is close to the bottom of a mostly urban watershed, where water column toxicity and sediment growth effects were previously found in samples collected by the SWAMP program (SFBRWQCB 2008).

While this approach for pesticide and toxicity monitoring site selection is not explicitly linked to the probabilistic design used to select bioassessment sites, water quality problems due to pesticide-related toxicity are similar in urban waterways across the region and state and sampling will continue to be coordinated in a regional context.

2.2.4 Monitoring Design Implementation

Sampling was conducted in accordance with the RMC Multi-year Monitoring Plan (BASMAA 2011). The sampling plan (**Error! Reference source not found.**) illustrates the total number of sites that each RMC program planned to sample within the term of MRP 1. It also illustrates the number of sampling years required to establish statistically representative samples for each strata (e.g., management unit and urban or non-urban land use) included in the regional monitoring design. At least 80% of the sites sampled annually by RMC participants are in urban areas and up to 20% may be in non-urban areas. Due to unforeseen field circumstances, however, this percentage may vary by year. For example, some sites may not be sampleable due to seasonal

[11] This provision may also be modified in the future in response to changes in pesticide use and efforts to develop a statewide coordinated program for monitoring pesticides and pesticide-related toxicity.

drying and/or access issues, thereby altering the relative proportion of urban-to-non-urban sites sampled in a given year, or requiring excessive effort to be expended in screening and reconnaissance of prospective sites. Such outcomes can be addressed in subsequent sampling years by adjusting the relative proportion of urban and non-urban sites.

3. Monitoring Methods

This section describes the methods used to evaluate monitoring sites identified in the regional sample draw, consistent with the Southern California Coastal Water Research Project (SCCWRP) Bioassessment Program (SCCWRP 2012), and to sample field data, consistent with the RMC workplan (BASMAA 2011), Field parameters sampled at all sites included benthic macroinvertebrate community, algal community and biomass, and physical habitat. Physico-chemical measurements (dissolved oxygen, temperature, conductivity, and pH), chlorine, and nutrients were sampled concurrently as required by the SWAMP protocol or MRP.

3.1 Site Evaluation

Sites identified in the regional sample draw were evaluated by each RMC participant in chronological order using a two-step process, consistent with that described by SCCWRP[12] (2012). Each site was evaluated to determine if it met the following RMC sampling location criteria:

1. The location (latitude/longitude) provided for a site is located on or is within 300 meters of a non-impounded receiving water body;
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 operating 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[13].

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** - Sites that met all seven criteria were classified as **target sampleable** status **(TS),** and sites that met criteria 1 through 4, but did not meet at least one of criteria 5 through 7 were classified as **target non-sampleable (TNS)**.
- **Non-Target (NT)** - Sites that did not meet at least one of criteria 1 through 4 were classified as non-target status.

[12]Communication with managers for the SMC and the PSA are ongoing to ensure consistency of site evaluation protocols.

[13]If landowners who 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.

- **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.

During the site evaluation field visits flow status was recorded as one of five categories:

- **Wet Flowing** - Continuously wet or nearly so, flowing water.
- **Wet Trickle** - Continuously wet or nearly so, very low flow (trickle, less than 0.1 L/second).
- **Majority Wet** - Discontinuously wet, greater than 25% by length of stream bed covered with water (isolated pools).
- **Minority Wet** - Discontinuously wet, less than 25% of stream bed by length covered with water (isolated pools).
- **No Water -** No surface water present.

Observations of flow status occurring during fall site reconnaissance events prior to occurrence of significant precipitation, and spring sampling occurring post- wet weather season were combined to classify sites as perennial or non-perennial as follows:

- **Perennial -** Fall flow status either Wet Flowing or Wet Trickle and spring flow sufficient to sample.
- **Non-Perennial** - Fall flow status either Majority Wet, Minority Wet, or No Water, and spring flow sufficient to sample.

3.2 Field Data Collection Methods

Field data were collected in accordance with existing SWAMP-comparable methods and procedures, as described in the RMC Quality Assurance Project Plan (QAPPv3) and the associated Standard Operating Procedures which were updated to maintain their currency and optimal applicability (BASMAA 2016a, 2016b). 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. The SOPs relevant to the monitoring discussed in this report are listed in Table 3-1.

Table 3-1 RMC Standard Operating Procedures (SOPs) pertaining to regional creek status monitoring.

SOP #	SOP
FS-1	Benthic Macroinvertebrate and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity Testing
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-6	Collection of Bedded Sediment Samples
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review

3.2.1 Bioassessments

In accordance with the RMC QAPP (BASMAA 2016a), bioassessments are intended to be conducted during the spring index period (approximately April 15 – June 15) and at a minimum of 30 days after any significant storm (roughly defined as at least 0.5-inch of rainfall within a 24-hour period).

In WY 2016 sampling at all sites was conducted between 5/2/2016 and 6/1/2016 and conformed with the relevant protocols listed above. Four reaches had to be shortened and their lengths, and explanations for the reduced reach lengths, are shown in Table 3-2-2 below.

Table 3-2. 2016 ACCWP Sites with Shortened Reaches

SiteCode	Length (m)	Rationale for Shortened Reach
204R01572	120	Avoid downstream culvert
204R02287	120	Limited access upstream (permissions not granted) and change in habitat downstream
204R02879	120	Roadway overpass upstream
204R02687	100	Avoid densest vegetation within channel

Benthic Macroinvertebrates

The BMI samples were collected using the Reachwide Benthos (RWB) method described in SOP FS-1 (BASMAA2016b).

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. The

sampling position within each transect alternated between 25%, 50% and 75% distance of the wetted width of the stream. Benthic macroinvertebrates (BMIs) were collected from a 1 ft^2 area approximately 1 m downstream of each transect. The benthos were disturbed by manually rubbing coarse substrate followed by disturbing the upper layers of substrate to a depth of 4-6 inches to dislodge any remaining invertebrates into the net. Slack water habitat procedures were used at transects with deep and/or slow moving water (Ode 2007). Material collected from the eleven subsamples was composited in the field by transferring entire sample into one to two 1000 ml wide-mouth jar(s) and preserved with 95% ethanol.

Algae

Filamentous algae and diatoms were collected using the Reach-wide Benthos (RWB) method described in SOP FS-1 (BASMAA 2016b). Algae samples were collected synoptically with BMI samples. The sampling position within each transect was the same as used for BMI sampling, however, samples were collected six inches upstream of the BMI sampling position and prior to BMI collection from that location. The algae were collected using a range of methods and equipment, depending on the particular substrate occurring at the site (i.e., erosional, depositional, large and/or immobile, etc.) per SOP FS-1. Erosional substrates included any material (substrate or organics) that was small enough to be removed from the stream bed, but large enough in size to isolate an area equal in size to a rubber delimiter (12.6 cm2 in area). When a sample location along a transect was too deep to sample, a more suitable location was selected, either on the same transect or from one further upstream. Algae samples were collected at each transect prior to moving on to the next transect. Sample material (substrate and water) from all eleven transects was combined in a sample bucket, agitated, and a suspended algae sample was then poured into a 500 mL cylinder, creating a composite sample for the site. A 45 mL subsample was taken from the algae composite sample and combined with 5 mL glutaraldehyde into a 50 mL sample tube for taxonomic identification of soft algae. Similarly, a 40 mL subsample was extracted from the algae composite sample and combined with 10 mL of 10% formalin into a 50 mL sample tube for taxonomic identification of diatoms. Laboratory processing included identification and enumeration of 300 natural units of soft algae and 600 diatom valves to the lowest practical taxonomic level.

The algae composite sample was also used for collection of chlorophyll *a* and ash free dry mass (AFDM) samples following methods described in Fetscher et al. (2009). For chlorophyll *a* samples, 25 mL of the algae composite volume was removed and run through glass fiber filter (47 mm, 0.7 um pore size) using a filtering tower apparatus. The AFDM sample was collected using a similar process using pre-combusted filters. Both samples were placed in whirlpaks, covered in aluminum foil and immediately placed on ice for transportation to the laboratory.

3.2.2 Physical Habitat

Physical habitat assessments (PHab) were conducted at each BMI bioassessment sampling event using the PHab protocols described in Ode (2007) and augmented by Fetscher et al. (2009) (see SOP FS-1, BASMAA 2016b). Physical habitat data were collected at each of the 11 transects and at 10 additional inter-transects (located between each main transect) by implementing the "Basic" level of effort, with the following additional measurements/assessments as defined in the "Full" level of effort (as prescribed in the MRP): water depth and pebble counts, cobble embeddedness, flow habitat delineation, and instream habitat complexity. At algae sampling locations, additional assessment of presence of micro- and macroalgae was conducted during the pebble counts. In addition, water velocities were measured at a single location in the sample reach (when possible) using protocols described in Ode (2007).

3.2.3 Physico-chemical Measurements

Field personnel measured dissolved oxygen, temperature, conductivity, and pH during bioassessment sampling using a multi-parameter probe (see SOP FS-3, BASMAA 2016b). Dissolved oxygen, specific conductivity, water temperature and pH measurements were made either by direct submersion of the instrument probe into the sample stream, or by collection and immediate analysis of grab sample in the field. Water quality measurements were taken approximately 0.1 m below the water surface at locations of the stream that appears to be completely mixed, ideally at the centroid of the stream. Measurements should occur upstream of sampling personnel and equipment and upstream of areas where bed sediments have been disturbed, or prior to such bed disturbance.

3.2.4 Other Water Quality Analytes

Chlorine

Field personnel collected and analyzed water grab samples for free and total chlorine using CHEMetrics test kits (K-2511 for low range, and K-2504 for high range). Chlorine measurements in water were conducted during bioassessments and during dry season monitoring for sediment chemistry, sediment toxicity, and water toxicity.

Nutrients and Conventional Analytes

Concurrent with bioassessments, field personnel collected water samples for nutrient analyses using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2016b). Sample containers were rinsed, as appropriate, using ambient water and completely filled and recapped below water surface whenever possible. An intermediate container was used to collect water for all sample containers pre-preserved by the laboratory. Syringe filtration method was used to collect samples for analyses of Dissolved Ortho-P, with Dissolved Organic Carbon now filtered in the lab within the requisite 48-hr hold time. Sample container size and type, preservative type and associated holding times for each analyte are described in Table 1 of

FS-9 (BASMAA 2016b). All sample containers were labeled and stored on ice for transportation to laboratory, with exception of analysis of Ash Free Dry Mass and Chlorophyll *a* samples, which were field-frozen on dry ice by sampling teams upon collection.

3.2.5 Water Toxicity

Field personnel collected water samples using the Standard Grab Sample Collection Method described above, filling the required number of 4-L amber glass bottles with ambient water, putting them on ice to cool to 4 ±2 °C, and delivering to the laboratory within the required hold time. Bottle labels and COCs included station ID, sample code, matrix type, analysis type, project ID, and date and time of collection. The laboratory was notified of the impending sample delivery to meet the 36-hour sample delivery time requirement. Procedures used for sampling and transporting samples are described in SOP FS-2 (BASMAA 2016b).

3.2.6 Sediment Chemistry & Sediment Toxicity

In the case where sediment samples and water samples / measurements were collected at the same event, sediment samples were collected after any water samples were collected. Before conducting sampling, field personnel surveyed the proposed sampling area to identify appropriate fine-sediment depositional areas, to avoid disturbing possible sediment collection sub-sites. Personnel carefully entered the stream and started sampling at the closest appropriate reach, continuing upstream. Sediment samples were collected from the top 2 cm of sediment in a compositing container, thoroughly homogenized, and then aliquotted into separate jars for chemical and toxicological analysis using standard clean sampling techniques (see SOP FS-6, BASMAA 2016b). Sample jars were submitted to respective laboratories per SOP FS-9 (BASMAA 2016b).

3.3 Laboratory Analysis Methods

ACCWP and other RMC participants agreed to use the same laboratories for individual parameters, developed standards for contracting with the labs, and coordinated quality assurance issues. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2016a). Analytical laboratory methods, are also reported in BASMAA (2012a). Analytical laboratory contractors used for analysis of benthic macroinvertebrate and algae taxonomic identification, chemistry, and toxicity included:

- BioAssessment Services, Inc. – BMI identification
- EcoAnalysts, Inc. – Algae identification
- CalTest, Inc. – Sediment Chemistry, Nutrients, Chlorophyll *a*, Ash Free Dry Mass
- Pacific EcoRisk, Inc. - Water and Sediment Toxicity

The laboratory analytical methods identified BMIs at a 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 Surface Water Ambient Monitoring Program (SWAMP) protocols (SWRCB 2011a, SWRCB 2011b, Stancheva et al. 2015). The taxonomic resolution for all data was compared and revised when necessary to match the SWAMP master taxonomic list.

3.4 Data Analysis

This section describes methods used to analyze bioassessment data collected during Water Year 2016. As the cumulative RMC sample sizes increase through monitoring conducted in future years (**Error! Reference source not found.**), it will be possible to develop a statistically representative data set to address management questions related to condition of aquatic life and report on these per MRP provision C.8.h.iii.

3.4.1 Biological Condition

The California Stream Condition Index (CSCI) is a biological index, developed by the State Water Resources Control Board (State Board), 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 represents the full range of natural conditions in California (Rehn et al. 2015). The CSCI combines two types of indices: 1) taxonomic completeness, as measured by the ratio of observed-to-expected taxa (O/E); and 2) ecological structure and function, measured as a predictive multi-metric index (pMMI) that is based on reference conditions. The CSCI score is computed as the average of the sum of O/E and pMMI.

The State Board is continuing to evaluate the performance of CSCI in a regulatory context. In the re-issued MRP 2.0 (adopted on November 19, 2015), 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 Stressor Source Identification (SSID) projects.

The State Water Board is also developing and testing a statewide index using benthic algae data as a measure of biological condition and identification of potential stressors. The statewide algae IBI Index is expected to be completed in 2017. This report applies selected algal indices of biological integrity (IBIs) that were developed and tested using algae data collected in Southern California (Fetscher et al. 2014). The 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).

Bioassessment Data Analysis

For BMI samples collected at 20 sites in Alameda County in WY 2016, the laboratory analytical methods identified BMIs at a 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 Surface Water Ambient Monitoring Program (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.

California Stream Condition Index Score

The CSCI is calculated using a combination of biological and environmental data following methods described in Rehn et al. (2015). Biological data include BMI data collected and analyzed using protocols described in the previous section. The environmental predictor data are generated in geographic information system (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).

EOA staff compiled and/or created drainage areas in ArcGIS using 10-meter Digital Elevation Model (DEM) data and the Arc Hydro tool. In most cases, the watershed/catchment polygons created with the Arc Hydro tool required editing to adjust the downstream edge of the drainage area to the sampling locations. When necessary, other existing data sources, including watershed/catchment data developed by the San Francisco Estuary Institute (SFEI) and the Oakland Museum and storm drain network data provided by municipalities, were used to modify the DEM-derived watershed boundaries. These modifications were typical in the low gradient urban areas along the San Francisco Bay and in Livermore Valley. All delineations were independently reviewed for accuracy using Google Earth.

To develop the CSCI scores, eight GIS datasets from the California Department of Fish and Wildlife were analyzed in ArcGIS to calculate a range of environmental predictors for each sampling location. Site elevation, temperature, and annual precipitation values were obtained directly at the sampling location. Elevation range was calculated from the difference in elevation between the top and the bottom of the watershed/catchment. Mean monthly precipitation, bulk

soil density, soil erodibility, and phosphorous geology are predictors that are averaged across each watershed, and are calculated in ArcGIS using zonal statistics.

The CSCI scores were evaluated using condition categories described in Rehn et al. (2015). Four classes representing a range of biological conditions were defined using a distribution of scores at reference calibration sites throughout the State of California (Table 3-3). The categories are described as "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). The likely altered category coincides with the threshold identified in MRP 2.0.

Algae Index of Biological Integrity Scores

Algae data collected in Alameda County were evaluated using an online calculator available on the Southern California Coastal Water Research Project (SCCWRP) website (http://www.sccwrp.org/Data/DataTools/algaeIBI.aspx). The Algae IBI Assessment Tool analyzes benthic algae data. The 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). Three of these algal IBIs were used to evaluate algae data collected in Alameda County; including a soft algae index (S2), a diatom index (D18) and a hybrid index (H20). Algae IBI Scores condition categories developed by Fetscher et al (2014) for the 30th, 10th and 1st percentile of reference sites are listed in Table 3-3.

Table 3-3. Condition categories used to evaluate CSCI and Algae IBI (D18 and S2) scores.

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

3.4.2 Physical habitat condition

BASMAA (2013) prepared a data analysis of physical habitat scores from all RMC bioassessment sites monitored in WY 2012, based on the combination of scores for three

physical habitat sub-categories. While these scores can be useful in interpreting results from individual sites, their interpretation did not add substantially to the information from the IBI scores. The CSCI uses characteristics of the watershed draining to each site to develop the score for that site and thus integrates larger-scale physical habitat structure into the condition assessment.

3.4.3 Water and Sediment Chemistry and Toxicity

As part of the Stressor Assessment for this report, 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 diminished biological conditions. Creek status monitoring and pesticides and toxicity data must be evaluated with respect to thresholds or "triggers" specified in the MRP to identify whether a site is a candidate for SSID project followup, . The trigger criteria listed in provisions C.8.d and C.8.g were used to identify sites where water quality impacts may have occurred. For water and sediment chemistry and toxicity data, the relevant trigger criteria are identified in provision C.8.g.iv and listed below as follows:

1) A toxicity test of growth, reproduction, or survival of any test organism is reported as "fail" in both the initial sampling and a second, followup sampling, and both have ≥ 50% Percent Effect;
2) A pollutant is present at a concentration exceeding its water quality objective (WQO) in the Basin Plan[14];
3) For pollutants without WQOs, results exceed Probable Effects Concentrations (PECs) or Threshold Effects Concentrations (TECs).

For sediment chemistry trigger criteria, threshold effect concentrations (TECs) and probable effect concentrations (PECs) are as defined in MacDonald et al. (2000). For all applicable contaminants specified in MacDonald et al. (2000), the ratio of the measured concentration to the respective TEC value was computed as the TEC quotient. PEC quotients were also computed for those same sediment chemistry constituents using PEC values from MacDonald et al. (2000). All results where a TEC or PEC quotient was equal to or greater than 1.0 were identified.

Criterion (1) above applies to toxicity results of water column and sediment monitoring in both dry weather and wet weather. Criterion (2) applies to results of water column chemistry monitoring in both dry weather and wet weather, and is also appropriate for water quality samples collected at regional bioassessment monitoring sites per provision C.8.d.i, which does

[14] The San Francisco Basin Water Quality Control Plan ,SFBRWQCB (2013) does not contain water quality objectives for pollutants in sediment. Environmental screening levels or sediment target concentrations defined by Total Maximum Daily Loads for specific pollutants are not considered applicable to Criterion (2).

not specify trigger criteria for those parameters. Criterion (3) applies to chemical results of sediment monitoring in dry weather.

3.5 Quality Assurance and Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA 2016a). They generally involved the following:

Measurement Quality Objectives (MQOs) were established to ensure that data collected were of sufficient and adequate quality for the intended use. DQOs include both quantitative and qualitative assessment of the acceptability of data. The qualitative goals include representativeness and comparability. The quantitative goals include completeness, sensitivity (detection and quantitation limits), precision, accuracy, and contamination. To ensure consistent and comparable field techniques, pre-monitoring field training and in-situ field assessments were conducted.

Data were collected according to the procedures described in the relevant SOPs (BASMAA 2016b), including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

All data were thoroughly reviewed for conformance with QAPP requirements and field procedures were reviewed for compliance with the methods specified in the relevant SOPs. Data quality was assessed and qualifiers were assigned as necessary in accordance with SWAMP requirements. See Section 7 for evaluations of Program-specific data quality associated with monitoring conducted in WY 2016.

4. Results & Discussion

The MRP places an emphasis on minimizing sources of pollutants that could impair water quality as a central purpose of urban runoff management programs. The MRP requires monitoring to address the management question,

- ***"What are the sources to urban runoff that contribute to receiving water problems?"***

The RMC accomplishes this through a multi-step process that involves conducting monitoring to provide data to inform an assessment of conditions and identification of stressors that may be

impacting water quality and/or biological conditions. The information generated through the condition assessment and stressor assessment will then be used to help direct efforts to identify sources of problematic pollutants or other stressors in urban runoff discharges.

In this section, following a brief statement of data quality, the bioassessment data are evaluated against the trigger criteria found in C.8.d, and data for toxicity and sediment chemistry are evaluated against trigger criteria in C.8.g of the MRP (SFBRWQCB 2015) to provide a preliminary identification of potential stressors. The results of the initial stressor assessment evaluation (BASMAA 2013) were used to initiate a stressor-source identification project as described in the 2014 Integrated Monitoring Report (ACCWP 2014).

4.1 Statement of Data Quality

The RMC established a set of guidance and tools to help ensure data quality and consistency implemented through collaborating Programs. Additionally, the RMC participants continue to meet and coordinate in an ongoing basis to plan and coordinate monitoring, data management, and reporting activities, among others.

A comprehensive QA/QC program was implemented by each of the RMC Programs, which is solely responsible for the quality of the data submitted on its behalf, covering all aspects of the regional/probabilistic monitoring. In general, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2016a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2016b), and in conformity with SWAMP protocols. Details of the results of evaluations of laboratory-generated QA/QC results are included elsewhere in the ACCWP UCMR and other appendices if applicable. Issues noted by the laboratories and/or RMC field crews are summarized below.

4.1.1 Sediment Chemistry

Several issues were identified by the analytical laboratory (Caltest) as being noncompliant with Project Measurement Quality Objectives (MQOs), and the sediment chemistry data were qualified accordingly. These issues included:

- Matrix Spike recoveries were reported as either not calculable or outside of control limits for multiple trace elements (chromium, copper, lead, nickel, zinc), carbaryl, and multiple PAHs (benzo(a)pyrene, benzo(b)fluouranthene, and benzo(k)fluouranthene).

Other issues in conflict with RMC QAPP MQOs were not identified by the laboratory, but were identified during QA review and were qualified as appropriate. These issues included:

- A small number of surrogates associated with analysis of carbaryl (Chloroxuron) and PAHs (Fluorobiphenyl, 2- and Nitrobenzene-d5) were reported as outside of QAPP control limits.

- Relative percent differences (RPDs) reported for Matrix Spike / Matrix Spike Duplicate (MS/MSD) pairs exceeded QAPP control limits for PAHs biphenyl, methylnaphthalene, 2- and dimethylnaphthalene, 2,6.
- For the original lab deliverable supplied by Caltest, the subcontractor performing analysis of total organic carbon (TOC) and particle size distribution (PSD) did not report a laboratory duplicate for either analysis as required by the RMC QAPP. Caltest had previously discussed this issue with the subcontract lab (SCL) and was able to obtain duplicate data for the analysis of PSD, which exhibit RPDs within QAPP control limits, and therefore required no additional qualification. The TOC data, however, was still lacking duplicate information; therefore the results of the blind field duplicate collected for SCVURPPP were used as a substitute indicator of precision, which should serve as a conservative indicator as it incorporates both analytical variability as well as field sampling variability. The field RPD of 4% fell within control limits and no additional qualification was therefore made. We will reiterate the request to supply lab duplicate information for all applicable subcontract analyses to Caltest prior to WY2017 monitoring.

4.1.2 Water Chemistry

Several issues were identified with respect to water chemistry analyses by either the laboratory or the QAO review, including:

- A limited number of Lab QA/QC sample results for nutrients and conventional parameters were reported by the laboratory as qualified data due to minor issues not thought to affect the use or interpretation of sample results. These issues included:
    - Percent recoveries (PRs) reported for MS/MSD samples associated with analysis of ammonia, total Kjeldahl nitrogen (TKN), silica, and phosphorus in one or more lab batches were outside control limits.
- A small number of analyses of nitrate were reported as a non-detects with reporting limits that exceeded QAPP target.
- Calculated field RPDs associated with analysis of blind field duplicate samples for several analytes exceeded QAPP MQOs. As the control limits for field duplicates are identical to those of lab duplicate analyses, this is not a surprising occurrence. WY2016 data were qualified as dictated by comparison with QAPP control limits.

4.1.3 Sediment Toxicity

There were no issues identified associated with sediment toxicity analyses.

4.1.4 Water Toxicity

There were no issues identified associated with aquatic toxicity analyses.

4.2 Condition Assessment

Condition assessment addresses the RMC core management question

- ***"What is the condition of aquatic life in creeks in the RMC area; are aquatic life beneficial uses supported?"***

Table 4-1 lists the beneficial uses of creeks sampled during WY 2016. By default creeks and other fresh water bodies not listed or included in larger creeks by the "tributary rule" are assigned the WARM and WILD presumptive uses in the Basin Plan (SFBRWQCB 2013).

Table 4-1. ACCWP creeks sampled in WY 2016 and associated designated beneficial uses listed in the San Francisco Bay Region Basin Plan. Sites not in or tributary to creeks listed in Chapter 2 of the Basin Plan do not appear in this table.

		← Human Consumptive Uses →							← Aquatic Life Uses →								Wildlife Use	Recreational Uses		
Site ID	**Waterbody**	**AGR**	**MUN**	**FRSH**	**GWR**	**IND**	**PROC**	**COMM**	**SHELL**	**COLD**	**EST**	**MAR**	**MIGR**	**RARE**	**SPWN**	**WARM**	**WILD**	**REC-1**	**REC-2**	**NAV**
ALAMEDA COUNTY																				
204R01863	Alameda Creek	E			E			E		E			E	E	E	E	E	E	E	
204R02015	Sulphur Creek															E	E	E	E	
204R02116	Arroyo Las Positas				E					E			E	E	E	E	E	E	E	
204R02175	San Lorenzo Creek		E	E	E					E			E		E	E	E	E	E	
204R02183	Alameda Creek	E			E			E		E			E	E	E	E	E	E	E	
204R02287	Arroyo Viejo									E						E	E	E	E	
204R02439 204R01572	Alameda Creek and tributary, Gold Creek	E			E			E		E			E	E	E	E	E	E	E	
204R02687	Arroyo del Valle		E		E					E			P	E	E	E	E	E	E	
204R02879	Estudillo Canal															E	E	E	E	
204R03783	Crandall Creek															E	E	E	E	
205R01582	Agua Caliente															E	E	E	E	
205R01838 204R02439	Agua Fria and unnamed tributary															E	E	E	E	
205R01902	Sabercat Creek															E	E	E	E	
205R02350	Agua Caliente															E	E	E	E	
205R03694	Mission Creek															E	E	E	E	
205R03886	Zone 6 Line C													E		E	E	E	E	

Abbreviations:

COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
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" (SFBRWQCB 2013).

4.2.1 Assessing Biological Condition

Table 4-2 summarizes the numbers of WY 2016 sites assigned to various condition categories by CSCI and algae assessments.

Table 4-2. Distribution of CSCI and Algae IBI condition categories for 20 probabilistic urban sites sampled in Alameda County during WY 2016.

Condition Category	CSCI	Diatom D18 IBI	Algae S2 IBI*	Hybrid "H20" Algae IBI*
Likely Intact (LI)	0	3	0	0
Possibly Intact (PI)	2	1	0	0
Likely Altered (LA)	3	8	1	0
Very Likely Altered (VLA)	15	8	15	19

*4 sites had no Algae S2 IBI scores and one site had no H20 score due to an insufficient number of soft algae taxa needed to calculate a score.

Table 4-3 and Figure 4-1 show the condition categories assigned to the 20 sites sampled in Alameda County during WY 2016. Biological condition scores for CSCI and algae IBIs (S2, D18, and H20) are listed in Table 4-4. Site characteristics related to impervious area, flow status, and channel modification status are also presented in the table for reference.

Using the algae IBI and CSCI condition categories shown in Table 3-3, the WY 2016 sites were rated as follows:

- CSCI - Fifteen sites (75%) were rated as “very likely altered” condition, three sites (15%) were rated as “likely altered” condition, two sites (10%) ranked as “possibly intact,” and none ranked as “likely intact” condition.
- D18 - There was a wide range of biological condition scores for D18, with eight sites (40%) rated as “very likely altered” condition, eight sites (40%) rated as “likely altered” condition, one site (5%) rated as “possibly intact” condition, and three sites (15%) rated as “likely intact” condition.
- S2 - Four sites had no Algae S2 IBI scores due to an insufficient number of soft algae taxa needed to calculate a score. Of the remaining sixteen sites, fifteen site (94%) rated as “Very Likely Altered” condition, and one site (6%) rated as “Likely Altered” condition.
- H20 - Nineteen sites (95%) were rated as “very likely altered” condition for H20 IBI score. There was no H20 IBI score for the one site classified as “unknown” due to inadequate presence of soft algae taxa.

Table 4-3. CSCI and Algae IBI condition categories for 20 probabilistic urban sites sampled in Alameda County during WY 2016.

Station Code	Creek	CSCI Category	Hybrid H20 Category	Diatom D18 Category	Algae S2 Category
204R01572	Gold Creek	Very Likely Altered	Very Likely Altered	Possibly Intact	NA
204R01863	Alameda Creek	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered
204R02015	Sulphur Creek	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered
204R02116	Arroyo Las Positas	Very Likely Altered	Very Likely Altered	Likely Altered	Very Likely Altered
204R02175	San Lorenzo Creek	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered
204R02183	Alameda Creek	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered
204R02287	Arroyo Viejo	Very Likely Altered	Very Likely Altered	Likely Altered	Very Likely Altered
204R02439	Alameda Creek	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered
204R02687	Arroyo del Valle	Likely Altered	Very Likely Altered	Likely Altered	Very Likely Altered
204R02879	Estudillo Canal	Very Likely Altered	Very Likely Altered	Possibly Intact	Very Likely Altered
204R03015	Zone 5 Line J-3	Very Likely Altered	Very Likely Altered	Very Likely Altered	Likely Altered
204R03783	Crandall Creek	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered
205R01070	Tributary to Agua Fria	Possibly Intact	NA	Likely Intact	NA
205R01582	Agua Caliente	Likely Altered	Very Likely Altered	Possibly Intact	NA
205R01838	Agua Fria	Possibly Intact	Very Likely Altered	Likely Altered	NA
205R01902	Sabercat Creek	Very Likely Altered	Very Likely Altered	Possibly Intact	Very Likely Altered
205R02350	Agua Caliente	Likely Altered	Very Likely Altered	Possibly Intact	Very Likely Altered
205R03438	Zone 6 Line G	Very Likely Altered	Very Likely Altered	Likely Altered	Very Likely Altered
205R03694	Mission Creek	Very Likely Altered	Very Likely Altered	Likely Altered	Very Likely Altered
205R03886	Zone 6 Line C	Very Likely Altered	Very Likely Altered	Very Likely Altered	Very Likely Altered

Table 4-4. CSCI and Algae IBI scores for 20 probabilistic urban sites sampled in Alameda County during WY 2016. Site characteristics related to impervious area, flow status, and channel modification status are also presented in the table.

Station Code	Creek	Impervious Area%	Flow Status	Highly Modified Channel	CSCI Score	Hybrid H20	Diatom D18	Algae S2	CSCI Condition Category
204R01572	Gold Creek	18%	NP	N	0.36	40	64	NA	Very Likely Altered
204R01863	Alameda Creek	7%	P	Y	0.48	30	46	17	Very Likely Altered
204R02015	Sulphur Creek	24%	NP	N	0.49	29	46	0	Very Likely Altered
204R02116	Arroyo Las Positas	13%	NP	Y	0.53	34	50	7	Very Likely Altered
204R02175	San Lorenzo Creek	15%	P	Y	0.40	24	36	3	Very Likely Altered
204R02183	Alameda Creek	7%	P	Y	0.58	20	30	25	Very Likely Altered
204R02287	Arroyo Viejo	28%	P	N	0.49	38	58	2	Very Likely Altered
204R02439	Alameda Creek	8%	P	Y	0.51	18	28	15	Very Likely Altered
204R02687	Arroyo del Valle	2%	HVF	N	0.66	42	62	17	Likely Altered
204R02879	Estudillo Canal	60%	P	Y	0.28	41	72	5	Very Likely Altered
204R03015	Zone 5 Line J-3	51%	P	Y	0.25	30	20	45	Very Likely Altered
204R03783	Crandall Creek	55%	P	Y	0.28	11	12	8	Very Likely Altered
205R01070	Tributary to Agua Fria	1%	U	N	0.86	NA	74	NA	Possibly Intact
205R01582	Agua Caliente	1%	P	N	0.71	40	64	NA	Likely Altered
205R01838	Agua Fria	2%	P	N	0.80	52	56	NA	Possibly Intact
205R01902	Sabercat Creek	22%	P	N	0.43	42	68	0	Very Likely Altered
205R02350	Agua Caliente	1%	NP	N	0.76	45	72	17	Likely Altered
205R03438	Zone 6 Line G	17%	P	Y	0.30	34	54	2	Very Likely Altered
205R03694	Mission Creek	10%	NP	N	0.51	35	56	2	Very Likely Altered
205R03886	Zone 6 Line C	21%	NP	Y	0.44	12	20	3	Very Likely Altered

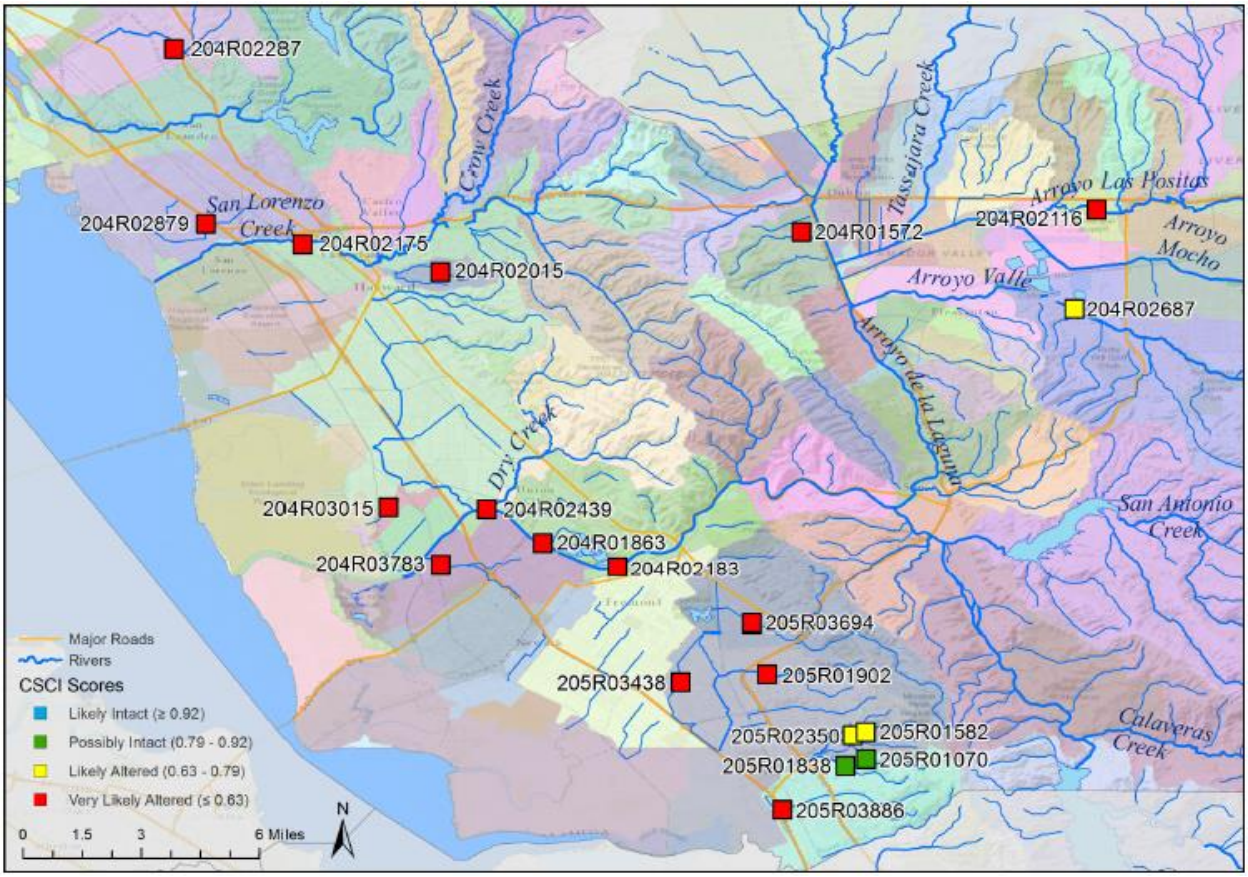

Figure 4-1. Condition categories for CSCI scores for 20 bioassessment locations sampled by ACCWP during WY 2016.

4.2.2 Stressor Indicators: Biological Assessment

Benthic Macroinvertebrates

Descriptive statistics for CSCI and algae IBI scores are shown in Table 4-5.

Table 4-5. Descriptive statistics for CSCI and algae IBI scores for the 20 probabilistic sites sampled in Alameda County during Water Year 2016.

Statistic	CSCI (>0)	Hybrid "H20" Algae IBI (0-100)	Diatom D18 IBI (0-100)	Algae S2 IBI (0-100)
Min	0.25	11	12	0
Median	0.49	34	55	6
Mean	0.5	32.5	49.4	10.5
Max	0.86	52	74	45

Site characteristic information presented in Table 4-4. CSCI and Algae IBI scores for 20 probabilistic urban sites sampled in Alameda County during WY 2016.

Site characteristics related to impervious area, flow status, and channel modification status are also presented in the table.

indicates that majority of the 20 bioassessment sites are highly impacted by human disturbance. Ten of the 20 sites (50%) were characterized as having modified channels. Fifteen of the 20 sites (75%) had watersheds/catchments with percent impervious area that was greater than 3%. Percent impervious area was correlated to CSCI scores across all bioassessment sites sampled during WY 2016 (Figure 4-2). The five bioassessment sites with the highest CSCI scores were in unmodified channels with watersheds having less than three percent imperviousness.

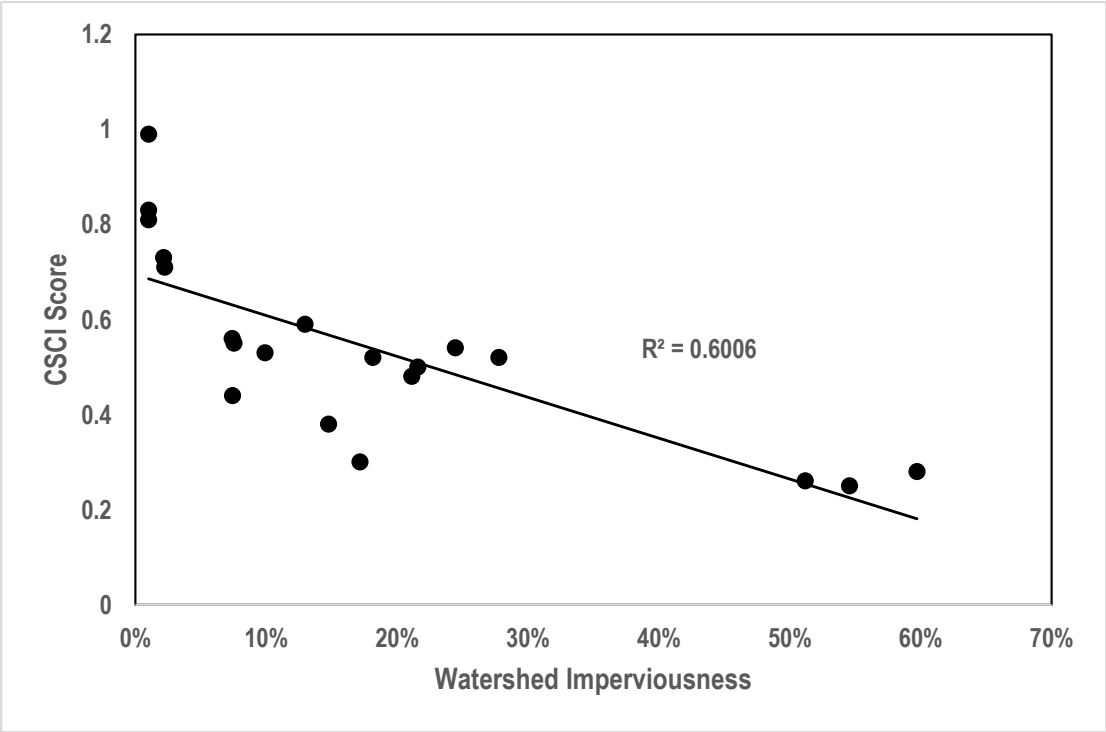

Figure 4-2. Linear regression between CSCI scores and percent watershed imperviousness for the 20 sites sampled in Alameda County during WY 2016.

Summary statistics for CSCI, H20 IBI and D18 IBI scores at non-perennial (n=6) and perennial sites (n=12) are presented in Table 4-6. One site was classified as “highly variable flow” (HVF) due to frequent changes in flow conditions, presumably due to human activity (e.g., dam operations). Flow status for one site was classified as “unknown”. Flow status was evaluated by ACCWP during site

observations conducted in the dry season. There were no apparent trends between any of the biological condition score indices and flow classification (perennial vs non-perennial) as shown in Figure 4-3.

Table 4-6. Descriptive statistics of CSCI, H20, and D18 in relation to stream flow for data collected in WY 2016 in Alameda County.

Flow		CSCI	H20	D18
Non-Perennial (n=6)	Min	0.36	12	20
	Max	0.76	45	72
	Mean	0.52	33	51
Perennial (n=12)	Min	0.25	11	12
	Max	0.80	52	72
	Mean	0.46	32	45

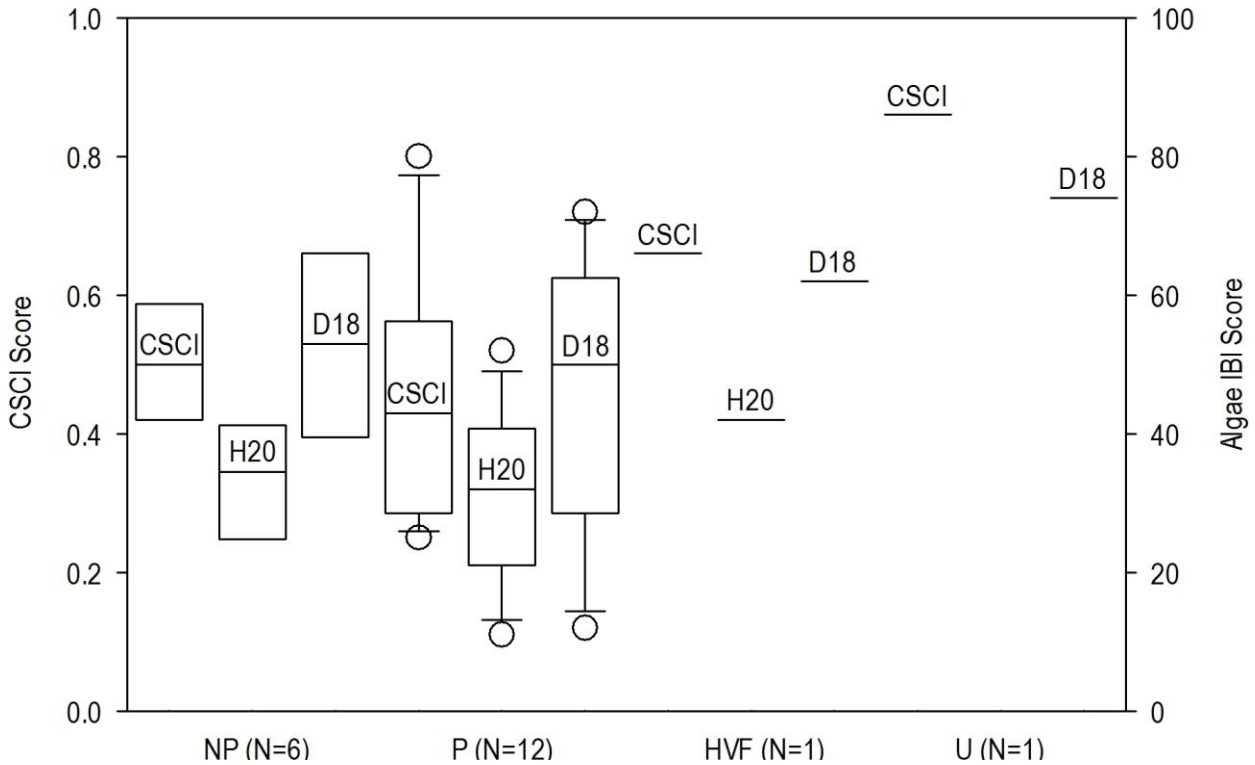

Figure 4-3. Box plots showing distribution of CSCI, Hybrid H20, and Diatom D18 scores for non-perennial (NP) (n=6) and perennial (P) (n=12) sites sampled in Alameda County during WY 2016. The flow status of one site was classified as "highly variable flow" (HVF), due to water operations. One site the flow status was classified as "unknown" (U).

There is a very weak positive correlation between H20 IBI and D18 IBI scores and CSCI scores, shown in Figure 4-4. This is likely due to the different responses from benthic macroinvertebrate communities and algal and diatom communities to the various environmental stressors present in streams.

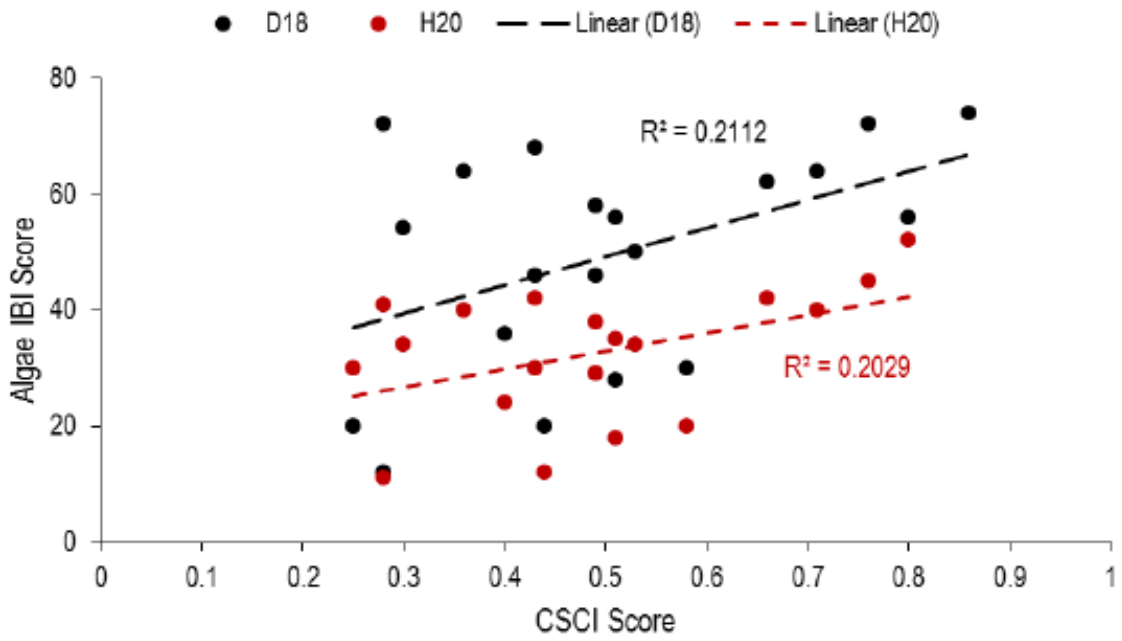

Figure 4-4. Linear regression between Hybrid H20 and D18 and CSCI scores for the 20 sites sampled in Alameda County during WY 2016.

A large proportion of streams in Alameda County are engineered or with highly modified channels, which appears to have an impact on CSCI and Algae IBI scores as shown in Figure 4-5. Mean scores for CSCI (0.61), H20 IBI (40), and D18 IBI (62), were higher at streams with unmodified channels, compared to the "Highly Modified Channel" sites at which mean scores for CSCI, H20 IBI, and D18 IBI were 0.40, 25, and 37 respectively. In contrast, the S2 IBI scores were generally higher at streams with "Highly Modified Channels".

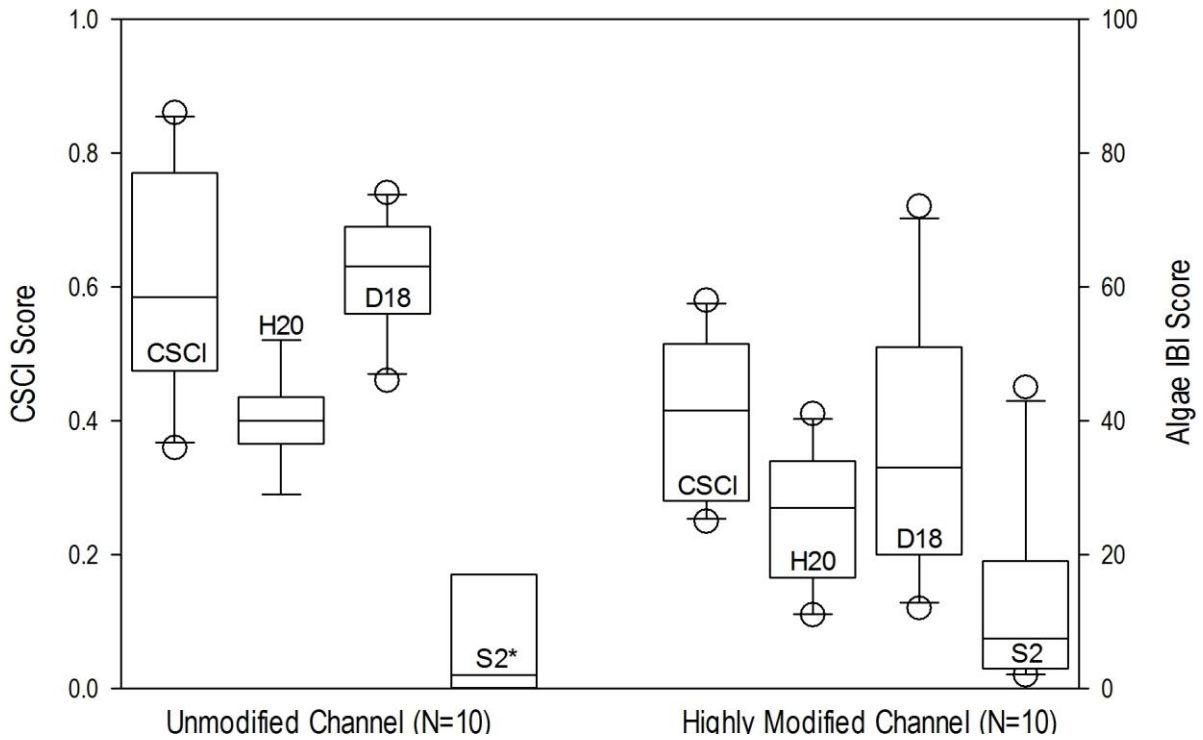

Figure 4-5. Box plots showing distribution of CSCI, Hybrid H20, Diatom D18, and Algae S2 scores for Unmodified Channels (n=10) and Highly Modified Channels(n=10) sites sampled in Alameda County during WY 2016. Four sites at unmodified channel streams did not have sufficient soft algae to calculate S2 IBI score.

WY 2016 was the fifth year of probabilistic bioassessment monitoring conducted by ACCWP in compliance with the MRP. There is now a robust dataset of 100 CSCI scores. CSCI condition categories for the 100 bioassessment sampling locations sampled in Alameda County between WY 2012 and WY 2016 are shown in Figure 4-65. These data will be compiled with results from other RMC programs for the planned BASMAA 5-year integrative report.

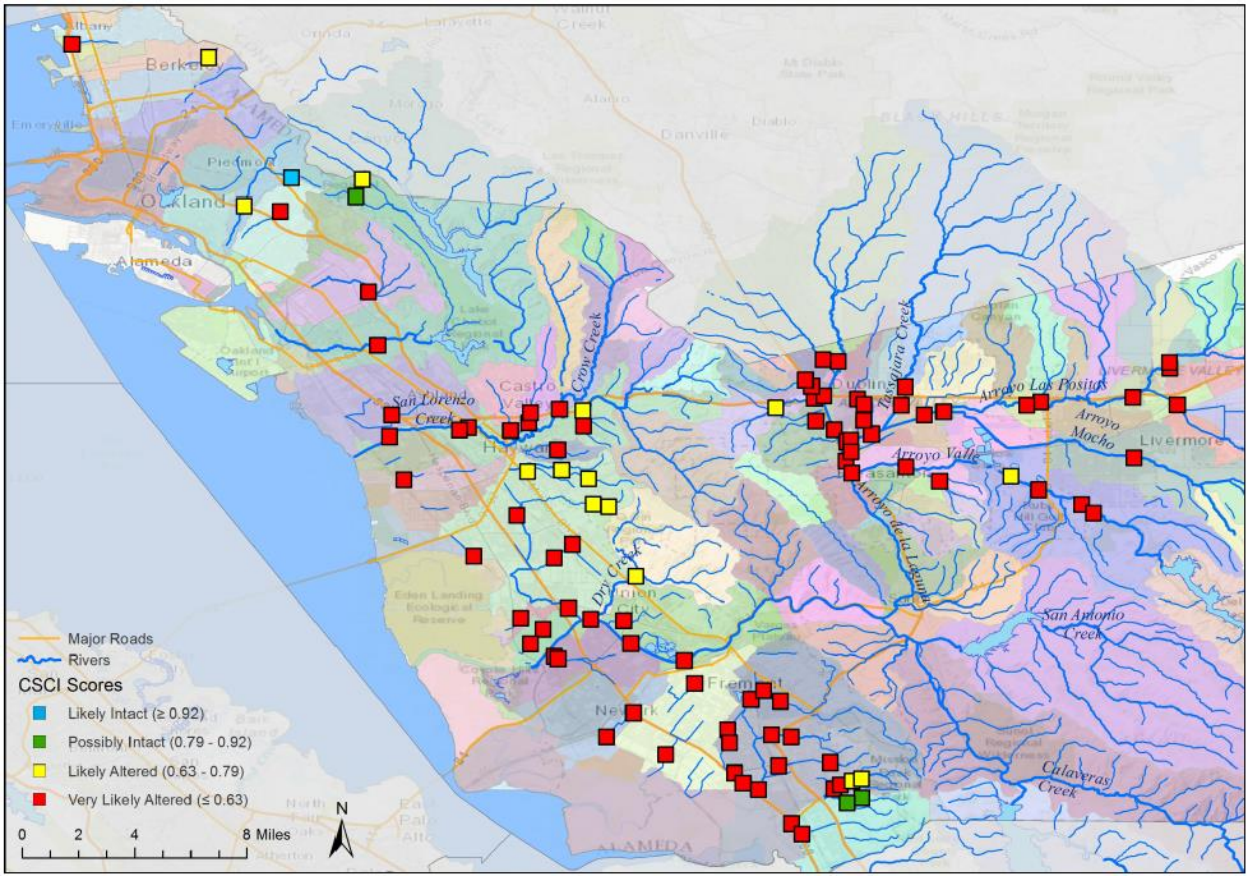

Figure 4-6. Condition categories for CSCI scores for 100 bioassessment locations sampled by ACCWP between WY 2012 and WY 2016.

4.2.3 Stressor Indicators: Chemistry and Toxicity

Water Chemistry Parameters associated with bioassessment

Table 4-7 provides a summary of descriptive statistics for the nutrients[15] and algae-related analytes[16] collected in association with the bioassessment samples in receiving waters. For the purposes of data analysis, Total Nitrogen was calculated as the sum of nitrate + nitrite + Total Kjeldahl Nitrogen (TKN).

Table 4-7. Descriptive statistics for water chemistry results collected at RMC sites during WY 2016.

Nutrients and Algal analytes	N	N ≥ RL	Min	Max	Max Detected	Mean
Ammonia as N (mg/l)	20	16	< 0.015	0.19	0.19	0.063
Nitrate as N (mg/l)	20	16	< 0.02	3.1	3.1	0.65
Nitrite as N (mg/l)	20	12	0.001	0.095	0.095	0.014
Nitrogen, Total Kjeldahl (mg/l)	20	20	0.35	1.2	1.2	0.76
Nitrogen, Total (calculated) (mg/l)	20	NA	NA	NA	NA	1.42
OrthoPhosphate as P (mg/l)	20	18	< 0.006	0.16	0.16	0.068
Phosphorus as P(mg/l)	20	19	0.009	0.17	0.17	0.089
Silica as SiO2 (mg/l)	20	20	8.7	33	33	20.6
Chloride (mg/l)	20	20	15	260	260	78
Ash Free Dry Mass (mg/m^3)	20	20	2,320	39,500	39,500	10,548
Chlorophyll a (mg/l)	20	20	150	8400	8400	2435

Water and Sediment Testing for Toxicity and Pesticides

The laboratory determines whether a sample is "toxic" by statistical comparison of the results from multiple test replicates of selected aquatic species in the environmental sample to multiple test replicates of those species in laboratory control water. The threshold for determining statistical significance between environmental samples and control samples is fairly small, with statistically significant toxicity often occurring for environmental test results that are as high as 90% of the Control. Therefore, there is a wide range of possible toxic effects that can be observed – from 0% to approximately 90% of the Control values.

[15] Listed in C.8.d.i(4).

[16] Required in C.8.d.i(1) along with taxonomic and habitat-related parameters.

For water and sediment sample toxicity and pesticide tests, provision C.8.g.iv requires Permittees to identify a site as a candidate SSID project when analytical results indicate any of the following, with applicability considerations noted in Section 3.4.3 above:

1) A toxicity test (of growth, reproduction, and/or survival depending on species) of any test organism is reported as "fail" if both the initial sampling and a second, followup sampling both have ≥ 50% Percent Effect;
2) A pollutant is present at a concentration exceeding its water quality objective (WQO) in the Basin Plan;
3) For pollutants without WQOs, results exceed Probable Effects Concentrations or Threshold Effects Concentrations.

The following sections discuss the results of WY 2016 monitoring in the context of MRP triggers.

The tables that follow present the results of pesticide and toxicity tests conducted in WY 2016 evaluating the growth, reproduction, or survival of test organisms. Where the initial sampling was reported as "fail," results are also shown for a second, followup sampling.

Dry Weather Aquatic Toxicity

Field personnel collected water samples during summer 2016 from two sites and these were tested for aquatic toxicity using five test species: an aquatic plant (*Selenastrum capricornutum*), three aquatic invertebrates (*Ceriodaphnia dubia, Hyalella azteca, and Chironomous dilutus*), and one fish species (*Pimephales promelas* or fathead minnow). The following sections discuss the results of WY 2016 monitoring in the context of MRP triggers. The results are summarized in Table 4-8. In comparison to the control samples, none of the samples surpassed the toxicity threshold therefore no follow-up sampling was required.

Table 4-8. Summary of WY 2016 dry season aquatic toxicity results.

Dry Weather Water Samples		Pass or fail in the initial sampling, and percent effect if toxic						
Sample Station	Collection Date	*S. capricornutum*	*C. dubia*		*H. azteca*	*P. Promelas*		*C. dilutus*
		Growth	Survival	Reproduction	Survival	Survival	Growth	Survival
204CVY010	7/11/2016	Pass	Pass	Pass	Pass	Pass	Pass	Pass
204SAU030	7/11/2016	Pass	Pass	Pass (20%)	Pass	Pass	Pass	Pass (15%)

Dry Weather Sediment Toxicity

During the dry season, field personnel collected sediment samples concurrently with water toxicity samples, and tested sample material for both sediment toxicity and the sediment chemistry constituents identified in provision C.8.g.ii. As required in provision C.8.g.ii, for sediment toxicity, testing was performed with two species, *H. azteca*, a common benthic invertebrate, and C. *dilutus*. Acute (survival) endpoints were reported.

The results of the ACCWP WY 2016 sediment toxicity testing are summarized in Table 4-9. In comparison to the control samples, none of the samples surpassed the toxicity threshold therefore no follow-up sampling was required.

Table 4-9. Summary of WY 2016 dry season sediment toxicity results.

Dry Season Sediment Samples		Pass or fail in the initial sampling, and % effect if toxic	
Sample Station	Collection Date	*H. azteca*	*C. dilutus*
		Survival	Survival
204CVY010	7/11/2016	Pass	Pass
204SAU030	7/11/2016	Pass	Pass (15%)

Sediment Chemistry Parameters

Descriptive statistics for sediment chemistry data for samples collected in WY 2016 are provided in Table 4-10. Analytes are presented in alphabetical order. Table 4-10 lists additional properties of the sediment samples.

It should be noted that a number of the sediment chemistry constituents assessed per the list in MacDonald et al. (2000) required some grouping of analytes. For example, the MacDonald list includes 10 individual PAH compounds, as well as “Total PAHs”. For this report, “Total PAHs” was computed as the sum of all 24 PAH compounds reported by the laboratory.

Table 4-10. Descriptive statistics for ACCWP WY 2016 sediment chemistry results

Analyte (units)	N	N ≥ MDL	Min	Max	Max Detected	Mean[1]
Arsenic (mg/Kg dw)	2	2	6.4	6.5	6.5	6.45
Bifenthrin (ng/g dw)	2	2	1.3	7.4	7.4	4.35
Cadmium (mg/Kg dw)	2	2	0.16	0.21	0.21	0.185
Carbaryl (mg/Kg dw)	2	0	0.01	0.01	0	0.01
Chromium (mg/Kg dw)	2	2	21	47	47	34
Copper (mg/Kg dw)	2	2	28	32	32	30
Cyfluthrin, total (ng/g dw)	2	2	0.44	1.7	1.7	1.07
Cyhalothrin, Total lambda- (ng/g dw)	2	1	0.031	0.14	0.14	0.085
Cypermethrin, total (ng/g dw)	2	2	0.15	0.47	0.47	0.31
Deltamethrin/Tralomethrin (ng/g dw)	2	0	0.06	0.06	0	0.06
Esfenvalerate/Fenvalerate, total (ng/g dw)	2	0	0.065	0.065	0	0.065
Fipronil (ng/g dw)	2	1	0.05	0.12	0.12	0.085
Lead (mg/Kg dw)	2	2	21	34	34	27.5
Nickel (mg/Kg dw)	2	2	30	73	73	51.5
Permethrin (ng/g dw)	2	2	1.6	3.4	3.4	2.5
Total Organic Carbon (% dw)	2	2	0.27	0.59	0.59	0.43
Total PAHs (ng/g dw)	2	NA	159.55	2665	2665	1412
Zinc (mg/Kg dw)	2	2	100	120	120	110

Notes:

[1]As described below, means calculated using a substitution of ½ MDL for non-detects.

Table 4-11. Total Organic Carbon and grain size statistics for ACCWP WY2016 dry weather sediment samples.

Sample Station	Total Organic Carbon (% dw)	Percentages of sieved sample in small size classes			Percent of bulk sample in granule & pebble (> 2 mm)
		Silt & clay (<0.0625 mm)	Very. fine to coarse sand (0.0625 - <1.0 mm)	Very coarse sand (1.0 - <2.0 mm)	
204CVY010	0.59	12.6	55.9	31.5	38.5
204SAU030	0.27	17.5	70.0	12.5	38.3

4.3 Stressor Assessment

This section addresses the question:

- "What are major stressors to aquatic life in the RMC area?"

The monitoring requirements of MRP provisions C.8.d and C.8.ginclude evaluation of results with respect to specified trigger thresholds to identify whether a site is a candidate for a SSID project followup as required by provision C.8.e The trigger criteria for each provision are listed below:

Bioassessment - Sites scoring less than 0.795 according to the California Stream Condition Index (CSCI), or sites where there is a substantial difference in CSCI score observed at a location relative to upstream or downstream sites, as described in provision C.8.d.i.(8).

Chlorine - A procedural follow-up is described in provision C.8.d ii(4) for chlorine samples when the initial field measurement is greater than 1.0 mg/L; the trigger is noted but not required to be listed as a candidate for SSID.

Pesticides and Toxicity – Sites at which any of the following criteria in provision C.8.g.iv are met (as applicable, see discussion in Section 3.4.3 above):

1) A toxicity test of growth, reproduction, or survival of any test organism is reported as "fail" in both the initial sampling and a second, followup sampling, and both have ≥ 50% Percent Effect;
2) A pollutant is present at a concentration exceeding its water quality objective (WQO) in the Basin Plan;
3) For pollutants without WQOs, results exceed Probable Effects Concentrations (PECs) or Threshold Effects Concentrations (TECs).

The biological, physical, chemical and toxicity testing data produced by ACCWP during WY 2016 were compiled and evaluated against these trigger criteria. When the data analysis indicated that the associated trigger criteria were reached, those sites and results were identified as potentially warranting further investigation.

When interpreting analytical chemistry results, laboratory data often contain a relatively high proportion that is reported as either below method detection limits (MDLs) or between detection and reporting limits (RLs). Dealing with data in this range of the analytical spectrum introduces some level of uncertainty, especially when attempting to generate summary statistics for a dataset. In the compilation of statistics for analytical chemistry that follow, non-detect data (ND) were substituted with a concentration equal to one-half of the respective MDL as reported by the laboratory. This follows procedures agreed on for reporting the WY2012 UCMR prepared for the four collaborating RMC Programs. The use of one-half of the MDL is the most common

substitution in environmental science (e.g., Helsel 2010), and is thought to be more representative of laboratory results. Some of the results may therefore be slightly biased high or low with this associated analytical uncertainty, but this is not expected to affect the conclusions to any great extent.

4.3.1 Stressor Analysis: Bioassessment

Biological assessment condition categories (e.g., good, fair, poor) can assist in the presentation of bioassessment data and may or may not be tied to regulatory outcomes. 18 of the 20 sites sampled in WY 2016 had CSCI scores below the threshold of 0.795.

The stressor analysis revealed that most sites show alteration of biological communities, and channel modification and other habitat changes associated with urbanization are likely stressors for benthic macroinvertebrate communities. The low scores and condition categories for most sites sampled in WY 2016 are consistent with results from of previous years of monitoring in Alameda County and also supported by studies elsewhere.

Geomorphic changes to stream systems are commonly considered to begin as the effective impervious area of their catchment reaches approximately 10% (e.g. Schuler, 2004, SFBRWQCB 2012). However, Coleman et al. (2005) found that much lower thresholds of imperviousness initiated channel enlargement in the Southern California streams they studied, suggesting that arid-climate ephemeral to intermittent streams are very sensitive to slight changes in impervious area within their watersheds.

4.3.2 Stressor Analysis: Chemistry and Toxicity

Stressor analysis provides an analysis of water and sediment chemistry and toxicity testing results in comparison to various “trigger” thresholds included in the MRP. This analysis is intended to provide a means of identifying potential stressors that may impact beneficial uses at the Creek Status and Pesticide/Toxicity monitoring locations.

All monitoring conducted per provision C.8.g is subject to trigger criteria listed in C.8.g.iv:

(1) A toxicity test (of growth, reproduction, and/or survival depending on species) of any test organism is reported as “fail” if both the initial sampling and a second, followup sampling, have ≥ 50% Percent Effect;
(2) A pollutant is present at a concentration exceeding its water quality objective in the Basin Plan;
(3) For pollutants without WQOs, results exceed Probable Effects Concentrations or Threshold Effects Concentrations”

As noted in Section 3.4.3 above, Criterion (1) applies to toxicity results of water column and sediment monitoring in both dry weather and wet weather. Criterion (2) can apply to results of water column chemistry monitoring in both dry weather and wet weather, and also to water quality and chemistry samples collected at bioassessment sites. Criterion (3) applies to chemical results of sediment monitoring in dry weather.

Water Chemistry Parameters

Water chemistry parameters were analyzed using the trigger criterion in MRP provision C.8.g.iv(2) to compare each analyte's concentration with an applicable water quality objective (WQO) in the Basin Plan.

For consistency with bioassessment monitoring data analyses in previous years, this criterion was interpreted to include other relevant water quality standards or accepted thresholds developed from available sources beyond the SF Basin Water Quality Control Plan (Basin Plan) (SFBRWQCB 2013), including the California Toxics Rule (CTR) (USEPA 2000a), and various USEPA sources. Of the nine nutrient-related water quality constituents monitored in association with the bioassessment monitoring, water quality standards or established thresholds are available only for ammonia (unionized form), chloride, and nitrate plus nitrite, the latter two for waters with MUN beneficial use only, as indicated in Table 4-12.

For ammonia, the standard provided in the Basin Plan (pp. 3-7) applies to the un-ionized fraction, as the underlying criterion is based on un-ionized ammonia, which is the more toxic form. Conversion of RMC monitoring data from the measured total ammonia to un-ionized ammonia was therefore necessary. The conversion was based on a formula provided by the American Fisheries Society[17], and calculates un-ionized ammonia in freshwater systems from analytical results for total ammonia and field-measured pH, temperature, and electrical conductivity.

For chloride, a Secondary Maximum Contaminant Level (MCL) of 250 mg/L applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations (CDPH, internet source), and the USEPA Drinking Water Quality Standards (USEPA, internet source). This same threshold is additionally established in the Basin Plan (Table 3-7) for waters in the Alameda Creek watershed above Niles. For all other waters, the Criteria Maximum Concentration (CMC) water quality criterion of 860 mg/L (acute) and the

[17]http://fisheries.org/hatchery

Criterion Continuous Concentration (CCC) of 230 mg/L (USEPA Water Quality Criteria[18]) for the protection of aquatic life were used for comparison purposes.[19]

The nitrate + nitrite primary MCL applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations, and the USEPA Drinking Water Quality Standards.

Table 4-12. Water quality thresholds available for comparison to ACCWP WY 2016 water chemistry constituents

Sample Parameter	Threshold	Units	Frequency/ Period	Application	Source
Ammonia	0.025	mg/L	Annual median	Unionized ammonia, as N. [Maxima also apply to Central Bay and u/s (0.16) and Lower Bay (0.4)]	SF Bay Basin Plan Ch. 3, p. 3-7
Chloride	230	mg/L	Criterion Continuous Concentration	Freshwater aquatic life	USEPA Nat'l. Rec. WQ Criteria, Aquatic Life Criteria
Chloride	860	mg/L	Criteria Maximum Concentration	Freshwater aquatic life	USEPA Nat'l. Rec. WQ Criteria, Aquatic Life Criteria Table
Chloride	250	mg/L	Secondary Maximum Contaminant Level	Alameda Creek Watershed above Niles and MUN waters, Title 22 Drinking Waters	SF Bay Basin Plan Ch. 3, Tables 3-5 and 3-7; CA Code Title 22; USEPA Drinking Water Stds. Secondary MCL
Nitrate + Nitrite (as N)	10	mg/L	Maximum Contaminant Level	Areas designated as Municipal Supply	SF Bay Basin Plan Ch. 3, Table 3-5

[18]National Recommended Water Quality Criteria. USEPA's compilation of national recommended water quality criteria is presented as a summary table containing recommended water quality criteria for the protection of aquatic life and human health in surface water for approximately 150 pollutants. These criteria are published pursuant to Section 304(a) of the Clean Water Act (CWA) and provide guidance for states and tribes to use in adopting water quality standards.

http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

[19]As agreed by RMC members for the first UCMR (BASMAA (2012) the RMC participants used the 230 mg/L threshold as a conservative benchmark for comparison purposes for all locations not specifically identified within the Basin Plan, i.e. sites not within the Alameda Creek watershed above Niles nor identified as MUN; rather than the maximum concentration criterion of 830mg/L .

The comparisons of the measured nutrients data to the thresholds listed in Table 4-120 are shown in Table 4-13. The results for these three constituents are plotted against the prevailing thresholds in Figure 4-76 through Figure 4-9.

Of the 20 sites monitored in 2016, the water quality standard was not exceeded at any sites for un-ionized ammonia. Three sites generated non-detects for ammonia and ammonia and un-ionized ammonia concentrations averaged 0.06 mg/L and 2.9 µg/L, respectively; an improvement over 2015 results, but still higher than values for 2014. In 2014, ammonia and un-ionized ammonia concentrations averaged 0.03 mg/L and 0.7 µg/L, respectively. In 2015, ammonia and un-ionized ammonia concentrations averaged 0.16 mg/L and 10.6 µg/L, respectively.

For chloride, the water quality standard was exceeded at one site (5% of sites) in 2016 (204R02116) and averaged 77.9 mg/L across all sites. There were four sites (18% of sites) above the threshold in 2015, with an average concentration of 172 mg/L.[20] There were 3 measurements of chloride (17% of sites) above the threshold in 2014. No samples exceeded the nitrate + nitrite standard in 2016, as was the case in 2015 and 2014.

Based upon the above information, one or more water quality standards or applicable thresholds were exceeded at 1 of the 20 sites (5%) which is less than the 23% of sites in 2015 and 17% of sites in 2014 with at least one result above identified thresholds.

[20] This assessment would drop to two sites above the standard with usage of the CMC (860 mg/L) in place of the CCC of 230 mg/L, as two of the instances occurred sites within Alameda Creek above Niles, and would therefore be measured against the criterion of 250 mg/L.

Table 4-13. Comparison of water quality (nutrient) data to associated water quality thresholds for WY 2016 water chemistry results. (NDs estimated as ½ MDL).

Site Code	Alameda Creek Above Niles	MUN	Parameter and Threshold			# of Parameters >Threshold/ Waterbody	% of Parameters >Threshold/ Waterbody
			Un-ionized Ammonia (as N)	Chloride	Nitrate + Nitrite (as N)		
			25 µg/L	230/250 mg/L [1]	10 mg/L [2]		
204R01572	X		0.14	78	0.09	0	0%
204R02175		X	6.43	64	0.11	0	0%
204R02116	X		0.73	**260**	1.62	1	33%
204R01863			8.59	80	0.01	0	0%
204R02183			0.29	69	0.01	0	0%
204R02015			0.90	150	0.14	0	0%
205R03886			6.77	90	0.01	0	0%
204R02287		X	0.25	67	0.46	0	0%
204R02439			0.19	86	1.44	0	0%
204R02687	X		0.55	57	0.01	0	0%
204R02879			11.49	34	1.50	0	0%
204R03015			2.76	120	3.12	0	0%
205R03694			0.14	33	0.58	0	0%
204R03783			0.78	92	0.23	0	0%
205R01070			2.65	17	0.52	0	0%
205R01582			2.23	15	0.49	0	0%
205R01838			5.23	18	0.34	0	0%
205R01902			0.95	120	1.51	0	0%
205R02350			1.59	16	0.73	0	0%
205R03438			4.69	92	0.35	0	0%
# Values >Threshold:			0	**1**	0		
% Values >Threshold:			0%	**5%**	0%		
Overall Number and % of Sites Meeting Trigger Criterion [3]:						**1**	**5%**

[1] 250 mg/L threshold applies for sites with MUN beneficial use and Alameda Creek above Niles per Basin Plan

[2] Nitrate + nitrite threshold applies only to sites with MUN beneficial use

[3] Sites where >20% of results exceed one or more water quality standard or established threshold

NA = threshold does not apply

Bolded value exceeds threshold

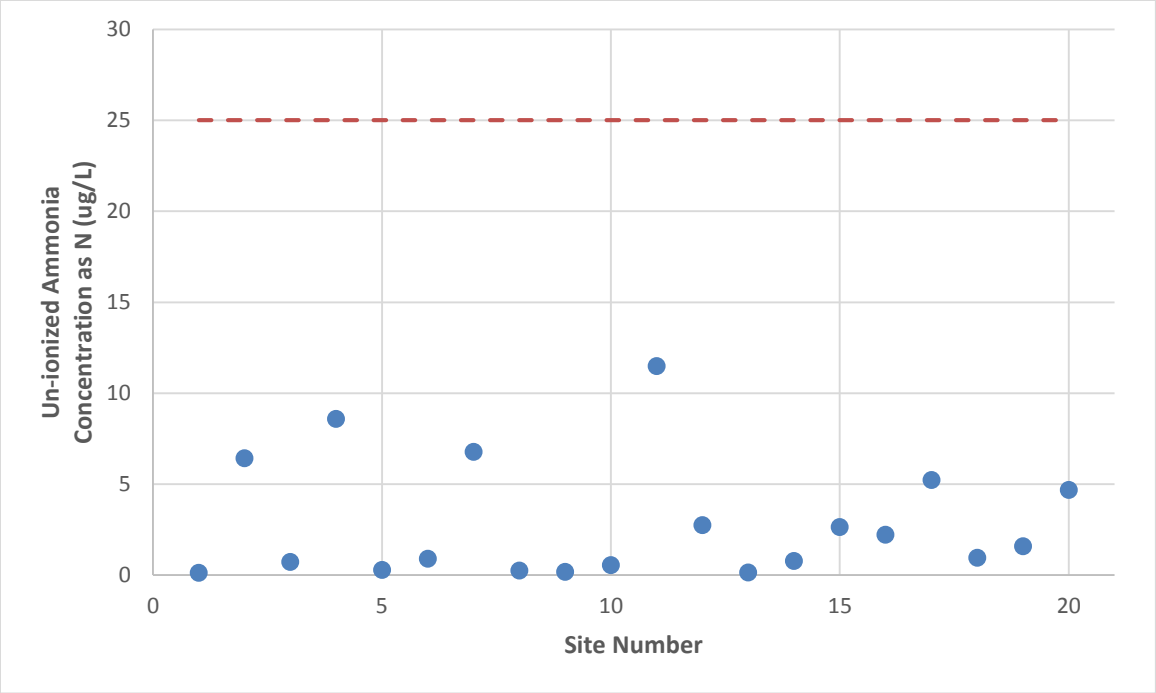

Figure 4-7. Plot of ACCWP WY 2016 unionized ammonia data (calculated from total ammonia, pH, temperature, and electrical conductivity) with threshold of 25 µg/L indicated.

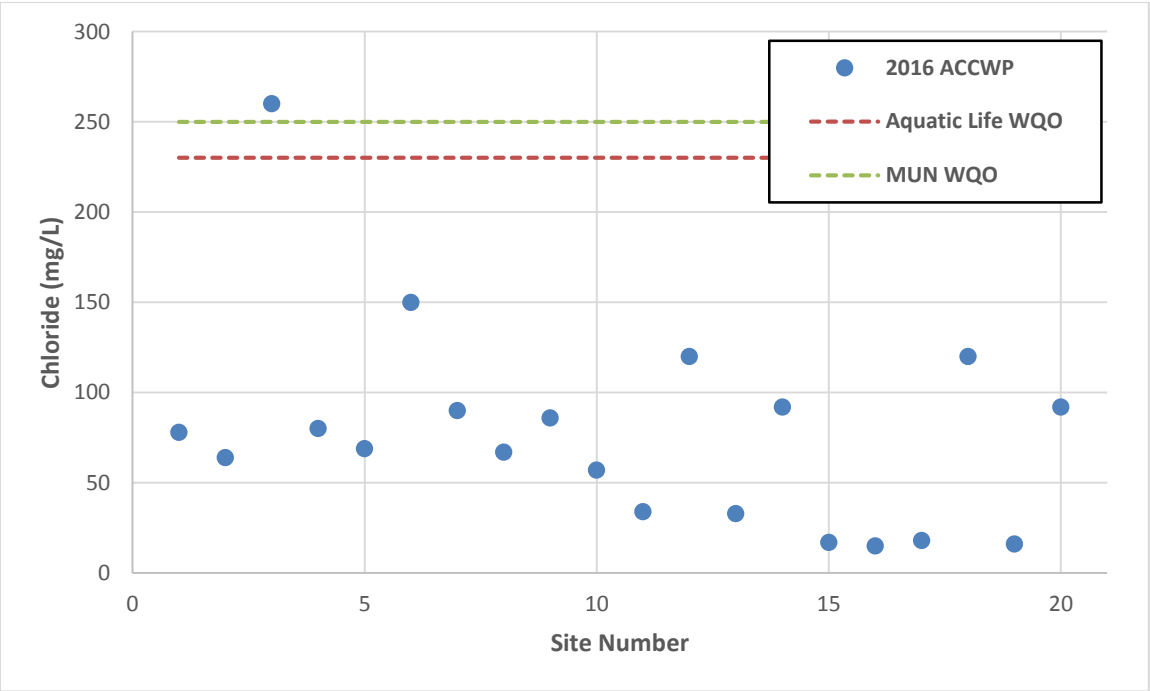

Figure 4-8. Plot of ACCWP WY 2016 chloride data with relevant Aquatic Life and MUN thresholds indicated.

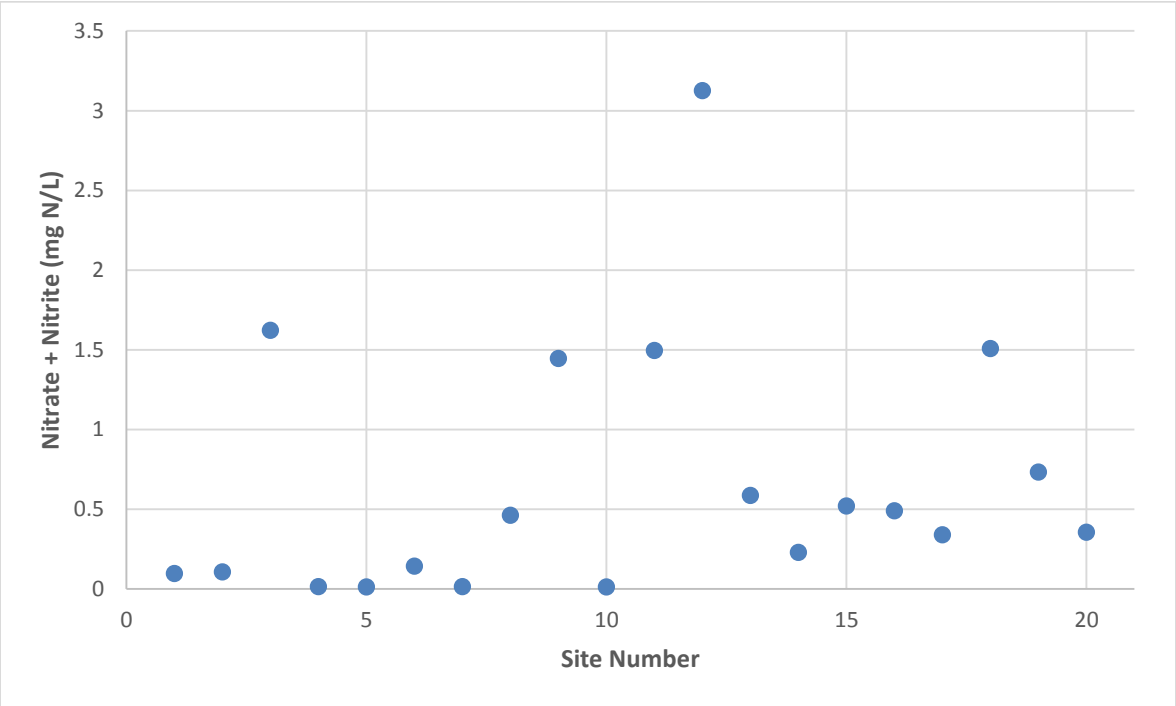

Figure 4-9. Plot of ACCWP WY 2016 nitrate + nitrite as N data, WY 2016 data (threshold not shown = 10 mg/L for MUN only).

Free and Total Chlorine Testing

The results of field testing for free and total chlorine and comparisons to the MRP trigger threshold are summarized in Table 4-14. The MRP trigger criterion for chlorine states, "After immediate resampling, concentrations remain >0.10 mg/L." If the resample is still greater than 0.1 mg/L, the observation is reported to the appropriate Permittee central contact point for illicit discharges, so that the illicit discharge staff can investigate and abate the associated discharge in accordance with its provision C.5.e – Spill and Dumping Complaint Response Program.

There were 20 site measurements for free and total chlorine collected by ACCWP in WY 2016. As was the case in 2015, none of the sites exceeded the thresholds for free and total chlorine that would trigger follow-up testing.

Table 4-14. Summary of ACCWP WY 2016 chlorine testing results in comparison to Municipal Regional Permit trigger criteria.

Site Code	Sample Date	Chlorine, Free	Chlorine, Total	Meets Trigger Threshold?
204R01572	5/5/2016	0.05	<0.04	No
204R01863	5/24/2016	<0.04	<0.04	No
204R02015	5/17/2016	<0.04	<0.04	No
204R02116	5/25/2016	<0.04	<0.04	No
204R02175	5/17/2016	<0.04	<0.04	No
204R02183	5/23/2016	<0.04	<0.04	No
204R02287	5/26/2016	<0.04	<0.04	No
204R02439	5/24/2016	<0.04	<0.04	No
204R02687	6/1/2016	<0.04	<0.04	No
204R02879	5/31/2016	<0.04	<0.04	No
204R03015	5/25/2016	<0.04	<0.04	No
204R03783	5/18/2016	<0.04	<0.04	No
205R01070	5/4/2016	<0.04	<0.04	No
205R01582	5/3/2016	<0.04	<0.04	No
205R01838	5/4/2016	<0.04	<0.04	No
205R01902	5/2/2016	<0.04	<0.04	No
205R02350	5/3/2016	<0.04	<0.04	No
205R03438	5/18/2016	<0.04	<0.04	No
205R03694	5/19/2016	<0.04	<0.04	No
205R03886	5/16/2016	<0.04	<0.04	No
Number of samples exceeding 0.1 mg/L:		0	0	0
Percentage of samples exceeding 0.1 mg/L:		0%	0%	0%

Water and Sediment Toxicity Testing

The analysis of toxicity testing results and comparisons to MRP trigger thresholds, as presented in detail earlier in this section, are summarized in Table 4-15 for those WY 2016 samples that exhibited statistically-significant toxicity.

The MRP provision C.8.g.iv trigger criteria for water column and sediment toxicity stipulates: The Permittees shall identify a site as a candidate SSID project when analytical results indicate any of the following:

(1) A toxicity test (of growth, reproduction, and/or survival depending on species) of any test organism is reported as "fail" if both the initial sampling and a second, followup sampling, have ≥ 50% Percent Effect;

(2) A pollutant is present at a concentration exceeding its water quality objective in the Basin Plan;
(3) For pollutants without WQOs, results exceed Probable Effects Concentrations or Threshold Effects Concentrations"

For the dry season sampling, none of the samples collected, either water or sediment, exhibited statistically-significant toxicity. There was therefore no requirement for follow-on testing.

Table 4-15. Overall summary of WY 2016 aquatic and sediment toxicity samples with toxic response in comparison to Municipal Regional Permit trigger criteria.

Test Initiation Date	Species Tested	Test Regimen	Treatment/ Sample ID	Comparison to Provision C.3.g.iv Trigger Criteria
Water				
7/11/2016	*C. dubia*	Reproduction	204SAU030	< 50% Effect
7/11/2016	*C. dilutus*	Survival	204SAU030	< 50% Effect
Sediment				
7/11/2016	*C. dilutus*	Survival	204SAU030	< 50% Effect

Sediment Chemistry Parameters

Sediment chemistry results could potentially be evaluated as potential stressors in two ways, based upon the criteria (2) and (3) from MRP provision C.8.g.iv:

(2) A pollutant is present at a concentration exceeding its water quality objective in the Basin Plan;
(3) For pollutants without WQOs, results exceed Probable Effects Concentrations or Threshold Effects Concentrations

The Basin Plan currently contains no WQOs for bedded sediment, so for WY2016 sediment chemistry results, atly influence interpretation.

Table 4-16 provides Threshold Effect Concentration (TEC) quotients and Probable Effects Concentrations (PEC) quotients as available for sediment chemistry constituents, calculated as the measured concentration divided by the TEC or PEC value given in MacDonald et al. (2000)[21]. This table also provides a count of the number of constituents that exceed TEC or PEC values for each site, as evidenced by a TEC or PEC quotient greater than or equal to 1.0.

For WY 2016 samples, the number of TEC quotients greater than or equal to 1.0 for each site, was 7 for and 3 for , out of the 17 measured constituents that were included in MacDonald et al. (2000). Each site had a PEC quotient greater than one for one constituent.

Some of the calculated numbers for TEC and PEC quotients may be artificially elevated due to the method used to account for filling in non-detect data (as discussed previously, concentrations equal to one-half of the respective laboratory MDLs were substituted for non-detect data so these statistics could be computed). This, however, is not expected to greatly influence interpretation.

[21] TEC and PEC values were not available in MacDonald et al. (2000) for the measured pesticides (pyrethroids, carbaryl and fipronil) and none were found in more recent literature.

Table 4-16. Threshold Effect Concentration (TEC) or Probable Effect Concentration (PEC) quotients for WY 2016 sediment chemistry constituents. Bolded values indicate individual TEC or PEC quotients > 1.0.

Site ID	TEC		PEC	
	204CVY010	204SAU030	204CVY010	204SAU030
Metals (mg/kg DW)				
Arsenic	0.65	0.66	0.19	0.20
Cadmium	0.16	0.21	0.03	0.04
Chromium	0.48	**1.08**	0.19	0.42
Copper	0.89	**1.01**	0.19	0.21
Lead	0.59	0.95	0.16	0.27
Nickel	**1.32**	**3.22**	0.62	**1.50**
Zinc	0.99	0.83	0.26	0.22
PAHs (µg/kg DW)				
Anthracene	0.72	0.07	0.05	0.00
Fluorene	**7.88**	0.26	**1.14**	0.04
Naphthalene	0.02	0.02	0.01	0.01
Phenanthrene	**1.52**	0.15	0.26	0.03
Benz(a)anthracene	0.56	0.03	0.06	0.00
Benzo(a)pyrene	0.47	0.01	0.05	0.00
Chrysene	**2.47**	0.19	0.32	0.02
Fluoranthene	**1.44**	0.05	0.27	0.01
Pyrene	**2.62**	0.10	0.34	0.01
Total PAHs	**1.66**	0.10	0.12	0.01
Number of constituents with TEC or PEC quotient ≥ 1.0	**7**	**3**	**1**	**1**

5. Conclusions and Next Steps

During WY 2016, ACCWP monitored 20 sites under the RMC regional probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. Two additional sites were monitored for water and sediment toxicity and sediment chemistry. The water and sediment chemistry and toxicity data were used to evaluate potential stressors that may affect aquatic habitat quality and beneficial uses. Each program also used bioassessment and related data to develop a preliminary condition assessment for the monitored sites, to be used in conjunction with the stressor assessment based on sediment chemistry and toxicity.

The following MRP reporting requirements (Provision C.8.h.vi) were addressed within this report as applicable:

- Descriptions of monitoring purpose and study design rationale
- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/longs coordinates); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for each monitoring program component;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards;

5.1 Summary of Stressor Analyses

The stressor analysis revealed the following potential stressors or stress conditions at WY 2016 sites:

- **Water Quality –** Of 11 parameters[22] sampled in association with WY 2016 bioassessment monitoring, applicable water quality standards were only identified for ammonia, chloride, and nitrate + nitrite (for sites with MUN beneficial use only). Of the results generated at

[22] Algal mass (ash-free dry weight), Chlorophyll a, Ammonia, Nitrate, Nitrite, TKN, Total Nitrogen, OrthoPhosphate, Phosphorus, Silica and Chloride

the 20 sites monitored by ACCWP reporting herein for those three parameters, one chloride and no un-ionized ammonia or nitrate + nitrite concentrations exceeded the applicable water quality standard or threshold.

- **Water Toxicity –** For WY 2016, 14 aquatic toxicity endpoints were derived through testing of 5 species at 2 sites county-wide during one dry season event. Of these endpoints, two sample / test combinations exhibited statistically-significant toxicity as reported by the analytical laboratory (*C. dubia* reproduction and *C. dilutus* survival at site 204SAU030 during wet season aquatic toxicity monitoring). Neither of these two samples exhibited toxicity with survival, growth, or reproduction beyond the threshold of >50% Effect.
- **Sediment Toxicity –** Of the bedded sediment collected from 2 sites, a toxic response for *C. dilutus* survival was observed at site 204SAU030, however it was below the threshold of >50% Effect.
- **Sediment Chemistry –** At each of the two sites, 1 constituent was present above the PEC threshold. Site 204SAU030 had 3 constituents above TEC thresholds and site 204CVY010 had 7.
- **Bioassessment –** 18 of the 20 sites sampled in WY 2016 had CSCI scores below the threshold of 0.795.

5.2 Next Steps

MRP provisions C.8.d and C.8.g require monitoring results to be evaluated for triggers according to the criteria in these provisions of the MRP as shown above. During WY 2017, the RMC will collaboratively review trigger results from WYs 2015 and 2016, and select a minimum of four sites from among the triggers identified from all five counties for initiation of stressor/source identification (SSID) projects by WY 2018 as required by provision C.8.e.ii(1) for regionally conducted projects. Attachment B of the main UCMR provides a status update on SSID projects initiated during MRP1, and progress reports on SSID projects in Alameda County are provided in Appendix A.4A.

ACCWP and other RMC participants will continue to implement the regional probabilistic monitoring design in WY 2017. Site evaluation is underway for new bioassessment sites for WY 2016. Candidate sites classified with unknown sampling status as of WY 2016 may continue to be evaluated for potential sampling in WY 2017.

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ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

CREEK STATUS MONITORING REPORT - TARGETED PARAMETERS

APPENDIX A.2

URBAN CREEKS MONITORING REPORT

OCTOBER 2015 THROUGH SEPTEMBER 2016

Report prepared by

Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region

FINAL

March 31, 2017

MEMBER AGENCIES:

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County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Protecting Alameda County Creeks, Wetlands & the Bay

Acknowledgements

Horizon Water and Environment, LLC contributed substantially to the preparation of this report. Applied Marine Sciences, Inc. contributed substantially to the implementation of monitoring activities and preparation of the data analysis and discussion for this report.

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) collaboratively developed framework for preparation of the Urban Creeks Monitoring Report (UCMR) used by ACCWP and other stormwater programs to comply with the Municipal Regional Stormwater Permit (MRP)[1] requirements for reporting on monitoring data collected under the MRP Monitoring Provision C.8.

The following participants make up the RMC and are responsible for preparing UCMR documents on behalf of their respective member agencies:

- 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); and
- City of Vallejo and Vallejo Sanitation and Flood Control District (Vallejo).

This report was prepared by ACCWP to fulfill reporting requirements for a portion of the Creek Status Monitoring data collected in Water Year 2016 (October 1, 2015 through September 30, 2016) in accordance with the RMC's Monitoring Plan (BASMAA, 2011) for certain parameters monitored according to Provision C.8.d of the MRP. This report is an Appendix to the full UCMR submitted by ACCWP on behalf of the following Permittees:

- The 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 of the Alameda County Flood Control and Water Conservation District.

Data presented in this report were produced under the direction of the ACCWP using a targeted (non-probabilistic) monitoring design. Other data collected in Alameda County during this period

[1] Unless otherwise noted references to the MRP are to the reissued "MRP2" (SFBRWQCB, 2015) which became effective January 1, 2016. Most of the monitoring requirements addressed in this Appendix have not changed substantially from the original "MRP1" (SFBRWQCB, 2009)

pursuant to MRP Provision C.8 are reported in the main body and other appendices of ACCWP's UCMR for Water Year (WY) 2016.

As described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA, 2011), targeted monitoring data were collected in accordance with the BASMAA RMC Quality Assurance Project Plan (QAPP; BASMAA, 2012a, 2014a and 2016a) and BASMAA RMC Standard Operating Procedures (SOPs, BASMAA, 2012b, 2014b and 2016b).

In accordance with the reissued MRP (also "MRP2", SFBRWQCB, 2015) ACCWP will also submit the data included in this report by March 31, 2017 to the California Environmental Data Exchange Network and San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) in electronic SWAMP-comparable format.

In addition to the RMC participants, San Francisco Bay Regional Water Quality Control Board staff, Kevin Lunde and Jan O'Hara, also participated in RMC workgroup meetings that contributed to design and implementation of the RMC Monitoring Plan. Additionally, these staff also provided input regarding previous Urban Creeks Monitoring Reports and threshold "trigger" criteria for stressor analyses conducted therein.

List of Acronyms

Acronym	**Definition**
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
ACFCWCD	Alameda County Flood Control Water Conservation District
BASMAA	Bay Area Stormwater Management Agency Association
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
CRAM	California Rapid Assessment Method
DO	Dissolved oxygen
DQO	Data Quality Objective
EBMUD	East Bay Municipal Utility District
E.coli	*Escherichia coli*
FOSC	Friends of Sausal Creek
FSURMP	Fairfield Suisun Urban Runoff Management Program
I-	Interstate Highway
IMR	Integrated Monitoring Report
MPC	Monitoring and Pollutants of Concern Committee
MPN	Most Probable Number
MRP	Municipal Regional Permit
MRP1	Municipal Regional Permit, issued 2009
MRP2	MRP, reissued 2015
MQO	Measurable Quality Objective
MWAT	Maximum Weekly Average Temperature
NPDES	National Pollution Discharge Elimination System
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board; (California Regional Water Quality Control Board, San Francisco Bay Region)
SFEI	San Francisco Estuary Institute
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
SSID	Stressor/Source Identification
SWAMP	Surface Water Ambient Monitoring Program
UCMP	Urban Creek Monitoring Report
USA	Unified Stream Assessment
USEPA	United States Environmental Protection Agency
WQO	Water Quality Objective
WY	Water Year

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Executive Summary

In 2010, the seventeen members of the Alameda Countywide Clean Water Program (ACCWP) joined other members of the Bay Area Stormwater Agencies Association (BASMAA) to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by Provision C.8 of the Municipal Regional Stormwater Permit (MRP). This report is an appendix to the Urban Creeks Monitoring Report (UCMR) prepared to assist ACCWP member agencies in complying with the MRP Reporting Provision C.8.h, reporting details of the Creek Status Monitoring for parameters that use a targeted (non-probabilistic) monitoring design. Other parameters were addressed using a regional probabilistic design, and are reported in a separate Regional Appendix A.1[2] to the UCMR.

The focus of ACCWP Targeted Creek Status Monitoring in Water Year 2016 (WY 2016) the Castro Valley and Crow Creek subwatersheds of the San Lorenzo Creek watershed. Overall targeted monitoring activities included:

- Continuous temperature monitoring at nine[3] locations at hourly intervals over six months;
- General Water Quality monitoring at three locations with assessment of temperature, dissolved oxygen (DO), pH and specific conductivity at 15-minute intervals during three one- to two-week periods in Spring, Midsummer, and late Summer/Fall; and
- Pathogen indicator (*E. coli* and Enterococci) quantification once at five sites with follow-up monitoring at repeat or new monitoring locations;

The results of the targeted Urban Creek Monitoring are summarized below:

Continuous Temperature

The temperature "trigger" described in the MRP for a candidate SSID project is defined as when two or more weekly average temperatures, calculated as non-overlapping periods, exceed a Maximum Weekly Average Temperature (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. All WY 2016 temperature monitoring sites were in streams with COLD Beneficial use, and experienced at least two MWATs above 17.0°C but none exceeded the 24°C instantaneous maximum in 20% of the results.

[2] Similar methods and QA/QC procedures are being implemented for Stressor-Source Identification (SSID) studies reported in Appendices A.4 to the UCMR;

[3] The minimum required number of temperature monitoring sites was eight.

General Water Quality

Results of the General Water Quality assessment are presented in Table E-1. MWATs reached a temperature trigger at one site in midsummer and late summer. High pH and low DO values each surpassed trigger thresholds at two stations. For additional discussion of these results, see the report of the ongoing Stressor Source Identification Study in UCMR Appendix A.4C.

Table E-1. Comparison of General Water Quality Observations to Trigger Thresholds at Sites 204CRW040, 204CRW041E, 204CRW045 in WY 2016.

Station	Monitoring Season (No of MWATs)	Applicable threshold or water quality standard					
		Temperature MWATs > 17˚C (> 19°C)	Temp % > 24˚C	Specific Cond. >2000 µS/cm	pH < 6.5	pH > 8.5	DO < 7 mg/L (COLD)
204CRW040	Spring (2)	0(0)	0%	0%	0%	22%	0%
	Midsummer (2)	1**(0)	0%	0%	0%	3%	3%*
	Summer-Fall (2)	1(0)	0%	0%	0%	0%	12%
204CRW041E	Spring (2)	0(0)	0%	0%	0%	39%	0%
	Midsummer (2)	0(0)	0%	0%	0%	24%	5%*
	Summer-Fall (2)	0(0)	0%	0%	0%	0%	79%
204CRW045	Spring (2)	0(0)	0%	0%	0%	0%	0%
	Summer-Fall (2)	0(0)	0%	0%	0%	0%	22%

*Dissolved oxygen were outside of instrument control limits for drift check, indicating possible high bias
**>17 ˚C MWAT was from partial week (~3 days) of data

Pathogen Indicator Bacteria

All water samples, including the two later samples, collected at the five sites on July 20, 2016 for pathogen indicators recorded elevated Enterococci or *E.coli* concentrations of between 320 and 17,000 most probable number (MPN) per 100mL. The results are presented in Tables E-2 and E-3. Actual creek contact at most of these sites does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard being used for comparison. Recreational use, as defined by USEPA, is sporadic at best. Due to high sample variability the results of a single sample are insufficient to determine average levels of pathogen indicators, and in dry weather urban runoff is likely to make little or no contribution to the observed bacterial levels. Extensive presence of homeless encampments has been documented along the creek.

Table E-2: Comparison of WY 2016 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP July 20, 2016 FIB Monitoring.

Site ID	Site Description	Creek Name	Enterococci (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204CVY020	Chabot Creek at Carlos Bee Park	Chabot Creek	**350**	**2,200**
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**4,400**	**14,000**
204CVY084	Castro Valley Creek south side of Grove Way	Castro Valley Creek	**1,000**	**3,000**
204CVY090	Castro Valley Creek upstream of Redwood Rd	Castro Valley Creek	**2,900**	**9,000**
204CVY125	Castro Valley Creek south of Castro Valley Blvd.	Castro Valley Creek	**1,000**	**800**

*Most Probable Number per 100mL

BOLD font indicates result meets trigger conditions.

Table E-3: Comparison of WY 2016 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP July 20, 2016 Follow-up FIB Monitoring.

Site ID	Site Description	Creek Name	Enterococci (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**320**	**17,000**
204CVY084	Castro Valley Creek south side of Grove Way	Castro Valley Creek	**660**	**17,000**

*Most Probable Number per 100mL

BOLD font indicates result meets trigger conditions.

Stressor Evaluation

Where applicable, targeted monitoring data were evaluated against numeric Water Quality Objectives or other applicable thresholds described for each parameter to determine whether "trigger" results qualify a site for a potential Stressor/Source Identification monitoring project as described in provision C.8.e of the MRP. The following trigger conditions were identified as the basis for potential SSID projects:

- **Temperature**[4]
    - For Temperature Monitoring data: Two or more weekly average temperatures exceed the Maximum Weekly Average Temperature 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
    - For Continuous Monitoring data: Maximum Weekly Average Temperature exceeds 17.0°C for a Steelhead stream, or 20 percent of the instantaneous results exceed 24°C
- pH – <6.5 or >8.5 for ≥20% of results
- DO – <7 mg/L for ≥20% of results
- Conductivity - >2000 µS/cm for ≥20% of results
- Pathogen Indicators: All sites sampled were found to have bacterial concentrations above the recommended thresholds for lightly and moderately used recreational areas. Extensive presence of homeless encampments has been documented along the creek.

Where triggers or potential trigger conditions have been identified in WY 2016 results, ACCWP will work with local stormwater managers to identify appropriate follow-up activities.

[4] The MRP's use of a 17°C trigger criterion may be overly conservative for steelhead in central California. See discussion in 4.2 for more information.

1 Introduction

This report fulfills a portion of the reporting requirements of Provision C.8.h.iii of the Bay Area Municipal Regional Stormwater Permit (MRP[5]) for Creek Status Monitoring data collected pursuant to MRP Provision C.8.d during Water Year (WY) 2016 (October 1, 2015 - September 30, 2016) under a targeted (non-probabilistic) monitoring design. Additional data required by Provision C.8 are reported in other appendices and portions of ACCWP's Urban Creeks Monitoring Report (UCMR), of which this is Appendix A.2.

The RMC was formed in early 2010 as a collaboration among a number of BASMAA members representing all MRP Permittees listed in

[5] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) 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) and reissued the permit on November 19, 2015 (MRP2, SFBRWQCB 2015) with an effective date of January 1, 2016. Unless otherwise noted references in this report to the MRP are to the reissued "MRP2"

Table 1-1. The RMC's focus is developing and implementing a regionally coordinated water quality monitoring program to improve stormwater management and address water quality monitoring required by the MRP[6]. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan allowed Permittees and the Water Board to effectively modify their existing creek monitoring programs, and 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 Committee (MPC) and its associated RMC Work Group, a subgroup of the MPC that meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. This workgroup includes staff from the SF Bay RWQCB at two levels – those generally engaged with the MRP as well as those working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

[6] The RMC includes 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. Note that the RMC regional monitoring design was expanded to include the portion of eastern Contra Costa County that drains to the San Francisco Bay in order to assist the CCCWP in fulfilling parallel provisions in their NPDES permit from the Region 5 Central Valley RWQCB.

Table 1-1. Regional Monitoring Coalition Participants.

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

This report includes the standard report content as required by MRP Provision C.8.h.vi and presents the results of the portions of Creek Status Monitoring that were conducted to comply with Provision C.8.d (Table 1-2) using a targeted (non-probabilistic) monitoring design as described in the RMC's Status and Long-Term Trends Monitoring Plan (BASMAA, 2011).

Table 1-2. Creek Status Monitoring and Pesticide/Toxicity Parameters Monitored in Compliance with MRP Provisions C.8.d and g. and the associated design approach and Appendix of the ACCWP UCMR.

Biological Response and Stressor Indicators	MRP Provision	Monitoring Design		Reporting
		Regional Ambient (Probabilistic)	Local (Targeted)	
Bioassessment & Physical Habitat Assessment	C.8.d.i	X		Appendix A.1
Nutrients	C.8.d.i	X		Appendix A.1
Chlorine	C.8.d.ii	X		Appendix A.1
Water Toxicity	C.8.g.i&iii	X		Appendix A.1
Sediment Toxicity	C.8.g.ii	X		Appendix A.1
Sediment Chemistry	C.8.g.ii	X		Appendix A.1
General Water Quality	C.8.d.iv		X	Appendix A.2
Temperature	C.8.d.iii		X	Appendix A.2
Bacteria	C.8.d.v		X	Appendix A.2

The remainder of this report describes the Study Area and Monitoring Design (Section 2), the Monitoring Methods (Section 3), the Results (Section 4), the preliminary Stressor Assessment (Section 5), and the Conclusions & Next Steps (Section 6). More specifically, this report includes the standard report content as required by MRP Provision C.8.h.vi in the respective sections referenced in Table 1-3. Additional details or discussion may also be found in other Appendices or in the main UCMR.

Table 1-3. Index to Standard Report Content per MRP Provision C.8.h.vi.

Report Section	Standard Report Content
2.0	Monitoring purpose and study design rationale
3.0	Sampling protocols and analytical methods
4.1	QA/QC summaries for sample collection and analytical methods
2.1	Sample location descriptions, sample dates, IDs
4..2-4.4	Sample concentrations detected, measurement units, detection limits
4.2-4.4, 5.1-5.3	Data assessment, analysis and interpretation
N/A	List of volunteer and other non-Permittee entities whose data are included in the report
5.1-5.3	Assessment of compliance with applicable water quality standards

2 Study Area & Design

2.1 Regional Monitoring Coalition Area

The RMC area encompasses 3,407 square miles of land in the San Francisco Bay Area. This includes the portions of the five participating counties that fall within the San Francisco Bay RWQCB boundary, as well as the eastern portion of Contra Costa County that drains to the Central Valley region (Figure 2-1). Creek Status monitoring is being conducted in flowing water bodies (i.e., creeks, streams and rivers) interspersed among the RMC area, including perennial and non-perennial creeks and channels that run through both urban and non-urban areas.

2.2 Alameda County Targeted Monitoring Areas

Alameda County occupies 739 square miles (1,914 sq. km) of land area in the East Bay region of the San Francisco Bay Area, and discharges to portions of the Central Bay, South Bay and Lower South Bay. Its population of 1,510,271 (as of April 2010) is densest in the Bay Plain western portion of the County, where the largest cities include Oakland, Fremont, Berkeley and Hayward. The eastern portion of the county includes the cities of Dublin, Livermore and Pleasanton occupying the Livermore-Amador Valley, a portion of the very large and mostly undeveloped Alameda Creek Watershed.

In WY 2016, ACCWP's targeted monitoring focused on portions of the San Lorenzo Creek watershed, including the tributaries Crow and Castro Valley Creeks.

Watersheds were chosen considering accessibility of creek and channels, in conjunction with management issues and stakeholder concerns as described in the sections below.

San Lorenzo Creek Watershed

The overall San Lorenzo Creek Watershed drains approximately 48 square miles (30,000 acres) of land and extends from the San Francisco Bay to the ridge-tops of the East Bay hills (Figure 2-2). The watershed encompasses both urban and non-urban areas, mostly in unincorporated portions of Alameda County. In WY 2016, targeted monitoring was conducted in the Crow Creek subwatershed. Within the San Lorenzo Creek watershed are over 81 linear miles of natural creeks including some segments of Castro Valley and Chabot Creeks within the urbanized area, and some segments of Crow Creek spanning both rural and suburban development. Table 2-1 shows the Beneficial Uses assigned to these creeks in the Basin Plan (SFBRWQCB 2015b).

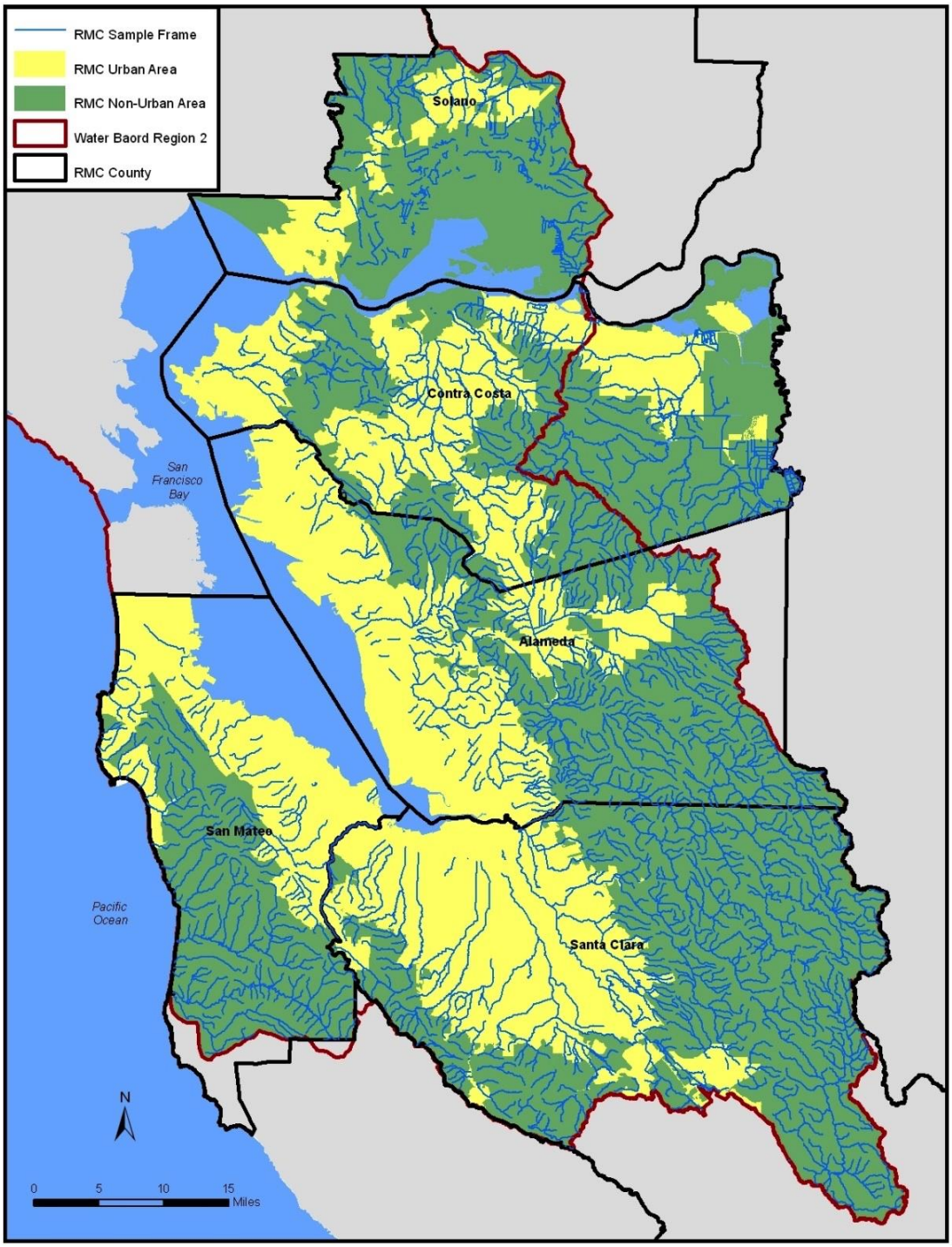

Figure 2-1. Map of BASMAA RMC Area and Major Creeks.

Table 2-1. Selected Beneficial Uses Assigned to the Subwatersheds of San Lorenzo Creek Monitored in Water Year 2016.

Creek	COLD	MIGR	WARM, WILD	REC-1, REC2
San Lorenzo Creek	X	X	X	X
Castro Valley Creek, including Chabot Creek	X	--	X	X
Crow Creek	X	X	X	X

Crow Creek Subwatershed

The upper tributaries of Crow Creek lie in grasslands and oak woodlands. Much of this estimated 11.2 square mile (29.1 km^2) square mile watershed is heavily grazed, and also has the most equine facilities of any of the subwatersheds of San Lorenzo Creek. The Unincorporated Alameda County Clean Water Program and the District have worked with the Alameda Resource Conservation District on outreach and inspection for these facilities. Most ownership of creeks is private. In the lower, suburban reaches of Crow Creek it receives sporadic inputs from Cull Creek, a primarily non-urban watershed that is partially detained in Cull Reservoir just above the confluence. Based on General Water Quality monitoring results in WY 2012, a Stressor-Source Identification (SSID) project was initiated for low Dissolved Oxygen (DO) in Crow Creek during WY2013 (see UCMR Appendix A.4A). Figure 2-3 shows The lower portion of this WY 2016 temperature and general water quality monitoring locations in this subwatershed.

Castro Valley and Chabot Creek Subwatersheds

The total Castro Valley Creek watershed encompasses about 5.5 square miles of primarily residential land use with smaller amounts of open space and commercial and industrial areas.

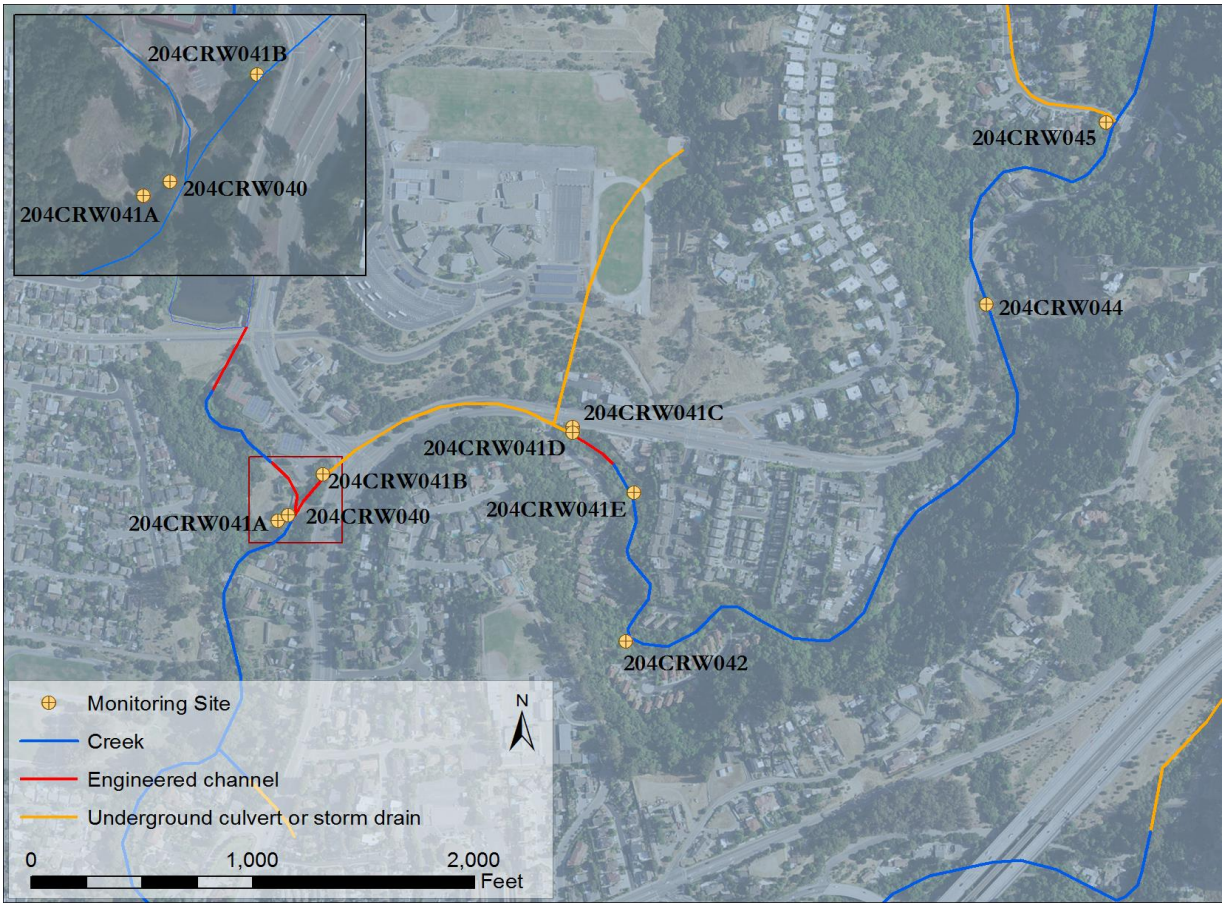

Figure 2-3 shows the creek's two main branches, which have undergone different degrees of channel alteration:

- Castro Valley Creek is the longer, eastern branch that flows from undeveloped open space through urbanized Castro Valley to its confluence with the main stem of San Lorenzo Creek. While most of the reaches have been extensively channelized, and culverted sections are extensive in side tributaries and under major roads or freeways, the main channel remains open for much of its length;

- Chabot Creek, the western branch, is located almost entirely in storm drains and engineered channels. A relatively natural channel section occurs in Carlos Bee Park just above its confluence with the Castro Valley branch.

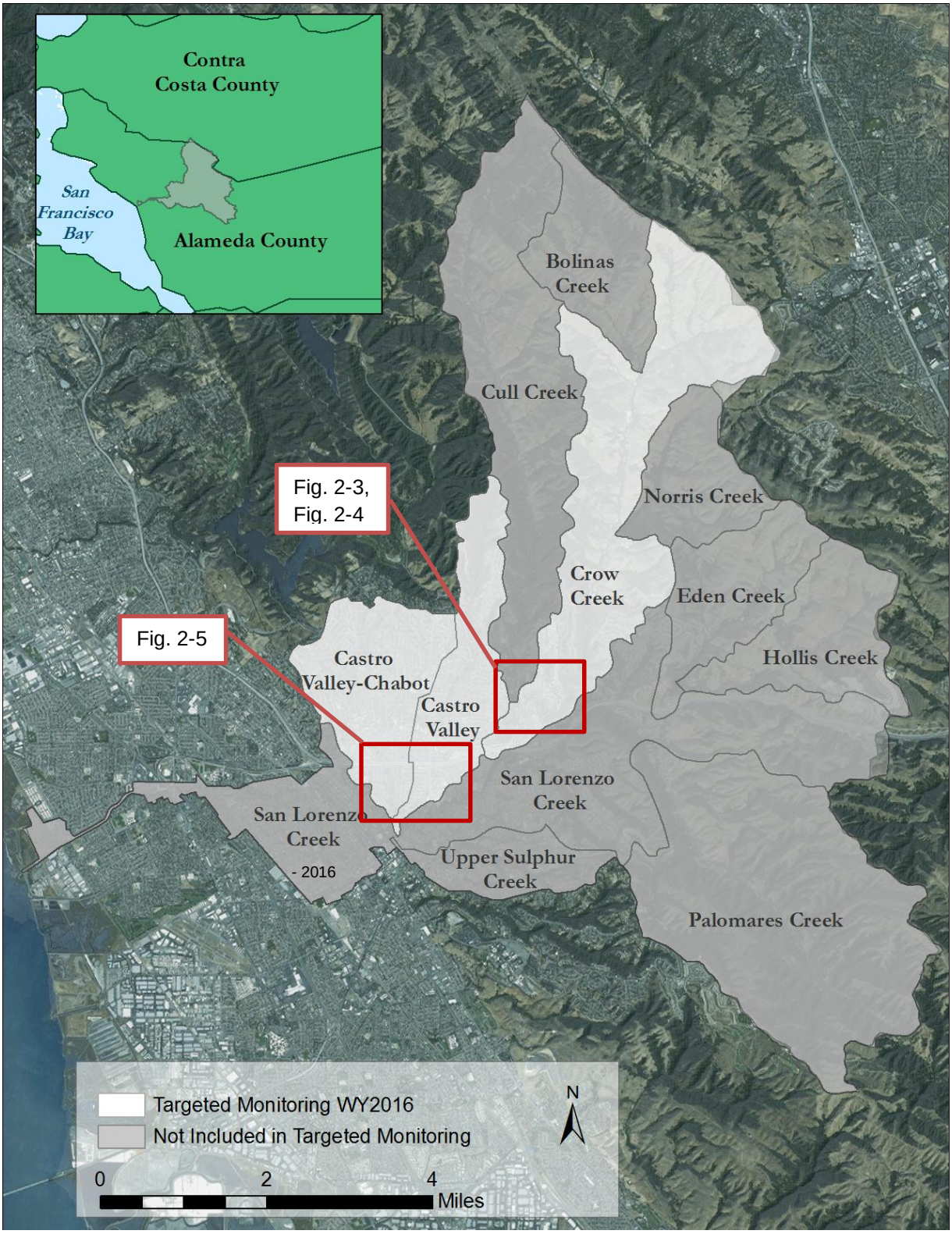

Figure 2-2. Map of the San Lorenzo Creek Watershed and Major Subwatersheds, showing locations of Figures 2-3, 2-4 and 2-5.

2.3 Targeted Monitoring Design

In the targeted monitoring program design, site locations were identified based on the directed principle[7] to address the following management questions:

1) *What is the range of general water quality measurements at targeted sites of interest?*
2) *Do general water quality measurements indicate potential impacts to aquatic life?*
3) *What are the pathogen indicator concentrations at creek sites where water contact recreation may occur?*
4) *What are the overall physical and/or ecological conditions of creek reaches and specific point impacts within each reach?*

Table 2-2 summarizes ACCWP targeted monitoring conducted during WY 2016 including:

- Nine Continuous Water Temperature monitoring locations[8] shown in Figure 2-3;
- Three General Water Quality monitoring locations shown in Figure 2-4;
- Five Pathogen Indicator monitoring locations shown in Figure 2-5;[9]

[7]The Directed Monitoring Design Principle is 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”.

8 One more site than the required 8 was monitored to account for potential loss or creek drying out. Concurrent measurements of conductivity at 5 of these sites are reported in UCMR Appendix A.4C.

9 Includes initial tests plus follow-up.

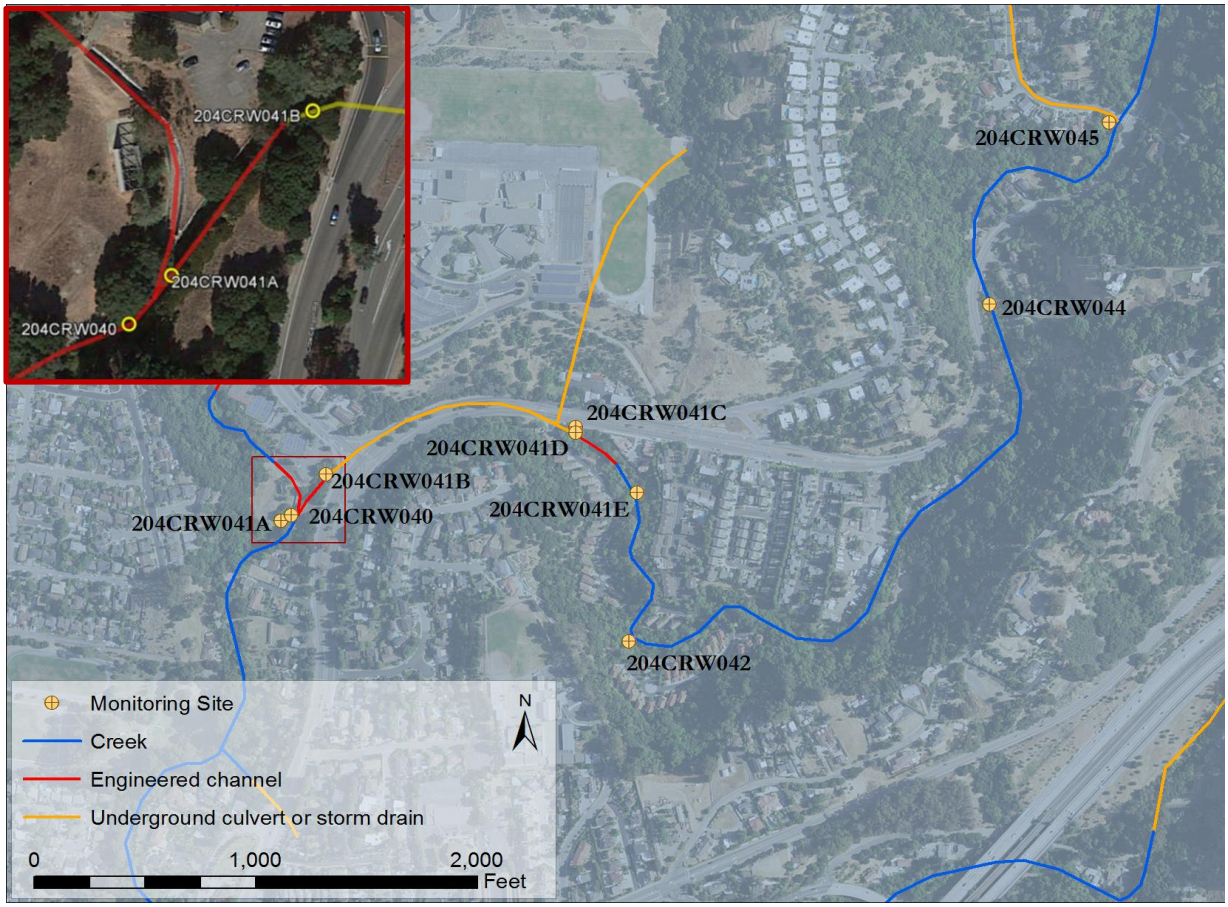

Figure 2-3. Temperature Monitoring Locations, Crow Creek, WY 2016.

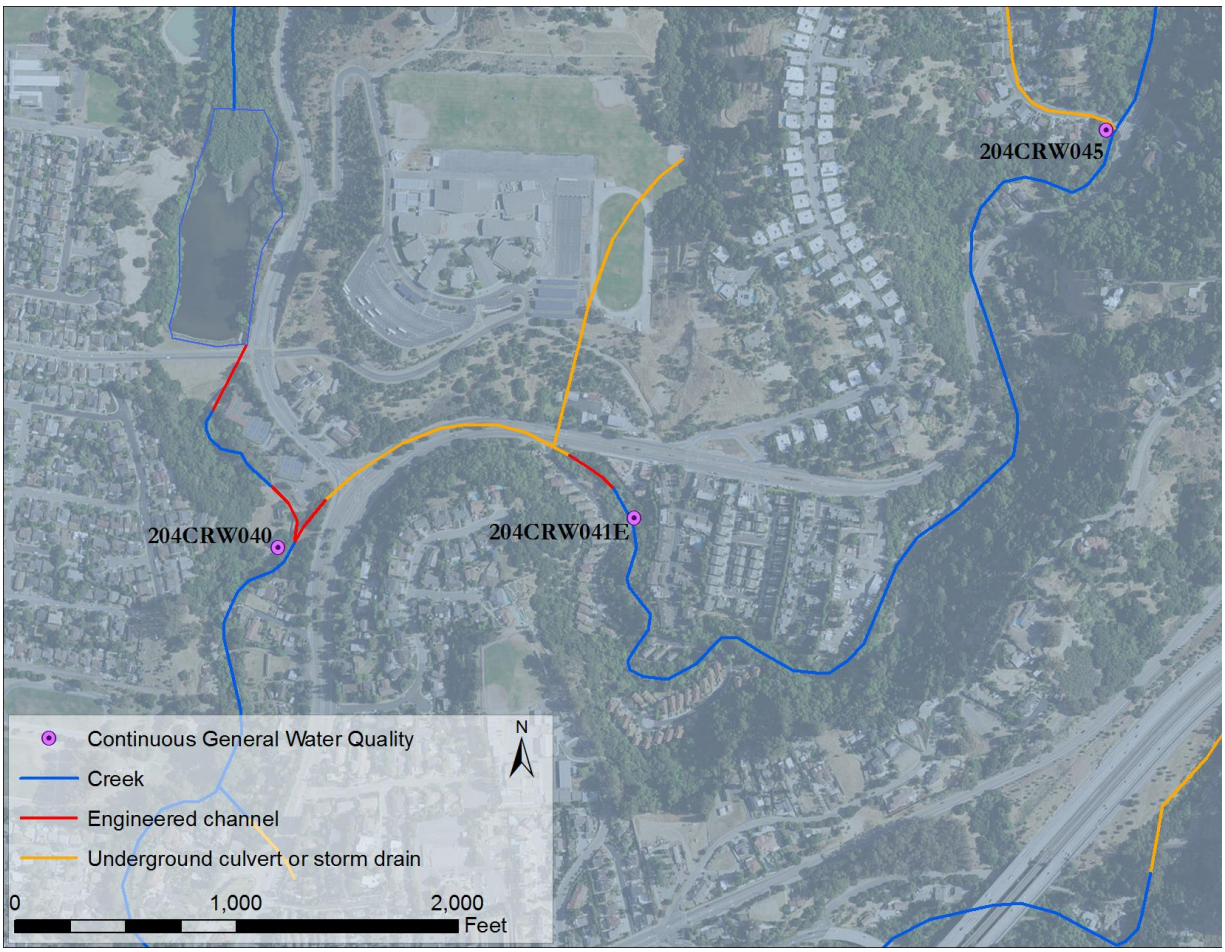

Figure 2-4. General Water Quality Monitoring Locations, Crow Creek, WY 2016.

Figure 2-5. Pathogen Indicator Sampling Locations, Castro Valley Creek, WY 2016.

Table 2-2. Summary of Targeted Monitoring Locations and Parameters for Water Year 2016 in Alameda County

Site Characteristics					Parameters		
Creek/Sub-watershed	**Site Code (RMC No)**	**Site Description**	**Latitude**	**Longitude**	**Pathogen Indicators**	**Water Temperature (continuous)**	**General Water Quality**
Crow Creek	204CRW040	Crow Creek, concrete channel segment below confluence with Cull	37.70143	-122.05467		X	Spring, Midsummer, Summer-Fall
Crow Creek	204CRW041A	Crow Creek, above outfall in eastern side of box culvert	37.70150	-122.05451		X	
Crow Creek	204CRW041B	Crow Creek, downstream end of box culvert under Cull Canyon Rd.	37.70204	-122.05398		X	
Crow Creek	204CRW041C	Crow Creek, upstream end of box culvert under Cull Canyon Rd., downstream of 48" outfall	37.70272	-122.0501		X	
Crow Creek	204CRW041D	Crow Creek, upstream end of box culvert under Cull Canyon Rd., upstream of 48" outfall	37.70265	-122.0501		X	
Crow Creek	204CRW041E	Crow Creek, upstream of box culvert	37.70189	-122.04912		X	Spring, Midsummer, Summer-Fall
Crow Creek	204CRW042	Crow Creek at Crow Creek HOA property	37.69996	-122.0492		X	
Crow Creek	204CRW044	Crow Creek East of culvert under Crow Canyon Rd.	37.70442	-122.04369		X	
Crow Creek	204CRW045	Crow Creek at Cold Water Dr.	37.70681	-122.04188		X	Spring, Summer-Fall
Castro Valley Creek	204CVY020	Chabot Creek at Carlos Bee Park	37.68192	-122.08078	X		
Castro Valley Creek	204CVY080	Castro Valley Creek above confluence with Chabot Creek	37.68184	-122.08044	X		
Castro Valley Creek	204CVY084	Castro Valley Creek south side of Grove Way	37.68402	-122.07576	X		
Castro Valley Creek	204CVY090	Castro Valley Creek upstream of Redwood Rd	37.68882	-122.07215	X		
Castro Valley Creek	204CVY125	Castro Valley Creek south of Castro Valley Blvd.	37.69417	-122.07234	X		

Criteria for Site Selection

All target sampling sites were selected by the ACCWP Monitoring Program Coordinator, in coordination with others as described below. Specific considerations applied to selection of locations for the different parameters as described below:

Continuous Temperature

Each monitoring year, a minimum of eight continuous water quality monitoring locations are chosen based on a combination of criteria. In general, a predominant criterion is that the streams have COLD beneficial use designation for which these parameters are important indicators.

For WY 2016, ACCWP chose sites on Crow Creek to support the ongoing SSID study, and also deployed sensors capable of collecting electrical conductivity data as well as temperature data at five of the nine temperature stations (for study design and discussion of results see Appendix A.4C to the main UCMR).

Sampling sites were adjusted in the field in order to deploy continuous monitoring equipment at locations where (1) water level was expected to be of sufficient depth to cover loggers over the course of the entire dry season, and (2) avoid highly trafficked areas.

General Water Quality

The goal of site selection for the three general water quality monitoring locations was to support the SSID follow-up by characterizing summertime DO conditions within a smaller target area for portions of the main stem above and below tributary or storm drain inputs

Pathogen Indicators

In WY 2016, five pathogen indicator sampling sites were distributed along an approximately 4 km segment of Castro Valley Creek and Chabot Creek. Castro Valley is an urban watershed and several of the Castro Valley Creek reaches have public access. As part of follow up investigation to previously elevated bacterial results, observations were also made of homeless encampments located along monitored stream reaches

3 Monitoring Methods

This section provides a brief overview of methods employed to measure each parameter in the targeted monitoring design. Greater detail on each method is included in the referenced SOPs.

3.1 Data Collection Methods

Field data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2016a) and Standard Operating Procedures (SOP) (BASMAA 2016b), updated in 2013 from the earlier 2012 versions to reflect lessons learned through 2012 implementation; these revisions also incorporated updated data Quality Assurance procedures consistent with added data checking functions of the RMC database to supplement the tools available from SWAMP[10]. The SOPs relevant to the monitoring discussed in this report are listed in Table 3-1.

Table 3-1: Standard Operating Procedures for BASMAA RMC Monitoring at Targeted Sites.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-5	Temperature, Automated, Digital Logger
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review

Continuous Temperature Monitoring

All sampling conformed to protocols identified in the RMC QAPP and SOPs (Table 3-1). Field crews deployed digital temperature loggers in April at nine sites as shown in Table 3-2. Temperature loggers were programmed to record temperature data at sixty-minute intervals.

AMS personnel conducted a mid-term maintenance and data download of deployed temperature probes on July 6th, 2016; all units were found submerged and in good condition.

[10] See http://waterboards.ca.gov/water_issues/programs/swamp/data_management_resources/index.shtml

Table 3-2. Water Year 2016 Continuous Water Temperature Monitoring at Alameda County Targeted Monitoring Locations.

Site Code (RMC No)	Site Name / Location	Latitude	Longitude	Install Date	Mid-term Re-install	Removal Date
204CRW040	Crow Creek, concrete channel segment below confluence with Cull	37.70143	-122.05467	April 26	July 6	September 29
204CRW041A	Crow Creek, above outfall in eastern side of box culvert	37.70150	-122.05451	April 26	July 6	September 29
204CRW041B	Crow Creek, downstream end of box culvert under Cull Canyon Rd.	37.70204	-122.05398	April 26	July 6	September 29
204CRW041C	Crow Creek, upstream end of box culvert under Cull Canyon Rd., downstream of 48" outfall	37.70272	-122.0501	April 26	July 6	September 29
204CRW041D	Crow Creek, upstream end of box culvert under Cull Canyon Rd., upstream of 48" outfall	37.70265	-122.0501	April 26	July 6	September 29
204CRW041E	Crow Creek, upstream of box culvert	37.70189	-122.04912	April 26	July 6	September 29
204CRW042	Crow Creek at Crow Creek HOA property	37.69996	-122.0492	April 26	July 6	September 29
204CRW044	Crow Creek East of culvert under Crow Canyon Rd.	37.70442	-122.04369	April 26	July 6	September 29
204CRW045	Crow Creek at Cold Water Drive	37.70681	-122.04188	April 26	July 6	September 29

General Water Quality Measurements

General water quality monitoring included continuous measurements for temperature, DO, pH and specific conductivity for deployment at three sites. Parameters were measured for a period of between one and two weeks twice per year, once during the spring index period for bioassessment sampling and again during the August – September timeframe (

). For purposes of the SSID study design (see Appendix A.4C of the UCMR) an additional deployment period was implemented at two sites in midsummer. All sampling conformed to protocols identified in the RMC QAPP and SOPs.

Automated monitoring equipment (YSI 6600 Sonde) was deployed with the data recorded automatically at fifteen-minute intervals.

Table 3-3. General Water Quality Monitoring at Alameda County Targeted Monitoring Locations, WY 2016.

Site Code (RMC No)	Description	Deployment	Latitude	Longitude	Dates
204CRW040	Crow Creek, concrete channel segment below confluence with Cull	Spring	37.70143	-122.05467	4/26/16 to 5/5/16
		Midsummer	37.70143	-122.05467	7/6/16 to 7/18/16
		Summer-Fall	37.70143	-122.05467	8/16/16 to 8/29/16
204CRW041E	Crow Creek, upstream of box culvert	Spring	37.70189	-122.04912	4/26/16 to 5/5/16
		Midsummer	37.70189	-122.04912	7/6/16 to 7/18/16
		Summer-Fall	37.70189	-122.04912	8/16/16 to 8/29/16
204CRW045	Downstream (east side) of culvert near mile 1.1 on Crow Canyon Rd.	Spring	37.70681	-122.04188	5/16/16 to 5/26/16
		Summer-Fall	37.70681	-122.04188	8/29/16 to 9/9/16

Pathogen Indicators Sampling

Single samples were collected for pathogen indicator enumeration in accordance with the requirements of provision C.8.d.v of the permit. Field crews conducted pathogen indicator sampling using the RMC SOPs (Table 3-1). Sampling techniques included direct filling of containers, and immediate transfer of samples to analytical laboratories within specified holding time requirements.

Field crews collected water samples for analysis of *Escherichia coli* (*E. coli*) and Enterococci at five sites on July 20, 2016 (Table 3-4). Two of these sites were resampled later that same day (Table 3-5).

Table 3-4. Pathogen Indicator Monitoring at Alameda County Targeted Monitoring Locations, July 20, 2016.

Site Code	Description	Latitude	Longitude
204CVY020	Chabot Creek at Carlos Bee Park	37.68192	-122.08078
204CVY080	Castro Valley Creek above confluence with Chabot Creek	37.68184	-122.08044
204CVY084	Castro Valley Creek south side of Grove Way	37.68402	-122.07576
204CVY090	Castro Valley Creek upstream of Redwood Rd	37.68882	-122.07215
204CVY125	Castro Valley Creek south of Castro Valley Blvd.	37.69417	-122.07234

Table 3-5. Follow-up Pathogen Indicator Monitoring at Alameda County Targeted Monitoring Locations, July 20, 2016.

Site Code	Description	Latitude	Longitude
204CVY080	Castro Valley Creek above confluence with Chabot Creek	37.68184	-122.08044
204CVY084	Castro Valley Creek south side of Grove Way	37.68402	-122.07576

Quality Assurance/Quality Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA 2016a). Data Quality Objectives (DQOs) 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. The qualitative goals include representativeness and comparability. The quantitative goals include specifications for completeness, sensitivity (detection and quantization limits), precision, accuracy, and contamination. To ensure consistent and comparable field techniques, pre-survey field training and *in-situ* field assessments were conducted. Data were collected according to the procedures described in the relevant SOPs, including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

3.2 Data Quality Assessment Procedures

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the Local Monitoring Coordinator or Quality Assurance Officer, and compared both against the methods and protocols specified in the SOPs and QAPP. The findings and results then were evaluated against the relevant DQOs to provide the basis for an assessment of programmatic data quality. The data quality assessment included the following elements:

- Conformance with field and laboratory methods as specified in SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.;
- Numbers of measurements/samples/analyses completed vs. planned, and identification of reasons for any missed samples;
- Results of duplicate analyses based on calculation of relative percent differences (precision results);
- Results of field blanks associated with filtered samples (bias results);
- Results of spiked sample analyses based on spike percent recovery (accuracy results); and
- Identification of any contamination issues based on analyses of lab blanks and field blanks.

3.3 Data Analysis and Interpretation

Continuous temperature (C.8.d.iii) and General Water Quality (C.8.d.iv) data from each deployment were graphed for each site. As specified in MRP Provision C.8.d.iii, Maximum Weekly Average Temperatures (MWATs) were calculated throughout the deployment from all data recorded for each seven-day, non-overlapping deployment period. For General Water Quality parameters the frequency of measurements was higher (15 minutes for General Water Quality vs. one hour for continuous temperature) and most analyses focused on comparing all available instantaneous values from a deployment to specified thresholds. By using the non-overlapping data averaging technique specified in the MRP, the number of weekly averages for General Water Quality temperature measurements was limited to a maximum of two for a one- to two-week deployment. Where these deployments extended for longer than a week, the weekly average for the 2nd week was calculated from data available for the subset of the week beginning after the initial seven-day calculation period.

Targeted monitoring data were evaluated against Water Quality Objectives (WQO) or other applicable thresholds, as described in Section 5, to determine whether results may “trigger” a site for a candidate stressor/source identification monitoring project (per MRP Provisions C.8.d.iii and C.8.d.iv).

4 Results

This section presents monitoring results based on each program component. Each section addresses the study question:

> *What are the ranges of general water quality, continuous water temperature, pathogen indicators, and stream ecosystem conditions at locations sampled in the Program area?*

4.1 Statement of Data Quality

The RMC established a set of guidance and tools to help ensure data quality and consistency implemented through collaborating Programs. Additionally, the RMC participants continue to meet and coordinate in an ongoing basis to plan and coordinate monitoring, data management, and reporting activities, among others.

A comprehensive QA/QC program was implemented by each of the RMC Programs, which is solely responsible for the quality of the data submitted on its behalf, covering all aspects of the regional/probabilistic monitoring. In general, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2016a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2016b), and in conformity with SWAMP protocols. The results of general evaluations of laboratory-generated QA/QC results are included in Section 7 of the main UCMR body. Issues noted by the laboratories and/or field crews are noted below where relevant.

Field data sheets and laboratory reports were reviewed by the local Monitoring Coordinator or Program Quality Assurance Officer, and the results evaluated against the relevant DQOs as described in the RMC QAPP (BASMAA, 2016a) and SOPs (BASMAA, 2016b). Results were compiled for the qualitative metrics (representativeness and comparability), as well as the quantitative metrics (completeness, sensitivity, detection and quantitation limits, precision, accuracy, and contamination). The following sections provide summaries of all pertinent data quality issues from the WY 2016 targeted parameters and corrective actions to address data quality issues.

Method Deviations

There were no deviations from the methods provided in the QAPP.

Number of Measurements Taken Compared to Planned

There were no deviations from the planned number of samples collected described in the QAPP with the exception of the following design changes:

- Two of the sites monitored for General Water Quality were monitored for an additional monitoring period in midsummer to support the SSID study design.
- Continuous temperature monitors were deployed at a total of nine locations, one more than the MRP requirement of eight locations, to account for potential loss or failure.
- A total of seven fecal indicator bacteria samples were collected at five stations, with the final two samples collected. at stations previously sampled to gain a measure of temporal variability.

Sensitivity

As measured by review of laboratory reporting limits and measurement equipment specifications, all laboratory analyses and field measurements met QAPP Measurement Quality Objectives (MQOs) for sensitivity.

Precision Results

All QA/QC measures for precision listed in the QAPP were met. Although the number of laboratory duplicates that have been calculated on ACCWP duplicates since initiation of the fecal indicator bacteria monitoring component of the CSM is still small (i.e., 5 for *E. coli*, 1 for Enterococcus), R_{log} values calculated for ACCWP WY 2016 data for both *E. coli* and Enterococcus achieved QAPP MQOs.

Accuracy Results

In general, accuracy for all targeted analyses / measurements was good. There were no issues with accuracy as determined by controls for indicator bacteria analyses or for continuous temperature monitoring measurements.

For continuous general water quality monitoring measurements of dissolved oxygen associated with July deployments (supplementary for SSID), there were deviations from QAPP MQOs. Drift checks performed associated with use of continuous monitoring equipment at the two SSID study sites, 204CRW040 and 204CRW041E, indicated that dissolved oxygen measurements did not achieve drift check control limits, indicating a possible high bias in reported DO measurements. Through communication with YSI technicians, field staff were able to identify the source of the measurement error and correct prior to fall deployments. All remaining parameters for all deployment intervals achieved QAPP MQOs.

Contamination Issues

There were no contamination issues observed in any of the samples, as determined by laboratory blanks performed by the indicator bacteria laboratory for samples collected during WY 2016 monitoring.

4.2 Continuous Water Temperature Monitoring

Data were collected over an approximately six-month period from April through September 2016 with measurements recorded at 60-minute intervals at the nine sites.

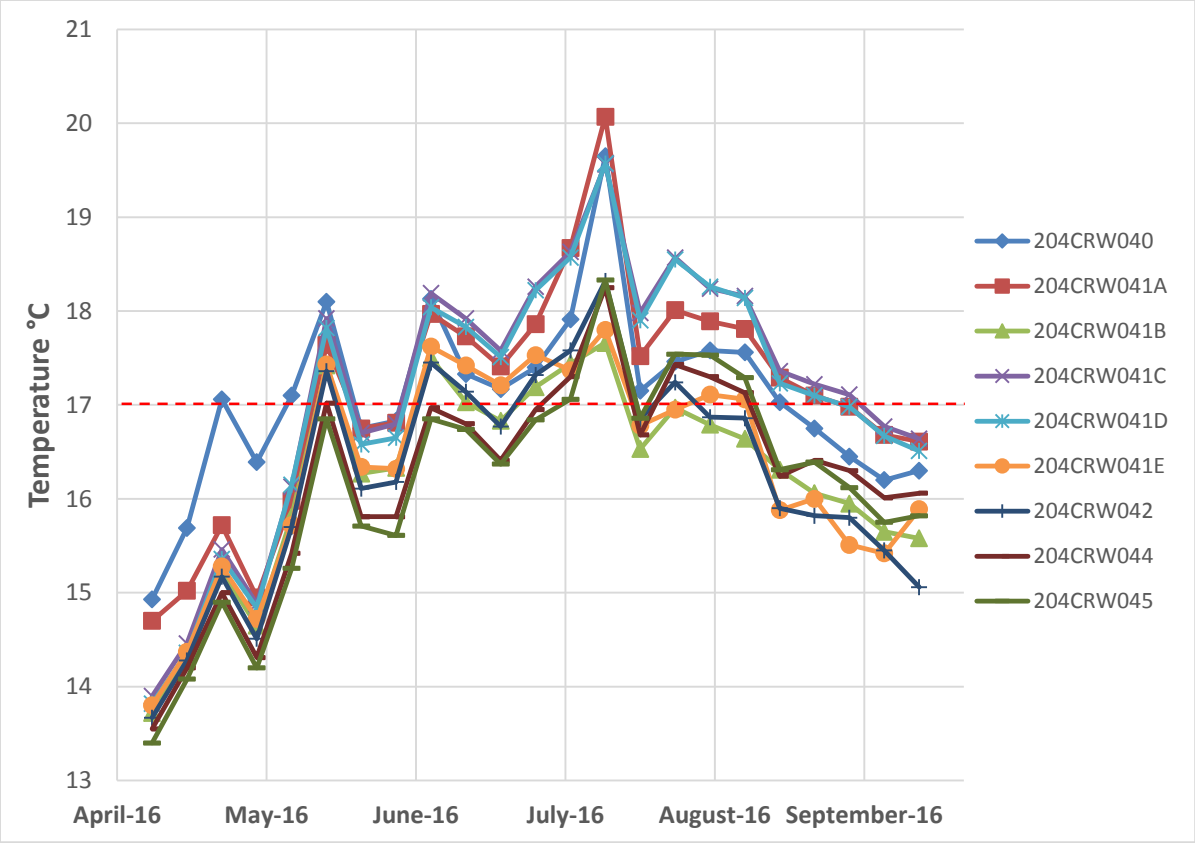
21
20
19
18
17
16
15
14
13
Temperature °C
April-16
May-16
June-16
July-16
August-16
September-16
204CRW040
204CRW041A
204CRW041B
204CRW041C
204CRW041D
204CRW041E
204CRW042
204CRW044
204CRW045

Figure 4-1 presents the results of the continuous monitoring results for WY 2016, and box plots[11] of the temperature data are shown in

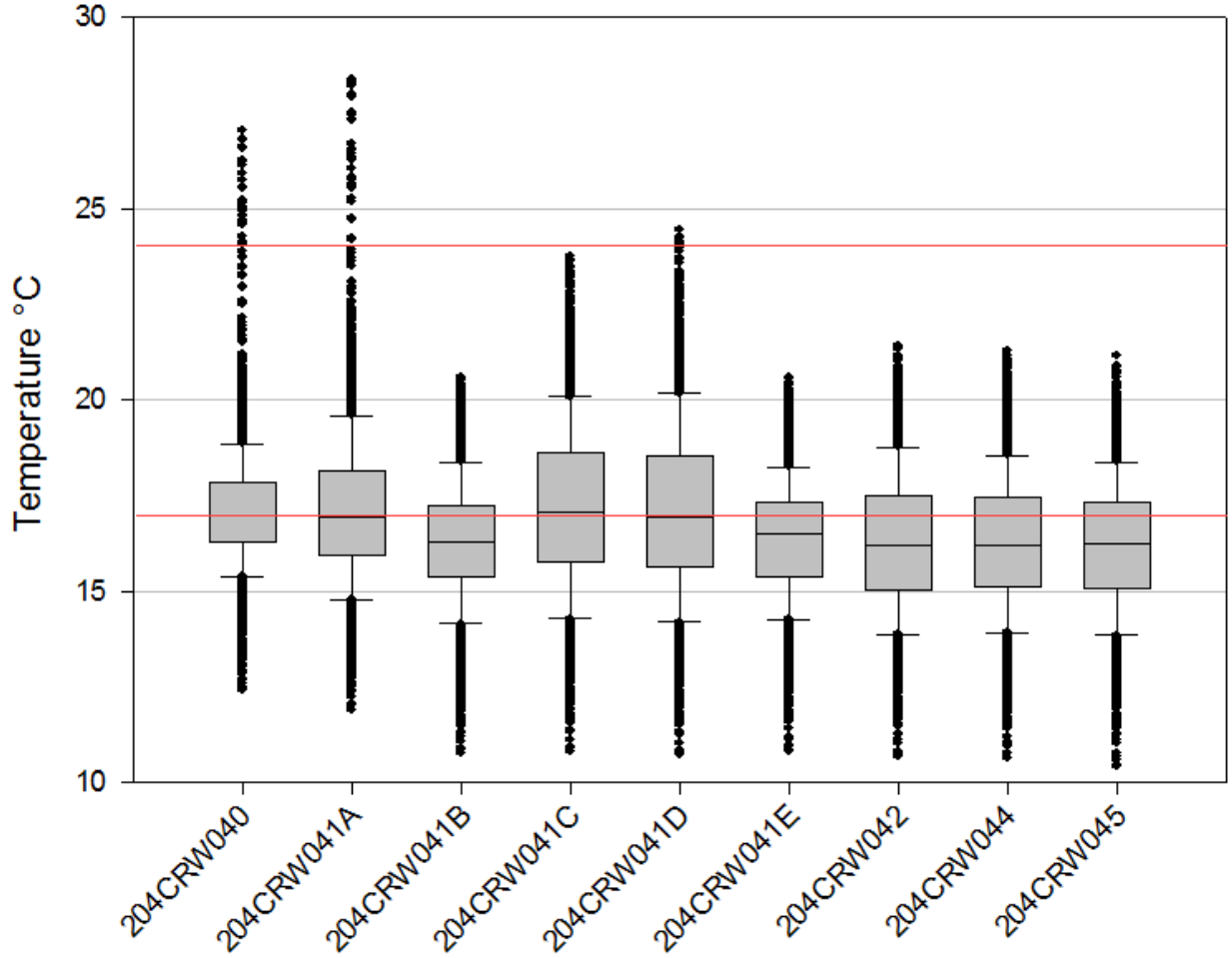

Figure 4-2.

[11]A box plot splits the data set into quartiles. The body of the plot consists of a "box", which goes from the first quartile to the third quartile. Within the box, a vertical line is drawn at the median of the data set. Two horizontal lines, called whiskers, extend from the front and back of the box. The front whisker goes from the first quartile to the smallest non-outlier in the data set, and the back whisker goes from the third quartile to the largest non-outlier. If the data set includes one or more outliers, they are plotted separately as points.

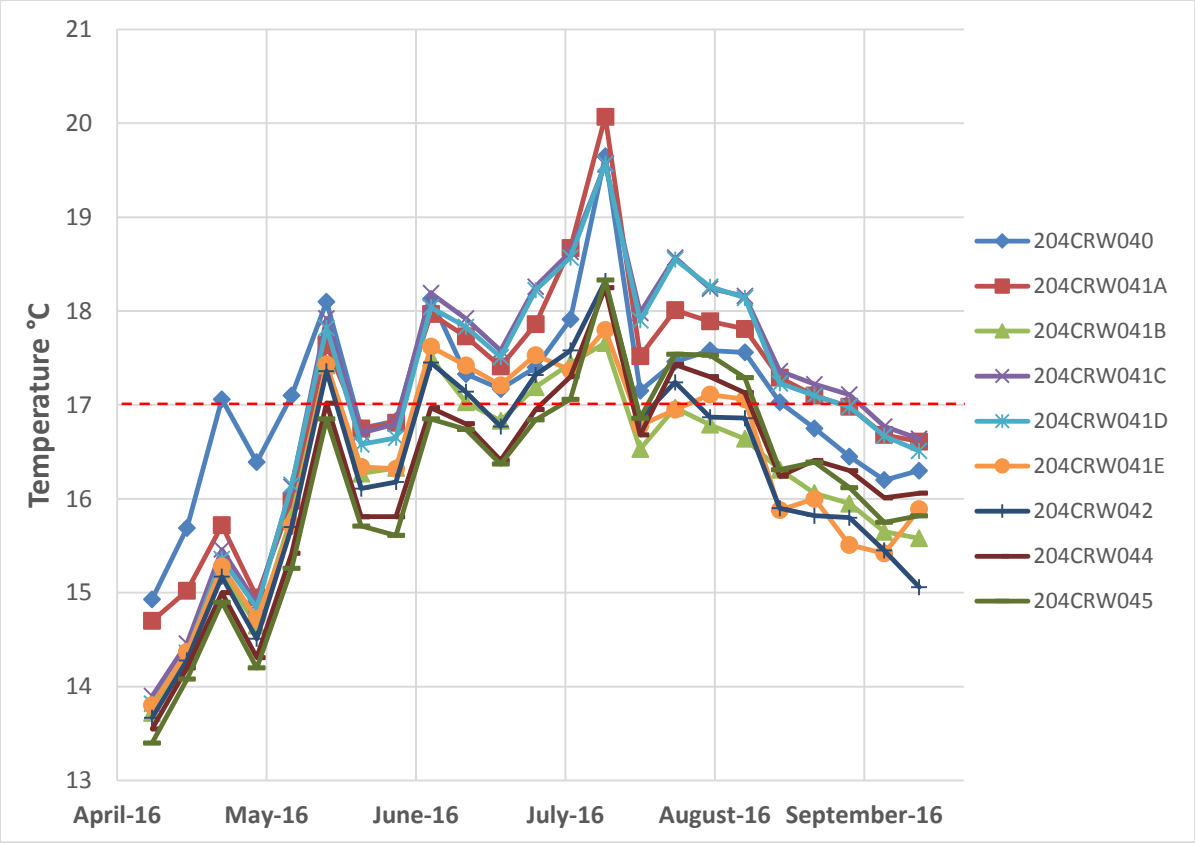

Figure 4-1. Temperature (Discrete 7-Day Average) Line Graph at Crow Creek Sites, April 26 through September 29, 2016.

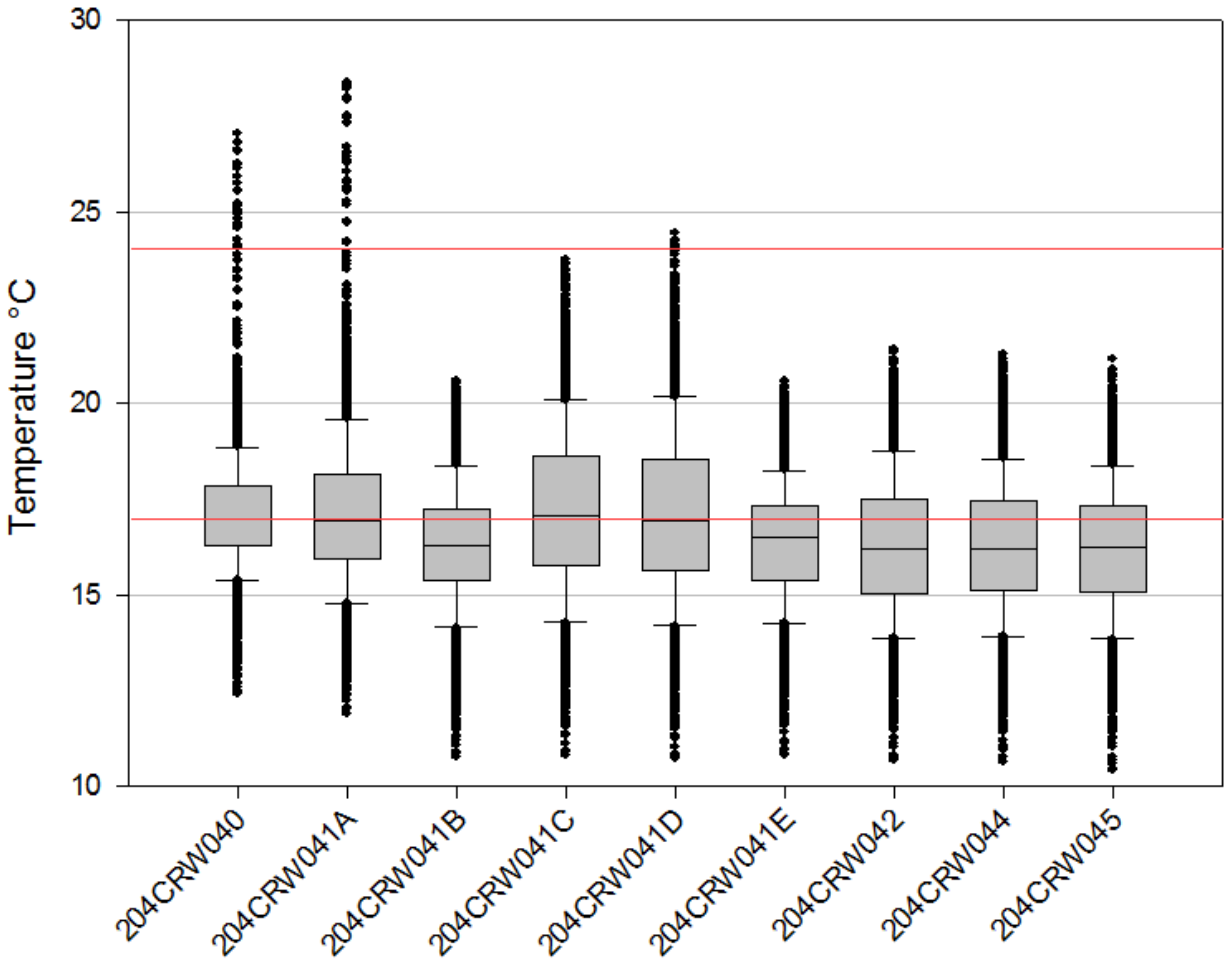

Figure 4-2. Temperature Box Plot at Sites, April 26 through September 29, 2016. 17°C & 24 °C thresholds are illustrated with red lines.

Summary 2016 statistics are presented for temperature monitoring data from Crow Creek in

Table 4-1. The highest temperature was recorded at 204CRW041A on July 28. The lowest temperature was recorded at the farthest upstream site, 204CRW045, on April 28. Average temperatures ranged from 16.2°C to 17.2°C.

Table 4-1. Summary of Continuous Temperature Data Statistics from WY 2016 at Crow Creek, Cull Creek, and San Lorenzo Creek Sampling Locations.

Station	Mean	St. Dev	Min	Max	Range
204CRW040	17.1	1.5	12.4	27.0	14.6
204CRW041A	17.1	2.0	11.9	28.4	16.5
204CRW041B	16.3	1.6	10.8	20.6	9.8
204CRW041C	17.2	2.2	10.8	23.7	12.9
204CRW041D	17.1	2.2	10.7	24.5	13.7
204CRW041E	16.3	1.5	10.8	20.6	9.8
204CRW042	16.3	1.8	10.7	21.4	10.8
204CRW044	16.2	1.7	10.6	21.3	10.7
204CRW045	16.2	1.7	10.4	21.2	10.7

Table 4-2 shows the number of exceedances of Maximum Weekly Average Temperatures (MWATs) compared to the threshold of 17°C. All sites had at least 2 MWATs greater than 17°C. Table 4-3 shows percent exceedance of the 24°C temperature threshold for each continuous monitoring site. The trigger of 20% exceedance of this threshold was not met at any of the sites.

Sullivan et al. (2000) is referenced in C.8.d.iii (4) of the MRP as a potential source for applicable thresholds to use for evaluating water temperature data for creeks that have salmonid fish communities, and illustrates the risk-based approach to evaluating temperature effects on salmonid communities in terms of relative reductions in growth at temperatures other than optimum. However, that study established its MWAT thresholds using data from salmonid populations in the Pacific Northwest and is likely overly conservative for steelhead in central California. Since fish growth is a function of both temperature and available food, optimum temperature and the incremental effect of temperature shifts on growth are ration-dependent and affected by other ecosystem factors, (for example see reviews in Myrick and Cech, 2001 and Atkinson et al., 2011). Streams in the Bay Area and Central California in general tend to be higher-nutrient systems than the glacially-derived geology of the Pacific Northwest, and can thus deliver the larger food supplies to support salmonid growth at warmer temperatures.

Table 4-2. Comparison of 2016 Continuous Temperature Maximum Weekly Average Temperature Measurements with 17°C Temperature Threshold at Crow Creek Sampling Locations in WY 2016. Bold values indicate two or more MWATs above the temperature trigger criterion.

Station	Site Description	# Weeks Deployed[1]	MWAT > 17º C	
			# Weeks	% Weeks
204CRW040	Crow Creek, concrete channel segment below confluence with Cull	23	**14**	61%
204CRW041A	Crow Creek, above outfall in eastern side of box culvert	23	**13**	57%
204CRW041B	Crow Creek, downstream end of box culvert under Cull Canyon Rd.	23	**6**	26%
204CRW041C	Crow Creek, upstream end of box culvert under Cull Canyon Rd., downstream of 48" outfall	23	**14**	61%
204CRW041D	Crow Creek, upstream end of box culvert under Cull Canyon Rd., upstream of 48" outfall	23	**13**	57%
204CRW041E	Crow Creek, upstream of box culvert	23	**9**	39%
204CRW042	Crow Creek at Crow Creek HOA property	23	**7**	30%
204CRW044	Crow Creek East of culvert under Crow Canyon Rd.	23	**6**	26%
204CRW045	Crow Creek at Cold Water Dr	23	**5**	22%

[1]Full or partial weeks

Table 4-3. Comparison of 2016 Continuous Temperature Records with 24°C Temperature Threshold at Crow Creek Sampling Locations.

Station	Number of Hourly Records	Mean Temp (˚C)	Number of readings > 24°C	% of readings > 24°C
204CRW040	3742	17.1	25	1%
204CRW041A	3743	17.1	29	1%
204CRW041B	3743	16.3	0	0%
204CRW041C	3741	17.2	0	0%
204CRW041D	3742	17.1	5	0%
204CRW041E	3742	16.3	0	0%
204CRW042	3743	16.3	0	0%
204CRW044	3748	16.2	0	0%
204CRW045	3747	16.2	0	0%

4.3 General Water Quality Measurement

General water quality measurements of temperature, DO, pH and specific conductivity were taken at locations during two periods: spring (May) and late summer to fall (August). In WY 2016, these data were collected from 3 sites (see Table 3-3):

- 204CRW040 – Crow Creek above confluence with Cull Creek; and
- 204CRW042 – Crow Creek south of Crow Creek Drive.
- 204CRW044 – Crow Creek downstream (east side) of culvert near mile 1.1 on Crow Canyon Road.

Table 4-4 summarizes WY 2016 spring and summer data in relation to the temperature, pH, and dissolved oxygen thresholds at each site; Figure 4-3, Figure 4-4 and

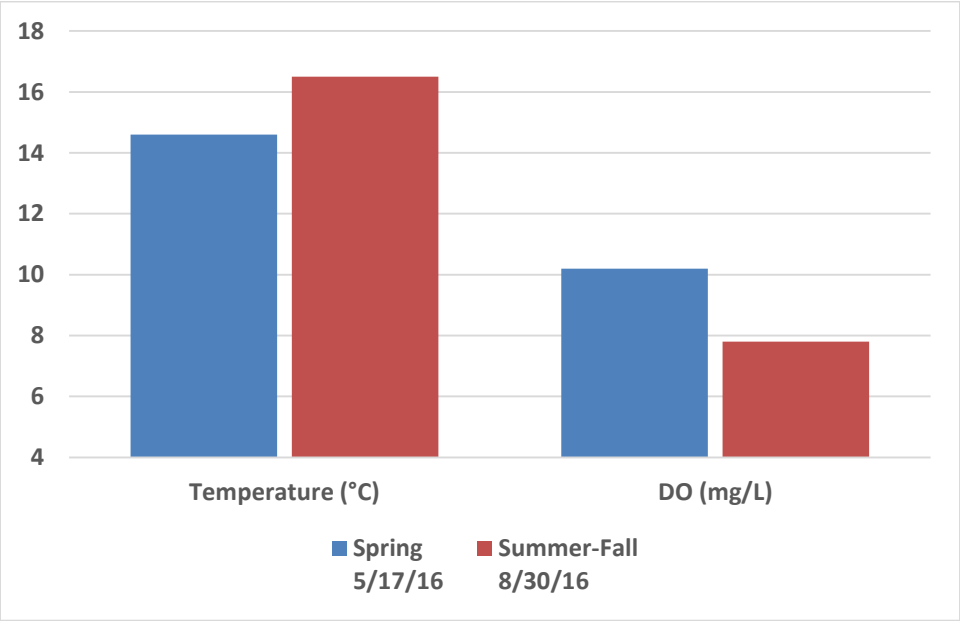

Figure 4-5 show graphical plots of temperature and DO for these sites (only the first week of each deployment are graphed). Summer discrete 7-day averages or MWATs for full or partial weeks of deployment were typically between 17°C and 19°C; otherwise the temperature thresholds were not exceeded. The water quality thresholds for conductivity and low pH were not exceeded more than 20% of the time at any of the General Water Quality monitoring sites, while thresholds for DO and high pH were exceeded more than 20% of the time at multiple sites.

Table 4-4. Comparison of General Water Quality Observations to Trigger Thresholds at Sites 204CRW040, 204CRW041E, 204CRW045 in WY 2016.

Station	Monitoring Season (No of MWATs)	Applicable threshold or water quality standard					
		Temperature MWATs > 17˚C (> 19°C)	Temp % > 24˚C	Specific Cond. >2000 µS/cm	pH < 6.5	pH > 8.5	DO < 7 mg/L (COLD)
204CRW040	Spring (2)	0(0)	0%	0%	0%	22%	0%
	Midsummer (2)	1**(0)	0%	0%	0%	3%	3%*
	Summer-Fall (2)	1(0)	0%	0%	0%	0%	12%
204CRW041E	Spring (2)	0(0)	0%	0%	0%	39%	0%
	Midsummer (2)	0(0)	0%	0%	0%	24%	5%*
	Summer-Fall (2)	0(0)	0%	0%	0%	0%	79%
204CRW045	Spring (2)	0(0)	0%	0%	0%	0%	0%
	Summer-Fall (2)	0(0)	0%	0%	0%	0%	22%

*Dissolved oxygen outside of control limits for drift check, possible high bias
**>17 ˚C MWAT was from partial week (~3 days) of data

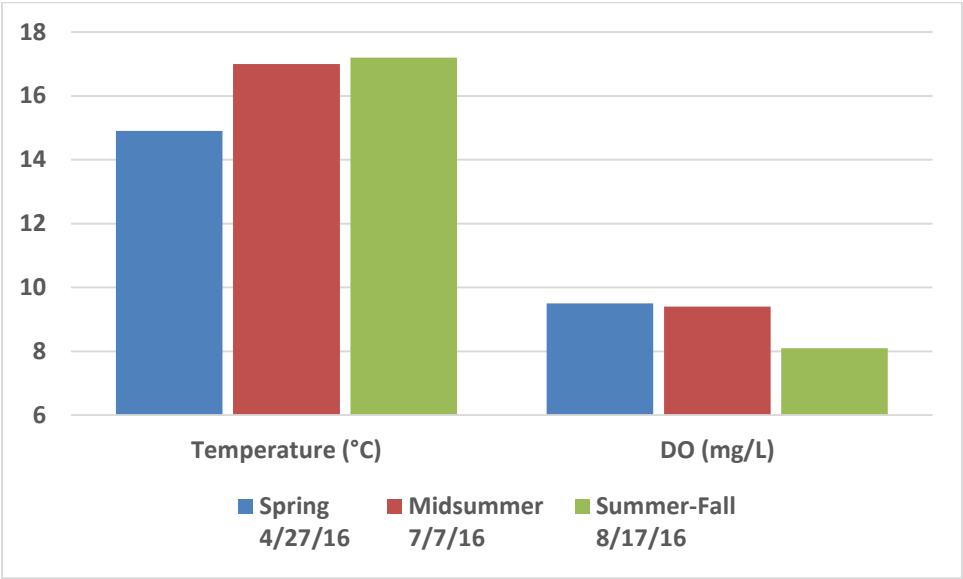

Figure 4-3. General Water Quality Monitoring Discrete 7-day Averages for Temperature and Dissolved Oxygen at 204CRW040 in Spring, Midsummer, and Summer-Fall, WY 2016

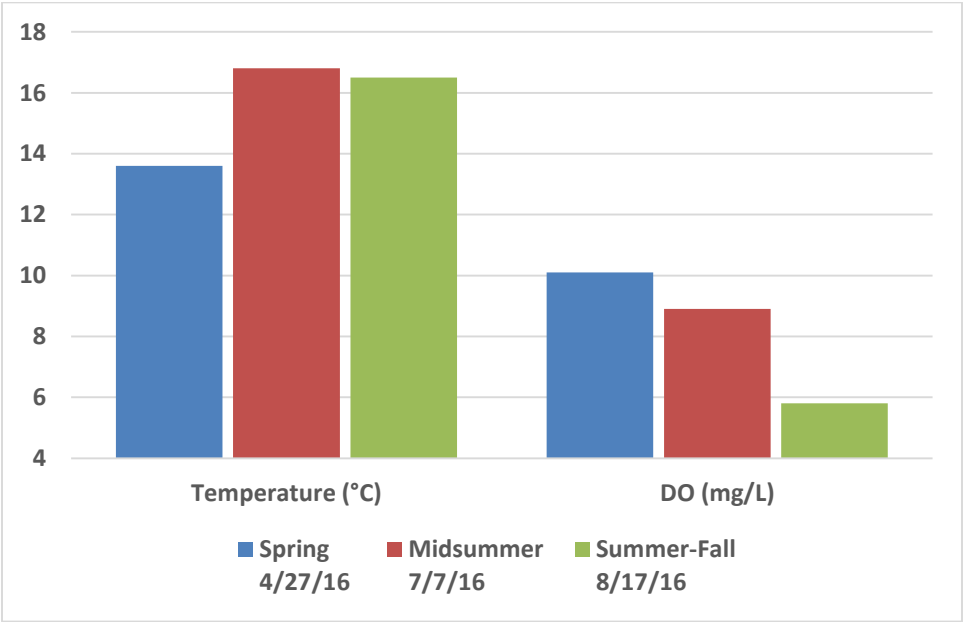

Figure 4-4.General Water Quality Monitoring Discrete 7-day Averages for Temperature and Dissolved Oxygen at 204CRW041E in Spring, Midsummer, and Summer-Fall, WY 2016.

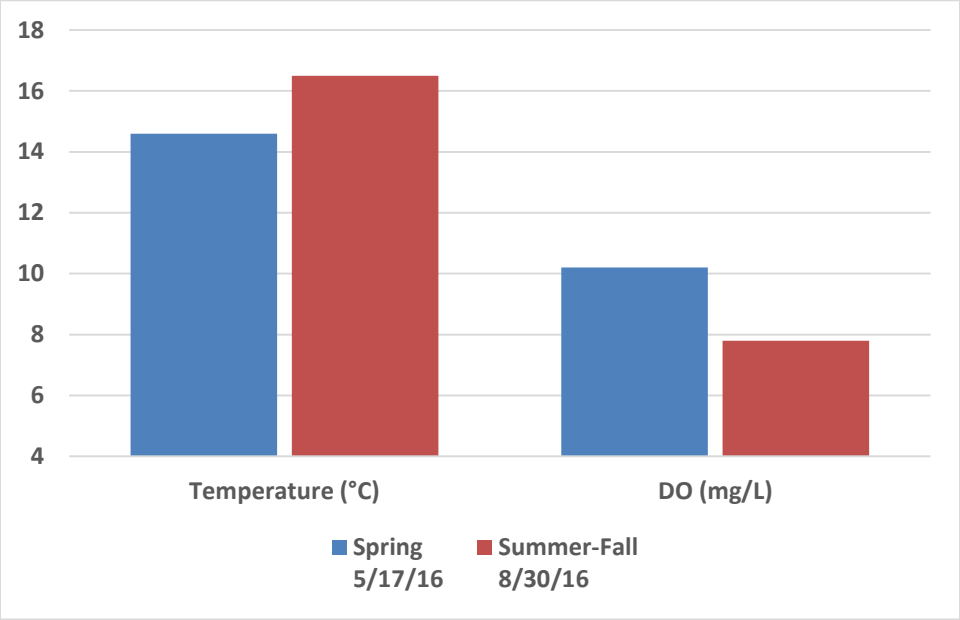

Figure 4-5. General Water Quality Monitoring Discrete 7-day Averages for Temperature and Dissolved Oxygen at 204CRW045 in Spring and Summer-Fall, WY 2016.

4.4 Pathogen Indicators

Single grab water samples for pathogen indicators were collected at five locations in the greater Castro Valley Creek watershed on July 20, 2016. *E. coli* and Enterococci were enumerated as individual grab samples as presented in

Table 4-5. As discussed earlier, two sites were sampled a second time later the same day. Results for these samples are presented in

Table 4-6.

Elevated Enterococci and *E.coli* concentrations were found in all samples. Of the two samples taken at 204CVY080, one measured Enterococci at 4,400 MPN and the other found *E. coli* at 17,000 MPN, the highest values obtained for each of the indicators.

Table 4-5. Enterococci and *E. coli* enumerations at Castro Valley Creek Monitoring Sites - July 20, 2016 FIB Monitoring.

Site ID	Site Description	Creek Name	Enterococci (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204CVY020	Chabot Creek at Carlos Bee Park	Chabot Creek	**350**	**2,200**
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**4,400**	**14,000**
204CVY084	Castro Valley Creek south side of Grove Way	Castro Valley Creek	**1,000**	**3,000**
204CVY090	Castro Valley Creek upstream of Redwood Rd	Castro Valley Creek	**2,900**	**9,000**
204CVY125	Castro Valley Creek south of Castro Valley Blvd.	Castro Valley Creek	**1,000**	**800**

*Most Probable Number per 100mL

BOLD font indicates result meets trigger conditions.

Table 4-6. Enterococci and *E. coli* enumerations at Castro Valley Creek Monitoring Sites - July 20, 2016 FIB Monitoring.

Site ID	Site Description	Creek Name	Enterococci (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**320**	**17,000**
204CVY084	Castro Valley Creek south side of Grove Way	Castro Valley Creek	**660**	**17,000**

*Most Probable Number per 100mL

BOLD font indicates result meets trigger conditions.

5 Stressor Assessment

This section is a preliminary review of targeted monitoring data to identify samples with results that meet the "trigger" conditions for potential further investigation via a SSID project, or other actions to reduce the stressor effect of urban runoff. Stressor assessment was conducted according to the trigger criteria in MRP Provisions C.8.d.iii through C.8.d.v, as listed in the following subsections).

5.1 Temperature

The reissued MRP (SFRWQCB 2015) defines the temperature trigger as when two or more weekly average temperatures exceed the Maximum Weekly Average Temperature 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[12].

All WY 2016 temperature monitoring sites were in streams with COLD Beneficial Use, and experienced at least two MWATs above 17.0°C during the summer, while none experienced at two or more MWATs above 19°C (Table 4-2 and Figure 4-1). No sites exceeded the 24°C instantaneous maximum for 20% or more of the records.

5.2 Continuous Monitoring of Dissolved Oxygen, Temperature, and pH

MRP trigger criteria occur when results at one sampling station exceed the applicable temperature or dissolved oxygen trigger or demonstrate a spike in temperature or drop in dissolved oxygen with no obvious natural explanation. The temperature trigger is defined as any of the following: Maximum Weekly Average Temperature exceeds 17.0°C for a Steelhead stream, or 20 percent of the instantaneous results exceed 24°C.

These trigger criteria were compared against the results obtained during General Water Quality monitoring. No MWAT triggers were observed during spring deployments; during the midsummer and summer-fall deployments one site had an MWAT above 17.0°C but below 19°C (Table 4-4). Comparisons with other threshold values identified in the MRP indicate that thresholds for conductivity and low pH were not exceeded more than 20% of the time at any of the General Water Quality monitoring sites, while thresholds for DO and high pH were exceeded more than 20% of the time at multiple sites.

[12] Permittees shall calculate the weekly average temperature by breaking the measurements into non-overlapping, 7-day periods.

5.3 Pathogen Indicators

The pathogen trigger criteria consist of the following[13]:

- Enterococci (marine and freshwater):
  - Geometric mean of 35 colony forming units (cfu) per 100 milliliters (mL)
  - Statistical threshold value of 130 cfu per 100 mL
- E. coli (freshwater)
  - Geometric mean of 126 colony forming units (cfu) per 100 milliliters (mL)
  - Statistical threshold value of 410 cfu per 100 mL

Table 5-1 and Table 5-2 present the results of the pathogen indicator enumeration with comparison against the trigger criteria identified above. All sites sampled on July 20 were found to have bacterial concentrations above the recommended thresholds for lightly and moderately used recreational areas. It should be noted that recreational usage, as defined by the USEPA, is not well supported within the sampled creeks. As a typical example, Castro Valley Creek is designated for both contact (REC-1) and non-contact (REC-2) recreation, although much of the creek system is inaccessible to the public. Two of the monitoring locations (204CVY020 and 204CVY080) do provide public access through parks and trails but there is little option for immersive swimming or contact recreation. Therefore actual recreational contact in this small creek is extremely limited and is not encouraged. Sites 204CVY150 and 204CVY170 have the least opportunity for legal public access. Extensive presence of homeless encampments has been documented along the creek but this represents a probable source rather than normal recreational use.

[13] Water Board staff have confirmed to the RMC Work Group that for the purposes of trigger assessment, units of cfu/100ML can be considered equivalent to the units of MPN/100ML reported in laboratory analysis results.

Table 5-1. Comparison of WY 2016 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP July 20, 2016 FIB Monitoring.

Site ID	Site Description	Creek Name	Enterococci (MPN/100mL)*	*E. coli* (MPN/100 mL)*
204CVY020	Chabot Creek at Carlos Bee Park	Chabot Creek	**350**	**2,200**
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**4,400**	**14,000**
204CVY084	Castro Valley Creek south side of Grove Way	Castro Valley Creek	**1,000**	**3,000**
204CVY090	Castro Valley Creek upstream of Redwood Rd	Castro Valley Creek	**2,900**	**9,000**
204CVY125	Castro Valley Creek south of Castro Valley Blvd.	Castro Valley Creek	**1,000**	**800**

*Most Probable Number per 100mL

BOLD font indicates result meets trigger conditions.

Table 5-2. Comparison of WY 2016 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP July 20, 2016 FIB Monitoring second round.

Site ID	Site Description	Creek Name	Enterococci (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**320**	**17,000**
204CVY084	Castro Valley Creek south side of Grove Way	Castro Valley Creek	**660**	**17,000**

*Most Probable Number per 100mL

BOLD font indicates result meets trigger conditions.

6 Next Steps

All sites identified in Section 5 as meeting trigger criteria as candidates for new SSID projects will be reviewed by the Program in conjunction with relevant Permittees and RMC programs to determine potential follow-up actions pursuant to MRP Provision C.8.e.. ACCWP initiated three SSID projects developed through the RMC selection process in the previous permit term, and together with other RMC participants will initiate new SSID projects as stipulated in MRP Provision C.8.e.ii (1). Where triggers or potential trigger conditions have been identified in WY 2016 results, ACCWP will also work with local stormwater managers to identify appropriate follow-up activities, which may be either incorporated in WY 2017 Creek Status Monitoring or conducted outside the scope of MRP Provision C.8.d.

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ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

POLLUTANTS OF CONCERN MONITORING 2015 SEDIMENT SAMPLING REPORT

APPENDIX A.3A

URBAN CREEKS MONITORING REPORT

OCTOBER 2015 THROUGH SEPTEMBER 2016

Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region

FINAL
March 31, 2016

Protecting Alameda County Creeks, Wetlands & the Bay

Acknowledgement

Applied Marine Sciences, Inc. contributed substantially to the site reconnaissance, implementation of monitoring and preparation of the data analysis in this report.

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) collaboratively developed an outline for preparation of the first Urban Creeks Monitoring Report (UCMR) that was submitted in March 2013 in compliance with the Municipal Regional Stormwater Permit (MRP) [1] Reporting Provision C.8.g.v regarding all monitoring conducted during the MRP permit term.

The following participants make up the RMC and are responsible for preparing IMR documents on behalf of their respective member agencies:

- 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 report was prepared by ACCWP to fulfill reporting requirements for a portion of the Pollutants of Concern Loads Monitoring data collected in Water Year 2015 (October 1, 2014 through September 30, 2015).This report is an Appendix to the full UCMR submitted by ACCWP on behalf of the following Permittees:

- The 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 of the Alameda County Flood Control and Water Conservation District.

[1] Unless otherwise noted references to the MRP are to the reissued "MRP2" (SFBRWQCB, 2015) which became effective January 1, 2016. Most of the monitoring requirements addressed in this Appendix have not changed substantially from the original "MRP1" (SFBRWQCB, 2009)

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1. Introduction

This report fulfills a portion of the reporting requirements of Provision C.8.h.iii of the Bay Area Municipal Regional Stormwater Permit (MRP[2]) for Pollutants of Concern (POC) Monitoring data collected pursuant to MRP Provision C.8.f during Water Year (WY) 2016 (October 1, 2015 - September 30, 2016). Additional data required by Provision C.8 are reported in other appendices and portions of ACCWP's Urban Creeks Monitoring Report (UCMR), of which this is Appendix A.3A.

Provision C.8.f of the MRP lists five priority POC management information needs 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.

As required in provision C.8.h.iv, ACCWP's Pollutants of Concern (POC) Monitoring Report (ACCWP 2016b) described accomplishments during Water Year 2016 and the allocation of POC monitoring sampling effort planned for WY 2017 to address these information needs. This report covers monitoring for Polychlorinated Biphenyls (PCBs) and total mercury primarily to address information need #1, to assist in PCB source identification studies as part of a process outlined ACCWP (2016a). The main objective of this monitoring is to identify individual properties (parcels) with elevated concentrations of PCBs that may be abated as a means of attaining pollutant load reduction targets.

[2] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) 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) and reissued the permit on November 19, 2015 (MRP2, SFBRWQCB 2015) with an effective date of January 1, 2016. Unless otherwise noted references in this report to the MRP are to the reissued "MRP2"

This report covers data collected by sampling bedded sediment in public rights-of-way (ROWs) within the city of Berkeley. All sampling was performed between in November 2015 by personnel of Applied Marine Sciences (AMS) and ADH Environmental under the direction of AMS.

2. Methods

The Program prepared a draft Quality Assurance Project Plan (QAPP) and Sampling and Analysis Plan (SAP) describing methods based on those used for Task 3 of Clean Watersheds for a Clean Bay (CW4CB), a regional program of pilot PCB implementation projects under the coordination of the Bay Area Stormwater Management Agencies Association (BASMAA 2012).

Surface soil/sediment samples were collected using the general procedures described in the RMC SOP FS-6, Collection of Bedded Sediment Samples for Chemical Analysis & Toxicity (BASMAA 2014).

Prior characterization efforts conducted on behalf of BASMAA member agencies have regularly used laboratory analyses with target Reporting Limits (RLs) consistent with California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Project Plan (SWAMP 2008); this project, however, as more of a screening level monitoring project, is not restricted to use of lowest obtainable RLs. Instead, the project selected laboratory methods that provide data at concentrations required to inform management actions, but at lower cost in order to allow a greater number of samples to be analyzed. Target Minimum RLs for this study are listed in

Table 2-1 and Table 2-2

Table 2-1. Target MRLs for Sediment Quality Parameters.

Analyte	MRL
Sediment Total Organic Carbon	0.01% OC
%Moisture	n/a
%Lipids	n/a
Mercury	30 µg/kg

Table 2-2. Target MRLs for Analyte PCB Congeners in Soils/Sediment.

Congener	Soils MRL (µg/kg)	Congener	Soils MRL (µg/kg)
PCB 8	10	PCB 118	10
PCB 18	10	PCB 128	10
PCB 28	10	PCB 132	10
PCB 31	10	PCB 138	10
PCB 33	10	PCB 141	10
PCB 44	10	PCB 149	10
PCB 49	10	PCB 151	10
PCB 52	10	PCB 153	10
PCB 56	10	PCB 156	10
PCB 60	10	PCB 158	10
PCB 66	10	PCB 170	10
PCB 70	10	PCB 174	10
PCB 74	10	PCB 177	10
PCB 87	10	PCB 180	10
PCB 95	10	PCB 183	10
PCB 97	10	PCB 187	10
PCB 99	10	PCB 194	10
PCB 101	10	PCB 195	10
PCB 105	10	PCB 201	10
PCB 110	10	PCB 203	10

3. Field Sampling

3.1. Objectives

The objectives of the sampling effort were to collect the following:

- Sediment samples from identified sites for analysis of PCB congeners, Hg, Total Organic Carbon (TOC), and particle size distribution (PSD)(analyzed as % fines, < 63 µm) by ALS Group (ALS).
- Sediment samples from one of the target sites for analysis of field duplicate samples by ALS.

3.2. Sampling Locations

A list of sites for which field staff completed reconnaissance operations in 2015, and those that were sampled if feasible, is summarized in Table 3-1. Figure 3-1 and Figure 3-2 show the locations of the targeted sites

.

Table 3-1. Sampling Activities for POCs Sediment Sampling 2015.

SiteID	AMEC ID	APN(s)	Date	Lat	Long	Comments
AC-BER-001-R	NA	53-1655-1	11/12/15	37.85446	-122.29629	Sampled at broken up driveway above road
AC-BER-002-R	NA	53-1655-2-2	11/6/15	37.85450	-122.29603	Sampled at grate on storm drain inlet (sampled during recon due to small amount of soil present and potential rain in forecast)
AC-BER-003-R	NA	53-1655-3-15	11/12/15	37.85502	-122.29357	
AC-BER-004-R	NA	53-1655-8	11/6/15	NS	NS	Not sampled, insufficient soil
AC-BER-005-R	NA	56-1947-1-1	11/6/15	NS	NS	Not sampled, insufficient soil
AC-BER-006-R	NA	57-2112-1-1	11/12/15	37.87251	-122.30383	Collected sand at driveway
AC-BER-007-R	NA	57-2112-1-2	11/12/15	37.87328	-122.30343	Swept at driveway
AC-BER-008-R	NA	57-2112-4-1	11/12/15	37.87163	-122.30294	Swept and collected street dust in driveway
AC-BER-009-R	NA	57-2112-4-2	11/12/15	37.87332	-122.30309	Swept at driveway
AC-BER-010-R	NA	59-2318-3-1	11/6/15	NS	NS	Not sampled, insufficient soil
AC-BER-011-R	NA	59-2341-3-2	11/12/15	NS	NS	Not sampled, insufficient soil present
AC-BER-012-R	NA	59-2344-1-2	11/12/15	37.87808	-122.30643	Swept multiple points along fence line. One point had rust-colored soils.
AC-BER-013-R	NA	59-2345-8-1	11/6/15	NS	NS	Not sampled, insufficient soil
AC-BER-014-R	NA	59-2345-9	11/12/15	37.87730	-122.30431	
AC-BER-015-R	NA	59-2346-6	11/12/15	37.87744	-122.30316	Swept along driveway
AC-BER-016-R	NA	59-2348-1-5	11/12/15	37.87871	-122.30220	Collected in abandoned railroad outside fence

Figure 3-1. Overview of Sites Successfully Sampled WY2016 Sites in Berkeley – North Cluster

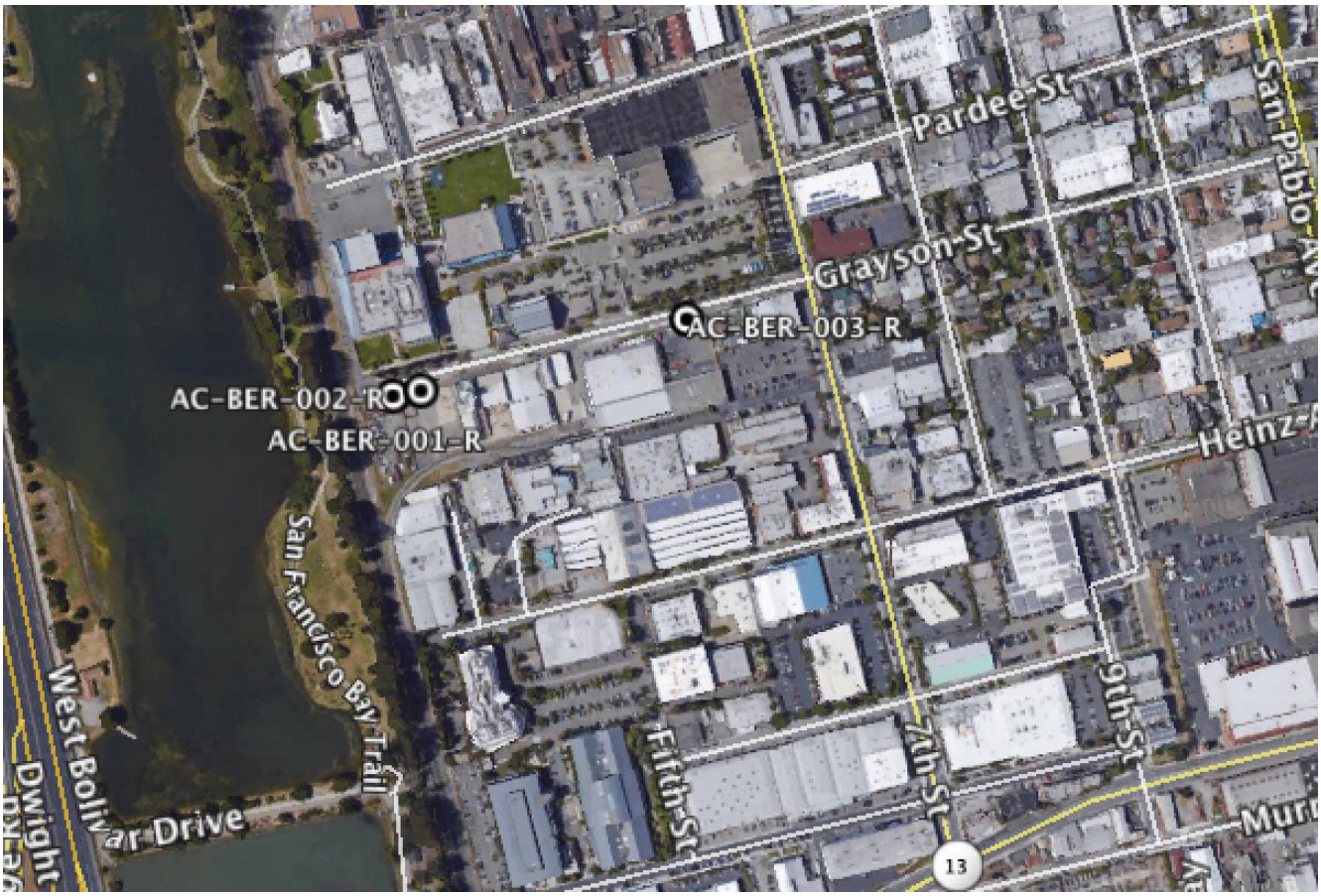

Figure 3-2. Overview of Sites Successfully Sampled in Berkeley – South Cluster

4. Results and Discussion

4.1. Quality Assurance

In keeping with the draft Project QAPP, a field duplicate samplewas collected at site BER-014, which exhibited sufficient soil present to support replicate analyses.

AMS performed validation and verification on laboratory data consistent with SWAMP Measurement Quality Objectives (MQOs). QA review indicated that data quality was generally good, with the following observations:

All analyses of conventional analytes met all MQOs and no qualification was required.

Precision:

Relative percent differences (RPDs) reported for Matrix Spike / Matrix Spike Duplicate (MS/MSD) pairs exceeded QAPP control limits for a subset of PCB congeners.

Calculated field RPDs associated with analysis of blind field duplicate samples for mercury and a subset of PCB congeners analyzed exceeded QAPP MQOs. As the control limits for field duplicates are identical to those of lab duplicate analyses, this is not a surprising occurrence. WY2016 data were qualified as dictated by comparison with QAPP control limits.

Accuracy:

Matrix Spike recoveries were reported outside of control limits for a number of mercury and PCB congener samples. The lab identified matrix interference as a potential root cause of the possible bias, and characterized the bias itself as likely to be relatively small.

4.2. Results and Next Steps

The summary results associated with all WY 2016 POC sediment monitoring are presented in Table 4-1. As a practice, ALS does not report sum of PCBs associated with analysis by EPA method 8082M. AMS calculated total PCBs as reported in Table 4-1 with substitution of ½ of the MDL for any non-detects, consistent with methodology employed for sum of various organic constituents for the RMC Creek Status Monitoring Program reporting. Of these samples, only BER-002 showed PCB concentrations suggesting a potential source of interest.

Pursuant to Provision C.8.h in the reissued MRP, in October of each year the Program will submit a separate POC Monitoring Report describing accomplishments during the preceding Water Year and the allocation of POC monitoring sampling effort for the forthcoming Water Year, i.e. for WY 2017 in the October 2016 report) (ACCWP 2016b). The POC Monitoring

Report also considers other data sources; as noted in Appendix A.3B, monitoring by the RMP at an outfall in West Berkeley provided an alternative line of evidence indicating possible sources or reservoirs of sediment with elevated concentrations of both PCBs and mercury. ACCWP's sediment sampling in WY2017 will return to West Berkeley and also expand coverage of unsampled parts of Oakland with Old Industrial landuse. POC sediment data will be used to support identification of priority watersheds and management areas for Permittee actions to reduce PCBs and for Annual Reporting pursuant to MRP provisions C.11 and C.12.

Table 4-1. Summary Results for WY2016 POC Sediment Monitoring.

Station ID	Latitude	Longitude	Total PCBs (ug/kg)	Total Hg (ug/kg)
BER-001	37.85446	-122.29629	9	0.33
BER-002	37.8545	-122.29603	780	0.09
BER-003	37.85502	-122.29357	134	0.19
BER-006	37.87251	-122.30383	3	0.03
BER-007	37.87328	-122.30343	2	0.19
BER-008	37.87163	-122.30294	38	0.90
BER-009	37.87332	-122.30309	28	0.24
BER-011	37.87577	-122.30501	3	0.01
BER-012	37.87808	-122.30643	69	0.04
BER-014	37.8773	-122.30431	52	0.30
BER-015	37.87744	-122.30316	16	0.47
BER-016	37.87871	-122.3022	3	0.03

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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

[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),

[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,

[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

[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.

[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).

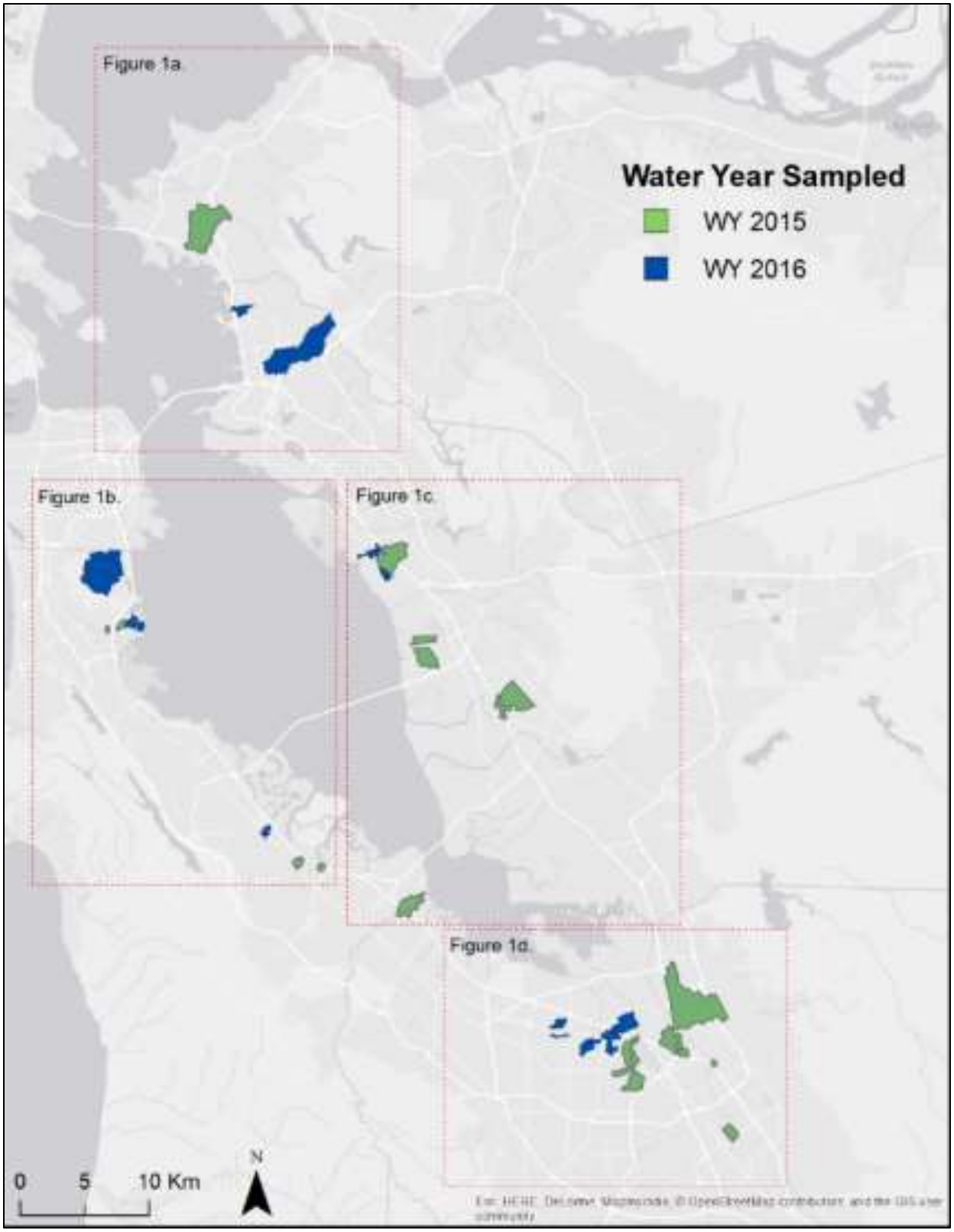


Figure 1. Sampling locations (marked by the dots) and watershed boundaries (shown in green and blue).

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.

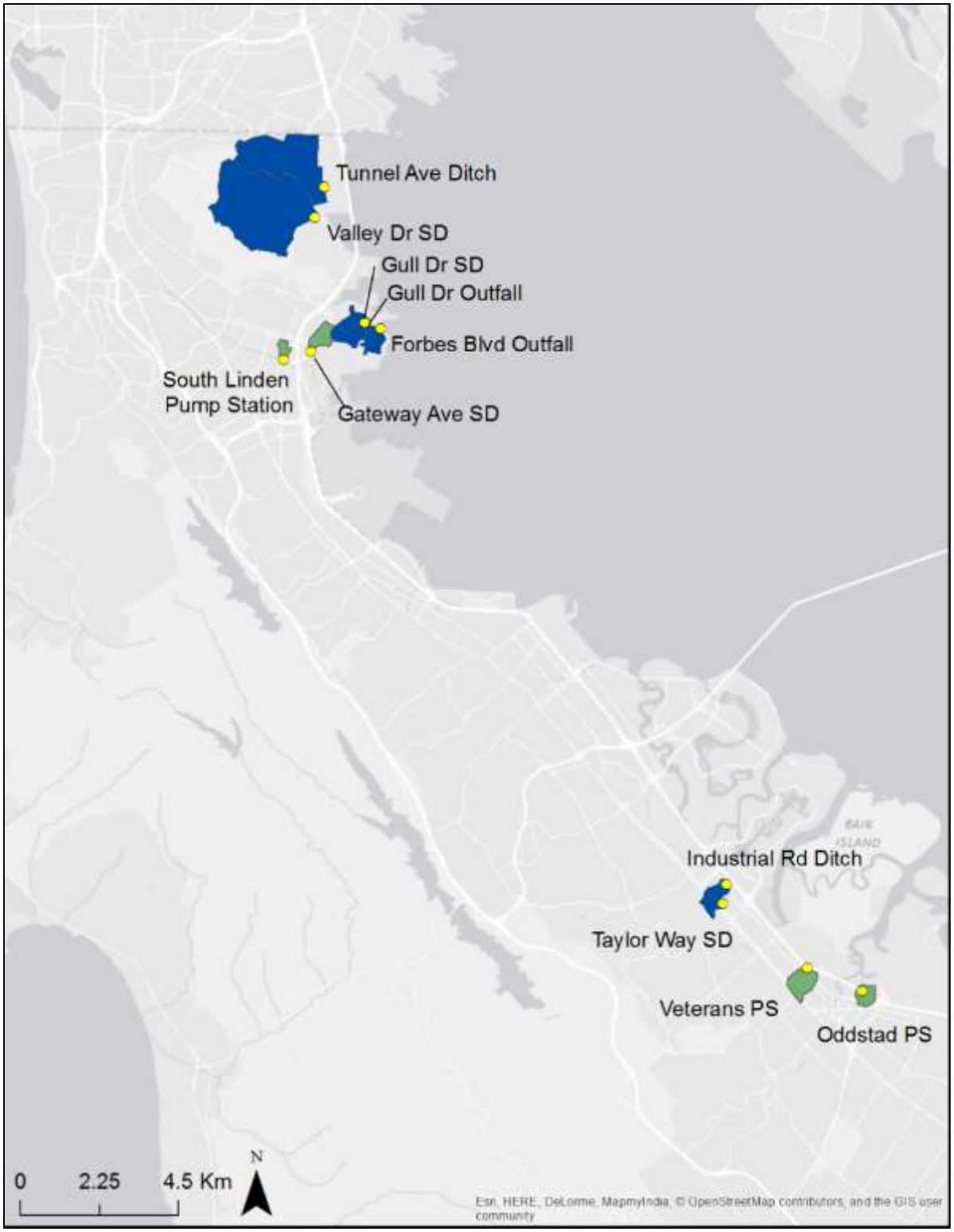


Figure 1b. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in central and northern San Mateo County.

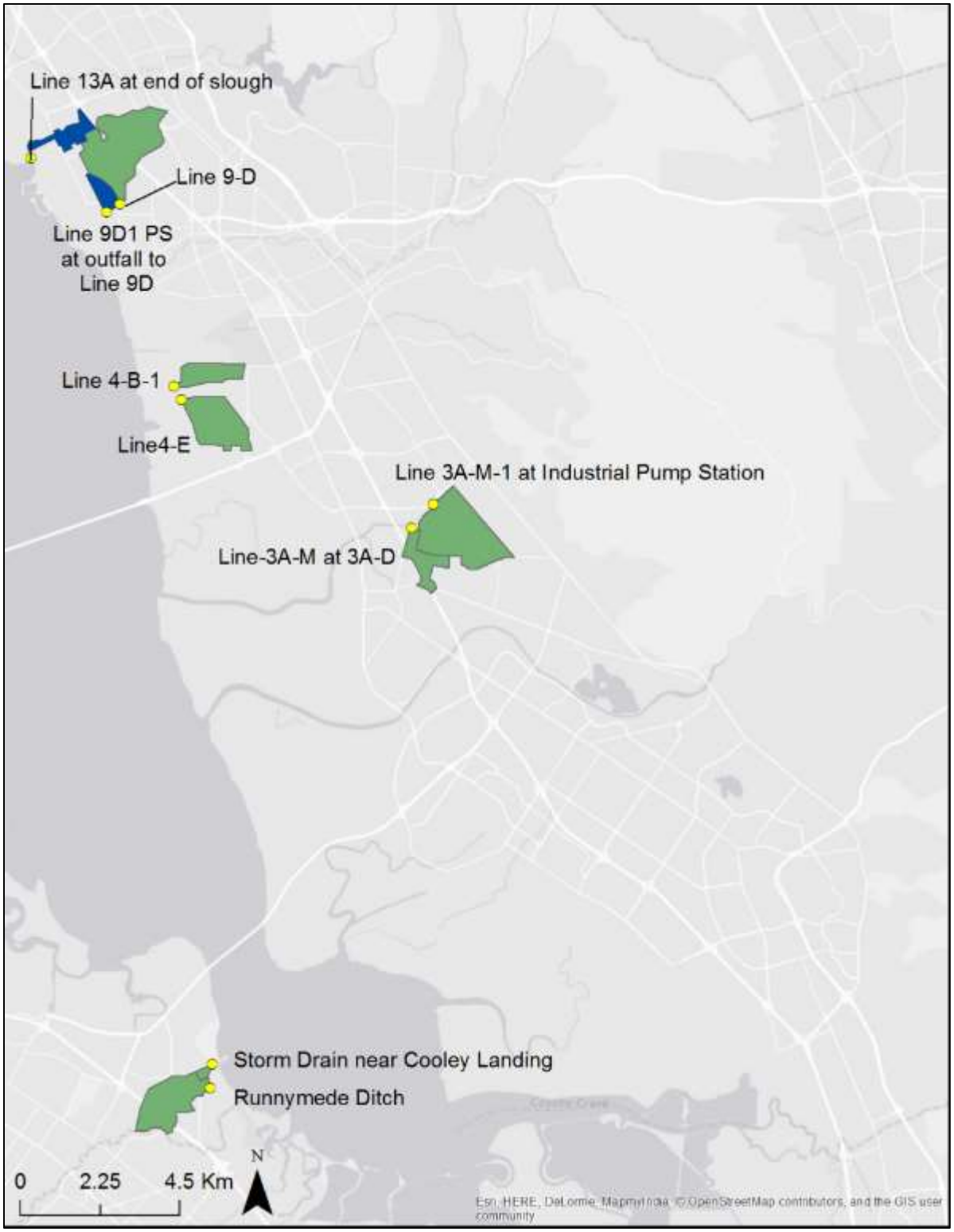


Figure 1c. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in southern Alameda and San Mateo counties.

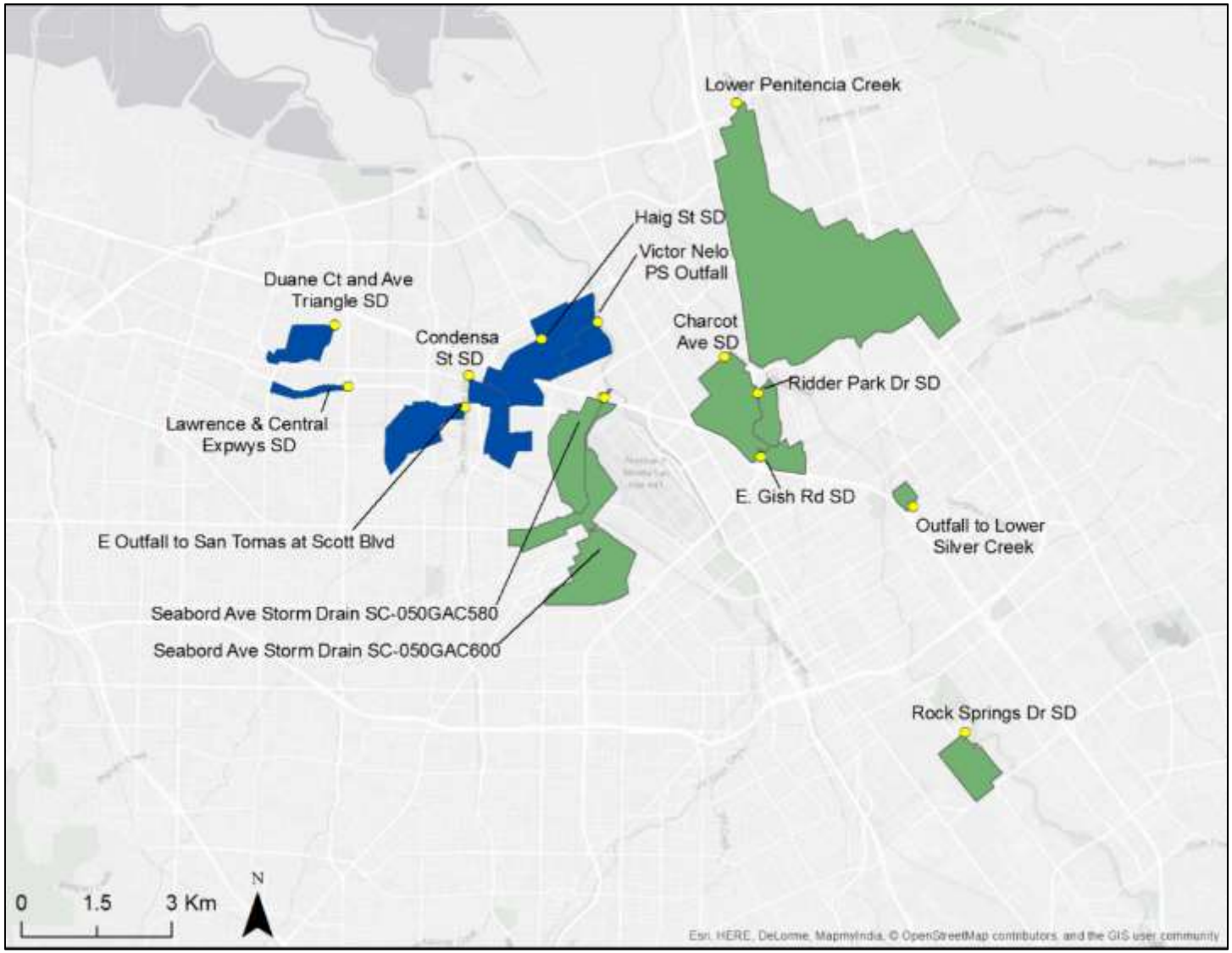


Figure 1d. Sampling locations (marked by the dots) and watershed boundaries (shown in green (WY 2015) and blue (WY 2016)) in Santa Clara County.

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

[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.

(a)

(b)

(c)

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.

[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.

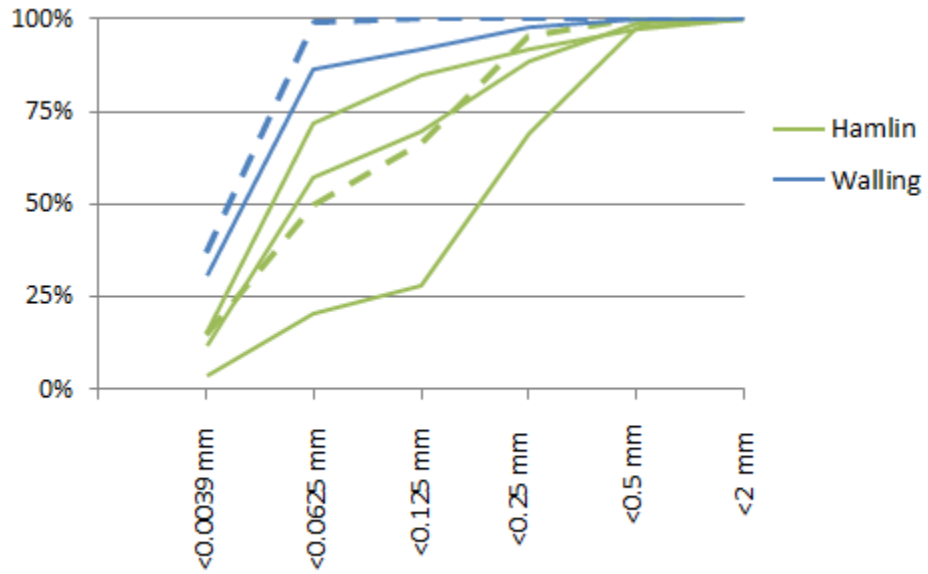


Figure 3. Cumulative grain size distribution in the Hamlin and Walling Tube samples. The dashed lined sample distributions were collected at the same site.

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.

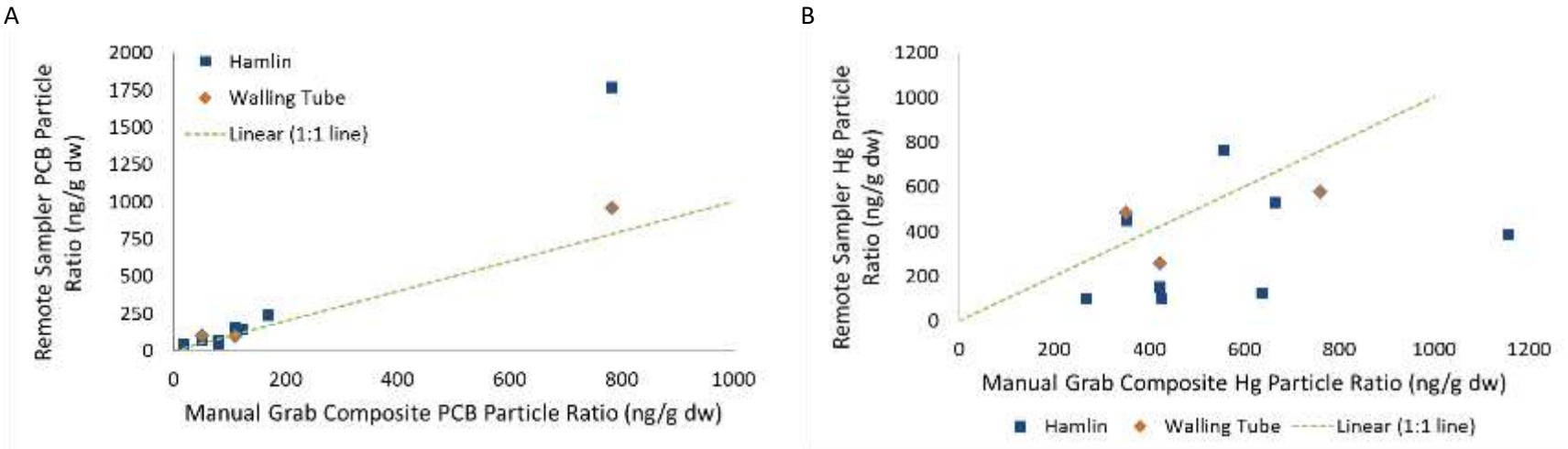


Figure 4. Particle Ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

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.

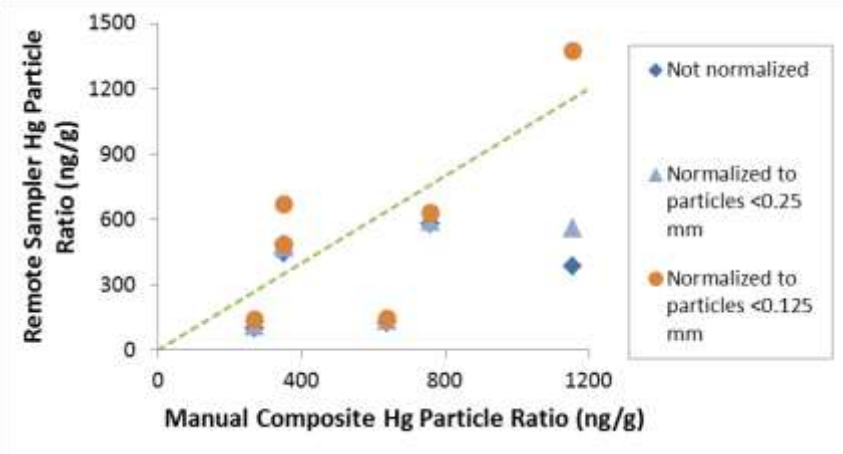
These variable results indicate some challenges in interpretation of data collected by composite versus remote methods. The composited stormwater water samples conflate some dissolved load in the indicator (particle ratio) where concentrations based on whole water samples were normalized to suspended 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.

A



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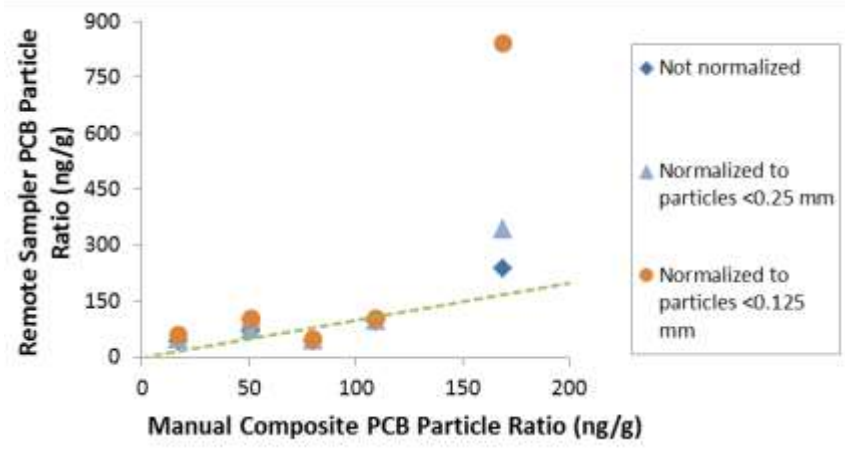

Figure 5. Grain size normalized particle ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

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.

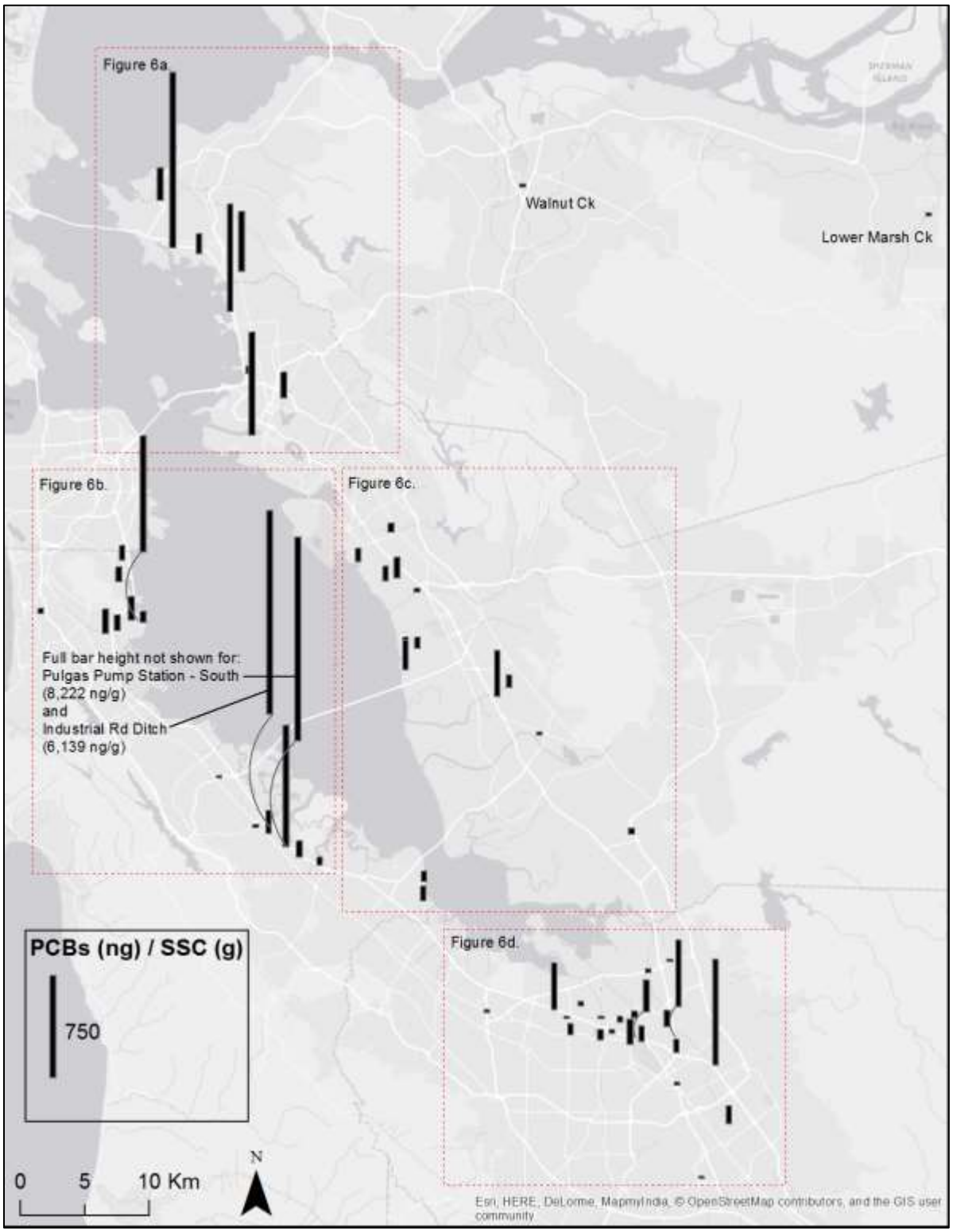

Figure 6. Regional distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date.

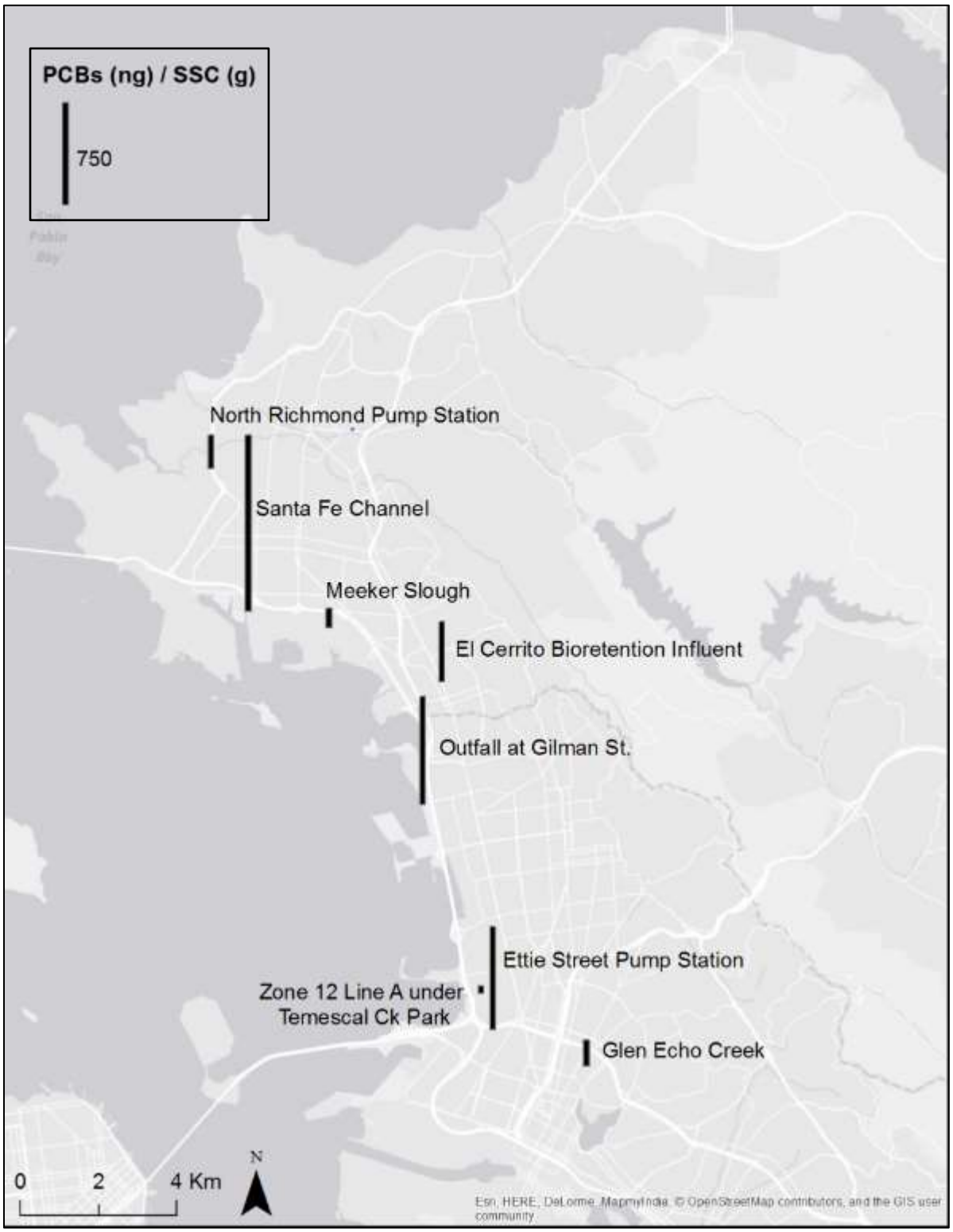

Figure 6a. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in northern Alameda and Contra Costa counties.

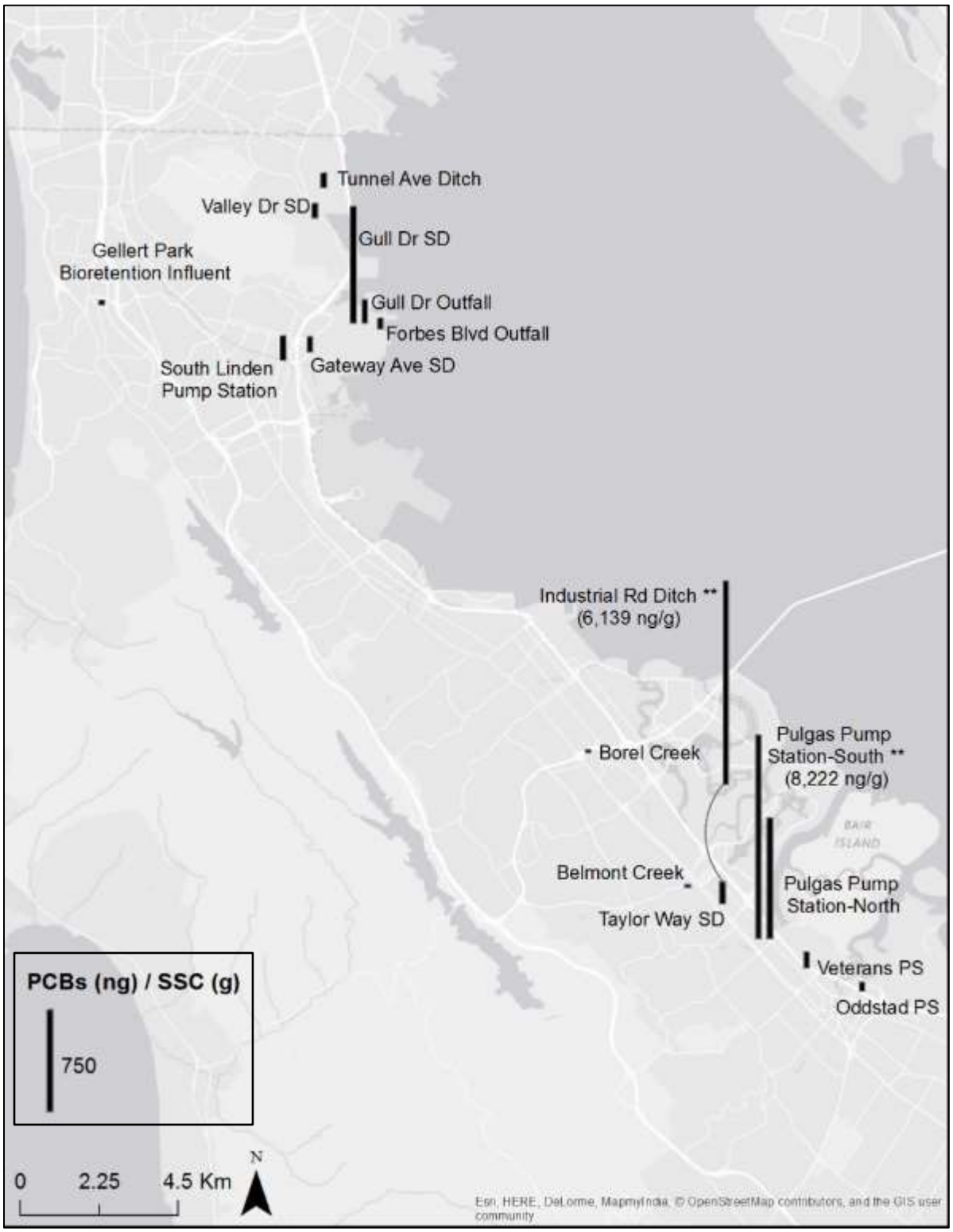

Figure 6b. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in central and northern San Mateo County.

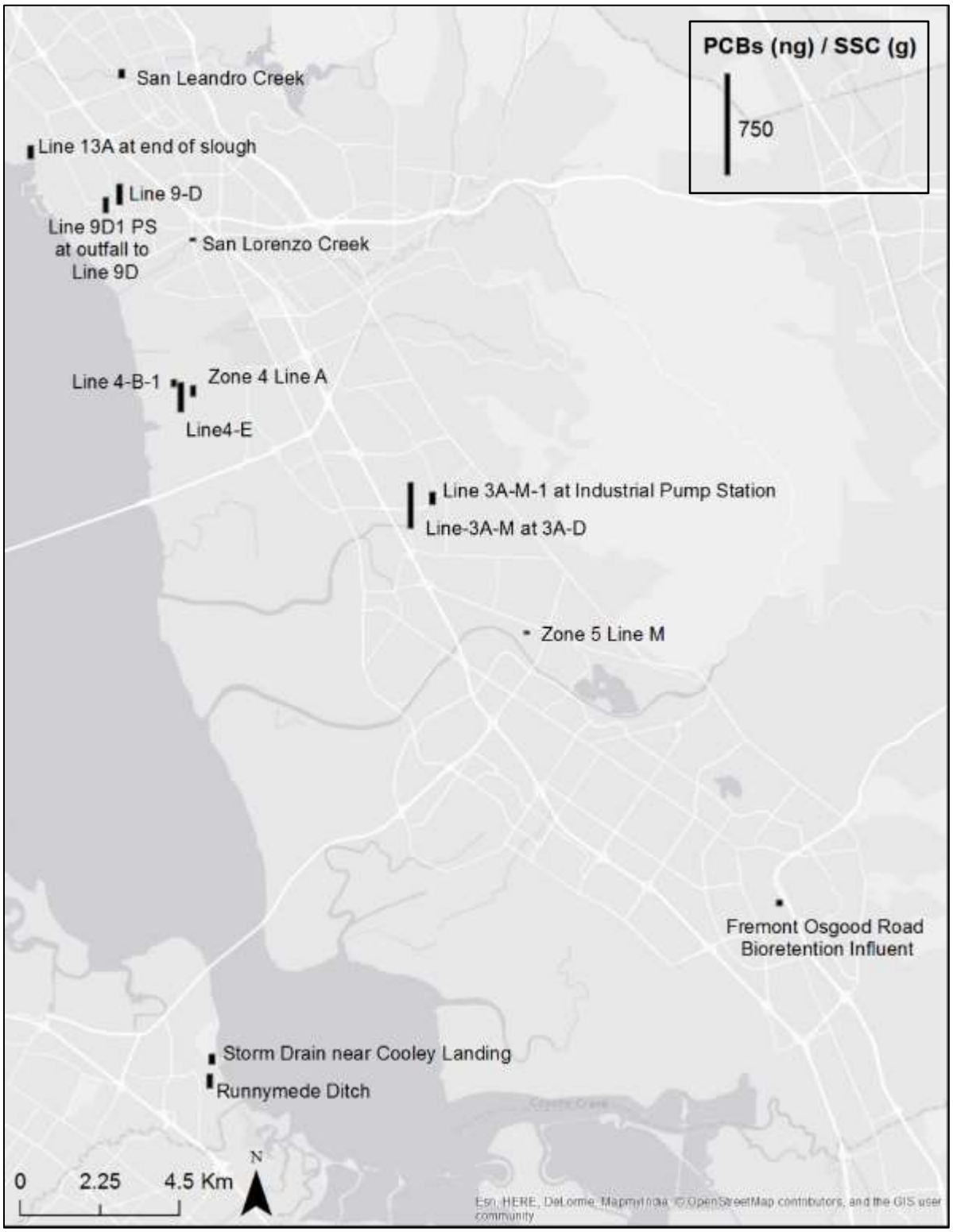

Figure 6c. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in southern Alameda and San Mateo counties.

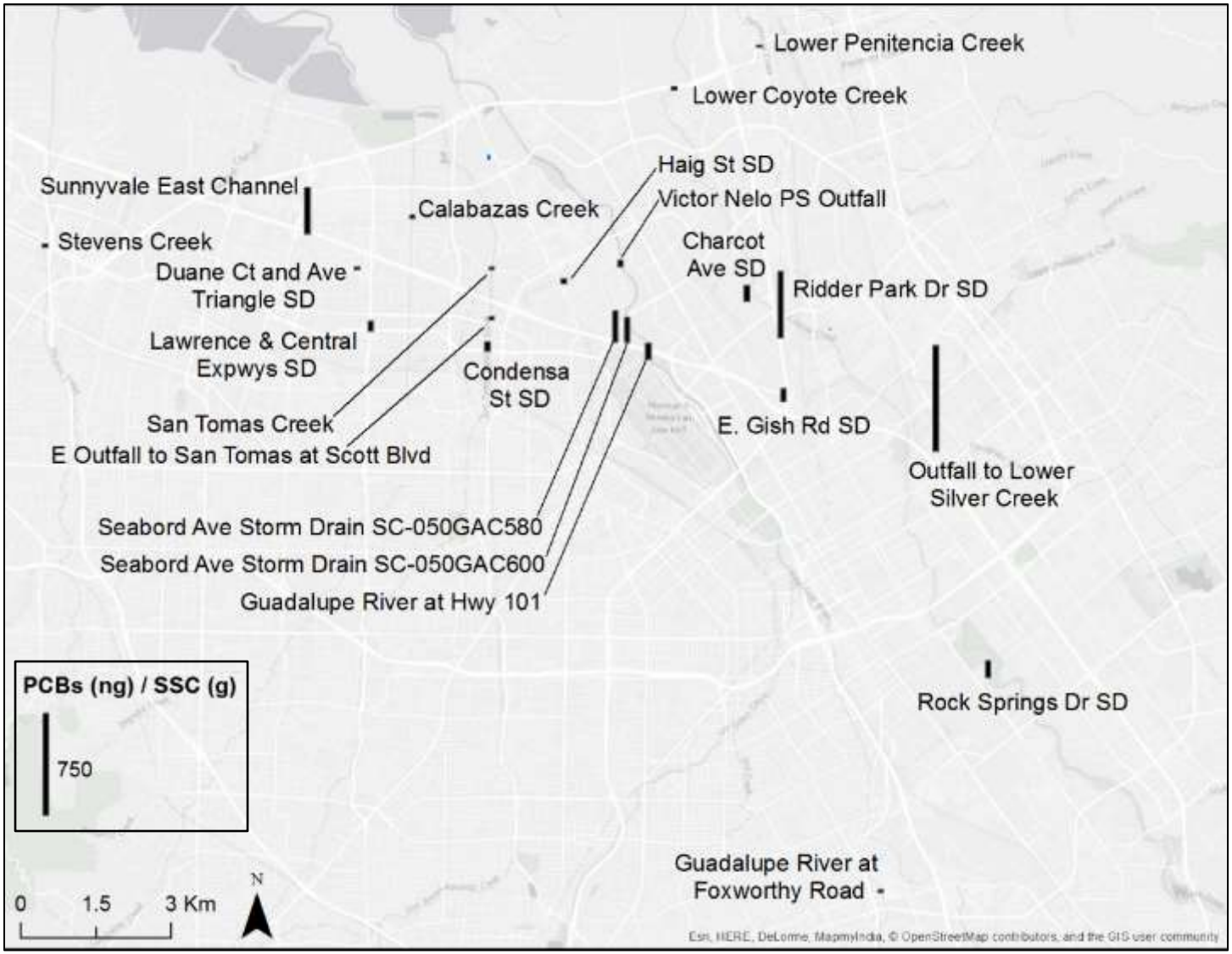

Figure 6d. Distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date in Santa Clara County.

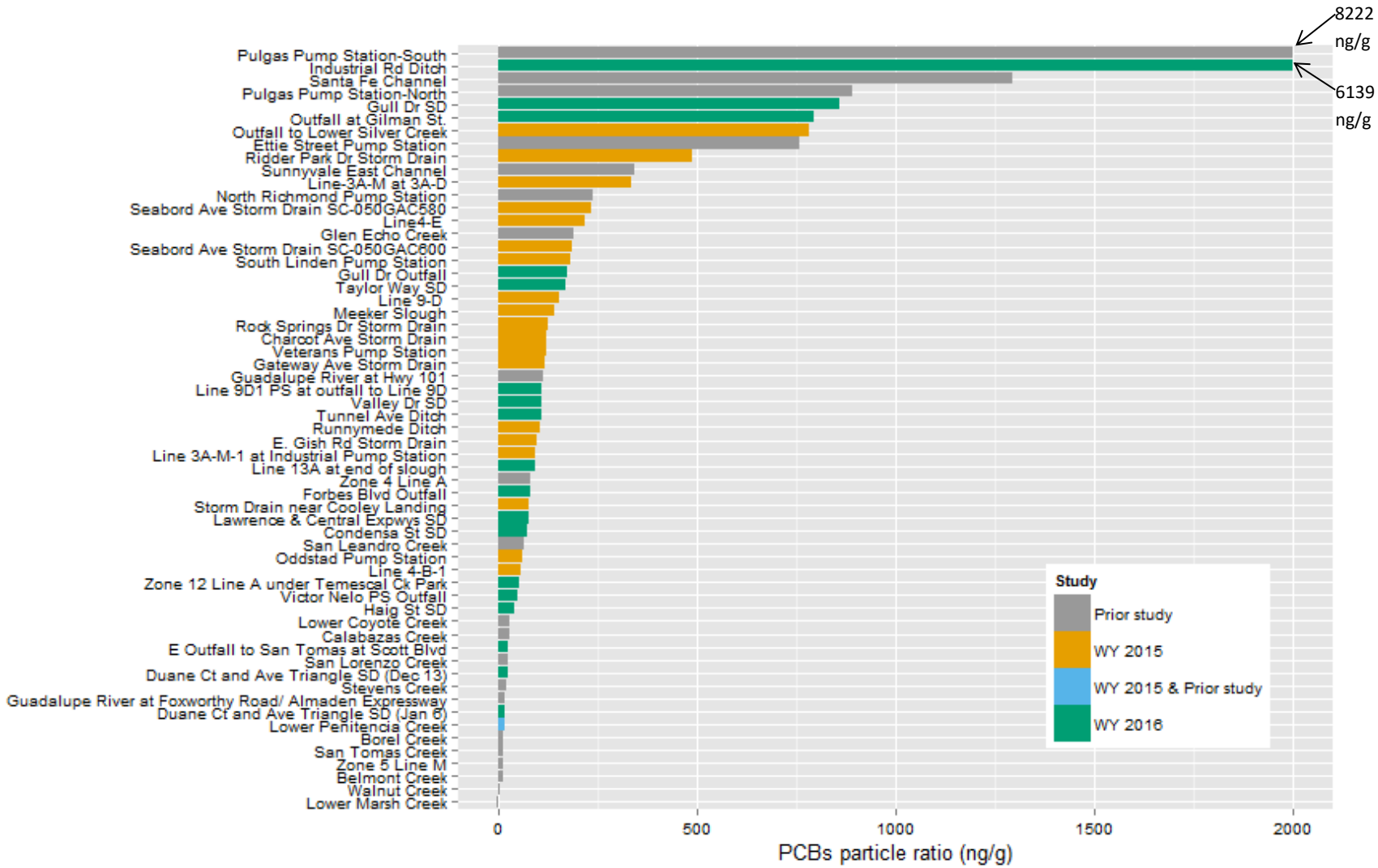

Figure 7. All watershed sampling locations measured to date ranked using PCB particle ratios. Note Pulgas Pump Station-South is beyond the extent of this graph at 8,222 ng/g as well as Industrial Road Ditch at 6139 ng/g.

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.

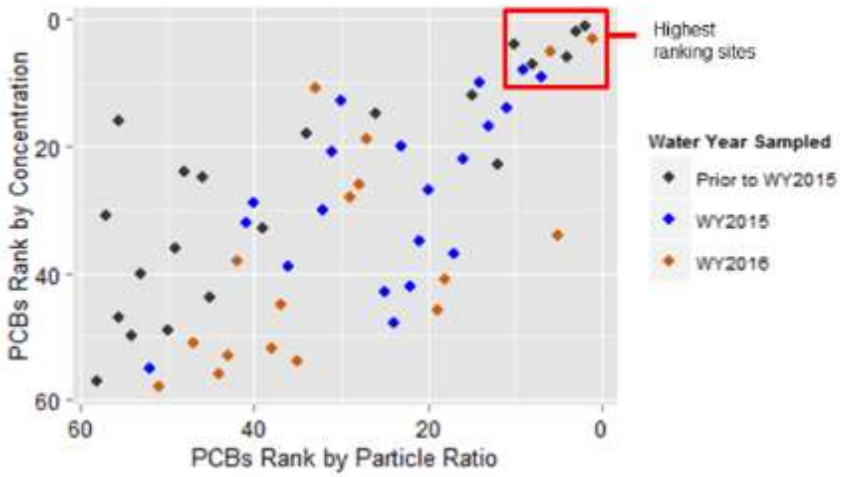

Figure 8. Correlation between site rankings for PCBs based on particle ratios versus water concentrations. 1 = highest rank; 58 = lowest rank.

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 µg/m^2/y (Tsai and Hoenicke, 2001) and 4.4 µg/m^2/y (Steding and Flegal, 2002) with Tsai and Hoenicke reporting a total (wet + dry) deposition rate of 18-21 µg/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.

[12] Again the reader is reminded that these regional estimates total suspended sediment loads are subject to change if future interpretations are completed.

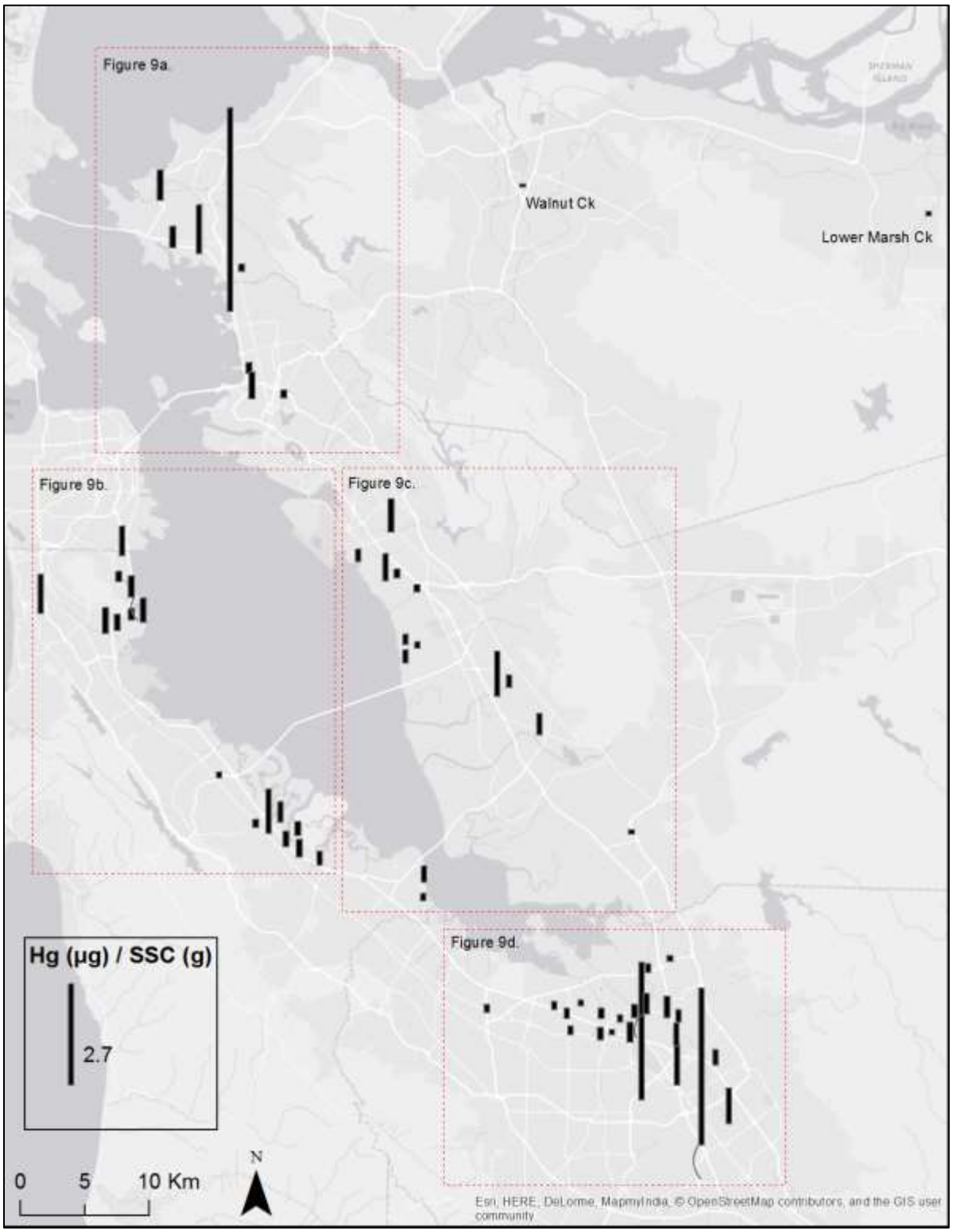

Figure 9. Regional distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date.

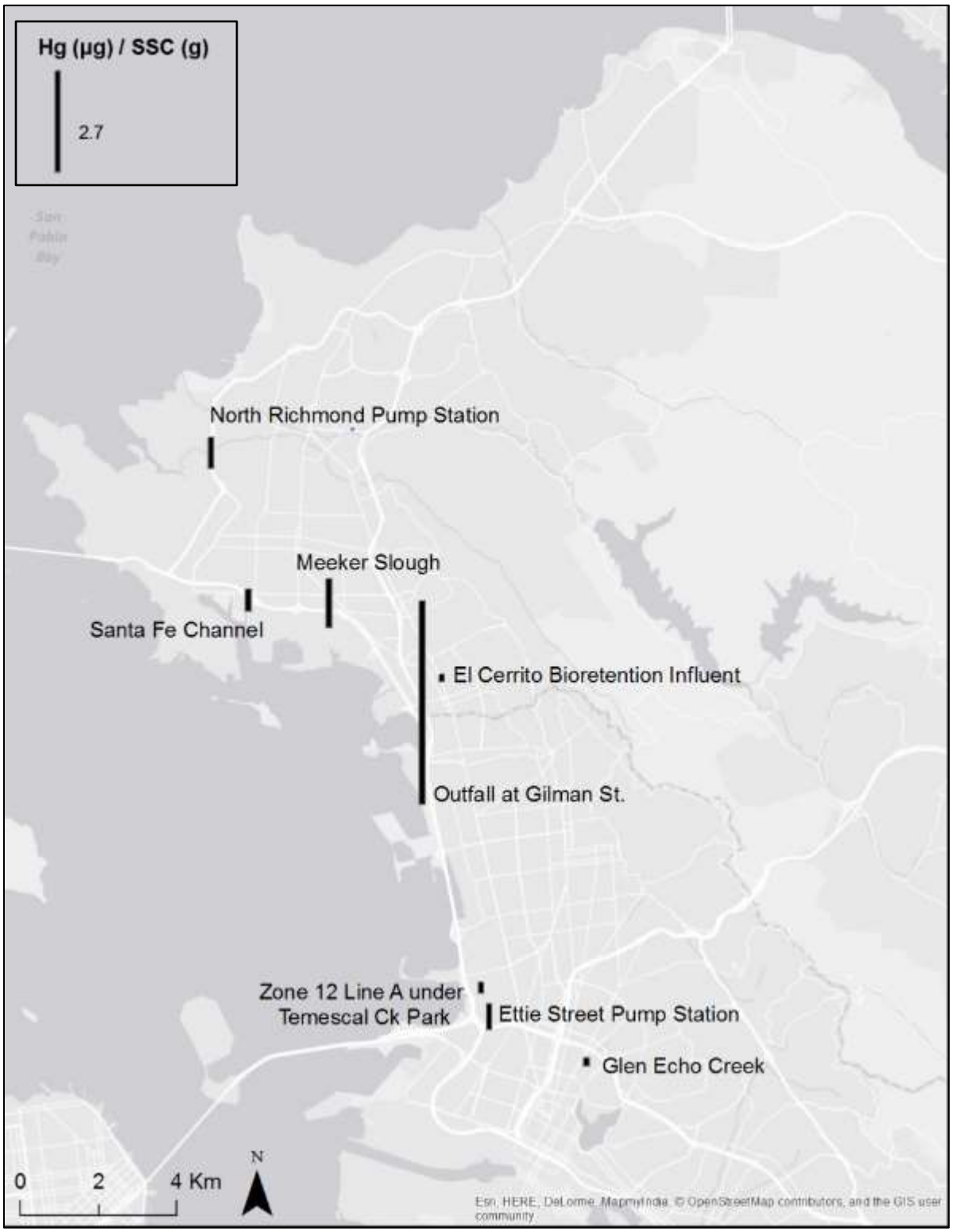

Figure 9a. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in northern Alameda and Contra Costa counties.

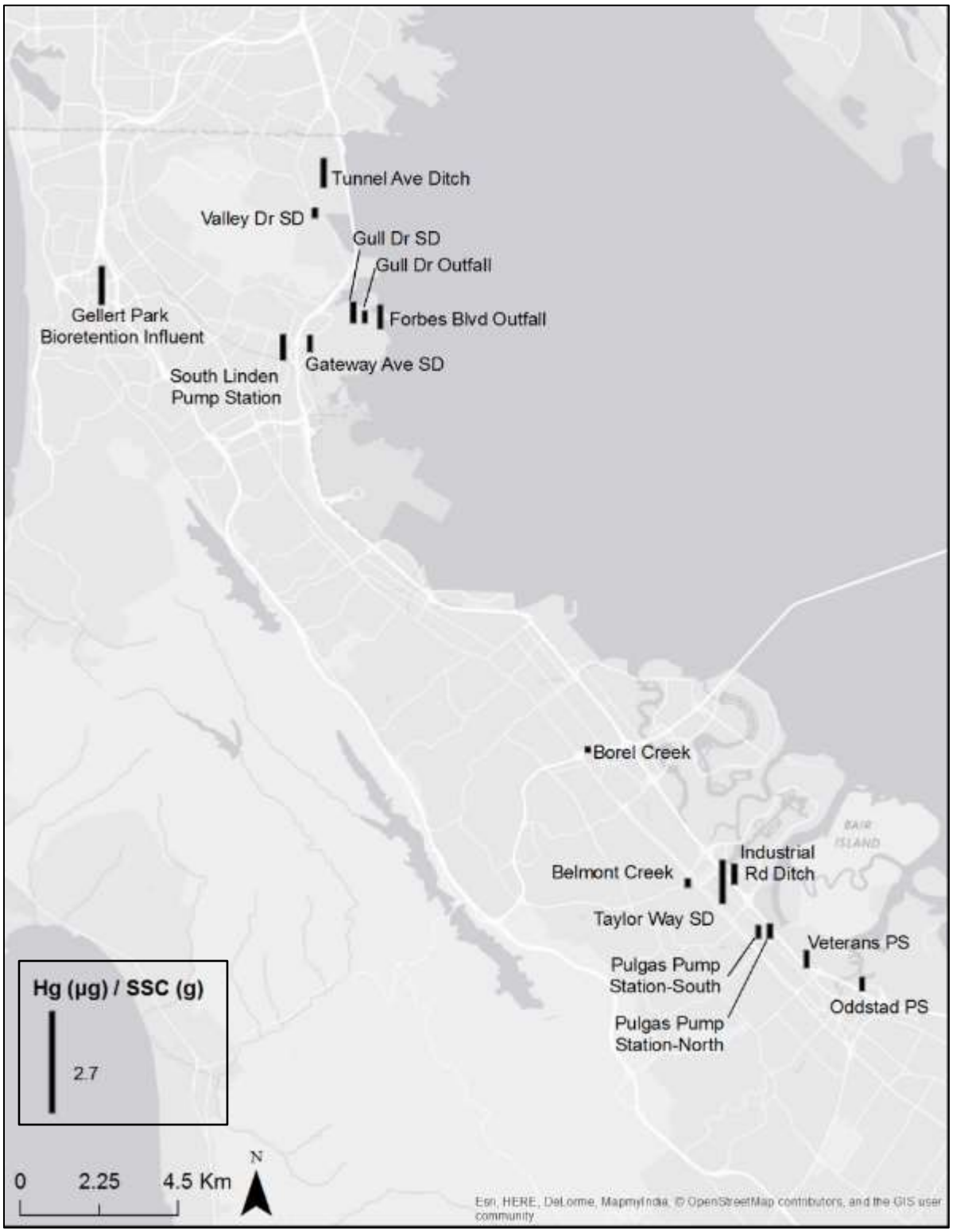

Figure 9b. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in central and northern San Mateo County.

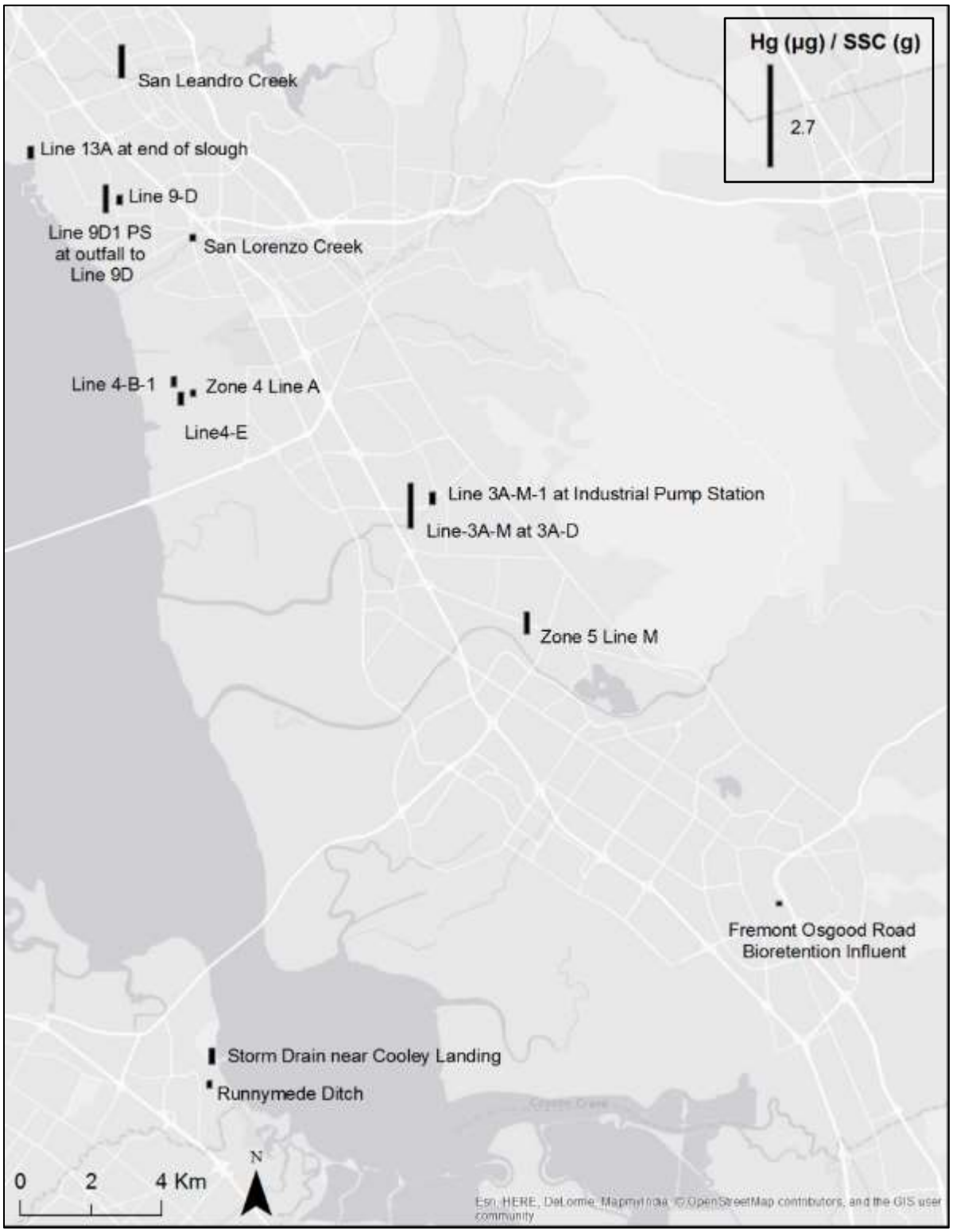

Figure 9c. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in southern Alameda and San Mateo counties.

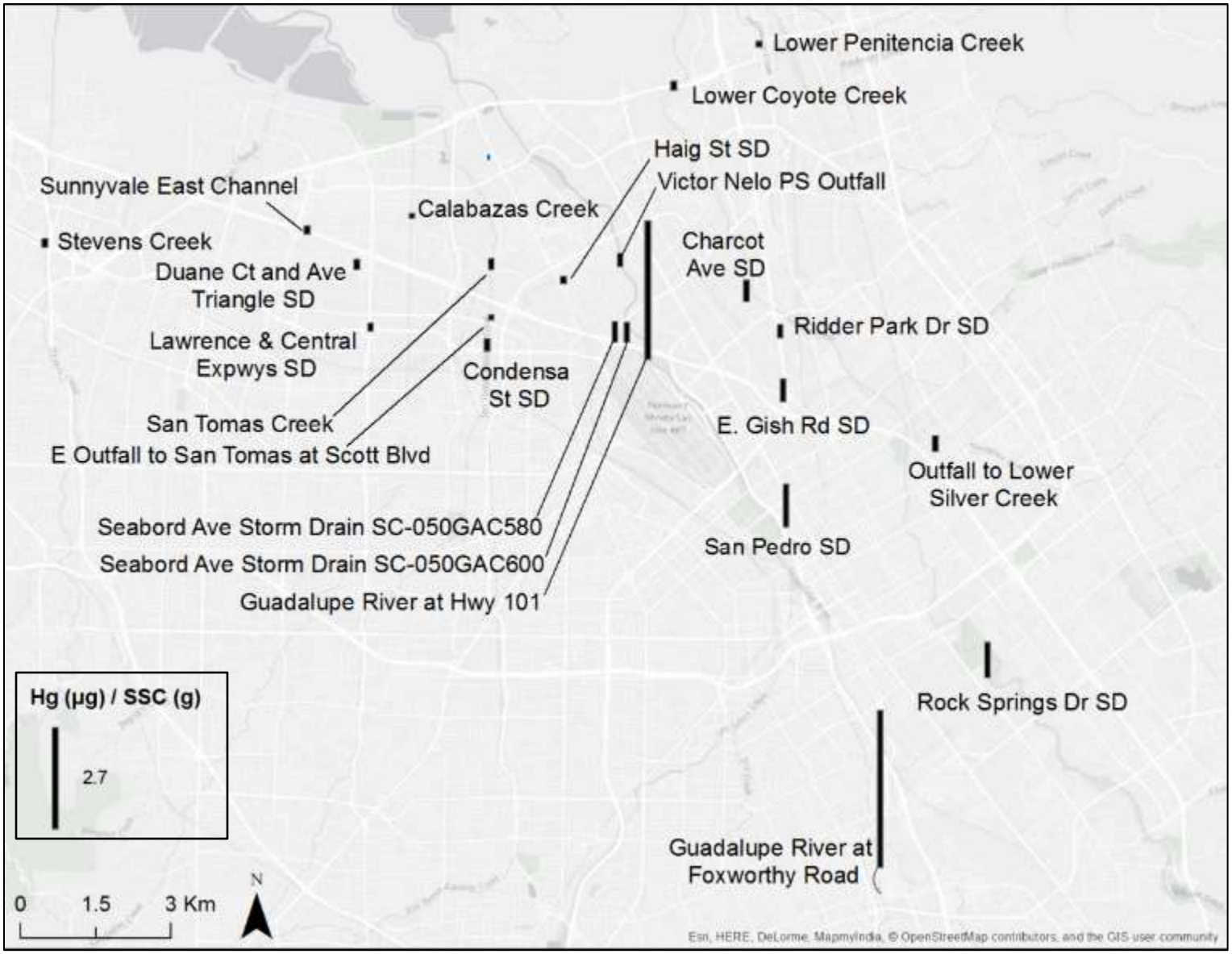

Figure 9d. Distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date in Santa Clara County.

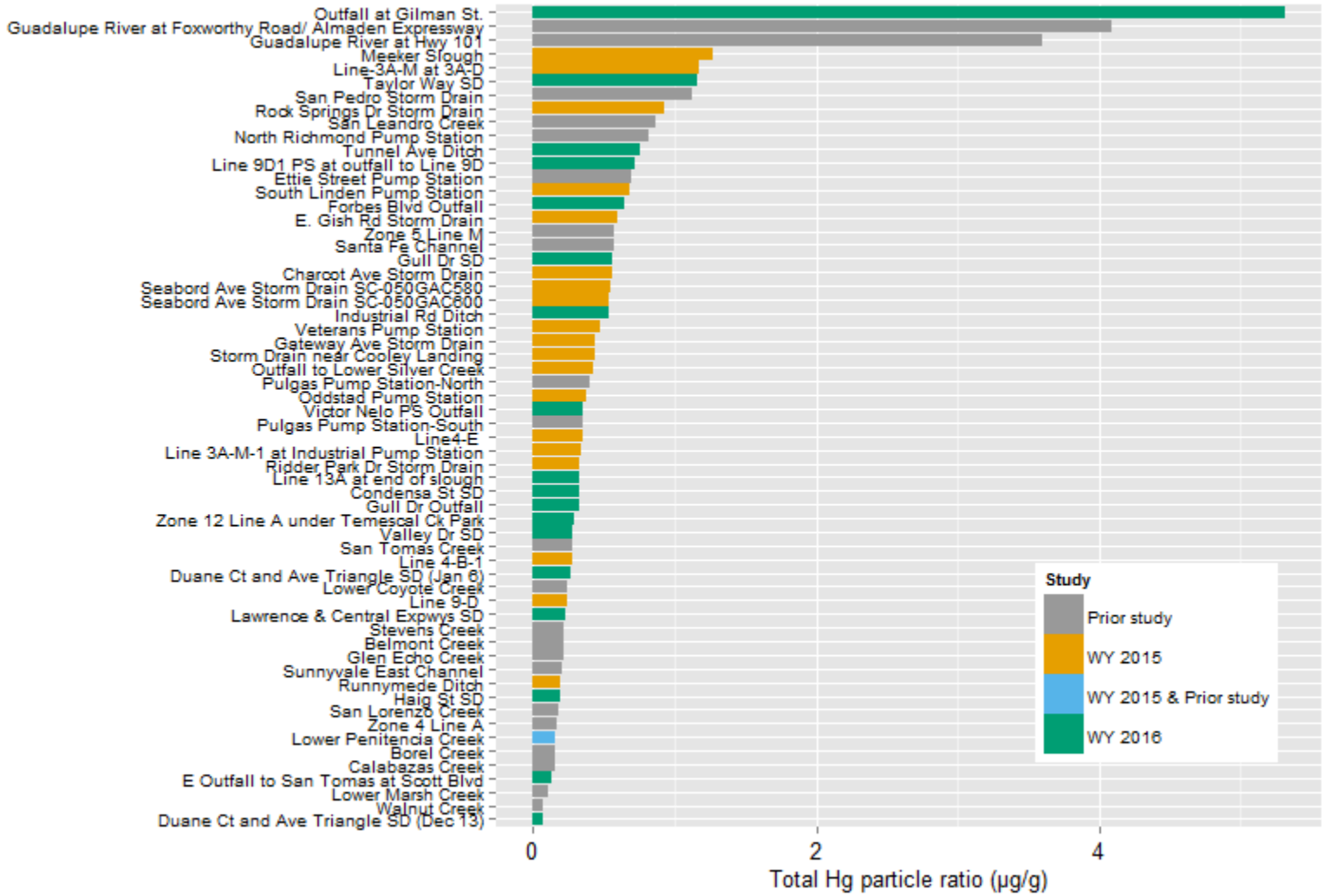

Figure 10. All watershed sampling locations measured to data ranked using total mercury (HgT) particle ratios.

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.

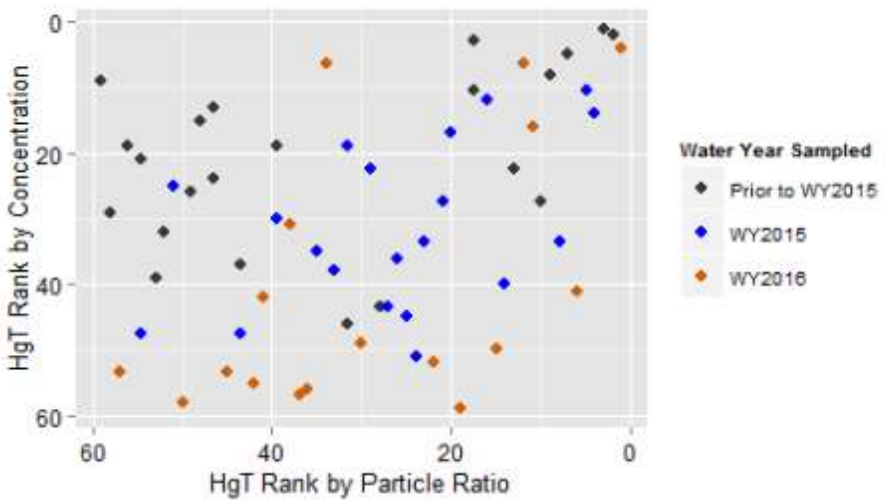

Figure 11. Relationship between site rankings for HgT based on particle ratios versus water concentrations. 1 = highest rank; 59 = lowest rank.

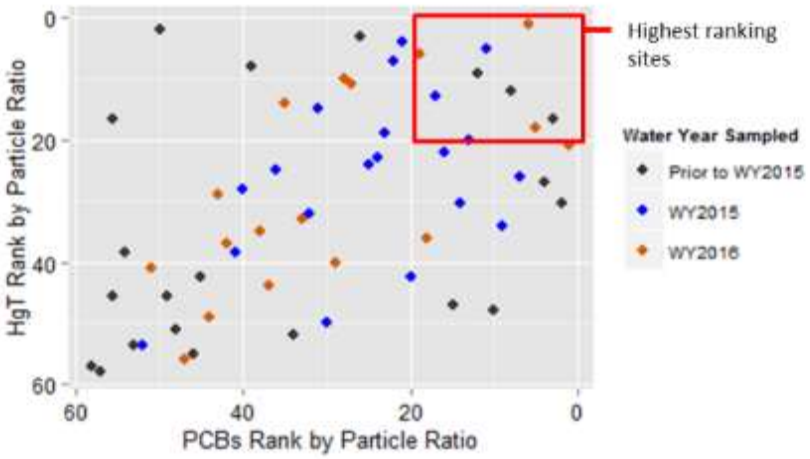

Figure 12. Relationship between site rankings for PCB particle ratios versus HgT particle ratios. 1 = highest rank; 58 = lowest rank. One watershed ranks in the top 10 for both PCBs and HgT, while nine watersheds rank in the top 20 for both pollutants.

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.

[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

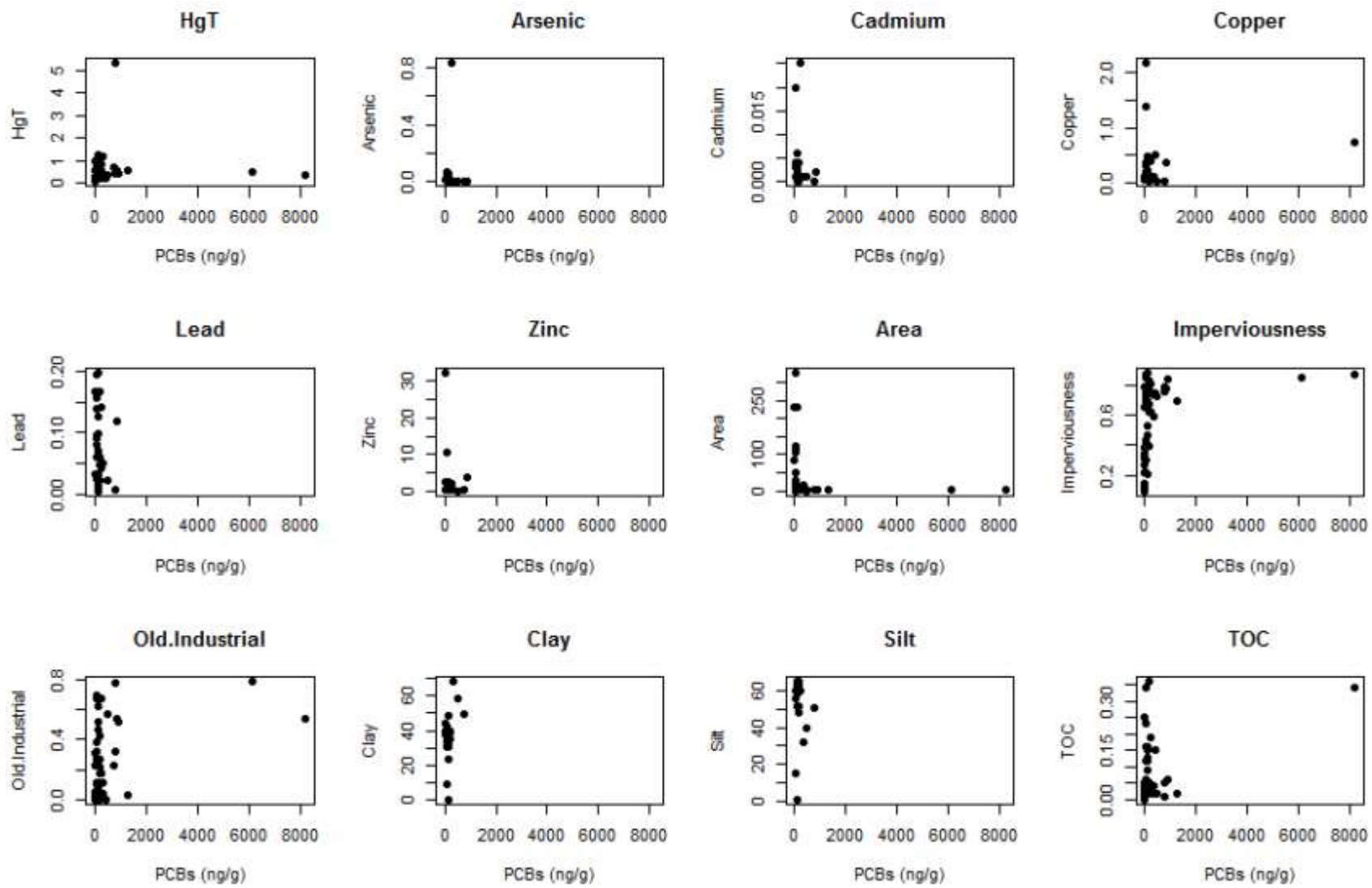

Figure 13. Relationships between observed particle ratios of PCBs and HgT, trace elements, and impervious land cover and old industrial land use.

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

[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 CaCO3), 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.

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

STRESSOR / SOURCE IDENTIFICATION PROJECT:

DUBLIN CREEK BIOLOGICAL COMMUNITY AND SEDIMENT QUALITY

WATER YEAR 2016 PROGRESS REPORT

URBAN CREEKS MONITORING REPORT,

APPENDIX A.4A

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by

Alameda Countywide Clean Water Program
399 Elmhurst Street,
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Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region

FINAL

March 31, 2017

Protecting Alameda County Creeks, Wetlands & the Bay

List of Acronyms

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practice
CSCI	California Stream Condition Index
DQO	Data Quality Objective
I-	Interstate Highway
IBI	Index of Biotic Integrity
LUCMP	Local Urban Creek Monitoring Program
MRP, MRP 2.0	Municipal Regional Stormwater Permit (reissuance from previous "MRP1.0")
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbon
PEC	Probable Effects Concentration
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board(California Regional Water Quality Control Board, San Francisco Bay Region)
SSID	Stressor/Source Identification
SoCal	Southern California
SOP	Standard Operating Procedure
SPoT	Stream Pollutant Trends
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TOC	Total Organic Carbon
USA	Unified Stream Assessment
USEPA	United States Environmental Protection Agency
WY	Water Year

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1 Introduction

The Alameda Countywide Clean Water Program (ACCWP) conducts Creek Status Monitoring as required by Provision C.8.c of the Municipal Regional Stormwater Permit (MRP, SFBRWQCB 2015)[1]. ACCWP's 17 member agencies have joined with 56 other MRP Permittees to form the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative to coordinate monitoring conducted pursuant to MRP Provision C.8, Water Quality Monitoring. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2014a and 2016a) and Standard Operating Procedures (SOPs, BASMAA 2012b, 2014b and 2016b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see Table 1-1

Table 1-1. Standard Operating Procedures Pertaining to BASMAA RMC Creek Status Monitoring.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review

The RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011) which assigns each of the Creek Status monitoring parameters listed in MRP Table 8.1 to one of two sub-design components:

- Regional: ambient monitoring to assess the condition of aquatic life in creeks across the

[1]The MRP was initially issued as SFBRWQCB 2009 (MRP 1.0) and reissued on November 19, 2015 with minor revisions in monitoring provisions regarding Stressor/Source Identification. Unless otherwise noted, references to trigger values and other permit requirements in this report refer to the original MRP1.0 unless identified as referring to the reissued MRP 2.0.

San Francisco Bay Area. Candidate monitoring sites were drawn from a probabilistically generated master list that included all perennial and non-perennial creeks and rivers within the applicable portions of the five participating counties. Sites from the RMC master list are identified by an alphanumeric code in which the last 6 characters are "Rnnnnn" with "R" designating the RMC probabilistic design and "nnnnn" the site's numeric sequence number generated through the RMC master draw[2]. RMC sites can also be assigned an alternative ID using the SWAMP naming procedure described in RMC SOP FS-11.

- Targeted: monitoring design and site selection address local watershed management questions. The last 6 characters of each Site ID reflect the watershed and numbering from the base of the watershed per the RMC SOP FS-11.

Creek Status Monitoring was initiated in WY2012 (October 2011 through September 2012) and reported in the first Urban Creeks Monitoring Report (UCMR, BASMAA 2013) submitted to the Regional Water Quality Control Board (RWQCB) in March 2013. The UCMR evaluated all data against "trigger criteria" listed for each parameter in MRP Table 8.1, which identified potential follow-up actions including Stressor/Source Identification (SSID) projects as required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP), subject to several conditions:

1. Creek Status Monitoring results meet one or more trigger criteria in MRP Table 8.1
2. When conducting monitoring through a regional collaborative, Permittees were collectively required to initiate no more than ten SSID projects during the MRP Permit term, and ACCWP's proportionate share were assumed to be three projects out of the 10.
3. If results indicated toxicity, at least 2 of the 10 SSID projects must be for toxicity
4. No need to repeat for continuing or recurring occurrences of the trigger in later results from the same receiving water limitations, unless directed to do so by the Water Board
5. No need to follow up on trigger results that are caused by Pollutants of Concern which are already being addressed by other portions of the MRP (e.g. pesticides).

The RMC programs developed a collaborative decision-making process for selecting sites for SSID follow-up. Program representatives reviewed the previous year's creek status monitoring results which reached "trigger" criteria, and prioritized sites for SSID follow-up based on several criteria including environmental significance of the trigger results and the feasibility of completing the project steps outlined in the MRP (see below). After consultation with affected Permittee(s), the RMC confirmed the candidate SSID project list with Water Board staff in April 2012 and individual programs planned initiation of SSID studies in their areas for FY 2013-14.

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[2]As recommended for SWAMP data compatibility per RMC SOP FS-11, all site ID codes begin with a 3 digit Hydrologic Unit Code.

MRP1.0 listed four steps[3] for a SSID project, with. ACCWP and other Countywide Programs leading the technically oriented steps 1 and 4 and collaborating with relevant Permittees on step 2: Permittee(s) will be the lead on step 3 to the extent that effective stormwater BMPs are within their power and jurisdiction.

(1) Conduct a site specific study (or non-site specific if the problem is wide-spread) to identify and isolate the cause(s) of the trigger stressor/source. If the trigger stressor or source is already known (e.g. toxicity), proceed directly to step 2.
(2) Identify and evaluate the effectiveness of options for controlling the cause(s) of the trigger stressor/source.
(3) Implement one or more controls.
(4) Confirm the reduction of the cause(s) of trigger stressor/source.

Previous progress reports (ACCWP 2014, 2016) describe s the first three years of an SSID study of sediment quality in the Dublin Creek watershed. This report documents further project activities through September 2016, and activities planned to complete the project in 2017.

[3] The reissued MRP modifies details and reporting requirements of these steps.

2 Background

2.1 Study Area

2.1.1 Dublin Creek

Site 204R00084 is located on Dublin Creek just west of the junction of Interstate Highways (I-) 580 and 680 in Dublin. At this location, Dublin Creek is within an area of mixed landuse and contains a variety of channel structures, both natural and artificial.

To the west (upstream) of Donlon Way, near the junction of Interstate Highway (I-) 580 and San Ramon Road the channel is predominantly natural, with some engineered channels interspersed within some residential housing developments. This upper portion of the creek includes two main branches that drain low density residential and rural landuses in portions of Dublin, Pleasanton and unincorporated Alameda County; it also crosses under I-580 twice and thus receives considerable runoff from the freeway. East of Donlon Way the creek is an engineered channel designated as the Zone 7 flood control channel “Line T”.

2.1.2 Beneficial Uses

Beneficial uses (SFRWQCB, 2015) assigned to Dublin Creek include:

- Warm freshwater habitat (WARM);
- Wildlife habitat (WILD); and
- Water Contact and Non-contact Recreation (REC-1 and REC-2). Public parks or other facilities allow access or approaches to sections of Dublin Creek.

2.2 Problem Statement

2.2.1 Water Quality Triggers

Comparison of WY2012 sampling results at site 204R00084 with MRP1.0 trigger criteria are presented in Table 2-1. Triggers for sediment quality were based on calculation of Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) for each analyte as determined following MacDonald et al. (2000).It should be noted that there are some limitations in the MacDonald method, which are discussed below.

Table 2-1. Water Year 2012 MRP Triggers and Significance at Dublin Creek Site 204R00084

Trigger type	Trigger status at site	Comment
"Triad" - bioassessment indication of alteration	**IBI score Very Poor**	Widespread in region, generally driven by habitat alteration
"Triad" - sediment chemistry	**12 chemicals > Threshold Effects Concentration**	TEC and PEC contributions by chemical groups: • PAHs - slightly elevated, • Pesticides (organochlorine) all somewhat elevated • Metals - slightly elevated for nickel, zinc, others
	Probable Effects Concentration: average Quotient not > 0.5	
	Pyrethroids calculated 1.06 >1 Toxic Unit Equivalent	
"Triad" - sediment toxicity	Not present or triggered	Pyrethroids likely not significant
Chlorine in water column	**Low: 0.10 mg/l >0.08 on one of 2 occasions**	Widespread in region; result is near limit of method detection
Toxicity in water column	Not present or triggered	Pyrethroids likely not significant
General Water Quality - DO	Not sampled	
General WQ - other	Not sampled	
Temperature	Not sampled	
Pathogen Indicators	Not sampled	

In assessing the effect of using one-half of the MDL in place of one-half of the MRL to estimate ND results for statistical purposes, relatively large differences were observed in some cases for the WY2012 assessments reported in the UCMR (BASMAA 2013), which have been recalculated for WY2013. Calculated TEC quotients for individual and total PAHs were lower across-the-board using the MDL due to the relatively large proportion of non-detects and the difference between MDLs and MRLs reported. It should be noted that WY2012 analyses are predominantly non-detects, and therefore that the TEC quotients calculated are driven by the MDL rather than quantified laboratory results.

While MacDonald (2000) generated PECs for multiple trace element, PAH, organochlorine pesticide, and pyrethroid pesticide parameters, there was insufficient data at time of its publication to evaluate the consensus PECs generated as to their predictive ability for associated sediment toxicity for each of the analytes reported. Analytes for which predictive ability is particularly uncertain include various PAH (anthracene, fluorine, and fluoranthene) and organochlorine pesticide (dieldrin, DDDs, DDTs, endrin, heptachlor epoxide, and lindane) parameters (MacDonald, 2000).

When examining pyrethroids concentrations, a similar degree of uncertainty exists. Weston (2005) reported that predictions of sediment toxicity to *H. azteca* were supported by observed results for sites with TU ratios below one (little or no mortality) and above four (high or full mortality). For TUs between one and four, however, the predictive ability of the TU is less certain (Weston 2005). The Toxicity Unit calculation for pyrethroids was eliminated as a trigger criterion in MRP2.0, as was the complex linkage of sediment chemistry, toxicity and bioassessment.

2.2.2 Potential Sources and Activities Contributing to Triggers

The Causal Analysis/Diagnosis Decision Information System (CADDIS) was developed by the US EPA as an online guidance tool for conducting causal assessments of impacts to aquatic ecosystems (US EPA 2010). The online tool provides a framework and resource base for Stressor Identification (SI) using 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
Step 5: Identify Probable Causes

The Stressor Identification process may be iterative, and if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors. It should be noted that the CADDIS is designed to be initiated following observations of a biological effect; however in this case the sediment quality concerns were triggered by chemical concentrations that were not accompanied by significant toxicity.

For the engineered channel condition found at site 204R00084, physical habitat alteration is the most likely cause of biological community degradation. Figure 2-1 shows a simple conceptual diagram from CADDIS, illustrating causal pathways related to physical habitat change as a candidate cause of biological impairment. CADDIS also notes that “urbanization” comprises several types of causal activities which together result in an “urban stream syndrome” of co-occurring, interacting changes in five general stressor categories:

- Water/Sediment Quality
- Temperature
- Hydrology
- Physical Habitat
- Energy Sources

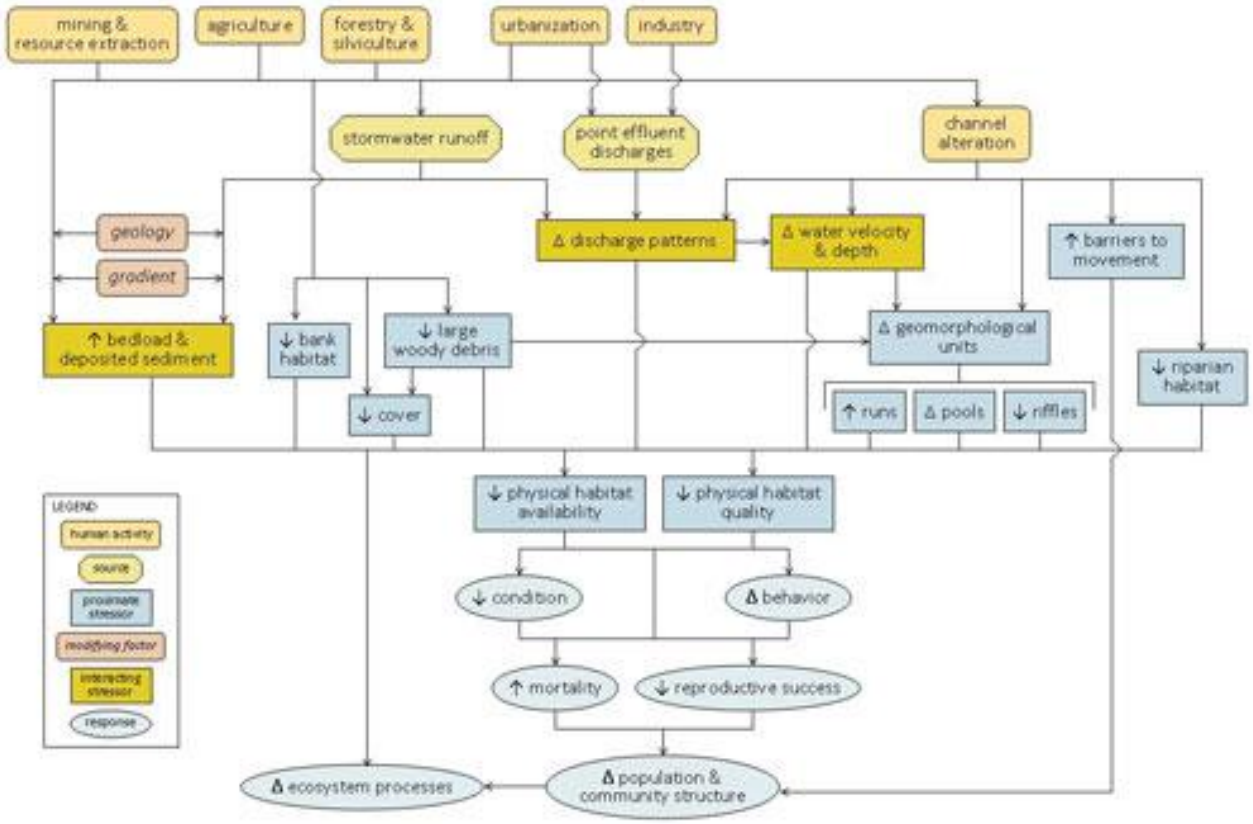

Figure 2-1. Conceptual diagram illustrating causal pathways, from sources to impairments, related to physical habitat (USEPA 2010).

3 Previous SSID Monitoring

ACCWP (2014) described a study design for WY 2013 sampling along an urbanization gradient in Dublin Creek. Figure 3-1 presents a schematic of the creek system with illustration of channelization and hydromodification as well as general watershed landuses.

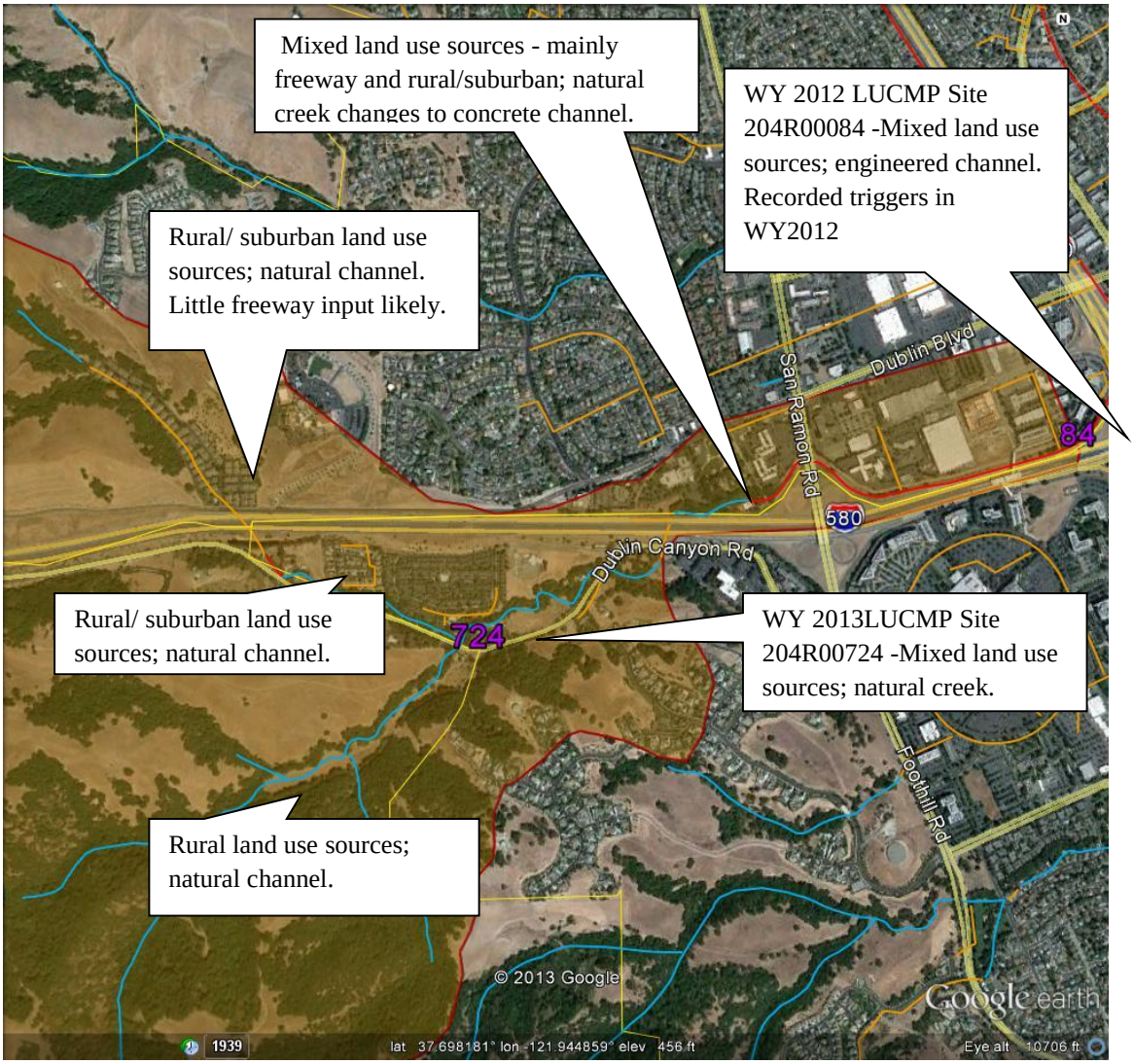

Figure 3-1. Conceptual Model of Candidate Causal Stressors in the Dublin Creek Watershed

The sampling locations and sampling strategies for SSID monitoring in the Dublin Creek Watershed in WY2013 are presented in Table 3-1andTable 3-2 , and shown in Figure 3-2 and Figure 3-3.

Table 3-1. WY 2013 Monitoring Locations and Sampling for Dublin Creek SSID.

Site	Site Description
204DUB005 (aka 204R00084)	Original RMC sampling location: also known as 204204R00084. Mixed commercial and industrial landuses (downtown area) adjacent to engineered channel at base of watershed
204DUB030	Slightly upstream of, but similar to, 204DUB005. Mixed landuse adjacent to concrete channel
204DUB040	Uppermost main stem site downstream of the lower culverted segment under freeway. Limited adjacent area of commercial, industrial and park land uses; mixed rural and suburban sources to culvert from upper watershed; natural channel.
204DUB055	2013 RMC Creek Status Site 204R00724 on main stem just downstream of confluence with Devaney Canyon branch; integrates land use sources from the branches at 204DUB060 and 204DUB080. Natural channel confluence with Devaney Canyon branch
204DUB060	Devaney Canyon branch above its confluence with main stem; unincorporated agricultural and former agricultural land use. Mostly natural channel (sediment sample composited from culvert under Dublin Canyon Rd. and pool downstream of culvert).
204DUB080	Main stem Dublin Creek above confluence with Devaney Canyon. Mixed rural and medium density residential landuse, and freeway runoff sources
204DUB090	Main stem Dublin Creek downstream of upper culvert under freeway-- sources from upper watershed include mixed residential and open landuses. For comparison with 204DUB040. Only to be analyzed if downstream sites show variability.

Table 3-2.WY2013 Monitoring Locations and Sampling for Dublin Creek SSID Study.

			Sediment sampling							
Site Code	**Latitude**	**Longitude**	**Available sampling and notes for 2013 sampling**	**Pyrethroids**	**Total metals + mercury**	**Organochlorine pesticides**	**Polycyclic Aromatic Hydrocarbons (PAHs)**	**% fines**	**Total Organic Carbon (TOC)**	**Bioassessment**
204DUB005 (aka 204R00084)	37.70100	-121.92537	RMC data WY12 for sediments and bio-assessment + WY13 sediment		X		X	X		
204DUB030	37.69932	-121.93290	WY13	X	X	X	X	X	X	
204DUB040	37.69921	-121.93824	WY13	X	X	X	X	X	X	X
204DUB055	37.69496	-121.94837	WY13	X	X	X	X	X		
204DUB060	37.69473	-121.94862	WY13		X	X	X	X		
204DUB080	37.69522	-121.94890	WY13		X	X	X	X	X	
204DUB090	37.69655	-121.9530	WY13 (archived sample)		X	X	X	X		

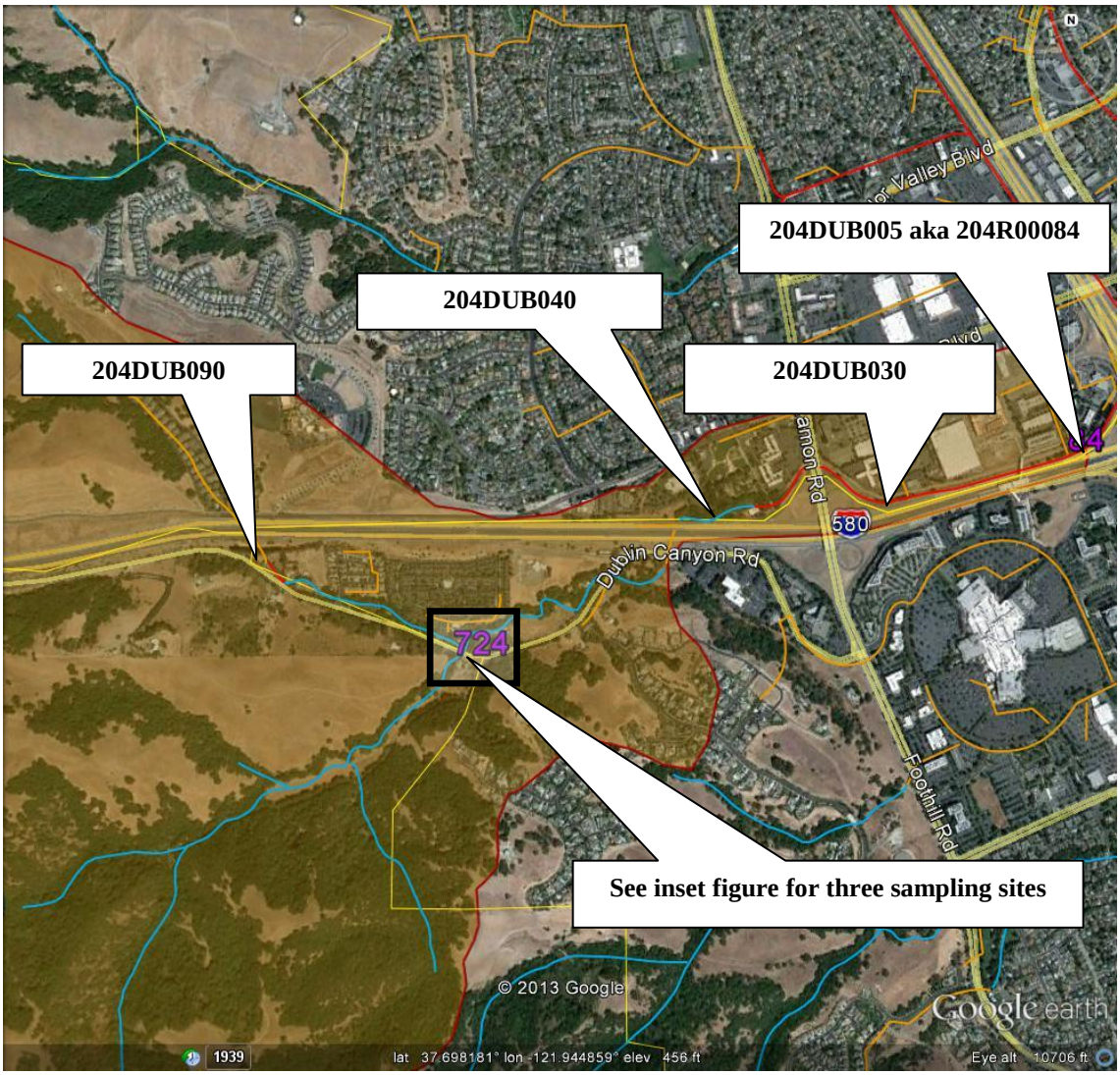

Figure 3-2.WY 2013 Monitoring Locations in the Dublin Creek Watershed

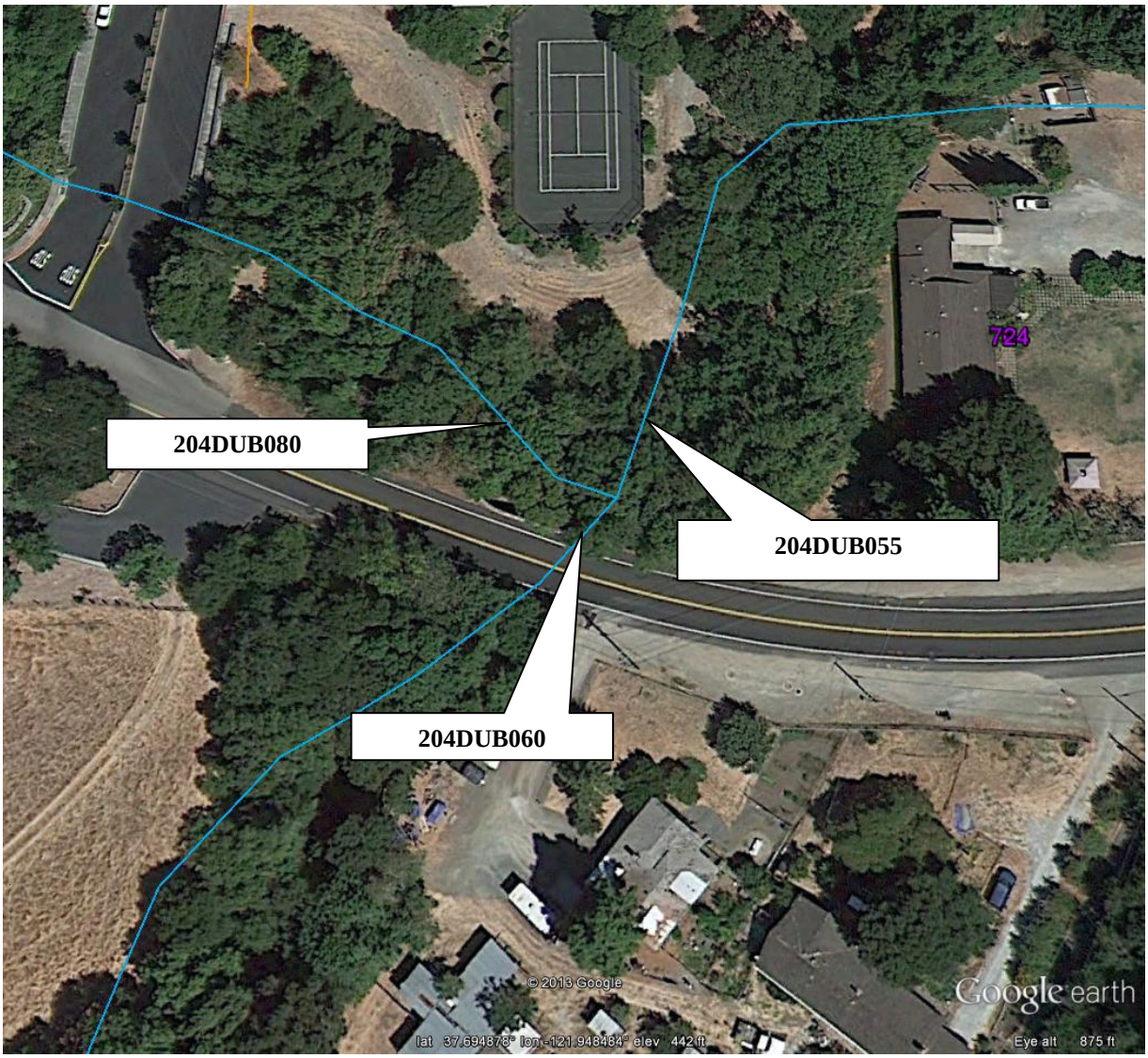

Figure 3-3.Inset Monitoring Locations for 204DUB055, 204DUB060 and 204DUB080

The following general trends and overall findings are based on the results of this monitoring:

- Particle size: Site 204DUB060 (predominantly rural landuse) had the smallest overall grain sizes (clays, silts and sand) of the sites assessed. The largest grain sizes (pebbles and granules) were associated with the Site 204DUB080 (mixed low density, freeway and rural landuse).

- Total Organic Carbon: Highest TOC was recorded at Site 204R030. There was no substantial difference between TOC concentrations at the three sites assessed.
- Pyrethroids: Bifenthrin was the only pyrethroid recorded at concentrations above detection limits in this study. This is consistent with published literature which finds bifenthrin to be the most common pyrethroid in sediments (Anderson *et al*, 2012). Compared with DPR investigations, the results presented here are very much lower than average concentrations found in other Californian sediments (Zhang, 2010).There was no observed difference between concentrations of pyrethroids at the three sites monitored.
- Organochlorine pesticides: In comparison with sediment results published in the literature, the results from the Dublin study suggest low concentrations of organochlorine pesticide presence (Kinnetic Laboratories and EOA, 2002 and Anderson *et al*, 2012). Of the Dublin sites investigated, Site 204DUB060 recorded the highest organochlorine pesticide concentrations.
- Metals: In general metal concentrations were similar to average concentrations found in the SPoT program (Anderson *et al*, 2012). Mercury concentrations were much lower than averages recorded in the joint Agency Program from 2002. Compared with the other sites investigated in this study, Sites 204DUB005 and 204DUB080 had generally higher concentrations of metals compared with other sites monitored in WY2013.
- PAHs: PAH concentrations were lower than those averages reported in the SPoT program (Anderson *et* al, 2012) and the Alameda County Sediment sampling program results from 2002 (ACCWP, 2002). In comparison to the other sites investigated in this study, Site 204DUB080 had higher concentrations of PAHs.
- Bioassessment: Sites in different zones of the watershed all showed relatively low condition scores compared to undeveloped reference conditions. Habitat modification due to urbanization is the main source of biological community alteration, especially for highly modified channels but also where natural channels have experienced changes due to increased watershed imperviousness and nearby roads (e.g. Schuler, 2004, SFBRWQCB 2012).

4 Discussion and Planned Activities

Overall, the results of investigation are inconclusive in terms of identifying sources of poor sediment quality. City of Dublin staff reported no inspection sites in the relatively small catchment area that would be highlighted as potential sources of the contaminants found in the sediments, which were found at concentrations similar to, or less than, those in other urbanized areas in California based on comparison with published literature.

In WY 2017 the site at 204DUB040 is a candidate for ACCWP bioassessment sampling. Since it is likely to be sampled, the results will be incorporated in a final project report to be submitted by March 2018.

4.1 Next Steps

In addition to the additional ACCWP bioassessment sampling, the final report will coordinate any insights from a planned BASMAA project to produce a 5 year bioassessment report analyzing data from all stormwater programs since WY 2012.Data from this project may also inform SSID projects initiated in other systems to focus on stressors or sources to macroinvertebrate communities.

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ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

STRESSOR SOURCE IDENTIFICATION PROJECT:

CASTRO VALLEYCREEK SEDIMENT QUALITY

WATER YEAR 2016 PROGRESS REPORT

URBAN CREEKS MONITORING REPORT, APPENDIX A.4B

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region

FINAL
MARCH 31, 2017

Protecting Alameda County Creeks, Wetlands & the Bay

List of Acronyms

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practice
DPR	Department of Pesticide Regulation
DQO	Data Quality Objective
I-	Interstate Highway
IBI	Index of Biotic Integrity
LUCMP	Local Urban Creek Monitoring Program
MRP, MRP 2.0	Municipal Regional Stormwater Permit (reissuance from previous "MRP1.0")
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbon
PEC	Probable Effects Concentration
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board(California Regional Water Quality Control Board, San Francisco Bay Region)
SSID	Stressor/Source Identification
SOP	Standard Operating Procedure
SPoT	Stream Pollutant Trends
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TOC	Total Organic Carbon
USA	Unified Stream Assessment
USEPA	United States Environmental Protection Agency
WY	Water Year

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1 Introduction

The Alameda Countywide Clean Water Program (ACCWP) conducts Creek Status Monitoring as required by Provision C.8.c of the Municipal Regional Stormwater Permit (MRP, SFRWQCB 2015)[1]. ACCWP's 17 member agencies have joined with 56 other MRP Permittees to form the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative to coordinate monitoring conducted pursuant to MRP Provision C.8, Water Quality Monitoring. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2014a and 2016a) and Standard Operating Procedures (SOPs, BASMAA 2012b, 2014b and 2016b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see Table 1-1.

Table 1-1. Standard Operating Procedures Pertaining to BASMAA RMC Creek Status Monitoring.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review

The RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011) which assigns each of the Creek Status monitoring parameters listed in MRP Table 8.1 to one of two sub-design components:

- Regional: ambient monitoring to assess the condition of aquatic life in creeks across the San Francisco Bay Area. Candidate monitoring sites were drawn from a probabilistically generated master list that included all perennial and non-perennial creeks and rivers within the applicable portions of the five participating counties. Sites from the RMC master list are identified by an alphanumeric code in which the last 6 characters are "Rnnnnn" with "R" designating the RMC probabilistic design and "nnnnn" the site's

[1]The MRP was initially issued as SFBRWQCB 2009 (MRP 1.0) and reissued on November 19, 2015 with minor revisions in monitoring provisions regarding Stressor/Source Identification, which was renumbered as provision C.8.e in the reissued MRP 2.0. Unless otherwise noted, references to trigger values and other permit requirements in this report refer to the original MRP (SFBRWQCB 2009)

numeric sequence number generated through the RMC master draw[2]. RMC sites can also be assigned an alternative ID using the SWAMP naming procedure described in RMC SOP FS-11.

- Targeted: monitoring design and site selection address local watershed management questions. The last 6 characters of each Site ID reflect the watershed and numbering from the base of the watershed per the RMC SOP FS-11.

Creek Status Monitoring was initiated in WY2012 (October 2011 through September 2012) and reported in the first Urban Creeks Monitoring Report (UCMR, BASMAA 2013) submitted to the Regional Water Quality Control Board (RWQCB) in March 2013. The UCMR evaluated all data against "trigger criteria" listed for each parameter in MRP Table 8.1, which identified potential follow-up actions including Stressor/Source Identification (SSID) projects as required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP), subject to several conditions:

1. Creek Status Monitoring results meet one or more trigger criteria in MRP Table 8.1
2. When conducting monitoring through a regional collaborative, Permittees were collectively required to initiate no more than ten SSID projects during the MRP Permit term, and ACCWP's proportionate share were assumed to be three projects out of the 10.
3. If results indicated toxicity, at least 2 of the 10 SSID projects must be for toxicity
4. No need to repeat for continuing or recurring occurrences of the trigger in later results from the same receiving water limitations, unless directed to do so by the Water Board
5. No need to follow up on trigger results that are caused by Pollutants of Concern which are already being addressed by other portions of the MRP (e.g. pesticides).

The RMC programs developed a collaborative decision-making process for selecting sites for SSID follow-up. Program representatives reviewed the previous year's creek status monitoring results which reached "trigger" criteria, and prioritized sites for SSID follow-up based on several criteria including environmental significance of the trigger results and the feasibility of completing the project steps outlined in the MRP (see below). After consultation with affected Permittee(s), the RMC confirmed the candidate SSID project list with Water Board staff in April 2012 and individual programs planned initiation of SSID studies in their areas for FY 2013-14.

MRP1.0 listed four steps[3] for a SSID project, with. ACCWP and other Countywide Programs leading the technically oriented steps 1 and 4 and collaborating with relevant Permittees on step 2: Permittee(s) will be the lead on step 3 to the extent that effective stormwater BMPs are within their power and jurisdiction.

(1) Conduct a site specific study (or non-site specific if the problem is wide-spread) to identify and isolate the cause(s) of the trigger stressor/source. If the trigger stressor or source is already known (e.g. toxicity), proceed directly to step 2.

(2) Identify and evaluate the effectiveness of options for controlling the cause(s) of the

[2]As recommended for SWAMP data compatibility per RMC SOP FS-11, all site ID codes begin with a 3 digit Hydrologic Unit Code.

[3] The reissued MRP modifies details and reporting requirements of these steps.

trigger stressor/source.

(3) Implement one or more controls.

(4) Confirm the reduction of the cause(s) of trigger stressor/source.

Previous progress reports (ACCWP 2014, 2016) describe s the first three years of an SSID study of sediment quality in the Castro Valley Creek watershed. This report documents further project activities through September 2016, and activities planned to complete the project in 2017.

2 Background

2.1 Study Area

2.1.1 Castro Valley Creek

Castro Valley Creek is a tributary to San Lorenzo Creek which covers an area of 5.5 square miles in an unincorporated area of Alameda County, located to the southeast of San Leandro in the western portion of the unincorporated area of Alameda County known as Castro Valley. The subwatersheds of interest in this study are presented in Figure 2-1. The landuse estimates for the targeted subwatersheds directly upstream of the area of interest are presented in Table 2-1 (Scanlin and Feng 1997).

Table 2-1. Estimated Land Use Percentages of Selected Subwatersheds of the Castro Valley Creek.

SubwatershedCode (per Map)	Area (acres)	Commercial	Open	Residential	Pervious Area
1	908	4%	52%	44%	80%
2	391	37%	3%	60%	41%

The site within Castro Valley for which trigger results were observed (Site 204R00047) is in an engineered channel receiving flows mixed commercial and residential land uses along with some non-urban areas in the upper watershed. There is also the potential for freeway impacts where Interstate-Highway (I-) 580 crosses the creek system a few hundred meters upstream of Site 204R00047.

At the site of interest, the creek is designated as a flood control channel of the ACFCWCD, i.e. Zone 2 Line I.

2.1.2 Beneficial Uses

Beneficial uses (SFRWQCB, 2015b) assigned to Castro Valley Creek include:

- Cold Freshwater Habitat (COLD);
- Preservation of rare or endangered species (RARE);
- Warm freshwater habitat (WARM);
- Wildlife habitat (WILD); and
- Water Contact and Non-contact Recreation (REC-1 and REC-2). Public parks or other facilities allow access or approaches to sections of Castro Valley.

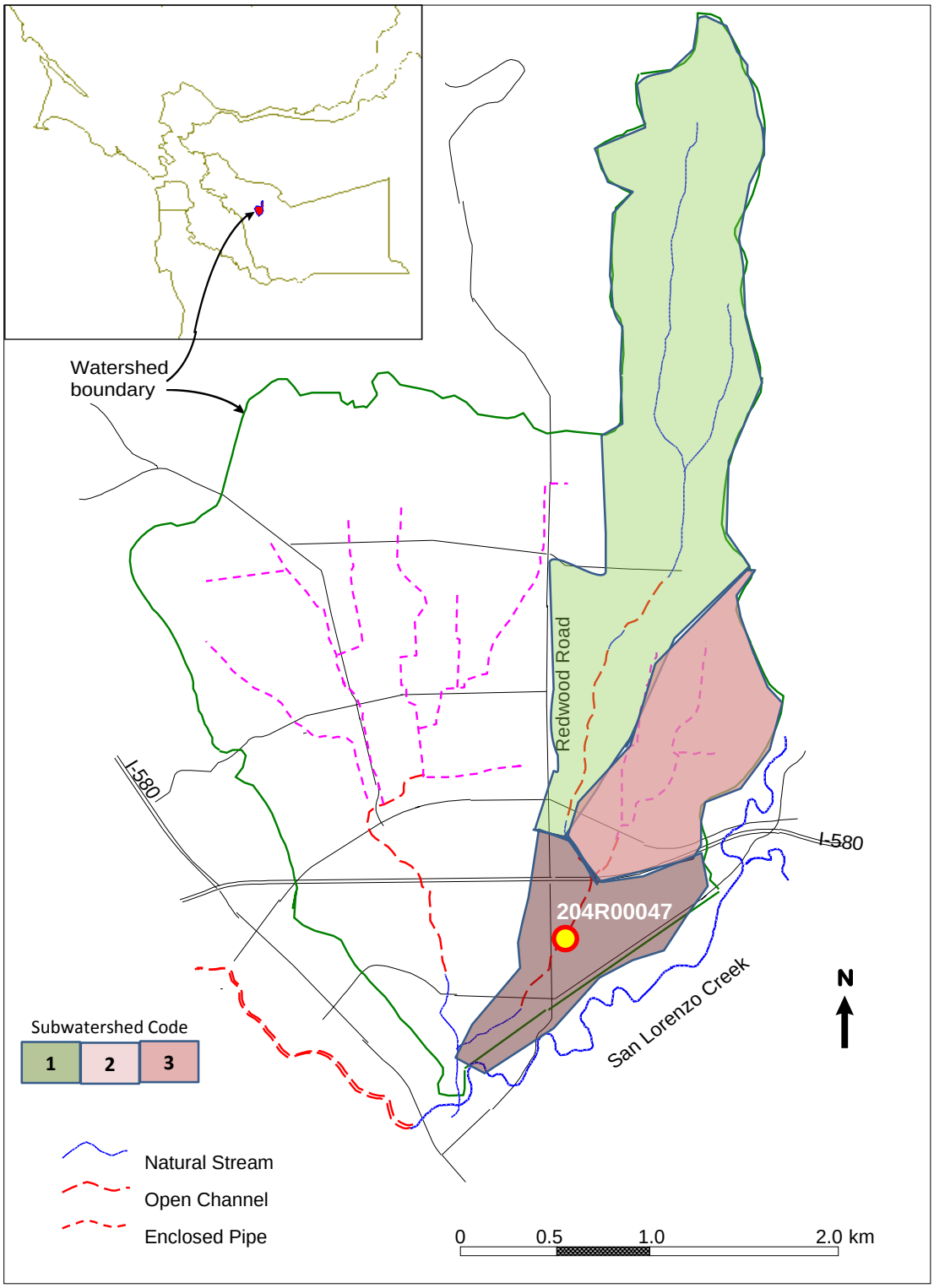

Figure 2-1.Map of the Castro Valley Creek Watershed and Targeted Subwatersheds Tributary to Site 204R00047.

2.2 Problem Statement

2.2.1 Water Quality Triggers

Comparison of W2012 sampling results at site 204R00047 with MRP1.0 trigger criteria are presented in Table 2-2.Triggers for sediment quality were based on calculation of Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) for each analyte as determined following MacDonald et al. (2000). It should be noted that there are some limitations in the MacDonald method, which are discussed below.

Table 2-2. Water Year 2012 MRP Triggers and Significance at Castro Valley Creek Site 204R00047

Trigger type	Trigger status at site	Comment
"Triad" - bioassessment indication of alteration	**IBI score Poor** (Poor chosen as trigger)[need to clarify in footnote]	Widespread in region, generally driven by habitat alteration
"Triad" - sediment chemistry	**16 chemicals > Threshold Effects Concentration**	TEC and PEC contributions by chemical groups: • PAHs - somewhat elevated • Pesticides (organochlorine) all significantly elevated • Metals - slight elevated zinc
	Probable Effects Concentration: average Quotient > 0.5	
	Pyrethroids calculated 2.38 >1 TU Equivalent	
"Triad" - sediment toxicity	Not present or triggered	
Chlorine in water column	**Low: 0.12 mg/l >0.08 on one of 2 occasions**	Widespread in region; result is near limit of method detection
Toxicity in water column	Present but not triggered	Hyalella initial sample 48% of control, retest did not confirm
General Water Quality - DO	Not sampled	
General WQ - other	Not sampled	
Temperature	Not sampled	
Pathogen Indicators	Not sampled	

In assessing the effect of using one-half of the MDL in place of one-half of the MRL to estimate ND results for statistical purposes, relatively large differences were observed in some cases for the WY2012 assessments reported in the UCMR (BASMAA 2013), which have been recalculated for WY2013. Calculated TEC quotients for individual and total PAHs were lower across-the-board using the MDL due to the relatively large proportion of NDs and the difference between MDLs and MRLs reported. It should be noted that WY2012 analyses are predominantly non-detects, and therefore that the TEC quotients calculated are driven by the MDL rather than quantified laboratory results.

While MacDonald (2000) generated PECs for multiple trace element, PAH, OC pesticide, and pyrethroid pesticide parameters, there was insufficient data at time of its publication to evaluate

the consensus PECs generated as to their predictive ability for associated sediment toxicity for each of the analytes reported. Analytes for which predictive ability is particularly uncertain include various PAH (anthracene, fluorine, and fluoranthene) and OC pesticide (dieldrin, DDDs, DDTs, endrin, heptachlor epoxide, and lindane) parameters (MacDonald, 2000).

When examining pyrethroids concentrations, a similar degree of uncertainty exists. Weston (2005) reported that predictions of sediment toxicity to *H. azteca* were supported by observed results for sites with TU ratios below one (little or no mortality) and above four (high or full mortality). For TUs between one and four, however, the predictive ability of the TU is less certain (Weston 2005). The Toxicity Unit calculation for pyrethroids was eliminated as a trigger criterion in MRP2.0, as was the complex linkage of sediment chemistry, toxicity and bioassessment.

2.2.2 Potential Sources and Activities Contributing to Poor Sediment Quality

The Causal Analysis/Diagnosis Decision Information System (CADDIS) was developed by the US EPA as an online guidance tool for conducting causal assessments of impacts to aquatic ecosystems (US EPA 2010). The online tool provides a framework and resource base for Stressor Identification (SI) using 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
Step 5: Identify Probable Causes

The Stressor Identification process may be iterative, and if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors. It should be noted that the CADDIS is designed to be initiated following observations of a biological effect; however in this case the sediment quality concerns were triggered by chemical concentrations that were not accompanied by significant toxicity.

Figure 2-2 shows a simple conceptual diagram from CADDIS, illustrating causal pathways related to unspecified toxic chemicals as a candidate cause of biological impairment. However CADDIS also notes that “urbanization” comprising several types of causal activities which together result in an “urban stream syndrome” of co-occurring, interacting changes in five general stressor categories:

- Water/Sediment Quality
- Temperature
- Hydrology
- Physical Habitat
- Energy Sources

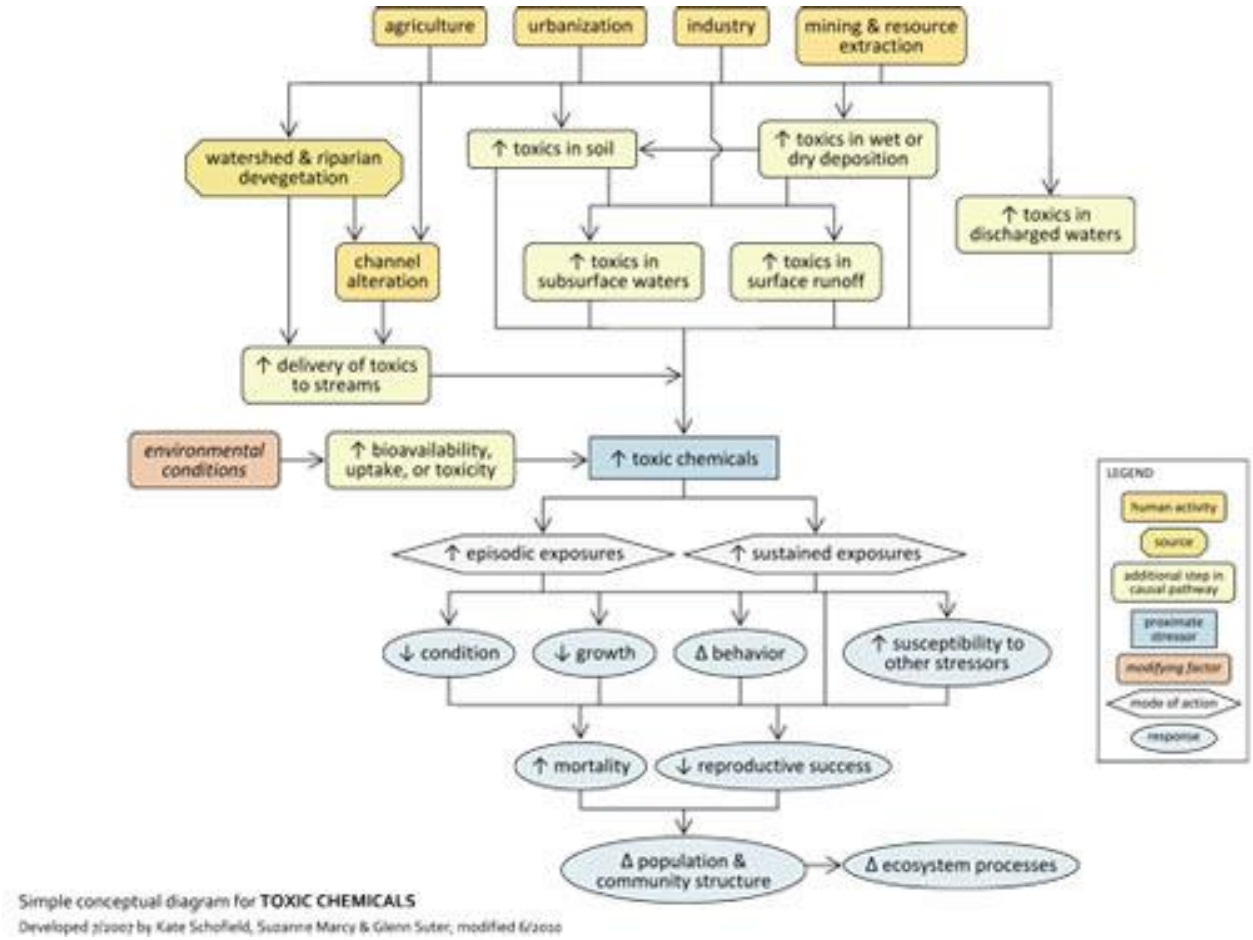

Figure 2-2. Conceptual diagram illustrating causal pathways, from sources to impairments, related to unspecified toxic chemicals (USEPA 2010).

Potential sources of poor sediment quality relevant to Castro Valley Creek included:

- commercial landuse discharges,
- residential landuse sources,
- freeway runoff,
- legacy pollutants and
- hydromodification of the channel.

3 Previous SSID Monitoring

ACCWP (2014) described a study design for WY 2013 sediment sampling in target subwatersheds of Castro Valley Creek, to try to characterize these potential source types. A literature review was also conducted.

Sediment sampling was conducted in July 2013 at 5 sites shown in Figure 3-1, in conjunction with sediment sampling for Creek Status Monitoring.

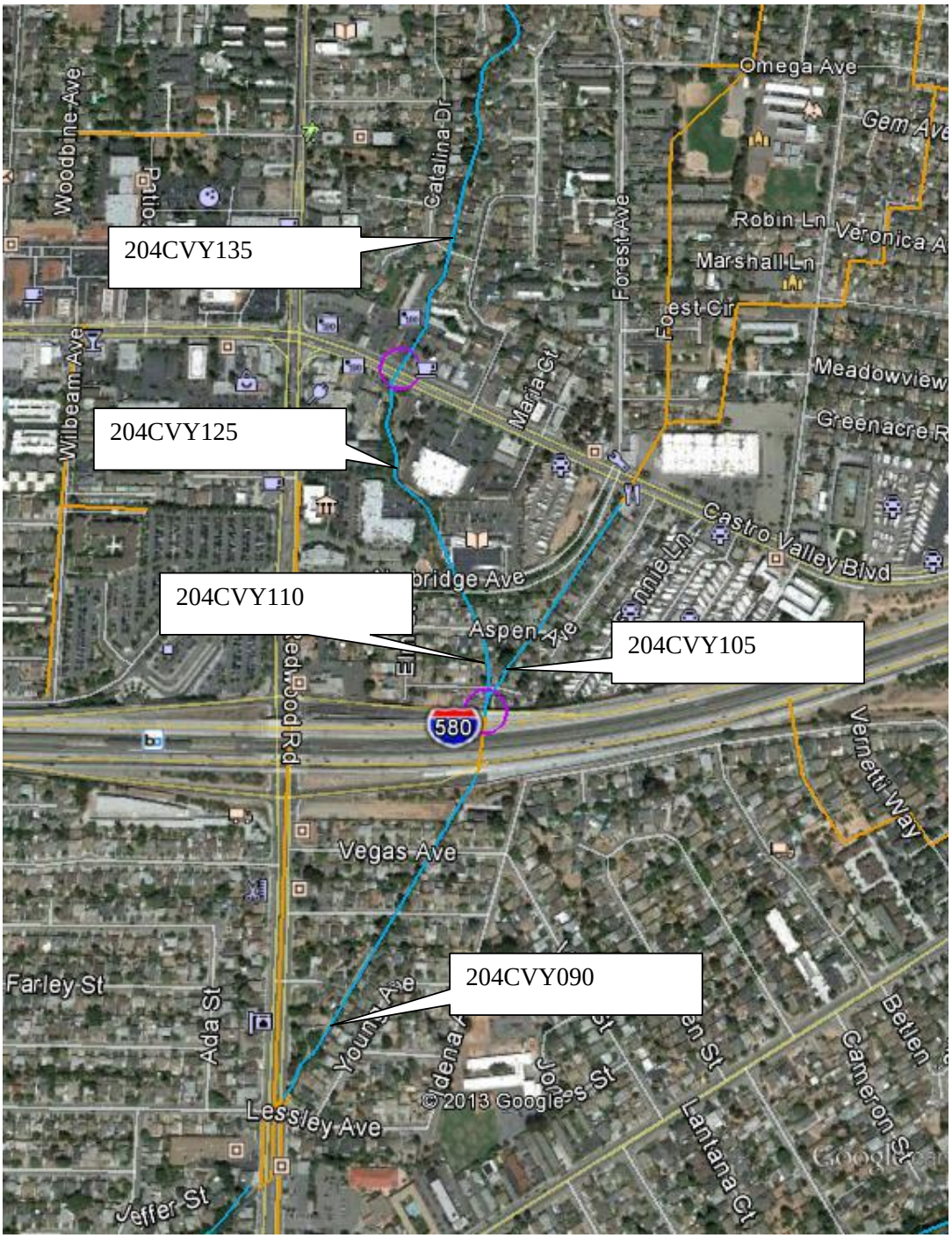

Figure 3-1. WY 2013 Monitoring Locations) for Source Identification in the Castro Valley Creek Watershed

At each of the five monitoring locations, sediment samples were collected and analyzed for:

- Pyrethroid pesticides;
- Total metals;
- Organochlorine pesticides;
- Polycyclic aromatic hydrocarbons;
- Percent fines; and
- Total organic carbon .

Results of this monitoring were generally similar to sediment chemistry concentrations observed in other urban areas in California:

- Pyrethroids were slightly higher in the eastern (mostly culverted) branch of Castro Valley Creek suggesting sources from the urbanized areas upstream. These results are consistent with published findings that pyrethroid concentrations increase with urbanization(Anderson *et al*, 2012, TDC, 2010a and 2010b). Bifenthrin was the most commonly found pyrethroid in the watershed. This result is consistent with other state and regional findings. Bifenthrin is stable in aquatic environments and is more commonly used in urbanized areas. However, pyrethroid concentrations in this study were lower than those reported as average concentrations in the SPoT program (Anderson *et al*, 2010) and by DPR (Zhang, 2010).
- PAH concentrations were lower than the averages found in other parts of the Alameda County (ACCWP, 2002) but generally higher than those found in Castro Valley sediment samples in 1989-1991. In this study the highest PAH concentrations were found in the most downstream site (Site 204CVY090), below I-580.
- Metal concentrations were generally comparable to concentrations previously found in Castro Valley Creek sediments in 1989-1991. Mercury concentrations were lower than those found in creek and channel sediments from western Alameda County (ACCWP. 2002). The upper western branch of the Castro Valley Creek, above the commercial landuse area, had higher metal concentrations compared with the eastern branch.
- Organochlorine pesticide concentrations were lower than those found in Castro Valley sediments in 1989-1991 and lower than averages found in the joint Agency sediment sampling program around the MRP region (Kinnetic Laboratories and EOA, 2002). Organochlorine pesticide concentrations were found to be slightly higher in the upper reaches of the western branch.

In WY2016, ACCWP selected the site 204CVY010 at the base of the watershed (at USGS gaging station 11181008) for Pesticides and Toxicity Monitoring per provision C.8.g of MRP 2.0. This provision combines all pesticide and toxicity monitoring that was formerly distributed between Creek Status and Pollutants of Concern Monitoring provisions and requires Permittees to select monitoring sites where toxicity could be likely.

No water or sediment toxicity was observed in dry season samples from this lower Castro Valley Creek site. Out of the reduced MRP 2.0 analyte list, 7 constituents had Threshold Effect Concentration (TEC) exceeding 1.0 and one had a Probable Effect Concentration (PEC) quotient exceeding 1.0.

4 Discussion and Planned Activities

Literature review and more recent sediment chemistry sampling in the course of Creek Status Monitoring confirm that the pollutant concentrations in Castro Valley Creek sediments are typical of urbanized areas in California. In WY 2015 another site in the same watershed (204R01951) displayed toxicity to *Hyalella azteca* in water samples, but not sediment samples although the pyrethroid equivalent Toxicity Units in sediment were high enough to cause toxicity according to the trigger criteria outlined in MacDonald et al. (2000). In WY 2016 the integrator site 204CVY010 also reached triggers according to MacDonald et al. (2000). Thus the trigger criteria seem likely to be overpredictive of potential toxicity in the types of creeks and channels found in Alameda County.

Program staff reviewed the initial monitoring results with stormwater program staff for the unincorporated Alameda County, who conducted a review of over 4 years of inspection reports in the vicinity and determined that no major illicit discharges had been reported that could be singled out as causing the observed sediment chemistry.

4.1 Next Steps

Although toxicity has not been regularly associated with the sediment chemistry, Program staff will continue to monitor conditions at 204CVY010 and incorporate results from WY 2017 in a final report for project completion by September 2018.

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ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

STRESSOR / SOURCE IDENTIFICATION PROJECT:

CROW CREEK LOW DISSOLVED OXYGEN

WATER YEAR 2016PROGRESS REPORT

URBAN CREEKS MONITORING REPORT, APPENDIX A.4C

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region

DRAFT
MARCH 31, 2017

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List of Acronyms

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
DO	Dissolved Oxygen
LUCMP	Local Urban Creek Monitoring Program
MRP, MRP 2.0	Municipal Regional Stormwater Permit (reissuance from previous "MRP1.0")
NPDES	National Pollutant Discharge Elimination System
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board(California Regional Water Quality Control Board, San Francisco Bay Region)
SSID	Stressor/Source Identification
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
USEPA	United States Environmental Protection Agency
WY	Water Year

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1. Introduction

The Alameda Countywide Clean Water Program (ACCWP) conducts Creek Status Monitoring as required by Provision C.8.c of the Municipal Regional StormwaterPermit (MRP, SFRWQCB 2015)[1]. ACCWP's 17 member agencies have joined with 56 other MRP Permittees to form the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative to coordinate monitoring conducted pursuant to MRP Provision C.8, Water Quality Monitoring. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a, 2014a and 2016a) and Standard Operating Procedures (SOPs, BASMAA 2012b, 2014b and 2016b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see Table 1-1.

Table 1-1. Standard Operating Procedures Pertaining to BASMAA RMC Creek Status Monitoring.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review

The RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011) which assigns each of the Creek Status monitoring parameters listed in MRP Table 8.1 to one of two sub-design components:

[1]The MRP was initially issued as SFBRWQCB 2009 (MRP 1.0) and reissued on November 19, 2015 with minor revisions in monitoring provisions regarding Stressor/Source Identification, which was renumbered as provision C.8.e in the reissued MRP 2.0. Unless otherwise noted, references to trigger values and other permit requirements in this report refer to the original MRP (SFBRWQCB 2009)

- Regional: ambient monitoring to assess the condition of aquatic life in creeks across the San Francisco Bay Area. Candidate monitoring sites were drawn from a probabilistically generated master list that included all perennial and non-perennial creeks and rivers within the applicable portions of the five participating counties. Sites from the RMC master list are identified by an alphanumeric code in which the last 6 characters are "Rnnnnn" with "R" designating the RMC probabilistic design and "nnnnn" the site's numeric sequence number generated through the RMC master draw[2]. RMC sites can also be assigned an alternative ID using the SWAMP naming procedure described in RMC SOP FS-11.
- Targeted: monitoring design and site selection address local watershed management questions. The last 6 characters of each Site ID reflect the watershed and numbering from the base of the watershed per the RMC SOP FS-11.

Creek Status Monitoring was initiated in WY2012 (October 2011 through September 2012) and reported in the first Urban Creeks Monitoring Report (UCMR, BASMAA 2013) submitted to the Regional Water Quality Control Board(RWQCB) in March 2013. The UCMR evaluated all data against "trigger criteria" listed for each parameter in MRP Table 8.1, which identified potential follow-up actions including Stressor/Source Identification (SSID) projects as required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP), subject to several conditions:

1. Creek Status Monitoring results meet one or more trigger criteria in MRP Table 8.1
2. When conducting monitoring through a regional collaborative,Permittees were collectivelyrequired to initiate no more than ten SSID projects during the MRP Permit term, and ACCWP's proportionate share were assumed to be three projects out of the 10.
3. If results indicated toxicity, at least 2 of the 10 SSID projects must be for toxicity
4. No need to repeat for continuing or recurring occurrences of the trigger in later results from the same receiving water limitations, unless directed to do so by the Water Board
5. No need to follow up on trigger results that are caused by Pollutants of Concern which are already being addressed by other portions of the MRP (e.g. pesticides).

The RMC programs developed a collaborative decision-making process for selecting sites for SSID follow-up. Program representatives reviewed the previous year's creek status monitoring results which reached "trigger" criteria, and prioritized sites for SSID follow-up based on several criteria including environmental significance of the trigger results and the feasibility of completing the project steps outlined in the MRP (see below). After consultation with affected Permittee(s), the RMC confirmed the candidate SSID project list with Water Board staff in April 2012 and individual programs planned initiation of SSID studies in their areas for FY 2013-14.

[2]As recommended for SWAMP data compatibility per RMC SOP FS-11, all site ID codes begin with a 3 digit Hydrologic Unit Code.

MRP1.0 listed four steps[3] for a SSID project, with. ACCWP and other Countywide Programs leading the technically oriented steps 1 and 4 and collaborating with relevant Permittees on step 2: Permittee(s) will be the lead on step 3 to the extent that effective stormwater BMPs are within their power and jurisdiction.

(1) Conduct a site specific study (or non-site specific if the problem is wide-spread) to identify and isolate the cause(s) of the trigger stressor/source. If the trigger stressor or source is already known (e.g. toxicity), proceed directly to step 2.
(2) Identify and evaluate the effectiveness of options for controlling the cause(s) of the trigger stressor/source.
(3) Implement one or more controls.
(4) Confirm the reduction of the cause(s) of trigger stressor/source.

Previous progress reports (ACCWP 2014b, 2016) describe s the first three years of an SSID study of low dissolved oxygen in the Crow Creek watershed. This report documents further project activities through September 2016, and outlines a workplan for continuing work in 2017 and subsequent completion of the project.

[3] The reissiued MRP modifies details and reporting requirements of these steps.

2. Background

2.1 Study Area

2.1.1 San Lorenzo Creek Watershed

The San Lorenzo Creek Watershed encompasses over 49 square miles (30,000 acres) of land and extends from the San Francisco Bay to the ridge-tops of the East Bay hills (Figure 2-1). The watershed encompasses both urban and non-urban areas, mostly in unincorporated portions of Alameda County. Within the watershed are over 81 miles of natural creeks including some segments of Castro Valley and Chabot Creeks within the urbanized area, and Crow Creek spanning both rural and suburban development. Upper Sulphur Creek (formerly a separate drainage) also discharges part of its runoff into San Lorenzo Creek near Second Street in Hayward.
The San Lorenzo Creek watershed has undergone extensive hydromodification in the 20th century, including construction of the flood control channel in the lower portions of the watershed by the US Army Corps of Engineers, and Cull Canyon and Don Castro Reservoirs by the Alameda County Flood Control and Water Conservation District (SFEI 2001). The San Lorenzo Creek Watershed is also coterminous with Zone 2 of the District, which has in recent years sponsored several restoration projects along Castro Valley Creek and other tributaries and sponsored geomorphic and fisheries surveys in non-urban portions of Crow and Cull creeks.

2.1.2 Beneficial Uses

Beneficial uses (SFRWQCB, 2015b) assigned to San Lorenzo Creek and its tributaries are as follows:

- Cold Freshwater Habitat (COLD) is assigned to San Lorenzo Creek and all of its tributaries;
- Fish Migration (MIGR) is assigned to the main stem of San Lorenzo Creek and to Crow Creek, along with the non-urban tributary Palomares Creek;
- Water Contact and Non-contact Recreation (REC-1 and REC-2). Public parks or other facilities allow access or approaches to sections of Castro Valley, Chabot and Crow Creeks. Swimming recreational areas at Cull and Don Castro Reservoirs are managed by the East Bay Regional Park District; and
- Municipal and Domestic Supply (MUN), Freshwater Replenishment (FRESH) and Groundwater Recharge (GWR) are assigned to San Lorenzo Creek but none of its tributaries. The aquifer beneath the downstream portion of San Lorenzo Creek is a site of an EBMUD project for groundwater storage to provide drought protection.

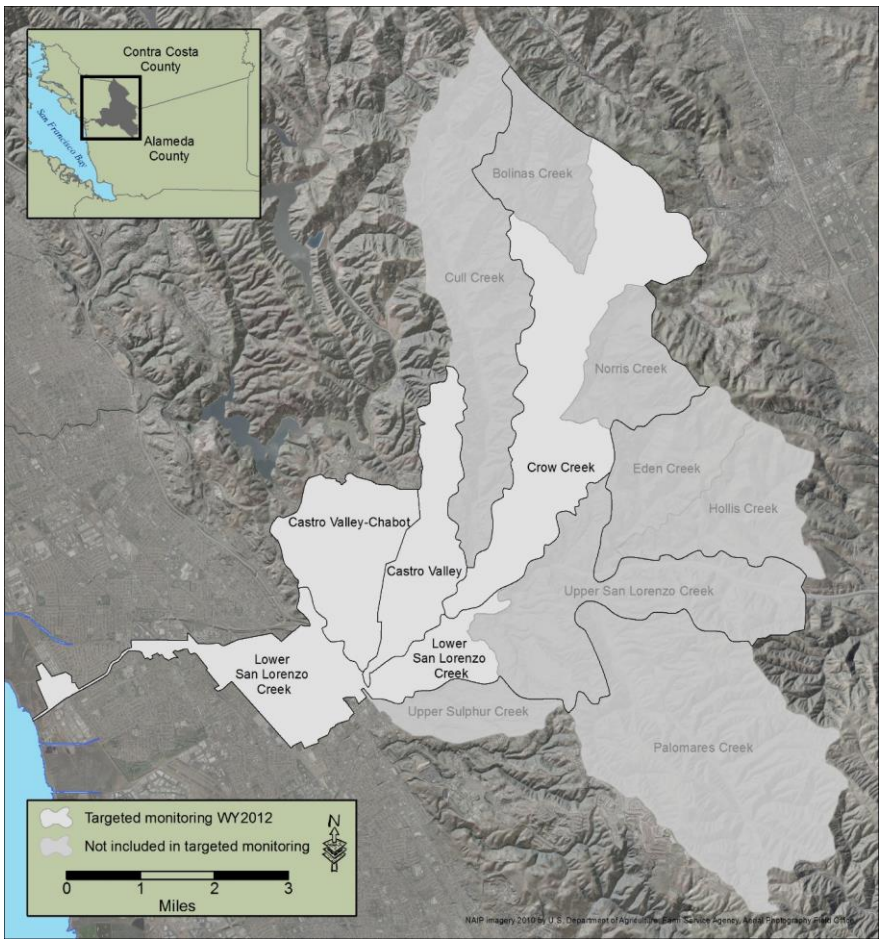

Figure 2-1.Map of the San Lorenzo Creek Watershed and Major Subwatersheds.

2.1.3 Crow Creek near confluence of Cull Creek

Cull Creek and Crow Creek are tributaries to San Lorenzo Creek. Crow Creek has a watershed area of about 5.8 square miles in unincorporated Alameda County (Figure 2-1). Most of the existing development in the upper watershed is concentrated along Crow Canyon Road, which parallels the creek. Rural land uses, mainly above Coldwater Drive, include grazing, some single-

family homes and also a number of equine facilities, primarily for horse boarding. The lower watershed contains some suburban residential tracts and also receives sporadic inputs from Cull Creek, a primarily non-urban watershed whose drainage is mostly impounded in Cull Reservoir just above its confluence with Crow Creek. The East Bay Regional Parks District manages the area around the reservoir as Cull Canyon Regional Recreation Area.The Crow Creek site where initial low DO triggers were observed (204CRW030) has a tributary watershed comprising only suburban drainage and open space (Figure 2-2**Error! Reference source not found.**).

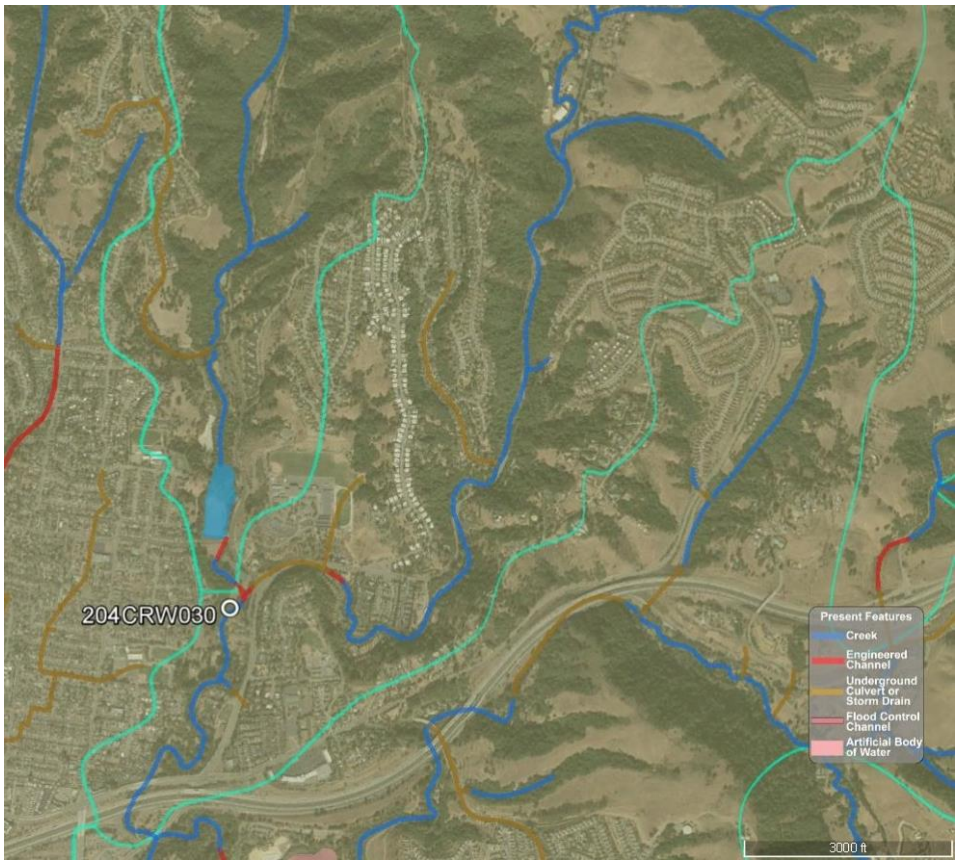

Figure 2-2. Study Area in Lower Crow Creek and Cull Creek Watersheds, showing flow network, subwatershed boundaries, and original site of low DO observations

2.2 Problem Statement

2.2.1 Water Quality Triggers

In 2012 low dissolved oxygen (DO) was observed during September Genera Water Quality monitoring at a site directly below the confluence of Cull Creek and Crow Creek.

Table 2-1 lists the potential triggers in MRP1.0 Table 8.1in comparison to available Creek Status monitoring data as of WY2015.

Commented [FA1]: Limit to DO trigger, state same for MRP2

Table 2-1. Review of Trigger Types and Significance at Crow Creek Sites near 204CRW030

Trigger type	Strength/magnitude	Comment
"Triad" - bioassessment indication of alteration	Not sampled	Site 204R00927 downstream of CRW030 was monitored in WY 2014
"Triad" - sediment chemistry	Not sampled	Site 204R00927 in WY 2014
"Triad" - sediment toxicity	Not sampled	Site 204R00927 in WY 2014
Chlorine in water column	Not sampled	Site 204R00927 in WY 2014
Toxicity in water column	Not sampled	Site 204R00927 in WY 2014
General Water Quality - DO	**67% <7 mg/L rolling average**	4 of 6 rolling averages were below 7mg/L – observed at 204CRW030 between 20th – 25th September, 2012, followed by similarly prevailing low DO at 204CRW030 in summer 2013 and at at 204CRW040 upstream of Cull Creek inflows in summer 2014
General WQ - other	Not triggered	
Temperature	Not triggered	
Pathogen Indicators	Not sampled	

2.2.2 Potential Sources and Activities Contributing to Low Dissolved Oxygen

In ACCWP (2016), data from initial WYs 12 through 15 were reviewed in the context of the the Causal Analysis/Diagnosis Decision Information System (CADDIS),an online guidance tool for conducting causal assessments of impacts to aquatic ecosystems(US EPA 2010). The online tool provides a framework and resource base for Stressor Identification (SI) using 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
Step 5: Identify Probable Causes

For the Crow Creek SSID Project, there was no observed impact in WY 2012 and the cause was defined by the 2012 trigger for low DO. The CADDIS framework lists seven types of sources or activities that may suggest or be associated with dissolved oxygen as a candidate cause of biological impairment. Below is a review of these source categories with information from previous ACCWP water quality investigations and stream surveys (2014a, 2014b, 2016) evaluated for relevance to the DO observations in Crow Creek reaches above 204CRW030.

- Impoundments: There is a reservoir on Cull Creek, just upstream from the confluence with Crow Creek. However records from the USGS Gage (#11180960) upstream of the reservoir show that Cull Creek only flows during the wet season (November-May), with no flow during the summer and early fall. Flow from the reservoir was not observed during dry-season sampling in 2013-2015. Thus, available data suggests it is unlikely that the reservoir had a negative effect on dissolved oxygen levels in Crow Creek during recent history.
- Wastewater inputs: No wastewater treatment outfalls exist within or upstream of the study reach; urban developments in the lower Crow Creek watershed receive sewage treatment provided by the Castro Valley Sanitation District, which discharges to San Francisco Bay. While a local sanitary sewer overflow was reported and investigated in August 2012at the time of a fish kill incident, it was unclear whether it caused any impact to the creek. Residences in the upper Crow Creek watershed have septic systems which may have some leakage to the creek.
- Industrial point sources: There are no point source discharges from industrial facilities within or upstream of the study reach.
- Agricultural and urban runoff: Three major stormwater lines deliver runoff from surrounding urban land use within the study reach. Contributing land uses include suburban residential housing developments, a school with large play fields and parking lots, and major roadways. Upstream land uses include rural residential homes, horse boarding facilities, nurseries, cattle grazing, and other activities characteristic of the urban-rural interface in Alameda County. Available water quality data, discussed in Section 3 below, indicates that variation in water quality conditions between monitoring sites may in part be a result of dry season urban runoff discharges within the study reach.
- Removal of riparian vegetation: Riparian vegetation, though still present in unmodified segments of the creek channel, has been substantially altered throughout the study reach

and to a somewhat lesser extent in the upstream watershed. Urban and rural development within the riparian zone has altered the presence and composition of riparian vegetation, likely resulting in reduced shading relative to pre-disturbance conditions.

- Channel alteration: Large portions of the channel network in the study reach have been modified into rectangular concrete channels or underground culverts. Most "natural" stream channels have been modified with reinforced banks. Additionally, the stream channel in the study reach is substantially incised into the floodplain, likely a result of historical processes related to changes in sediment supply and watershed hydrology. Together, these channel alterations have likely had a substantial impact on channel form, stream hydrology, hydrologic pathways, stream channel shading, turbulence and re-aeration, and primary production, with unknown effects on dissolved oxygen conditions.
- Groundwater inflow: Groundwater exchange with the stream has undoubtedly been altered as a result of watershed development. Portions of the stream channel upstream of Crow Canyon Road are incised down to the underlying bedrock, suggesting a strong connection with alluvial groundwater. However, groundwater storage in the alluvium filling the valley has likely been substantially reduced as a result of channel incision.

Of the seven sources or activities discussed above, agricultural and urban runoff, channel alteration, and riparian vegetation removal seem the most likely significant contributors to low dissolved oxygen conditions in the study area.

2.2.3 Conceptual Model and Initial Study Design in WYs 2013-2015

Figure 2-3shows a simple conceptual diagram from CADDIS, illustrating causal pathways related to dissolved oxygen.

CADDIS also highlights "urbanization" as comprising several types of causal activities (Riparian/Channel Alteration, Wastewater Inputs, Stormwater Runoff) that cluster on the left side of the conceptual diagram and together result in an "urban stream syndrome" of co-occurring, interacting changes in five general stressor categories:

- Water/Sediment Quality
- Temperature
- Hydrology
- Physical Habitat
- Energy Sources

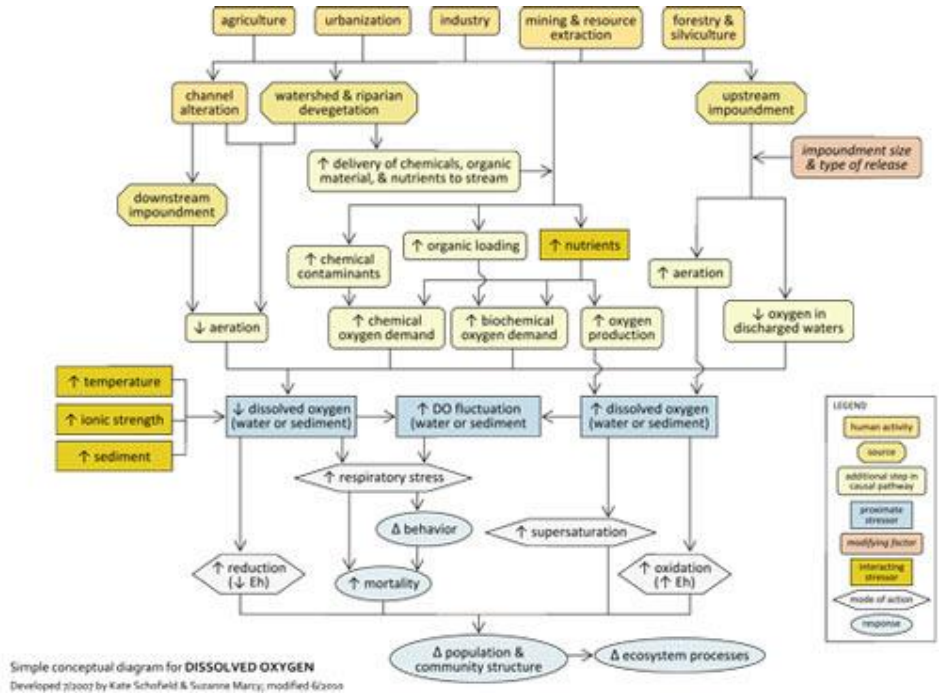

Figure 2-3. Conceptual diagram illustrating causal pathways, from sources to impairments, related to dissolved oxygen (USEPA 2010).

The SSID project monitoring design in WYs 2012 and 2013 (ACCPW 2014b) focused on the area immediately around the Crow-Cull confluence. Sampling sites were established upstream and downstream of the confluence of Cull Creek and Crow Creek as shown in Figure 2-4 and Table 2-2. Monitoring was conducted at 2-3 sites each year during spring and summer periods from 2012-2015, using two main approaches:

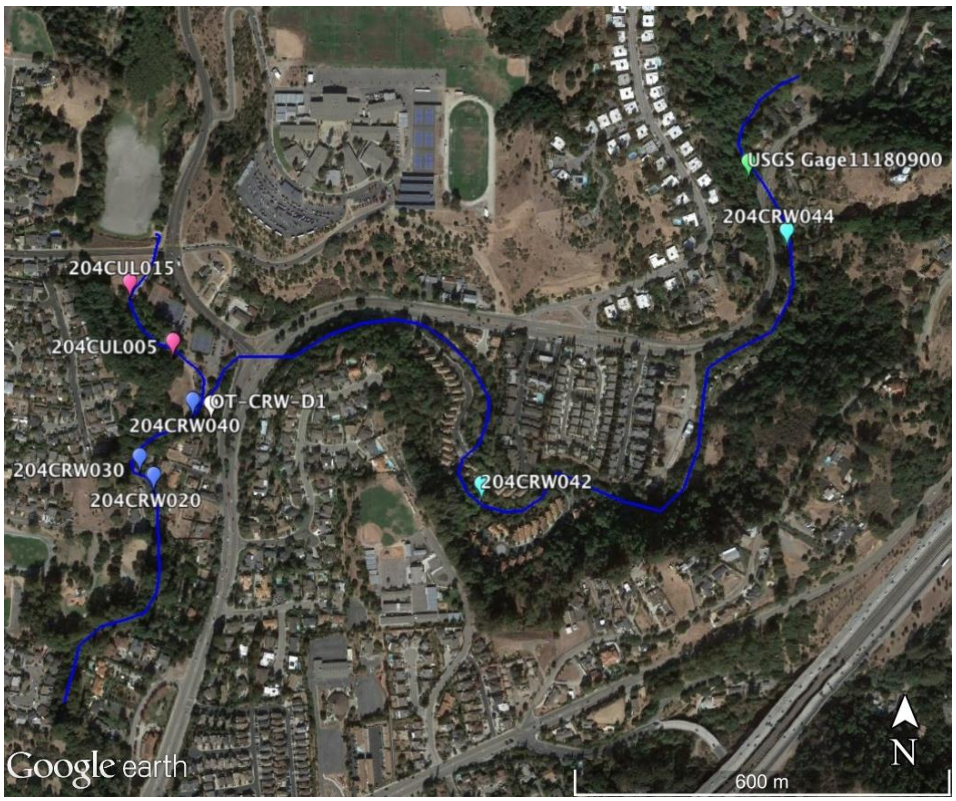

Figure 2-4. Location map of Crow Creek SSID study sites WYs 2012-2015.

Symbol Legend for monitoring sites:

dark blue = sites on Crow Creek downstream of the confluence with Cull Creek
pink = sites on Cull Creek
light blue = sites on Crow Creek upstream of the confluence with Cull Creek
white = stormwater outfall pipe OT-CRW-D1

Table 2-2. Crow Creek SSID creek monitoring sites, WYs 2012-2015.

Site Code	Description	Latitude	Longitude
204CRW030	Crow Creek 150 m downstream of Crow Creek/Cull Creek confluence in natural creek	37.70118	-122.05505
204CRW040	Crow Creek 5 m downstream of Crow Creek/Cull Creek confluence at transition from concrete channel to natural creek	37.70130	-122.05468
204CUL015	Cull Reservoir spillway settling pond, comprised of reinforced concrete approximately 12,000ft^2 volume	37.70308	-122.05587
204CRW042	Crow Creek 50 m upstream of first bridge on Crow Creek Road	37.70004	-122.04920
204CRW044	Crow Creek 100 m downstream from USGS Gage at Crow Canyon Road crossing	37.70379	-122.043447

General Water Quality: Continuous monitoring of basic water quality parameters (dissolved oxygen, temperature, conductivity, and pH) was conducted at 15-minute intervals over 10-14 day periods using YSI sondes as described in RMC SOP FS-4.

Water Quality Sampling and supplemental field measurements: Grab samples were collected per RMC SOP FS-4 during summer at all creek sites and analyzed for Chemical Oxygen Demand, Biochemical Oxygen Demand, nutrients (TKN, Nitrate, Nitrite, Ammonia, Total Phosphorus, Orthophosphate), Total Suspended Solids, Total Dissolved Solids and Total Organic Carbon. Supplemental field measurements were made at the time of sampling for instantaneous flow, Temperature, Conductivity, Turbidity, Chlorine, pH and DO, based on RMC SOP FS-1.

Table 2-3 summarizes the findings from WYs 2012 and 2013 in relation to the original study questions outlined in ACCWP (2014b).

Table 2-3. Key findings from initial Crow Creek SSID monitoring in WYs 2012 and 2013.

Study Question	Key Finding
Is the Reservoir spillway a contributor to lower DO in the creek system?	There was no summertime connectivity between Cull Reservoir and Crow Creek. Flow rates were negligible in the Cull creek system which was mainly pooled and stagnant, but did not discharge into Crow Creek.
Is seasonality contributing to lower DO concentrations?	Dissolved oxygen concentrations were found to decrease between July and September
Is low flow contributing to lower DO concentrations?	Dry season flows within Crow Creek were found to be low (generally less than 10L/sec) but there was no significant decrease in flows between July and September
Is nutrient availability contributing to lower DO concentrations?	2013 water quality analyses showed little evidence of elevated nutrient concentrations, suggesting that increased biomass and nutrient presence was not a significant cause of lower DO. There is evidence that acute episodes of decreased DO have occurred in the past.

In 2014 and 2015 general water quality monitoring was extended upstream of the confluence area to assess the potential contributions from upstream sources to the low DO conditions. Section 3 reviews the sonde data from all monitoring years.

ACCWP (2016) reviewed cumulative dissolved oxygen data as a 7-day rolling average for purposes of comparison to trigger criteria in provision C.8.c and Table 8.1 of MRP1.0. Weekly rolling values less than the 7 mg/L cold-water benchmark in 5 out of 15 deployment periods (Table 2-4). Low DO concentrations were more commonly observed downstream of the confluence of Cull Creek and Crow Creek and in the summer than the spring.

Table 2-4. Percentage of weekly (7-day average) rolling average D.O. less than the 7 mg/ benchmark for COLD beneficial use during previous General Water Quality deployment periods (dates shown in parentheses).

Study Site	Spring 2012	Summer 2012	Summer 1 2013	Summer 2 2013	Spring 2014	Summer 2014	Spring 2015	Summer 2015
204CRW030	0% 5/23-6/5	66.7% 9/13-9/25	100% 7/8-7/18	100% 8/13-8/23				
204CRW040				0% 8/13-8/23	0% 5/13-5/22	100% 8/26-9/9	0% 5/6-5/15	0% 8/3-8/17
204CUL015			100% 7/8-7/18					
204CRW042					0% 5/13-5/22	n/a* 8/26-9/9	0% 5/15-5/27	0% 8/17-8/31
204CRW044							0% 5/6-5/15	0% 8/3-8/17

*Note: DO data for Summer 2014 at 204CRW040 did not pass data quality objectives and are not included in analyses below.

Dissolved oxygen conditions were generally suitable in 2015 at all sites (204CRW040, 204CRW042, 204CRW044) in both spring and summer, although, excessively high maximum values at 204CRW040 during the daylight hours are indicative of high instream productivity, perhaps related to the lack of shading, altered channel morphology, and altered substrate conditions associated with the concrete channel immediately upstream.

Consistent throughout the 4-year dataset is a pattern of high fluctuations in specific conductivity in the section of Crow Creek below the confluence with Cull Creek (i.e., 204CRW020, 204CRW030, 204CRW040), which suggests regular, localized discharges into the stormwater system; the timing and patterns suggest a mixture of irrigation runoff and other urban sources. Fluctuations in conductivity at these sites generally do not align with patterns observed at reference sites (as well as upstream sites on Crow Creek), which typically have smooth, low amplitude (<5 uS) diel curves in conductivity. Additionally, elevated conductivity at 204CRW030 relative to

204CRW040 (just 150 upstream) during the dry season suggests localized inputs of high conductivity water.

3. Monitoring Design for WY2016

3.1 Approach and Methods

To further characterize potential sources of dissolved oxygen stressors in Crow Creek, spatially-intensive spot sampling of dissolved oxygen and specific conductivity was conducted to identify specific locations where water quality conditions change. Due to the maintenance requirements for dissolved oxygen sensors and very low flow conditions in Crow Creek during the summer, data loggers for conductivity and temperature (HOBO U24by Onset Computer Corporation) were deployed at several points in a study reach bounded by 204CRW040 and 204CRW042. Since these are similar to the temperature loggers used for Creek Status Monitoring, their use followed the procedures in RMC SOP FS-4.

Additionally, continuous General Water Quality monitoring of dissolved oxygen was conducted at the ends of the study reach during the mid-summer season (i.e., July) as well as the spring and late summer

3.2 Monitoring Locations

WY 2016 monitoring locations are shown in Figure 3-1 and described in Table 3-1. The close spacing of stations was intended to isolate the possible influences of multiple storm drain lines entering the study reach.

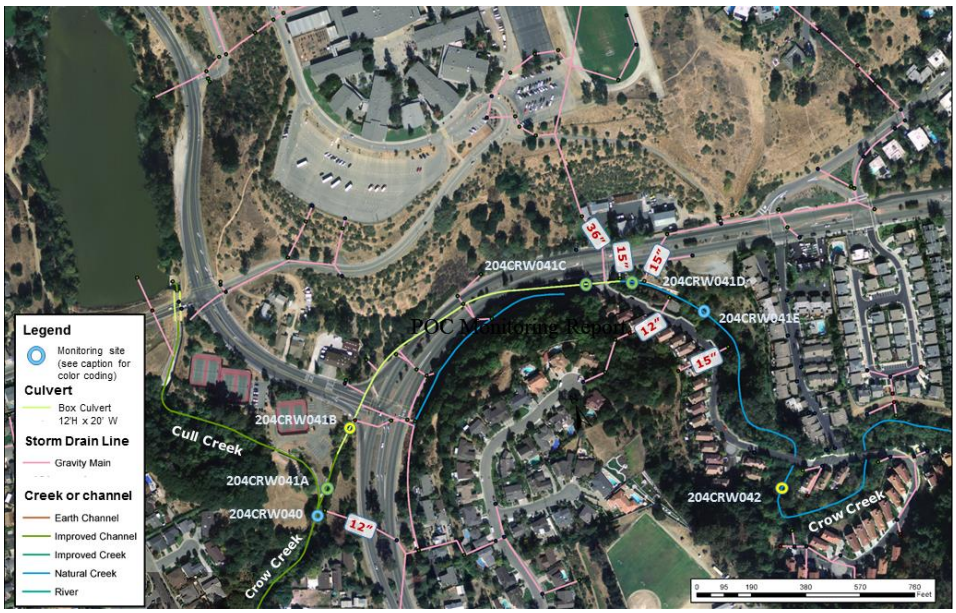

Figure 3-1. Crow Creek SSID Monitoring Locations for WY2016 and Related Storm Drainage Features.

Locations of stations with temperature / conductivity and general water quality loggers co-deployed are indicated by blue circles; location of stations with continuous temperature only measurements are indicated by yellow circles; location of stations with temperature and conductivity measurements are indicated by green circles.

Table 3-1.Monitoring Locations and Methods for WY 2016 Crow Creek SSID Monitoring.

Site Code	Description	Lat	Long	Temp + Cond	Temp Only	Basic WQ
204CRW040	Crow Creek 5 m downstream of Crow Creek/Cull Creek confluence at transition from concrete channel to natural creek	37.70143	-122.05467	X		X
204CRW041A	Inside Crow Creek box culvert approximately 75 m upstream of Crow Creek/Cull Creek confluence	37.70150	-122.05451	X		
204CRW041B	Crow Creek, near downstream end of box culvert under Crow Canyon Rd., above confluence with Cull Creek	37.70204	-122.05398		X*	
204CRW041C	Inside Crow Creek box culvert approx.. 30- m below upstream end, downstream of large outfall located under entrance to Crow Creek Rd.	37.70272	-122.0501	X*		
204CRW041D	Crow Creek upstream of box culvert, between 2 large outfalls approximately 30 m upstream of entrance to Crow Creek Rd.	37.70265	-122.0501	X*		
204CRW041E	Crow Creek upstream of box culvert, upstream of second large outfall approximately 100 m upstream of entrance to Crow Creek Rd.	37.70189	-122.04912	X		X
204CRW042	Crow Creek 50 m upstream of first bridge on Crow Creek Road	37.69996	-122.04920		X	

* indicates where Hobo loggers were installed with a sandbag weir to maintain water depth in a shallow channel or box culvert.

4. Discussion and results

This analysis begins with consideration of patterns in streamflow and dissolved oxygen during the three short-term deployments of YSI sondes, followed by an evaluation of conductivity records from the Hobo sensors that were deployed from late April through late September.

4.1 Streamflow During WY 2016

Streamflow conditions were improved in WY2016 relative to the previous four years of drought. A number of rainfall events caused elevated flows in April and May, and streamflow in Crow Creek (measured at the USGS Gage 11180900) remained above 1 cfs until June (Figure 4-1). Streamflow dropped below 0.1 cfs on August 1, and fluctuated between 0.06 cfs and 0.1 cfs through September.

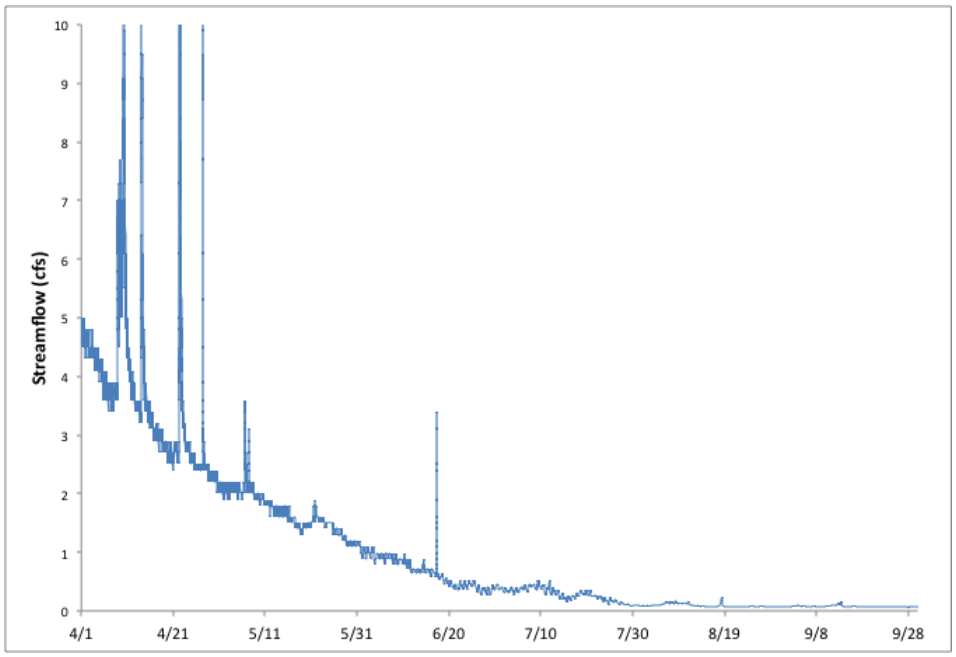

Figure 4-1. Streamflow in Crow Creek from April through September 2016 as measured at USGS Gage 11180900.

4.2 Dissolved Oxygen

In WY2016, DO was measured as part of general water quality monitoring using YSI sondes deployed simultaneously at a downstream site (204CRW040) and an upstream site (204CRW041E) during 10-14 day periods in spring (April 26-May 5), early summer (July 6-18), and late summer (August 16-29). All basic water quality data met QA targets, except for dissolved oxygen data from the early summer deployment, when post deployment checks were outside of control limits and indicated possible high bias for sondes at both sites.

Dissolved oxygen data were reviewed as a 7-day rolling average for purposes of comparison to trigger criteria in provision C.8.c and Table 8.1 of the MRP. Of the 6 deployments (3 deployments at each of 2 sites), weekly rolling values less than the 7 mg/L cold-water benchmark only occurred at 204CRW041E during the late summer deployment, when values ranged from 5.8-6.0 mg/L. However, as discussed below, diurnal DO patterns during this deployment were extremely anomalous, and cannot be explained by normal physical and biological processes that affect DO in streams.

Spring

DO concentration was consistently greater than 7 mg/L during the spring deployment (Figure 4-2). At the upstream site, DO percent saturation (which accounts for the differential potential for oxygen solubility with temperature) exhibited normal diurnal patterns, with a steady rise in DO beginning around 7am and continuing until around 2pm, when the daily maximum of 104-107% was reached (Figure 5). DO then gradually dropped until 8-9pm, and remained relatively constant at 95% until 7am. DO patterns were similar at the downstream site, except that daily maxima were higher (often 110-115%), daily minima were lower (80-88%), and nighttime values were less stable and fluctuated more than at the upstream site (Figure 4-3).

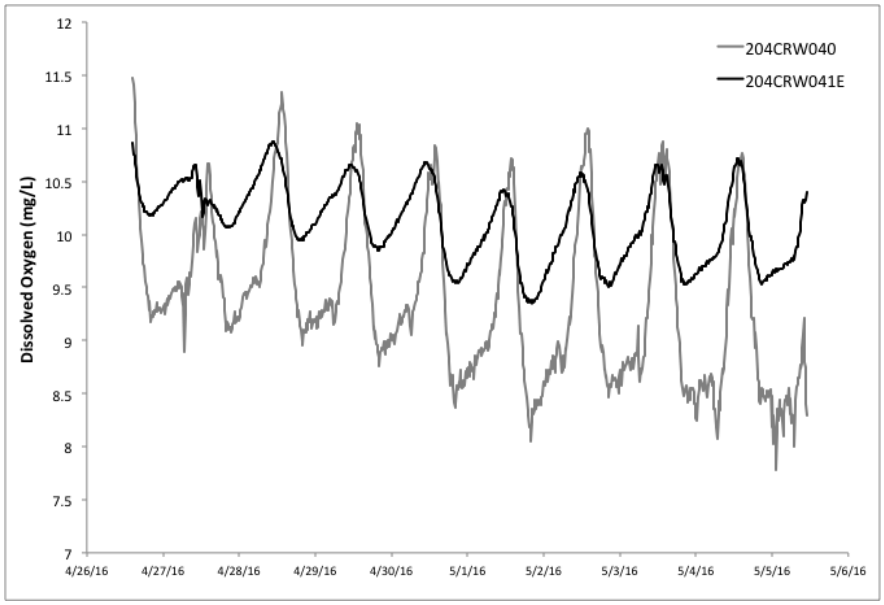

Figure 4-2. Dissolved oxygen concentration at the downstream site, 204CRW040 (gray), and the upstream site, 204CRW041E (black), during the spring deployment period (April 26-May 6, 2016).

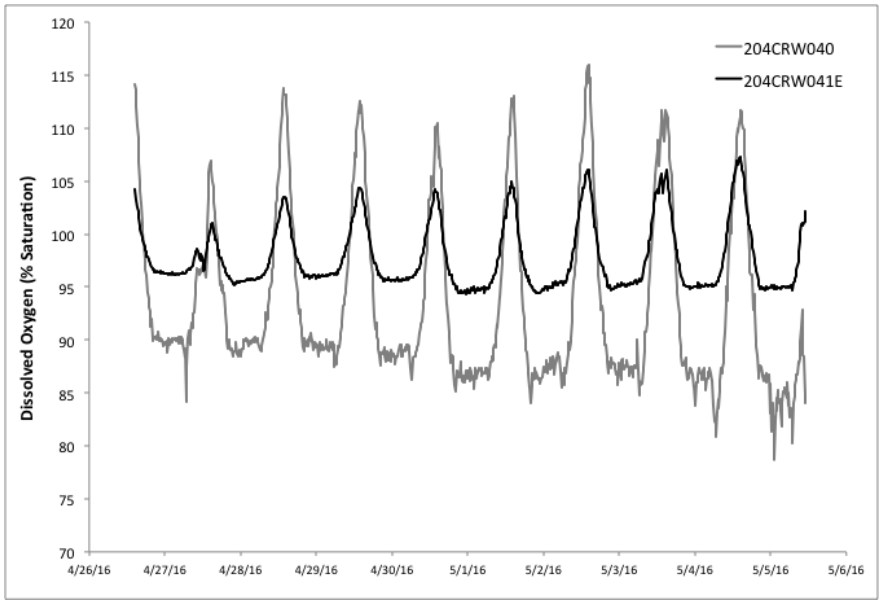

Figure 4-3. Dissolved oxygen percent saturation at the downstream site, 204CRW040 (gray), and the upstream site, 204CRW041E (black), during the spring deployment period (April 26-May 6, 2016).

Early Summer

Post deployment checks of dissolved oxygen were outside of control limits and indicated possible high bias for sondes at both sites during the early summer deployment period. Changes in DO patterns over the course of the deployment period also suggest degradation of the sensors, with a decreased in data quality as time progressed (Figure 4-4 and Figure 4-5). For example, while diurnal patterns in DO during the first few days of the deployment look similar to patterns observed during the spring deployment, patterns become more erratic as the deployment progresses, including major fluctuations during the nighttime hours when dissolved oxygen percent saturation is often fairly steady. For these reasons, it may be safe to assume that data from the first 24-48 hours of the deployment may be more accurate than subsequent data. An alternative possibility,

which seems unlikely, is that the erratic patterns later in the deployment reflect actual physical or biological processes.

Dissolved oxygen patterns during the initial 24-48 hour period of the early summer deployment were similar to conditions during the spring deployment: DO concentrations were consistently above 7 mg/L, and both sites exhibited consistent and strong diurnal patterns (Figure 4-4). Nighttime DO minima at both sites were around 87-88%, while daytime maxima were much higher at the downstream site (~150%) than at the upstream site (~115%) (Figure 4-5).

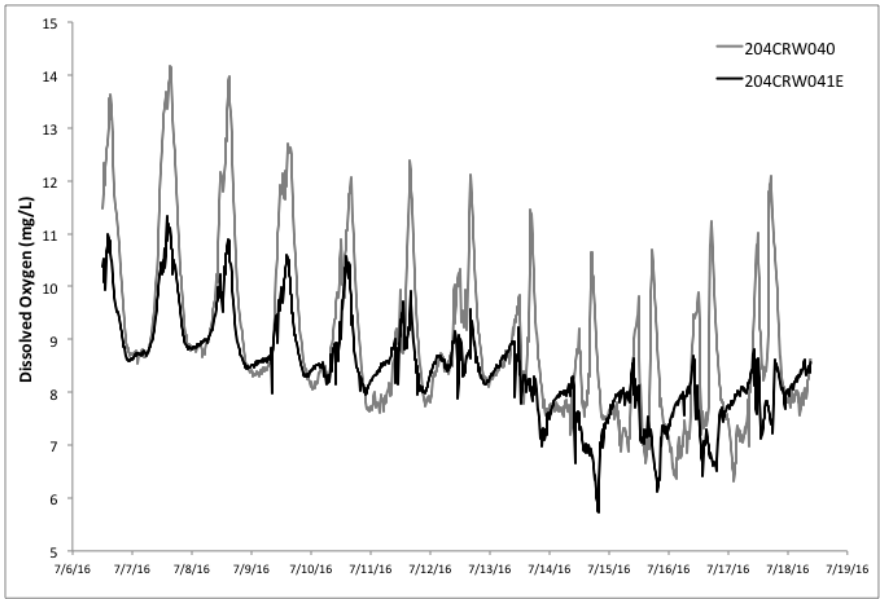

Figure 4-4. Dissolved oxygen concentration at the downstream site, 204CRW040 (gray), and the upstream site, 204CRW041E (black), during the early summer deployment period (July 6-19, 2016).

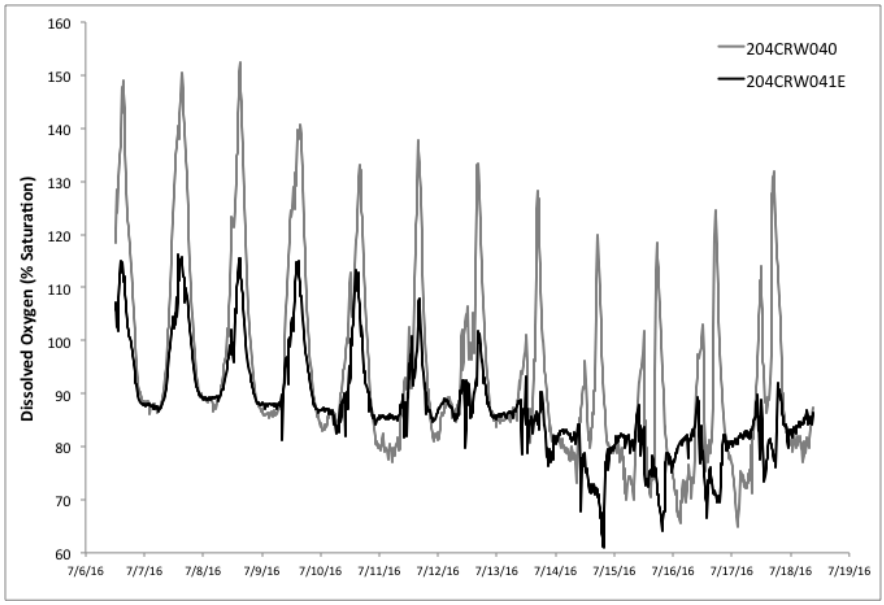

Figure 4-5. Dissolved oxygen percent saturation at the downstream site, 204CRW040 (gray), and the upstream site, 204CRW041E (black), during the early summer deployment period (July 6-19, 2016).

Late Summer

Dissolved oxygen exhibited diurnal patterns at the downstream site during the late summer deployment that were similar to previous deployments (Figure 4-6 and Figure 4-7). DO concentrations at the downstream site dropped below 7 mg/L during the nighttime on most days during the deployment period, but daytime concentrations were typically >8 mg/L and 7-day rolling averages were all >7 mg/L (Figure 4-6). DO percent saturation typically reached a minimum at 6am, then increased during the day and reached a maximum around 6pm (Figure 4-7). However, most days there were two separate peaks during the daylight hours, with a secondary peak around noon. This could be a result of a tree canopy (and other forms of shade) that cause two distinct periods of bright sunlight on the stream; oxygen levels increase with photosynthetic activity, which is often limited by light in small streams.

Dissolved oxygen concentrations were <7 mg/L for the vast majority of the deployment period at the upstream site (Figure 4-6); 7-day average concentrations ranged from 5.8-6.0 mg/L. Diurnal DO patterns were highly abnormal. Typically, DO reached a minimum near midnight. A short time later, usually around 2am, there was an extremely rapid rise in DO over the course of one hour, then a more gradual rise to a daily maximum around 9am. This is unexpected, because biological processes would tend to decrease DO during the nighttime, when no photosynthesis is occurring but respiration (by autotrophs and heterotrophs, i.e. plants, algae, animals, and microbes) is still occurring. The only ways for DO to increase during the nighttime would be increased rates of aeration (due to an increase in stream flow) and/or an increase in the dissolved oxygen of upstream sources, or a decrease in rates of respiration. During the remaining daylight hours there were fluctuations in DO, but an overall decrease from 9am to midnight. The fall in DO was especially rapid starting around 8pm and until midnight, when DO reached a minimum (Figure 4-7). It is hard to imagine a process that would cause DO to rapidly rise 2-4 mg/L (or from 40-70% saturation) at 2am (when DO should be stable due to constant respiration and aeration), or cause DO to drop rapidly by nearly an equivalent magnitude at 11am (when DO should be increasing due to photosynthesis). While it is possible the DO sensor was malfunctioning, the post-deployment check met QA standards, and the regularity and consistency of the diurnal patterns suggests that the sensor was responding to real changes in the environment.

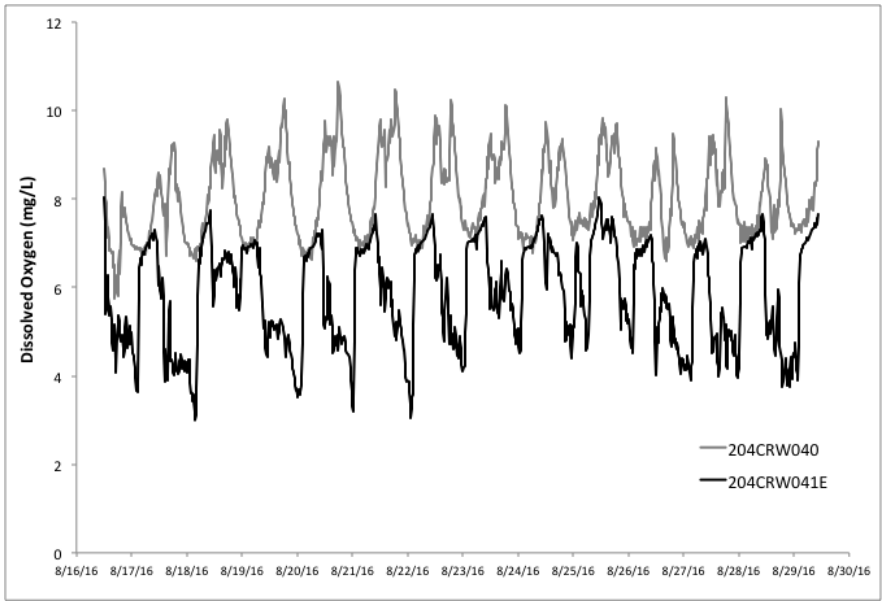

Figure 4-6, Dissolved oxygen concentration at the downstream site, 204CRW040 (gray), and the upstream site, 204CRW041E (black), during the late summer deployment period (August 16-30, 2016).

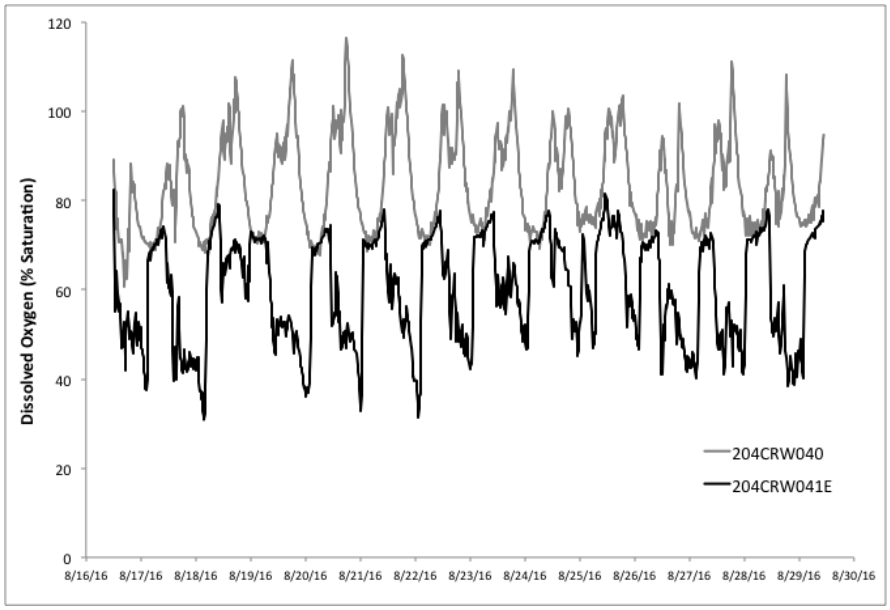

Figure 4-7. Dissolved oxygen percent saturation at the downstream site, 204CRW040 (gray), and the upstream site, 204CRW041E (black), during the late summer deployment period (August 16-30, 2016).

4.3 Conductivity

Conductivity is a valuable parameter to help us understand and verify hydrologic processes, and to substantiate or refute anomalous patterns observed in other variables. Conductivity is a measure of the amount of dissolved solutes in water. Different sources of water tend to have distinct conductivity signals. For example, drinking water provided by EBMUD has a system-wide average of 174 uS/cm[4], reflecting the large proportion of water that comes from the relatively low-conductivity Mokelumne River (like most rivers draining the granitic batholith of the Sierra Nevada). Groundwater-fed streams in the Bay Area often have background conductivity levels

[4] EBMUD 2015 Annual Water Quality Report. Available at: http://www.ebmud.com/wqr

between 200 and 800 uS/cm, depending on the local geology. Rainwater usually has conductivity levels <100 uS/cm. Non-stormwater related urban runoff with high loads of salts and other dissolved chemicals can have conductivity levels >1000 uS/cm. Like many other variables, conductivity often varies on diurnal patterns in relation to photosynthesis and evapotranspiration. Temporal variation in conductivity that is different from smooth diurnal curves often suggests variation in water sources, and/or sources of dissolved pollutants.

A number of anomalies in conductivity patterns were observed in the WY 2016 Crow Creek data. At the upstream site where conductivity was measured, 204CRW041E, a major phase shift in conductivity occurred on July 6, coinciding with a sensor maintenance visit. Prior to this event, conductivity had generally varied from 650-800 uS/cm; immediately following sensor maintenance, and for the remainder of the deployment, conductivity generally varied from 825-1000 uS/cm. Although this shift is associated with handling the sensor during the maintenance operation, which included downloading of data, the cause of the shift is unknown. Diurnal patterns before and after the 6July shift are fairly similar, so the relative patterns both before and after the event are assumed to reflect reality, even though actual values are clearly not accurate. Data from site 204CRW041D was much more problematic. This location is in a box culvert, and the field crew installed a sandbag weir to create enough water depth for the sensor to rest below the water surface. Following sensor maintenance on 6July conductivity readings flat-lined until field crews revisited this site on 18July and added additional sandbags to increase water depth. Additionally, temporal patterns from the beginning of the deployment through mid-August do not reflect the normal diurnal curves seen at all other sites, and include large jumps in conductivity. For this reason, only data from mid-August until the end of the deployment is considered accurate.

All five conductivity data sets contain a number of anomalous, sudden, short-lived changes in conductivity. The synchronous occurrence of these events at multiple sites indicates that these fluctuations reflect actual environmental changes, such as dry weather runoff discharges. The vast majority of these events were detected at the upstream-most site, 204CRW041E, indicating that the source of the change originated upstream of the urbanized area that was the scope of this study.

4.4 Discussion and recommendations

Low DO (7-day average < 7 mg/L) was not observed at 204CRW040, the stream reach where DO problems had been especially apparent in past years. Low DO was observed at 204CRW041E (the most upstream site monitored in this study) during the late summer (late-August), but the diurnal patterns were not consistent with eutrophic conditions typically associated with low DO. Instead, DO reached a minimum near midnight, there was an extremely rapid rise in DO over the course of one hour around 2am, a more gradual rise to a daily maximum around 9am, an overall decrease

from 9am to midnight, and a rapid decline in DO starting around 8pm. These unusual fluctuations were fairly consistent from day-to-day over the course of the deployment period. Several anomalous changes in conductivity occurred during this period in late August that could be indicative of urban runoff, but these short-term events cannot explain the unusual diurnal DO patterns at this site.

In WY 2016 the site farthest downstream in the study reach (204CRW040) exhibited much greater diurnal swings in dissolved oxygen than the upstream site (204CRW041E) in the spring and early summer deployments, suggesting that conditions favored greater potential for eutrophic responses, possibly related to less shading, greater nutrients, and/or higher productivity. While high DO concentrations (well over 100% saturation) were observed during every deployment at 204CRW040, it did not lead to eutrophic conditions with low DO. It seems likely that the "normal" amounts of precipitation that occurred in WY 2016 (in contrast to previous years of drought) contributed to improved water quality conditions in the reach downstream of the confluence with Cull Creek, i.e. 204CRW040. It also seems likely that low DO problems may reoccur in future years with below-average precipitation.

Continuous monitoring indicated multiple events when conductivity suddenly changed in unexpected ways that were very likely caused by urban runoff. However, while it remains possible that these events may have had negative impacts on water quality and/or biological integrity, they were not associated with periods of low dissolved oxygen.

Given the above average cumulative precipitation in WY 2017, high summer base flows may reduce the potential for low DO this summer in the reach of Crow Creek downstream of the confluence with Cull Creek. Continued monitoring of DO may help to support or reject the hypothesis that low DO is primarily a problem during years with below-average precipitation and streamflow.

5. Next Steps

The WY 2016 study design will be repeated in WY 2017, with possible elimination of some problematic sites in the culvert and additional attention to the reaches just above the urban area. Inspection records and incident reports will also be reviewed to evaluate the possible inputs to storm drain lines draining to the study reach, which may develop recommendations for project completion by September 2018.

6. References

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BASMAA. 2011. Regional Monitoring Coalition Final Creek Status and Long-Term Trends Monitoring Plan. Prepared by EOA, Inc. Oakland, CA. 23 pp.

BASMAA.2012a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 1.0.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.80 pp plus appendices.

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BASMAA.2014a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Version 2.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.81 pp plus appendices.

BASMAA.2014b. Creek Status Monitoring Program Standard Operating Procedures, Final Version 2.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.203 pp.

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BASMAA. 2016b. Creek Status Monitoring Program Standard Operating Procedures. Version 3, March 2016. 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.http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/SWAMP/BASMAA_RMC_SOP_V3_Final%20March%202016.pdf

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Protecting Alameda County Creeks, Wetlands & the Bay

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Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

March 31, 2017

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

SUBJECT: Electronic Data Submittal - ACCWP Creek Status Monitoring from October 2015 through September 2016 Pursuant to Provision C.8.h

Dear Bruce:

The member agency Permittees of the Alameda Countywide Clean Water Program (Program) through their Management Committee, and in conformance with the Memorandum of Agreement signed by their governing bodies, have authorized and directed me to prepare and submit certain reports as part of their compliance with Monitoring requirements of the Municipal Regional Stormwater NPDES Permit CAS612008 (MRP, reissued on November 19, 2015 as Order No. R2015-0049).

With this letter I am submitting a CD-ROM containing the Program's Monitoring data collected between October 1, 2015 and September 30, 2016 pursuant to the following provisions of Order No. R2015-0049:

- C.8.d Creek Status Monitoring
- C.8.e Stressor/Source Identification Projects
- C.8.f Pollutants Of Concern Monitoring
- C.8.g Pesticides And Toxicity Monitoring

These data are provided in Microsoft Excel files listed in Attachment A, which are formatted according to templates compatible with data management requirements of the Surface Water Ambient Monitoring Program (SWAMP). The Program is submitting these data to the Regional Water Board by March 31, 2017 and also to the Regional Data Center for upload into the California Environmental Data Exchange Network (CEDEN) as specified in Provision C.8.h.ii of Order No. R2015-0049, with the exception of the non-surface water data collected pursuant to C.8.f[1]

[1] As stated in a letter sent on March 20, 2017 by the Bay Area Stormwater Management Agencies Association to Jarma Bennett, manager of the CEDEN at the State Water Resources Control Board regarding recently announced changes to CEDEN's scope, the SWRCB's decision for CEDEN to include and display non-surface water data (previously explicitly excluded) is insufficiently supported by guidance and documentation to clarify whether MRP Permittees should now submit non-surface water data to CEDEN for compliance with MRP Provision C.8.h.ii, which was written on the bases of CEDEN's original scope.

Other data addressing the requirements of Provision C.8.f, which are fulfilled in part or in whole through the efforts of third parties other than the Program, will be submitted through the entities responsible for Quality Assurance in a time schedule determined by their respective programs[2].

By signing this letter on behalf of the program, I certify under penalty of law that this document and all attachments are 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. [40CFR 122.22(d)].

The quality of all monitoring data was evaluated through data collection and evaluation methods consistent with the 2016 updates of the Standard Operating Procedures and Quality Assurance Project Plan developed through the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative that includes all ACCWP member Permittees. These documents have been reviewed by Region 2 SWAMP staff for SWAMP-comparability where applicable, as provided in Provision C.8.b of Order No. R2015-0049.

We are in the process of identifying potential persistent water quality issues that would warrant a programmatic response as required by the MRP. If it is determined that discharges under this permit are causing or contributing to persistent exceedances of the applicable water quality objectives, the Permittees will follow up as required by MRP Provisions C.1 and C.8.

Please contact me if you have any questions or comments.

Sincerely,

James Scanlin
Program Manager

Attachment: CD ROM
Attachment A: list of data files on CD-ROM (2 pp)

Copy via email: Alameda Countywide Clean Water Program Management Committee Representatives

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[2] As described in the ACCWP Pollutants of Concern Monitoring Report submitted October 2016, this will include electronic submittal of Regional Monitoring Program monitoring results by the San Francisco Estuary Institute and of data collected by the SWAMP Sediment Pollution Trends (SPoT) program.

Attachment A

Data files for ACCWP Creek Status, Stressor-Source Identification, Pesticides and Toxicity and Pollutants of Concern Monitoring
October 1, 2015-September 30, 2016

Sources of templates for data files (see Contents file ACCWP-CSM+POC-all_ToC_2016-0328.xlsx for details):

SWAMP v2.5 Database references currently available through http://www.waterboards.ca.gov/water_issues/programs/swamp/data_management_resources/index.shtml

Kevin Lunde, SFRWQCB SWAMP Program (Continuous Monitoring)

Sample Purpose	Filename	Comment
BMI, Algae, FieldMeasure, Habitat	AC_2016_BA_PHAB_BIOTA_ EXPORT_2017-03-23_1of2.xls	File 1 of 2, compiles data for statio 204R01572, 204R02015, 204R021 205R01070, 205R01582, 205R018 205R01902, 205R02350, 205R034 and 205R03886
BMI, Algae, FieldMeasure, Habitat	AC_2016_BA_PHAB_BIOTA_ EXPORT_2017-03-23_2of2.xls	File 2 of 2, compiles data for statio 204R01863, 204R02116, 204R021 204R02287, 204R02439, 204R026 204R02879, 204R03015, 204R037 and 205R03694
WaterChem	AC_BIO_WQ_2016_Export_051616_ 17-03-15-10-28-39.xls	Compiles data for all 20 bioassessment stations
SedChem, SedTox, WaterTox,Chlorine	AC_SedToxChem_2016_WQ_Export_ 071116_17-03-15-10-45-01.xls	Compiles data for sites 204CVY010 and 204SAU030
WaterChem (Pathogens)	AC_FIB_5sites_WQ_Export_072016_ 17-03-15-14-17-03_rev.xls	Compiles data for sites 204CVY02 204CVY080, 204CVY084, 204CVY090, 204CVY125
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW040_ 2016_Spring.xls	
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW041E_ 2016_Spring.xls	
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW045_ 2016_Spring.xls	
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW040_ 2016_JulySSID.xls	added for SSID study design
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW041E_ 2016_JulySSID.xls	added for SSID study design
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW040_ 2016_fall.xls	
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW041E_ 2016_fall.xls	
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204CRW045_ 2016_fall.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW040_ 2016.xls	

Sample Purpose	Filename	Comment
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW041A_ 2016.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW041B_ 2016.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW041C_ 2016.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW041D_ 2016.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW041E_ 2016.ls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW042_ 2016.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW044_ 2016.xls	
ContinuousMonitoring (Temp)	ACCWP_HOBO_204CRW045_ 2016.xls	
POCs WaterChem, Receiving Water	AC_POC_RW_Export_071116_ 17-03-21-14-27-16.xls	204CVY010 and 204SAU030
POCs SedChem, Non-Receiving Water	ACCWP_POC_BERK_2015_template_ QAcomplete.xls	Multiple sites in Right of Way

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.	
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