Protecting Alameda County Creeks, Wetlands & the Bay

cleanwater PROGRAM

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

March 31, 2016

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 2015 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 for October 2014 through September 2015 and the following appendices:

| | |
|---|---|
| A.1 | Creek Status Monitoring Report - Regional Parameters |
| A.2 | Creek Status Monitoring Report -Targeted Parameters |
| A.3A | ACCWP Pollutants of Concern Monitoring 2015 Sediment Sampling Report |
| A.3B | Pollutants of Concern (POC) Loads Monitoring Progress Report, Water Years (WYs) 2012, 2013, and 2014 |
| A.4A | Castro Valley Creek Sediment Quality Progress Report |
| A.4B | Dublin Creek Biological Community and Sediment Quality Progress Report |
| A.4C | Crow Creek Low Dissolved Oxygen WY 2015 Progress Report |

### Third party monitoring

Please note that consistent with provision C.8.a.iv of the original MRP (Order R2-2009-074) in effect during the reporting period (C.8.a.iii of the reissued MRP), two water quality monitoring requirements were fulfilled or partially fulfilled by third party monitoring in Water Year 2015:

- As described in Section 5.1 of the attached Urban Creeks Monitoring Report, the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) conducted a portion of the data collection in Water Year 2015 on behalf of Permittees, pursuant to provision C.8.e – pollutants of concern loads monitoring (i.e., Table 8.4, Categories 1 and 2). The results of that monitoring are reported in Appendix A.3B of the attached Urban Creeks Monitoring Report. The Electronic Data submittal to the Water Board (and the California Environmental Data Exchange Network) of data collected from all stations monitored by both permittees and the RMP in Water Year 2015 pursuant to this provision is planned for spring 2016 following completion of final quality assurance review.

- Additionally, as noted in Section 5.2 of the Urban Creeks Monitoring Report, data collected pursuant to provision C.8.e.iii of the original MRP (Long-term Monitoring – Table 8.4 – Category 3) was initiated by the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Stream Pollutant Trend Monitoring Program at two locations identified in Table 8.3 of the original MRP. As stated in provision C.8.e.iii Permittees may use these data to comply with the monitoring requirements included in this provision. The schedule for SWAMP's review and reporting of data collected pursuant to this provision, however, differs from the schedule described in the MRP.

Per MRP provision C.8.a.iv the Permittees requested in March 2013 that the Executive Officer adjust the MRP due dates for these reporting deliverables to synchronize with the third party reporting schedules of SWAMP and the RMP, beginning with Water Year 2012 and continuing for all years covered under the original MRP.

# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# URBAN CREEKS MONITORING REPORT

# OCTOBER 2014 THROUGH SEPTEMBER 2015

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 30, 2016

**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 and Pollutants of Concern sediment sampling. Additional acknowledgements for preparation of specific Appendices are included in those documents.

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## LIST OF ATTACHMENTS

Attachment A. Electronic Data Submittal Transmittal Letter dated March 31, 2016 with attached file list.
Attachment B.BASMAA Regional Monitoring Coalition 2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status

## LIST OF APPENDICES

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

**STRESSOR-SOURCE IDENTIFICATION PROJECT REPORTS**

A.4A Castro Valley Creek Sediment Quality Progress Report
A.4B Dublin Creek Biological Community and Sediment Quality Progress Report
A.4C Crow Creek Low Dissolved Oxygen WY 2015 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 |
| 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 |
| EDD | Electronic Data Deliverable |
| LDM | Local Data Manager |
| LQAO | Local Quality Assurance Officer |
| MRP | Municipal Regional Stormwater Permit |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| NPDES | National Pollutant Discharge Elimination System |
| 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 |
| 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 |
| SWAMP | Surface Water Ambient Monitoring Program |
| TOC | Total Organic Carbon |
| USA | Unified Stream Assessment |
| USEPA | United States Environmental Protection Agency |
| WY | Water Year |

**WY 2015 Summary of Creek Status 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 | CI | WQ Tox | SED | PATH | TEMP | GWQ |
| 204R01391 | Zeile Creek | U | 37.64547 | -122.03133 | X | X | X | | | | | |
| 204R01735 | Zone 5 Line J-2 | U | 37.57482 | -122.07164 | X | X | X | | | | | |
| 204R01828 | Arroyo Mocho | U | 37.67927 | -121.90686 | X | X | X | | | | | |
| 204R01855 | San Leandro Creek | U | 37.72823 | -122.15025 | X | X | X | | | | | |
| 204R01876 | South San Ramon Creek | U | 37.72070 | -121.92112 | X | X | X | X | X | | | |
| 204R01945 | Altamont Creek | U | 37.71918 | -121.74272 | X | X | X | | | | | |
| 204R01951 | Castro Valley Creek | U | 37.69344 | -122.07167 | X | X | X | X | X | | | |
| 204R02095 | San Lorenzo Creek | U | 37.68572 | -122.10347 | X | X | X | | | | | |
| 204R02132 | Zone 7 Line J-2 | U | 37.71029 | -121.93006 | X | X | X | | | | | |
| 204R02351 | Zone 5 Line D | U | 37.68643 | -122.04430 | X | X | X | | | | | |
| 204R02375 | Ward Creek | U | 37.64099 | -122.07871 | X | X | X | | | | | |
| 204R02457 | Arroyo Seco | U | 37.69758 | -121.73877 | X | X | X | | | | | |
| 204R02503 | Old Alameda Creek | U | 37.59327 | -122.05206 | X | X | X | | | | | |
| 204R02527 | Zone 3A Line B-5 | U | 37.66343 | -122.07318 | X | X | X | | | | | |
| 204R02596 | Chabot Canal | U | 37.68947 | -121.90010 | X | X | X | | | | | |
| 204R02815 | Tassajara Creek | U | 37.69729 | -121.88090 | X | X | X | | | | | |
| 204R02852 | Pleasanton Canal | U | 37.67367 | -121.90653 | X | X | X | | | | | |
| 205R00622 | Zone 6 Line L | U | 37.54639 | -121.95815 | X | X | X | X | X | | | |
| 205R02327 | Zone 5, Line F-1 | U | 37.52714 | -122.03251 | X | X | X | | | | | |
| 205R02478 | Laguna Creek | U | 37.50027 | -121.95446 | X | X | X | | | | | |
| 205R02583 | Zone 5 Line D | U | 37.51798 | -122.00192 | X | X | X | | | | | |
| 205R02670 | Zone 6 Line L | U | 37.55083 | -121.95170 | X | X | X | | | | | |
| 204CVY020 | Chabot Creek | U | 37.68167 | -122.08082 | | | | | | X | | |
| 204CVY080 | Castro Valley Creek | U | 37.68182 | -122.08047 | | | | | | X | | |
| 204CVY084 | Castro Valley Creek | U | 37.68414 | -122.07565 | | | | | | X | | |
| 204CVY090 | Castro Valley Creek | U | 37.68778 | -122.07286 | | | | | | X | | |
| 204CVY125 | Castro Valley Creek | U | 37.69458 | -122.07241 | | | | | | X | | |
| 204CVY150 | Castro Valley Creek | U | 37.70477 | -122.06903 | | | | | | X | | |
| 204CVY170 | Castro Valley Creek | U | 37.71159 | -122.06359 | | | | | | X | | |

**WY 2015 Summary of Creek Status 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 |
| 204CRW020 | Crow Creek | U | 37.70008 | -122.05542 | | | | | | | X | |
| 204CRW030 | Crow Creek | U | 37.70046 | -122.05567 | | | | | | | X | |
| 204CRW040 | Crow Creek | U | 37.70143 | -122.05467 | | | | | | | X | X |
| 204CRW042 | Crow Creek | U | 37.69996 | -122.04920 | | | | | | | X | X |
| 204CRW044 | Crow Creek | U | 37.70375 | -122.04363 | | | | | | | X | X |
| 204CRW050 | Crow Creek | U | 37.71864 | -122.03835 | | | | | | | X | |
| 204SLO065 | San Lorenzo Creek | U | 37.67790 | -122.08132 | | | | | | | X | |
| 204SLO080 | San Lorenzo Creek | U | 37.68609 | -122.06401 | | | | | | | X | |
| 204CUL010 | Cull Creek | U | 37.70247 | -122.05541 | | | | | | | X | |

Legend:
BA = Bioassessment; N = Nutrients; Cl = Chlorine; WQ Tox = Water Column Toxicity; SED = Sediment Toxicity and Chemistry; PATH = Pathogen Indicators; TEMP = Continuous Temperature Monitoring; GWQ = Continuous General Water Quality Monitoring.
**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; Order R2009-0074) issued by the San Francisco Regional Water Quality Control Board (Water Board) on October 14, 2009. The MRP was reissued on November 19, 2015 (Order R2015-0049) and became effective January 1, 2016.

This report (including all appendices and attachments) fulfills the requirements of MRP Provision C.8.gfor interpreting and reporting monitoring data collected during Water Year 2015(WY 2015, October 1, 2014 - September 30, 2015). 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/.

This report is organized into two main parts – the main body and appendices. The main body provides brief summaries of accomplishments made in Water Year 2015in compliance with MRP provision C.8 from the previous permit. 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 the reissued MRP. Unless otherwise noted, references in the body and appendices of this report are to the original MRP in effect during WY 2015.

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 and referenced within the applicable sections of the report's main body.

[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).

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

| Urban Creeks Monitoring Report Section | | MRP provision | |
|---|---|---|---|
| | | R2009-0074 | R2015-0049 |
| 1. Introduction | | n/a | n/a |
| 2. San Francisco Estuary Receiving Water Monitoring | | C.8.b | C.8.c |
| 3. Creek Status Monitoring | Biological, Chlorine, Nutrients, General Water Quality, Temperature, Bacteria | C.8.c | C.8.d |
| | Pesticides and Toxicity Monitoring (including dry weather sediment chemistry) | C.8.c | C.8.g |
| | Stream Survey | C.8.c | n/a |
| 4. Monitoring Projects | Stressor/Source Identification | C.8.d | C.8.e |
| | BMP effectiveness Investigation | C.8.d | n/a* |
| | Geomorphic Project | C.8.d | n/a |
| 5. Pollutants of Concern and Long-Term Trends Monitoring | | C.8.e | C.8.f |
| 6. Citizen Monitoring and Participation | | C.8.f | n/a |
| 7. Reporting, Monitoring Protocols, and Data Quality | | C.8.g, h | C.8.b, h |

*incorporated in new Provision C.8.f for PCBs and mercury only.

The main body of this report and associated appendices address the following reporting requirements for the annual Urban Creeks Monitoring Report (Provision C.8.g.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/longs); 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.

## Regional collaborative monitoring (BASMAA RMC)

Provision C.8.a (Compliance Options) of the MRP allows Permittees to address monitoring requirements through a "regional collaborative effort," their Stormwater Program, and/or individually. In June 2010, Permittees notified the Water Board in writing of their agreement to participate in a regional monitoring collaborative to address

requirements in Provision C.8[2]. The regional monitoring collaborative is referred to as the Bay Area Stormwater Management Agencies (BASMAA) Regional Monitoring Coalition (RMC). With notification of participation in the RMC, Permittees were required to commence water quality data collection by October 2011. In a November 2, 2010 letter to the Permittees, the Water Board's Assistant Executive Officer (Thomas Mumley) acknowledged that all MRP Permittees have opted to conduct monitoring required by the MRP through a regional monitoring collaborative, i.e. the BASMAA RMC.

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 summarizes 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 are identified in the RMC Work Plan, based on the requirements described in provision C.8 of the MRP.

Regionally-implemented activities in the RMC Work Plan are 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 or in-kind project implementation mechanisms for BASMAA regional projects follow BASMAA's Operational Policies and Procedures, approved by the BASMAA BOD. MRP Permittees, through their stormwater program representatives on the 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.

## SECTION 2 - SAN FRANCISCO ESTUARY RECEIVING WATER MONITORING (C.8.b)

As described in MRP provision C.8.b, 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 MRP, Permittees have complied with this provision by making financial contributions to the RMP directly or through stormwater programs (Table 2-1). 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.

[2] See Appendix A.1 for a list of all participants in the RMC.

**Table 2-1. Stormwater Program annual contributions to the Regional Monitoring Program for Water Quality in the San Francisco Bay Estuary in 2015 by MRP-related Programs**

| RMC Participant | 2015 Contribution |
|---|---|
| Santa Clara Valley Urban Runoff Pollution Prevention Program | $190,959 |
| Alameda Countywide Clean Water Program | $182,979 |
| Contra Costa Clean Water Program | $149,303 |
| San Mateo Countywide Water Pollution Prevention Program | $90,115 |
| Vallejo Sanitation and Flood Control District | $13,708 |
| Fairfield-Suisun Urban Runoff Management Program | $16,199 |
| 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.[3] 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?
- 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 2014 the S&T Program was comprised of the following program elements that collect data to address RMP management questions described above:

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

- 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 data collection activities or elements in future years so that more funding will be available for pilot and special studies. 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 Year2015, 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) and the STLS Multi-Year Monitoring Plan (MYP). Pilot and special studies associated with the STLS are intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small tributaries to the San Francisco Bay. Additional information is provided on STLS-related studies under section C.8.e (POC and Long-Term Trends Monitoring) of this Report.

Participation in Committees, Workgroups and Strategy Teams

In Water Year2015, 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)
- Emerging Contaminant Workgroup (ECWG)
- PCB Workgroup
- 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 Year2015 ACCWP Program staff actively participated in the SPLWG, EEWG, Small Tributaries Loading Strategy Team (see Section 5 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 Pulse of the Estuary, 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 3 - CREEK STATUS MONITORING (C.8.c)

Provision C.8.c 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 Table 8.1 of the MRP. Based on the implementation schedule described in MRP Provision C.8.a.ii, creek status monitoring coordinated through the RMC began in October 2011.

### Regional and Local Monitoring Designs

The RMC's regional monitoring strategy for complying with MRP provision C.8.c - 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)[4].

The Program submitted its Creek status monitoring data for Water Year 2014to the Water Board by January 15, 2015. The analyses of results from Creek Status Monitoring conducted by the Program in Water Year2015 are presented in Appendices A.1 and A.2 to this report. Table 3-1provides a list of which Creek Status monitoring parameters are included in specific appendices.

[4]MRP provision C.8.a.i states 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".

**Table 3-1. Location of Creek Status Monitoring result analyses for each parameter in MRP Table 8.1.**

| 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 | X | | Appendix A.1 |
| Water Toxicity | X | | Appendix A.1 |
| Sediment Toxicity | X | | Appendix A.1 |
| Sediment Chemistry | X | | Appendix A.1 |
| General Water Quality | | X | Appendix A.2 |
| Temperature | | X | Appendix A.2 |
| Bacteria | | X | Appendix A.2 |
| Stream Survey | | X | Appendix A.2 |

# SECTION 4 - MONITORING PROJECTS (C.8.d)

Three types of monitoring projects were required by provision C.8.d of the MRP:

- Stressor/Source Identification Projects (C.8.d.i);
- BMP Effectiveness Investigations (C.8.d.ii); and,
- Geomorphic Projects (C.8.d.iii).

The overall scopes of these projects are generally described in the MRP and the RMC Work Plan. Based on MRP compliance schedules and program-specific requirements for these provisions, the following sections provide brief summaries of the Program's progress made up to WY 2015 on monitoring projects required by the MRP.

## 4.1 STRESSOR/SOURCE IDENTIFICATION PROJECTS

As described in the MRP, Permittees who conduct Creek Status monitoring through a regional collaborative shall be required to initiate no more than ten Stressor/Source Identification projects when monitoring results trigger a follow-up action as indicated in MRP Table 8.1. To ensure consistency in interpretation of the Stressor/Source ID requirements (C.8.d.i) and a coordinated approach to compliance with that provision, RMC Permittee efforts in Water Year 2013includeda collaborative evaluation of Water Year 2012 Creek Status monitoring results and joint decision-making process for selecting sites for Stressor/Source Identification (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 each of the Alameda County SSID projects in FY2013-14. As required by MRP Provision C.8.d.i, 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 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 progress report describes describing BMPs implemented and 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 further review of land use inputs and freeway runoff, and comparison with other evaluations of habitat values affecting 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 includes an updated WY2016 monitoring plan to evaluate summer inflows from culvert outfalls using continuous monitoring of conductivity as well as temperature.

## 4.2 BMP EFFECTIVENESS INVESTIGATION

The MRP requires Permittees to investigate the effectiveness of one Best Management Practice (BMP) for stormwater treatment or hydrograph modification control. ACCWP Permittees are addressing this project through monitoring of a BMP that is also being used to fulfill provisions C.11.e and C.12.e, as allowed by provision C.8.d.ii. A pair of media filters for stormwater treatment are to be retrofitted at the Ettie Street Pump

Station (ESPS) in Oakland with funding from a grant to BASMAA for the Clean Watersheds for a Clean Bay (CW4CB) project. As part of CW4CB Task 5, a consultant team prepared an effectiveness monitoring design for 8-10 pilot retrofit projects located throughout the jurisdictions of all MRP Permittees, which is limited to evaluating removal of mercury and PCBs. While the grant timeline will not allow for post-construction monitoring of the media filters during the extended grant period, ACCWP has committed to implement the CW4CB monitoring design after the filter installation and also designed supplemental monitoring which will include additional analyses to address the full range of pollutants generally found in urban runoff.

### 4.3 GEOMORPHIC PROJECT

MRP provision C.8.d.iii requires Permittees to conduct one of three types of projects within Alameda County to answer the question: How and where can our creeks be restored or protected to cost-effectively reduce the impacts of pollutants, increased flow rates, and increased flow durations of urban runoff?

As discussed in ACCWP's March 2014 Integrated Monitoring Report, the Permittees collaborated with Community Conservation Solutions on the Green Solution Project to address the MRP project option in provision C.8.d.iii(2) to inventory locations for potential retrofit projects in which decentralized landscape-based stormwater retention units can be installed.

## SECTION 5 - POC AND LONG-TERM TRENDS MONITORING (C.8.e)

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 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. While monitoring data will continue to be included in the UCMR each March, beginning in October 2016 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). The POC Monitoring Report will include monitoring locations, number and types of samples collected for each purpose of sampling (management question addressed), and analytes measured.

### 5.1 POC LOADS MONITORING

Pollutants of Concern (POC) loads monitoring is required by provision C.8.e.i of the MRP. Loads monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for these pollutants. In particular, there are four priority management questions that need to be addressed though POC loads monitoring:

1. Which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from POCs?
2. What are the annual loads or concentrations of POCs from tributaries to the Bay?
3. What are the decadal-scale loading or concentration trends of POCs from small tributaries to the Bay? and,
4. 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?

To assist participants in effectively and efficiently conducting POC loads monitoring required by the MRP and answer POC loads management questions listed above, 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 between the RMP and RMC participants. This framework and a summary of activities and products to date were provided in the STLS Multi-Year Plan (STLS-MYP) under oversight of the STLS Team and the associated RMP Sources Pathways Loadings Work Group (SPLWG).

With concurrence of participating Water Board Staff, the STLS-MYP presented an alternative approach to the POC loads monitoring requirements described in MRP Provision C.8.e.i, as allowed by Provision C.8.e. The most recent version of the STLS Multi-Year Plan was appended to the BASMAA RMC's Urban Creeks Monitoring Report in 2013, with various appendices provided along with previous semi-annual Monitoring Status Reports. The main body of Version 2013 described the major STLS elements, for which recent activities summarized below.

SFEI's 2015 review of the first three years of watershed monitoring (Gilbreath et al. 2015) found that in general sufficient pollutant and discharge data have been collected at the fixed-station sites to support reasonable pollutant load estimates and calibration of the Regional Watershed Spreadsheet Model (RWSM), a regional-scale planning tool developed primarily to estimate long-term average annual loads from the small tributaries surrounding San Francisco Bay. With concurrence of Water Board staff the STLS Team discussed reallocation of resources from the MYP alternative approach to additional monitoring activities as described below

**PCB Source Area Identification Activities**

RMC participant activities associated with POC loads monitoring during Wr2015 represented a redirection of monitoring resources from bottom-of-watershed monitoring toward identification of potential source areas for TMDL pollutants, 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 to be submitted by the Permittees by April 1, 2016 and in the 2016 Annual Report as required by Provision C.12.a of the reissued MRP. Appendix A.3A reports the monitoring locations, numbers and types of samples collected by the Program during 2015 sediment sampling near properties screened as potential PCB sources.

**STLS Multi-Year Plan Activities**

Based on the consensus of the STLS Team, RMC representatives in coordination with SFEI staff created the STLS Multi-Year Plan to assist Permittees in complying with provision C.8.e (POC Monitoring). The Multi-Year Plan is an alternative POC monitoring program to the one described in the MRP that equally addresses the management information needs described in the MRP. The alternative approach addresses the four core POC loads monitoring management questions, while integrating activities funded by BASMAA via the RMC with those funded by the RMP. The Multi-Year Plan provides a more comprehensive description and work plan for STLS activities on a 5 to10 year timeframe, including a detailed rationale for the methods and locations of proposed activities (e.g., POC loads monitoring in small tributaries).

The MYP includes four main elements that collectively address the four priority management questions for POC monitoring:

- Watershed modeling (Regional Watershed Spreadsheet Model);
- Bay Margins Modeling;
- Source Area Runoff Monitoring; and,
- Small Tributaries Monitoring

During WY 2015 the STLS team began development of Trends Strategy to guide long-term planning for STLS-related work by the RMP and stormwater programs. Initially focused on PCB loads, the Trends Strategy will identify key indicators to monitor, confirm the amount of baseline information needed and recommend timelines and efforts for later trends monitoring.

The following paragraphs provide brief summaries of each of these elements and activities conducted during the period from October 2014 through September 2015.

**Watershed Modeling** –In Water Year 2015 the Permittees continued oversight of the RWSM development via the STLS Team and RMP Sources, Pathways and Loading Work Group (SPLWG). Program staff participated in review of updated modeling workplan and preliminary results for PCBs and mercury after switching from a sediment-based model to a water-based model and making incremental enhancements to GIS-based inputs and changes in the model calibration approach as suggested by SPLWG advisers.

**Bay Margins Modeling** –In WY 2015 Program staff participated in RMP planning discussions of a pilot study to develop Bay Margin conceptual models and sediment mass balances for one or two high Priority Margin Units (PMUs) where PCB impacts on the local foodweb may be significant. The RMP approved a multi-year workplan for this study in support of an anticipated future update of the PCB TMDL. In WY 2015 the PCB Strategy Team selected the Emeryville Crescent as the first PMU for development of a Conceptual Model in 2016.

**Source Area Runoff Monitoring** – This element of the STLS was intended as a placeholder for studies to develop Event Mean Concentrations (EMCs) of POCs to parameterize the

Regional Watershed Model. With recent improvements in the model, the new Trends Strategy may alter the priorities for further monitoring design.

**Small Tributaries Watershed Characterization or "Reconnaissance" Monitoring**– For WY 2015, Gilbreath et al (2015) recommended a "reconnaissance characterization " design for monitoring to reflect the increasing focus towards finding watersheds and land areas within watersheds for management actions. The approach comprises:

- Collaboration with stormwater Countywide programs to identify locations with possible PCB and/or mercury sources (based on a GIS based analysis);
- Focused sampling in older industrial drainages (some of which are tidally influenced);
- Composite sampling: 1 composite of 5-15 aliquots per storm, with analysis for PCB, total mercury, total metals, SSC, grain size, TOC/DOC;
- Pilot testing passive sediment samplers

Progress results of WY 2015 POC Monitoring conducted by the STLS team are included in Appendix A.3B.

**Small Tributaries Watershed Monitoring** – For this STLS element, the approach outlined in the Multi-Year Plan consisted of intensively monitoring a total of six "bottom-of-watershed" stations, over several years to accumulate samples needed to calibrate the watershed model and assist in developing loading estimates from small tributaries for priority POCs. Monitoring is also intended to provide a more limited characterization of additional lower priority analytes. Monitoring was initiated in Water Years 2012 or 2013 at the following watershed stations:

- Lower Marsh Creek(Contra Costa County) in WY2012
- Guadalupe River (Santa Clara County) in WY2012
- Lower San Leandro Creek (Alameda County) in WY2012
- Sunnyvale East Channel (Santa Clara County) in WY2012
- North Richmond Pump Station (Contra Costa County) in WY2013
- Pulgas Pump Station (San Mateo County) in WY2013

**Water Year 2015 Results from San Leandro Creek watershed station**

In WY 2015 the program conducted limited monitoring at this station for one storm event and one dry weather sampling event for methylmercury.

Table 5-1 summarizes the analytes and analysis methods used in Water Year 2015, which were consistent with those used in previous years. Since other POC loads stations were not monitored, SFEI was not contracted by BASMAA for data quality assurance and database management, so ADH Environmental performed initial data quality assurance for the ACCWP results which will be submitted electronically after receiving verification that the QA review matches the procedures used by SFEI. WY 2015 monitoring results from San Leandro Creek are shown in Table 5-2.

**Table 5-1. Laboratory analysis methods used for POC (loads) monitoring at San Leandro Creek in Water Year 2015.**

| Analyte | Analytical Method[1] | Analytical Laboratory |
|---|---|---|
| Suspended Sediment Concentration | ASTM D3977 | Caltest Analytical Laboratory |
| Total Phosphorus | (EBMUD 488 Phosphorus) SM20 4500-P E | Caltest Analytical Laboratory |
| Nitrate + Nitrite as N | (EPA 300.1) EPA 353.2 | Caltest Analytical Laboratory |
| Dissolved Orthophosphate | (EPA 300.1) SM20 4500-P E | Caltest Analytical Laboratory |
| Total Methylmercury | EPA 1630M | Caltest Analytical Laboratory |
| Total Mercury | EPA 1631EM | Caltest Analytical Laboratory |
| Total PCB | EPA 1668A | ALS |
| Total Organic Carbon | {SM 5310 C) SM20 5310B | Caltest Analytical Laboratory |

**Table 5-2. Results for POC (loads) Monitoring at San Leandro Creek in Water Year 2015.**

| Analyte | Results | | Units |
|---|---|---|---|
| | Stormwater 12/4/14 | Dry weather 1/5/15 | |
| Suspended Sediment Concentration | 52 | Not detected | mg/L |
| Total Phosphorus | 1.8 | n/a | mg/L |
| Nitrate + Nitrite as N | 0.41 | n/a | mg/L |
| Dissolved Orthophosphate | 0.12 | n/a | mg/L |
| Total Methylmercury | 0.86 | 0.12 | ng/L |
| Total Mercury | 0.24 | n/a | ug/L |
| Total PCB | 4800 | n/a | pg/L |
| Total Organic Carbon | 8.2 | n/a | mg/L |

Comparisons to Numeric Water Quality Objectives/Criteria for Specific Analytes

Provision C.8.g.iii requires RMC participants to assess all data collected pursuant to provision C.8 for compliance with applicable water quality standards. In compliance with this requirement, an assessment of data collected at ACCWP's POC monitoring station at San Leandro Creek in Water Year2015 is provided in the following section.

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.

Total mercury was the only WY 2015 analyte for which acute water quality objectives or criteria have been promulgated. All four mercury samples collected in WY 2015 were below the applicable numeric water quality objective/criterion adopted by the Water Board in the San Francisco Bay Water Quality Control Plan (SFRWQCB 2011), i.e. the freshwater acute objective for aquatic life of 2.1 ug/L. Stormwater management activities are currently underway for mercury via MRP provision C.11.

## 5.2 LONG-TERM TRENDS MONITORING (C.8.E)

In addition to POC loads monitoring, Provision C.8.e requires Permittees to conduct long-term trends monitoring to evaluate if stormwater discharges are causing or contributing to toxic impacts on aquatic life. Required long-term monitoring parameters, methods, intervals and occurrences are included as Category 3 parameters in Table 8.4 of the MRP, and prescribed long-term monitoring locations are included in Table 8.3. Similar to creek status and POC loads monitoring, long-term trends monitoring was scheduled to begin in October 2011 for RMC participants.

As described in the *RMC Creek Status and Trends Monitoring Plan* (BASMAA 2011), the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Statewide Stream Pollutant Trend Monitoring (SPoT) Program currently monitors the seven long-term monitoring sites required by Provision C.8.e.ii. Sampling via the SPoT program is currently conducted at the sampling interval and for parameters as described in Provision C.8.e.iii in the MRP. The SPoT program is generally conducted to answer the management question:

- What are the long-term trends in water quality in creeks?

Based on discussions with Region 2 SWAMP staff, RMC participants are complying with MRP provision C.8.e that are associated with long-term trends via monitoring conducted by the SPoT program. This manner of compliance is consistent with the MRP language in provision C.8.e.ii. The most recent SPoT program technical report covers data collected from 2008-2012 (Phillips et al., 2014). RMC representatives will continue to coordinate with the SPoT program on long-term monitoring to ensure MRP monitoring and reporting requirements are addressed[5]. Additional information on the SPoT program can be found at http://www.waterboards.ca.gov/water_issues/programs/swamp/spot/

## 5.3 SEDIMENT DELIVERY ESTIMATE / BUDGET (C.8.E.VI) AND EMERGING POLLUTANTS WORK PLAN (C.8.E.VII)

Provision C.8.e.vi of the MRP requires Permittees to develop a design for a robust sediment delivery estimate/sediment budget in local tributaries and urban drainages, and implement the study by July 1, 2012. The purpose of the sediment delivery estimate is to improve the Permittees' ability to estimate urban runoff contributions to loads of POCs, most of which are closely associated with sediment. To determine a strategy for a robust sediment estimate/budget, BASMAA representatives reviewed recent sediment delivery estimates developed by the RMP, and determined that these objectives would be met effectively through sediment-specific submodeling with the Regional Watershed Spreadsheet Model (RWSM), under the ongoing oversight of the RMP Sources Pathways Loadings Work Group and the Small Tributaries Loading Strategy (STLS) Work Group.

The implementation of the sediment delivery/budget study was designed to occur in coordination with the STLS Multi-Year Plan, with funding from both the RMP and BASMAA regional projects. Sediment-specific model developments included:

- Literature-based refinement of land-use based Event Mean Concentrations;
- Development of a sub-model incorporating bedrock type, hillslope and convergence processes, and level /age of urbanization;
- Incorporation and calibration of specific watershed sediment loads calculated from available USGS gauge data or previous monitoring stations; and
- Coordination of sediment submodeling with RWSM model development for PCBs and mercury
- Mapping of areas upstream of reservoirs and application of estimated delivery ratios to adjust modeled loads for storage of sediment within watersheds

BASMAA-funded activities included:

[5]MRP Provision C.8.a.iv "Third Party Monitoring" states that where an existing third-party organization has initiated plans to conduct monitoring that would fulfill one or more requirements of Provision C.8 but the monitoring would not meet MRP due date(s) by a year or less, the Permittees may request that the Executive Officer adjust the due date(s) to synchronize with such efforts.

- Sensitivity analyses and evaluation of weaknesses in the initial set of sediment runoff coefficients for the RWSM;
- Implementation of high-priority improvements and convening a panel of local experts to provide input on the geological bases for model coefficients;
- Analysis of results of calibration on modeled sediment estimates and model loads; and
- Development of a RWSM geoprocessing tool to incorporate the sediment model structure and its parameterization from locally derived land use/geological sediment erosion coefficients and equations.

SFEI produced annual progress reports on overall RWSM development (e.g. Lent et al. 2012) and provided a June 2013 internal update to BASMAA on the sediment model. In 2014 SFEI distributed for STLS and SPLWG review a draft report section with preliminary results of the RWSM models for PCBs and mercury, which apply coefficients based on particle concentrations to the estimates of suspended sediment loadings from the modeled watersheds. SFEI noted that the sediment model remained unverified and the parameterization calibration runs would potentially be improved by the addition of a climatic parameter as recommended by the expert panel.

Provision C.8.e.vii of the MRP required Permittees to develop a work plan and schedule for initial loading estimates and source analyses for contaminants of emerging concern (CECs). Contaminants that are mentioned in the MRP include: endocrine-disrupting compounds, PFOS/PFAS (PerfluorooctaneSulfonates (PFOS), Perfluoroalkylsulfonates (PFAS), and NP/NPEs (nonylphenols/nonylphenol esters -estrogen-like compounds). The work plan developed by Permittees is to be implemented in the next Permit term.

Consistent with these requirements, Permittees (via Countywide Stormwater Programs) have and will continue to coordinate the investigation and significance of CECs with the San Francisco Bay Regional Monitoring Program for Water Quality (RMP). As such, Permittees have participated in the development and funding of a CEC strategy entitled "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations" (Sutton et.al. 2013). In addition, Permittees have and continue to participate in the broader Statewide CEC investigation and monitoring efforts through RMP coordination with the State Water Board's contractor, the Southern California Coastal Water Research Project (SCCWRP). The Permittees submitted details of these statewide and the RMP planning efforts in the March 2014 Integrated Monitoring Report as required by provision C.8.e.vii. During the next Permit term, Permittees will continue to work with the RMP staff through BASMAA and update the current CEC strategy as needed based on the significance of the results of the various ongoing investigations.

## SECTION 6 - CITIZEN MONITORING AND PARTICIPATION (C.8.f)

In compliance with Provision C.8.f, Permittees are required to make reasonable efforts to seek out citizen and stakeholder input regarding waterbody function and quality, and to demonstrate within annual reports of their outreach efforts to these groups.

During the reporting period in WY 2015, ACCWP staff communications with local residents, creek groups and other residents, included:

- ACCWP notified creek groups and municipal staff of the increased observations of introduced, invasive New Zealand Mud Snails in bioassessment samples.
- ACCWP staff shared Pollutants of Concern Loads Monitoring station data summaries and reports for the San Leandro Creek monitoring with staff of the Friends group and officials at the City of San Leandro.

# SECTION 7 - REPORTING, DATA QUALITY AND DATA MANAGEMENT (C.8.g&h)

Provision C.8.g 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) creek status monitoring electronic reporting; and 3) urban creeks monitoring reporting. In accordance with the reporting schedule of the reissued MRP, the Program's WY 2015 creek status monitoring electronic data are to be submitted to the Water Board by March 31, 2015, concurrent with the UCMR.

Provision C.8.h requires that water quality data collected by Permittees in compliance with the MRP should be of a quality that is consistent with the 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 has drafted Version 3 to reflect changes in the reissued MRP, which will be used starting in WY2016.

For POC Loads Monitoring, a draft Field Manual and QAPP were developed through the STLS Team and described in the Multi-Year Plan. BASMAA implemented a master contract with SFEI to contract for laboratory analyses in WYs 2012 through 2014 for all sites operated by RMC programs as well as those operated by SFEI for the RMP.

**Information Management**

For Creek Status 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 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 anticipated for POC Monitoring during the second permit term.

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.g.

**Monitoring Data Quality Review**

All Creek Status findings and data reported during Water Year 2015 were reviewed against RMC measurement quality objectives (BASMAA, 2014a). Appendices A.1 and A.2 contain statements of data quality resulting from data quality review for Creek Status Monitoring data.

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

# SECTION 8 - REFERENCES

Anderson B.S., B.M.Phillips, K.Siegler, J. Voorhees. 2013. Initial Trends in Chemical Contamination, Toxicity and Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program. Second Technical Report - Field Years 2009-2010. California State Water Resources Control Board, Sacramento, CA. 92 pp (with appendices).

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.

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.

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.

Coleman, D., C. MacRae and E.D. Stein. 2005. Effect of increases in peak flows and imperviousness on the morphology of southern California streams. Technical Report 450. Southern California Coastal Water Research Project. Westminster, CA.

Gilbreath, A.N., Hunt, J.A., Wu, J., Kim, P.S., and McKee, L.J., 2015. Pollutants of concern (POC) loads monitoring progress report, water years (WYs) 2012, 2013, and 2014. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small

Tributaries Loading Strategy (STLS). Contribution No. 741. San Francisco Estuary Institute, Richmond, California. (Submitted by ACCWP as Appendix A.3 to the Urban Creeks Monitoring Report for October 2013 Through September 2014).

Lent, M.A., Gilbreath A.N., McKee L.J. 2012. Development of Regional Suspended Sediment and Pollutant Load Estimates for San Francisco Bay Area Tributaries using the Regional Watershed Spreadsheet Model (RWSM): Year 2 Progress Report. RMP Technical Report.

Phillips B.M., Anderson, B.S., Siegler, K., Voorhees, J., Tadesse, D., Webber, L., Breuer, R. 2014. Trends in Chemical Contamination, Toxicity and Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program. Third Report - Five-Year Trends 2008-2012. California State Water Resources Control Board, Sacramento,

PSOMAS and GreenInfo Network. 2011. The Green Solution Project – Alameda County, Phase 1 San Francisco Bay Area. Technical Report, Analysis and Mapping, August 2, 2011.

SFBRWQCB. 2008. Water Quality Monitoring and Bioassessment in Selected San Francisco Bay Region Watersheds in 2004-2006. Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

SFBRWQCB. 2011. San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). San Francisco Bay Regional Water Quality Control Board. Dec 31.

SFBRWQCB. 2012. The Reference Site Study and the Urban Gradient Study Conducted in Selected San Francisco Bay Region Watersheds in2008-2010 (Years 8 to 10). Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Schuler, T. 2004. Urban Subwatershed Restoration Manual Series, No. 1: An integrated Framework to Restore Small Urban Watersheds. Version 1.0. Center for Watershed Protection. Ellicott City, Maryland. March 2004.

Sutton, R., Sedlak M., Yee D. 2013. Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations. RMP Contribution 700.
USEPA. 2000. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California. 40 CTR Part 131. Federal Register: Vol. 65, No 97. May 18.

# SECTION 9 - ATTACHMENTS

**Attachment A. Electronic Data Submittal Transmittal Letter dated March 31, 2016 with attached file list.**

**Attachment B. BASMAA Regional Monitoring Coalition 2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status**

cleanwater
PROGRAM

Protecting Alameda County Creeks, Wetlands & the Bay

399 Elmhurst St.
Hayward, CA
94544
p. 510-670-5543

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

March 31, 2016

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 2014 through September 2015 Pursuant to Provision C.8.h

Dear Mr. Wolfe:

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, originally Order No. R2-2009-0074, reissued on November 19, 2015 as Order No. R2015-0049).

With this letter I am submitting a CD-ROM containing the Program's Creek Status Monitoring data collected between October 1, 2014 and September 30, 2015 pursuant to Provision C.8.c of Order No. R2-2009-0074. 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, 2016 as specified in Provision C.8.h.ii of Order No. R2015-0049. Other data addressing the requirements of the original MRP Provision C.8.e, 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 consistent with the Provisions of the MRP[1].

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

[1] Data management and Quality Assurance of the alternative approach to Pollutants of Concern Loads Monitoring for all sites, including the San Leandro Creek site operated by ACCWP, were performed by the San Francisco Estuary Institute through a collaboration between BASMAA and the RMP. Data collection and reporting for Long Term Trends Monitoring are the responsibility of the SWAMP Sediment Pollution Trends (SPoT) program.

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 Creek Status Monitoring data was evaluated through data collection and evaluation methods consistent with 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.h of Order No. R2-2009-0074 (C.8.b of Order No. R2015-0049).

In conformance with Provision C.8.g.ii of Order No. R2-2009-0074, the Program has participated in the RMC's development of a regional information management system that supports electronic transfer of data to the Regional Data Center of the California Environmental Data Exchange Network (CEDEN). As requested by Water Board staff on August 5, 2011, concurrent with this submission the Program is transferring the subject monitoring data directly to CEDEN.

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 datafiles on CD-ROM (3 pp)

Copy via email: Alameda Countywide Clean Water Program Management Committee Representatives

# Attachment A

Data files for ACCWP Creek Status Monitoring
October 1, 2014-September 30, 2015

Sources of templates for data files (see file ACCWP-EDS_ToC_2015_r1.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)

EOA, Inc. (Stream Survey using Urban Streams Assessment)

| Sample Purpose | Filename, including site ID |
|---|---|
| BMI, Algae, FieldMeasure, Habitat | AC_204R01391_BA_Export_060215_15-07-08-11-18-10_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R01735_BA_Export_050715_15-07-08-11-14-30_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R01828_BA_Export_052015_15-07-08-11-22-30_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R01855_BA_Export_042715_15-07-08-11-26-52_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R01876_BA_Export_052015_15-07-08-11-30-07_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R01945_BA_Export_051115_15-07-08-11-35-06_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R01951_BA_Export_042815_15-07-08-11-40-54_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02095_BA_Export_042715_15-07-08-13-25-32_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02132_BA_Export_051115_15-07-08-13-37-40_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02351_BA_Export_051415_15-07-08-13-44-20_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02375_BA_Export_042915_15-07-08-13-47-58_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02457_BA_Export_051915_15-07-08-13-50-39_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02503_BA_Export_043015_15-07-08-14-32-32_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02527_BA_Export_042915_15-07-08-13-56-00_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02596_BA_Export_052115_15-07-08-13-58-57_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02815_BA_Export_060315_15-07-08-14-03-21_final |
| BMI, Algae, FieldMeasure, Habitat | AC_204R02852_BA_Export_060315_15-07-08-14-17-29_final |

| Sample Purpose | Filename, including site ID |
|---|---|
| BMI, Algae, FieldMeasure, Habitat | AC_205R00622_BA_Export_051815_15-07-08-14-20-43_final |
| BMI, Algae, FieldMeasure, Habitat | AC_205R02327_BA_Export_051315_15-07-08-14-23-55_final |
| BMI, Algae, FieldMeasure, Habitat | AC_205R02478_BA_Export_051215_15-07-08-14-26-44_final |
| BMI, Algae, FieldMeasure, Habitat | AC_205R02583_BA_Export_051315_15-07-08-14-35-21_final |
| BMI, Algae, FieldMeasure, Habitat | AC_205R02670_BA_Export_051815_15-07-08-14-41-38_final |
| WaterChem | ACCWP_WQ_template_204R01391 |
| WaterChem | ACCWP_WQ_template_204R01735 |
| WaterChem | ACCWP_WQ_template_204R01828 |
| WaterChem | ACCWP_WQ_template_204R01855 |
| WaterChem | ACCWP_WQ_template_204R01876 |
| WaterChem | ACCWP_WQ_template_204R01945 |
| WaterChem | ACCWP_WQ_template_204R01951 |
| WaterChem | ACCWP_WQ_template_204R02095 |
| WaterChem | ACCWP_WQ_template_204R02132 |
| WaterChem | ACCWP_WQ_template_204R02351 |
| WaterChem | ACCWP_WQ_template_204R02375 |
| WaterChem | ACCWP_WQ_template_204R02457 |
| WaterChem | ACCWP_WQ_template_204R02527 |
| WaterChem | ACCWP_WQ_template_204R02596 |
| WaterChem | ACCWP_WQ_template_204R02815 |
| WaterChem | ACCWP_WQ_template_204R02852 |
| WaterChem | ACCWP_WQ_template_205R00622 |
| WaterChem | ACCWP_WQ_template_205R02327 |
| WaterChem | ACCWP_WQ_template_205R02478 |
| WaterChem | ACCWP_WQ_template_205R02503 |
| WaterChem | ACCWP_WQ_template_205R02583 |
| WaterChem | ACCWP_WQ_template_205R02670 |
| WaterTox | AC_WetAqTox_2015_2016-0111_204R00622 |
| WaterTox | AC_WetAqTox_2015_2016-0111_204R01876 |
| WaterTox | AC_WetAqTox_2015_2016-0111_204R01951 |
| WaterTox | AC_WetAqTox_2015_2016-0111_204R01951_retest.xls |
| SedChem, SedTox, WaterTox,Chlorine | AC_dry_sed_chem_tox_204R01876.xls |
| SedChem, SedTox, WaterTox,Chlorine | AC_dry_sed_chem_tox_204R01951.xls |
| SedChem, SedTox, WaterTox,Chlorine | AC_dry_sed_chem_tox_205R00622.xls |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY020 |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY080_2events |

| Sample Purpose | Filename, including site ID |
|---|---|
| WaterChem (Pathogens) | AC_FIB_2015_204CVY084 |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY090 |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY120_2events |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY125 |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY150 |
| WaterChem (Pathogens) | AC_FIB_2015_204CVY170 |
| ContinuousMonitoring (GenWQ) | CM_ACCWP_YSI_204CRW040_2015_spring.xls |
| ContinuousMonitoring (GenWQ) | CM_ACCWP_YSI_204CRW042_2015_spring.xls |
| ContinuousMonitoring (GenWQ) | CM_ACCWP_YSI_204CRW044_2015_spring.xls |
| ContinuousMonitoring (GenWQ) | CM_ACCWP_YSI_204CRW040_2015_summer.xls |
| ContinuousMonitoring (GenWQ) | CM_ACCWP_YSI_204CRW042_2015_summer.xls |
| ContinuousMonitoring (GenWQ) | CM_ACCWP_YSI_204CRW044_2015_summer.xls |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CRW020_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CRW030_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CRW040_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CRW042_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CRW044_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CRW050_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204CUL010_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204SLO065_2015 |
| ContinuousMonitoring (Temp) | CM_ACCWP_HOBO_204SLO080_2015 |
| StreamSurvey | USA_ACCWP_2015_compiled.xlsx |

BASMAA Regional Monitoring Coalition
2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status
*Updated February 2016*

| SSID Project ID | Date Updated | County/ Program | Creek/Channel Name | Site Code(s) or alternative site ID | Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project | | | | | | | | | Creek Status Indicator Result Summary | Rationale for Proposing/Selecting Project | Current Status of SSID Project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bioassess | General WQ | Chlorine | Temp | Water Tox | Sed Tox | Sed Chem | Pathogen Indicators | Other | | | |
| AL-1 | 3/23/15 | 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 includes Appendix 4A summary report describing BMPs implemented and completion of the site-specific elements of this project. |
| AL-2 | 3/23/15 | 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 2016 UCMR includes Appendix 4B progress report with schedule for review of land use inputs and freeway runoff. |
| AL-3 | 3/23/15 | 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 2016 UCMR includes Appendix 4C progress report with updated WY2016 monitoring plan to evaluate summer inflows using continuous monitoring of conductivity as well as temperature. |

BASMAA Regional Monitoring Coalition
2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status
*Updated February 2016*

| SSID Project ID | Date Updated | County/ Program | Creek/Channel Name | Site Code(s) or alternative site ID | Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project | | | | | | | | | Creek Status Indicator Result Summary | Rationale for Proposing/Selecting Project | Current Status of SSID Project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bioassess | General WQ | Chlorine | Temp | Water Tox | Sed Tox | Sed Chem | Pathogen Indicators | Other | | | |
| CC-1 | 1/7/16 | 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, including 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 the compiled pesticide use data from 2009-2013, it appears that 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 Contra Costa County. |
| CC-2 | 1/7/16 | 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, including 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 the compiled pesticide use data from 2009-2013, it appears that 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 Contra Costa County. |

BASMAA Regional Monitoring Coalition
2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status
*Updated February 2016*

| SSID Project ID | Date Updated | County/ Program | Creek/Channel Name | Site Code(s) or alternative site ID | Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project | | | | | | | | | Creek Status Indicator Result Summary | Rationale for Proposing/Selecting Project | Current Status of SSID Project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bioassess | General WQ | Chlorine | Temp | Water Tox | Sed Tox | Sed Chem | Pathogen Indicators | Other | | | |
| CC-1 | 3/17/15 | 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, including 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. |
| CC-2 | 3/17/15 | 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, including 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. |
| 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. |
| 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. |

BASMAA Regional Monitoring Coalition
2010-2016 Stressor/Source Identification (SSID) Project Locations, Rationales, Status
*Updated February 2016*

| SSID Project ID | Date Updated | County/ Program | Creek/Channel Name | Site Code(s) or alternative site ID | Primary Creek Status Indicator(s) Triggering Stressor/Source ID Project | | | | | | | | | Creek Status Indicator Result Summary | Rationale for Proposing/Selecting Project | Current Status of SSID Project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bioassess | General WQ | Chlorine | Temp | Water Tox | Sed Tox | Sed Chem | Pathogen Indicators | Other | | | |
| SC-3 | 5/11/15 | 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. | Work plan was developed to assess existing data sources for potential causes for low biological condition and identify future monitoring actions. Work plan was submitted in March 2015 as Appendix B of the Urban Creeks Monitoring Report. Monitoring activities have been delayed due to the drought. Monitoring will begin in spring season of 2016. |
| 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. |
| 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. |

# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# CREEK STATUS MONITORING REPORT - REGIONAL PARAMETERS,

## APPENDIX A.1

## URBAN CREEKS MONITORING REPORT

## OCTOBER 2014 THROUGH SEPTEMBER 2015


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 30, 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

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. 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 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) Reporting Provision C.8.g.v regarding all monitoring conducted during the MRP permit term. The organization and formatting of this report, as well as analyses for water and sediment toxicity and chemistry, derive in large part from Regional Appendix A to the Urban Creeks Monitoring Report for WY2012 (BASMAA 2013).

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 Creek Status monitoring data collected in Water Year 2015 (October 1, 2014 through September 30, 2015) as part of the RMC's Monitoring Plan (BASMAA 2011) for certain "regionally designed" parameters monitored according to Provision C.8.c of the MRP using a probabilistic monitoring design. 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.

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) 2015.

As described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011), RMC participants collected data by implementing Standard Operating Procedures (SOPs) in accordance with the Quality Assurance Program Plan (QAPP). Analytical laboratory analyses were also conducted under the direction of RMC participants.

In accordance with the reissued MRP (SFBRWQCB, 2015) ACCWP will also submit the data included in this report by March 31, 2016 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 to the outline of the initial Urban Creeks Monitoring Report (BASMAA 2013) and threshold trigger analyses conducted herein.

# 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 National Pollutant Discharge Elimination System (NPDES) Stormwater Permit. This report presents the results of Creek Status Monitoring data collected by ACCWP during the Water Year (WY) 2014 extending from October 1, 2013 through September 30, 2014 using a regional probabilistic design. Other parameters were addressed using a targeted design, with regional coordination and common methodologies. These parameters are reported in a separate Targeted Appendix A.2[1] to the Urban Creeks Monitoring Report prepared to assist ACCWP member agencies in complying with the MRP Reporting Provision C.8.g.

During WY 2015, ACCWP monitored 22 sites under the regional probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. Three of the 22 sites were also monitored for water and sediment toxicity and sediment chemistry, as described in this report.

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 following MRP reporting requirements (per Provision C.8.g.iv) 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/longs); sample ID, collection date (and time where relevant), media (e.g., water,

[1] Similar methods and QA/QC procedures are being implemented for Stressor-Source Identification (SSID) studies to investigate certain sites where WY2012 monitoring results indicated potential need for follow-up monitoring projects according to trigger criteria described in the MRP.

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 potential follow-up actions 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 2015 sampling sites:

- All 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 stressor analysis for water quality, sediment chemistry and water and sediment toxicity data revealed the following potential stressors for WY 2015 sites:

- **Nutrients (and Conventional Constituents):** The MRP Table 8.1 trigger criterion for "Nutrients" (20% of results in one waterbody exceed one or more water quality standards or applicable thresholds) was considered to be met at 5 of the 22 monitoring sites.
- **Water Toxicity:** For the wet season sampling, sites 204R01951 and 205R00622 exhibited statistically significant toxicity to *Hyalella azteca* survival, but only at the former site was toxicity of a sufficient magnitude to indicate re-sampling; resampling at site 204R01951 again identified statistically-significant toxicity to *H. azteca*. For the dry season sampling, none of the water samples collected at each of three sites exhibited statistically-significant toxicity.
- **Sediment Toxicity:** None of the sediment samples collected at each of three sites exhibited statistically-significant toxicity.
- **Sediment Chemistry:** Sediment chemistry results produced evidence of potential stressors in several ways, based on the criteria from MRP Table H-1. At two of three sites sampled (204R01951 in Castro Valley and 205R00622 adjacent to Lake Elizabeth in Fremont), TEC

quotients for three or more constituents were above 1.0; the mean PEC quotient, which indicates whether effects are probable or not, however, was below 0.5 at each of the three sites. TEC quotients that fell above the 1.0 threshold included constituents from all analyte types measured, trace elements, PAHs, and OC pesticides. At all three sites sampled, including 204R01876 located in a suburban area in Dublin, the sum of TU equivalents for all measured pyrethroid pesticides fell above 1.0, with the great majority of the TU equivalents attributable to bifenthrin.

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

# 1. Introduction

This report fulfills a portion of the reporting requirements of Provision C.8.g.v of the Bay Area Municipal Regional Stormwater Permit (MRP[2]) for creek status monitoring data produced pursuant to MRP Provision C.8.c during Water Year (WY) 2015 (October 1, 2014 - September 30, 2015) under a regional probabilistic design. The regional probabilistic design was developed and implemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). Additional ProvisionC.8.c data 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 and all MRP Permittees (

[2] 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.

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[3]. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan allows 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).

3. The BASMAA programs supporting RMC Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities. 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 SF Bay 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 |

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 San Francisco Bay Area, through the improved coordination among RMC participants, SF Bay RWQCB[4] and other agencies with common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining monitoring-related activities.

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.c (Table 1-2). The list of parameters in Table 1-2 derive from the MRP Table 8-1 (SFBRWQCB 2009; BASMAA 2014a, 2014b).

[4]The intent is to coordinate with SF Bay RWQCB staff working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

**Table 1-2. Creek Status Monitoring Parameters sampled in compliance with MRP Provision C.8.c. and the associated design approach and Appendix of the ACCWP UCMR.**

| 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 | X | | Appendix A.1 |
| Water Toxicity | X | | Appendix A.1 |
| Sediment Toxicity | X | | Appendix A.1 |
| Sediment Chemistry | X | | Appendix A.1 |
| General Water Quality | | X | Appendix A.2 |
| Temperature | | X | Appendix A.2 |
| Bacteria | | X | Appendix A.2 |
| Stream Survey | | 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.c[5] by addressing the core monitoring questions listed below, which are further elaborated upon later in this report and in the main IMR. 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?

[5] The MRP states that Provision C.8.c status 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?". The management questions described in this plan are intended to answer the questions posed in the MRP.

2. What are the major stressors[6] 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.g.v in the respective sections referenced in Table 1-3. Additional details or discussion may also be found in other Appendices or in the main IMR.

**Table 1-3.Index to Standard Report Content per MRP Provision C.8.g.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 |
| See Main UCMR body, Section 6 | List of volunteer and other non-Permittee entities whose data are included in the report. |
| 5.0 | Assessment of compliance with applicable water quality standards |

# 2. Study Area & Monitoring Design

## 2.1 RMC Area

Status and trends 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 rivers 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). A total of 60 sites were sampled in 2012 by RMC participants, with another 70 sites sampled in 2013, 58 sites in 2014, and 62 sites in 2015. This report presents data collected by ACCWP during WY 2015.

[6] Stressors are interpreted per MRP Table 8-1 (SFBRWQCB 2009) 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 (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

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[7] (BASMAA 2011). This approach was agreed to by SF Bay RWQCB staff during RMC workgroup meetings although it differs from that specified in MRP Provision C.8.c.iv., 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 MRP Provision C.8.c 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 land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas

[7]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.

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. 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.

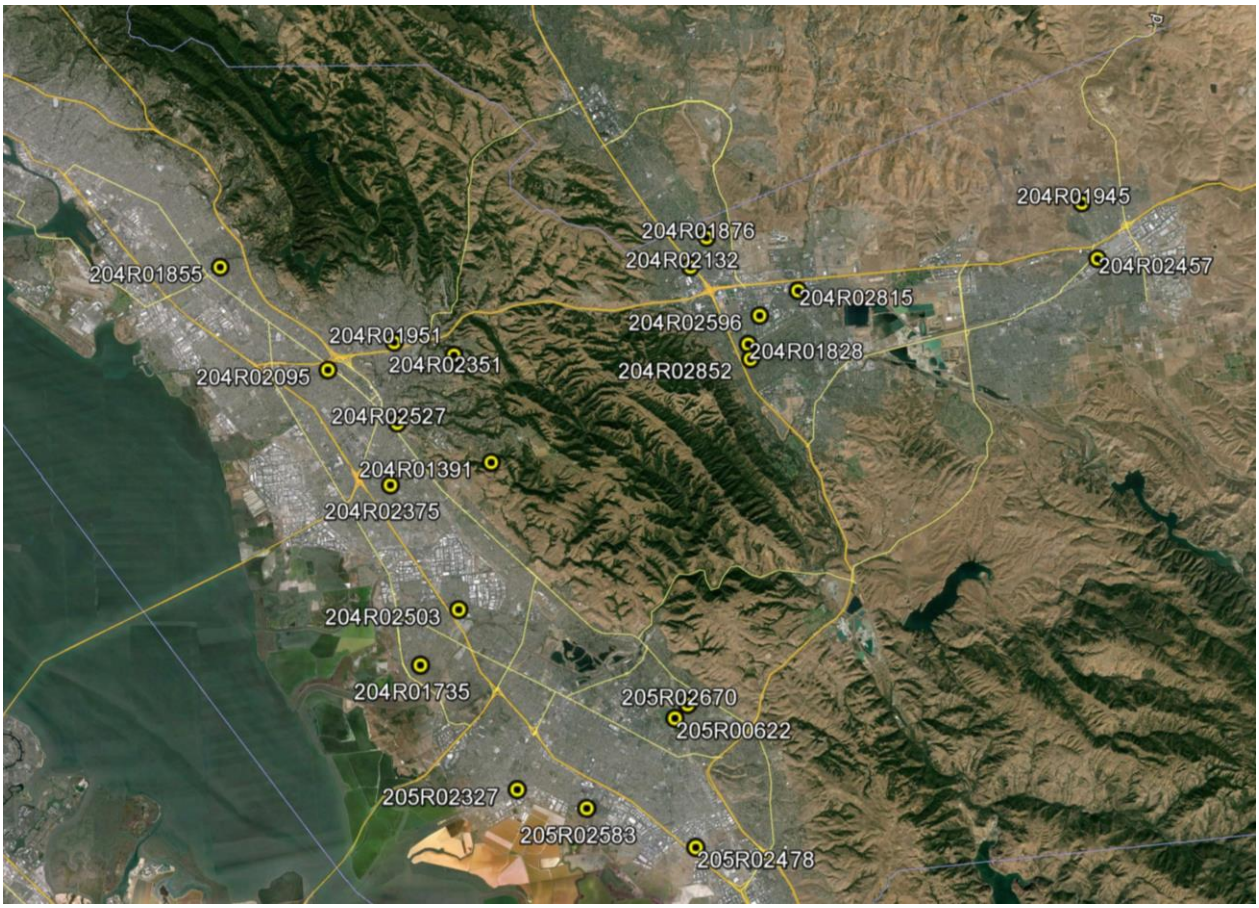


**Figure 2-1. Alameda County sites sampled from the RMC probabilistic monitoring design in Water Year 2015.**

**Table 2-1. Alameda County Bioassessment Sites Sampled in Water Year 2015 by ACCWP. Triad sites also were sampled for water toxicity on 2/6/15 and 4/7/2015 (follow-up testing at 204R01951 only), and for sediment toxicity and chemistry on 7/7/15.**

| Site ID | Creek Name | Land Use | Latitude | Longitude | Sampling Date | Triad samples |
|---|---|---|---|---|---|---|
| 204R01391 | Zeile Creek | Urban | 37.64547 | -122.03133 | 6/2/15 | No |
| 204R01735 | Zone 5 Line J-2 | Urban | 37.57482 | -122.07164 | 5/7/15 | No |
| 204R01828 | Arroyo Mocho | Urban | 37.67927 | -121.90686 | 5/20/15 | No |
| 204R01855 | San Leandro Creek | Urban | 37.72823 | -122.15025 | 4/27/15 | No |
| 204R01876 | South San Ramon Cr. | Urban | 37.7207 | -121.92112 | 5/20/15 | Yes |
| 204R01945 | Altamont Creek | Urban | 37.71918 | -121.74272 | 5/11/15 | No |
| 204R01951 | Castro Valley Creek | Urban | 37.69344 | -122.07167 | 4/28/15 | Yes |
| 204R02095 | San Lorenzo Creek | Urban | 37.68572 | -122.10347 | 4/27/15 | No |
| 204R02132 | Zone 7 Line J-2 | Urban | 37.71029 | -121.93006 | 5/11/15 | No |
| 204R02351 | Zone 5 Line D | Urban | 37.68643 | -122.0443 | 5/14/15 | No |
| 204R02375 | Ward Creek | Urban | 37.64099 | -122.07871 | 4/29/15 | No |
| 204R02457 | Arroyo Seco | Urban | 37.69758 | -121.73877 | 5/19/15 | No |
| 204R02503 | Old Alameda Creek | Urban | 37.59327 | -122.05206 | 4/30/15 | No |
| 204R02527 | Zone 3A Line B-5 | Urban | 37.66343 | -122.07318 | 4/29/15 | No |
| 204R02596 | Chabot Canal | Urban | 37.68947 | -121.9001 | 5/21/15 | No |
| 204R02815 | Tassajara Creek | Urban | 37.69729 | -121.8809 | 6/3/15 | No |
| 204R02852 | Pleasanton Canal | Urban | 37.67367 | -121.90653 | 6/3/15 | No |
| 205R00622 | Mission Creek (Zone 6 Line L) | Urban | 37.54639 | -121.95815 | 5/18/15 | Yes |
| 205R02327 | Plummer Creek (Zone 5, Line F-1) | Urban | 37.52714 | -122.03251 | 5/13/15 | No |
| 205R02478 | Laguna Creek | Urban | 37.50027 | -121.95446 | 5/12/15 | No |
| 205R02583 | Zone 5 Line D | Urban | 37.51798 | -122.00192 | 5/13/15 | No |
| 205R02670 | Mission Creek (Zone 6 Line L) | Urban | 37.55083 | -121.9517 | 5/18/15 | No |

### 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 at this time due to the limited sample size available from the initial two years of monitoring, but can be answered in future years once sample sizes increase.

Table 2-2 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 present 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?**

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

### 2.2.3 Monitoring Design Implementation

Sampling was conducted in accordance with the RMC Multi-year Monitoring Plan (BASMAA 2011). The sampling plan (Table 2-2) illustrates the total number of sites that each RMC program plans to sample within the MRP term (SFBRWQCB 2009). 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. Approximately 80% of the sites sampled annually by RMC participants are in urban areas and 20% are 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 drying and/or access issues, thereby altering the relative proportion of urban-to-non-urban sites sampled in a given year. Such outcomes can be addressed in subsequent sampling years by adjusting the relative proportion of urban and non-urban sites. ACCWP sampled a total of 22 sites in the WY 2015 field season to make up for a sample count of only 18 samples in 2014 due to earlier than usual drying of non-perennial or marginally perennial streams.

**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 012) | **48** | 22 | 16 | 6 | 16 | 6 | 8 | 4 | 8 | 4 | 0 | 2 |
| Year 2 (WY2013) | **100** | **44** | **32** | 12 | **32** | 12 | 16 | 8 | 16 | 8 | 8 | 0 |
| Year 3 (WY2014) | **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 (WY2016) | **256** | **110** | **80** | **30** | **80** | **30** | **40** | 20 | **40** | 20 | 16 | 10 |

Notes: 1. Non-Urban sample numbers assume that San Francisco Bay RWQCB will continue WY2012-2013 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.

# 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. At three of the sites, separate field visits were made to collect water samples for testing water toxicity, and sediment samples for testing sediment toxicity and chemistry (providing for “sediment triad” evaluation of conditions at those sites).

## 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[8] (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 300meters 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[9].

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.
- **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); or

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

[9]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.

- 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.

Due to low seasonal rainfall in the first part of WY 2015, many Target sites were unsampleable due to low or no streamflow present during the index period.

## 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 (QAPP) and the associated Standard Operating Procedures which were updated to maintain their currency and optimal applicability (BASMAA 2014a, 2014b). 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 2014a), 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). For WY 2015 monitoring, there was one deviation from this protocol, as discussed below.

On April 7th, a precipitation event of over 0.5” occurred in a large portion of the County. A search of historic records compiled at Weather Underground weather stations (http://www.wunderground.com/) indicated that rainfall exceeded the 0.5” threshold at all County locations, with the exception of eastern Livermore.

Due to the overall low rainfall associated with WY 2015, field sampling was conducted in some areas that exceeded the 0.5” threshold within the thirty-day waiting period to avoid situations similar to those experienced in WY2014 where insufficient flow existed in many candidate sites to allow sampling of the target of 20 bioassessments within the index period for the year. Monitoring was delayed, but still conducted at the following sites at the tail end of this 30-day exclusion period:

- 204R02095 (sampled 4/27/15);
- 204R01855 (sampled 4/27/15);
- 204R01951 (sampled 4/28/15);
- 204R02527 (sampled 4/29/15);
- 204R02375 (sampled 4/29/15);
- 205R02503 (sampled 4/30/15); and
- 204R01735 (sampled 5/7/15).

Prior communications with Moss Landing Marine Lab Quality Assurance Team personnel indicated that bioassessment QA protocols are under development, and that there are no result qualifiers appropriate for this situation. AMS personnel developing the SWAMP templates associated with these seven sites will, at the recommendation of MLML personnel, enter a detailed sample comment to reflect this situation. The comment will be applied to both algae enumerations as well as to AFDM and Chl-A results.

The 30-day minimum waiting period applies when the SWAMP algae protocol is used, while a 15 day interval is sufficient for macroinvertebrate sampling alone. Of the above seven sites, 204R01951 (sampled on 4/28/15) displayed evidence of recent surface runoff that appeared to have increased the stream flow by more than 10%. Such evidence included large mats of algae and vegetation debris present on both stream banks. This observation was noted in the field data sheets and will be reported in the SWAMP forms submitted to CEDEN.

**Benthic Macroinvertebrates**

The BMI samples were collected using the Reachwide Benthos (RWB) method described in SOP FS-1 (BASMAA 2012b, 2014b).

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 ft2 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 2012b, 2014b). 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 sample, 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 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 2012b, 2014b). 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 2014b). 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 2014b). 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 2014b). 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 2014b).

### 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 2014b). Sample jars were submitted to respective laboratories per SOP FS-9 (BASMAA 2014b).

## 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 2012a, 2014a). 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 2015. As the cumulative RMC sample sizes increase through monitoring conducted in future years (Table 2-2), 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.g.iv.

### 3.4.1 Biological Condition

The California Stream Condition Index (CSCI) is an assessment tool, developed by the State Water Resources Control Board (State Water Board), to support the development of California's statewide Biological Integrity Plan. The CSCI translates benthic macroinvertebrate data into an overall measure of stream health. The CSCI was developed using a large reference data set that represents the full range of natural conditions in California and by the use of site-specific models for predicting biological communities (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 a Stressor Source Identification (SSID) project.

Indices of biological integrity (IBIs) are another type of analytical tools that calculate a site condition score based on a series of biological metrics representing taxonomic richness, composition, tolerance, and functional feeding groups. IBI development in California is better established for BMIs (i.e., B-IBIs) than for algae. Regional benthic macroinvertebrate IBIs have been developed and tested extensively for four regions of California, including Southern California (Ode et al. 2005), Northern California (Rehn et al. 2005), Eastern Sierra Nevada (Herbst et al. 2009) and the Central Valley (Rehn et al. 2008). Due to similarity in ecoregions with Alameda County, previous monitoring reports used the Southern California (SoCal) B-IBI to evaluate biological condition and found that the results were fairly similar to the CSCI (ACCWP 2014, ACCWP 2015) .

The State Water Board is currently developing and testing assessment tools for benthic algae data as a measure of biological condition and identification of potential stressors. A comprehensive set of 25 stream algal indices of biological integrity (IBIs) have been 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). 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). The algae IBI results should be considered preliminary until additional research shows that these tools perform well for algae data collected in San Francisco Bay area.

## Bioassessment Data Analysis

### 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) and Mazor et al. (in press). Biological data include benthic macroinvertebrate 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.

Staff at EOA, Inc. compiled or created drainage areas in ArcGIS, using 30 meter Digital Elevation Model (DEM) data and the Arc Hydro tool in ArcGIS. In most cases, the watershed/catchments polygons created in ArcGIS 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 SFEI and the Oakland Museum and storm drain network data, where used to modify the DEM-derived watershed boundaries. These modifications were typical in the low gradient urban areas along the San Francisco Bay and 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 in the watershed of the lowest and highest values. Summer precipitation, soil bulk density, soil erodibility, and soil phosphorus content 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 3-1). 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 the MRP.

**Algae Index of Biological Integrity Scores**

Algae scores for S2, D18 and H20 were developed using an online IBI calculator available on the Southern California Coastal Water Research Project (SCCWRP) website (http://www.sccwrp.org/Data/DataTools/algaeIBI.aspx). As previously mentioned, the algae IBIs were developed and tested on data collected in Southern California. Further study is needed to determine their applicability for assessing the biological condition of San Francisco Bay Area streams.

Condition categories for selected algae IBIs have been established using a similar approach as that described for CSCI scores. Fetscher et al (2014) developed three thresholds using the 30th, 10th and 1st percentile of reference sites for S2, D18 and H20 scores (Table 3-1).

**Table 3-1. 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 |

The algae data were compiled, formatted and sent to the Moss Landing Marine Laboratory, where the "H20" hybrid algae IBI (Algal IBI) was calculated use the SWAMP Reporting Module. The Algal IBI is comprised of the following eight metrics ("d" indicates that a given metric is based on diatoms and "s" indicates soft algae; of the latter, "sp" indicates that the metric is based on relative species numbers):

- Proportion nitrogen heterotrophs (d)
- Proportion requiring >50% dissolved oxygen saturation (d)
- Proportion sediment tolerant (highly motile) (d)
- Proportion halobiontic (d)
- Proportion low N indicators (d)
- Proportion high Cu indicators (s, sp)

- Proportion high DOC indicators (s, sp)
- Proportion low TP indicators (s, sp)

**Southern California Index of Biological Integrity**

The SoCal B-IBI was calculated from the following metrics:

- EPT Taxa
- Number Coleoptera Taxa
- Number Predator Taxa
- Percent Intolerant
- Percent Non-Insecta Taxa
- Percent Collector-Filter + Collector-Gather Individuals
- Percent Tolerant Taxa (8-10)

Condition categories for evaluating SoCal B-IBI scores are shown in Table 3-2.Since reporting requirements of the reissued MRP reflect the State Water Board's focus on the CSCI for evaluating benthic macroinvertebrate data, the SoCal B-IBI scores are reported mainly as an interpretive check on CSCI scores and for comparison to previous years' assessments.

**Table 3-2. Condition categories used to evaluate SoCal B-IBI scores.**

| Condition Category | Southern California B-IBI |
|---|---|
| Very Good | 80-100 |
| Good | 60-79 |
| Fair | 40-59 |
| Poor | 20-39 |
| Very Poor | 0-19 |

### 3.4.3 Physical habitat condition

BASMAA (2013) prepared a data analysis of physical habitat scores from all RMC bioassessment sites monitored in WY2012, 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.

### 3.4.4 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 2015 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or diminished biological conditions. Per Table 8.1 of the MRP (SFBRWQCB 2009), creek status monitoring data must be evaluated with respect to specified "Results that Trigger a Monitoring Project in Provision C.8.d.i." The trigger criteria listed in Table 8.1 were used as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. For water and sediment chemistry and toxicity data, the relevant trigger criteria are as follows:

- **Nutrients**: 20% of results in one waterbody exceed one or more water quality standard or established threshold. (Note: per MRP Table 8.1, this group of constituents includes variants of nitrogen and phosphorous, as well as conventional constituents.)
- **Water Toxicity**: if toxicity results are less than 50% of Laboratory Control results, re-sample and re-test; if second sample yields less than 50% of Laboratory Control results, proceed to C.8.d.i. (Stressor/Source Identification).
- **Sediment Toxicity**: toxicity results are statistically different than and more than 20% less than results for Laboratory Control.
- **Sediment Chemistry**: three or more chemicals exceed Threshold Effect Concentrations (TECs), mean Probable Effect Concentrations (PEC) Quotient greater than 0.5, or pyrethroids Toxicity Unit (TU) sum is greater than 1.0.

For sediment chemistry trigger criteria, threshold effect concentrations (TECs) and probable effect concentrations (PECs) are as defined in MacDonald et al., 2000. For all non-pyrethroid contaminants specified in MacDonald et al. (2000), the ratio of the measured concentration to the respective TEC value was computed as the TEC quotient. All results where a TEC quotient was equal to or greater than 1.0 were identified. PEC quotients were also computed for those same non-pyrethroid sediment chemistry constituents using PEC values from MacDonald et al. (2000). For each site the mean PEC quotient was then computed, and sites where mean PEC quotient was equal to or greater than 0.5 were identified. Pyrethroids toxic unit equivalents (TUs) were computed for individual pyrethroid results, based on available literature values for pyrethroids in sediment LC50 values.[10] Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Therefore, the pyrethroid concentrations as reported by the lab were divided by the measured total organic carbon (TOC) concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid. Then for each site, the TU equivalents for the various individual pyrethroids were summed, and sites where the summed TU was equal to or greater than 1.0 were identified.

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

## 3.5 Quality Assurance and Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA 2014a). 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 2014b), 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 2015.

# 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 shown in Table 8.1 and Table H-1 (for sediment triad data) of the

MRP (SFBRWQCB 2009) 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 projects as described in the 2014 IMR.

## 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, 2014a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2014b), 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 QA reviewer for regional parameters are noted below where relevant.

### 4.1.1 Sediment Chemistry

Several issues were reported by the analytical laboratory (Caltest), and the sediment chemistry data were qualified accordingly. These issues included:

- Matrix Spike recoveries outside of control limits for a subset of inorganic (i.e., chromium, copper, nickel, zinc) and organic analytes (i.e., DDTs, fluoranthen, and phenanthrene).

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:

- Low Laboratory Control Sample recoveries were reported for a subset of organic analytes (i.e., DDD (p,p’), DDT (p,p’), benz(a)anthracene, benzo(a)pyrene, perylene, and anthracene).
- Matrix Spike recoveries outside of control limits for a subset of PAHs (i.e., benzo(g,h,i)perylene, dimethylnapthalene, 2,6-, indeno(1,2,3-c,d)pyrene, benzo(b)fluoranthene, flouranthene, phenanthrene, and pyrene) and pyrethroid pesticides (i.e., endrin and cypermethrin). The fact that some MS/MSD datapoints were qualified by the laboratory and others were not indicates that Control Limits employed for the analyses extend beyond the range of those specified in the QAPP.
- Matrix Spike RPDs outside of control limits for a subset of PAHs (i.e., benzo(a)anthracene, benzo(a)pyrene, beno(e)pyrene, benzo(k)fluoranthene, chrysene, and pyrene) and pyrethroid pesticides (i.e., cyhalothrin, total lambda- and cypermethrin).

- Laboratory reporting limits (RLs) for multiple trace metals exceeded RMC QAPP RLs due to the dry weight conversion, as well as target and non-target matrix interferences, which required the laboratories to concentrate less than normal. These data were not flagged, however, as the datapoints in question were all reported at concentrations above the reporting limits.
- The subcontractor performing analysis of total organic carbon (TOC) and particle size distribution (SCL) did not report a laboratory duplicate as required by the RMC QAPP due to a miscommunication between the contract lab and subcontract lab. We have requested that Caltest inform SCL of the need for duplicates to be conducted in the future, which will be incorporated within WY2016 pricing and reporting.

### 4.1.2 Water Chemistry

Several issues were noted with respect to water chemistry analyses, 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 accuracy of sample results.
- Results of required field duplicates 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. WY2014 data were qualified as dictated by comparison with RMC MQOs (BASMAA 2014a).
- Results of required field duplicates 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. WY 2015 data were qualified as dictated by comparison with RMC MQOs (BASMAA 2014a).
- Three analyses of Ash Free Dry Mass were rejected because the laboratory analyst misplaced initial measurement data that would have allowed for calculation of dry mass (sites 204R01391, 204R02815, and 204R02852).

## 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 2014. By default creeks and other fresh water bodies not listed are assigned the WARM and WILD presumptive uses in the Basin Plan (SFBRWQCB 2013).

**Table 4-1. ACCWP creeks sampled in WY 2015 and associated designated beneficial uses listed in the San Francisco Bay Region Basin Plan (SFBRWQCB 2013). Creeks not 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*** | | | | | | | | | | | | | | | | | | | | |
| 204R01391 | Zeile Creek | | | | | | | | | | | | | | | E | E | E | E | |
| 204R01828 | Arroyo Mocho | | | | E | | | | | E | | | E | | E | E | E | E | E | |
| 204R01855 | Lower San Leandro Creek | | | E | | | | | | E | | | E | E | E | E | E | E | E | |
| 204R01876 | South San Ramon Creek | | | | | | | | | | | | | | | E | E | E | E | |
| 204R01945 | Altamont Creek | | | | E | | | | | E | | | | E | | E | E | E | E | |
| 204R01951 | Castro Valley Creek | | | | | | | | | E | | | | E | | E | E | E | E | |
| 204R02095 | San Lorenzo Creek | | E | E | E | | | | | E | | | E | | E | E | E | E | E | |
| 204R02375 | Ward Creek | | | | | | | | | | | | | | | E | E | E | E | |
| 204R02457 | Arroyo Seco | | | | E | | | | | E | | | E | E | E | E | E | E | E | |
| 204R02503 | Old Alameda Creek | | | | | | | | | | E | | | | | | E | E | E | |
| 204R02815 | Tassajara Creek | | | | E | | | | | P | | | E | E | E | E | E | E | E | |
| 205R00622 | Mission Creek (Zone 6 Line L) | | | | | | | | | | | | | | | E | E | E | E | |
| 205R02327 | Plummer Creek (Zone 5 Line F-1) | | | | | | | | | | E | | | E | | | E | E | E | |
| 205R02478 | Laguna Creek | | | | E | | | | | E | | | E | | E | E | E | E | E | |
| 205R02670 | Mission Creek (Zone 6 Line L) | | | | | | | | | | | | | | | 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 and Table 4-3 summarize the numbers of WY 2015 sites assigned to various condition categories by CSCI and algae assessments and the SoCal B-IBI.

**Table 4-2. Distribution of CSCI and Algae IBI condition categories for 22 probabilistic urban sites sampled in Alameda County during WY 2015.**

| Condition Category | CSCI | Diatom D18 IBI | Algae S2 IBI | Hybrid "H20" Algae IBI |
|---|---|---|---|---|
| Likely Intact (LI) | 0 | 3 | 2 | 0 |
| Possibly Intact (PI) | 0 | 4 | 1 | 1 |
| Likely Altered (LA) | 3 | 3 | 5 | 4 |
| Very Likely Altered (VLA) | 19 | 12 | 14 | 17 |

**Table 4-3. Distribution of SoCal B-IBI condition categories for 22 probabilistic urban sites sampled in Alameda County during WY 2015.**

| Condition Category | SoCal B-IBI |
|---|---|
| Very Good (VG) | 0 |
| Good (G) | 0 |
| Fair (F) | 2 |
| Poor (P) | 10 |
| Very Poor (VP) | 10 |

Table 4-4 shows the condition categories assigned to the 22 sites sampled in Alameda County during WY 2015. Biological condition scores for CSCI and algae IBIs (S2, D18, and H20) are listed in Table 4-5. Site characteristics related to impervious area, flow status, and channel modification status are also presented in the table for reference.

Using the condition categories for CSCI, 19 sites (86%) were rated as "very likely altered" condition and three sites (14%) were rated as "likely altered" condition. There were no WY 2015 sites in the two classes representing "intact" biological condition. The algae IBI scores showed a wider range of condition categories among the 22 bioassessment sites. Using the condition categories for algae IBI D18 (diatom only metric), 7 sites (32%) scored within the top two classes representing "intact" biological condition. The algae IBI S2 (soft algae only metric)

had only 3 sites (15%) in the top two classes. CSCI and D18 condition categories for the 22 bioassessment sites are shown in **Error! Reference source not found.**.

**Table 4-4. CSCI, SoCal B-IBI, and Algae IBI condition categories for 22 probabilistic urban sites sampled in Alameda County during WY 2015.**

| Station Code | Creek | CSCI Category | SoCal B-IBI Category | Diatom D18 Category | Algae S2 Category | Hybrid H20 Category |
|---|---|---|---|---|---|---|
| 204R01391 | Zeile Creek | LA | F | PI | LA | LA |
| 204R01735 | Zone 5 Line J2 | VLA | VP | VLA | VLA | VLA |
| 204R01828 | Arroyo Mocho | VLA | VP | VLA | VLA | VLA |
| 204R01855 | San Leandro Creek | VLA | VP | PI | LA | LA |
| 204R01876 | South San Ramon Creek | VLA | VP | VLA | VLA | VLA |
| 204R01945 | Altamont Creek | VLA | P | VLA | VLA | VLA |
| 204R01951 | Castro Valley Creek | VLA | VP | PI | VLA | VLA |
| 204R02095 | San Lorenzo Creek | VLA | VP | VLA | VLA | VLA |
| 204R02132 | Zone 7 Line J-3 | VLA | P | LA | VLA | VLA |
| 204R02351 | Unnamed tributary to Don Castro Reservoir | VLA | P | LA | VLA | VLA |
| 204R02375 | Ward Creek | LA | VP | LI | LA | LA |
| 204R02457 | Arroyo Seco | VLA | P | LI | VLA | PI |
| 204R02503 | Old Alameda Creek | VLA | VP | VLA | LI | VLA |
| 204R02527 | Zone 3A Line B-5 | LA | P | PI | VLA | VLA |
| 204R02596 | Chabot Canal | VLA | VP | VLA | LA | VLA |
| 204R02815 | Tassajara Creek | VLA | P | VLA | PI | VLA |
| 204R02852 | Pleasanton Canal | VLA | VP | VLA | LI | VLA |
| 205R00622 | Mission Creek | VLA | P | VLA | LA | VLA |
| 205R02327 | Plummer Creek (Zone 5 Line F-1) | VLA | F | LI | VLA | LA |
| 205R02478 | Laguna Creek | VLA | P | VLA | VLA | VLA |
| 205R02583 | Zone 5 Line D | VLA | P | LA | VLA | VLA |
| 205R02670 | Mission Creek | VLA | P | VLA | VLA | VLA |

**Table 4-5. CSCI, SoCal B-IBI, and Algae IBI scores for 22 probabilistic urban sites sampled in Alameda County during WY 2015. Site characteristics related to impervious area, flow status, and channel modification status are presented in the table.**

| Station Code | Creek | Impervious Area% | Flow Status | Highly Modified Channel | CSCI Score | SoCal B-IBI Score | Diatom D18 | Algae S2 | Hybrid H20 |
|---|---|---|---|---|---|---|---|---|---|
| 204R01391 | Zeile Creek | 14% | Non Perennial | N | 0.76 | 53 | 70 | 35 | 59 |
| 204R01735 | Zone 5 Line J2 | 53% | Perennial | Y | 0.18 | 6 | 8 | 27 | 20 |
| 204R01828 | Arroyo Mocho | 12% | Perennial | Y | 0.25 | 6 | 16 | 2 | 10 |
| 204R01855 | San Leandro Creek | 9% | Unknown | N | 0.49 | 13 | 66 | 42 | 61 |
| 204R01876 | South San Ramon Creek | 33% | Perennial | Y | 0.45 | 14 | 36 | 17 | 28 |
| 204R01945 | Altamont Creek | 4% | Perennial | Y | 0.38 | 21 | 10 | 17 | 15 |
| 204R01951 | Castro Valley Creek | 28% | Unknown | N | 0.32 | 13 | 62 | 8 | 40 |
| 204R02095 | San Lorenzo Creek | 14% | Perennial | Y | 0.56 | 10 | 20 | 20 | 19 |
| 204R02132 | Zone 7 Line J-3 | 17% | Perennial | Y | 0.38 | 21 | 60 | 27 | 45 |
| 204R02351 | Unnamed tributary to Don Castro Reservoir | 18% | Unknown | N | 0.61 | 21 | 54 | 13 | 40 |
| 204R02375 | Ward Creek | 33% | Perennial | Y | 0.68 | 16 | 78 | 30 | 59 |
| 204R02457 | Arroyo Seco | 9% | Perennial | Y | 0.39 | 20 | 92 | 27 | 69 |
| 204R02503 | Old Alameda Creek | 77% | Non Perennial | N | 0.20 | 13 | 36 | 62 | 45 |
| 204R02527 | Zone 3A Line B-5 | 43% | Perennial | N | 0.69 | 36 | 68 | 20 | 45 |
| 204R02596 | Chabot Canal | 50% | Perennial | Y | 0.30 | 7 | 14 | 32 | 21 |
| 204R02815 | Tassajara Creek | 5% | Non Perennial | Y | 0.32 | 27 | 30 | 53 | 39 |
| 204R02852 | Pleasanton Canal | 68% | Non Perennial | Y | 0.28 | 4 | 18 | 67 | 34 |
| 205R00622 | Mission Creek | 13% | Perennial | Y | 0.17 | 21 | 26 | 33 | 25 |
| 205R02327 | Plummer Creek (Zone 5 Line F-1) | 64% | Perennial | Y | 0.25 | 40 | 82 | 25 | 61 |
| 205R02478 | Laguna Creek | 43% | Perennial | Y | 0.41 | 20 | 38 | 13 | 25 |
| 205R02583 | Zone 5 Line D | 66% | Non Perennial | Y | 0.37 | 24 | 50 | 28 | 44 |
| 205R02670 | Mission Creek | 11% | Perennial | Y | 0.56 | 31 | 36 | 18 | 30 |

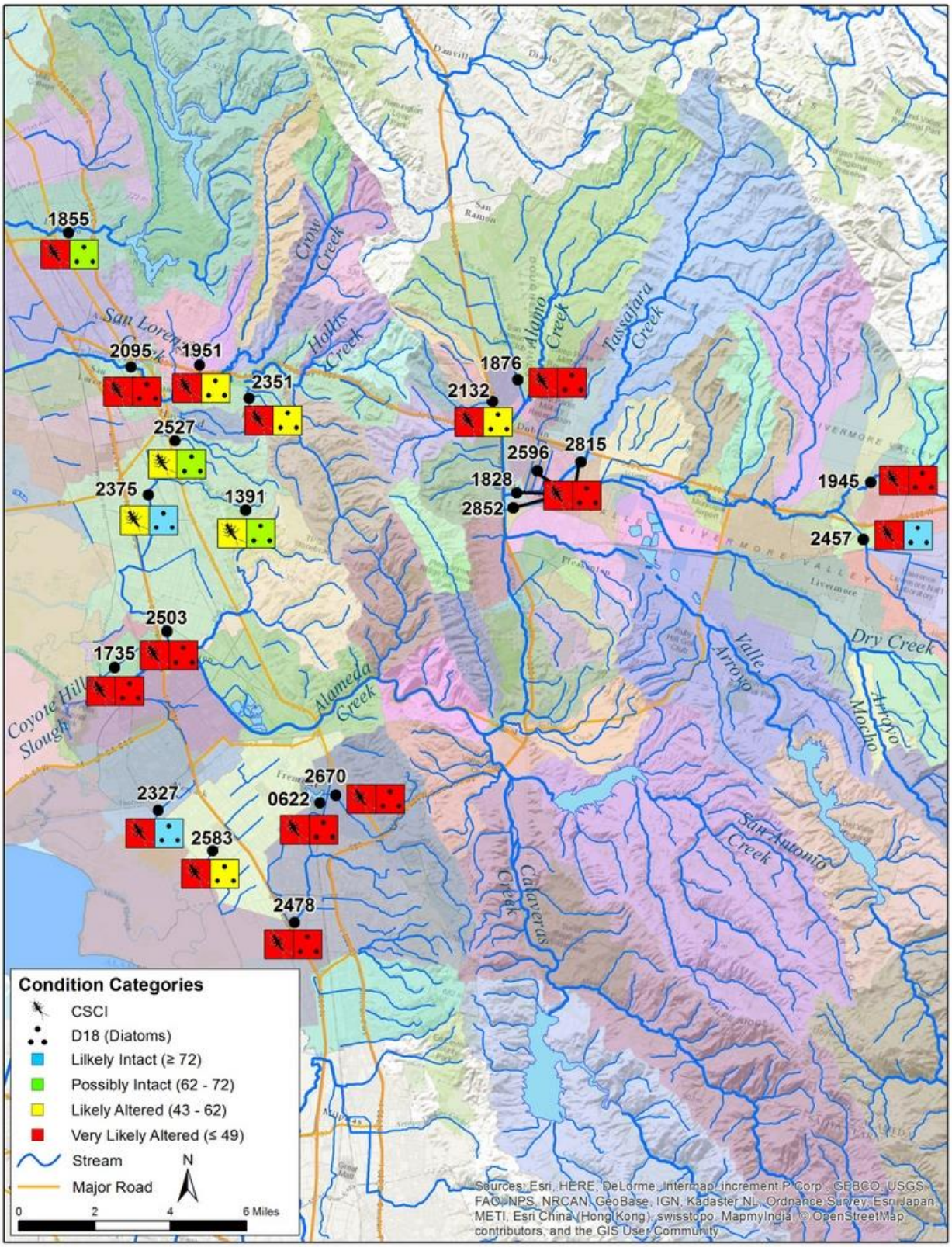


**Figure 4-1. Condition categories for CSCI and Diatom D18 scores for 22 bioassessment locations sampled by ACCWP during WY 2015.**

### 4.2.2 Stressor Indicators: Biological Assessment

**Benthic Macroinvertebrates**

Descriptive statistics for CSCI, SoCal B-IBI and algae IBI scores are shown in **Error! Reference source not found.** (**Error! Reference source not found.**). The distribution of algae IBI scores showed greater variability among the sites compared to the macroinvertebrate indices. (**Error! Reference source not found.**).

**Table 4-6. Descriptive statistics for CSCI, SoCal B-IBI and algae IBI scores for the 22 probabilistic sites sampled in Alameda County during Water Year 2015.**

| Statistic | CSCI (>0) | SoCal B-IBI (0-100) | Diatom D18 IBI (0-100) | Algae S2 IBI (0-100) | Hybrid "H20" Algae IBI (0-100) |
|---|---|---|---|---|---|
| Min | 0.17 | 4 | 8 | 2 | 10 |
| Median | 0.38 | 20 | 37 | 27 | 40 |
| Mean | 0.41 | 20 | 44 | 28 | 38 |
| Max | 0.76 | 53 | 92 | 67 | 69 |

Site characteristic information presented in Table 4-5 indicates that majority of the 22 bioassessment sites are highly impacted by human disturbance. Sixteen of the twenty-two sites (73%) were characterized as having modified channels. Across all the bioassessment sites, the percent impervious area in the watershed ranged from 4% – 77%, with mean of 31%. Despite overall high level of urbanization across the sites, percent impervious area was poorly correlated to CSCI scores (Figure 4-2). It is likely that confounding factors associated with physical habitat and/or water quality are impacting the biological condition of sites.

Algae IBI D18 and H20 scores were not well correlated with CSCI scores (Figure 4-3 and Figure 4-4, respectively), suggesting that algae may be responding to different stressors than BMIs. Studies in Southern California suggest that algae communities can do well at sites with highly modified channel when "good" water quality is present (personal communication, Betty Fetcher, 2015). As a result, algae IBI scores may be more useful than CSCI scores for evaluating water quality conditions at sites with highly modified channels. A comparison of H20 and CSCI scores show that the two indices generally respond very differently from site to site (Figure 4-5).

The D18 and S2 scores also showed no correlation to each other (Figure 4-6). As a result, it appears that diatoms and soft algae are responding very differently to physical habitat and water quality related stressors.

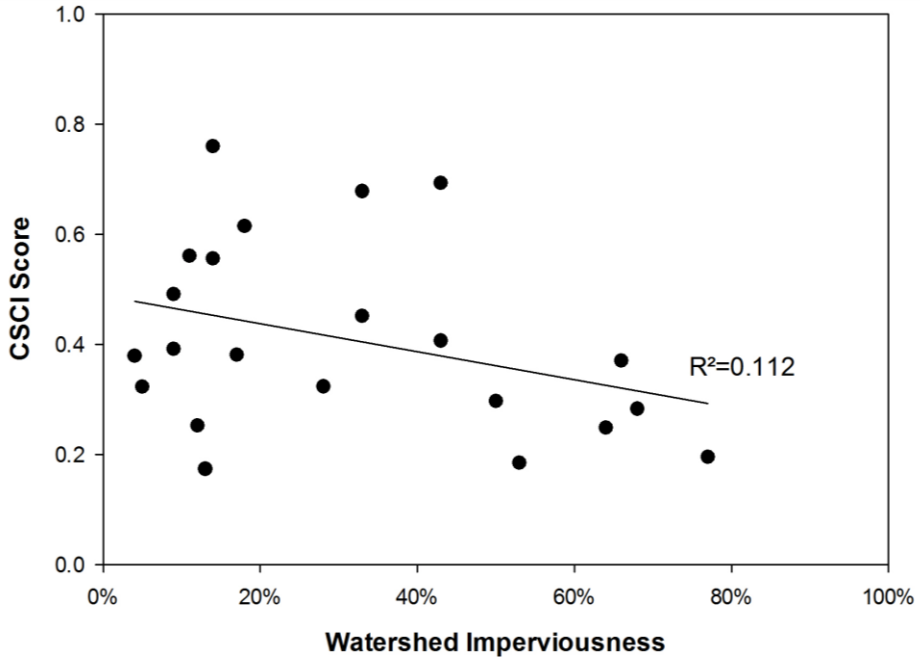


**Figure 4-2. Linear regression between CSCI scores and percent watershed imperviousness for the 22 sites sampled in Alameda County during WY 2015.**

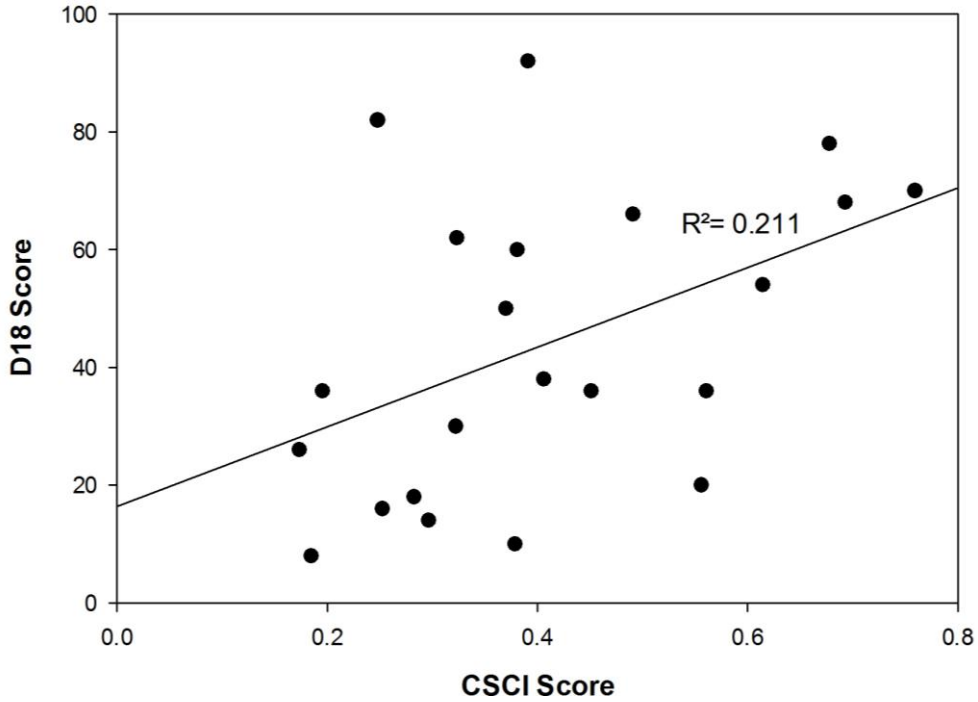


**Figure 4-3. Linear regression between D18 (diatom only metric) and CSCI scores for the 22 sites sampled in Alameda County during WY 2015.**

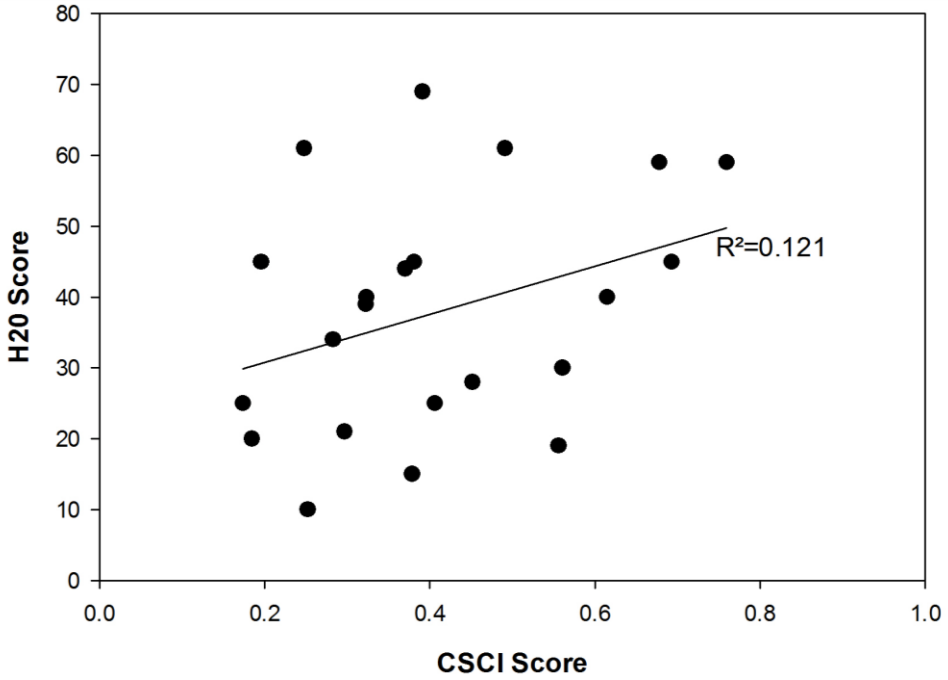


**Figure 4-4. Linear regression between H20 (hybrid metric) and CSCI scores for the 22 sites sampled in Alameda County during WY 2015.**

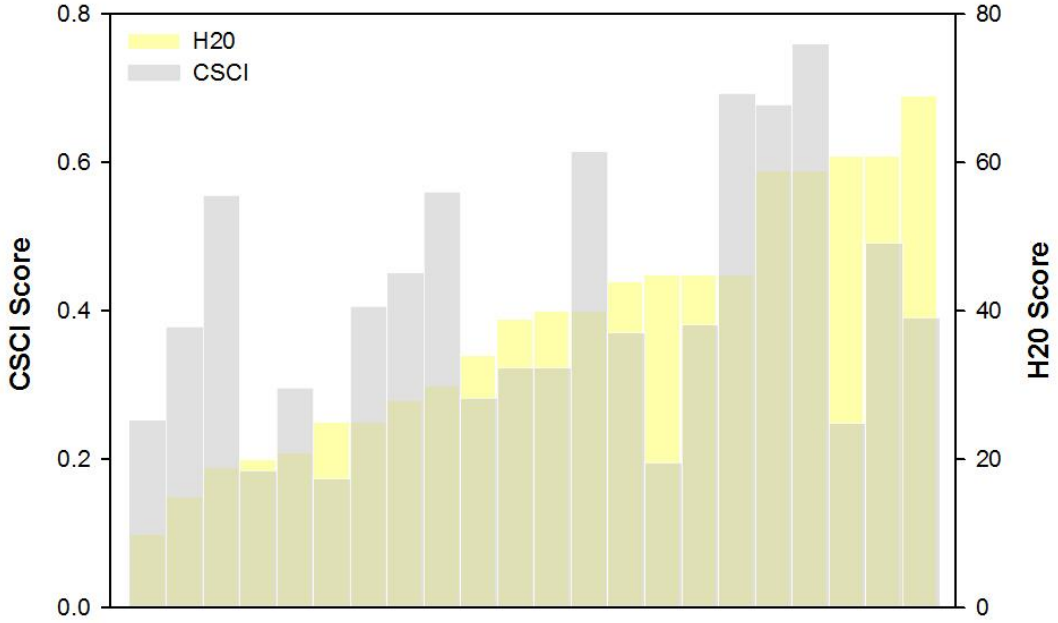


**Figure 4-5. CSCI and H20 scores plotted for the 22 sites sampled in Alameda County during WY 2015. Data are sorted with H20 Algae IBI scores increasing from left to right.**

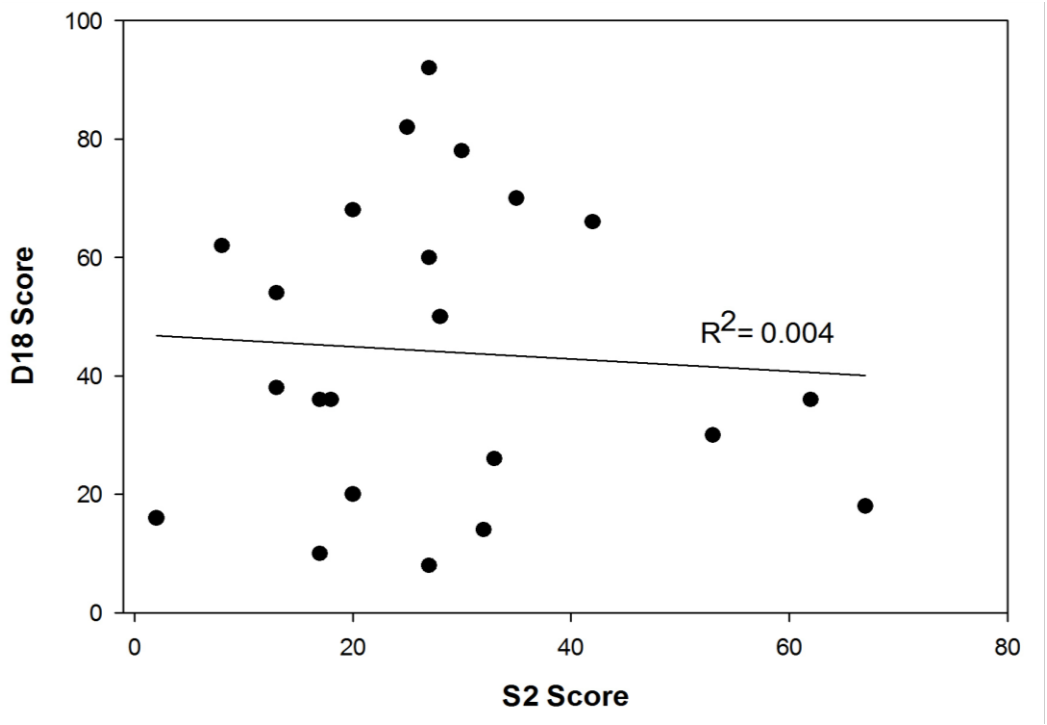


**Figure 4-6. Linear regression of D18 and S2 scores for 22 sites sampled in Alameda County during WY 2015.**

The H20 and CSCI scores were compared for non-perennial (n=5) and perennial (n=14) sites sampled in Alameda County during WY2014 (Figure 4-7). Flow status was evaluated by ACCWP during site observations conducted during the dry season. Sites with no flow status information[11] were indicated as "unknown" (n=3). Perennial sites (n=14) had a wider range of CSCI and H20 scores compared to non-perennial sites (n=5). The median CSCI scores for perennial sites were slightly higher than those for non-perennial sites, whereas, median H20 scores for perennial sites were approximately 20 points lower than for non-perennial streams.

WY 2015 is the fourth year of probabilistic bioassessment monitoring conducted by ACCWP in compliance with the MRP. There is now a robust dataset of 81 CSCI scores. CSCI condition categories for the 81 bioassessment sampling locations sampled in Alameda County between WY2012 and WY 2015 are shown in Figure 4-8.

[11]"Unknown" flow status includes sites on streams with flows regulated by dam releases or water imports.

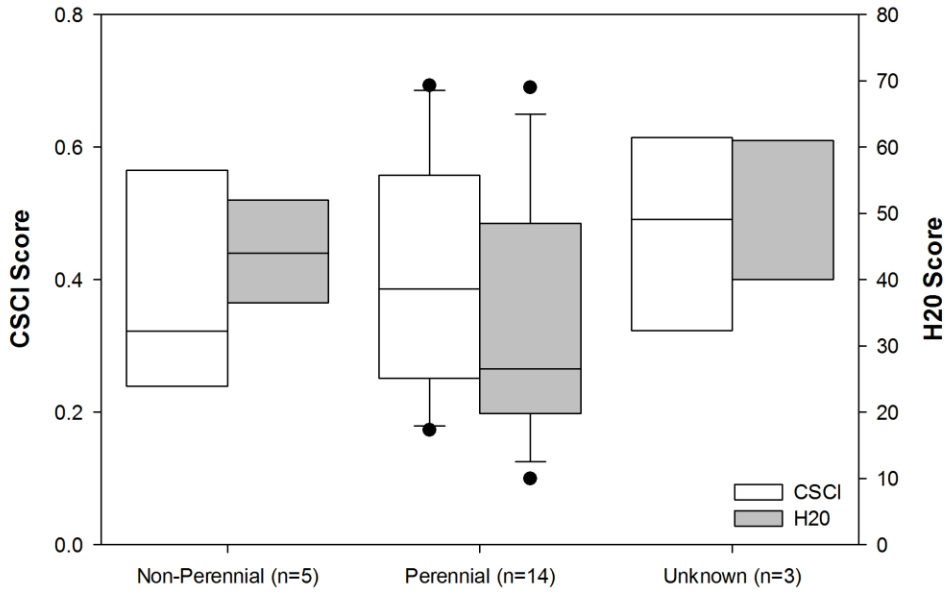


**Figure 4-7. Box plots showing distribution of H20 and CSCI scores for non-perennial (n=5) and perennial (n=14) sites sampled in Alameda County during WY 2015. The flow status of three sites is unknown, and they are grouped separately.**

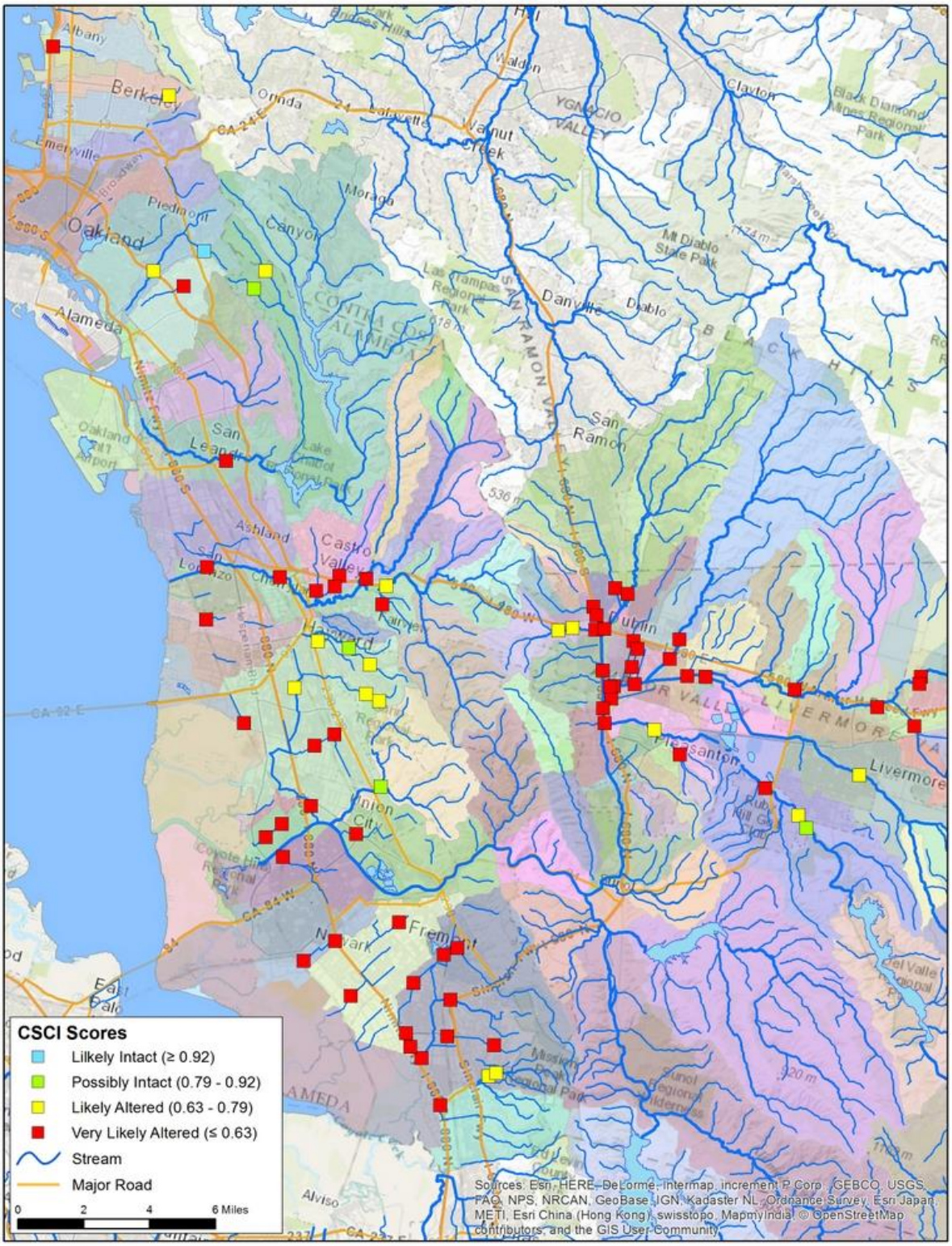


**Figure 4-8. Condition categories for CSCI scores for 81 bioassessment locations sampled by ACCWP between WY2012 and WY 2015.**

### 4.2.3 Stressor Indicators: Chemical and Toxicity

**Water Chemistry Parameters**

Table 4-7 provides a summary of descriptive statistics for the nutrients and related conventional constituents collected in association with the bioassessments 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 2015.**

| "Nutrients" | N | N ≥ RL | Min | Max | Max Detected | Mean |
|---|---|---|---|---|---|---|
| Chloride | 22 | 22 | 16 | 940 | 940 | 172 |
| Chlorophyll a | 22 | 22 | 190 | 12000 | 12000 | 3930 |
| Dissolved Organic Carbon | 22 | 22 | 1.2 | 20 | 20 | 5.3 |
| Ammonia as N | 22 | 12 | <0.04 | 0.6 | 0.6 | 0.17 |
| Nitrate as N | 22 | 14 | <0.01 | 2.9 | 3.6 | 0.17 |
| Nitrite as N | 22 | 2 | <0.01 | 0.065 | 0.065 | 0.01 |
| Nitrogen, Total Kjeldahl | 22 | 22 | 0.13 | 2.4 | 2.4 | 0.88 |
| Nitrogen, Total (calculated) | 22 | NA | NA | NA | NA | 1.07 |
| OrthoPhosphate as P | 22 | 18 | <0.01 | 0.5 | 0.5 | 0.08 |
| Phosphorus as P | 22 | 22 | 0.012 | 0.88 | 0.88 | 0.15 |
| Suspended Sediment Concentration | 22 | 10 | <2 | 39 | 39 | 8.7 |
| Silica as SiO2 | 22 | 22 | 1.2 | 41 | 41 | 17.6 |

**Water and Sediment Toxicity Testing**

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.

For water sample toxicity tests, MRP Table 8.1 identifies toxicity results of less than 50% of the Control (e.g., increased mortality, decreased reproduction, etc.) as requiring follow-up action. For sediment sample tests, MRP Table H-1 identifies toxicity results more than 20% less than the

control as requiring follow-up action.[12] Therefore, in the tables that follow, samples that are identified by the lab as toxic (based on statistical comparison of samples vs. Control at $p < 0.05$) are further evaluated to determine whether the result was less than 50% of the associated Control (for water samples) or statistically different and more than 20% less than the Control (for sediment samples).

Samples for triad sites were targeted to be collected within creeks at sites where bioassessments were conducted in the same water year, where flow regime was assessed as perennial, and where sufficient fine-grained surficial sediments were likely to be present during dry season. The toxicity testing results are presented in context of the following three groups: 1) wet season water samples, 2) dry season water samples, and 3) dry season sediment samples. For each of these groups, the results are first presented in a table indicating which samples were found to be toxic by virtue of a statistically significant difference from the Control as determined by the laboratory. Detailed results are then presented in a subsequent table for the toxic samples, along with an assessment as to whether the toxic effect was less than 50% of the Control for water samples, or more than 20% less than the Control for sediment samples.

Wet Season Aquatic Toxicity

Per the MRP, field personnel collected ambient water samples at three locations during storm events in February 2015, and tested for toxic effects using four species: an aquatic plant (*Selenastrum capricornutum*), two aquatic invertebrates (*Ceriodaphnia dubia* and *Hyalella azteca*), and one fish species (*Pimephales promelas* or fathead minnow). The following sections discuss the results of WY 2015 monitoring in the context of MRP triggers.

Field samples were collected on February 6, 2015 for analysis of aquatic toxicity using the four test species. No wet season samples were found to be toxic to *P. promelas, C. dubia,* or *S. capricornutum*. Two samples, collected at sites 204R01951 and 204R01876, were identified as exhibiting statistically significant toxic to *H. Azteca* survival (Table 4-8), however. Unlike some results of prior years, no pathogen-related mortality (PRM) was identified in ACCWP samples.

Per the requirements of the MRP, AMS conducted re-testing at site 204R01951 for *H. azteca* during the subsequent precipitation event influencing the site. A new sample was collected and submitted for analysis on April 7, 2015. Results of this analysis similarly indicated a toxic response (**Error! Reference source not found.**). The February sample collected at site 204R01876, which was also identified with statistically-significant toxicity to *H. azteca* did not

[12] Footnote #162 to Table H-1 of the MRP reads, "Toxicity is exhibited when Hyallela (sic) survival statistically different than and < 20 percent of control". Consistent with the UCMR (BASMAA 2013), for the purposes of this report, this is assumed to be intended to read "…statistically different than and more than 20 percent less than control".

meet the MRP trigger for follow-on testing (90% survival in the sample compared with 100% survival in the control)

**Table 4-8. Summary of WY 2015 wet season water toxicity results for four-species tests.**

| Wet Season Water Samples | | Toxicity relative to the Lab Control treatment? | | | | | |
|---|---|---|---|---|---|---|---|
| Sample Station | Collection Date | *S. capricornutum* | *C. dubia* | | *H. azteca* | *P. Promelas* | |
| | | Growth | Survival | Reproduction | Survival | Survival | Growth |
| 204R01876 | 2/6/15 | No | No | No | Yes | No | No |
| 204R01951 | 2/6/15 | No | No | No | Yes | No | No |
| 205R00622 | 2/6/15 | No | No | No | No | No | No |

**Table 4-9. Summary of WY 2015 wet season water toxicity re-test results for *H. Azteca* at site 204R01951.**

| Wet Season Water Samples | | Toxicity relative to the Lab Control treatment? | | | | | |
|---|---|---|---|---|---|---|---|
| Sample Station | Collection Date | *S. capricornutum* | *C. dubia* | | *H. azteca* | *P. Promelas* | |
| | | Growth | Survival | Reproduction | Survival | Survival | Growth |
| 204R01951 | 4/7/15 | NA | NA | NA | **Yes** | NA | NA |

Dry Season Aquatic Toxicity

Field personnel collected water samples during the summer 2015 from the same three sites where wet season sampling occurred, and were again tested for aquatic toxicity using the same four test species. The results are summarized in Table 4-10. In comparisons to the control samples, none of samples were identified with statistically-significant toxicity.

**Table 4-10. Summary of WY 2015 dry season aquatic toxicity results.**

| Dry Season Water Samples | | Toxicity relative to the Lab Control treatment? | | | | | |
|---|---|---|---|---|---|---|---|
| Sample Station | Collection Date | *S. capricornutum* | *C. dubia* | | *H. azteca* | *P. Promelas* | |
| | | Growth | Survival | Reproduction | Survival | Survival | Growth |
| 204R01876 | 7/7/15 | No | No | No | No | No | No |
| 204R01951 | 7/7/15 | No | No | No | No | No | No |
| 205R00622 | 7/7/15 | No | No | No | No | No | No |

Dry Season 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 an extensive list of sediment chemistry constituents. For sediment toxicity, testing was performed with just one species, *H. azteca*, a common benthic invertebrate. Both acute (survival) and chronic (growth) endpoints were reported.

The results of the ACCWP WY 2015 sediment toxicity testing are summarized in Table 4-11. . In comparison to the laboratory controls, none of samples were identified with statistically-significant toxicity.

**Table 4-11. Summary of WY 2015 dry season sediment toxicity results.**

| Dry Season Sediment Samples | | Toxicity relative to the Lab Control treatment? | |
|---|---|---|---|
| **Sample Station** | **Collection Date** | ***H. azteca*** | |
| | | Survival | Growth |
| 204R01876 | 7/7/15 | No | No |
| 204R01951 | 7/7/15 | No | No |
| 205R00622 | 7/7/15 | No | No |

**Sediment Chemistry Parameters**

Descriptive statistics for sediment chemistry data for samples collected in WY 2015 are provided in

Table 4-12. Analytes are presented in alphabetical order.

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 "chlordane" constituent required the combination of "chlordane, cis" and "chlordane, trans" from the laboratory data, and the MacDonald "total DDTs" parameter required the aggregation of 6 isomers of DDD, DDE and DDT. The MacDonald list also 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 4-12. Descriptive statistics for ACCWP WY 2015 sediment chemistry results**

| Analyte | N | N ≥ MDL | Min | Max | Max Detected | Mean[1] |
|---|---|---|---|---|---|---|
| Acenaphthene | 3 | 0 | -3.3 | -3 | NA | 2 |
| Acenaphthylene | 3 | 0 | -3.3 | -3 | NA | 2 |
| Anthracene | 3 | 2 | -3.3 | 20 | 20 | 9 |
| Arsenic | 3 | 3 | 4.1 | 4.9 | 4.9 | 5 |
| Benz(a)anthracene | 3 | 2 | -3.3 | 41 | 41 | 18 |
| Benzo(a)pyrene | 3 | 2 | -3.3 | 81 | 81 | 45 |
| Benzo(b)fluoranthene | 3 | 0 | -3.3 | -3 | NA | 2 |
| Benzo(e)pyrene | 3 | 1 | -3.3 | 100 | 100 | 34 |
| Benzo(g,h,i)perylene | 3 | 1 | -3.3 | 51 | 51 | 18 |
| Benzo(k)fluoranthene | 3 | 0 | -3.3 | -3 | NA | 2 |
| Bifenthrin | 3 | 3 | 1.4 | 4.8 | 4.8 | 4 |
| Biphenyl | 3 | 0 | -3.6 | -3.4 | NA | 2 |
| Cadmium | 3 | 3 | 0.18 | 0.67 | 0.67 | 0.4 |
| Chlordane, cis- | 3 | 1 | -1.1 | 5.3 | 5.3 | 2 |
| Chlordane, trans- | 3 | 1 | -1.1 | 5.7 | 5.7 | 2 |
| Chromium | 3 | 3 | 18 | 48 | 48 | 34 |
| Chrysene | 3 | 2 | -3.3 | 200 | 200 | 92 |
| Copper | 3 | 3 | 21 | 26 | 26 | 23 |
| Cyfluthrin, total | 3 | 3 | 0.42 | 1.3 | 1.3 | 1 |
| Cyhalothrin, Total lambda- | 3 | 2 | -0.061 | 0.15 | 0.15 | 0 |
| Cypermethrin, total | 3 | 2 | -0.1 | 0.22 | 0.22 | 0 |
| DDD(o,p') | 3 | 0 | -2.2 | -2 | NA | 1 |
| DDD(p,p') | 3 | 1 | -1.3 | 5.7 | 5.7 | 2 |
| DDE(o,p') | 3 | 0 | -2.2 | -2 | NA | 1 |
| DDE(p,p') | 3 | 2 | 1.3 | 8.8 | 8.8 | 5 |
| DDT(o,p') | 3 | 0 | 2.2 | -2 | NA | 1 |
| DDT(p,p') | 3 | 0 | -1.1 | -1 | NA | 1 |
| Deltamethrin/Tralomethrin | 3 | 1 | -0.13 | 0.29 | 0.29 | 0 |
| Dibenz(a,h)anthracene | 3 | 0 | -3.3 | -3 | NA | 2 |
| Dibenzothiophene | 3 | 0 | -3.6 | -3.4 | NA | 2 |
| Dieldrin | 3 | 0 | -1.3 | -1.2 | NA | 1 |
| Dimethylnaphthalene, 2,6- | 3 | 3 | 20 | 43 | 43 | 31 |
| Endrin | 3 | 0 | -1.1 | -1 | NA | 1 |
| Esfenvalerate/Fenvalerate, total | 3 | 1 | -0.14 | 0.18 | 0.18 | 0.1 |
| Fluoranthene | 3 | 2 | -3.3 | 200 | 200 | 85 |
| Fluorene | 3 | 1 | -3.3 | 8.1 | 8.1 | 4 |
| HCH, gamma- | | 0 | -0.76 | -0.71 | NA | 0 |
| Heptachlor epoxide | 3 | 0 | -1.2 | -1.1 | NA | 1 |
| Indeno(1,2,3-c,d)pyrene | 3 | 1 | -3.3 | 41 | 41 | 15 |

| Analyte | N | N ≥ MDL | Min | Max | Max Detected | Mean[1] |
|---|---|---|---|---|---|---|
| Lead | 3 | 3 | 8.2 | 90 | 90 | 38 |
| Mercury | 3 | 3 | 0.036 | 0.053 | 0.053 | 0 |
| Methylnaphthalene, 1- | 3 | 1 | -3.3 | 10 | 10 | 4 |
| Methylnaphthalene, 2- | 3 | 1 | -3.3 | 7.1 | 7.1 | 3 |
| Methylphenanthrene, 1- | 3 | 0 | -3.3 | -3 | NA | 2 |
| Naphthalene | 3 | 1 | -3.3 | 4.1 | 4.1 | 2 |
| Nickel | 3 | 3 | 24 | 57 | 57 | 39 |
| Permethrin, cis- | 3 | 3 | 0.37 | 1.2 | 1.2 | 1 |
| Permethrin, trans- | 3 | 2 | -0.12 | 0.75 | 0.75 | 0 |
| Perylene | 3 | 2 | -3.3 | 30 | 30 | 18 |
| Phenanthrene | 3 | 2 | -3.3 | 100 | 100 | 44 |
| Pyrene | 3 | 2 | -3.3 | 100 | 100 | 55 |
| Total Organic Carbon | 3 | 3 | 1.3 | 3 | 3 | 2 |
| Zinc | 3 | 3 | 70 | 340 | 340 | 169 |

Notes:

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

## 4.3 Stressor Assessment

This section addresses the question:

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

Each monitoring category required by MRP Provision C.8.c is associated in Table 8-1 with a specification for "Results that Trigger a Monitoring Project in Provision C.8.d.i" (Stressor/Source Identification). These definitions in Table 8.1 are considered to represent "trigger criteria", meaning that the relevant monitoring results should be forwarded for consideration as potential Stressor/Source Identification Projects per Provision C.8.d.i.

The biological, physical, chemical and toxicity testing data produced by ACCWP during WY 2015 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 followed in reporting the WY2012 and 2013 Integrated Monitoring Report Appendix A.2 prepared for the four collaborating RMC Programs (AMS 2014). 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.

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 2015 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 the water and sediment chemistry and toxicity testing results in comparison to various 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 monitoring locations.

**Water Chemistry Parameters**

According to MRP Table 8.1, the trigger criterion ("Results that Trigger a Monitoring Project in Provision C.8.d.i) for the "Nutrients" constituents analyzed in conjunction with the bioassessment monitoring is *"20% of results in one waterbody exceed one or more water quality standard or established threshold*." A search for relevant water quality standards or accepted thresholds was conducted using available sources, including the SF Basin Water Quality Control Plan (Basin Plan) (SFBRWQCB 2013), the California Toxics Rule (CTR) (USEPA 2000a), and various USEPA sources. Of the eleven water quality constituents monitored in association with the bioassessment monitoring (referred to collectively as "Nutrients" in MRP Table 8.1), 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 4-13.

For ammonia, the standard provided in the SF Bay Basin Plan (p. 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[13], 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 Criterion Continuous

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

Concentration (CCC) of 230 mg/L (USEPA Water Quality Criteria[14]) for the protection of aquatic life were used for comparison purposes.[15]

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 4-13. Water quality thresholds available for comparison to ACCWP WY 2015 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 |

[14]National Recommended Water Quality Criteria**.** EPA'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

[15]Per 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 4-13 are shown in Table 4-14. The results for these three constituents are plotted against the prevailing thresholds in Figure 4-9 through Figure 4-11.

Of the 22 sites monitored, the water quality standard was exceeded at two sites for un-ionized ammonia (sites 204R01945 and 205R02478). This equates to 9% of the sites sampled. It should be noted that un-ionized ammonia concentrations appear to have increased across-the-board at ACCWP sites in 2015. This appears largely attributable to increases observed in NH3-N concentrations measured. Cumulatively, between 2012 and 2014, 22% of ACCWP sites sampled generated results for NH3-N above reporting limits, which remained consistent at 0.1 mg/L over the three years. In 2015, 12 of 22 sites sampled generated results above reporting limits (55%). In 2014, of the 18 sites monitored, ammonia concentrations reported by Caltest fell below the detection limits at 15 sites, and were between detection and reporting limits at the other 3 sites; ammonia and un-ionized ammonia concentrations averaged 0.03 mg/L and 0.7 µg/L, respectively. In 2015, of the 22 sites monitored, only 2 sites generated non-detects for ammonia, and ammonia and un-ionized ammonia concentrations averaged 0.16 mg/L and 10.6 µg/L, respectively.

In order to assess if this observed increase in NH3-N concentrations was attributable to a change in laboratory operations, we contacted data managers for CCCWP, SCVURPPP, and SMCSWPPP to compare findings. Their findings indicated that CCCWP did observe an increase in the number of NH3-N results reported above reporting limits from 2014 to 2015 (Pete Wilde, personal communication, February 10, 2016), but that both SCVURPPP and SMCSWPPP found a decrease in the number from 2014 to 2015 (Courtney Siu, personal communication, February 10, 2016).

In order to assess whether the ACCWP increase in NH3-N concentrations in 2015 was potentially attributable to a change in sampling technique, we compared the number of samples reported above reporting limits for all analytes in 2014 and 2015, excluding NH3-N, The proportion of samples measured above reporting limits remained stable from 2014 to 2015, dropping slightly from 82% to 80%. Anecdotally, these comparisons suggest that there is no clear external factor that would have led to the increase in NH3-N concentrations observed.

For chloride, the water quality standard was exceeded at four sites (18% of sites) in 2015 (204R01735, 204R01945, 204R02132, and 204R02596), with an average concentration of 172

mg/L.[16] There were 3 measurements of chloride (17% of sites) above the threshold in 2014. No samples exceeded the nitrate + nitrite standard in 2015, as was the case in 2014.

Based upon the above information, the MRP Table 8.1 trigger criterion for "Nutrients" (20% of results in one waterbody exceed one or more water quality standards or applicable thresholds) was therefore considered to be exceeded at 5[17] of the 22 sites (23%), which is above the 17% of sites with at least one result above identified thresholds observed in 2014.

[16] 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.

[17] Site 204R01945 exceeded both the un-ionized ammonia and chloride criteria.

**Table 4-14. Comparison of water quality (nutrient) data to associated water quality thresholds for WY 2015 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] | | |
| 204R01391 | | | 10.05 | 53 | 0.13 | 0 | 0% |
| 204R01735 | | | 5.91 | **430** | 1.14 | 1 | 33% |
| 204R01828 | X | | 3.82 | 200 | 0.02 | 0 | 0% |
| 204R01855 | | | 1.06 | 16 | 0.01 | 0 | 0% |
| 204R01876 | X | | 9.53 | 100 | 0.06 | 0 | 0% |
| 204R01945 | X | | **52.04** | **940** | 0.02 | 2 | **67%** |
| 204R01951 | | | 3.33 | 66 | 0.01 | 0 | 0% |
| 204R02095 | | X | 11.73 | 52 | 0.36 | 0 | 0% |
| 204R02132 | X | | 16.82 | **480** | 0.11 | 1 | 33% |
| 204R02351 | | | 0.67 | 83 | 0.20 | 0 | 0% |
| 204R02375 | | | 4.28 | 37 | 1.27 | 0 | 0% |
| 204R02457 | X | | 10.18 | 110 | 1.52 | 0 | 0% |
| 204R02527 | | | 3.70 | 30 | 0.57 | 0 | 0% |
| 204R02596 | | | 1.61 | **310** | 0.24 | 1 | 33% |
| 204R02815 | X | | 16.79 | 130 | 0.01 | 0 | 0% |
| 204R02852 | X | | 1.66 | 160 | 0.01 | 0 | 0% |
| 205R00622 | | | 5.39 | 96 | 0.32 | 0 | 0% |
| 205R02327 | | | 0.86 | 120 | 2.93 | 0 | 0% |
| 205R02478 | | | **61.81** | 160 | 0.89 | 1 | 33% |
| 205R02503 | | | 1.01 | 40 | 0.01 | 0 | 0% |
| 205R02583 | | | 8.12 | 82 | 0.01 | 0 | 0% |
| 205R02670 | | | 2.95 | 92 | 2.11 | 0 | 0% |
| **# Values >Threshold:** | | | 2 | 4 | 0 | | |
| **% Values >Threshold:** | | | 9% | 18% | 0% | | |
| **Overall Number and % of Sites Meeting Trigger Criterion [3]:** | | | | | | **6** | **23%** |

[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

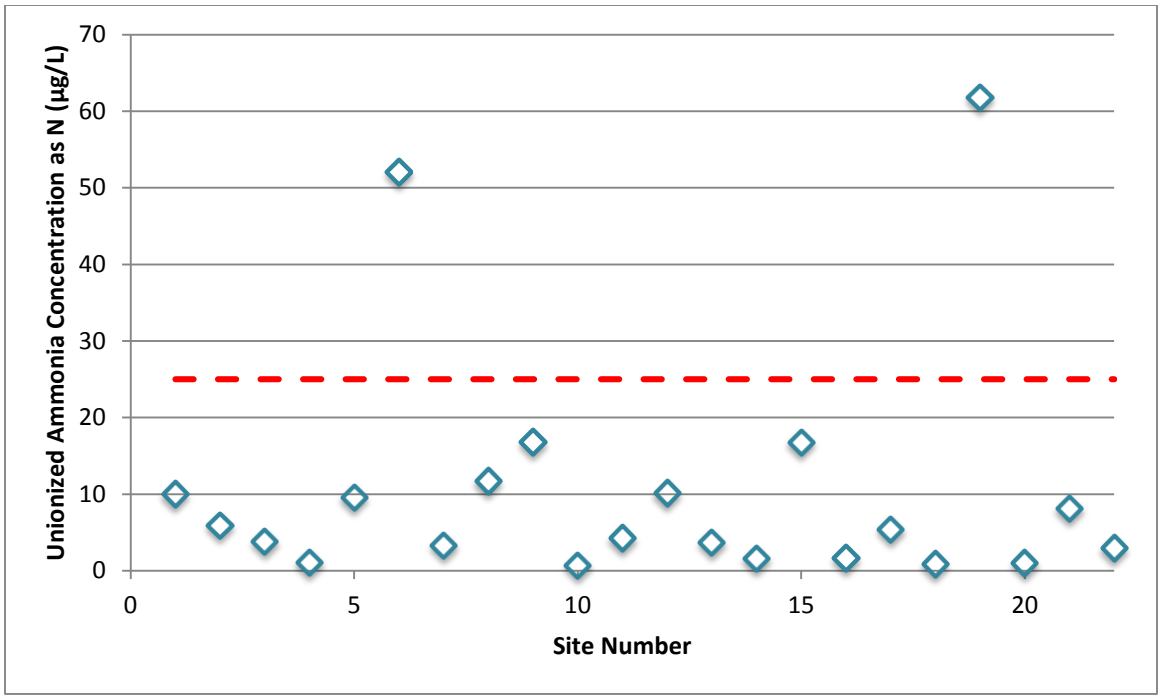


**Figure 4-9. Plot of ACCWP WY 2015 unionized ammonia data (calculated from total ammonia, pH, temperature, and electrical conductivity) with threshold of 25 µg/L indicated.**

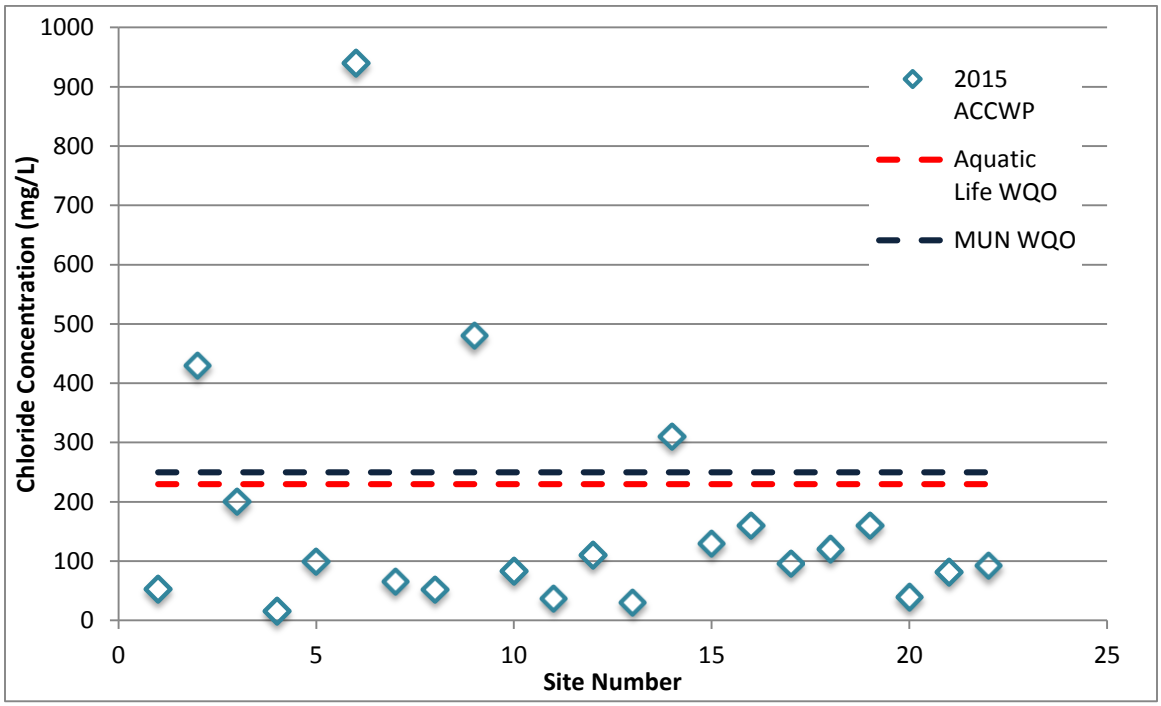


**Figure 4-10. Plot of ACCWP WY 2015 chloride data with relevant Aquatic Life and MUN thresholds indicated.**

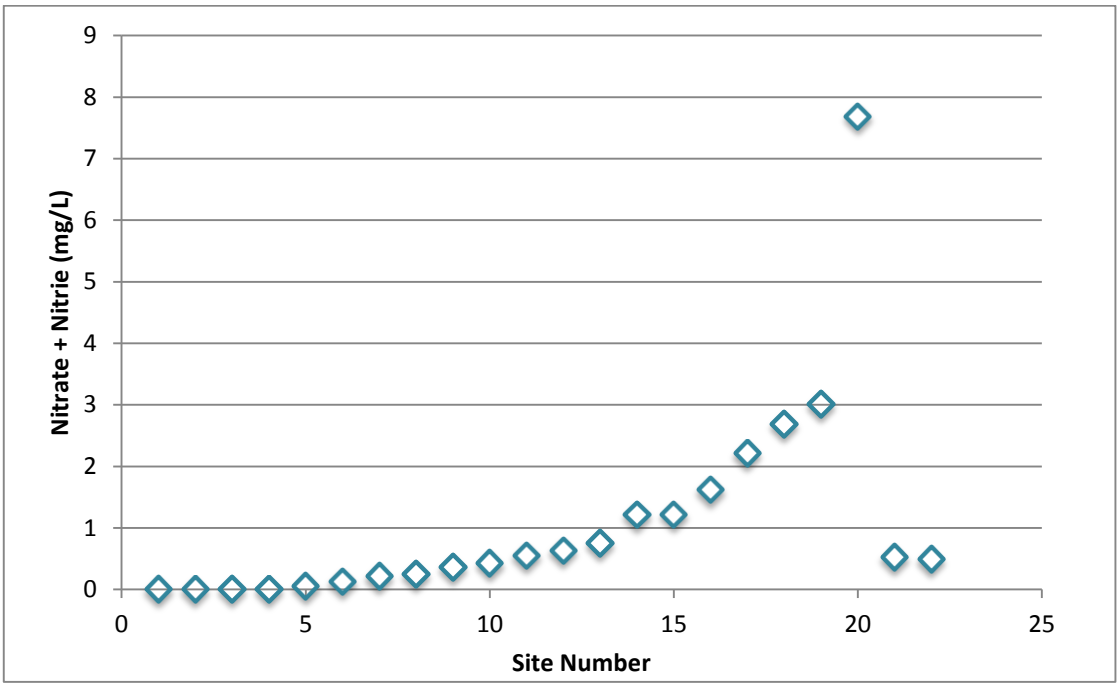


**Figure 4-11. Plot of ACCWP WY 2015 nitrate + nitrite as N data, WY 2015 data (threshold not shown = 10 mg/L for MUN only).**

### Free and Total Chlorine Testing

The results of field testing for free and total chlorine and comparisons to the MRP Table 8.1 trigger threshold are summarized in

. The MRP2 trigger criterion for chlorine states, “After immediate resampling, concentrations remain >0.10 mg/L”.

There were 24 site measurements for free and total chlorine collected by ACCWP in WY 2015, as the toxicity sites were each tested twice (spring and summer). None of the 24 sites exceeded the thresholds for free and total chlorine that would trigger follow-up testing. In 2014, there were 21 measurements collected overall by ACCWP; 10% of the measurements exceeded the threshold for free chlorine, and 5% exceeded the threshold for total chlorine. Unlike prior years, there were no instances where measure concentration of free chlorine was greater than total chlorine.

**Table 4-15. Summary of ACCWP WY 2015 chlorine testing results in comparison to Municipal Regional Permit trigger criteria.**

| Site Code | Sample Date | Chlorine, Free | Chlorine, Total | Meets Trigger Threshold? |
|---|---|---|---|---|
| 204R01391 | 6/2/15 | <0.04 | <0.04 | No |
| 204R01735 | 5/7/15 | <0.04 | <0.04 | No |
| 204R01828 | 5/20/15 | <0.04 | <0.04 | No |
| 204R01855 | 4/27/15 | <0.04 | <0.04 | No |
| 204R01876 | 5/20/15 | <0.04 | <0.04 | No |
| 204R01945 | 5/11/15 | <0.04 | <0.04 | No |
| 204R01951 | 4/28/15 | <0.04 | <0.04 | No |
| 204R02095 | 4/27/15 | 0.04 | 0.04 | No |
| 204R02132 | 5/11/15 | <0.04 | <0.04 | No |
| 204R02351 | 5/14/15 | <0.04 | <0.04 | No |
| 204R02375 | 4/29/15 | <0.04 | <0.04 | No |
| 204R02457 | 5/19/15 | <0.04 | <0.04 | No |
| 204R02527 | 4/29/15 | <0.04 | <0.04 | No |
| 204R02596 | 5/21/15 | <0.04 | <0.04 | No |
| 204R02815 | 6/3/15 | <0.04 | <0.04 | No |
| 204R02852 | 6/3/15 | NR | NR | NA |
| 205R00622 | 5/18/15 | <0.04 | <0.04 | No |
| 205R02327 | 5/13/15 | <0.04 | <0.04 | No |
| 205R02478 | 5/12/15 | <0.04 | <0.04 | No |
| 204R02503 | 4/30/15 | <0.04 | <0.04 | No |
| 205R02583 | 5/13/15 | <0.04 | <0.04 | No |
| 205R02670 | 5/18/15 | <0.04 | <0.04 | No |
| 204R01876 | 7/7/15 | <0.04 | 0.04 | No |
| 204R01951 | 7/7/15 | <0.04 | <0.04 | No |
| 205R00622 | 7/7/15 | 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 4-16 for those WY 2015 samples that exhibited statistically-significant toxicity.

The MRP Table 8.1 trigger criterion for water column toxicity stipulates "If toxicity results less than 50% of control results, repeat sample. If 2nd sample yields less than 50% of control results,

proceed to C.8.d.i." For the wet season sampling, sites 204R01876 and 204R01951 each exhibited statistically significant toxicity to *Hyalella azteca* survival, but only the latter site, 204R01951, was of a sufficient magnitude to indicate re-sampling. A sample for re-test was collected on April 7, 2015, and results confirmed the initial test results of statistically-significant toxicity to *H. azteca*.

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 4-16. Overall summary of WY 2015 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 Table 8.1 (Water) and Table H-1 (Sediment) Trigger Criteria |
|---|---|---|---|---|
| **Water** | | | | |
| 2/7/15 | *H. Azteca* | Acute (Survival) | 204R01876 | Not < 50% of Control |
| 2/7/15 | *H. Azteca* | Acute (Survival) | 204R01951 | < 50% of Control |
| 4/7/15 | *H. Azteca* | Acute (Survival) | 204R01951 | < 50% of Control |
| **Sediment** | | | | |
| NA | NA | NA | NA | NA |

## Sediment Chemistry Parameters

Sediment chemistry results are evaluated as potential stressors in three ways, based upon the following criteria from MRP Table H-1:

- Calculation of threshold effect concentration (TEC) quotients by analyte; determine whether site has three or more TEC quotients greater than or equal to 1.0;[18]
- Calculation of probable effect concentration (PEC) quotients for all analytes at a given site; determine whether site has mean PEC quotient greater than or equal to 0.5; and,
- Calculation of pyrethroid toxic unit (TU) equivalents as sum of TU equivalents for all measured pyrethroids; determine whether site has sum of TU equivalents greater than or equal to 1.0.

More detail is provided below on each of these three factors.

[18] Consistent with 2012 Regional UCMR (BASMAA 2013) interpretation, this analysis assumes that there is a typographical error in Table H-1 and that the criterion is meant to read, "3 or more chemicals exceed TECs".

For sediment chemistry results, Table 4-17 provides threshold effect concentration (TEC) quotients for all non-pyrethroid sediment chemistry constituents, calculated as the measured concentration divided by the TEC value, per MacDonald et al. (2000). This table also provides a count of the number of constituents that exceed TEC values for each site, as evidenced by a TEC quotient greater than or equal to 1.0.

For WY 2015 samples, the number of TEC quotients greater than or equal to 1.0 for each site ranges from a low of 2 to a high of 8, out of 27 constituents included in MacDonald et al. (2000). Two of three sites sampled in 2015 (204R01951 in Castro Valley and 205R00622 adjacent to Lake Elizabeth in Fremont) met the relevant trigger criterion from MRP Table H-1, which is interpreted to stipulate three or more constituents with TEC quotients greater than or equal to 1.0. Individual TEC quotients that fell above the 1.0 threshold included constituents from all analyte types measured, trace elements, PAHs, and OC pesticides.

Table 4-18 provides PEC quotients for all non-pyrethroid sediment chemistry constituents, and calculated mean values of the PEC quotients for each site. None of the sites sampled in WY 2015 met the MRP Table H-1 action criterion of a mean PEC greater than 0.5. The mean PEC quotients are shown graphically by site in Figure 4-12.

Table 4-19 provides a summary of the calculated toxic unit equivalents for the pyrethroids for which there are published LC50 values in the literature, as well as a sum of calculated toxic unit (TU) equivalents for each site. Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Therefore, the pyrethroid concentrations as reported by the lab were divided by the measured TOC concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid. The individual TU equivalents were then summed to produce a total pyrethroid TU equivalent value for each site. At all three of the sites sampled in WY 2015 (204R01876, 204R01951, and 205R00622), individual pyrethroid TU equivalents met the MRP Table H-1 action criterion with at least one TU quotient greater than or equal to 1.0; the pyrethroid generating TUs above 1 was bifenthrin (TU=2.1, 6.5, and 7.1 at 204R01876, 204R01951, and 205R00622, respectively). These results are shown graphically in Figure 4-13. Bifenthrin made up more than 60% of the sum TUs at 204R01876 and more than 80% of the sum TUs at 204R01951 and 205R00622.

Some of the calculated numbers for TEC quotients, PEC quotients, and pyrethroid TU equivalents 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.

**Table 4-17. Threshold Effect Concentration (TEC) quotients for WY 2015 sediment chemistry constituents. Bolded values indicate TEC quotient ≥ 1.0**

| Site ID | 204R01876 | 204R01951 | 205R00622 |
|---|---|---|---|
| Metals (mg/kg DW) | | | |
| Arsenic | 0.50 | 0.42 | 0.48 |
| Cadmium | 0.25 | 0.18 | 0.68 |
| Chromium | 1.11 | 0.41 | 0.83 |
| Copper | 0.82 | 0.70 | 0.66 |
| Lead | 0.23 | 2.51 | 0.45 |
| Mercury | 0.20 | 0.20 | 0.29 |
| Nickel | 2.51 | 1.06 | 1.63 |
| Zinc | 0.58 | 2.81 | 0.79 |
| PAHs (µg/kg DW) | | | |
| Anthracene | 0.03 | 0.35 | 0.09 |
| Fluorene | 0.02 | 0.10 | 0.02 |
| Naphthalene | 0.01 | 0.02 | 0.01 |
| Phenanthrene | 0.01 | 0.49 | 0.15 |
| Benz(a)anthracene | 0.02 | 0.38 | 0.09 |
| Benzo(a)pyrene | 0.01 | 0.54 | 0.35 |
| Chrysene | 0.01 | 1.20 | 0.44 |
| Fluoranthene | 0.00 | 0.47 | 0.12 |
| Pyrene | 0.01 | 0.51 | 0.32 |
| Total PAHs | 0.05 | 0.64 | 0.22 |
| Pesticides (µg/kg DW) | | | |
| Chlordane | 0.34 | 3.40 | 0.31 |
| Dieldrin | 0.34 | 0.32 | 0.34 |
| Endrin | 0.0.25 | 0.23 | 0.23 |
| Heptachlor Epoxide | 0.24 | 0.22 | 0.24 |
| Lindane (gamma-HCH) | 0.16 | 0.15 | 0.15 |
| Sum DDD | 0.31 | 1.37 | 0.30 |
| Sum DDE | 0.55 | 3.10 | 2.04 |
| Sum DDT | 0.40 | 0.36 | 0.37 |
| Total DDTs | 0.93 | 3.41 | 1.79 |
| Number of constituents with TEC quotient ≥ 1.0 | 2 | 8 | 3 |

**Table 4-18. Probable Effect Concentration (PEC) quotients for WY 2015 sediment chemistry constituents. Yellow highlighted cells indicate sites where mean PEC quotient ≥ 0.5 (trigger threshold per MRP Table H-1); bolded values indicate individual PEC quotients > 1.0.**

| Site ID | 204R01876 | 204R01951 | 205R00622 |
|---|---|---|---|
| **Metals (mg/kg DW)** | | | |
| Arsenic | 0.15 | 0.12 | 0.14 |
| Cadmium | 0.05 | 0.04 | 0.13 |
| Chromium | 0.43 | 0.16 | 0.32 |
| Copper | 0.17 | 0.15 | 0.14 |
| Lead | 0.06 | 0.70 | 0.13 |
| Mercury | 0.03 | 0.03 | 0.05 |
| Nickel | 1.17 | 0.49 | 0.76 |
| Zinc | 0.15 | 0.74 | 0.21 |
| **PAHs (µg/kg DW)** | | | |
| Anthracene | 0.00 | 0.02 | 0.01 |
| Fluorene | 0.00 | 0.02 | 0.00 |
| Naphthalene | 0.00 | 0.01 | 0.00 |
| Phenanthrene | 0.00 | 0.09 | 0.03 |
| Benz(a)anthracene | 0.00 | 0.04 | 0.01 |
| Benzo(a)pyrene | 0.00 | 0.06 | 0.04 |
| Chrysene | 0.00 | 0.16 | 0.06 |
| Fluoranthene | 0.00 | 0.09 | 0.02 |
| Pyrene | 0.00 | 0.07 | 0.04 |
| Total PAHs | 0.00 | 0.04 | 0.02 |
| **Pesticides (µg/kg DW)** | | | |
| Chlordane | 0.06 | 0.63 | 0.06 |
| Dieldrin | 0.01 | 0.01 | 0.01 |
| Endrin | 0.00 | 0.00 | 0.00 |
| Heptachlor Epoxide | 0.04 | 0.03 | 0.04 |
| Lindane (gamma-HCH) | 0.08 | 0.07 | 0.07 |
| Sum DDD | 0.05 | 0.24 | 0.05 |
| Sum DDE | 0.06 | 0.31 | 0.21 |
| Sum DDT | 0.03 | 0.02 | 0.02 |
| Total DDTs | 0.01 | 0.03 | 0.02 |
| Mean PEC Quotient | 0.10 | 0.16 | 0.10 |

**Table 4-19. Calculated pyrethroid toxic unit equivalents, WY 2015 sediment chemistry data. Yellow highlighted cells indicate sites where the sum of the pyrethroid TU equivalents is ≥ 1.0; bolded values indicate individual pyrethroid TUs > 1.0.**

| Pyrethroid | LC50 | 204R01876 | 204R01951 | 205R00622 |
|---|---|---|---|---|
| Bifenthrin, TOC-normalized | 0.52 | **2.07** | **6.51** | **7.10** |
| Cyfluthrin, TOC-normalized | 1.08 | 0.30 | 0.78 | 0.93 |
| Cypermethrin, TOC-normalized | 0.38 | 0.26 | 0.45 | 0.10 |
| Deltamethrin, TOC-normalized | 0.79 | 0.28 | 0.06 | 0.06 |
| Esfenvalerate, TOC-normalized | 1.54 | 0.03 | 0.09 | 0.03 |
| Lambda-Cyhalothrin, TOC-normalized | 0.45 | 0.16 | 0.05 | 0.26 |
| Permethrin, TOC-normalized | 10.83 | 0.04 | 0.13 | 0.09 |
| **Sum of Toxic Unit Equivalents per Site** | | **3.15** | **8.07** | **8.57** |

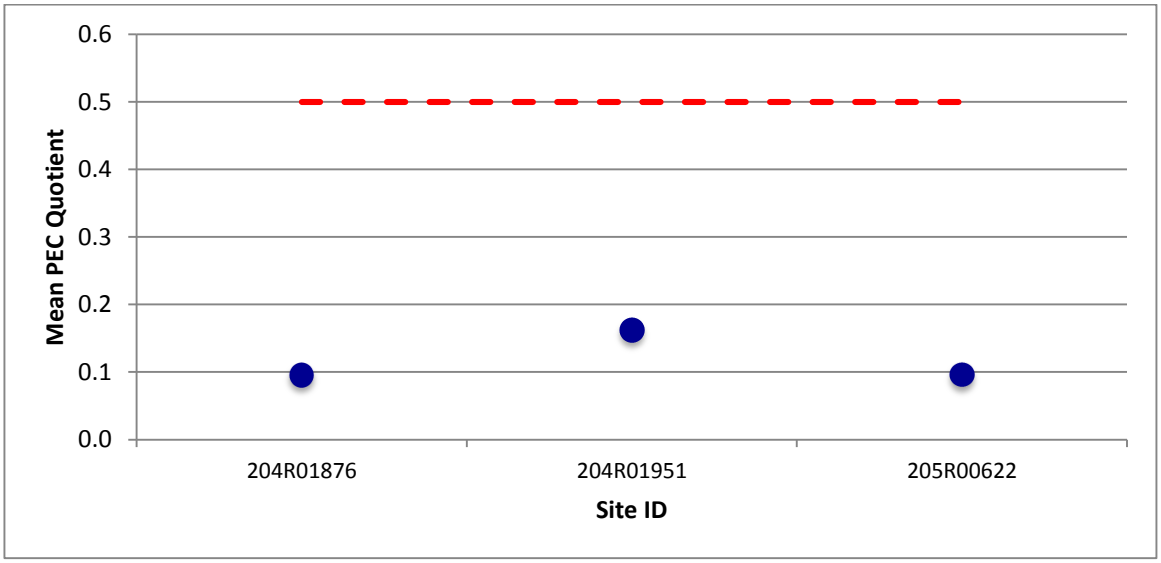


**Figure 4-12. Plot of mean PEC quotient per site, WY 2015 data. The dashed line indicates a threshold of 0.5 mean PEC quotient.**

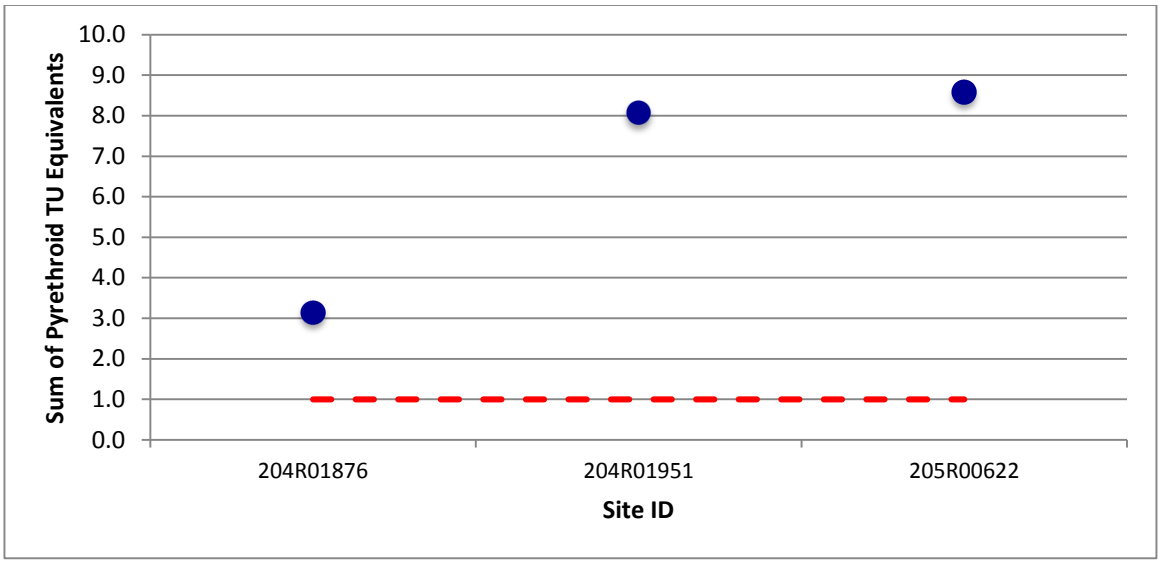


**Figure 4-13. Plot of the sum of pyrethroid toxic unit equivalents per site, WY 2015 data. The dashed line indicates a threshold of 1.0 TUs.**

## Sediment Triad Analysis

Table 4-20 summarizes stressor evaluation results for those sites with data collected for sediment chemistry, sediment toxicity and bioassessment parameters. Biological condition assessments are also shown for these sites based on the CSCI.

**Table 4-20. Summary of sediment quality triad evaluation results, WY 2015 data. Yellow highlighted cells indicate results above MRP trigger threshold.**

| Waterbody | Site ID | CSCI Condition Category | Sediment Toxicity | # TEC Quotients ≥ 1.0: | Mean PEC Quotient | Sum of TU Equiv. | Next Step per MRP Table H-1 |
|---|---|---|---|---|---|---|---|
| South San Ramon Cr | 204R01876 | Very Likely Altered | No | 2 | 0.10 | 3.15 | A |
| Castro Valley Cr | 204R01951 | Very Likely Altered | No | 8 | 0.16 | 8.07 | A |
| Mission Creek | 205R00622 | Very Likely Altered | No | 3 | 0.10 | 8.57 | A |

**Key to Next Steps:**

| Action Code | Exceeds Bioassessment/ Toxicity/ Chemistry Threshold | Next Step per MRP Table H-1 (selected) |
|---|---|---|
| **A** | Yes/No/Yes | (1) Identify cause of impacts.<br>(2) Where impacts are under Permittee's control, take management actions to minimize the impacts caused by urban runoff; initiate no later than the second fiscal year following the sampling event. |
| **B** | No/No/Yes | If PEC exceedance is Hg or PCBs, address under TMDLs. |
| **C** | Yes/Yes/Yes | (1) Identify cause(s) of impacts and spatial extent.<br>(2) Where impacts are under Permittee's control, take management actions to address impacts. |
| **D** | No/Yes/Yes | (1) Take confirmatory sample for toxicity.<br>(2) If toxicity repeated, attempt to identify cause and spatial extent.<br>(3) Where impacts are under Permittee's control, take management actions to minimize upstream sources. |

While MacDonald et al. (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 et al. 2000).

Additionally, MacDonald et al. (2000) TECs and PECs were generated with the assumption that the predictive ability of the thresholds would be acceptable if the prediction was correct 75% of the time. For the three samples collected by ACCWP in WY 2015, no samples exceeded the mean PEC criterion of 0.5. For the two samples that had more than three analytes exceed associated TECs, neither sample met the MRP threshold for toxicity. This is similar to triad results from previous WY sampling.

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). For the three samples analyzed by ACCWP in WY 2015, one fell within the uncertain category and two within the high mortality category. The uncertainty regarding the predictive ability of TU ratios can potentially be seen in the results where even the high mortality category samples were not associated with statistically-significant sediment toxicity.

# 5. Conclusions and Next Steps

During WY 2015, ACCWP monitored 22 sites under the RMC regional probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. Three sites were also 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.g.iv) 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); 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;

## 5.1 Summary of Stressor Analyses

The stressor analysis revealed the following potential stressors or stress conditions at WY 2015 sites:

- **Water Quality –** Of 11 parameters[19] sampled in association with WY 2015 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 22 sites monitored by ACCWP reporting herein for those three parameters, four chloride concentrations and two un-ionized ammonia concentrations exceeded the applicable water quality standard or threshold. The MRP Table 8.1 trigger thresholds for "Nutrients" (i.e., 20% of results in one waterbody exceed one or more water quality standards or applicable thresholds) was therefore exceeded at 5 of the 22 sites.[20]
- **Water Toxicity –** For WY 2015, 24 aquatic toxicity endpoints were derived through testing of 4 species at 3 sites county-wide during one wet season and one dry season event. Of these endpoints, two sample / test combinations exhibited statistically-significant toxicity as reported by the analytical laboratory (*H. azteca* survival at site 204R01951 and 205R00622 during wet season aquatic toxicity monitoring). One of these two samples (204R01951) exhibited toxicity with survival and/or growth "< 50% of Control," indicating re-testing per MRP Table 8.1. Follow-on testing at this site confirmed presence of statistically-significant toxicity for a subsequent precipitation event.
- **Sediment Toxicity –** Of the bedded sediment collected from 3 sites, no toxic response was observed.
- **Sediment Chemistry -** Results produced evidence of potential stressors in 2 ways, based on the criteria from MRP Table H-1: **(**1) at 2 of 3 sites, 3 or more constituents exhibited TEC quotients greater than 1.0[21] and (2) at 3 of 3 sites, the sum of TU equivalents for all measured pyrethroids was greater than or equal to 1.0. In relation to the third metric, at no site was the mean PEC quotient > 0.5.
- **Sediment Triad Analyses including bioassessment –** All triad sites showed significant biological community alteration, sediment chemistry and toxicity results were evaluated as

[19] Algal mass (ash-free dry weight), Chlorophyll a, Dissolved Organic Carbon, Ammonia, Nitrate, Total Nitrogen, Dissolved OrthoPhosphate, Phosphorus, Suspended Sediment Concentration, Silica and Chloride

20 Measurements of both un-ionized ammonia and chloride were above identified thresholds at one site.

21 For most sites, chromium and nickel concentrations in sediment exceeded TEC values. Considering that both metals are naturally occurring at relatively high levels in Bay Area soils, and concentrations generally exceed TEC values in reference or non-urban sites, TEC values presented in MacDonald et al. (2000) may not be applicable to the Bay Area. These observations should be considered in future evaluations of sediment chemistry data collected by RMC participants in Bay Area creeks.

the other two lines of evidence used in the triad approach for assessing overall stream condition, which provided mixed results.

## 5.2 Next Steps

MRP Table 8.1 requires bioassessment results to be evaluated for triggers as a triad along with results of sediment toxicity and chemistry according to the criteria in MRP Attachment H-1 as shown above. During WY2013, the RMC collaboratively reviewed trigger results from WY2012 and selected a total of ten sites in four counties for implementation of stressor/source identification (SSID) projects based on prioritization of the type, extent and geographic spread of the triggers. Technical studies for SSID projects are to be initiated by the second Fiscal Year following the year in which the potential stressor was identified. ACCWP's progress reports on an SSID projects in Dublin Creek (Appendix A.4A to IMR Part A) reviews bioassessment scores for three sites along an urbanization gradient within that watershed.

ACCWP and other RMC participants will continue to implement the regional probabilistic monitoring design in WY2016. Site evaluation is underway for new bioassessment sites for WY 2015. Candidate sites classified with unknown sampling status as of WY 2015 may continue to be evaluated for potential sampling in WY2016.

# 6. References

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.

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.

BASMAA 2013. Regional Urban Creeks Status Monitoring Report, Water Year 2012 (October 1, 2011 – September 30, 2012). 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 and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program.

BASMAA. 2014a. Creek Status Monitoring Program Standard Operating Procedures. Regional Monitoring Coalition Creek Status Monitoring Program Quality Assurance Project Plan. Version 2, January 2014. 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.

BASMAA. 2014b. 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. 203 pp.

Coleman, D., C. MacRae and E.D. Stein. 2005. Effect of increases in peak flows and imperviousness on the morphology of southern California streams. Technical Report 450. Southern California Coastal Water Research Project. Westminster, CA.

Fetscher, A.E, L. Busse, and P.R. Ode. 2009. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface

Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 002. (Updated May 2010)

Fetscher AE, Stancheva R, Kociolek JP, Sheath RG, Mazor RD, Stein ED, Ode PR, Busse LB. 2014. Development and comparison of stream indices of biotic integrity using diatoms vs. non-diatom algae vs. a combination. J Appl Phycology, Volume 26:433-450.

Herbst, D.B., and E.L. Silldorff. 2009. Development of a benthic macroinvertebrate index of biological integrity (IBI) for stream assessments in the Eastern Sierra Nevada of California. Sierra Nevada Aquatic Research Lab. Mammoth Lakes, CA Hill et al. 2000

Mazor, R.D., A. Rehn, P.R. Ode, M. Engeln, K. Schiff, E. Stein, D. Gillett, D. Herbst, C.P. Hawkins. In press. Bioassessment in complex environments: Designing an index for consistent meaning in different settings. Freshwater Science.

Ode, P.R. 2007. Standard Operating Procedures for Collection Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

Ode, P.R., T.M. Kincaid, T. Fleming and A.C. Rehn. 2011. Ecological Condition Assessments of California's Perennial Wadeable Streams: Highlights from the Surface Water Ambient Monitoring Program's Perennial Streams Assessment (PSA) (2000-2007). A Collaboration between the State Water Resources Control Board's Non-Point Source Pollution Control Program (NPS Program), Surface Water Ambient Monitoring Program (SWAMP), California Department of Fish and Game Aquatic Bioassessment Laboratory, and the U.S. Environmental Protection Agency.

Ode P.R., A.C. Rehn, and J.T. May. 2005. A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams. Environmental Management 35(4):493-504.

Rehn A.C., P.R. Ode, and J.T. May. 2005. Development of a Benthic Index of Biotic Integrity (B-IBI) for Wadeable Streams in Northern Coastal California and its Application to Regions 305(B) Assessment. Technical Report for the California State Water Quality Control Board. California Department of Fish and Game Aquatic Bioassessment Laboratory, Rancho Cordova, CA. available at http://www.SWRCB.CA.Gov/Water_Issues/Programs/Swamp/Docs/Reports/Final_North_Calif_Ibi.Pdf

Rehn, A.C., J.T. May and P.R. Ode. 2008. An Index of Biotic Integrity (IBI) for Perennial Streams in California's Central Valley. Report to the State Water Resources Control Board. California Department of Fish. Rancho Cordova, CA.

Rehn, A.C., R.D. Mazor and P.R. Ode. 2015. The California Stream Condition Index (CSCI): A new statewide biological scoring tool for assessing the health of freshwater streams. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) TM-2015-0002. September 2015.

Schuler, T. 2004. Urban Subwatershed Restoration Manual Series, No. 1: An integrated Framework to Restore Small Urban Watersheds. Version 1.0. Center for Watershed Protection. Ellicott City, Maryland. March 2004.

SFBRWQCB. 2009. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074 NPDES Permit No. CAS612008 October 14, 2009. 279 pp.

SFBRWQCB. 2012. The Reference Site Study and the Urban Gradient Study Conducted in Selected San Francisco Bay Region Watersheds in2008-2010 (Years 8 to 10). Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

SFBRWQCB. 2013. San Francisco Bay Basin (Region 2) Water Quality Control Plan. California Regional Water Quality Control Board, San Francisco Bay Region. 167 pp.

SFBRWQCB. 2015. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015.Southern California Coastal Water Research Project. 2012. Guide to evaluation data management for the SMC bioassessment program. 11 pp.

Southern California Stormwater Monitoring Coalition (SMC). 2007. Regional Monitoring of Southern California's Coastal Watersheds. 32 pp.

Stancheva, R., L.B. Busse, J.P. Kociolek, and R.G. Sheath. 2015. Standard Operating Procedures for Laboratory Processing, Identification, and Enumeration of Stream Algae. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 0003.

Stevens, D.L. Jr., and A.R. Olsen. 2004. Spatially Balanced Sampling of Natural Resources. Journal of the American Statistical Association 99(465): 262-278.

# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# CREEK STATUS MONITORING REPORT - TARGETED PARAMETERS

## APPENDIX A.2

## URBAN CREEKS MONITORING REPORT

## OCTOBER 2014 THROUGH SEPTEMBER 2015


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

MEMBER AGENCIES:

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

Protecting Alameda County Creeks, Wetlands & the Bay

# Acknowledgements

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 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) Reporting Provision C.8.g. The organization and formatting of this report derive in part from targeted Appendices for previous UCMRs.

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 2015 (October 1, 2014 through September 30, 2015) as part of the RMC's Monitoring Plan (BASMAA, 2011) for certain parameters monitored according to Provision C.8.c 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 pursuant to MRP Provision C.8 are reported in the main body and other appendices of ACCWP's UCMR for Water Year (WY) 2015.

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 Program Plan (QAPP; BASMAA, 2012a and 2014a) and BASMAA RMC Standard Operating Procedures (SOPs, BASMAA, 2012band 2014b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[1].

In accordance with the reissued MRP (MRP2, SFBRWQCB, 2015) ACCWP will also submit the data included in this report by March 31, 2016 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 to the outline of the initial Urban Creeks Monitoring Report (BASMAA 2013) and threshold trigger analyses conducted herein.

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

# 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 |
| 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 National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (MRP[2]). This report presents the 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 Targeted Appendix A.1[3] to the Urban Creeks Monitoring Report prepared to assist ACCWP member agencies in complying with the MRP Reporting Provision C.8.g.

The focus of ACCWP Targeted Creek Status Monitoring in Water Year 2015 (WY 2015) was the San Lorenzo Creek Watershed, including, the Castro Valley and Crow Creek tributaries. In addition, stream surveys were conducted in southern Alameda County. Overall targeted monitoring activities included:

- Continuous temperature monitoring at nine 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 two one- to two-week periods in Spring and late Summer/Fall;
- Pathogen indicator (*E. coli* and fecal coliform) quantification once at five sites, with follow-up monitoring at an additional four repeat or new monitoring locations; and
- Approximately 8.1 miles of stream surveys using the Center for Watershed Protection's protocol for Unified Stream Assessment.

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

**Continuous Temperature**

The temperature trigger described in the reissued MRP2 (SFBRWQCB 2015) 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 2015 temperature monitoring sites were in streams with COLD Beneficial use, and experienced at least

[2] 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 ("MRP2".

[3] Similar methods and QA/QC procedures are being implemented for Stressor-Source Identification (SSID) studies to investigate certain sites where WY2012 monitoring results indicated potential need for follow-up monitoring projects according to trigger criteria described in the MRP.

the two MWATs above 17.0°C but none exceeded the 24°C instantaneous maximum in 20% of the results.

### General Water Quality

Results of the General Water Quality assessment are presented in Table E-1. MWATs reached temperature triggers at all sites in summer but not in spring. Rolling 7-day averages for other parameters did not reach the 20% occurrence at threshold trigger levels in the MRP Table 8.1.

**Table E-1. Comparison of General Water Quality Observations to Trigger Thresholds at Sites 204CRW040, 204CRW042, 204CRW044 in WY 2015.**

| 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% | 5% | 0% |
| | Summer (3) | 3(0) | 0% | 0% | 0% | 0% | 0% |
| 204CRW042 | Spring (2) | 0(0) | 0% | 0% | 0% | 0% | 0% |
| | Summer (3) | 3(0) | 0% | 0% | 0% | 0% | 0% |
| 204CRW044 | Spring (2) | 0(0) | 0% | 0% | 0% | 0% | 0% |
| | Summer (3) | 3(0) | 0% | 0% | 0% | 0% | 0% |

### Pathogen Indicator Bacteria

Six of ten water samples collected at five sites on June 30, 2015 for pathogen indicators recorded elevated fecal coliform or *E.coli* concentrations of between 800 and 90,000 most probable number (MPN) per 100mL. Two out of eight of water samples collected at four sites on August 4, 2015 recorded elevated fecal coliform and *E.coli* concentrations in this range. The results are presented in Tables E-2 and E-3. Actual creek contact at most of these sites is sporadic at best and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard being used for comparison. 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.

**Table E-2: Comparison of WY 2015 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP June 30, 2015 FIB Monitoring.**

| Site ID | Site Description | Creek Name | Fecal Coliform (MPN*/100mL) | *E. coli* (MPN*/100 mL) |
|---|---|---|---|---|
| 204CVY020 | Chabot Creek at Carlos Bee Park | Chabot Creek | **1,300** | **1,300** |
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | Castro Valley Creek | **90,000** | **90,000** |
| 204CVY120 | Castro Valley Creek Park at Castro Valley Library | Castro Valley Creek | **24,000** | **24,000** |
| 204CVY150 | Castro Valley Creek North side of Heyer Ave | Castro Valley Creek | **800** | **800** |
| 204CVY170 | Castro Valley Creek north side of Seaview Ave | Castro Valley Creek | **800** | **800** |
| | | | | |

*Most Probable Number per 100mL
**BOLD** font indicates result meets trigger conditions.

**Table E-3: Comparison of WY 2015 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP August 4, 2015 Follow-up FIB Monitoring.**

| Site ID | Site Description | Creek Name | Fecal Coliform (MPN*/100mL) | *E. coli* (MPN*/100 mL) |
|---|---|---|---|---|
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | Castro Valley Creek | 80 | 80 |
| 204CVY084 | Castro Valley Creek south side of Grove Way | Castro Valley Creek | **17,000** | **17,000** |
| 204CVY090 | Castro Valley Creek east side of Redwood Rd | Castro Valley Creek | 500 | 500 |
| 204CVY125 | Castro Valley Creek under Castro Valley Blvd | Castro Valley Creek | **8,000** | **8,000** |
| | | | | |

*Most Probable Number per 100mL

**Stream Survey**

The overall instream habitat scores ranged by reach from 20 to 54. Agua Fria reaches had the highest average score of 44, with the most natural creek mileage and more optimal instream habitat. The highly modified reaches of Line 5-K-1 and Line 6-B had the lowest average scores of 24 and 25, respectively, with poor instream habitat complexity, sparse bank vegetation, and deeply entrenched streams. Toroges Creek also was also characterized by a relatively low average instream habitat score of 27, with poor instream habitat complexity and sparse bank vegetation. However, the Toroges Creek reaches exhibited less erosion than those on Line 5-K-1 and Line 6-B.

**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 results "trigger" a potential Stressor/Source Identification monitoring project as described in the permit[4]. The following trigger conditions were identified:

- Temperature

- Sixteen of eighteen water samples analyzed for pathogen indicators were above trigger levels for lightly and moderately used REC1 beneficial use, although limited public accessibility at many sites make human usage much less likely to produce the exposure risks assumed in developing the water quality criteria used for reference.

Where triggers or potential trigger conditions have been identified in WY 2015 results, ACCWP will work with local stormwater managers to identify appropriate follow-up activities.

[4] To facilitate planning and selection of potential follow-up Stressor/Source Identification (SSID) Projects, where feasible stressor assessment was conducted according to the trigger criteria in MRP2 Provision C.8.d, where different from those listed in Table 8.1 of the MRP1. See main UCMR Table x for numbering of C.8 Monitoring provisions in MRP1 vs. MRP2.

# 1 Introduction

This report fulfills a portion of the reporting requirements of Provision C.8.g.v of the Bay Area Municipal Regional Stormwater Permit (MRP[5]) for creek status monitoring data produced pursuant to MRP Provision C.8.c during Water Year (WY) 2015 (October 1, 2014 - September 30, 2015) under a targeted (non-probabilistic) monitoring design. Additional ProvisionC.8.c data 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 and MRP Permittees listed in Table 1-1. The RMC's focus is developing and implementing a regionally coordinated water quality monitoring program to address water quality monitoring required by the MRP[6]. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan allows 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.

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 reporting.

[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 specifically noted otherwise all references in this report to MRP provisions refer to SFBRWQCB 2009.

[6] The BASMAA programs supporting RMC Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities. 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 SF Bay 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.g.v in the and presents the results of the portions of Creek Status Monitoring that were conducted to comply with Provision C.8.c (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 Parameters Monitored in Compliance with MRP Provision C.8.c. and the associated design approach and Appendix of the ACCWP UCMR.**

| 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 | X | | Appendix A.1 |
| Water Toxicity | X | | Appendix A.1 |
| Sediment Toxicity | X | | Appendix A.1 |
| Sediment Chemistry | X | | Appendix A.1 |
| General Water Quality | | X | Appendix A.2 |
| Temperature | | X | Appendix A.2 |
| Bacteria | | X | Appendix A.2 |
| Stream Survey | | 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).

# 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 rivers 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 2015, ACCWP's targeted monitoring focused on two areas:

- San Lorenzo Creek watershed, including tributaries Crow and Castro Valley Creeks, were monitored for temperature, General Water Quality, and Pathogen Indicators.
- Stream surveys were conducted on several creeks and channels in multiple watersheds in southern Alameda County.

Watersheds were chosen from those not previously surveyed, considering accessibility of creek and channels and management issues and stakeholder concerns as described in the sections below.

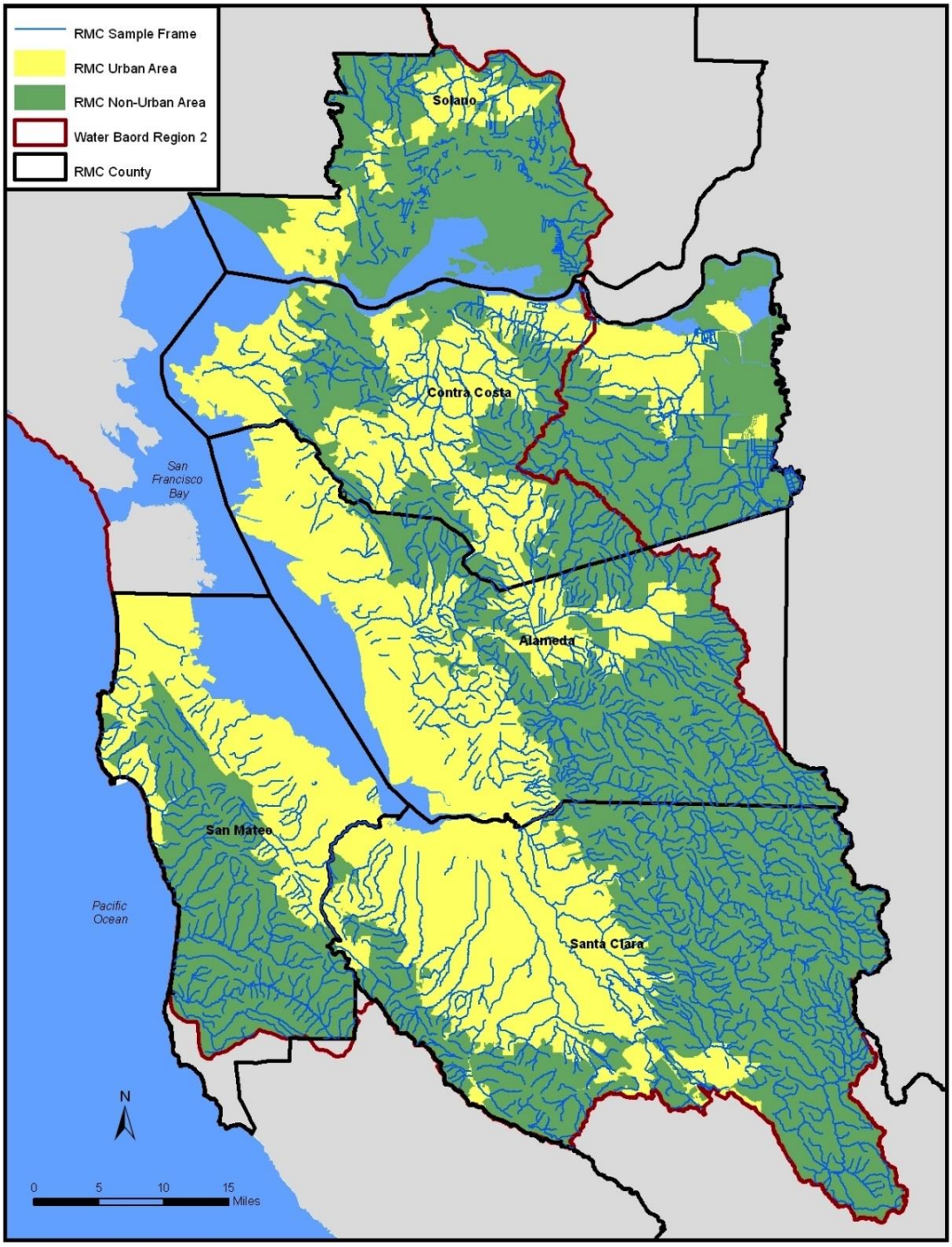



**Figure 2-1. Map of BASMAA RMC Area and Major Creeks.**

## 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. Within the watershed are over 81 linear 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. Table 2-1 shows the Beneficial Uses assigned to these creeks in the Basin Plan (SFBRWQCB 2015b).

**Table 2-1. Selected Beneficial Uses Assigned to Subwatersheds of San Lorenzo Creek Monitored in Water Year 2015.**

| Creek | COLD | MIGR | WARM, WILD | REC-1, REC2 |
|---|---|---|---|---|
| San Lorenzo Creek | X | X | X | X |
| Castro Valley Creek, including Chabot | 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 (Figure 2-3). Based on General Water Quality monitoring results in WY2012, a Stressor-Source ID project was initiated for low Dissolved Oxygen (DO) in Crow Creek during the summer.

### 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.

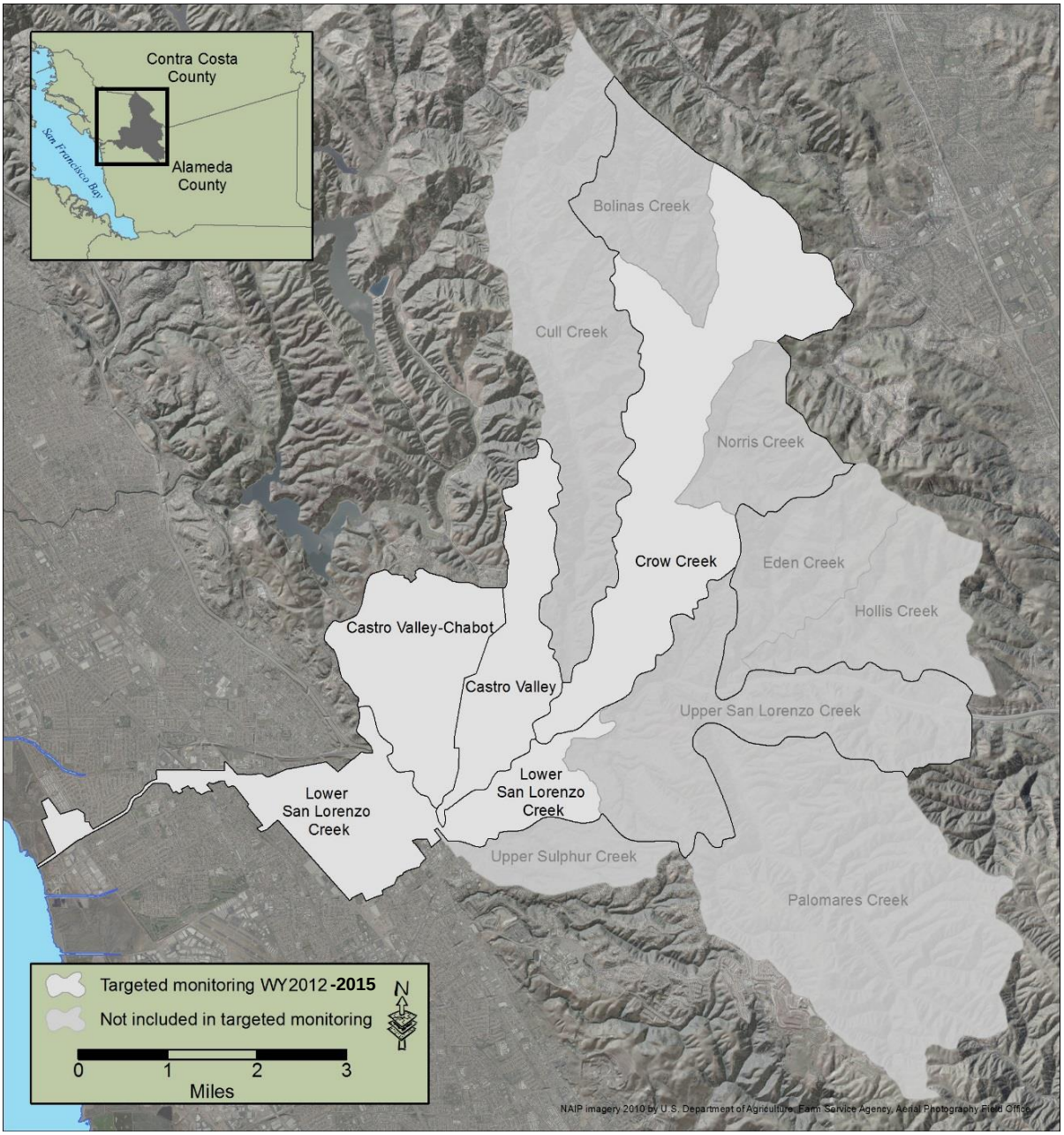



**Figure 2-2. Map of the San Lorenzo Creek Watershed and Major Subwatersheds.**

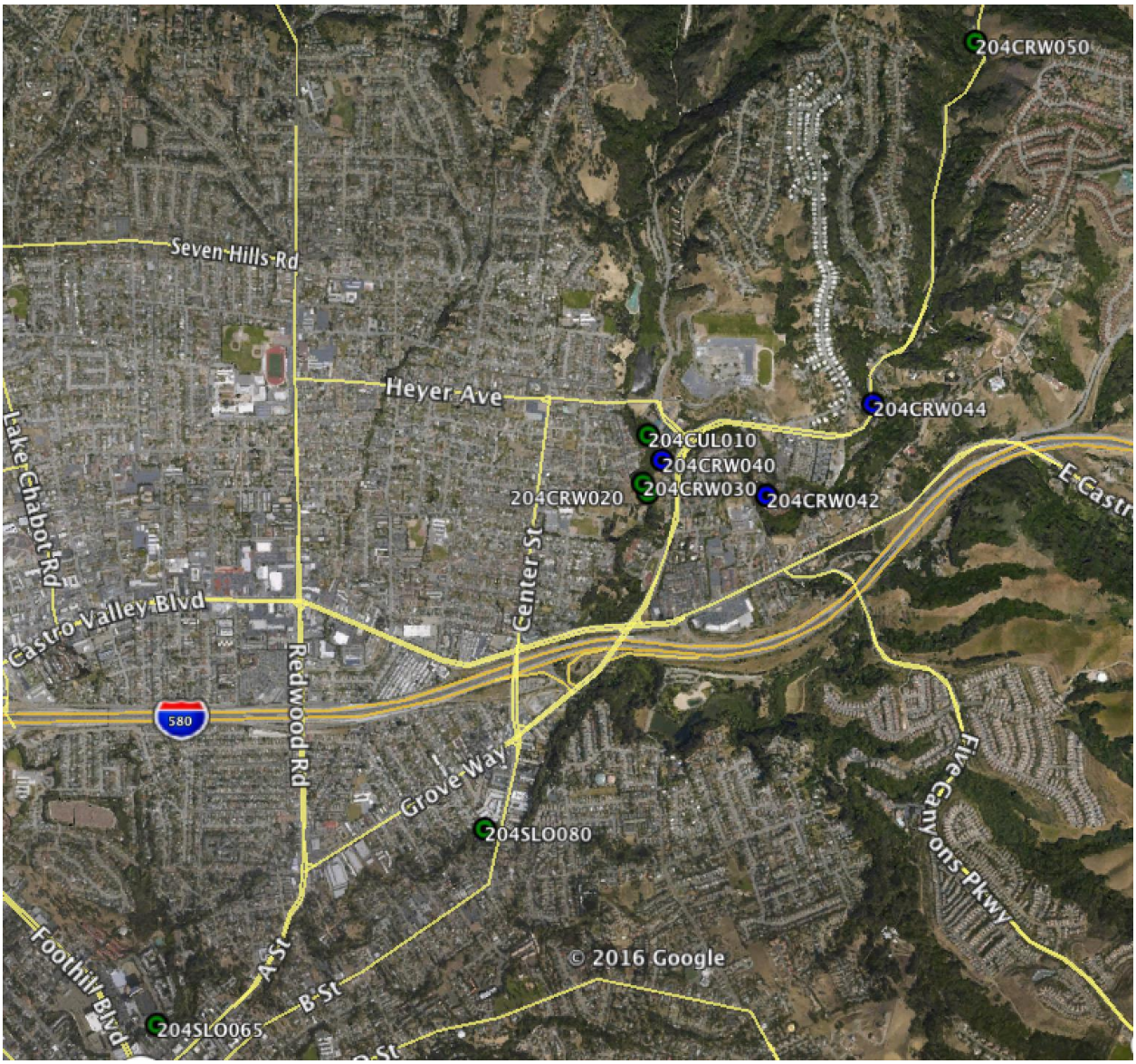



**Figure 2-3. Temperature and General Water Quality Monitoring Locations in San Lorenzo, Castro Valley, and Crow Creeks in Water Year 2015 (temperature-only sites shown in green, General Water Quality sites shown in blue).**

## Southern Alameda County Creeks

All surveyed creek segments were located in southern Alameda County including portions of the Lower Alameda Creek and Agua Fria watersheds. The Crandall Creek watershed is a 6.5 $mi^2$ area of Fremont that drains into the tidal portion of Alameda Creek and contains mostly engineered channels including Line 5-K-1. The Dry Creek watershed is a 9.9 $mi^2$ area of Union City, containing mostly natural creek segments above a small urbanized tributary area. Agua Fria drains

an 8 $mi^2$ watershed which includes portions of Fremont and unincorporated Alameda County; the lowest reaches of Agua Fria receive flow from Toroges Creek, Lines 6-B and 6-B-1 as well as other unnamed channels before discharging into Coyote Slough at the southern end of San Francisco Bay.

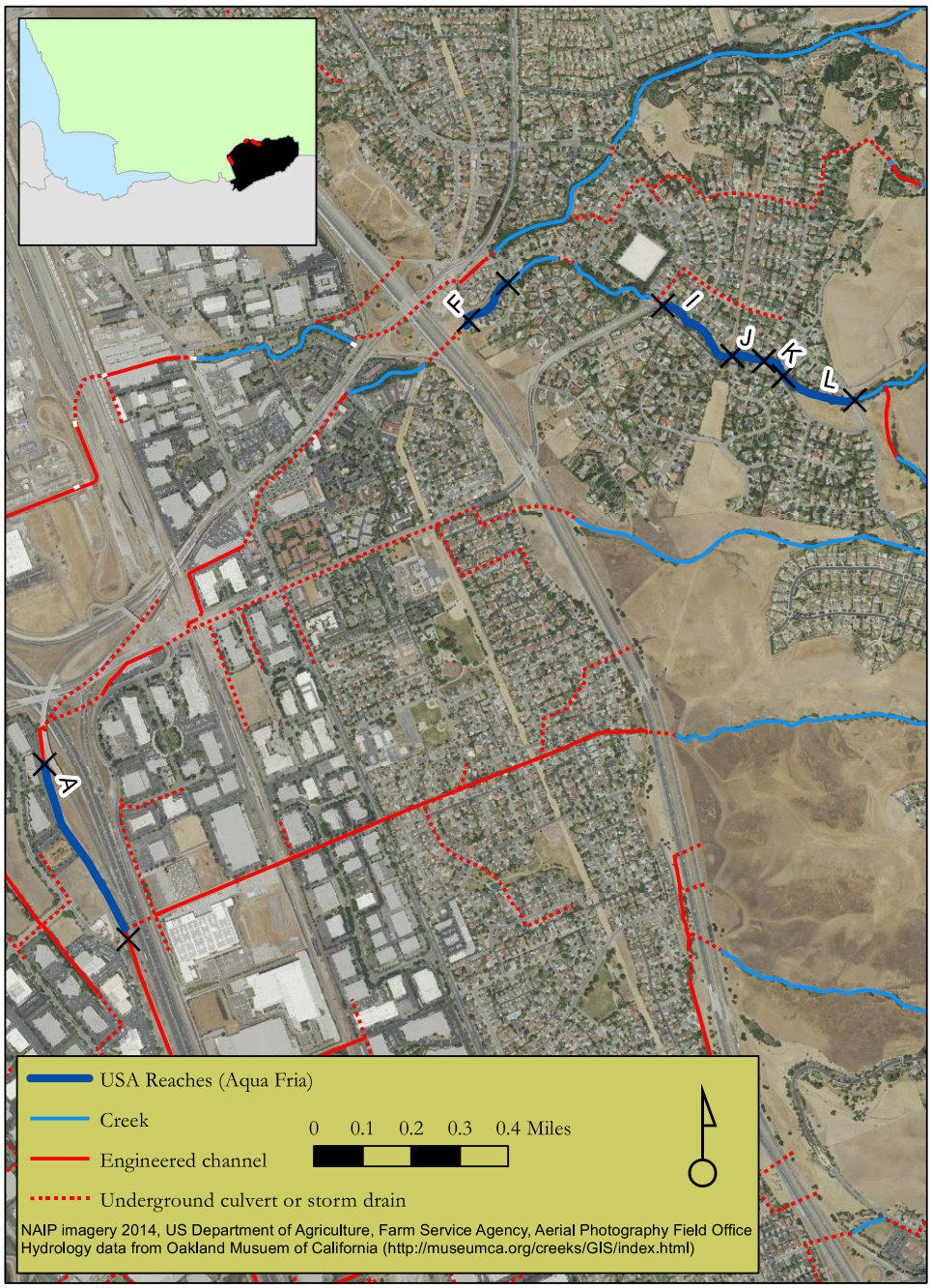



**Figure 2-4. 2015 Surveyed Reaches in Agua Fria**

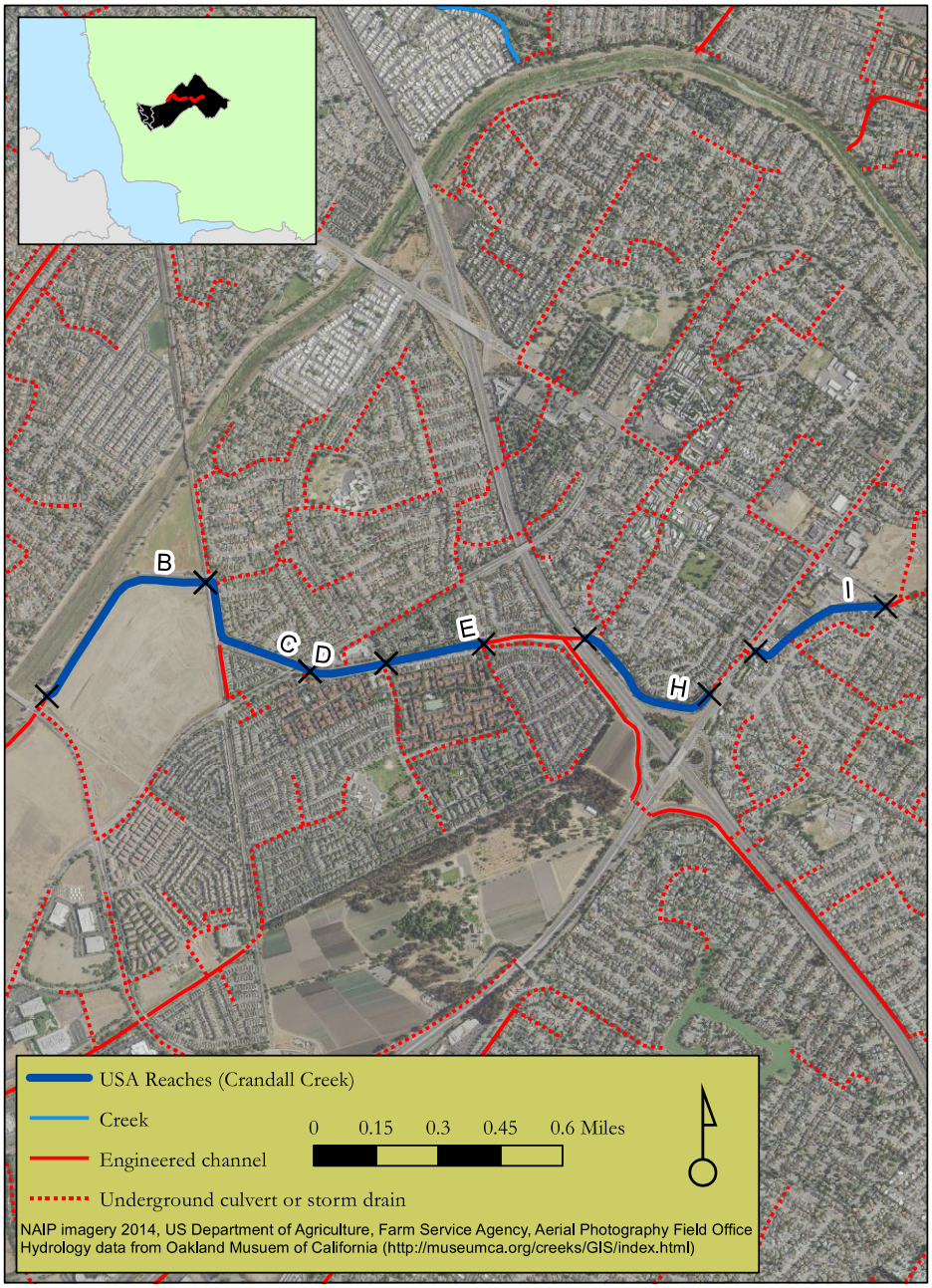



**Figure 2-5. 2015 Surveyed Reaches in Crandall Creek**

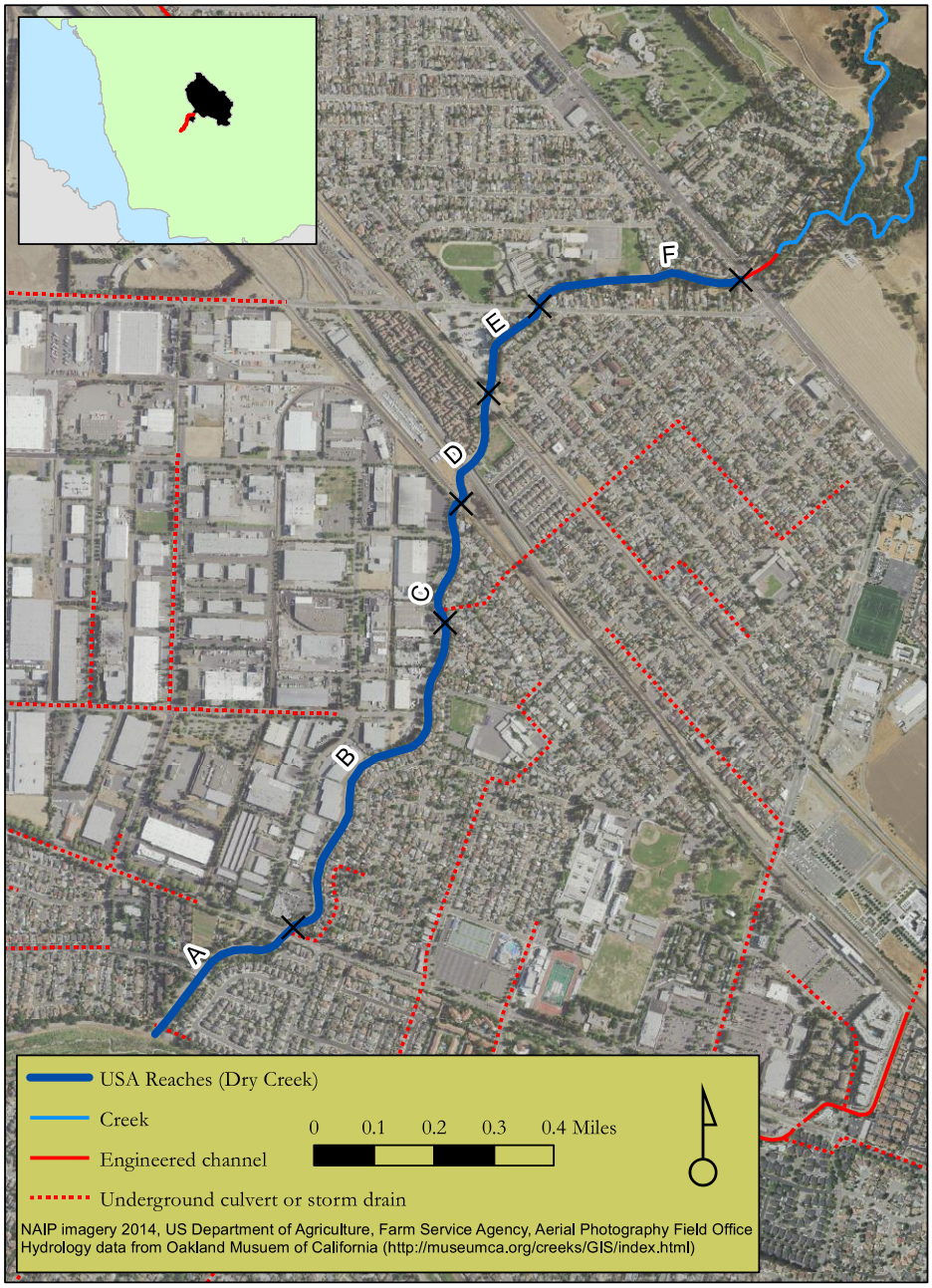



**Figure 2-6. 2015 Surveyed Reaches in Dry Creek**

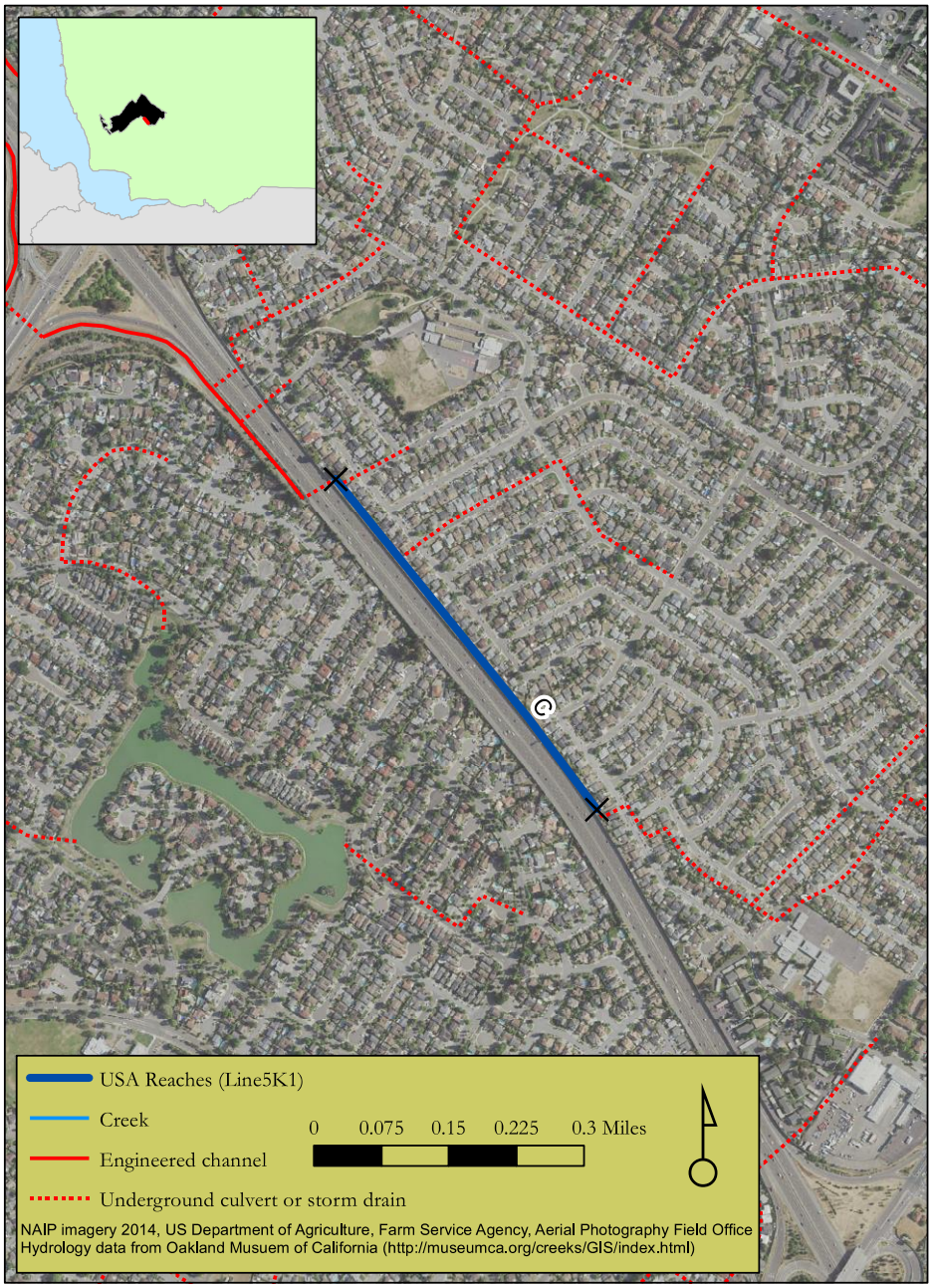



**Figure 2-7. 2015 Surveyed Reaches in Line 5-K-1**

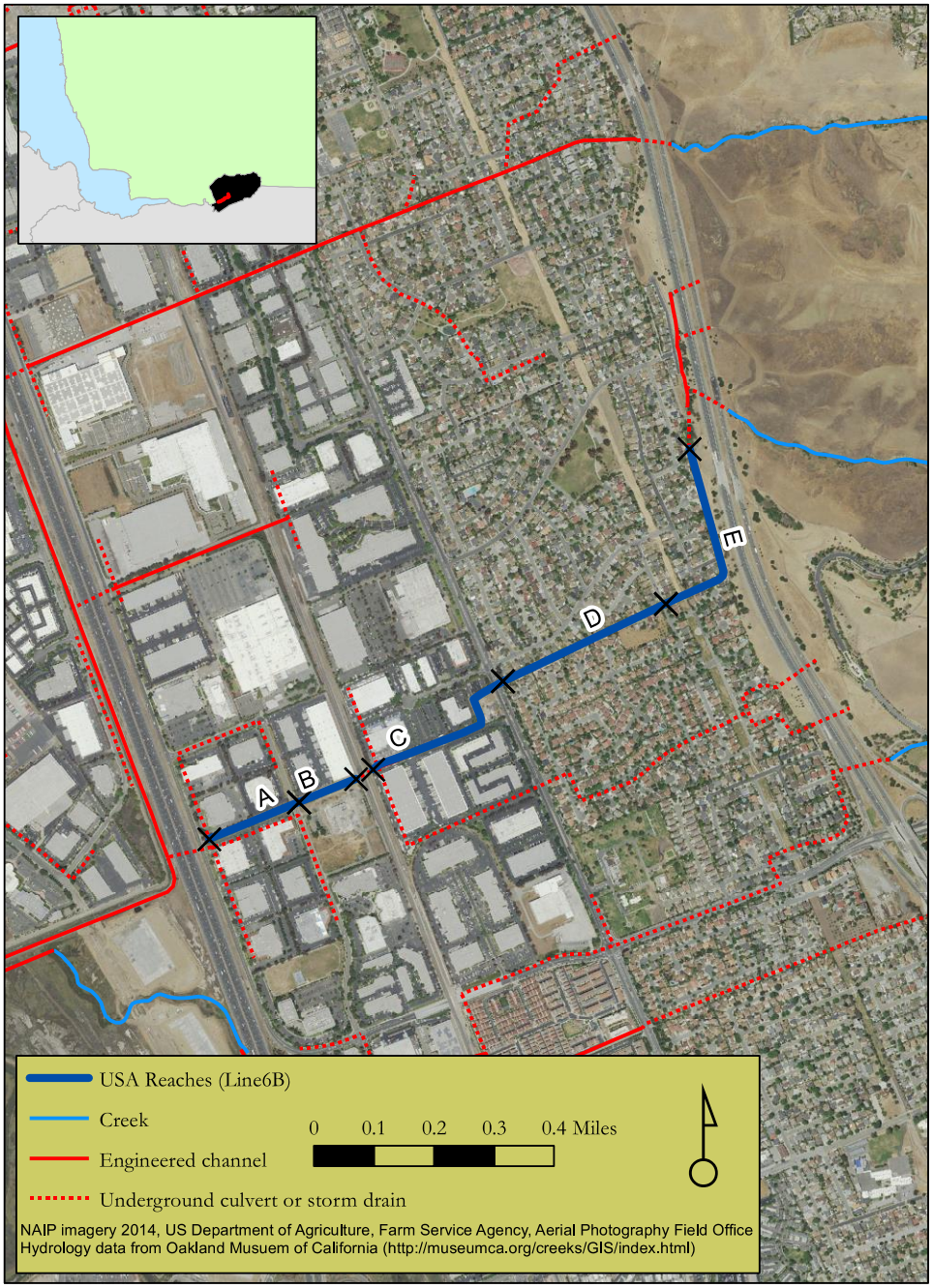



**Figure 2-8. 2015 Surveyed Reaches in Line 6-B**

**Figure 2-9. 2015 Surveyed Reaches in Line 6-B-1**

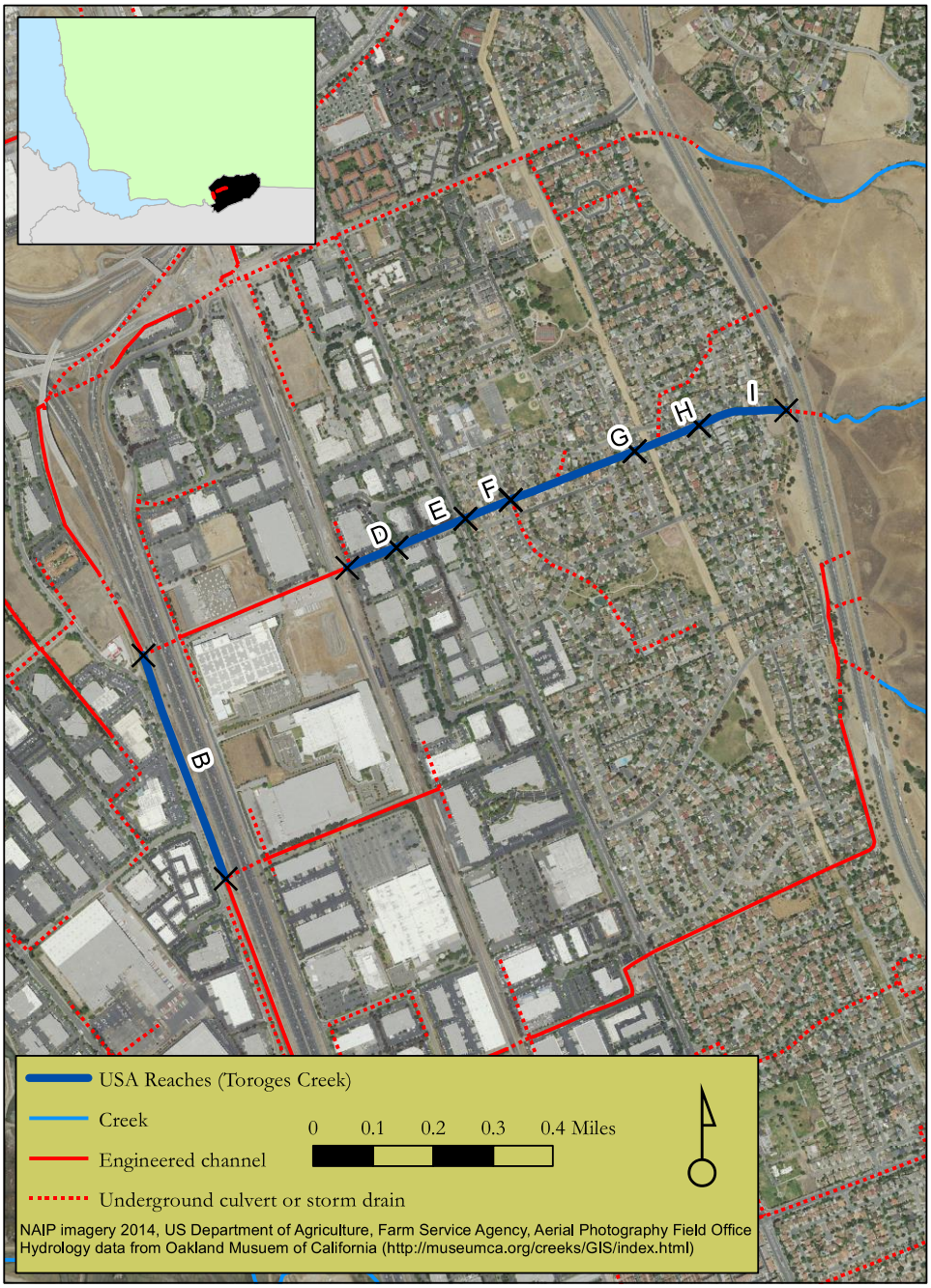



**Figure 2-10. 2015 Surveyed Reaches in Toroges Creek**

## 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 2015 including:

- Nine Continuous Water Temperature monitoring locations;[8]
- Three General Water Quality monitoring locations;
- Nine Pathogen Indicator monitoring locations;[9] and

Thirty-two Stream Survey Reaches were also monitored encompassing approximately 8.1 creek miles (See Section 4.5 for listing). The required average annual minimum of 9 creek miles was maintained when WY 2015 effort was combined with surveyed reaches from the previous WYs.

[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 than the required 8 to account for potential loss or creek drying out.

9 Includes initial tests plus follow-up

## Table 2-2. Summary of Targeted Monitoring Locations and Parameters for Water Year 2015 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 | 204CRW020 | Crow Creek near Earl Warren Park | 37.70008 | -122.05542 | | X | |
| Crow Creek | 204CRW030 | Crow Creek below confluence with Cull Creek | 37.70046 | -122.05567 | | X | |
| Crow Creek | 204CRW040 | Crow Creek, concrete channel segment below confluence with Cull Creek | 37.70143 | -122.05467 | | X | |
| | | | 37.70140 | -122.05470 | | | Spring |
| | | | 37.70132 | -122.05463 | | | Summer |
| Crow Creek | 204CRW042 | Crow Creek below Norris, approximately 200m above 204CRW50 | 37.69996 | -122.0492 | | X | |
| | | | 37.69996 | -122.04922 | | | Spring |
| | | | 37.70092 | -122.04928 | | | Summer |
| Crow Creek | 204CRW044 | Crow Creek near mile 1.1 on Crow Canyon Rd | 37.70379 | -122.04363 | | X | |
| | | | 37.70430 | -122.04359 | | | Spring |
| | | | 37.70449 | -122.04364 | | | Summer |
| Crow Creek | 204CRW050 | Crow Creek at Crow Creek HOA | 37.71864 | -122.03839 | | X | |
| Cull Creek | 204CUL010 | Cull Creek | 37.70247 | -122.05541 | | X | |
| San Lorenzo Creek | 204SLO065 | San Lorenzo Creek at 2nd St | 37.67790 | -122.08132 | | X | |
| San Lorenzo Creek | 204SLO080 | San Lorenzo Creek below Center St | 37.68609 | -122.06401 | | X | |
| Castro Valley Creek | 204CVY020 | Chabot Creek at Carlos Bee Park | 37.68187 | -122.08082 | X | | |
| Castro Valley Creek | 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | 37.68182 | -122.08047 | X | | |
| Castro Valley Creek | 204CVY084 | Castro Valley Creek south side of Grove Way | 37.68414 | -122.07565 | X | | |
| Castro Valley Creek | 204CVY090 | Castro Valley Creek upstream of Redwood Rd | 37.68778 | -122.07286 | X | | |
| Castro Valley Creek | 204CVY120 | Castro Valley Creek at Castro Valley Library | 37.69297 | -122.07166 | X | | |
| Castro Valley Creek | 204CVY125 | Castro Valley Creek south of Castro Valley Blvd. | 37.69505 | -122.07245 | X | | |
| Castro Valley Creek | 204CVY150 | Castro Valley Creek north of Heyer Ave. | 37.70462 | -122.06915 | X | | |
| Castro Valley Creek | 204CVY170 | Castro Valley Creek north of Seaview Ave. | 37.71159 | -122.06359 | 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. For WY 2015, a predominant criterion was that the streams have COLD beneficial use designation for which these parameters are important indicators. Based on available historical data for the San Lorenzo Creek watershed, simple temperature monitoring was chosen for the less urbanized portions of Crow Creek to complement the shorter-duration water quality monitoring in more urbanized reaches in Castro Valley and Oakland.

In choosing sampling sites for WY2014, ACCWP included several Crow Creek sites to assist with SSID follow-up (see Appendix A.4C to the main UCMR), and otherwise focused on Oakland watersheds with as many as possible of the following attributes:

- Significant natural resource quality, combined with COLD beneficial use; and
- Known or likely areas of perennial flow.

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 provide more intra-annual characterization of sites previously monitored for either or temperature alone. A new site above 204CRW040 was also selected to support the SSID follow-up by characterizing summertime DO conditions upstream of inputs from the urban storm drain system. However DO monitoring at this site was unsuccessful in the summer-fall deployment due to equipment failure.

Other considerations in site selection included:

- Opportunities to compare different tributaries or portions of the main stem above and below tributary or storm drain inputs;
- Public access to portions of the creek; and
- Stewardship interest by active creek groups or municipal/institutional managers

**Pathogen Indicators**

In WY 2015, five pathogen indicator sampling sites were distributed along an approximately 4 km segment of Castro Valley Creek. Castro Valley is an urban watershed and several of the Castro Valley Creek reaches have public access.

**Stream Survey**

Surveyed reaches in WY 2015 targeted several watersheds in Southern Alameda County, as described below.

# 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 2014a) and Standard Operating Procedures (SOP) (BASMAA 2014b), 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.

[10] Available at://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/qaprp082209.pdf

**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 |
| N/A | Unified Stream Assessment: A User's Manual, v2.0 |

## 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 10$^{th}$, 2015; eight of the nine maintained units were found submerged and in good condition. One site required additional activity at this time:

- 204CRW040 – The unit would not download and was replaced.

**Table 3-2. Water Year 2015 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 |
|---|---|---|---|---|---|---|
| 204CRW020 | Crow Creek near Earl Warren Park | 37.70012 | -122.05506 | April 30 | July 10 | October 14 |
| 204CRW030 | Crow Creek below confluence with Cull Creek | 37.70056 | -122.055 | April 30 | July 10 | October 14 |
| 204CRW040 | Crow Creek, concrete channel segment below confluence with Cull | 37.7013 | -122.05468 | April 30 | July 10 | October 14 |
| 204CRW042 | Crow Creek below Norris, approx 200m above 204CRW50 | 37.70004 | -122.0492 | May 15 | July 10 | October 14 |
| 204CRW044 | Crow Creek near mile 1.1 on Crow Canyon Rd | 37.704415 | -122.043693 | April 30 | July 10 | October 14 |
| 204CRW050 | Crow Creek at Crow Creek HOA | 37.7175 | -122.0375 | April 30 | July 10 | October 14 |
| 204CUL010 | Cull Creek | 37.7027 | -122.05539 | April 30 | July 10 | October 14 |
| 204SLO065 | San Lorenzo Creek at 2nd St | 37.67801 | -122.08066 | April 30 | July 10 | October 14 |
| 204SLO080 | San Lorenzo Creek below Center St | 37.686036 | -122.063593 | April 30 | July 10 | October 14 |

## 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 (

). 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 2015.**

| Site Code (RMC No) | Description | Deployment | Latitude | Longitude | Dates |
|---|---|---|---|---|---|
| 204CRW040 | Crow Creek at confluence with Cull (concrete section) | Spring | 37.70140 | -122.05470 | 5/6/15 to 5/15/15 |
| | | Summer-Fall | 37.70132 | -122.05463 | 8/3/15 to 8/17/15 |
| 204CRW042 | Approx 50 m upstream (south) of Crow Creek Rd. at first crossing | Spring | 37.69996 | -122.04922 | 5/15/15 to 5/27/15 |
| | | Summer-Fall | 37.70092 | -122.04928 | 8/17/15 to 9/2/15 |
| 204CRW044 | Downstream (east side) of culvert near mile 1.1 on Crow Canyon Rd. | Spring | 37.70430 | -122.04359 | 5/6/15 to 5/15/15 |
| | | Summer-Fall | 37.70449 | -122.04364 | 8/3/15 to 8/17/15 |

## Pathogen Indicators Sampling

Single samples were collected for pathogen indicator enumeration in accordance with the requirements of provision C.8.c 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 fecal coliform at five sites on June 30, 2015. At the initial sampling, conducted June 30, 2015 (Table 3-4), three of the five sites sampled exhibited unusually high turbidity levels. Turbid water was observed entering the creek from a culvert draining into Castro Valley Creek just downstream of the furthest most upstream sampling site. This issue was communicated to ACPWA and later inspected by ACPWA staff, by which time the discharge had ceased.

Based upon the findings of the initial monitoring, the ACCWP Program Coordinator authorized follow-up monitoring at five locations in Castro Valley Creek. Monitoring personnel conducted sampling on 8/4/2015, at which time the unusual flow pattern observed in June was not present and reaches exhibited low flow conditions. Samples were collected at four of the five target locations, with a single site not sampleable due to low flow conditions (Table 3-5).

**Table 3-4. Pathogen Indicator Monitoring at Alameda County Targeted Monitoring Locations, June 30, 2015.**

| Site Code | Description | Latitude | Longitude |
|---|---|---|---|
| 204CVY020 | Chabot Creek at Carlos Bee Park | 37.68189 | -122.08083 |
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | 37.68237 | -122.07858 |
| 204CVY120 | Castro Valley Creek Park at Castro Valley Library | | |
| 204CVY150 | Castro Valley Creek at north h side of Heyer Ave. | 37.70462 | -122.06915 |
| 204CVY170 | Castro Valley Creek north side of Seaview Ave | 37.71159 | -122.06359 |

**Table 3-5. Follow-up Pathogen Indicator Monitoring at Alameda County Targeted Monitoring Locations, August 4, 2015.**

| Site Code | Description | Latitude | Longitude |
|---|---|---|---|
| 204CVY020 | Chabot Creek at Carlos Bee Park | 37.68189 | -122.08083 |
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | 37.68237 | -122.07858 |
| 204CVY084 | Castro Valley Creek south side of Grove Way | 37.68414 | -122.07565 |
| 204CVY090 | Castro Valley Creek east side of Redwood Rd | 37.68778 | -122.07286 |
| 204CVY125 | Castro Valley Creek under Castro Valley Blvd | 37.69458 | -122.07241 |

## Stream Surveys

Field crews conducted stream surveys using the *Unified Stream Assessment: A User's Manual* (Center for Watershed Protection, 2005) with data forms modified by SCVURPPP to better reflect conditions in urbanized streams (SCVWD, 2005). The Unified Stream Assessment (USA) uses visual observations and limited measurements taken during a continuous walk of accessible portions of the targeted creek corridor to rapidly evaluate creek conditions, problems, and opportunities for improvement within the urban creek corridor.

In order to increase survey efficiency and be consistent with previous investigations performed for the ACCWP (e.g., EOA 2006), minor modifications were made to the standard USA protocol in the way in which assessed information was recorded. Modified versions of several impact forms were used when less detailed data were needed for the purposes of the assessment. For example, in place of using a separate sheet to record each occurrence of an outfall, stream crossing, and utility within a reach, field crews compiled information for multiple occurrences of these on a single form.

The USA protocol includes separating the creek corridor into survey reaches. Each reach represents a relatively uniform set of conditions within the creek corridor. Factors that contribute to delineating a reach include land use in the immediate vicinity, elevation, creek order, access, and total length. In this study, reaches were identified and delineated by the ACCWP Program

Coordinator, began and ended at major creek crossings or grade changes. Creek sections that were inaccessible (due to factors such as culverts, vegetation, or access permission not granted) were not assessed.

A single overall reach assessment was conducted for each reach. The reach level assessment qualitatively evaluated characteristics such as base flow, dominant substrate, water clarity, biota, shading, and active channel dynamics. In addition, each reach was ranked for overall creek condition and overall buffer and floodplain condition based on eight subcategories:

- instream habitat;
- vegetative protection;
- bank erosion;
- floodplain connection;
- vegetated buffer width;
- floodplain vegetation, floodplain habitat; and
- floodplain encroachment.

Each subcategory was given a score on a 20-point scale. The subcategory scores were summed to give a total reach score ranging from zero (poor condition) to 160 (optimal condition).

Per the USA protocol, field datasheets were completed to identify within each reach the locations and general characteristics of seven potential creek impacts:

- erosion;
- channel modification;
- outfalls;
- creek crossings;
- trash/debris;
- utilities; and
- miscellaneous features.

All survey work was completed between September 29, 2015 and October 8, 2015.

## Quality Assurance/Quality Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA 2014a). 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 and general water quality data were plotted as box plots[11] for each site during each deployment.

The hourly water temperature measurements were calculated as daily arithmetic means over a 24-hour period from midnight to 11:00 PM. Using the specifications of MRP2 (SFRWQCB 2015) weekly average temperatures were calculated throughout the deployment from all data recorded for a seven-day, non-overlapping deployment period. Weekly averages for general water quality parameters were calculated in a similar fashion, although the frequency of measurements was

[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.

higher (15 minutes for general water quality vs. one hour for continuous temperature). By using the non-overlapping data averaging technique specified in MRP2, this limits the number of weekly averages for general water quality measurements to a maximum of two for a one- to two-week deployment. Where 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

Table 5-1, to determine whether results may "trigger" a potential stressor/source identification monitoring project (per MRP2 Provision 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, 2014a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2014b), 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, 2014a) and SOPs (BASMAA, 2014b). Results were

compiled for the qualitative metrics (representativeness and comparability), as well as the quantitative metrics (completeness, sensitivity [detection and quantization limits], precision, accuracy, and contamination). The following sections provide summaries of all pertinent data quality issues from the WY 2015 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:

- 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. At one site, 204CRW050, the creek had dried out completely between the time of maintenance and retrieval; data that are suspected to have been generated during this dry period have been assigned the qualifier of "FS" in the data deliverable (using a criterion of a 2º C change in a single hour to identify time of first "dry" datapoint). .
- Fecal indicator bacteria samples were collected at a total of nine locations, with the final four samples collected as a follow-up activity initiated by the results of the initial monitoring event.
- Approximately 8.1 miles were surveyed with the USA protocol, which brought the four-year total of surveyed reaches conducted by ACCWP during the first MRP permit term to just over 36 miles. This met the MRP required minimum of 9 miles per year.

### Non-detects – Reporting Limits Not Met

All QA/QC measures listed in the QAPP were met. There were no issues with non-detects reported.

### Precision Results

All QA/QC measures listed in the QAPP were met. There were no issues with precision. The indicator bacteria lab did not generate a sufficient number of duplicate samples to allow quantification of

### Accuracy Results

All QA/QC measures listed in the QAPP were met. There were no issues with accuracy as determined by controls for indicator bacteria analyses and by equipment calibrations and drift checks performed associated with use of continuous monitoring equipment.

### 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 2015 monitoring.

## 4.2 Continuous Water Temperature Monitoring

Data were collected over an approximately six-month period from April through September 2015 with measurements recorded at 60-minute intervals at the equivalent of nine sites, with one break in the record at site 204CRW050 due to dry conditions as noted above.

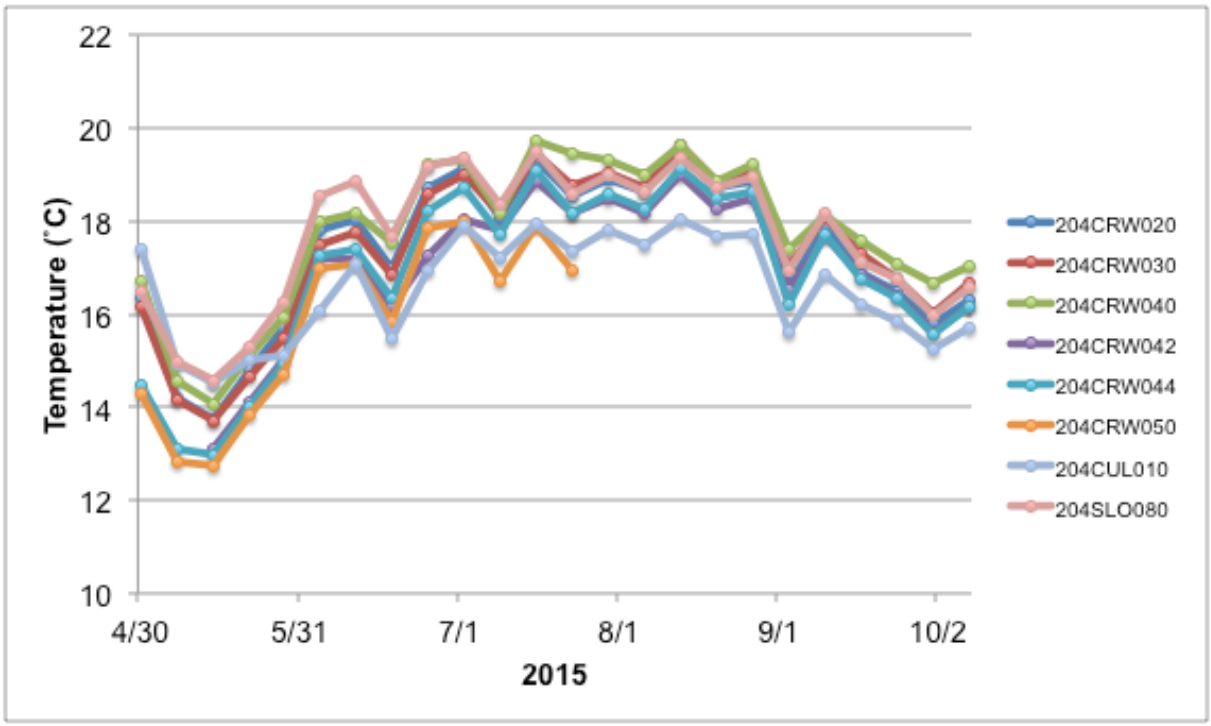


Figure 4-1 presents the results of the continuous monitoring results for WY 2015, and box plots of the temperature data are shown in

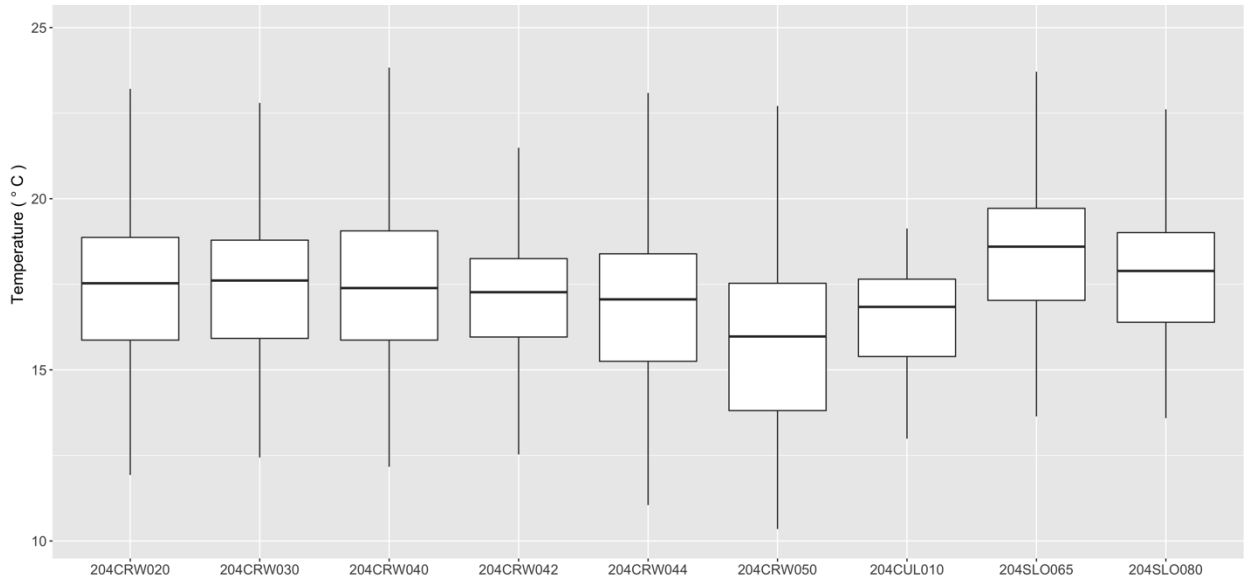



Figure 4-2.

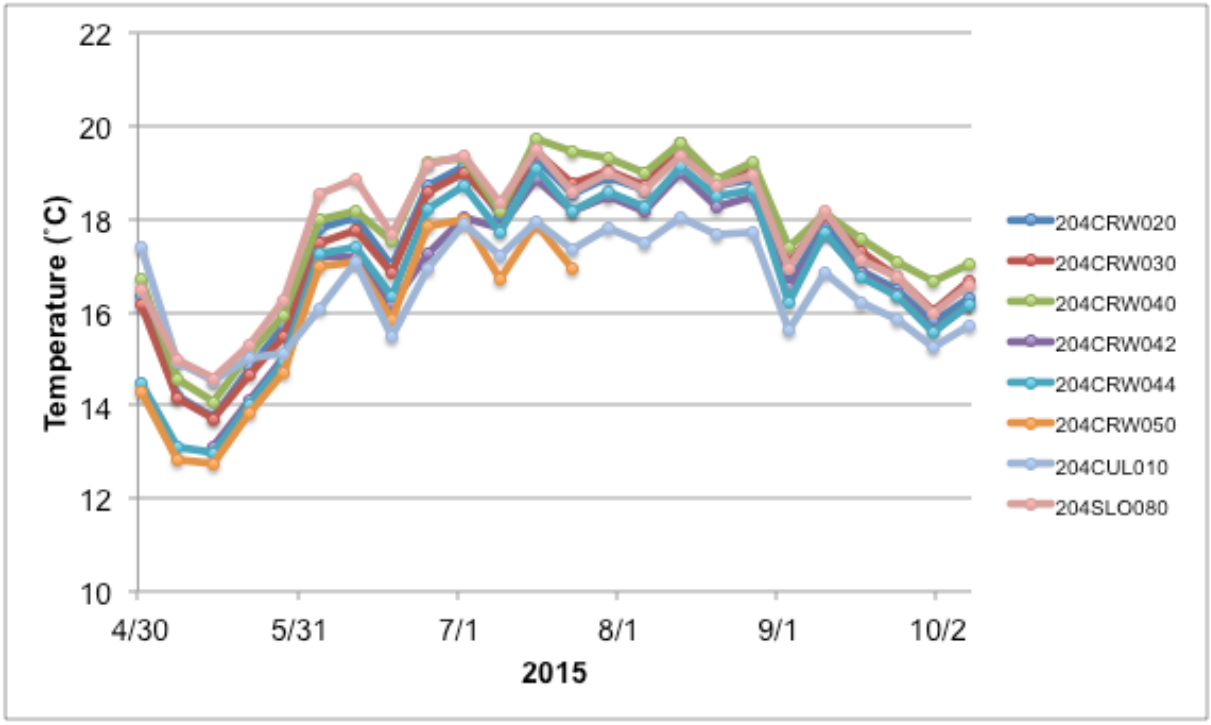


**Figure 4-1. Temperature (Discrete 7-Day Average) Line Graph at Crow Creek, Cull Creek, and San Lorenzo Creek Sites, April 30 through October 14, 2015.**

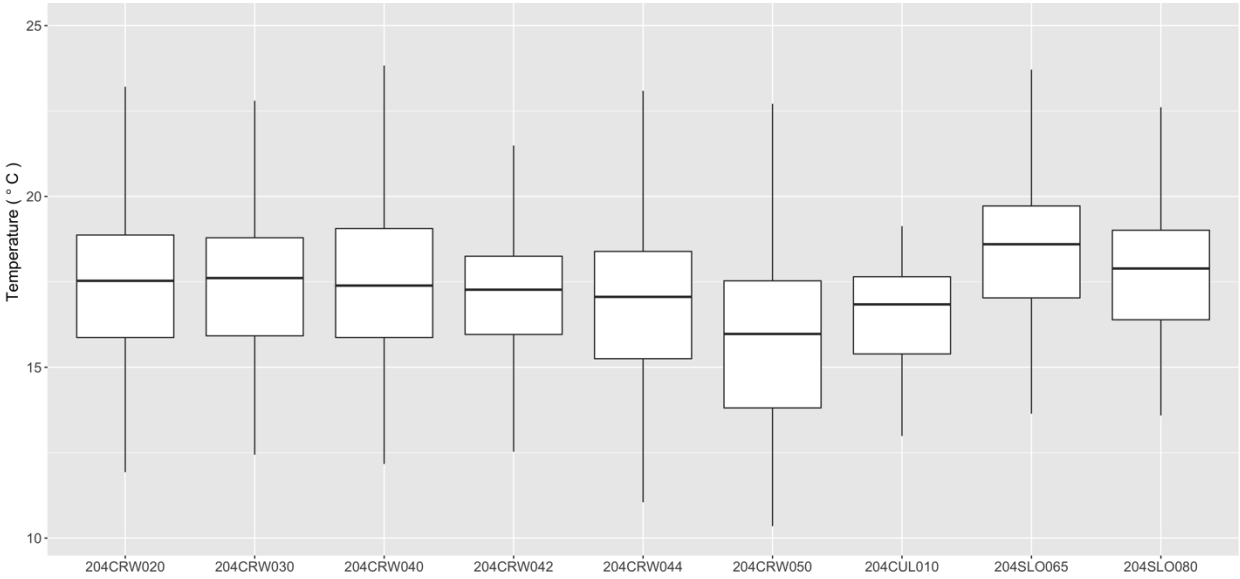



**Figure 4-2. Temperature Box Plot at Crow Creek, Cull Creek, and San Lorenzo Creek, April 30 through October 14, 2015.**

Summary 2015 statistics are presented for temperature monitoring data from Crow, Cull, and San Lorenzo Creeks in

Table 4-1. The highest temperature was recorded at 204CRW040 on July 20. The lowest temperature was recorded at the farthest upstream site, 204R0CRW050, on May 8. Average temperatures ranged from 15.83°C to 18.51°C. Table 4-2. Comparison of 2015 Continuous Temperature Maximum Weekly Average Temperature Measurements with 17°C and 19ºC Temperature Thresholds at Crow Creek, Cull Creek, and San Lorenzo Creek Sampling Locations in WY 2015. Bold values indicates two or more MWATs above the temperature trigger criterion.

**Table 4-1. Summary of Continuous Temperature Data Statistics from from WY 2015 at Crow Creek, Cull Creek, and San Lorenzo Creek Sampling Locations.**

| Station | Mean | St. Dev | St. Error of Mean | Min | Max | Range |
|---|---|---|---|---|---|---|
| 204CRW020 | 17.35 | 2.1 | 0.03 | 11.93 | 23.42 | 11.49 |
| 204CRW030 | 17.40 | 2.1 | 0.03 | 12.44 | 22.8 | 10.36 |
| 204CRW040 | 17.76 | 2.7 | 0.04 | 12.17 | 27.55 | 15.38 |
| 204CRW042 | 17.08 | 1.8 | 0.03 | 12.36 | 21.77 | 9.41 |
| 204CRW044 | 16.86 | 2.3 | 0.04 | 11.05 | 23.09 | 12.04 |
| 204CRW050 | 15.83 | 2.4 | 0.05 | 10.35 | 22.71 | 12.36 |
| 204CUL010 | 16.55 | 1.3 | 0.02 | 12.99 | 19.13 | 6.14 |
| 204SLO065 | 18.51 | 2.1 | 0.03 | 13.64 | 25.14 | 11.5 |
| 204SLO080 | 17.68 | 1.7 | 0.03 | 13.59 | 22.61 | 9.02 |

Table 4-2 shows the number of exceedances of Maximum Weekly Average Temperatures (MWATs) compared to thresholds of 17°C and 19ºC. All sites had at least 2 MWATs greater than 17°C and 5 of these had at least 2 MWATs greater than 19°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.

**Table 4-2. Comparison of 2015 Continuous Temperature Maximum Weekly Average Temperature Measurements with 17°C and 19ºC Temperature Thresholds at Crow Creek, Cull Creek, and San Lorenzo Creek Sampling Locations in WY 2015. Bold values indicates two or more MWATs above the temperature trigger criterion.**

| Station | Site Description | # Weeks Deployed[1] | MWAT > 17º C | | MWAT > 19º C | |
|---|---|---|---|---|---|---|
| | | | # Weeks | % Weeks | # Weeks | % Weeks |
| 204CRW020 | Crow Creek near Earl Warren Park | 24 | **13** | 54% | **3** | 13% |
| 204CRW030 | Crow Creek below Cull Creek | 24 | **15** | 63% | **3** | 13% |
| 204CRW040 | Crow Creek, concrete channel segment below confluence with Cull | 24 | **18** | 75% | **8** | 33% |
| 204CRW042 | Crow Creek at Crow Creek HOA | 22 | **12** | 55% | 0 | 0% |
| 204CRW044 | Crow Creek near mile 1.1 on Crow Canyon Rd | 24 | **13** | 54% | 1 | 4% |
| 204CRW050 | Crow Creek below Norris | 13[2] | **6** | 46% | 0 | 0% |
| 204CUL010 | Cull Creek, below dam | 24 | **11** | 46% | 0 | 0% |
| 204SLO065 | San Lorenzo Creek below Center St | 24 | **18** | 75% | **11** | 46% |
| 204SLO080 | San Lorenzo Creek at 2nd St | 24 | **15** | 63% | **4** | 17% |

[1]Full or partial weeks

[2]Creek dried out mid-deployment

**Table 4-3. Comparison of 2015 Continuous Temperature Records with 24°C Temperature Threshold at Crow Creek, Cull Creek, and San Lorenzo Creek Sampling Locations.**

| Station | Number of Hourly Records | Mean Temp (˚C) | S.E of Mean | Number of readings > 24°C | % of readings > 24°C |
|---|---|---|---|---|---|
| 204CRW020 | 4008 | 17.34605 | 0.03290468 | 0 | 0% |
| 204CRW030 | 4006 | 17.40318 | 0.03247242 | 0 | 0% |
| 204CRW040 | 4008 | 17.75672 | 0.04303765 | 138 | 3% |
| 204CRW042 | 3644 | 17.08071 | 0.02977419 | 0 | 0% |
| 204CRW044 | 4007 | 16.86193 | 0.03577148 | 0 | 0% |
| 204CRW050 | 2162 | 15.83242 | 0.05081027 | 0 | 0% |
| 204CUL010 | 4008 | 16.55258 | 0.02014379 | 0 | 0% |
| 204SLO065 | 4008 | 18.50607 | 0.03245436 | 6 | 0% |
| 204SLO080 | 4008 | 17.67712 | 0.02750819 | 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 2015, 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 2015 spring and summer data in relation to the temperature, pH, and dissolved oxygen thresholds at each site; Figure 4-3, Figure 4-4 and

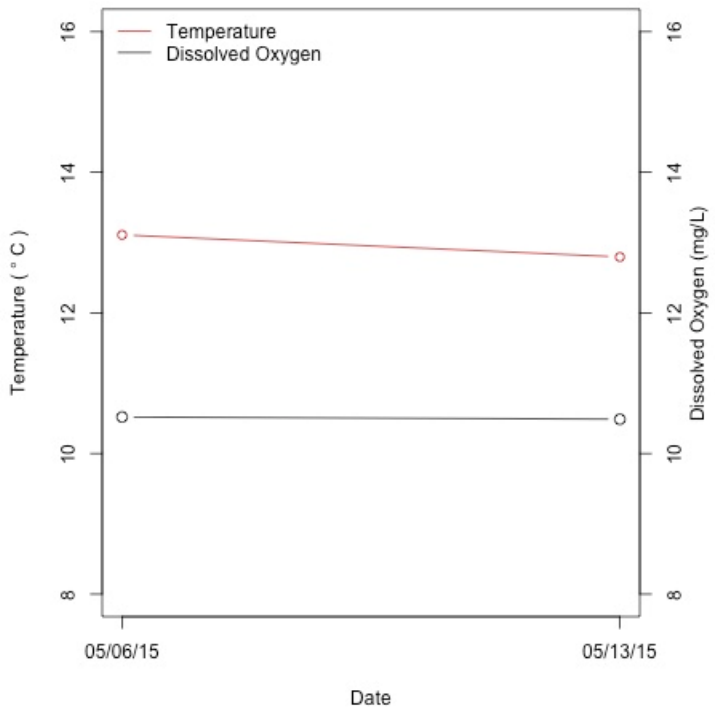



Figure 4-5 show graphical plots of temperature and DO for these sites in the spring and summer periods. Summer discrete 7-day averages or MWATs for full or partial weeks of deployment were typically between 17°C and 19°C; otherwise the temperature thresholds were not exceeded. The water quality thresholds for conductivity, pH, and dissolved oxygen were not exceeded more than 20% of the time at any of the General Water Quality monitoring sites.

**Table 4-4. Comparison of General Water Quality Observations to Trigger Thresholds at Sites 204CRW040, 204CRW042, 204CRW044 in WY 2015.**

| Station | | Applicable threshold or water quality standard |
|---|---|---|

| | Monitoring Season (No of MWATs) | 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% | 5% | 0% |
| | Summer (3) | 3(0) | 0% | 0% | 0% | 0% | 0% |
| 204CRW042 | Spring (2) | 0(0) | 0% | 0% | 0% | 0% | 0% |
| | Summer (3) | 3(0) | 0% | 0% | 0% | 0% | 0% |
| 204CRW044 | Spring (2) | 0(0) | 0% | 0% | 0% | 0% | 0% |
| | Summer (3) | 3(0) | 0% | 0% | 0% | 0% | 0% |

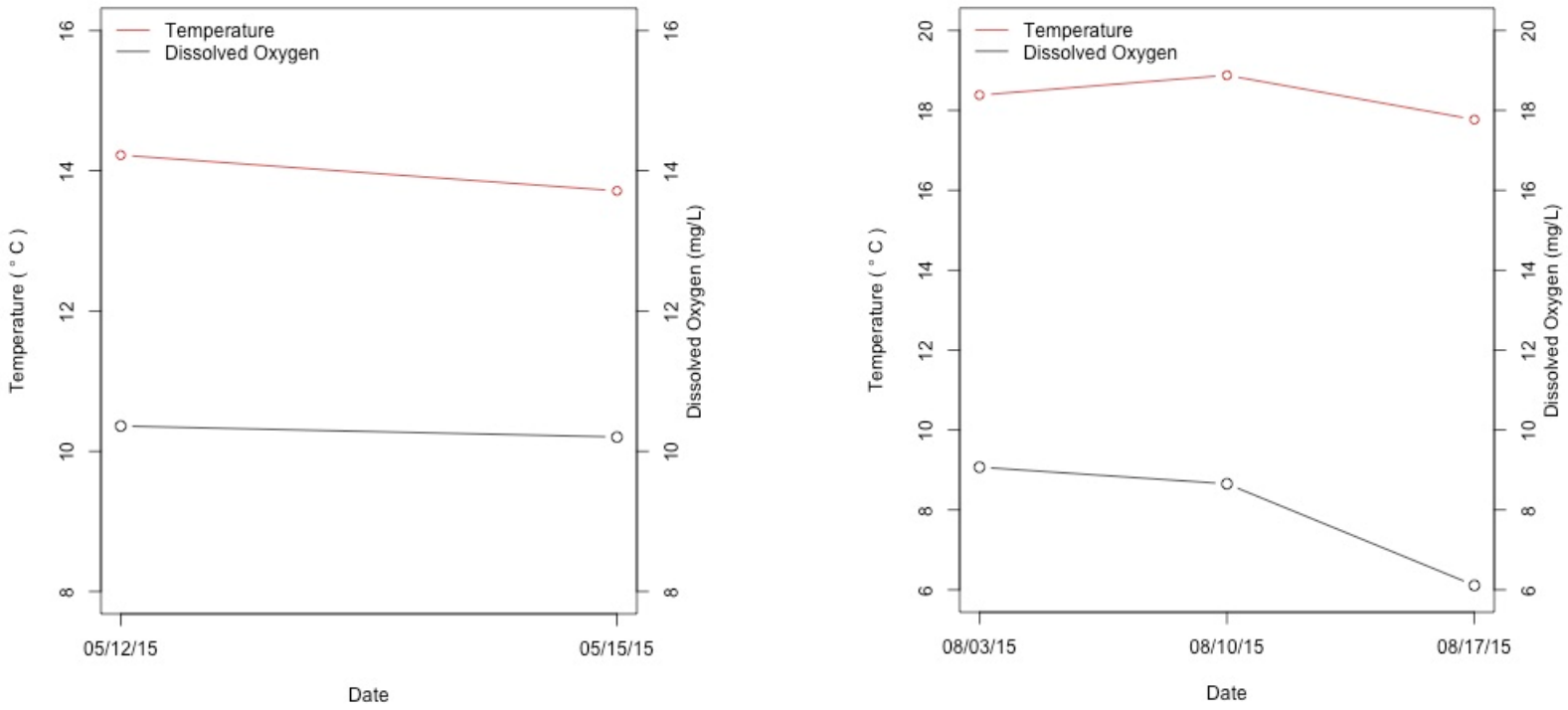



**Figure 4-3. General Water Quality Monitoring Discrete 7-day Averages for Temperature and Dissolved Oxygen at 204CRW040 in Spring (left) and Summer (right), WY 2015**

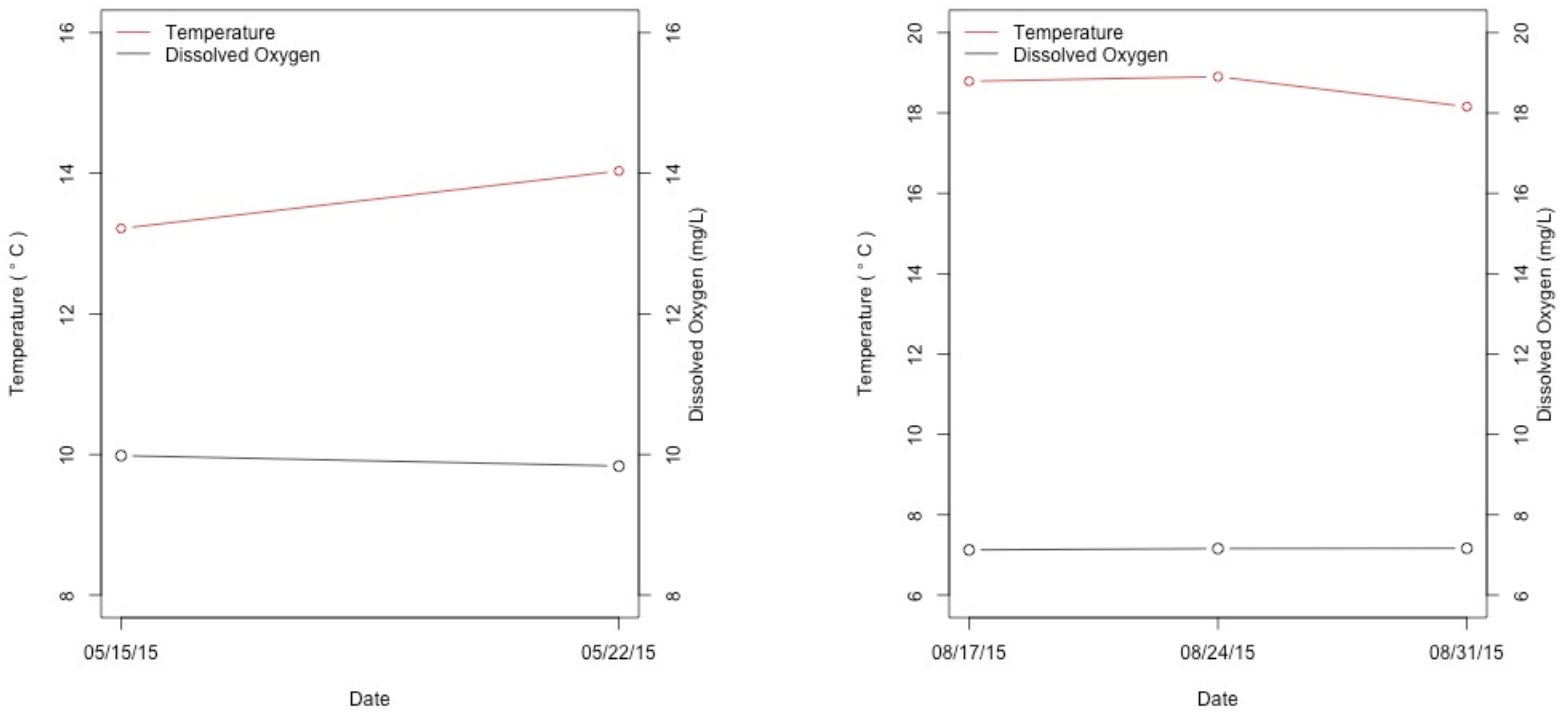



**Figure 4-4.General Water Quality Monitoring Discrete 7-day Averages for Temperature and Dissolved Oxygen at 204CRW042 in Spring (left) and Summer (right), WY 2015.**

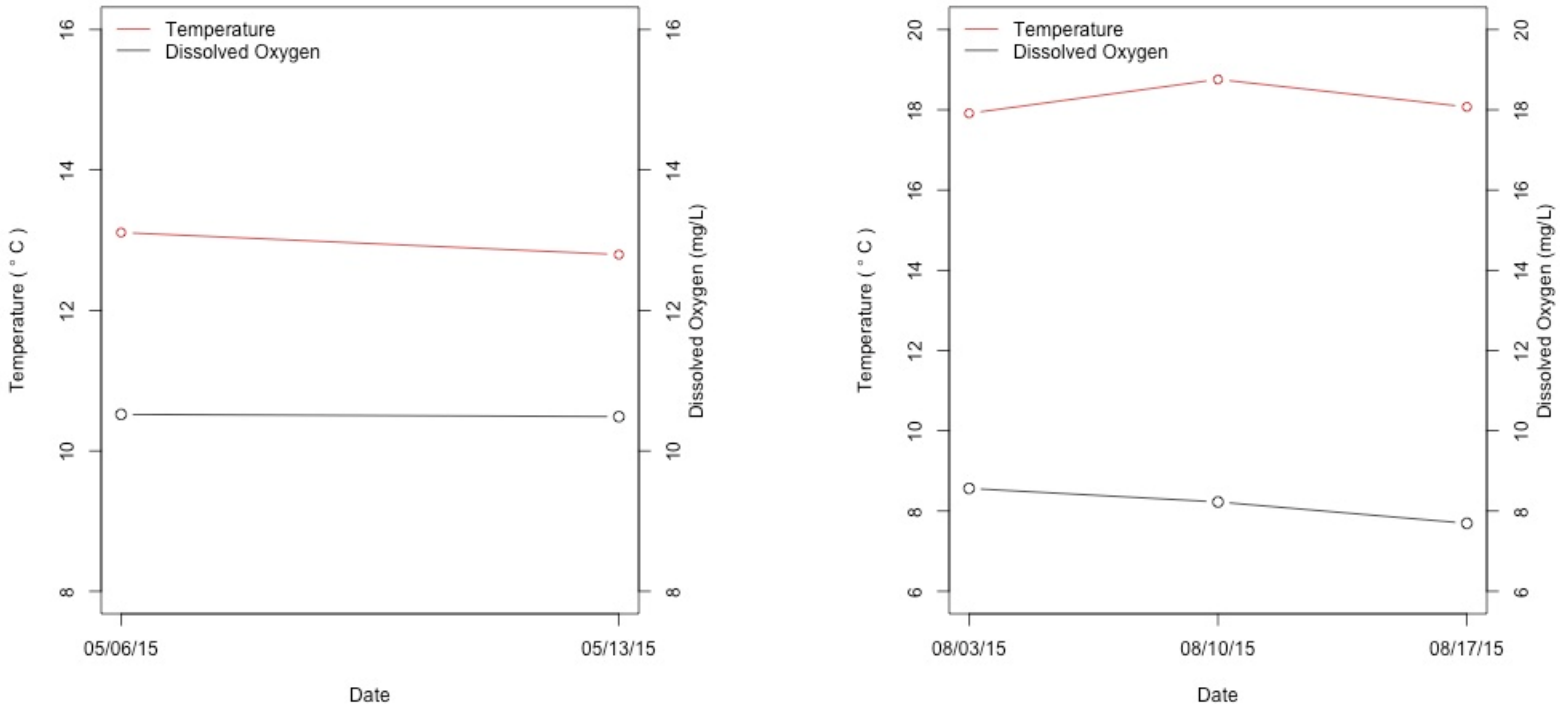



**Figure 4-5. General Water Quality Monitoring Discrete 7-day Averages for Temperature and Dissolved Oxygen at 204CRW044 in Spring (left) and Summer (right), WY 2015.**

## 4.4 Pathogen Indicators

Single grab water samples for pathogen indicators were collected at five locations in the greater Castro Valley Creek watershed on June 30, 2015. *E. coli* and fecal coliform were enumerated as individual grab samples as presented in Table 4-5

The highest 2015 concentrations of fecal indicator bacteria were found at 204CVY080 where both fecal coliform and *E.coli* numbers were 90,000 MPN/100mL. Elevated fecal coliform and *E.coli* concentrations were also found at Sites 204CVY020 and 204CVY120. As discussed previously, these concentrations were identified concurrent with an irregular flow event, and led to follow-up resampling in the same watershed_on August 4, 2015. Results for the resampling event are presented in Table 4-6. Concentrations dropped substantially at the 204CVY080 site in the August repeat of initial sampling, but concentrations remained elevated over typical background levels at other locations monitored.

**Table 4-5. Fecal coliform and *E. coli* enumerations at Castro Valley Creek Monitoring Sites - June 30, 2015 FIB Monitoring.**

| Site ID | Site Description | Creek Name | Fecal Coliform (MPN*/100mL) | *E. coli* (MPN*/100 mL) |
|---|---|---|---|---|
| 204CVY020 | Chabot Creek at Carlos Bee Park | Chabot Creek | 1,300 | 1,300 |
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | Castro Valley Creek | 90,000 | 90,000 |
| 204CVY120 | Castro Valley Creek Park at Castro Valley Library | Castro Valley Creek | 24,000 | 24,000 |
| 204CVY150 | Castro Valley Creek North side of Heyer Ave | Castro Valley Creek | 800 | 800 |
| 204CVY170 | Castro Valley Creek north side of Seaview Ave | Castro Valley Creek | 800 | 800 |

*Most Probable Number per 100mL
**BOLD** font indicates result meets trigger conditions.

**Table 4-6. Fecal coliform and *E. coli* enumerations at Castro Valley Creek Monitoring Sites - August 4, 2015 FIB Monitoring.**

| Site ID | Site Description | Creek Name | Fecal Coliform (MPN*/100mL) | *E. coli* (MPN*/100 mL) |
|---|---|---|---|---|
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | Castro Valley Creek | 80 | 80 |
| 204CVY084 | Castro Valley Creek south side of Grove Way | Castro Valley Creek | 17,000 | 17,000 |
| 204CVY090 | Castro Valley Creek east side of Redwood Rd | Castro Valley Creek | 500 | 500 |
| 204CVY125 | Castro Valley Creek under Castro Valley Blvd | Castro Valley Creek | 8,000 | 8,000 |

## 4.5 Stream Survey

In 2015 the Program surveyed approximately 8.1 creek miles in western Alameda County using the modified Unified Stream Assessment protocol.

The field team identified no immediate impacts of concern. The following tables summarize the Stream Survey portions of the Creek Status monitoring data for the following creeks, shown with their Zone-Line designations used by the Alameda County Flood Control and Water Conservation District:

- Agua Fria (Section 4.5.1)
- Crandall Creek (Section 4.5.2)
- Dry Creek (Section 4.5.3)
- Line 5-K-1 (Section 4.5.4)
- Line 6-B (Section 4.5.5)
- Line 6-B-1 (Section 4.5.6)
- Toroges Creek (Section 4.5.7)

Attachments A through F provide more detailed maps of the surveyed reaches. Surveyed reach characteristics are presented in Table 4-7 through Table 4-13. Findings generated through the assessments are described in the sections that follow.

## Table 4-7. Surveyed Reaches, Agua Fria

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| A | Confluence with Toroges Creek to culvert under I-880 | 2,013 | <0.1 | Concrete |
| F | East side of I-680 Mission Blvd off-ramp to east side of Briar Pl. | 696 | 1.8 | Earth |
| I | Paseo Padre to culvert under Fremont Trail. | 1021 | 1.1 | Earth |
| J | FCD gate at 46987 Sentinel Dr. Trail culvert to east side of Sentinel Dr. | 351 | 1.7 | Earth |
| K | Sentinel Dr. to east side of driveway. Culvert at 1290 Curtner. | 297 | 1.1 | Earth |
| L | Driveway under culvert to Rancho Higuera Rd. FC gate at 45996 Rancho Higuera Rd. | 851 | 1.9 | Earth |
| | | | | |

## Table 4-8. Surveyed Reaches, Crandall Creek

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| B | 34116 Ardenwood Blvd – north side of Ardenwood to railroad tracks | 2,783 | <0.1 | Concrete |
| C | Railroad tracks to SE Paseo Padre Pkwy | 2,010 | <0.1 | Earth and concrete |
| D | Paseo Padre to east side of Deep Creek Rd | 988 | <0.1 | Earth |
| E | Deep Creek to east side of Siward Dr. | 1,269 | <0.1 | Earth |
| H | Northeast side of 880 to start of culvert at northwest side of Decoto Rd | 2,031 | <0.1 | Concrete |
| I | Southeast side of Decoto Rd to start of culvert under Fremont Blvd | 1,863 | <0.1 | Earth |
| | | | | |

## Table 4-9. Surveyed Reaches, Line 6-B

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| A | North side of Kato Rd to northeast side of Milmont Dr. | 854 | <0.1 | Concrete |
| B | Milmont Dr. to railroad tracks | 543 | 0.2 | Concrete |
| C | Southwest side of Warm Springs Blvd south of Whitney Pl | 1,573 | 0.4 | Concrete |
| D | Warm Springs Rd to Ursa | 1,584 | 0.5 | Concrete |
| E | Ursa to 680 | 1,715 | 0.7 | Concrete |
| | | | | |

## Table 4-10. Surveyed Reaches, Toroges Creek

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| B | Confluence with Line 6-B-1 to southwest side of I-880 (just past confluence Line 6-D) | 2,098 | <0.1 | Earth and concrete |
| D | Railroad tracks to northeast side of Westinghouse Dr. | 469 | 0.6 | Concrete |
| E | West side of Westinghouse Dr. to east side of Warm Springs Blvd | 661 | 0.8 | Concrete |
| F | West side of Warm Springs Blvd to east side of Fortner St. | 426 | 0.6 | Concrete |
| G | West side of Fortner St to east side of Hoyt St | 1,176 | 0.9 | Concrete |
| H | West side of Hoyt St. to east side of Papago St | 609 | 1.0 | Concrete |
| I | West side of Papago St. to culvert under I-680 | 794 | 1.3 | Concrete |
| | | | | |

**Table 4-11. Surveyed Reaches, Dry Creek**

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| A | Line A to north side of Alvarado-Niles Rd | 1,626 | 0.2 | Earth |
| B | Alvarado-Niles Rd to OT line 5-L-1 | 3,311 | 0.2 | Earth |
| C | Line 5-L-1 to northeast side of first single railroad track | 1,141 | 0.3 | Earth |
| D | From railroad track through culvert/bridge under Bart tracks to start of culvert under Railroad Ave and track | 1,062 | 0.3 | Earth |
| E | Northeast side of track east of Railroad Ave to north side of Whipple Rd | 958 | 0.2 | Earth |
| F | Whipple Rd to northeast side of Mission Blvd | 1,877 | 0.3 | Earth |
| | | | | |

**Table 4-12. Surveyed Reaches, Line 5-K-1**

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| C | Northeast side of I-880S along freeway to end of open channel near gate on San Pedro Dr. near Pizarro Dr. | 2,474 | <0.1 | Earth |
| | | | | |

**Table 4-13. Surveyed Reaches, Line 6-B-1**

| Reach | Geographic Extent | Reach Length (ft) | Valley Slope (%) | General Characteristics |
|---|---|---|---|---|
| A | Northeast side of Kato to culvert under railroad tracks | 1,364 | 0.4 | Earth |
| | | | | |

## Reach Assessment

Summary results of the USA reach assessments are provided in Table 4-14 through Table 4-20 and Figure 4-6 through **Figure 4-11.** The attributes making up the overall reach assessment scores are discussed below.

### Instream Habitat

The overall instream habitat scores ranged by reach from 20 to 54. Agua Fria reaches had the highest average score of 44, with the most natural creek mileage and more optimal instream habitat. The highly modified reaches of Line 5-K-1 and Line 6-B had the lowest average scores of 24 and 25, respectively, with poor instream habitat complexity, sparse bank vegetation, and deeply entrenched streams. Toroges Creek also was also characterized by a relatively low average instream habitat score of 27, with poor instream habitat complexity and sparse bank vegetation. However, the Toroges Creek reaches exhibited less erosion than those on Line 5-K-1 and Line 6-B.

### Buffer and Floodplain Condition

Overall buffer and floodplain condition reach scores ranged from 4 to 33. Agua Fria reaches had the highest average score of 28, while the Line 6-B, Line 6-B-1, Line 5-K-1, Toroges Creek, and Dry Creek reaches were all characterized by very low average scores, ranging from 4 to 7. The average score for Crandall Creek was slightly higher at 12. These relatively low scores documented for all but the Agua Fria reaches indicate that the majority of the surveyed reaches were in highly urbanized areas with minimal vegetated buffer width and significant floodplain encroachment.

### Overall Reach Assessment

The overall reach assessment scores ranged from 25 to 91. Agua Fria reaches had the highest average score of 71, with more complex instream habitat and vegetated banks. Line 5-K-1 had the lowest average score of 31, with heavily modified channel reaches and significant floodplain encroachment.

**Table 4-14. Reach Assessment Scores, Agua Fria**

| Agua Fria Reach | A | F | I | J | K | L |
|---|---|---|---|---|---|---|
| Overall Stream Condition | | | | | | |
| Instream Habitat | 2 | 15 | 13 | 14 | 14 | 15 |
| Vegetative Protection (LB) | 1 | 6 | 6 | 6 | 7 | 8 |
| Vegetative Protection (RB) | 1 | 8 | 6 | 5 | 7 | 8 |
| Bank Erosion (LB) | 10 | 7 | 7 | 7 | 5 | 8 |
| Bank Erosion (RB) | 10 | 8 | 6 | 7 | 5 | 8 |
| Floodplain Connection | 1 | 2 | 11 | 6 | 4 | 7 |
| Instream Habitat Total Score | 25 | 46 | 49 | 45 | 42 | 54 |
| Overall Buffer & Floodplain Condition | | | | | | |
| Vegetative Buffer Width (LB) | 1 | 4 | 3 | 3 | 3 | 5 |
| Vegetative Buffer Width (RB) | 1 | 4 | 3 | 3 | 3 | 5 |
| Floodplain Vegetation | 2 | 14 | 11 | 12 | 13 | 14 |
| Floodplain Habitat | 2 | 4 | 6 | 7 | 9 | 5 |
| Floodplain Encroachment | 1 | 4 | 6 | 4 | 5 | 8 |
| Floodplain and Buffer Total Score | 7 | 30 | 29 | 29 | 33 | 37 |
| Reach Assessment Total Score | 32 | 76 | 78 | 74 | 75 | 91 |

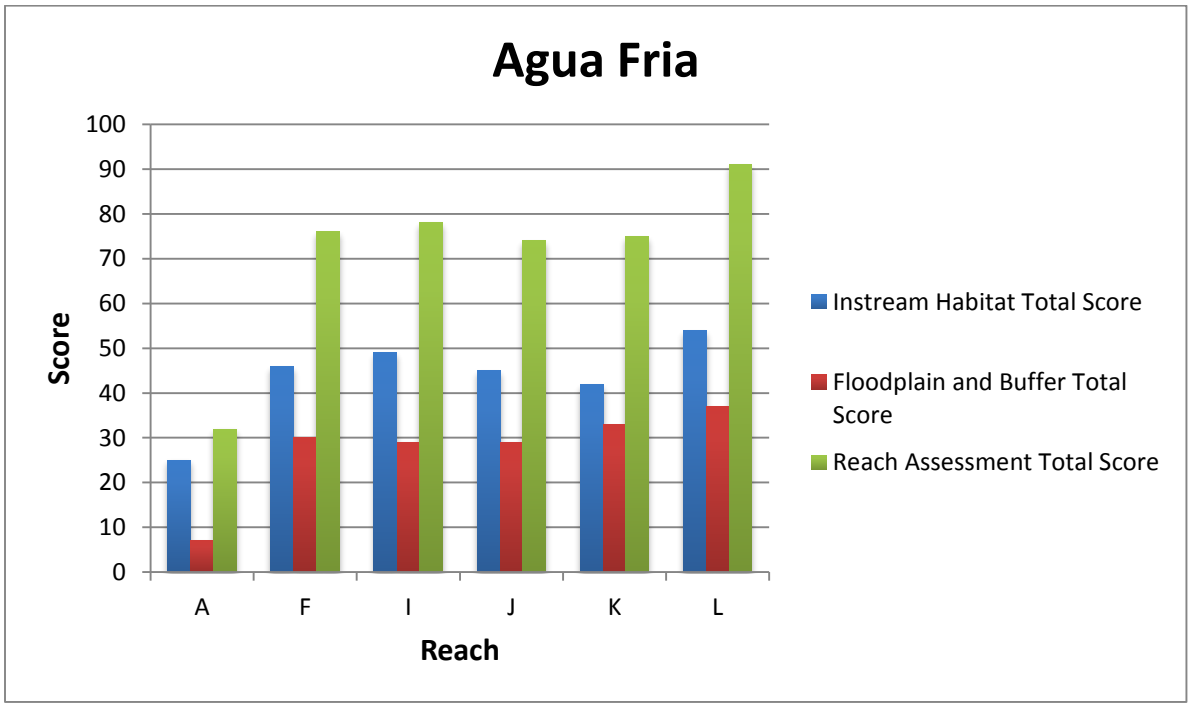



**Figure 4-6. Summary of Unified Assessment Scores for Agua Fria Reaches**

**Table 4-15. Reach Assessment Scores, Crandall Creek Reaches**

| Crandall Creek Reach | B | C | D | E | H | I |
|---|---|---|---|---|---|---|
| Overall Stream Condition | | | | | | |
| Instream Habitat | 10 | 7 | 7 | 2 | 4 | 4 |
| Vegetative Protection (LB) | 5 | 4 | 4 | 2 | 5 | 5 |
| Vegetative Protection (RB) | 5 | 4 | 4 | 2 | 5 | 2 |
| Bank Erosion (LB) | 7 | 8 | 8 | 8 | 6 | 4 |
| Bank Erosion (RB) | 7 | 8 | 8 | 5 | 6 | 3 |
| Floodplain Connection | 7 | 5 | 4 | 5 | 4 | 15 |
| Instream Habitat Total Score | 41 | 36 | 35 | 24 | 30 | 33 |
| Overall Buffer & Floodplain Condition | | | | | | |
| Vegetative Buffer Width (LB) | 5 | 2 | 1 | 1 | 2 | 1 |
| Vegetative Buffer Width (RB) | 8 | 2 | 1 | 1 | 2 | 1 |
| Floodplain Vegetation | 1 | 4 | 2 | 5 | 2 | 2 |
| Floodplain Habitat | 2 | 4 | 3 | 5 | 2 | 2 |
| Floodplain Encroachment | 4 | 2 | 2 | 2 | 2 | 1 |
| Floodplain and Buffer Total Score | 20 | 14 | 9 | 14 | 10 | 7 |
| Reach Assessment Total Score | 61 | 50 | 44 | 38 | 40 | 40 |

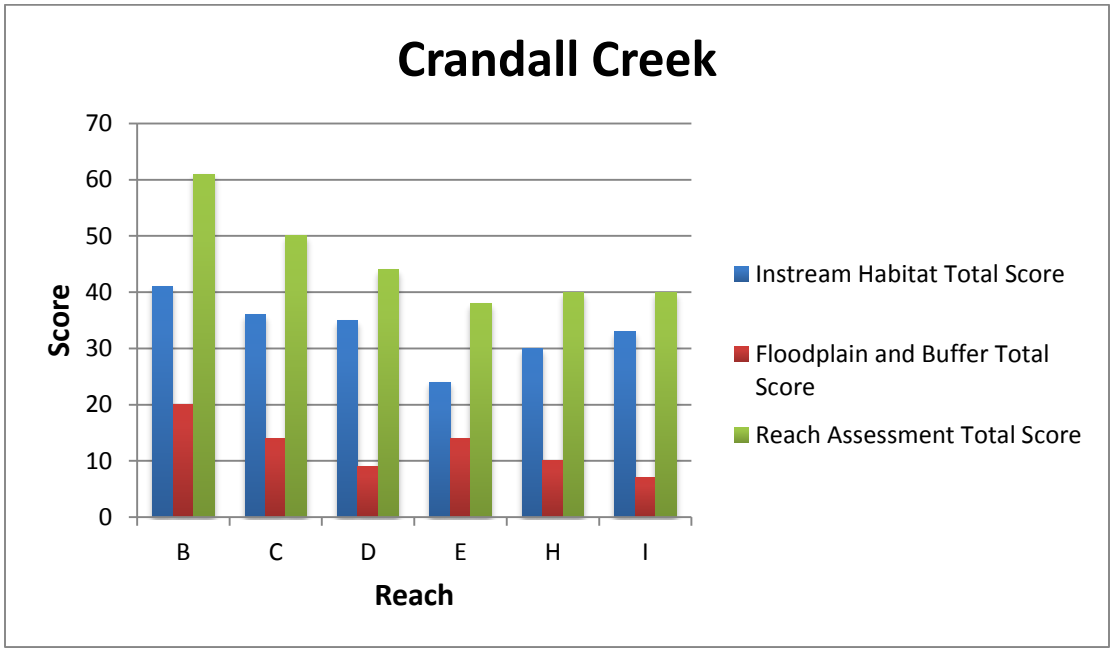



**Figure 4-7. Summary of Unified Stream Assessment Scores for Crandall Creek Reaches**

**Table 4-16. Reach Assessment Scores, Line 6-B Reaches**

| Line 6-B Reach | A | B | C | D | E |
|---|---|---|---|---|---|
| Overall Stream Condition | | | | | |
| Instream Habitat | 7 | 9 | 8 | 1 | 1 |
| Vegetative Protection (LB) | 2 | 1 | 1 | 0 | 1 |
| Vegetative Protection (RB) | 2 | 1 | 2 | 0 | 1 |
| Bank Erosion (LB) | 4 | 7 | 5 | 10 | 10 |
| Bank Erosion (RB) | 4 | 5 | 5 | 10 | 10 |
| Floodplain Connection | 5 | 2 | 9 | 2 | 2 |
| Instream Habitat Total Score | 24 | 25 | 30 | 23 | 25 |
| Overall Buffer & Floodplain Condition | | | | | |
| Vegetative Buffer Width (LB) | 0 | 0 | 1 | 0 | 1 |
| Vegetative Buffer Width (RB) | 0 | 0 | 1 | 0 | 1 |
| Floodplain Vegetation | 0 | 1 | 3 | 3 | 1 |
| Floodplain Habitat | 0 | 1 | 1 | 2 | 1 |
| Floodplain Encroachment | 8 | 7 | 2 | 0 | 3 |
| Floodplain and Buffer Total Score | 8 | 9 | 8 | 5 | 7 |
| Reach Assessment Total Score | 32 | 34 | 38 | 28 | 32 |

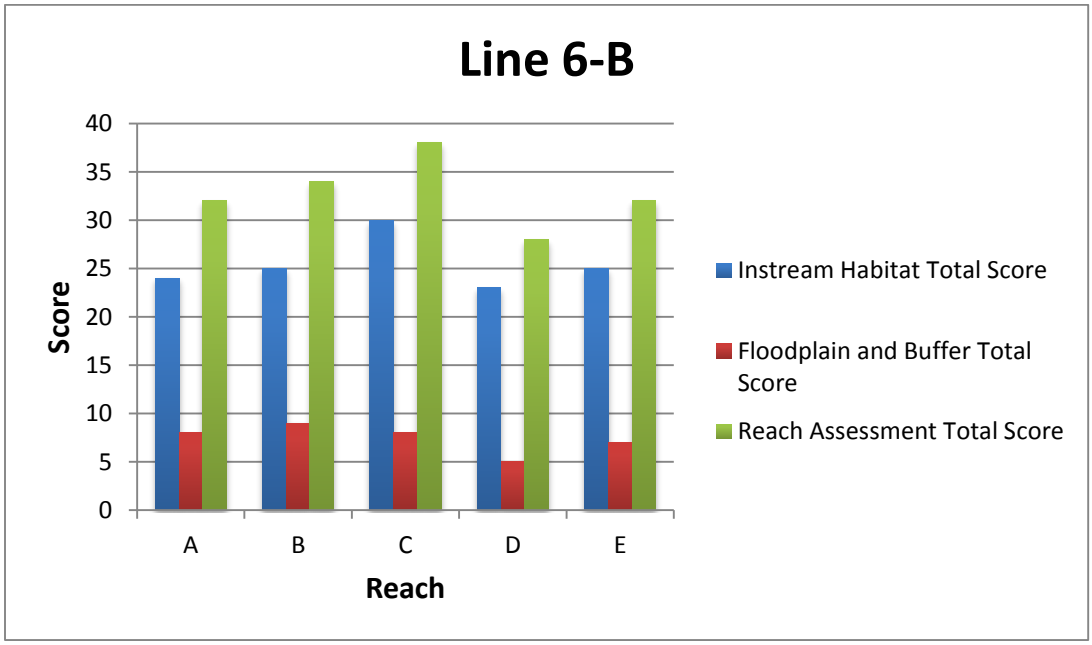



**Figure 4-8. Summary of Unified Stream Assessment Scores for Line 6-B Reaches**

**Table 4-17. Reach Assessment Scores, Toroges Creek Reaches**

| Toroges Creek Reach | B | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|
| Overall Stream Condition | | | | | | | |
| Instream Habitat | 10 | 0 | 0 | 0 | 0 | 2 | 2 |
| Vegetative Protection (LB) | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vegetative Protection (RB) | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bank Erosion (LB) | 6 | 10 | 10 | 10 | 10 | 10 | 10 |
| Bank Erosion (RB) | 6 | 10 | 10 | 10 | 10 | 10 | 10 |
| Floodplain Connection | 2 | 10 | 10 | 5 | 5 | 0 | 0 |
| Instream Habitat Total Score | 36 | 30 | 30 | 25 | 25 | 22 | 22 |
| Overall Buffer & Floodplain Condition | | | | | | | |
| Vegetative Buffer Width (LB) | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| Vegetative Buffer Width (RB) | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| Floodplain Vegetation | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Floodplain Habitat | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Floodplain Encroachment | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Floodplain and Buffer Total Score | 6 | 4 | 4 | 4 | 4 | 4 | 4 |
| Reach Assessment Total Score | 42 | 34 | 34 | 29 | 29 | 26 | 26 |

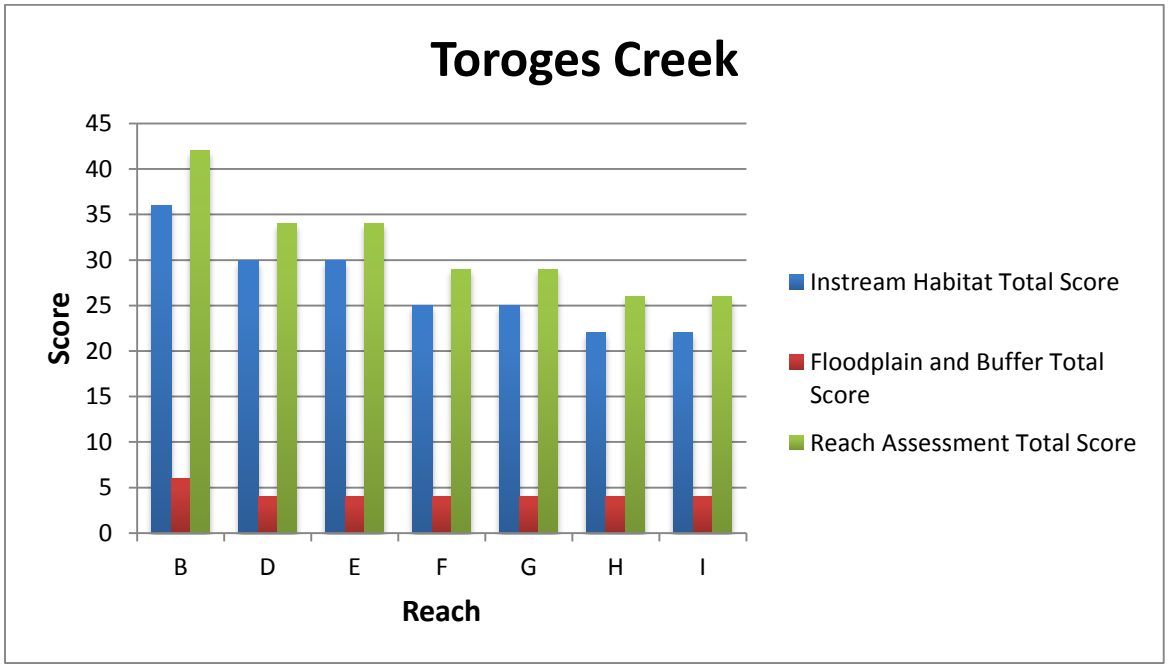



**Figure 4-9. Summary of Unified Stream Assessment Scores for Toroges Creek Reaches**

**Table 4-18. Reach Assessment Scores, Dry Creek Reaches**

| Dry Creek Reach | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Overall Stream Condition | | | | | | |
| Instream Habitat | 12 | 8 | 8 | 5 | 5 | 7 |
| Vegetative Protection (LB) | 4 | 5 | 5 | 2 | 5 | 5 |
| Vegetative Protection (RB) | 4 | 5 | 5 | 2 | 5 | 5 |
| Bank Erosion (LB) | 8 | 9 | 9 | 7 | 7 | 0 |
| Bank Erosion (RB) | 8 | 9 | 9 | 7 | 7 | 0 |
| Floodplain Connection | 5 | 2 | 2 | 8 | 3 | 3 |
| Instream Habitat Total Score | 41 | 38 | 38 | 31 | 32 | 20 |
| Overall Buffer & Floodplain Condition | | | | | | |
| Vegetative Buffer Width (LB) | 2 | 1 | 1 | 1 | 1 | 0 |
| Vegetative Buffer Width (RB) | 5 | 3 | 3 | 1 | 2 | 2 |
| Floodplain Vegetation | 7 | 2 | 2 | 2 | 3 | 3 |
| Floodplain Habitat | 1 | 0 | 0 | 0 | 0 | 0 |
| Floodplain Encroachment | 2 | 0 | 0 | 0 | 0 | 0 |
| Floodplain and Buffer Total Score | 17 | 6 | 6 | 4 | 6 | 5 |
| Reach Assessment Total Score | 58 | 44 | 44 | 35 | 38 | 25 |

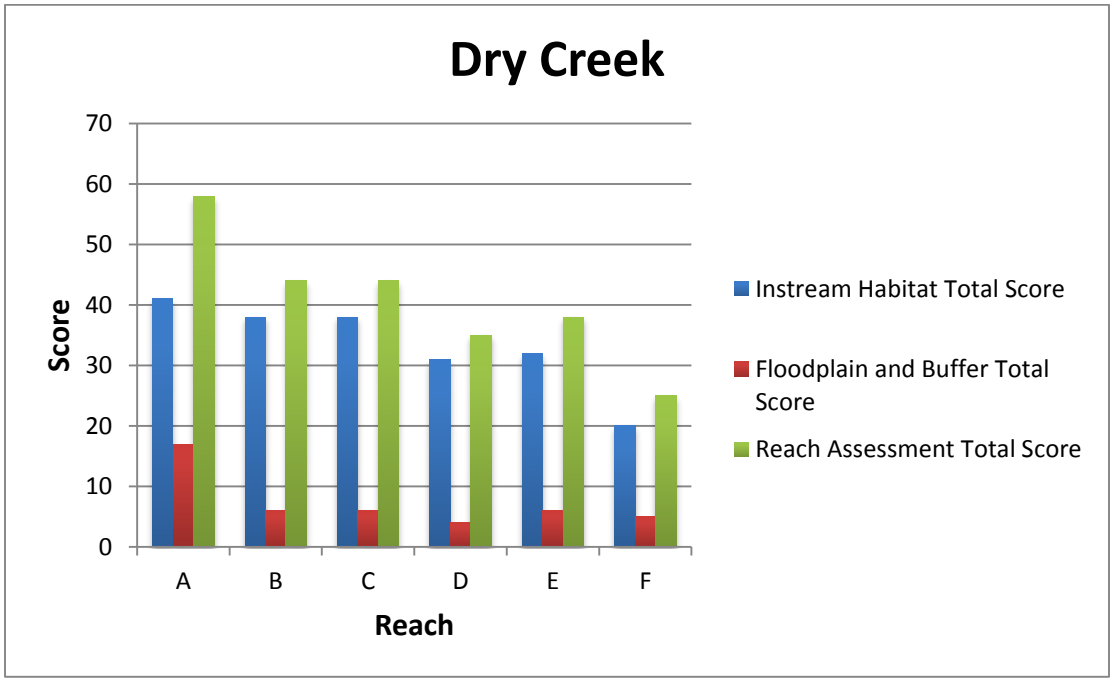



**Figure 4-10. Summary of Unified Stream Assessment Scores for Dry Creek Reaches**

**Table 4-19. Reach Assessment Scores, Line 5-K-1 Reaches**

| Line 5-K-1 Reach | **C** |
|---|---|
| Overall Stream Condition | |
| Instream Habitat | 4 |
| Vegetative Protection (LB) | 4 |
| Vegetative Protection (RB) | 1 |
| Bank Erosion (LB) | 3 |
| Bank Erosion (RB) | 5 |
| Floodplain Connection | 7 |
| Instream Habitat Total Score | 24 |
| Overall Buffer & Floodplain Condition | |
| Vegetative Buffer Width (LB) | 1 |
| Vegetative Buffer Width (RB) | 1 |
| Floodplain Vegetation | 2 |
| Floodplain Habitat | 2 |
| Floodplain Encroachment | 1 |
| Floodplain and Buffer Total Score | 7 |
| Reach Assessment Total Score | 31 |

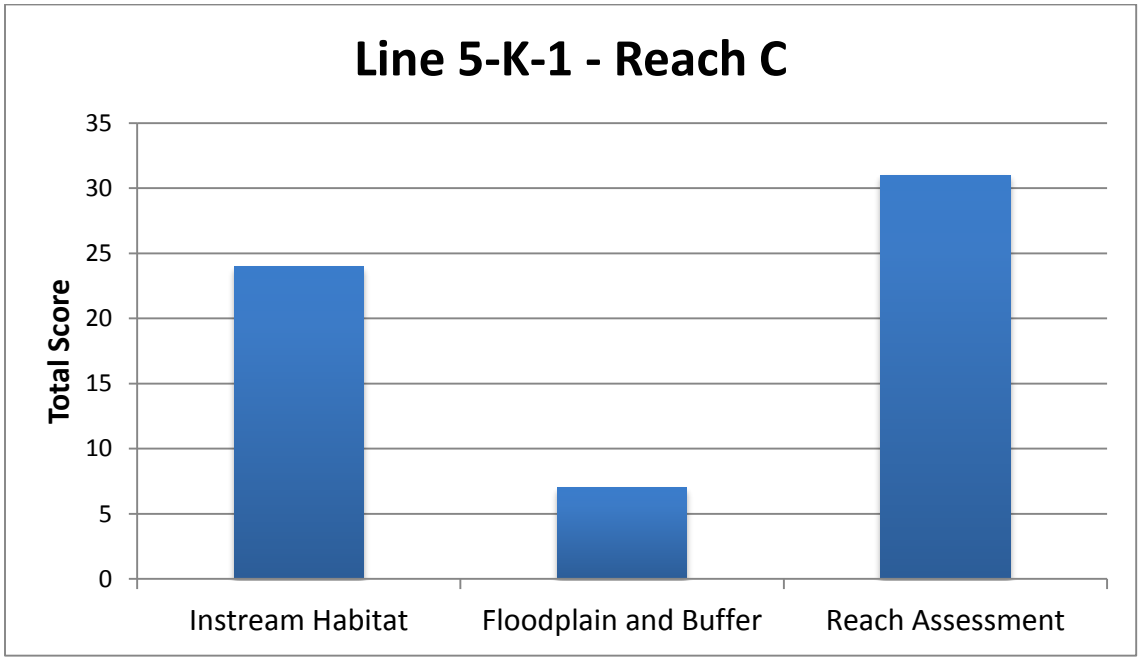



**Figure 4-11. Summary of Unified Stream Assessment Scores for Line 5-K-1 Reaches**

**Table 4-20. Reach Assessment Scores, Line 6-B-1 Reaches**

| Line 6-B-1 Reach | **A** |
|---|---|
| Overall Stream Condition | |
| Instream Habitat | 13 |
| Vegetative Protection (LB) | 2 |
| Vegetative Protection (RB) | 2 |
| Bank Erosion (LB) | 6 |
| Bank Erosion (RB) | 6 |
| Floodplain Connection | 1 |
| Instream Habitat Total Score | 30 |
| Overall Buffer & Floodplain Condition | |
| Vegetative Buffer Width (LB) | 1 |
| Vegetative Buffer Width (RB) | 1 |
| Floodplain Vegetation | 1 |
| Floodplain Habitat | 1 |
| Floodplain Encroachment | 1 |
| Floodplain and Buffer Total Score | 5 |
| Reach Assessment Total Score | 35 |

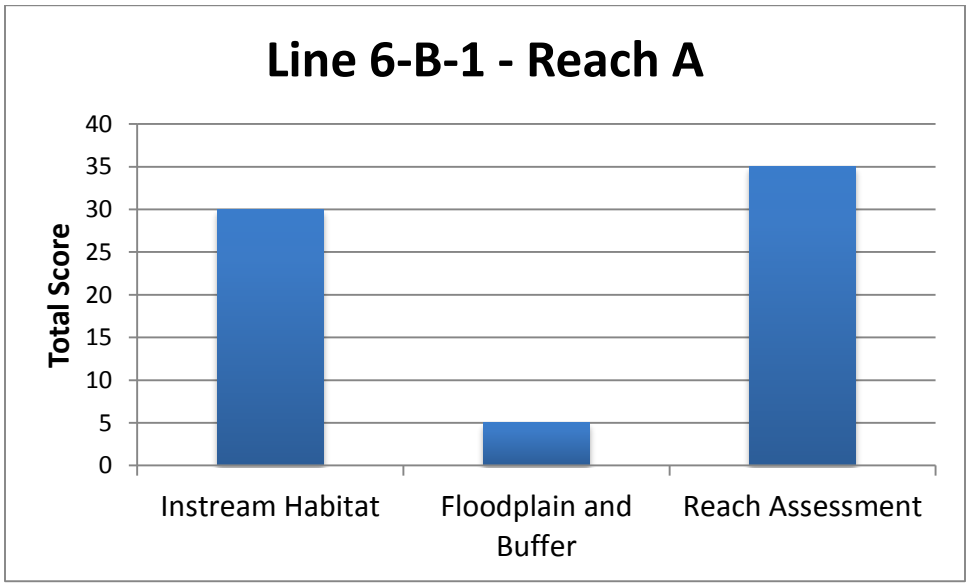



**Figure 4-12. Summary of Unified Stream Assessment Scores for Line 6-B-1 Reaches**

## Impact Assessment Summary

Schematic maps showing location of impacts within each reach are found in the Attachments A through F. Findings relative to individual impact categories are discussed below.

### Outfalls

The greatest frequency of outfalls per surveyed mile occurred in Crandall Creek Reach D and Toroges Creek Reach I (approximately 37/mi and 33/mi, respectively). Approximately 13% of the reaches surveyed were devoid of outfalls. The majority of outfalls that occurred in all creeks were classified as storm drains, while the remaining outfalls with a 1 – 6" diameter were suspected to be private (Figure 4-13). Sampling personnel did not investigate potential sources of the suspected private outfalls. Approximately 94% of the outfalls had no dry weather flow, and the remaining outfalls had trickle flows. Sampling personnel did not observe any suspicious discharges during surveys.

**Figure 4-13. Suspected Private Outfall, Small Plastic Exposed Pipe, Dry Creek Reach C**

### Channel Modification

Most of the creeks surveyed exhibited a high degree of channel modification. Among the highly urbanized channels surveyed, Toroges Creek and Line 6-B-1 had the highest degree of distinct structural modification, primarily consisting of bank armoring and one small drop structure. On Toroges Creek, five out of seven reaches were characterized by 100% channel modification by length, and all of the reaches had some degree of modification. The entire reach surveyed for Line 6-B-1 was characterized by bank armoring. In comparison, Agua Fria exhibited the lowest level of channel modification.

### Erosion

A minimal amount of bank erosion / slope failure was found in the reaches surveyed. Only Line 6-B and Toroges Creek had any notable erosion occurring (17% and 3% slope failure by individual reach length) (Figure 4-14). The observed erosion was likely from historic channel incision that resulted in steeper channel gradients and steeper bank slopes, as well as storm damage to banks that were sparsely vegetated.

**Figure 4-14. Bank Failure, Line 6-B Reach B**

### Trash

No instances of significant trash accumulation were observed in the survey reaches.

### Recreation

Field personnel observed no recreation sites during 2015 surveys.

### Utilities

Utility impacts were not observed in the surveyed reaches. However, multiple reaches were shortened in order to avoid a San Francisco Public Utilities Commission (SFPUC) corridor requiring permission for access.

# 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. To facilitate planning and selection of potential follow-up Stressor/Source Identification (SSID) Projects, where feasible stressor assessment was conducted according to the trigger criteria in MRP2 Provision C.8.d, where different from those listed in Table 8.1 of the MRP (see

Table 5-1).

**Table 5-1. Description of Triggers for Potential Follow-up About Creek Status Targeted Parameters.**

| Monitoring Parameter | Trigger Description Per MRP2 Section C.8.d.iv |
|---|---|
| **General Water Quality** | 20% of results in one water body with Coldwater Beneficial Use exceed one or more water quality standards or established thresholds:<br>• Dissolved Oxygen: < 7.0 mg/l<br>• Water Temperature: see below<br>• Conductivity: > 2000 µS/cm or there is a spike in readings with no obvious natural explanation<br>• pH results: < 6.5 or >8.5 |
| **Temperature** | Temperatures in one water body cause a spike in temperature or exceed applicable temperature thresholds:<br>• The maximum 7-day Weekly Average Temperature should not exceed 17°C for a steelhead stream<br>• 20% of the instantaneous temperature measurements should not exceed 24°C |
| **Pathogen Indicators** | Fecal coliform: Basin Plan Table 3.1 not applicable [12].<br><br>*E. coli:* Basin Plan Table 3.2 for Water Contact Recreation in fresh water[13]<br>Steady State: 126 colonies per 100 ml<br>Moderately used area:< 298 colonies per 100 ml<br>Lightly used area:< 406 colonies per 100 ml |

[12] Water Quality Objectives listed in Table 3.1 of the Basin Plan for fecal coliform are based on five consecutive samples that are collected over an equally spaced 30-day period, which do not correspond to the sampling frequency in the MRP. The WQOs for Water Contact Recreation include concentrations for the calculated geometric mean (< 200 MPN/100ml) and the 90th percentile (< 400 MPN/100ml).

[13]Water Quality Objectives listed in Table 3.1 of the Basin Plan for *E. coli* are maximum values to "provide for a level of production based on the frequency of usage of a given water contact recreation area. For this reason the maximum criterion for "designated beach" and "Steady State" are not applicable to the creeks monitored.

| | |
|---|---|
| | Infrequently used area:< 576 colonies per 100 ml (USEPA 1986) |
| **Stream Survey** | NA |

## 5.1 Continuous Temperature

The reissued MRP2 (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[14]. Continuous temperature non-overlapping weekly averages were also compared to a MWAT threshold of 19°C established by USEPA (Brungs and Jones, 1977) for juvenile rainbow trout (*Oncorhynchus mykiss*)[15]: While the 19°C threshold was derived mainly from laboratory studies, they are reasonable in light of habitat characteristics for similar Bay Area salmonid populations (Leidy et al., 2005)[16].

All WY 2015 temperature monitoring sites were in streams with COLD Beneficial Use, and experienced at least two MWATs above 17.0°C during the summer, while 5 out of 9 experienced at least two MWATs above 19°C. No sites exceeded the 24°C instantaneous maximum for 20% or more of the records.

## 5.2 General Water Quality

Water quality triggers were compared against the results obtained during General Water Quality monitoring. No MWAT triggers were observed during spring deployments; during summer all 3 sites had MWATs above 17.0°C but below 19°C. Comparisons with other threshold values

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

[15] This species, in either the anadromous (steelhead) or resident (rainbow trout) form, is the only salmonid species that naturally occurs in the San Lorenzo and Sausal watersheds.

[16]Sullivan et al. (2000) is referenced in Table 8.1 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.

identified in MRP2 indicate that in no case did 20% of the instantaneous measurements of pH, DO, temperature, or conductivity fall above the trigger thresholds.

## 5.3 Pathogen Indicators

Table 5-1 presents the United States Environmental Protection Agency (USEPA) criteria for ambient water quality bacteria concentrations as stipulated in Provision C.8 of MRP1. The Basin Plan includes two water quality standards that could potentially be used for comparison in determining triggers.

Table 3.1 of the Basin Plan references a USEPA assessment of public health risk that assumes multiple sampling at recreational bathing beaches and derives a statistical probability of illness from those assumptions. Under the provisions of the MRP, permittees collect single samples, once at each sampling location within that Water Year. As such, the monitoring frequency stipulated within the MRP is not consistent with the sampling requirements of the USEPA WQOs in Table 3, although it is the only comparison offered for fecal coliform bacteria, which may be derived from a wide range of sources and may not be indicative of pathogen risks to human health.

Table 3.2 of the Basin Plan references an alternative USEPA standard that is applicable for single samples of *E. coli* or the enterococci group, which are considered better predictors of human illness. Actual water contact by creek visitors is likely rare to sporadic at many of the sites sampled and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard in Table 3.2 of the Basin Plan, which were based on studies of users at bathing beaches that received direct bacteriological contamination from treated human wastewater. These criteria are, however, associated with presumptive recreational uses and so are used as benchmarks to define trigger criteria as required in the MRP; although the results of the monitoring are not an accurate indication of the risk to public health they may be used to derive coarse assessments of potential fecal pollution sources in watersheds.

Table 5-2 and Table 5-3 present the results of the pathogen indicator enumeration with comparison against the USEPA criteria in Table 3.2 of the Basin Plan. All sites sampled on June 30 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 EPA, cannot be directly reflected in appropriate usage 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 public access. At the August 4 sampling event bacterial concentrations at

204CVY080 were below the trigger criterion for either fecal coliforms or *E. coli*. The rest of the sites met the trigger criterion for at least one of the pathogen indicators, whether assessed as lightly or moderately used areas. 204CVY090 results were above the trigger threshold for lightly or moderately used areas but the site is fenced off from public access and would not meet the trigger conditions for infrequently used areas.

**Table 5-2. Comparison of WY 2015 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP June 30, 2015 FIB Monitoring.**

| Site ID | Site Description | Creek Name | Fecal Coliform (MPN/100mL)* | *E. coli* (MPN/100 mL)* |
|---|---|---|---|---|
| 204CVY020 | Chabot Creek at Carlos Bee Park | Chabot Creek | **1,300** | **1,300** |
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | Castro Valley Creek | **90,000** | **90,000** |
| 204CVY120 | Castro Valley Creek Park at Castro Valley Library | Castro Valley Creek | **24,000** | **24,000** |
| 204CVY150 | Castro Valley Creek North side of Heyer Ave | Castro Valley Creek | **800** | **800** |
| 204CVY170 | Castro Valley Creek north side of Seaview Ave | Castro Valley Creek | **800** | **800** |

*Most Probable Number per 100mL
**BOLD** font indicates result meets trigger conditions.

**Table 5-3.Comparison of WY 2015 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers – ACCWP August 4, 2015 FIB Monitoring.**

| Site ID | Site Description | Creek Name | Fecal Coliform (MPN*/100mL) | *E. coli* (MPN*/100 mL) |
|---|---|---|---|---|
| 204CVY080 | Castro Valley Creek above confluence with Chabot Creek | Castro Valley Creek | 80 | 80 |
| 204CVY084 | Castro Valley Creek south side of Grove Way | Castro Valley Creek | **17,000** | **17,000** |
| 204CVY090 | Castro Valley Creek east side of Redwood Rd | Castro Valley Creek | 500 | 500 |
| 204CVY125 | Castro Valley Creek under Castro Valley Blvd | Castro Valley Creek | **8,000** | **8,000** |

# 6 Next Steps

All sites identified in Section 5 as meeting trigger conditions will be reviewed by the Program in conjunction with relevant Permittees and RMC programs to determine potential follow-up actions pursuant to MRP2 Provision C.8.e, Stressor/Source Identification (SSID). ACCWP initiated three SSID projects developed through the RMC selection process in the MRP1 permit term, which together with those proposed by other RMC participants comprised the regional collaborative limit of 10 projects for the MRP1 permit term as stipulated in provision C.8.d.i(5) of MRP1. Where triggers or potential trigger conditions have been identified in WY 2015 results, ACCWP will also work with local stormwater managers to identify appropriate follow-up activities, which may be either incorporated in WY 2016 Creek Status Monitoring or conducted outside the scope of MRP2 Provision C.8.d.

# 7 References

Applied Marine Sciences (AMS), 2013. ACCWP Creek Status Monitoring, 2012 Unified Stream Assessments Conducted with San Lorenzo Watershed, Draft. Prepared for the Alameda Countywide Clean Water Program. January 31, 2013.

Applied Marine Sciences (AMS), 2014. ACCWP Creek Status Monitoring, 2013 Unified Stream Assessments. Prepared for the Alameda Countywide Clean Water Program. February 21, 2014

Atkinson, K., Fuller, J., Hanon, C. and B. Trush. 2011. Evaluating Water Temperature and Turbidity Effects on Steelhead Life History Tactics in Alameda Creek Watershed. Prepared for Alameda Creek Fisheries Restoration Workgroup. Technical memorandum, March, 2011.

BASMAA Regional Monitoring Coalition. 2011. RMC Creek Status and Long-Term Trends Monitoring Plan.

BASMAA Regional Monitoring Coalition. 2014a. 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.

BASMAA. 2014b. 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. 203 pp.

Brungs, W.S. and B.R. Jones. 1977. Temperature Criteria for Freshwater Fish: Protocols and Procedures. EPA-600/3-77-061. Environ. Research Lab, Ecological Resources Service, U.S. Environmental Protection Agency, Office of Research and Development, Duluth, MN.

Center for Watershed Protection. 2005. Urban Subwatershed Restoration Manual Series, No. 10 Unified Stream Assessment: A User's Manual. Version 2.0. Center for Watershed Protection. Ellicott City, Maryland. February 2005.

EOA, Inc. 2006.Martin Canyon Watershed Characterization and Monitoring Plan. Prepared for Alameda Countywide Clean Water Program. September 2006.

Hansen, S.R. and Associates. 1995. Identification and Control of Toxicity in Storm Water Discharges to Urban Creeks. Final report prepared for the Alameda County Urban Runoff Clean Water Program, Hayward CA, March 7, 1995.

Leidy, R.A., Becker, G.S. and B.N. Harvey. 2005. Historical distribution and current status of steelhead/rainbow trout (*Oncorhynchus mykiss*) in streams of the San Francisco Estuary, California. Center for Ecosystem Management and Restoration, Oakland, CA.

Myrick, C. A. and J.J. Cech, Jr. 2001. Bay-Delta Modeling Forum. Technical publication 01-1. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations.

San Francisco Estuary Institute (SFEI), 2001. Land Use Timeline for Crow Canyon and the San Lorenzo Creek Watershed. June 2001.

SFBRWQCB. 2009. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074 NPDES Permit No. CAS612008, October 14, 2009...

SFBRWQCB. 2015. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015

SFBRWQCB. 2015b. California Regional Water Quality Control Board, San Francisco Bay Region, San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). Incorporating all amendments approved by the Office of Administrative Law as of March 20, 2015. http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtmlSanta Clara Valley Water District (SCVWD). 2005. West Valley Watershed Stewardship Plan Final Report. Chapter 9 Calabazas Creek. Prepared by team of consultants led by Tetra Tech, Inc. Prepared for the Santa Clara Valley Water District.

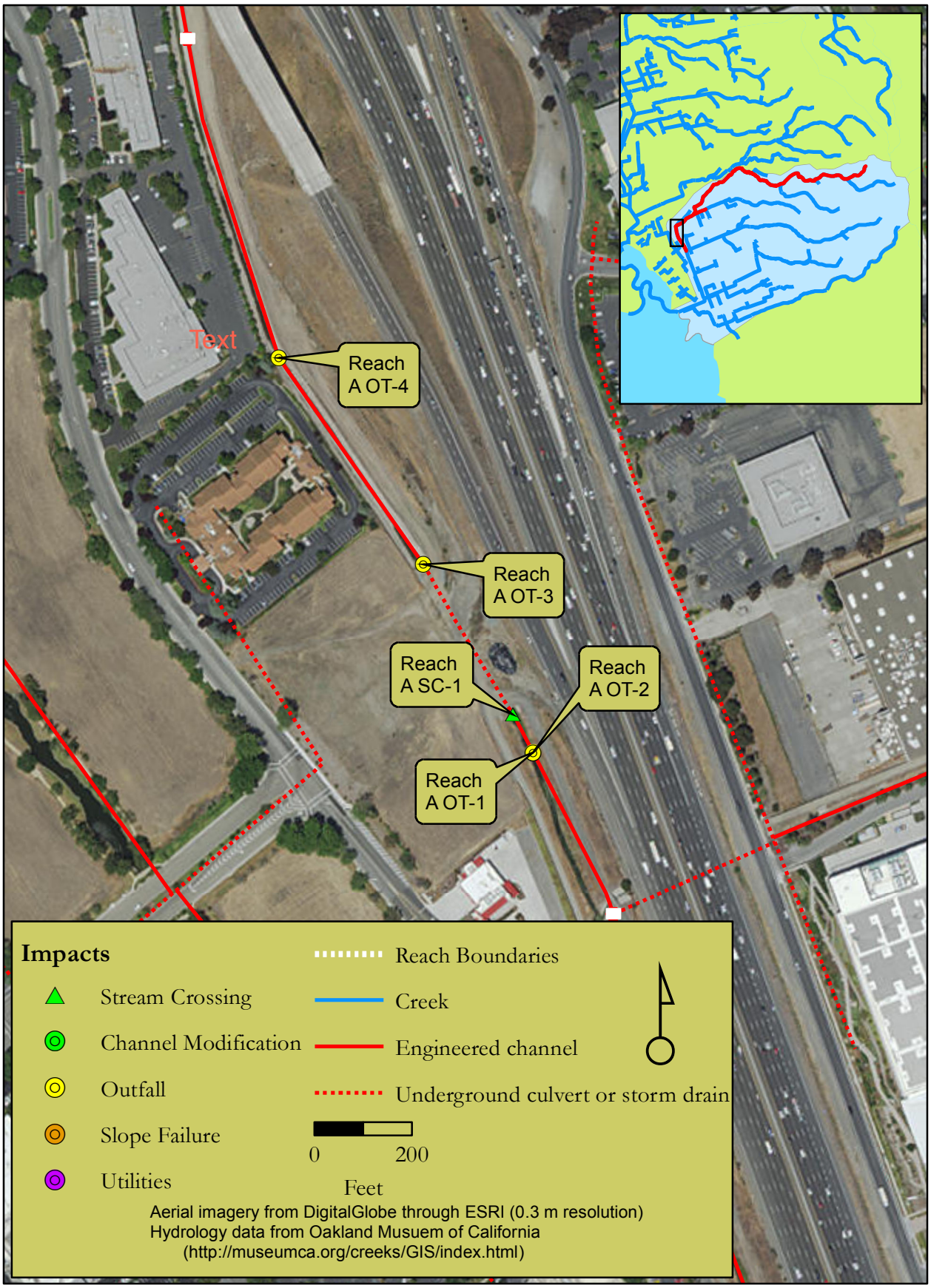
Sullivan, K., Martin, D.J., Cardwell, R.D., Toll, J.E., and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute, Portland, OR. December 2000.

Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPP), Version 1.0. September 1, 2008. http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/qaprp082209.pdf

United States Environmental Protection Agency (USEPA). 1986. Ambient Water Quality Criteria for Bacteria. January 1986

# 8 Attachments

| | |
|---|---|
| **Attachment A** | **Agua Fria Surveyed Reaches** |
| **Attachment B** | **Crandall Creek Surveyed Reaches** |
| **Attachment C** | **Dry Creek Surveyed Reaches** |
| **Attachment D** | **Line 5-K-1 Surveyed Reaches** |
| **Attachment E** | **Line 6-B Surveyed Reaches and Line 6-B-1 Surveyed Reaches** |
| **Attachment F** | **Toroges Creek Surveyed Reaches** |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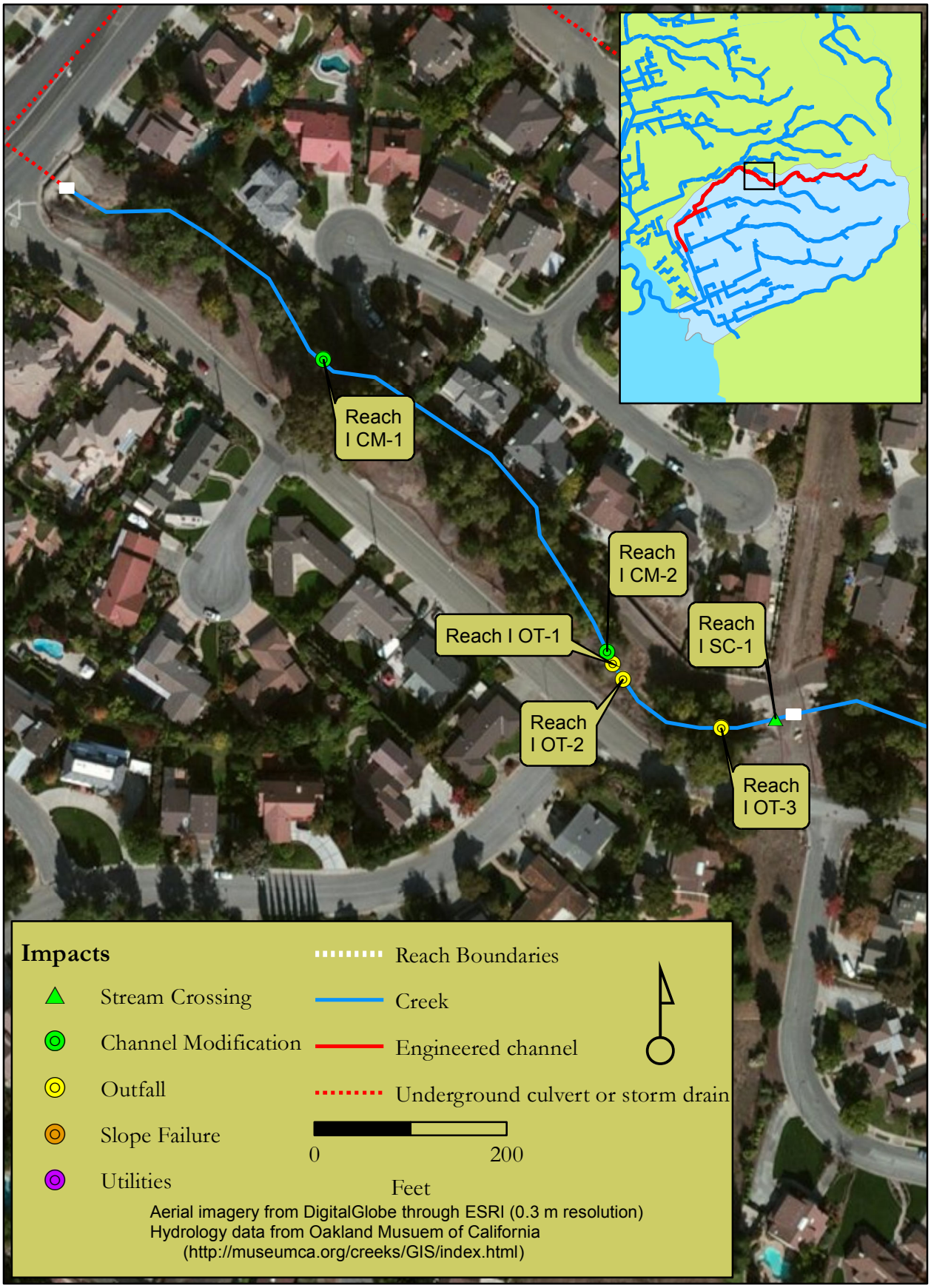
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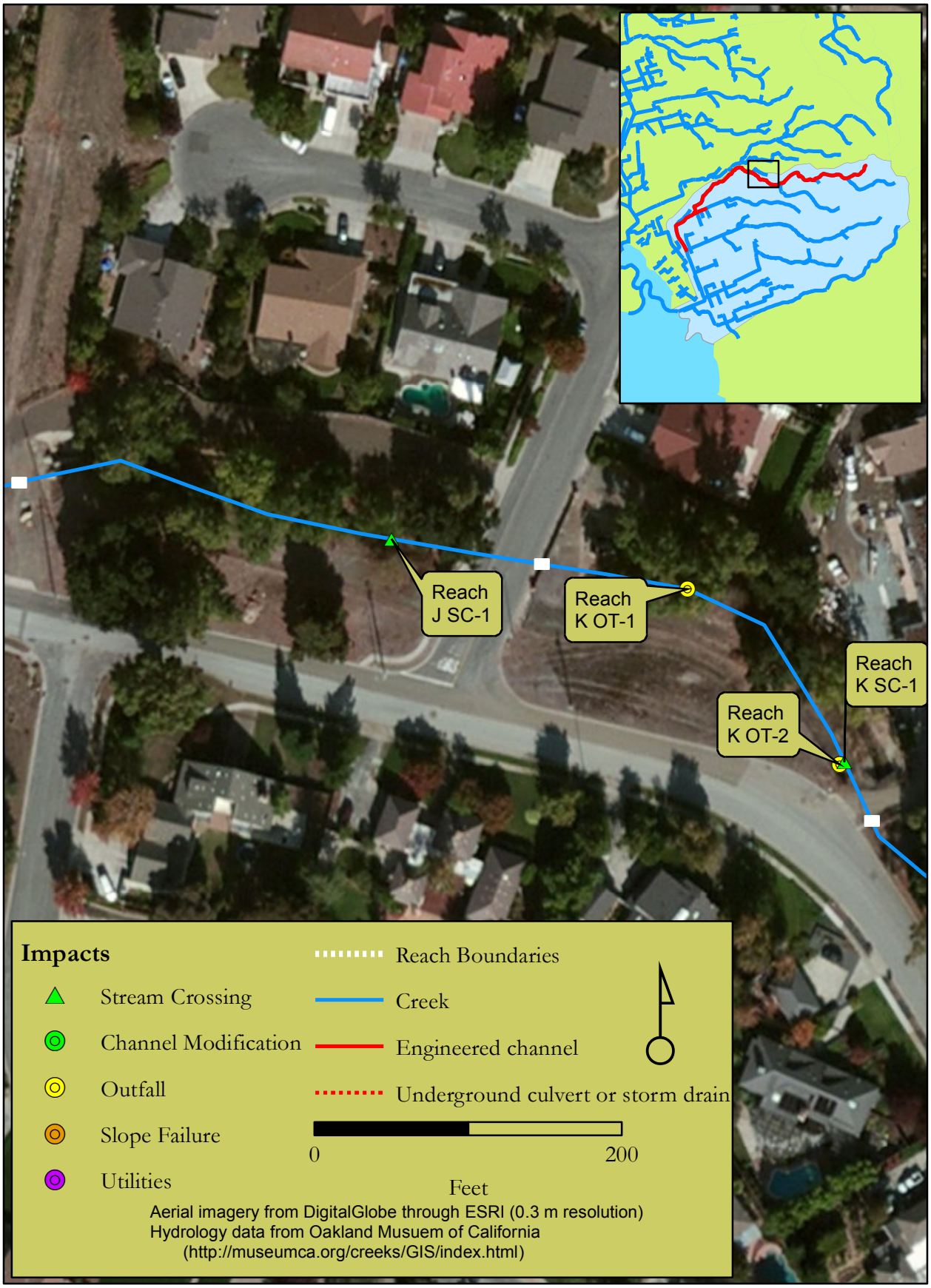
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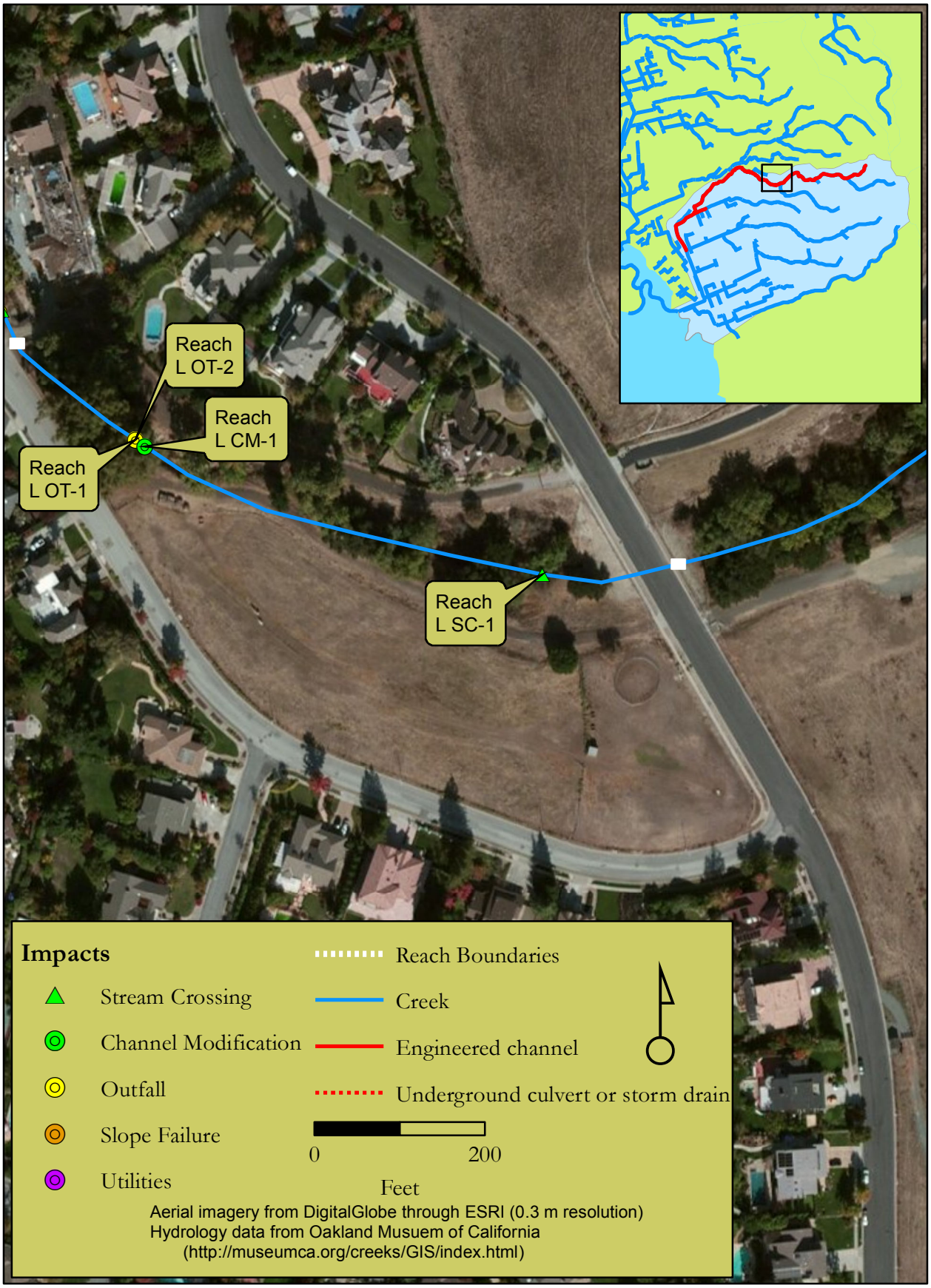
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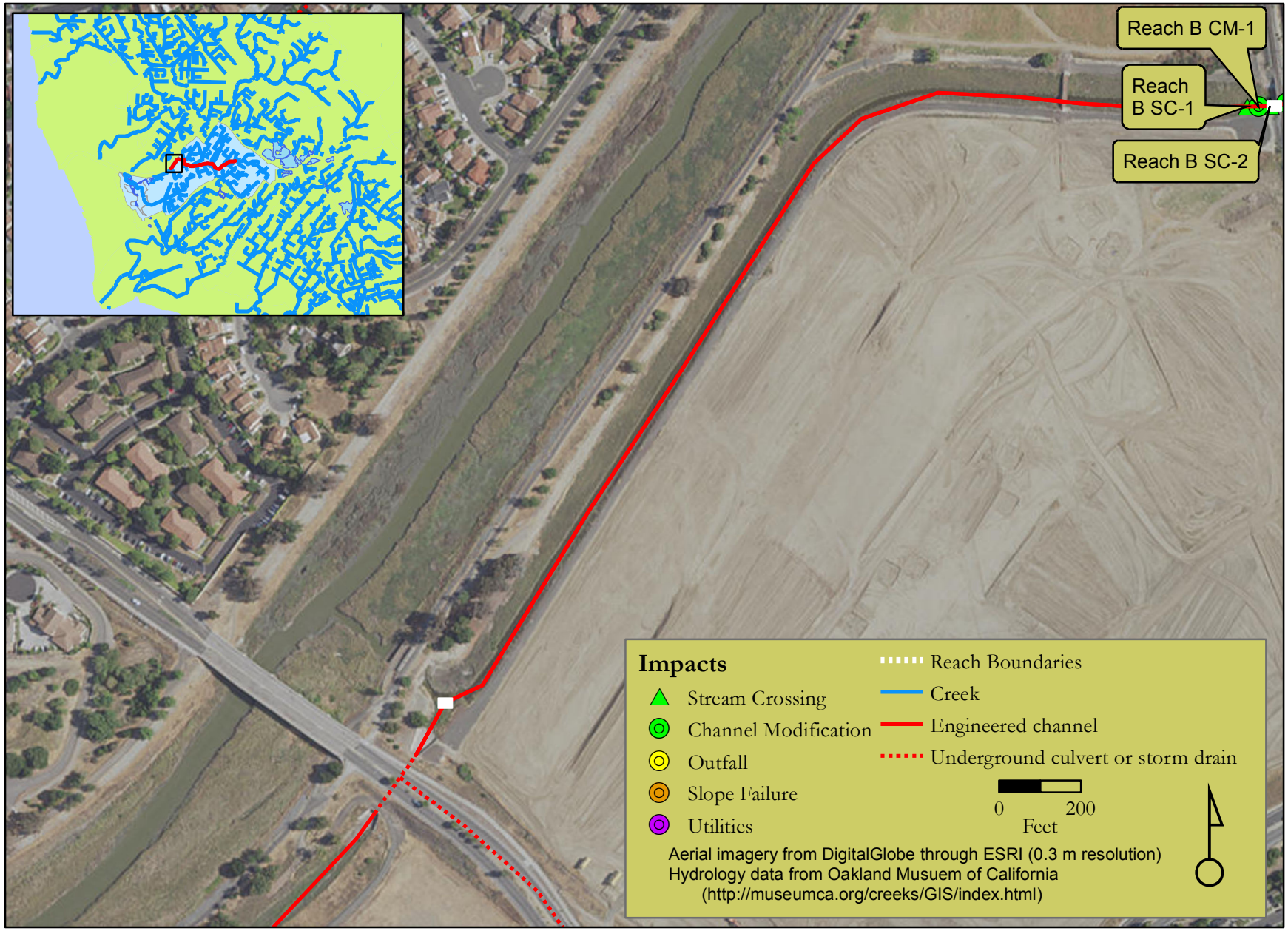
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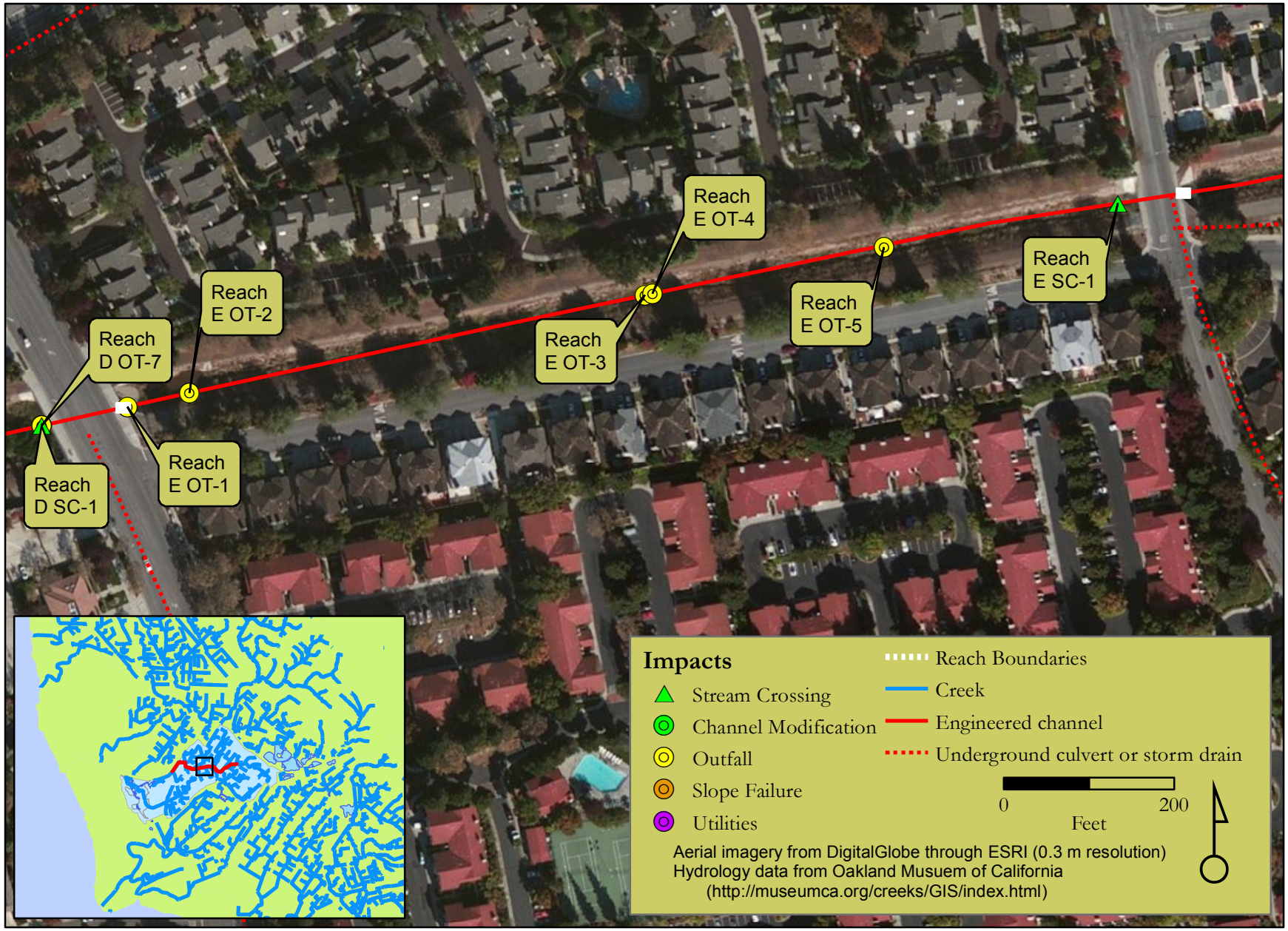
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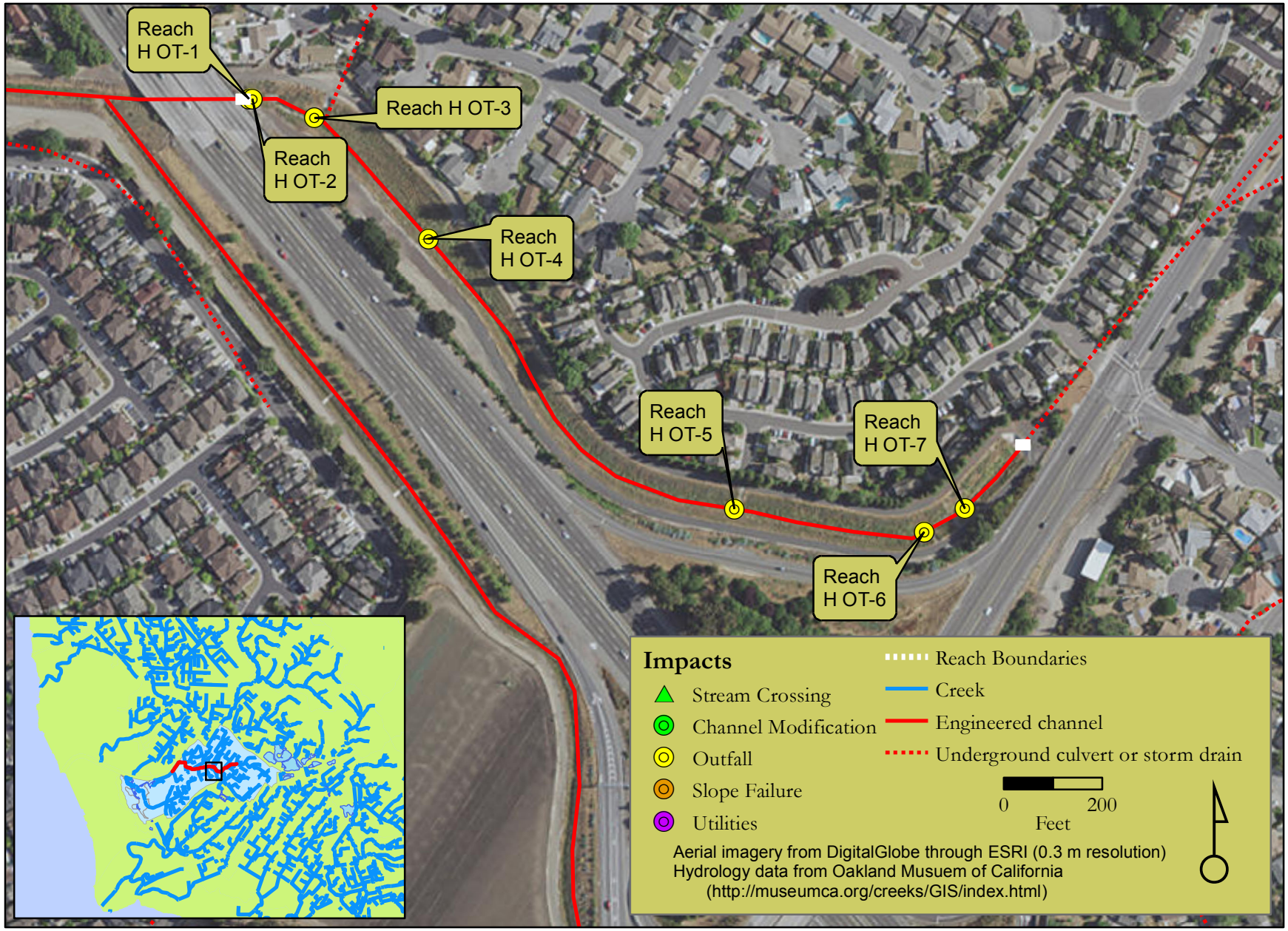
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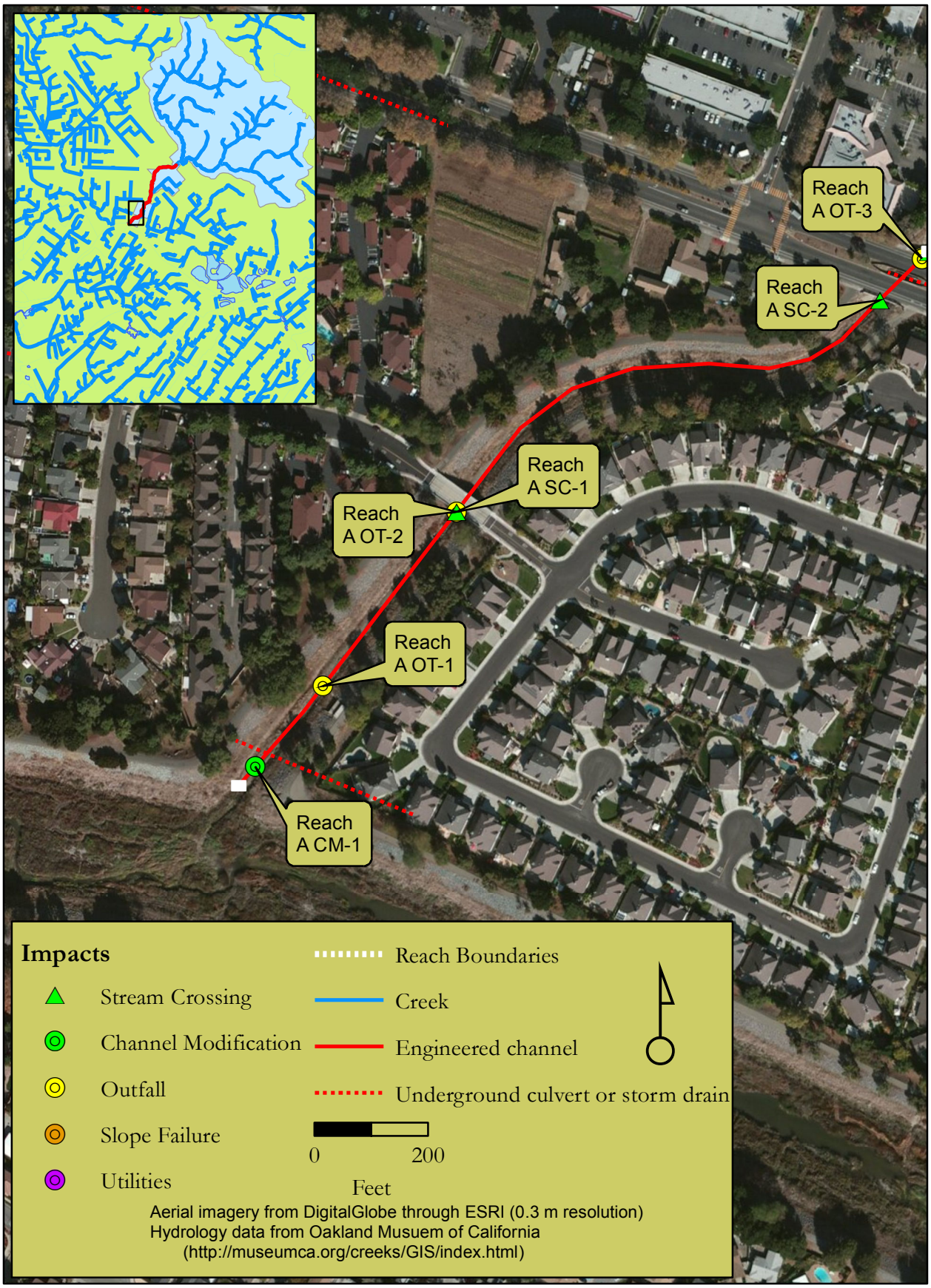
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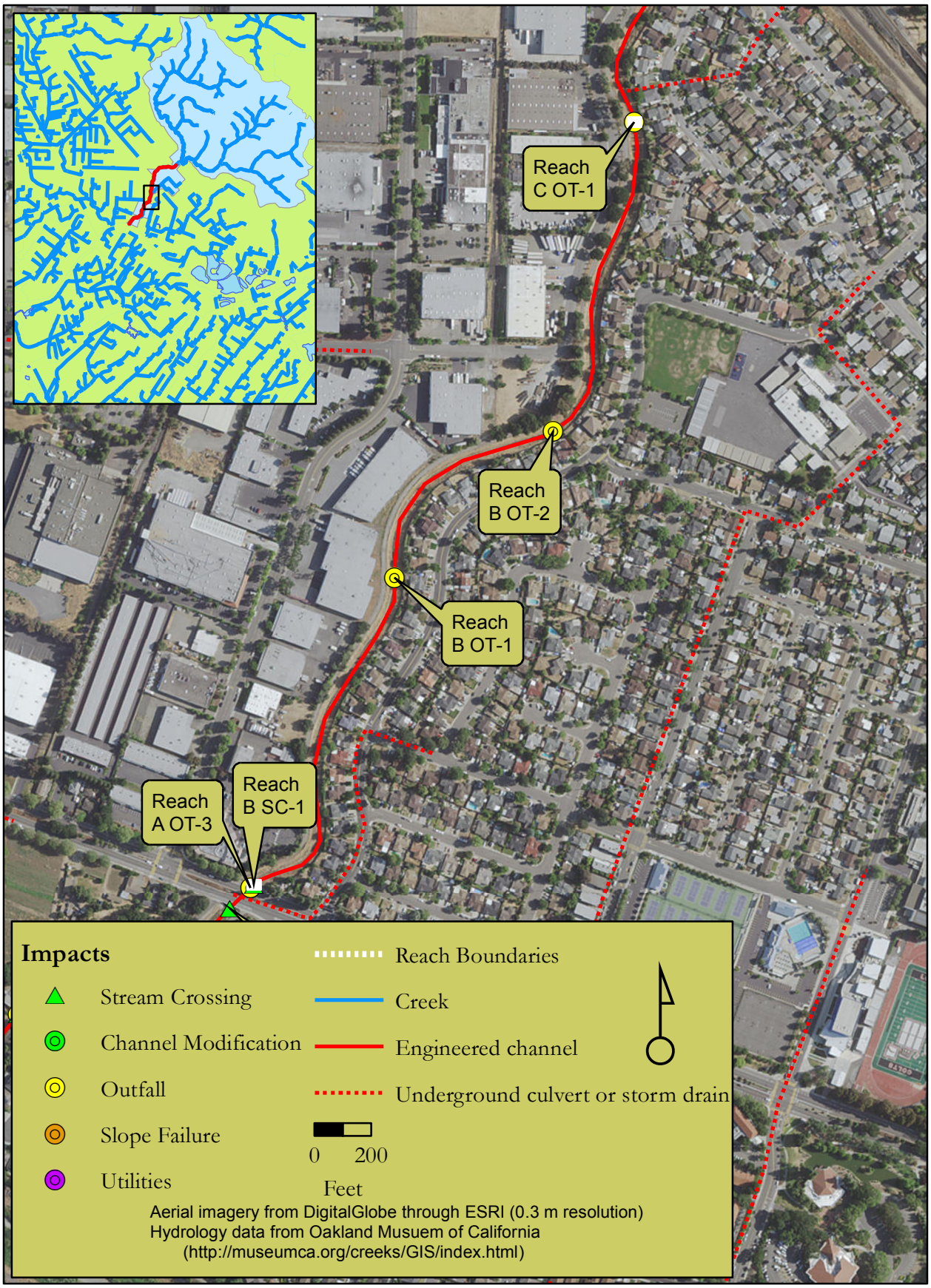
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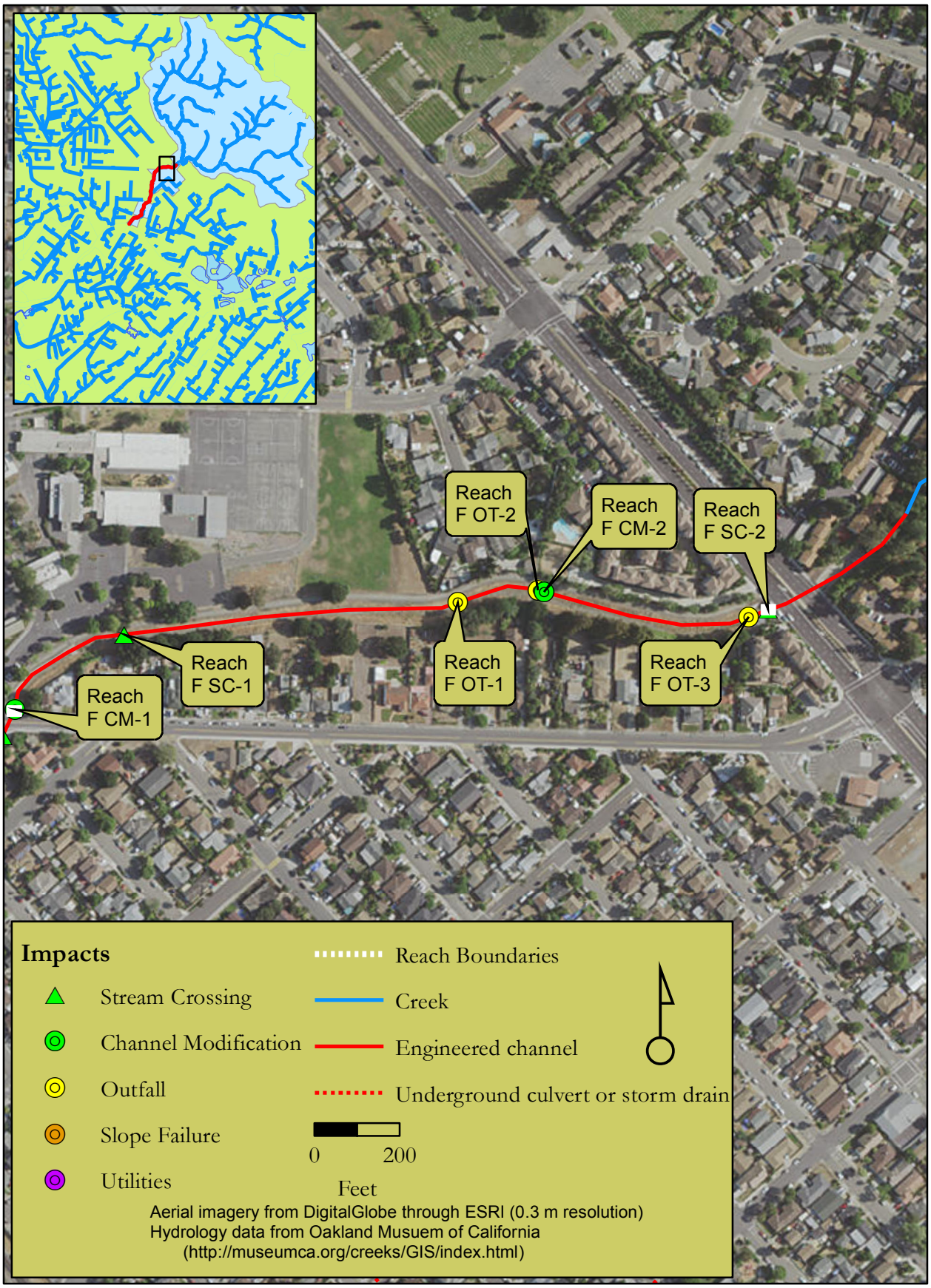
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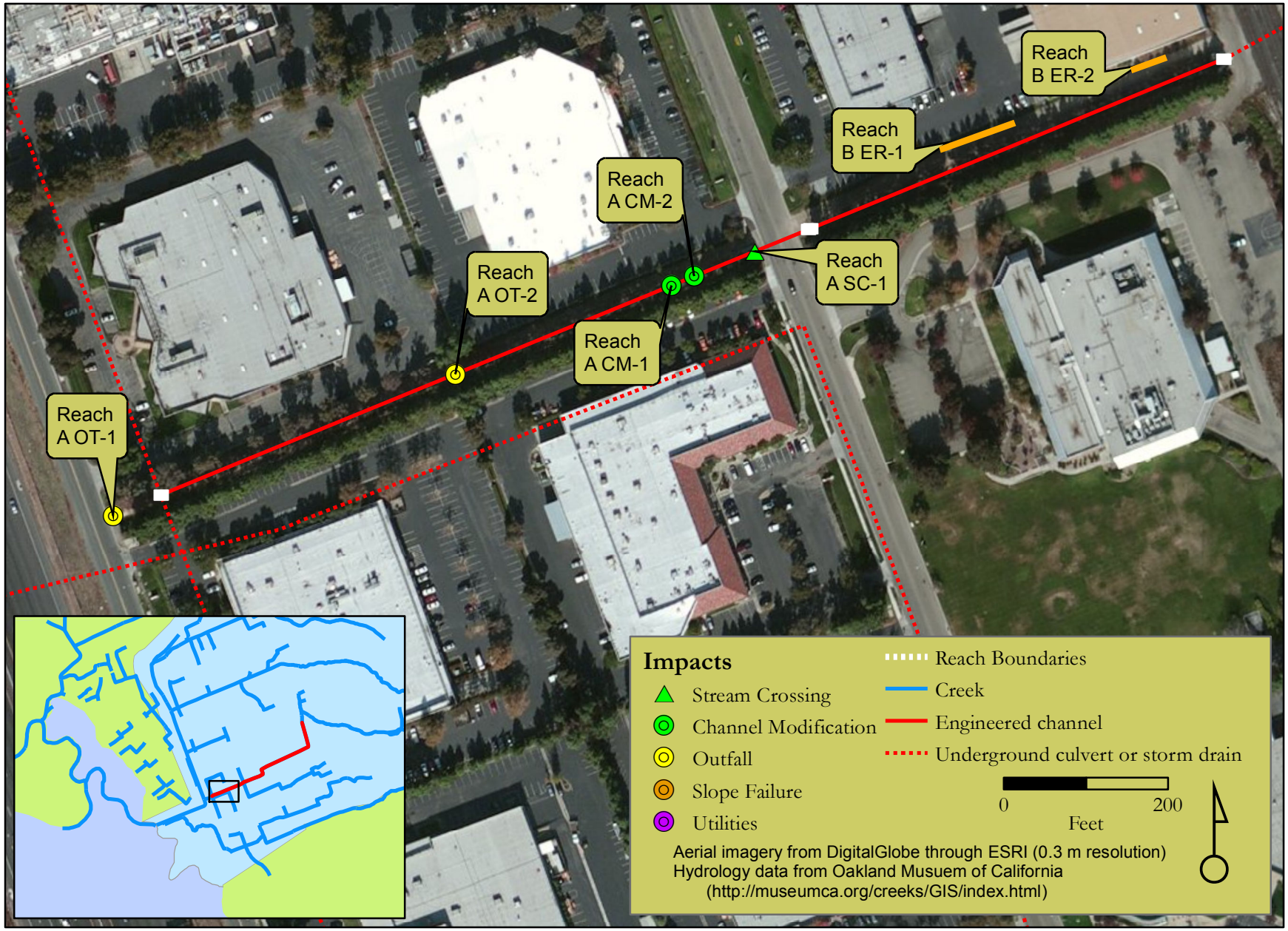
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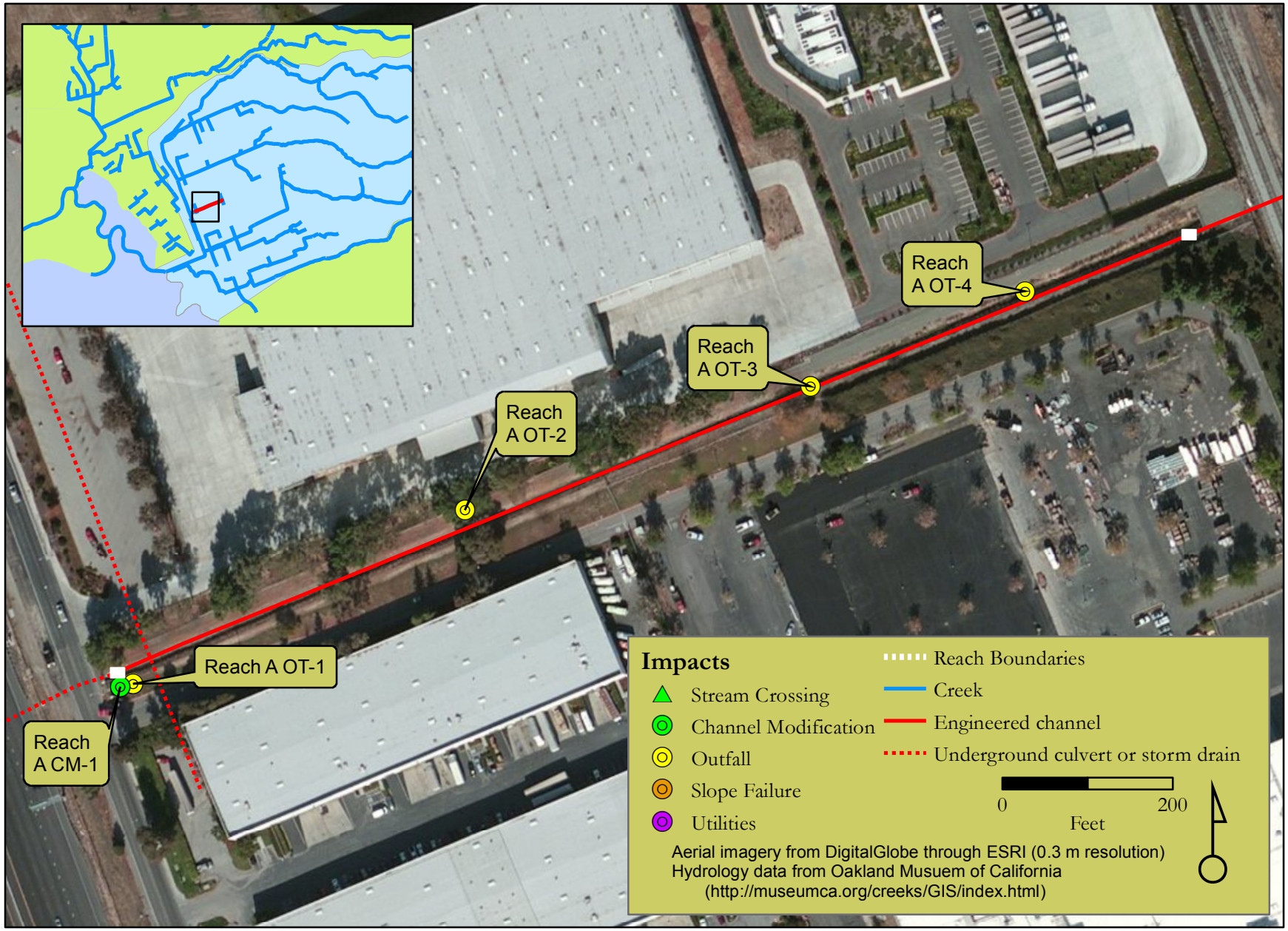
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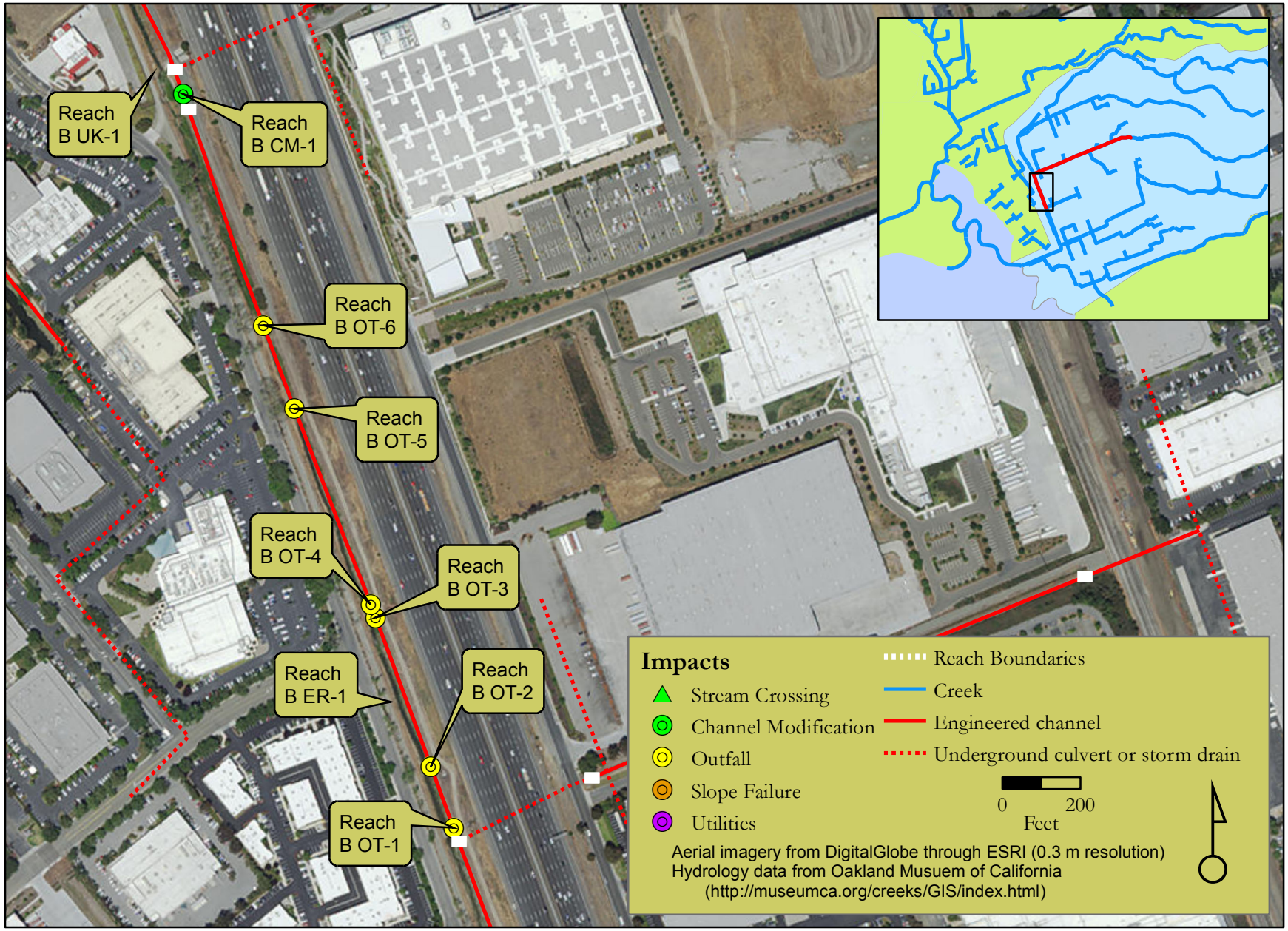
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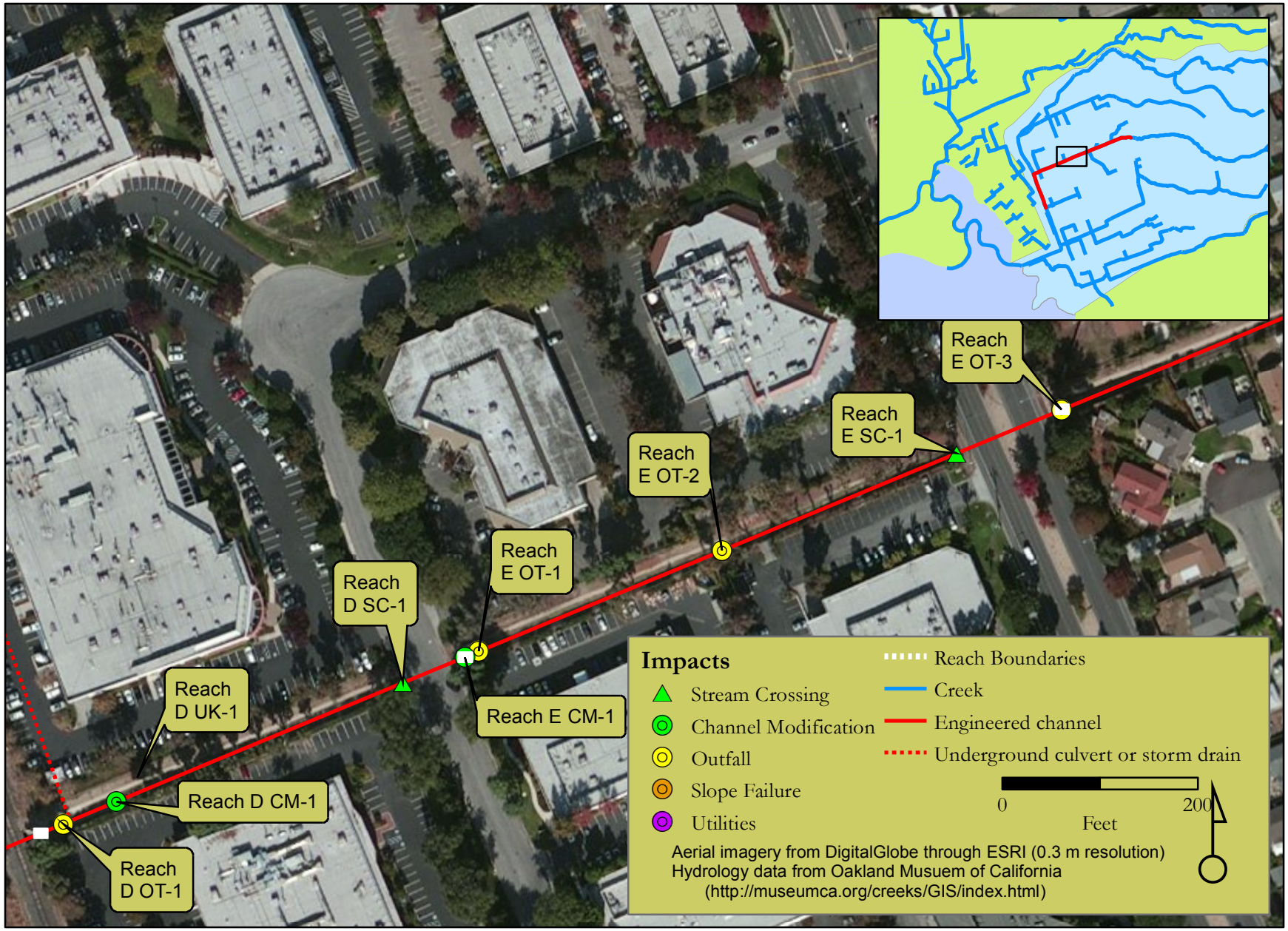
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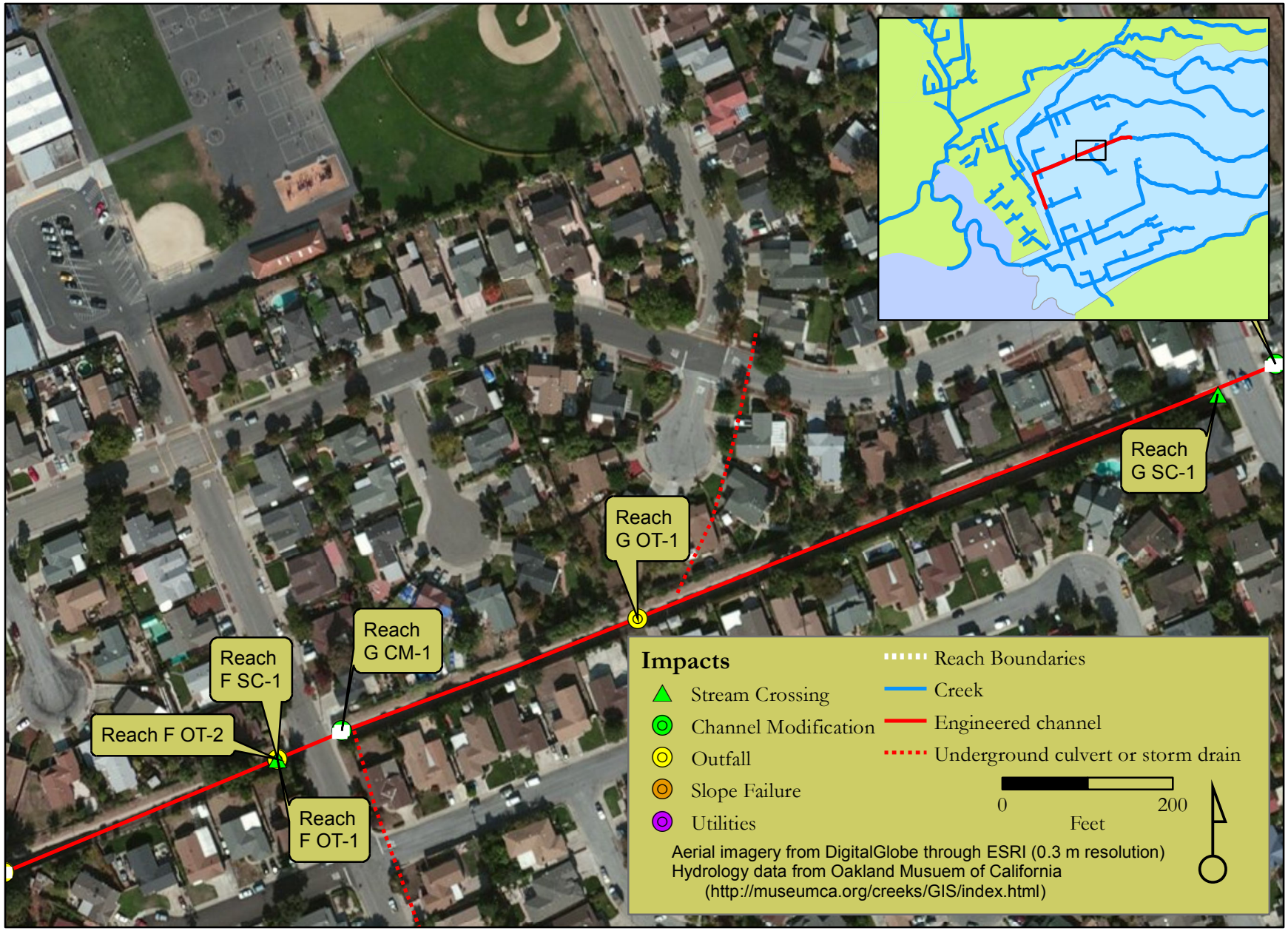
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# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# POLLUTANTS OF CONCERN MONITORING 2015 SEDIMENT SAMPLING REPORT

# APPENDIX A.3A URBAN CREEKS MONITORING REPORT OCTOBER 2014 THROUGH SEPTEMBER 2015

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

Protecting Alameda County Creeks, Wetlands & the Bay

## Acknowledgements

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) 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.

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# 1. Introduction

This report details activities associated with implementation of Pollutants of Concern (POC) monitoring conducted by the Alameda Countywide Clean Water Program (ACCWP, Program) in partial fulfillment of the POC loads monitoring requirements described in Provision C.8.e.i of the Municipal Regional Stormwater Permit (MRP, SFBRWQCB 2009), using a revised alternative approach as allowed by Provision C.8.e. As described in the main body of the ACCWP UCMR, the Program and permittees are in the process of identifying potential sources of polychlorinated biphenyls (PCBs) to municipal storm drain systems by conducting PCB source identification studies as part of a process outlined in a separate report[1]. 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.

This report covers data collected by sampling bedded sediment in public rights-of-way (ROWs) within the Ettie Street Pump Station and San Leandro Bay drainage areas in Oakland, and other areas of Old Industrial land use in the cities of Hayward and Berkeley. All sampling was performed between April and 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

1 Mercury and PCBs Control Measures Implementation Status Report, to be submitted by April 1, 2016

**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 Activities

A list of sites for which field staff completed reconnaissance operations in 2015, and that were sampled if feasible, is summarized in Table 3-1. Sites that were successfully sampled during 2015 are shown in Figures 1 through 6.

For the Oakland sites, the City of Oakland contracted with AMEC, Inc. to develop a list of prospective sampling sites through conduct of windshield surveys. The ACCWP Program Coordinator identified priorities for sampling sites from this list. Sampling personnel determined sample collection method at time of sampling from a list of options provided within the project SAP (AMS 2016). For the Hayward and Berkeley sites, municipal staff identified a list of prospective sampling sites for field staff to survey for sampling feasibility. From this list, AMS field staff sampled higher priority sites that exhibited required characteristics, namely safe access, availability of finer soils in the right-of-way, and a clear linkage of the soils to processes occurring at identified facilities.

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

| SiteID | AMEC ID | APN(s) | Date | Lat | Long | Comments |
|---|---|---|---|---|---|---|
| AC-OES-001-R | 1 | 5-402-5-2 | 4/14/15 | 37.81538 | -122.28768 | Sampled soil mounded at fence line, heavily vegetated |
| AC-OES-002-R | 2 | 5-419-1-4 | 4/14/15 | 37.81601 | -122.28739 | Sampled soil mounded at fence line, heavily vegetated |
| AC-OES-003-R | 3 | 5-421-3-4 | 4/14/15 | 37.81617 | -122.29006 | Sampled at curb (depositional soil tracked out) |
| AC-OES-004-R | 4 | 5-426-22-1 | 4/14/15 | 37.81676 | -122.28463 | Sampled soil mounded at fence line, heavily vegetated |
| AC-OES-008-U | 8 | 7-586-2 | 4/14/15 | 37.82059 | -122.28824 | Not sampled, no depositional soil obvious, collected surface soil present at drip line of identified parcel; possible low priority for analysis. Unsure of ownership of this lot (behind gated end of roadway, marked as parking lot for Brown Sugar Kitchen); APN identified by AMEC survey (7-585-1-3) is across street from target sampling area at reported APN |
| AC-OES-009-R | 9 | 7-589-24 | 4/14/15 | 37.82272 | -122.28650 | Sampled soil at fence line; mostly hard-packed, no archive collected |
| AC-OES-010-R | 10 | 7-589-28 | 4/14/15 | NS | NS | Not sampled, soil in ROW hard-packed, no evidence of migration. |
| AC-OES-011-R | 11 | 7-589-29 | 4/14/15 | NS | NS | Not sampled, no evidence of soil in ROW originating on-site; soil on sidewalk appears to be dumped potting soil |
| AC-OES-013-R | 13 | 7-599-2 | 4/14/15 | NS | NS | Not sampled - minimum soil present, appears to be predominantly concrete dust |
| AC-OES-014-R | 14 | 7-613-5-4<br>7-614-1 | 4/14/15 | 37.82692 | -122.28208 | Sampled between broken concrete in driveway; also sampled CW4CB T3, possible low priority for analysis |
| AC-OES-016-R | 16 | 18-310-3-8<br>18-310-3-9<br>18-310-3-10<br>18-310-3-11 | 4/14/15 | 37.81848 | -122.29385 | Sampled soil mounded at fence line, heavily vegetated |
| AC-OES-020-R | 20 | 18-310-418-310-7-7 | 4/14/15 | 37.81701 | -122.29498 | Sampled soil mounded at fence line |
| AC-OES-021-R | 21 | 18-310-12-1 | 4/14/15 | 37.81393 | -122.29747 | Sampled soil mounded at fence line within depression that pools runoff from site; some influence from roadway |
| AC-OES-022-R | 22 | 18-310-13-1 | 4/14/15 | 37.81544 | -122.29623 | Sampled soil mounded at fence line |

| SiteID | AMEC ID | APN(s) | Date | Lat | Long | Comments |
|---|---|---|---|---|---|---|
| AC-OSL-024-R | 24 | 33-2164-16 | 4/15/15 | 37.77093 | -122.21699 | Sampled unconsolidated soil at multiple points along fence line |
| AC-OSL-025-R | 25 | 34-2254-2-1 | 4/15/15 | 37.76977 | -122.21306 | Sampled soil accumulating in abandoned RR tracks in driveway (some influence from roadway likely) |
| AC-OSL-026-R | 26 | 34-2260-3-1 | 4/15/15 | NS | NS | Not sampled - low priority site and no appropriate sampling material (hard packed soil, broken glass, debris) |
| AC-OSL-027-R | 27 | 34-2261-8 | 4/15/15 | 37.76921 | -122.21429 | Sampled dried soil in depression in concrete just outside of fence line |
| AC-OSL-29A-R | 29 | 34-2287-1-5 | 4/15/15 | 37.76521 | -122.21243 | Not sampled - soil / debris present, but does not appear to originate on-site |
| AC-OSL-29B-R | 29 | 34-2287-1-5 | 4/15/15 | NS | NS | Not sampled - soil around fence hard-packed, no migration evident |
| AC-OSL-030-R | 30 | 34-2291-6-4 | 4/15/15 | NS | NS | Not sampled - low priority site and ROW occupied at time of sampling; no soil migration apparent |
| AC-OSL-031-R | 31 | 34-2293-2-2 | 4/15/15 | 37.76688 | -122.21671 | Sampled soil / mixed debris accumulating at fence line |
| AC-OSL-033-R | 33 | 41-3848-23-2 | 4/15/15 | 37.76148 | -122.20481 | Sampled soil accumulating in cracks / gaps in driveway |
| AC-OSL-36A-R | 36 | 41-3908-15 | 4/15/15 | 37.75611 | -122.20706 | Sampled abundant soil in driveway |
| AC-OSL-36B-R | 36 | 41-3908-15 | 4/15/15 | 37.75586 | -122.20629 | Sampled soil in driveway |
| AC-OSL-037-R | 37 | 471-3910-10 | 4/15/15 | 37.75687 | -122.20604 | Sampled soil accumulating in cracks / gaps in driveway |
| AC-OSL-040-P | 40 | 41-4056-5 | 4/15/15 | NS | NS | No sample collected - private property, no public access |
| AC-OSL-41A-R | 41 | 41-4162-32-4 | 4/15/15 | 37.75281 | -122.19529 | Sampled soil mounded at fence line; no sample collected at AMEC sampling point #2 (no migration from site) |
| AC-OSL-41B-R | 41 | 41-4162-32-4 | 4/15/15 | NS | NS | No sample collected – hard-packed soil with no track out |
| AC-HAY-002-R | NA | 439-70-3 | 7/27/15 | 37.63800 | -122.13095 | Collected in driveway |
| AC-HAY-003-R | NA | 439-70-4 | 7/27/15 | 37.63799 | -122.13154 | Collected in driveway |
| AC-HAY-004-R | NA | 439-70-5-1 | 7/27/15 | 37.63797 | -122.13195 | Collected in driveway |
| AC-HAY-005-R | NA | 439-70-5-2 | 7/27/15 | 37.63789 | -122.13259 | Collected in driveway |
| AC-HAY-006-R | NA | 439-70-6 | 7/27/15 | NS | NS | Construction site, sidewalk blocked, no safe access to ROW |
| AC-HAY-007-R | NA | 439-70-8-4 | 7/27/15 | 37.63783 | -122.13345 | Composite from three sites near/in driveway |
| AC-HAY-008-R | NA | 439-70-13-1 | 7/27/15 | 37.63778 | -122.13481 | Sampled apron of stormdrain inlet |

| SiteID | AMEC ID | APN(s) | Date | Lat | Long | Comments |
|---|---|---|---|---|---|---|
| AC-HAY-009-R | NA | 439-70-14 | 7/27/15 | 37.63776 | -122.13558 | Collected a mix of sediment from curb and from edge of fence line |
| AC-HAY-016-R | NA | 432-114-36 | 7/27/15 | 37.65308 | -122.12818 | Collected on left side of driveway at W. Winton and Bulldog |
| AC-HAY-019-R | NA | 432-114-38 | 7/27/15 | NS | NS | Approximately 2' curb wall between property and planting strip. No track off evident at driveway. |
| AC-HAY-020-R | NA | 432-114-39 | 7/27/15 | 37.65425 | -122.12602 | Collected from driveway |
| AC-HAY-029-R | NA | 432-76-5-4 | 7/27/15 | 37.65310 | -122.12697 | To the left of Fry's metals, right outside fence line |
| AC-HAY-030-R | NA | 438-30-13-1 | 7/27/15 | NS | NS | Does not appear to be much track off from site. Large, impervious area adjacent to fence. |
| 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 |

| SiteID | AMEC ID | APN(s) | Date | Lat | Long | Comments |
|---|---|---|---|---|---|---|
| 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 |

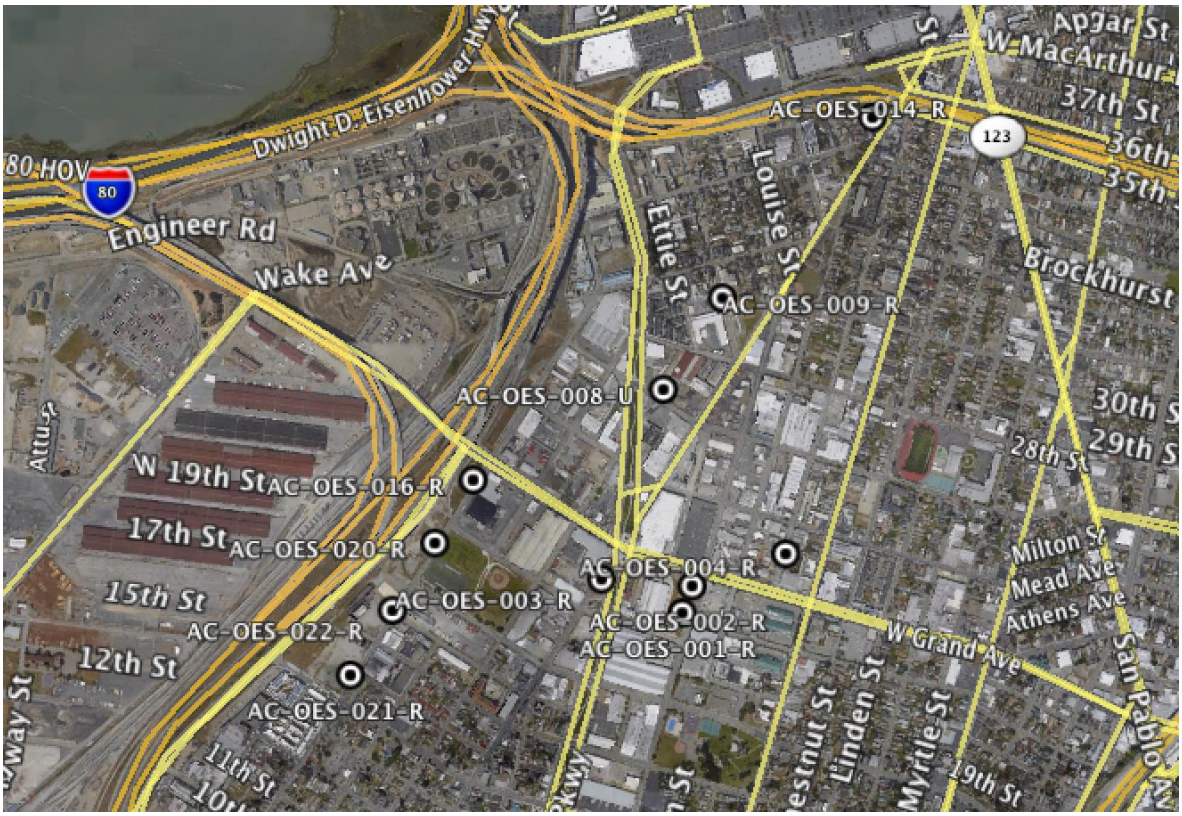


**Figure 1. Overview of Sites Successfully Sampled, Ettie Street Pump Station Watershed, Oakland.**

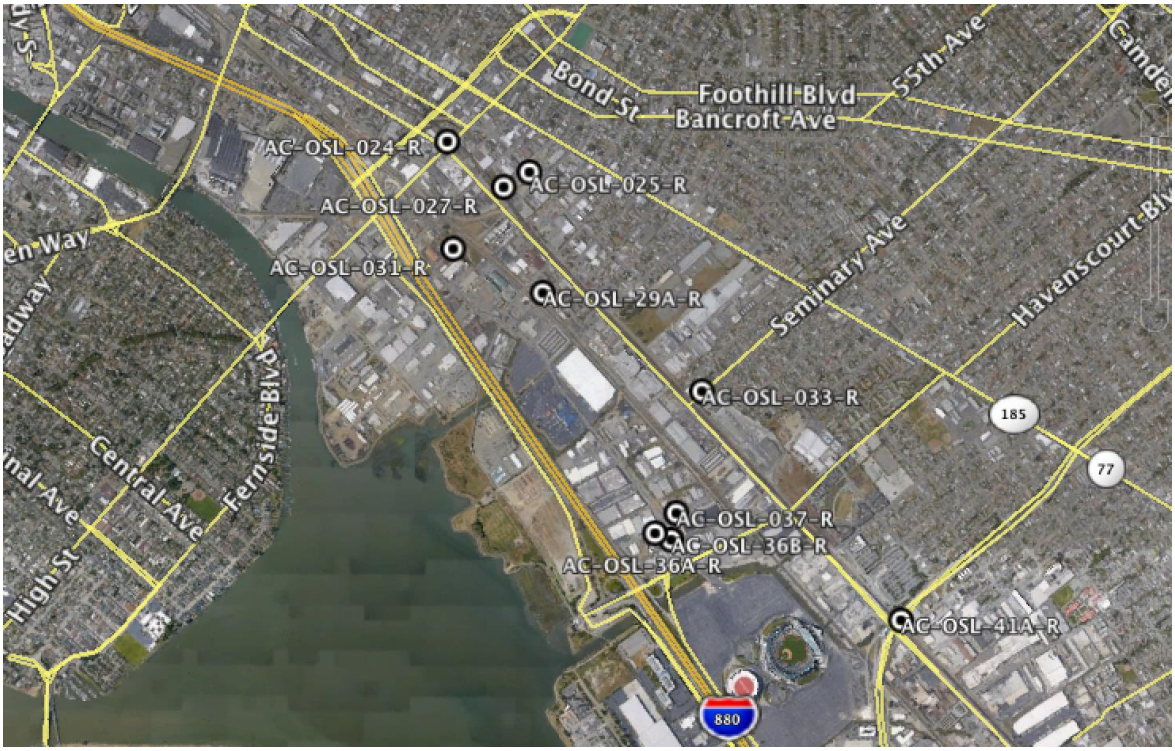

**Figure 2. Overview of Sites Successfully Sampled, San Leandro Bay Old Industrial Drainage Area Oakland.**

**Figure 3. Overview of Sites Successfully Sampled, Hayward – North Cluster**

**Figure 4. Overview of Sites Successfully Sampled, Hayward – South Cluster**

**Figure 5. Overview of Sites Successfully Sampled, Berkeley – North Cluster**

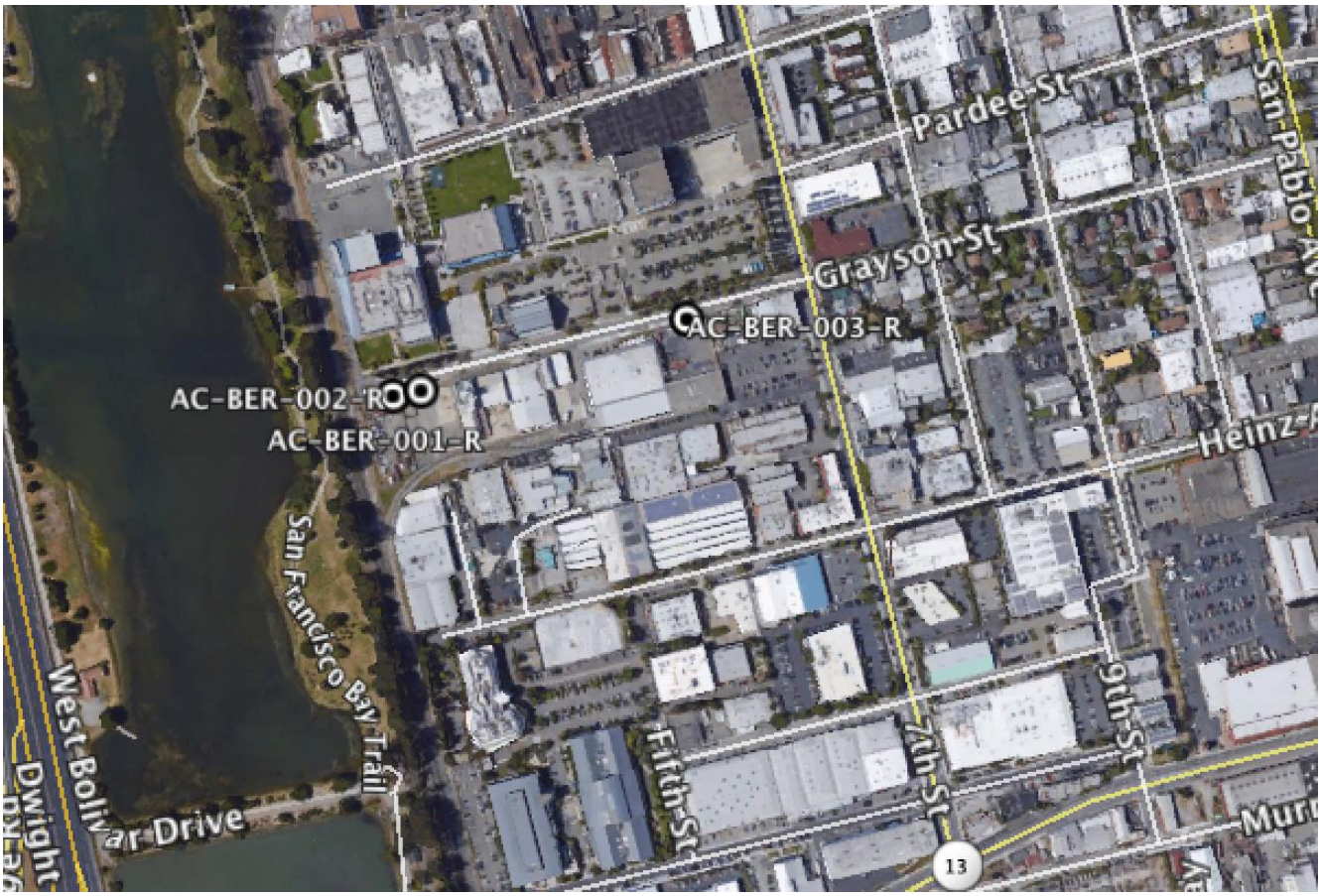


**Figure 6. Overview of Sites Successfully Sampled, Berkeley – South Cluster**

# 4. Discussion

## 4.1. Completeness

Samples were collected at 43of 59identifiedsites for which a field reconnaissance was performed.[2] The sampling failures are attributed to one of the following factors: (1) no public access to target; (2) soils present, but no evidence they originated on target site (e.g., adjacent sidewalk at higher elevation than site; appear to be product of dumping); or (3) no depositional soils present.

## 4.2. Quality Assurance

In keeping with the draft Project QAPP, field duplicate samples were collected at site OSL-36A and BER-014, which both 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.

One of the three batches analyzed for mercury exhibited a % recovery of an MS sample slightly outside of control limits (CLs), with 132% recovery. The MSD sample was, however, within control limits. Affected samples were flagged with the VGB qualifier to indicate MS sample outside of CLs.

For a small subset of PCB congeners within three of the four batches analyzed, calculated % recoveries on MS/MSD samples exceeded CLs, suggesting a potential bias in their reported results. The laboratory attributed these results to a possible matrix interference associated with the sample media. Affected congeners were flagged with the VGB qualifier to indicate MS sample outside of CLs. AMS conducted a simple sensitivity analysis to gauge the effect of this potential bias upon calculated PCB sums, which suggests minimal effect upon calculated totals (i.e., the affected congeners did not contribute greatly to the sums).

For a small subset of PCB congeners within each batch, LCS % recoveries were flagged by the laboratory for falling outside of laboratory CLs. However, all recoveries met SWAMP MQOs for recovery (50% to 150%), so qualifiers were removed from laboratory EDDs.

[2] Interpretation can vary depending on how multiple sampling points associated with a single property are counted.

For a small subset of PCB congeners within lab batch ALS/KWG1511361B/K1513203/S/8082A, precision results for field duplicate / field sample pairs exceeded SWAMP CLs. Affected results were flagged with VFDP qualifier. However, exceedances of the MQO for field duplicates, especially within sediment sample matrix, are typical and not expected to affect results of interpretation.

## 4.3. Results and Next Steps

The summary results associated with all 2015 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.

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). The October 2016 POC Monitoring Report will summarize the outcomes of ACCWP POC sediment from WY 2015 and WY2016, and the data will be used to support identification of priority watersheds and management areas for Permittee actions to reduce PCBs in a report to be submitted with the September 2016 Annual Report.

**Table 4-1. Summary Results for Calendar Year 2015 POCs Monitoring.**

| Station ID | Latitude | Longitude | Total PCBs (ug/kg) | Total Hg (ug/kg) |
|---|---|---|---|---|
| HAY-002 | 37.63800 | -122.13095 | 24 | 0.12 |
| HAY-003 | 37.63799 | -122.13154 | 20 | 0.14 |
| HAY-004 | 37.63797 | -122.13195 | 92 | 1.72 |
| HAY-005 | 37.63789 | -122.13259 | 7 | 0.07 |
| HAY-007 | 37.63783 | -122.13345 | 25 | 0.14 |
| HAY-008 | 37.63778 | -122.13481 | 38 | 0.11 |
| HAY-009 | 37.63776 | -122.13558 | 118 | 0.60 |
| HAY-016 | 37.65308 | -122.12818 | 112 | 0.54 |
| HAY-020 | 37.65425 | -122.12602 | 27 | 0.26 |
| HAY-029 | 37.65310 | -122.12697 | 122 | 2.72 |
| OES-001 | 37.81538 | -122.28768 | 75 | 0.33 |
| OES-002 | 37.81601 | -122.28739 | 106 | 0.24 |
| OES-003 | 37.81617 | -122.29006 | 125 | 0.13 |
| OES-004 | 37.81676 | -122.28463 | 93 | 0.15 |
| OES-008 | 37.82059 | -122.28824 | 270 | 0.21 |

| Station ID | Latitude | Longitude | Total PCBs (ug/kg) | Total Hg (ug/kg) |
|---|---|---|---|---|
| OES-009 | 37.82272 | -122.2865 | 10280 | 0.91 |
| OES-014 | 37.82692 | -122.28708 | 52 | 0.10 |
| OES-016 | 37.81848 | -122.29385 | 62 | 0.10 |
| OES-020 | 37.81701 | -122.294982 | 199 | 0.18 |
| OES-021 | 37.81393 | -122.29747 | 2149 | 0.11 |
| OES-022 | 37.81544 | -122.29623 | 83 | 0.14 |
| OSL-024 | 37.77093 | -122.21699 | 91 | 0.2 |
| OSL-025 | 37.76977 | -122.21306 | 46 | 0.31 |
| OSL-027 | 37.76921 | -122.21429 | 93 | 0.29 |
| OSL-031 | 37.76688 | -122.21671 | 588 | 0.14 |
| OSL-033 | 37.76148 | -122.20481 | 24 | 0.39 |
| OSL-036A | 37.75611 | -122.20706 | 42 | 0.20 |
| OSL-036B | 37.75586 | -122.20629 | 44 | 0.14 |
| OSL-037 | 37.75687 | -122.20604 | 326 | 0.40 |
| OSL-041A | 37.75281 | -122.19529 | 631 | 0.74 |
| 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 |

# 5. References

BASMAA 2012. Sampling and Analysis Plan: Clean Watersheds for a Clean Bay – Implementing the San Francisco Bay's PCBs and Mercury TMDLs with a Focus on Urban Runoff, Task 3, EPA San Francisco Bay Water Quality Improvement Fund Grant #CFDA 66.202. Prepared by Applied Marine Sciences, Inc. September 4, 2012.

BASMAA 2014. BASMAA Regional Monitoring Coalition Standard Operating Procedures for Creek Status Monitoring. Prepared by AMS, ARC, and EOA for the Regional Monitoring Coalition. Version 2, January 2014.

SWAMP 2008. Surface Water Ambient Monitoring Program Quality Assurance Project Plan, Version 1.0. Prepared for the California State Water Quality Control Board by the SWAMP Quality Assurance Team. September 1, 2008.

SFBRWQCB. 2009. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074 NPDES Permit No. CAS612008, October 14, 2009...

SFBRWQCB. 2015. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015

# Pollutants of concern (POC) reconnaissance monitoring draft final progress report, water year (WY) 2015

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**On**

**February 29, 2016**

**For**

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

## Preface

WY 2015 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 two winter monitoring seasons: Water Year (WY) 2015 and WY 2016). This version of the report was submitted to BASMAA in support of materials being submitted on or before March 31st 2016 in compliance with the Municipal Regional Stormwater Permit (MRP) Order No. R2-2015-0049. Possible further changes may be made in response to SPLWG and TRC review comments before a final version is submitted to the RMP Steering Committee for approval.

## 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) during a series of meetings in the summer of 2014. Local members on the STLS 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. SFEI's data management team is acknowledged for their diligent delivery of quality assured well-managed data. Over the first year of this project, this team included: Cristina Grosso, Amy Franz, John Ross, Don Yee, Adam Wong, and Michael Weaver. Arleen Feng, Kristine Corneillie, Bonnie de Berry, and Chris Sommers provided helpful written reviews of this report.

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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, sources 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 beginning in Water Year (WY) 2015. This same design is being implemented in the winter of WY 2016 by the RMP and 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. During WY 2015, composite stormwater samples were collected from 20 watershed locations. At three of these locations, data were also collected using 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. The data collected is contributing to a broader based effort to identify potential management areas. The report is designed to be updated in subsequent years as more data are collected.

Total PCB concentrations measured in the composite water samples collected from the 20 sites varied 27-fold between 2,033-55,503 pg/L. When normalized by suspended sediment concentrations (SSC) to generate particle ratios, the three sites with highest particle ratios were the Outfall to Lower Silver Creek in San Jose (783 ng/g), Ridder Park Drive Storm Drain in San Jose (488 ng/g) and Line-3A-M at Line 3A-D in Hayward (337 ng/g). Particle ratios of this magnitude are relatively elevated but lower than some of the previous highest observations made during the reconnaissance study of WY 2011 (Santa Fe Channel (1,403 ng/g), Pulgas Creek Pump Station-North (1,050 ng/g), Ettie St. Pump Station (745 ng/g))[1].

Total Hg (HgT) concentrations in composite water samples ranged 6-fold between sites from 13.7-85.9 ng/L. The greatest HgT concentrations were observed in Line-3A-M at Line 3A-D in Hayward, East Gish Rd Storm Drain in San Jose, and Meeker Slough in Richmond. When the data were normalized by SSC, the three most highly ranked sites were Meeker Slough in Richmond (1.3 µg/g), Line-3A-M at Line 3A-D in Hayward (1.2 µg/g), and Rock Springs Drive Storm Drain in San Jose (0.93 µg/g). Particle ratios of this magnitude are similar to the upper range of those observed previously (mainly in WY 2011). The six

[1] Note the concentrations and particle ratios for these three sites have been modified slightly since publication in 2011 to reflect a new method of computing the central tendency of the data (see the methods section in this report: Derivations of central tendency for comparisons with past data).

highest ranking sites for PCBs based on particle ratios only ranked 12th, 16th, 2nd, 7th, 14th, and 8th respectively in relation to HgT.

Both of the remote suspended sediment sampler types generally characterized sites similarly to the composite stormwater sampling methods (higher concentrations matching higher and lower matching lower), but further testing is needed to determine the overall reliability and practicality of deploying these 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 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. This challenge accepted, a total of 45 sites have so far been sampled for PCBs and HgT in stormwater by SFEI during various field sampling efforts since WY 2003. About 19.2% 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 (61% of this land use has been sampled), followed by Alameda County (17%), San Mateo County (9%), and Contra Costa County (3%). 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, 48% of it lies within 1 km of the Bay and 65% 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 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 provisions aimed at improving information on stormwater loads in selected watersheds (Provision C.8.) and piloting a number of management techniques to reduce PCB and Hg loading entering the Bay from smaller urbanized tributaries (Provisions C.11. and C.12.). 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.

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], expenditure of RMP funds continued to focus on refining pollutant loadings but with additional emphasis on finding and prioritizing potential “high leverage” watersheds and subwatersheds (those with disproportionally high concentrations or loads with connections to sensitive Bay margins). These efforts included

1. a 2009/2010 study to explore relationships between watershed characteristics (Greenfield et al., 2010),
2. a 2009/2010 study to explore optimal sampling design for loads and trends (Melwani et al., 2010),
3. a reconnaissance study in water year 2011 to characterize concentrations during winter storms at 17 locations (McKee et al., 2012),
4. the completion of a number of “pollutant profiles” describing what is known about the sources and release processes for each pollutant (McKee et al., 2014),

[2] For a full list of permittees that included cities and special districts, the reader is referred to the individual countywide program websites or the MRP (SFRWQCB, 2009).

5. the development and operation of a loads monitoring program at six fixed station locations for water years 2012-2014 (Gilbreath et al., 2015a), and
6. 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).

These efforts were consistent with implementation plans outlined in the PCBs and Hg policy documents. As a result, 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 the a reasonable calibration of the regional watershed spreadsheet model (RWSM) has been achieved for water, Cu, and PCBs (Wu et al., 2016)[3].

Discussions between the Bay Area Stormwater Management Agencies Association (BASMAA)[4] 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 a scale paralleling management efforts (areas as small as subwatersheds, areas of old industrial land use, or source properties). This changing focus is consistent with the management trajectory outlined in the Fact Sheet (MRP Appendix I) issued with the November 2011 revision of the October 2009 MRP (SFRWQCB, 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 can address this focus and discussion is still ongoing through the development of a STLS Trend Strategy. In November 2015, the Regional Water Board issued the second MRP (Water Board, 2016). “MRP 2.0” places an increased focus on finding watersheds, source areas, and source properties that are potentially more polluted and located upstream from sensitive Bay margin areas (potential high leverage). Specifically the permit states that effort should be made to better understand contributions to Bay impairment by identifying watershed source areas that contribute most to the impairment of San Francisco Bay beneficial uses (due to source intensity and sensitivity of discharge location). To help support this focus, the Sources Pathways and Loadings Workgroup (SPLWG) and the STLS local team developed and implemented a stormwater characterization monitoring program in Water Year (WY) 2015. 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 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

[3] The calibration of the RWSM for Hg still remains a challenge. Work in early 2016 may help to resolve this.
[4] BASMAA is made up of a number of programs which represent Permittees and other local agencies

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 is being implemented in the winter of WY 2016 by the RMP, the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program.

In parallel, the STLS team is designing a sampling program for monitoring stormwater loading trends in response to management efforts. Data collected using the characterization design 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. The data collected and presented here is contributing to a broader based effort to identify potential management areas. The report is designed to be updated annually in subsequent years as more data are 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 ($PO_4$)[5], 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, 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 WY 2015 design 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 (1, 2, and 4 storms: 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 larger storms causing runoff from the upper

[5] 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 analysis is completed using the ascorbic acid + molybdate blue reagents.

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 Creek 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 tradeoff 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[6] 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)

[6] Note that only 3 locations could be sampled during WY 2015 due to climatic constraints. The remaining nine samples are planned for WY 2016.

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 larger pool of sites was visited during summer 2014 to survey each for safety, logistical constraints, and identification of feasible drainage line entry points. From this larger set, a final set of 25 sites were identified for monitoring during WY 2015. Of these 25 sites, 20 sites were sampled despite climatic constraints (Figure 1; Table 1). The remaining five sites were carried over for possible sampling in WY 2016.

It is seen, from Figure 1 and Table 1, that watershed sites with a wide variety of characteristics were sampled in WY 2015. In total, eight sites were sampled in Santa Clara County, six sites in San Mateo County, five sites in Alameda County, and just one site in Contra Costa County[7]. Areas upstream from sample locations ranged between 0.11 $km^2$ and 11.50 $km^2$ and were characterized by a high degree of imperviousness (53%-85%: mean = 74%). The percentage of the watersheds designated as old industrial[8] range between 2% and 78% and average 30%. 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 and where the resulting concentrations appeared to be surprisingly low and therefore warranting re-sampling. In addition, 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). A matrix of site characteristics for potentially sampling strategic larger watersheds was also developed (Table 2). However, none of these could be sampled during WY 2015 because climatic conditions for rainfall and flow were not met.

# Field methods

## Mobilization and preparing to sample

Based on a minimum rainfall weather forecast for at least a quarter inch[9] over six hours, sampling teams were deployed to each of the sampling sites, ideally reaching the sampling site about one hour before

[7] 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 periods.
[8] Note the definition of "old Industrial" land use used here is based on definitions developed by the Santa Clara Valley Urban Run-off Pollution Prevention Program (SCVURPPP) building on GIS development work completed during the development of the RWSM (Wu et al., 2016).
[9] Note, this was relaxed due to a lack of larger storms. Ideally, mobilization would only proceeded with a 0.5" forecast.

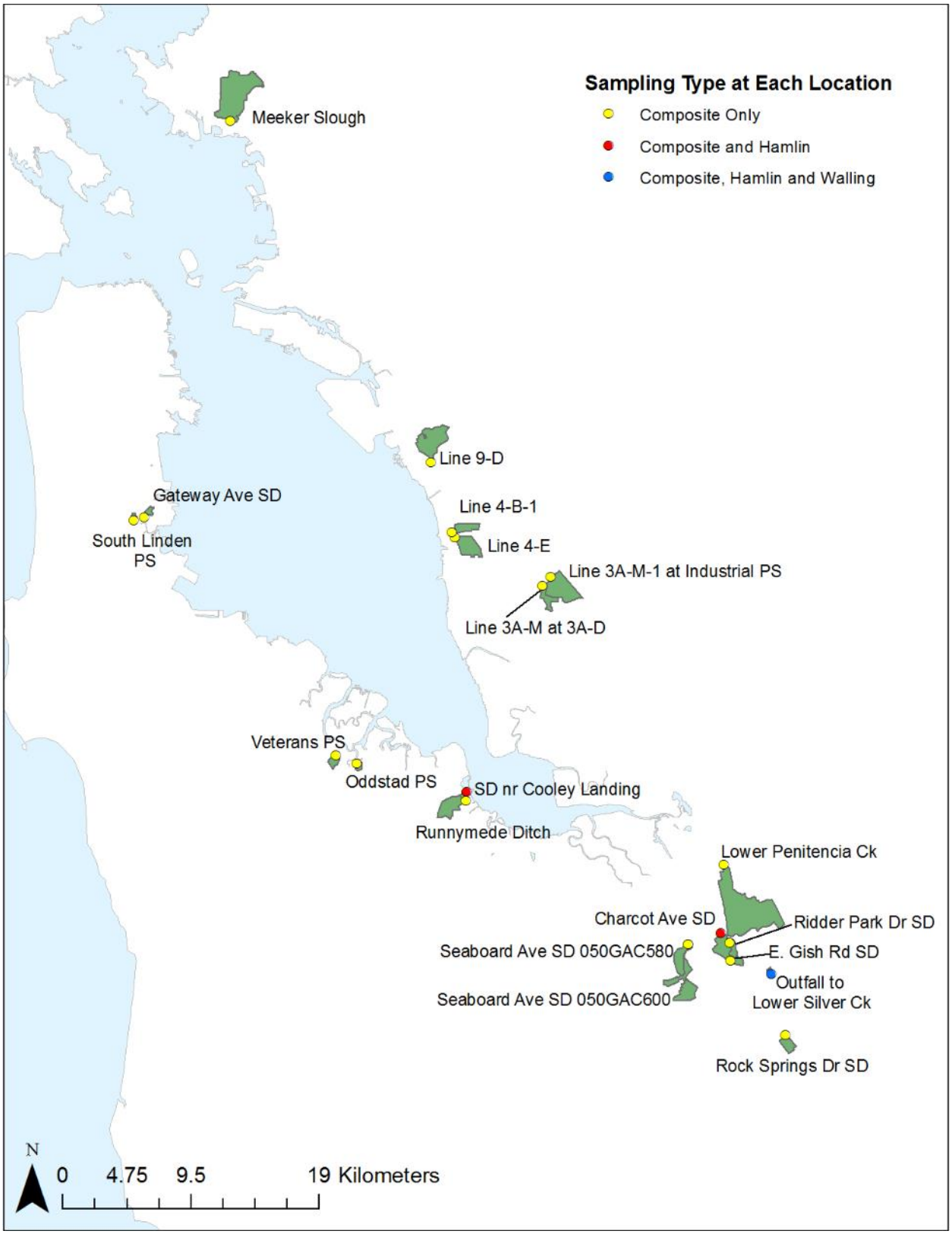


Figure 1. Sampling locations (marked by the dots), watershed boundaries (shown in green) and sampler type (color of the dots).

Table 1. Key characteristics of WY 2015 sampling locations.

| County Program | City | Watershed name | Catchment Code | Latitude | Longitude | Year Sampled | Watershed area (sq km) | Impervious cover (%) | Old Industrial (%) |
|---|---|---|---|---|---|---|---|---|---|
| Alameda | Hayward | Line3A-M-1 at Industrial PS | AC-Line3A-M-1 | 37.618933 | -122.05949 | WY 2015 | 3.44 | 78% | 26% |
| Alameda | Hayward | Line-3A-M at 3A-D | AC-Line-3A-M | 37.612853 | -122.06629 | WY 2015 | 0.88 | 73% | 12% |
| Alameda | Hayward | Line4-B-1 | AC-Line4-B-1 | 37.647519 | -122.14362 | WY 2015 | 0.96 | 85% | 28% |
| Alameda | Hayward | Line4-E | AC-Line4-E | 37.64415 | -122.14127 | WY 2015 | 2.00 | 81% | 27% |
| Alameda | San Leandro | Line9-D | AC-Line9-D | 37.693833 | -122.16248 | WY 2015 | 3.59 | 78% | 46% |
| Contra Costa | Richmond | Meeker Slough | Meeker Slough | 37.917861 | -122.33838 | WY 2015 | 7.34 | 64% | 6% |
| Santa Clara | Milpitas | Lower Penitencia Ck | Lower Penitencia | 37.429853 | -121.90913 | WY 2011, 2015 | 11.50 | 65% | 2% |
| Santa Clara | Santa Clara | Seabord Ave SD SC-050GAC580 | SC-050GAC580 | 37.376367 | -121.93793 | WY 2015 | 1.35 | 81% | 68% |
| Santa Clara | Santa Clara | Seabord Ave SD SC-050GAC600 | SC-050GAC600 | 37.376356 | -121.93767 | WY 2015 | 2.80 | 62% | 18% |
| Santa Clara | San Jose | Charcot Ave SD | SC-051CTC275 | 37.384128 | -121.91076 | WY 2015 | 1.79 | 79% | 25% |
| Santa Clara | San Jose | Ridder Park Dr SD | SC-051CTC400 | 37.377836 | -121.90302 | WY 2015 | 0.50 | 72% | 57% |
| Santa Clara | San Jose | E. Gish Rd SD | SC-066GAC550 | 37.366322 | -121.90203 | WY 2015 | 0.44 | 84% | 71% |
| Santa Clara | San Jose | Outfall to Lower Silver Ck | SC-067SCL080 | 37.357889 | -121.86741 | WY 2015 | 0.17 | 79% | 78% |
| Santa Clara | San Jose | Rock Springs Dr SD | SC-084CTC625 | 37.317511 | -121.85459 | WY 2015 | 0.83 | 80% | 10% |
| San Mateo | Redwood City | Oddstad PS | SM-267 | 37.491722 | -122.21886 | WY 2015 | 0.28 | 74% | 11% |
| San Mateo | South San Francisco | Gateway Ave SD | SM-293 | 37.652444 | -122.40257 | WY 2015 | 0.36 | 69% | 52% |
| San Mateo | South San Francisco | South Linden PS | SM-306 | 37.650175 | -122.41127 | WY 2015 | 0.14 | 83% | 22% |
| San Mateo | Redwood City | Veterans PS | SM-337 | 37.497231 | -122.23693 | WY 2015 | 0.52 | 67% | 7% |
| San Mateo | East Palo Alto | Runnymede Ditch | SM-70 | 37.468828 | -122.12701 | WY 2015 | 2.05 | 53% | 2% |
| San Mateo | East Palo Alto | SD near Cooley Landing | SM-72 | 37.474922 | -122.1264 | WY 2015 | 0.11 | 73% | 39% |

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 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 mi)** | **Impervious surface (%)** | **Industrial (%)** | **Sampling objective** | **Commentary** | **Proposed sampling triggers** | **Gauge number** | **Area at USGS gauge (sq mi)** |
| Alameda Creek at EBRPD Bridge at Quarry Lakes | 352 | 8.5 | 0.4 | 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 | 633 |
| Dry Creek at Arizona Street (Purposely downstream from historic industrial influences) | 9.8 | 3.5 | 0.2 | 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 | 9.39 |
| San Francisquito Creek at University Avenue (as far down as possible to capture urban influence upstream from tide) | 42.7 | 6.9 | 0.3 | 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. | 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 | 37.4 |
| Matadero Creek at Waverly Street (purposely downstream from the railroad) | 9.8 | 22.4 | 3.3 | 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 | 7.26 |
| Colma Creek at West Orange Avenue (location strategically downstream from historic industrial influence but still upstream from tide) | 10.6 | 38 | 0.5 | 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 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 | 10.8 |

**Key for sampling objectives**: 1. Identify potential high leverage watersheds; 2. Strategic watersheds with USGS gauges for loads computations and RWSM model calibration/verification; 3. Validating false negative finding or unexpected concentrations; 4. Filling gaps along environmental gradients or source areas.

the onset of rainfall[10]. 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 along as the minimum volume was reached, was usually adjusted depending upon how the rain event 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 sedimentation sampling procedures

The Hamlin and Walling tube remote suspended sediment samplers were deployed approximately mid-channel/ storm drain. The Hamlin sampler sat flush with the bed of either the stormdrain or concrete channel[11], and was weighted down to the bed either by itself (the sampler weighs approximately 25 lbs) or additionally using Olympic weights bungee-corded to the sampler (see Figure 2b). The Walling tube could not be deployed in storm drains due to its size and requirement for staying horizontal, but was secured in open channels either by being weighted down to a concrete bed using hose clamps to secure Olympic 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 cord 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.

[10] 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, atmospheric and other ongoing sources are less important than the mobilization of in-situ legacy sources.

[11] In future years, if the Hamlin is deployed within a natural bed channel, elevating the sampler off the bed may be necessary but was not the case in WY 2015.

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.

The suspended sediment sedimentation samplers were deployed for the duration of the manual water quality sampling (Table 4 for site list and success rate). At the end of water quality sampling at a site with a remote sampler, the remote sedimentation sampler was removed from the channel bed /storm drain bottom at approximately the same time as the last water quality sample aliquot. Water and sediments collected into the sedimentation 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. Three samples were analyzed as whole water samples and one was analyzed as separated dissolved and sediment fractions.

## 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).

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 in milliliters (mL)** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **3 to 6** | **4 to 8** | **5 to 10** | **6 to 12** | **7 to 14** | **8 to 16** |
| HgT/ trace metals | 2 | 0.25 | 333 | 250 | 200 | 167 | 143 | 125 |
| SSC | 1 | 0.3 | 167 | 125 | 100 | 83 | 71 | 63 |
| PCBs | 2.5 | 1 | 333 | 250 | 200 | 167 | 143 | 125 |
| Grain size | 2 | 1 | 333 | 250 | 200 | 167 | 143 | 125 |
| TOC | 1 | 0.25 | 167 | 125 | 100 | 83 | 71 | 63 |

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 separate dissolved and sediment (particulate) samples. |
| Cooley Landing Storm Drain | 2/06/15 | Hamlin | Sampling effort was successful. This sample was analyzed as a water sample. |

Table 5. Laboratory analysis methods for 2015 samples.

| 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 |
| PCBs (40)-Particulate | Water | EPA 1668 | AXYS | Yes | 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 |
| Mercury-Particulate | Water | EPA 1631E | BRL | Yes | BrCl | BRL preservation within 28 days |
| Organic carbon-Total | Water | 5310 C | EB mud | No | HCL | NA |
| Organic carbon-Dissolved | Water | 5310 C | EB mud | Yes | HCL | NA |
| Mercury | Sediment | EPA 1631E, Appendix | BRL | NA | NA | |
| PCBs | Sediment | EPA 1668 | AXYS | NA | NA | NA |

# Interpretive methods

## Particle normalized concentrations

It has previously been shown that stormwater concentrations tend to vary more at a site than particle ratios, depending on storm characteristics. Since each site was only monitored at the characterization level and there was no averaging of data for a site across many storm events and suspended sediment erosion and concentrations in stormwater vary greatly between sites, it was argued that the particle ratio from a single sample is likely a better summary of water quality of a site than a single water concentration (McKee et al., 2012). But even so, it is noted that, in addition to sediment variability, climatic conditions can influence the interpretations of relative ranking between watersheds although the absolute nature of that influence may differ between watershed locations. 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. For other watersheds, the source may be a remote 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. WY 2015 was a drier than average year. For example, the San Francisco gauge (047772) recorded 18.2 in or 82% of the 40 year (1976-2015) normal. However, most of this rainfall (11.7 in) fell in December. In contrast, WY 2011 (when the last spatially intensive sampling occurred) was a wetter year with 130% 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

429 computed for each composite water sample collected for each analyte at each site by taking the water
430 concentration (mass per unit volume) and dividing it by its suspended sediment concentration pair
431 (mass of suspended sediment per unit volume) (Equation 1).

Equation 1 (example PCBs):

$$PR\ (\frac{ng}{mg}) = \frac{PCB\ (\frac{ng}{L})}{SSC\ (\frac{mg}{L})}$$

432

433 These ratios where then used as the primary method for comparisons between sites without regard to
434 climate or rainfall intensity. Such comparisons are assumed valid for providing evidence to differentiate
435 a group of sites with higher pollutant concentrations from a contrasting group with lower pollutant
436 concentrations. To generate information on the absolute relative ranking between individual sites, a
437 much more rigorous sampling campaign sampling many storms over many years would be required (c.f.
438 the Guadalupe River study: McKee et al., 2006, or the Zone 4 Line A study: Gilbreath et al., 2012a).

### 439 Derivations of central tendency for comparisons with past data

440 As commonly discussed in water quality literature, mean, median, geomean, or flow-weighted mean can
441 be used measures of central tendency of a dataset. In the Bay Area, the average or median of water
442 concentrations at a site had sometimes been used, or the average or median of the particle ratios
443 (McKee et al., 2012; McKee et al., 2014; Wu et al., 2016). To best compare WY 2015 results with past
444 data (always collected as discrete stormwater samples rather than composite samples), a different
445 technique was used to estimate the central tendency than had been done in the past. It was reasoned
446 that a water composite collected over a single storm is equivalent to taking several discrete samples
447 collected over multiple storms and mixing them all into a single bottle for analysis. In order to calculate
448 the equivalent of a single storm composite particle ratio for an analyte, for previous studies that
449 resulted in multiple stormwater samples, all of the water concentration samples were summed together
450 for the analyte and divided that by the sum of all the suspended sediment concentrations for the site
451 (note: this method is mathematically not equivalent to averaging together the particle ratios of each
452 discrete sample paired with its SSC). Due to the use of this alternate method for estimating the central
453 tendency of the data for a site, particle ratios reported here will differ slightly from those reported
454 previously for the same site (e.g. McKee et al., 2012; McKee et al., 2014; Wu et al., 2016).

## 455 Quality assurance

456 The sections below reports on WY 2015 data only. The data were reviewed using the quality assurance
457 (QA) program developed for the San Francisco Bay Regional Monitoring Program for Water Quality (Yee
458 et al., 2015). Yee et al. (2015) describes how RMP data are reviewed for concerns in relation to hold
459 times, sensitivity, blank contamination, precision, accuracy, comparison of dissolved and total phases,
460 magnitude of concentrations versus concentrations from previous years, other similar local studies or
461 studies described from elsewhere in peer-reviewed literature, and PCB (or other organics)
462 fingerprinting. Data handling procedures and acceptance criteria differ among programs, however, the
463 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 Appendix A in addition to the following narrative.

## Suspended Sediment Concentration and Particle Size Distribution

The SSC and particle size distribution (PSD)[12] data from USGS-PCMSC were acceptable. Samples were all analyzed within hold time. Minimum detection limits (MDLs) were generally sufficient with <20% non-detects reported for SSC and the more abundant Clay, Silt, and Very Fine Sand fractions. Extensive non-detects (>50% NDs) were generally reported for the coarser fractions, with 100% NDs for the coarsest (Granule + Pebble/2.0 to <64 mm) fraction. Method blanks and spiked samples are not typically reported for SSC and PSD. The blind field replicate sample was used to evaluate precision in the absence of any other replicates. Particle size fractions had average relative standard deviation (RSD) ranging from 12% for Silt to 62% for Fine Sand. Although both SSC and 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 represented the largest proportion (~85%) of the results. Average results could not be compared to previous years, except for SSC, because particle size has not been measured before in POC water samples. Excluding three results from Hamlin (suspended sediment trap) samplers, the mean SSC concentration was 102 mg/L, 78% of the average concentration of the 2012-2014 POC water samples, suggesting similar flow regimes and/or sediment sources.

## Total Organic Carbon and Dissolved Organic Carbon

Reported TOC and DOC data from EBMUD were acceptable. TOC samples were field acidified on collection, DOC samples 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. Recoveries in the remaining matrix spikes for DOC were generally good, with an average 9% error, below the 10% target measurement quality objective (MQO). TOC averaged 14% error, above the 10% MQO, and was therefore qualified but not censored. Lab replicate samples were used to evaluate precision, with average RSD of 2% for DOC and TOC, well within the target MQO (10%). RSDs even including field replicates remained below the target MQO of 10% (RSDs were 3% and 9% for DOC and TOC, respectively), so no precision qualifiers were needed. TOC samples averaged 82% of the average for 2012-2014 POC water samples. DOC was not measured in previous POC project water samples so could not be compared.

[12] 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.

## 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 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 direct comparison could be made. PCB concentrations in water samples were similar to previous years (2012-2014) ranging from 25% to 323% of previous averages, depending on the congener. Ratios of congeners generally followed expected abundances in the environment.

## Trace Elements in Water

Overall the 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. Also, 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 sample 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.

## Trace Elements in Sediment

A single sediment sample was obtained 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 given runoff samples' likely greater proximity to terrestrial anthropogenic metal sources.

# 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 and managing areas in the landscape that may be disproportionally impacting downstream water quality.

## Suspended Sediment Concentrations

Concentrations of suspended sediments ranged between 29-265 mg/L (Table 6). Concentrations of this magnitude are typical of urban stormwater runoff in the Bay Area. For example, concentrations of between 1.4-2,700 mg/L with a flow-weighted mean concentration of 160 mg/L have been observed in Zone 4 Line A, a small urban drainage in Hayward (Gilbreath et al. 2012a). McKee et al. (2012) reported mean concentrations of 38.4-484 mg/L for 14 out of 16 urban tributaries in the Bay Area (excluding Marsh Creek and Walnut Creek that exhibited high concentrations associated with rural areas). McKee et al. (2015) reported flow-weighted mean concentrations (FWMC) of 34 mg/L, 28 mg/L, 171 mg/L, and 66 mg/L for North Richmond Pump Station, San Leandro Creek, Sunnyvale East Channel, and Pulgas Creek Pump Station-South, respectively.

## Total Organic Carbon and Dissolved Organic Carbon

TOC ranged from 3.1-20 mg/L. At all but three sites, TOC was composed of more than 90% dissolved phase (DOC). The three exceptions were Ridder Park Dr Storm Drain (88%), Line4-E (78%), and Meeker Slough (83%). On average, TOC was 98% transported in dissolved phase, functionally DOC. These concentrations are also similar to those observed previously. For example, McKee et al., (2012) observed a range of 2.1-13 mg/L for 16 tributaries around the Bay Area. FWMCs for TOC of 9.7 mg/L, 6.4 mg/L, 7.6 mg/L, and 9.4 mg/L have been observed for North Richmond Pump Station, San Leandro Creek, Sunnyvale East Channel, and Pulgas Creek Pump Station-South respectively (McKee et al., 2015). There was no correlation between SSC and TOC, probably due to the high proportion in the dissolved phase but also perhaps because the production of organic carbon in an urban landscape is

575 Table 6. Concentrations of total mercury, sum of PCBs (RMP 40), selected trace metals, and ancillary constituents measured at each of the sites
576 during winter storms of water year 2015. Both the sum of PCBs and total mercury are also expressed at a particle ratio (mass of pollutant divided
577 by mass of suspended sediment). The table was sorted from high to low based on PCB particle ratios.

| | SSC | DOC | TOC | PCBs | | | | Total Hg | | | | As | Cd | Cu | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (mg/L) | (pg/L) | Rank | (ng/g) | Rank | (ng/L) | Rank | (µg/g) | Rank | (µg/L) | (µg/L) | (µg/L) | (µg/L) | (µg/L) |
| Outfall to Lower Silver Ck | 57.0 | 8.6 | 8.3 | 44,643 | 2 | 783 | 1 | 24.1 | 17 | 0.423 | 12 | 2.11 | 0.267 | 21.8 | 5.43 | 337 |
| Ridder Park Dr SD | 114 | 7.7 | 8.8 | 55,503 | 1 | 488 | 2 | 37.1 | 12 | 0.326 | 16 | 2.66 | 0.335 | 19.6 | 11.0 | 116 |
| Line-3A-M at 3A-D | 73.6 | 9.5 | 7.3 | 24,791 | 5 | 337 | 3 | 85.9 | 1 | 1.17 | 2 | 2.08 | 0.423 | 19.9 | 17.3 | 118 |
| Seabord Ave SD SC-050GAC580 | 84.5 | 9.5 | 10 | 19,915 | 6 | 236 | 4 | 46.7 | 8 | 0.553 | 7 | 1.29 | 0.295 | 27.6 | 10.2 | 168 |
| Line4-E | 170 | 2.8 | 3.6 | 37,350 | 3 | 219 | 5 | 59.0 | 5 | 0.346 | 14 | 2.12 | 0.246 | 20.6 | 13.3 | 144 |
| Seabord Ave SD SC-050GAC600 | 72.5 | 7.9 | 8.6 | 13,472 | 9 | 186 | 6 | 38.3 | 10 | 0.528 | 8 | 1.11 | 0.187 | 21.0 | 8.76 | 132 |
| South Linden PS | 43.0 | 7.4 | 7.4 | 7,814 | 15 | 182 | 7 | 29.2 | 15 | 0.679 | 4 | 0.792 | 0.145 | 16.7 | 3.98 | 141 |
| Line9-D | 68.5 | 5.0 | 4.6 | 10,451 | 10 | 153 | 8 | 16.6 | 19 | 0.242 | 18 | 0.470 | 0.0530 | 6.24 | 0.910 | 67.0 |
| Meeker Slough | 60.3 | 4.4 | 5.3 | 8,560 | 14 | 142 | 9 | 76.4 | 3 | 1.27 | 1 | 1.75 | 0.152 | 13.6 | 14.0 | 85.1 |
| Rock Springs Dr SD | 41.0 | 11 | 11 | 5,252 | 17 | 128 | 10 | 38.0 | 11 | 0.927 | 3 | 0.749 | 0.0960 | 20.4 | 2.14 | 99.2 |
| Charcot Ave SD | 121 | 20 | 20 | 14,927 | 7 | 123 | 11 | 67.4 | 4 | 0.557 | 6 | 0.623 | 0.0825 | 16.1 | 2.02 | 115 |
| Veterans PS | 29.2 | 5.9 | 6.3 | 3,520 | 19 | 121 | 12 | 13.7 | 20 | 0.469 | 9 | 1.32 | 0.0930 | 8.83 | 3.86 | 41.7 |
| Gateway Ave SD | 45.0 | 9.9 | 10 | 5,244 | 18 | 117 | 13 | 19.6 | 18 | 0.436 | 10 | 1.18 | 0.0530 | 24.3 | 1.04 | 78.8 |
| Runnymede Ditch | 265 | 16 | 16 | 28,549 | 4 | 108 | 14 | 51.5 | 7 | 0.194 | 20 | 1.84 | 0.202 | 52.7 | 21.3 | 128 |
| E. Gish Rd SD | 145 | 12 | 13 | 14,365 | 8 | 99.2 | 15 | 84.7 | 2 | 0.585 | 5 | 1.52 | 0.552 | 23.3 | 19.4 | 152 |
| Line3A-M-1 at Industrial PS | 93.1 | 4.2 | 4.5 | 8,923 | 12 | 95.8 | 16 | 31.2 | 14 | 0.335 | 15 | 1.07 | 0.176 | 14.8 | 7.78 | 105 |
| SD near Cooley Landing | 82.0 | 13 | 13 | 6,473 | 16 | 78.9 | 17 | 35.0 | 13 | 0.427 | 11 | 1.74 | 0.100 | 9.66 | 1.94 | 48.4 |
| Oddstad PS | 148 | 8.0 | 7.5 | 9,204 | 11 | 62.4 | 18 | 54.8 | 6 | 0.372 | 13 | 2.45 | 0.205 | 23.8 | 5.65 | 117 |
| Line4-B-1 | 152 | 2.8 | 3.1 | 8,674 | 13 | 57.0 | 19 | 43.0 | 9 | 0.282 | 17 | 1.46 | 0.225 | 17.7 | 8.95 | 108 |
| Lower Penitencia Ck | 144 | 5.9 | 6.1 | 2,033 | 20 | 14.1 | 20 | 29.0 | 16 | 0.202 | 19 | 2.39 | 0.113 | 16.4 | 4.71 | 64.6 |
| | | | | | | | | | | | | | | | | |
| Minimum | 29 | 2.8 | 3.1 | 2,033 | | 14.1 | | 13.7 | | 0.194 | | 0.470 | 0.053 | 6.24 | 0.910 | 41.7 |
| Maximum | 265 | 20 | 20 | 55,503 | | 783 | | 85.9 | | 1.27 | | 2.66 | 0.552 | 52.7 | 21.3 | 337 |

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likely complex and associated with vegetation debris, pet wastes, soot carbon from combustion of fossil fuels, and the organic components of human derived trash rather than from erosion of low carbon soils (<10%) which would be more typical of rural soils and watersheds of the Bay area.

## PCBs Concentrations and Particle Ratios

Total PCB concentrations measured in the composite water samples across the 20 watershed sampling sites ranged 27-fold from 2,033-55,503 pg/L (Table 6). The highest concentration was observed in Ridder Park Dr. Storm Drain in San Jose, a site with 57% 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 Creek 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 Outfall to Lower Silver Creek in San Jose (783 ng/g) (78% old industrial), Ridder Park Drive Storm Drain in San Jose (488 ng/g) (57% old industrial), and Line-3A-M at 3A-D in Hayward (337 ng/g) (12% old industrial). Particle ratios of this magnitude are relatively elevated but lower than some of the more extreme examples in the Bay Area that have been previously sampled (Santa Fe Channel (1,403 ng/g) (3% old industrial), Pulgas Creek Pump Station-North (1,050 ng/g) (52% old industrial), Pulgas Creek Pump Station-South (906 ng/g) (54% old industrial), Ettie St. Pump Station (745 ng/g) (22% old industrial): McKee et al., 2012)[13]. Line 4-B-1 in Hayward and Lower Penitencia Creek in Milpitas were ranked the lowest using PCB particle ratios. The sample taken in Lower Penitencia Creek corroborates a similar finding that was previously reported (McKee et al., 2012). In general, on average, the particle ratios for the WY 2015 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 sites.

## Mercury Concentrations and Particle Ratios

Total Hg concentrations in composite water samples varied 6-fold between the 20 watershed sampling sites from 14-86 ng/L (Table 6). This relatively small variation between sites is quite a change from the previous reconnaissance effort in WY 2011 when mean HgT concentrations were observed to vary by 36-fold between sites (McKee et al., 2012). This lower variation at least in part reflects the lower variation in SSC between sites (36-fold for sites observed in WY 2011 and just 9-fold for WY 2015 sites). The greatest HgT concentrations were observed in Line-3A-M at 3A-D in Hayward (12% old industrial), E. Gish Rd Storm Drain in San Jose (71% old industrial), and Meeker Slough in Richmond (6% old industrial). This helps to illustrate that mercury concentrations don't appear to follow a strong relationship with old industrial land use. When the data were normalized to SSC, the five most highly ranked sites were Meeker Slough in Richmond (6% old industrial), Line-3A-M at 3A-D in Hayward (12% old industrial), Rock Springs Dr. Storm Drain in San Jose (10% old industrial), South Linden Pump Station in South San Francisco (22% old industrial), and E. Gish Rd Storm Drain in San Jose (71% old industrial). Particle ratios at these sites were 1.3, 1.3, 0.93, 0.68, and 0.59 µg/g, respectively. Particle ratios of this magnitude are

[13] Note, these particle ratios do not match those in Table 8 of this report 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 Creek 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.

similar to the upper range of those observed during the WY 2011 sampling campaign (Pulgas Creek 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 12 above]

Since there was much lower variation in SSC among the sites, the choice of ranking method for both PCBs and HgT was less important within the WY 2015 dataset than it was when interpreting the 2011 data set (McKee et al., 2012). But as will be discussed further below, 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. 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 12$^{th}$, 16$^{th}$, 2$^{nd}$, 7$^{th}$, 14$^{th}$, and 8$^{th}$, 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 WY 2015 site selection process and the resulting focus on smaller watersheds with higher imperviousness and old industrial land use, or perhaps it might 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 ranged between 0.47-2.7 µg/L, 0.053-0.55 µg/L, 6.2-53 µg/L, 0.91-21 µg/L, and 42-337 µg/L respectively (Table 6). Total As concentrations of this magnitude have been measured in the Bay Area before (Guadalupe River at Hwy 101: mean=1.9 µg/L; Zone 4 Line A: mean=1.6 µg/L) but 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 WY 2015 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 Creek 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). In contrast, Zn measurements at 12 of the sites measured during the WY 2015 sampling effort exceeded the greatest 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). The sites exhibiting the highest Zn concentrations in order from higher to lower were the Outfall to Lower Silver Creek in San Jose (79% imperviousness; 78% old industrial), the Seabord Ave Storm Drain in San Jose (81% imperviousness; 68% old industrial), the E. Gish Rd Storm Drain in San Jose (84% imperviousness; 71% old industrial), the Line4-E in Hayward (81% imperviousness; 27% old industrial). These sites ranked 2$^{nd}$, 6$^{th}$, 8$^{th}$ and 3$^{rd}$ using PCB concentrations, 1$^{st}$, 4$^{th}$, 5$^{th}$ and 15$^{th}$ using PCB particle ratios, 17$^{th}$, 8$^{th}$, 5$^{th}$ and 2$^{nd}$ using HgT concentrations, and 12$^{th}$, 7$^{th}$, 14$^{th}$ and 5$^{th}$ using HgT particle ratios. It is not clear from these comparisons what might be the cause of the elevated Zn concentrations in these watersheds.

## Comparisons between Composite Water and Remote Sediment Sampling Methods

The four results from remote (primarily suspended sediment trapping) sedimentation samplers that were successfully gathered in WY 2015 were compared to the results from water composite samples collected in parallel at those sites for the same storm events. Results for the remote samplers are all compared on a particle ratio basis, whether analyzed as whole water or separate dissolved and sediment fractions. Although most of the remotely collected samples included reported suspended sediment concentrations, these are not environmentally linked SSCs, but rather the total mass of sediment collected and slurried in an arbitrary volume of water needed to wash the sediment into a collection jar. However, due to the arbitrary volume of water used to slurry the sample, rather than SSC, a more environmentally linkable measure in remote samplers is the total mass of sediment collected. A first order metric of the effectiveness of the remote sampler sediment collection is the volume of composite water that would need to be filtered to generate the same collected sediment mass. These are inexact estimates due to the possibility of different grain sizes captured by the remote sampler and composite stormwater samples, but differences between the Hamlin and Walling are qualitatively consistent with their different cross sectional areas at the sample entry points. Table 7 shows the site water composite SSC, and the total mass of sediment (dry weight (dw) basis) collected in the remote sampler, and the water volume equivalent that the remote sampler sediment represents.

Table 7. Remote sampler collected sediment mass and volume equivalent (relative to composite).

| Sampler | Site | Composite SSC (mg/L) | Remote sediment mass (g) | Remote volume equivalent (liters (L)) |
|---|---|---|---|---|
| Hamlin | Charcot Ave Storm Drain | 121 | 93.3 | 771 |
| Hamlin | Storm Drain near Cooley Landing | 82 | 53.9 | 657 |
| Hamlin | Outfall to Lower Silver Creek | 57 | 5.9 | 104 |
| Walling | Outfall to Lower Silver Creek | 57 | 0.48 | 8.4 |

For the Hamlin samplers, higher SSC in the separately collected composite stormwater samples consistently translated to larger masses of sediment collected, but in a non-linear fashion. Some of the differences may be related to deployment site geometry, as well as the particle size distribution of sediment carried in the flow. The composite samples, whether collected via peristaltic pump or using a DH-81, could only sample ~5 cm or more above the channel bed, and attempts were made for integrated collection throughout the water column. In contrast, the Hamlin samplers sat directly on the channel bed, or slightly elevated (~3 cm) when attached atop a weighted plate. The Hamlin samples therefore would be more likely than the composited stormwater samples to capture coarser grained near-bed or bedload sediment. Similarly, although the inlet for the Walling tube would be above the channel bed (~5 cm minimum, much like the DH-81), rather than integrating throughout the water column, it would remain fixed at that depth throughout the collection, and thus more of the flow

passing through the sampler would be nearer to the bed than the flow captured by the composite water sampling techniques. In addition, the finest grained sediments would likely remain suspended within and wash out from both Hamlin and Walling samplers, leading to samples that could disproportionately over-sample coarser sediments and under-sample finer grained sediments. The remote sampler from one site (Charcot Ave SD) had large amounts of coarse grained material, but whether that was appreciably different from that seen in composite water samples (~15% sand) was not visually determinable. Future collections using remote samplers will measure grainsize in the laboratory to verify these hypotheses.

Figure 4 shows remote sampler particle ratio results for PCBs and mercury plotted versus particle ratios for composited stormwater samples. The data generally show some correlation, i.e., higher remote sampler particle ratios occur for sites with higher particle ratios obtained from composite stormwater samples, although based on the small number of samples, the correlation for PCBs is not quite significant ($p \sim 0.09$) at alpha=0.05. 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.

Results for PCBs showed that most of the composited stormwater samples had lower particle ratios than those obtained from remote samplers. Prior settling experiments 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. If this trend holds true for other systems in the Bay Area, PCB results would therefore generally be less influenced by a bias of including the dissolved phase in calculating particle ratios for composited stormwater samples with lower suspended sediments. Secondly, remote samplers affixed to the bed of discharge channels would preferentially sample heavier and larger particles near-bed load, compared to composited stormwater samples that represent more of the entire water column. Thus the results might be conceptually reasonable. Three of the four remote samplers showed PCB particle ratios higher than those from corresponding composited stormwater samples. The exception (from a Hamlin sampler at Cooley Landing) showed only a modest excursion in the opposite direction, with a particle ratio 13% lower than that in the composited stormwater sample from that site. Overall, the differences between remotely collected and composited stormwater samples was generally small for PCBs, with particle ratios differing by <20% except for one pair differing 2-fold. 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 mercury showed that some of the composited stormwater water samples had greater particle ratios than those obtained from remote samplers. For mercury, the highest particle ratios occurred in the samples collected from Charcot Avenue Storm Drain in San Jose for both the composite of stormwater samples as well as a sample analyzed as sediment collected with a Hamlin sampler. Interestingly, results for Charcot ran counter to our general expectations and results for other sites, namely that the mercury particle ratios for the remote samplers would be lower than those for composited stormwater samples collected at the same sites. This latter pattern would be expected at most sites because the particle ratio includes any dissolved phase mercury measured. Composited stormwater samples would be expected to show higher particle ratios than from remote samplers, due

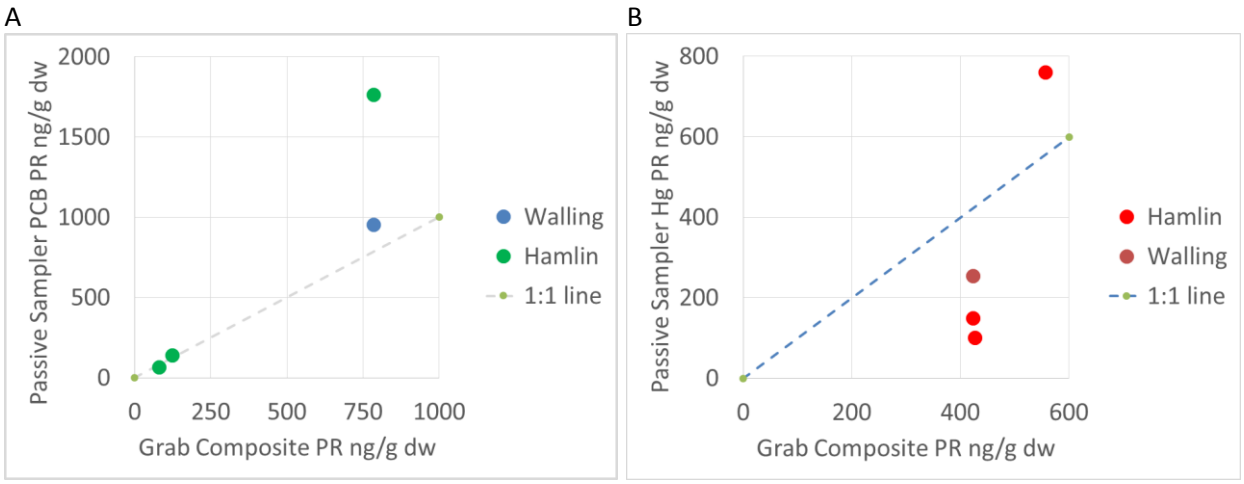


Figure 4. Particle Ratio (PR) comparisons between remote (sediment) versus composite (water) samples for A) PCBs and B) total mercury.

to lower sediment content and thus a greater relative proportion of mercury in the dissolved phase or on fine particles biasing the calculated particle ratio higher. Even if the Charcot Avenue Storm Drain composite sample contained high suspended solids, a similar but smaller high bias (nearer the 1:1 line) would still be accepted. Although conclusions are hard to draw based on data from just three sites, the contrary results for the Charcot Avenue Storm Drain sample could be either associated with differing sources or environmental processes for mercury at that site at least for this one event, or alternatively, greater variability in the subsampling of its composite water sample (e.g., if the composite subsample analyzed for SSC contained more sediment than that for mercury, a lower apparent particle ratio would result). The differences in particle ratio were lowest for Charcot Avenue (25%), which is similar to a plausible degree of subsampling and analytical variation. The particle ratios for other sites differed up to 4-fold (as noted previously, with the composited stormwater samples biased higher). This difference cannot be accounted for through sub-sampling or analytical errors and the representativeness of the composite sample (time paced with a limited number of sub-samples) is ruled out by the Hg results from the remote samplers being lower than 1:1. Also, the Charcot Avenue Storm Drain composite water sample contained 15% sand, versus the other two sites with primarily clays and silts and little sand (<0.1%). This may have also influenced the comparison, as water samples with higher sand content are more difficult to subsample uniformly; if the field sampling crew or the analytical labs biased differently in the fraction of sand captured in mercury versus SSC analyses, random variations in particle ratio (either up or down) could result. The possibility of a coarse sediment associated mercury source (similar to the case for most sites for PCBs) also cannot be totally ruled out but is counter to the hypothesis put forward previously by Yee and McKee (2010) that mercury is more dominantly transported on finer particles than PCBs.

Although only a limited number of samples were able to be collected using the remote samplers during the WY 2015 sampling effort, the results obtained thus far show some promise at least as a qualitative site ranking tool. For both PCBs and mercury, the samples with the highest particle ratios for composited stormwater samples were also the highest in the remote samplers. For PCBs, the site with the lowest particle ratio for a composited stormwater sample also had the lowest for a remote sampler. The remaining mercury results were more difficult to distinguish, with particle ratios in the composited stormwater samples nearly identical (differing ~1%), while results for remotely collected samples differed from the composited stormwater samples by 1.7- to 4-fold (including differences for paired Hamlin (2.8x) and Walling (1.7x) samplers at Lower Silver Creek).

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 87% to 230% 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. Although this is also true for the water composite methodology, there is always going to be more certainty that the sample for water composites 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 2016 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 nine planned sample pairs, better confidence maybe 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). The data obtained to date from remote samplers show some promise as relative ranking or prioritization tools; 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. In the event that after the pilot study is completed and a total of 12 samples have been collected 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.

## What is the cost/benefit and pros/cons of all sampling methods including remote samplers practiced to date?

The pilot study to assess effectiveness of remote samplers is still in the early stages. Due to a low number of storm events during WY 2015, these devices were only successfully deployed at three locations. A more comprehensive analysis of effectiveness and cost versus benefit of this method will be completed after the sampling effort for the winter of WY 2016 is completed. Generally speaking, it is anticipated that non-manual sampling methods will be more cost-effective. Conceptually, this method will 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 will be initial capital costs to purchase the equipment and labor will be required to deploy and process samples. In addition, there will always be logistical constraints (such as turbulence or tidal influences) that negate the use of the remote settling devices and cause the need for manual monitoring at a particular site, and as mentioned above, the data derived from the remote sampling methodologies will be less easy to interpret and overall will have less versatility for other uses outside ranking sites for relative pollution, for example loadings estimates. But used as a companion to manual monitoring methods, costs will most likely be reduced and data suitable for other purposes will continue to be collected. Factoring in the more limited data uses in the cost-effectiveness analysis will be challenging.

## 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 is further interpretations are completed, only one sampling location (Gellert Park bioretention influent stormwater) observed to date has a composite averaged PCB concentration of < 1.33 ng/L (Table 8) and none out of 45 sampling locations have composite averaged PCB particle ratios <1.4 ng/g (Table 8; Figure 5 and 6). The elevated PCB concentrations and particle ratios measured in WY 2015 may be due, in part, to the site selection process which focused on finding potential higher leverage areas for PCBs. The lowest observed PCB particle ratio to date was at 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

Table 8. 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 (45 sites in total for PCBs and HgT). Data for both PCBs and HgT were sorted high to low based on particle ratio to provide preliminary information on potential leverage.

| Watershed/ Catchment | County | Water Year sampled | Area ($km^2$) | Impervious cover (%) | Old Industrial land use (%) | Polychlorinated biphenyls (PCBs) | | | | Total Mercury (HgT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Particle Ratio | | Composite /mean water concentration | | Particle Ratio | Rank (HgT PR) | Composite /mean water concentration | |
| | | | | | | (ng/g) | Rank | (pg/L) | Rank | (µg/g) | Rank | (ng/L) | Rank |
| Pulgas Creek Pump Station-South | San Mateo | 2011-2014 | 0.584 | 87% | 54% | 8222 | 1 | 447984 | 1 | 0.35 | 24 | 19 | 40 |
| Santa Fe Channel | Contra Costa | 2011 | 3.26 | 69% | 3% | 1295 | 2 | 197923 | 2 | 0.57 | 14 | 86 | 7 |
| Pulgas Creek Pump Station-North | San Mateo | 2011 | 0.552 | 84% | 52% | 893 | 3 | 60320 | 4 | 0.40 | 22 | 24 | 36 |
| Outfall to Lower Silver Creek | Santa Clara | 2015 | 0.171 | 79% | 78% | 783 | 4 | 44643 | 7 | 0.42 | 21 | 24 | 37 |
| Ettie Street Pump Station | Alameda | 2011 | 4.03 | 75% | 22% | 759 | 5 | 58951 | 5 | 0.69 | 10 | 55 | 19 |
| Ridder Park Dr Storm Drain | Santa Clara | 2015 | 0.497 | 72% | 57% | 488 | 6 | 55503 | 6 | 0.33 | 27 | 37 | 30 |
| El Cerrito Bioretention Influent | Contra Costa | 2011 | 0.00408 | 74% | 0% | 442 | 7 | 37690 | 8 | 0.19 | 37 | 16 | 43 |
| Sunnyvale East Channel | Santa Clara | 2011 | 14.5 | 59% | 4% | 343 | 8 | 96572 | 3 | 0.20 | 35 | 50 | 22 |
| Line-3A-M at 3A-D | Alameda | 2015 | 0.881 | 73% | 12% | 337 | 9 | 24791 | 12 | 1.17 | 4 | 86 | 8 |
| North Richmond Pump Station | Contra Costa | 2011-2014 | 1.96 | 62% | 18% | 241 | 10 | 13226 | 20 | 0.81 | 9 | 47 | 23 |
| Seabord Ave Storm Drain SC-050GAC580 | Santa Clara | 2015 | 1.35 | 81% | 68% | 236 | 11 | 19915 | 15 | 0.55 | 16 | 47 | 24 |
| Line4-E | Alameda | 2015 | 2.00 | 81% | 27% | 219 | 12 | 37350 | 9 | 0.35 | 25 | 59 | 14 |
| Glen Echo Creek | Alameda | 2011 | 5.45 | 39% | 0% | 191 | 13 | 31078 | 10 | 0.21 | 34 | 73 | 12 |
| Seabord Ave Storm Drain SC-050GAC600 | Santa Clara | 2015 | 2.80 | 62% | 18% | 186 | 14 | 13472 | 19 | 0.53 | 17 | 38 | 28 |
| South Linden Pump Station | San Mateo | 2015 | 0.137 | 83% | 22% | 182 | 15 | 7814 | 31 | 0.68 | 11 | 29 | 35 |
| Line 9-D | Alameda | 2015 | 3.59 | 78% | 46% | 153 | 16 | 10451 | 23 | 0.24 | 30 | 17 | 42 |

| 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 | Rank (HgT PR) | Composite /mean water concentration | |
| | | | | | | (ng/g) | Rank | (pg/L) | Rank | (µg/g) | Rank | (ng/L) | Rank |
| Meeker Slough | Contra Costa | 2015 | 7.34 | 64% | 6% | 142 | 17 | 8560 | 29 | 1.27 | 3 | 76 | 11 |
| Rock Springs Dr Storm Drain | Santa Clara | 2015 | 0.829 | 80% | 10% | 128 | 18 | 5252 | 34 | 0.93 | 7 | 38 | 29 |
| Charcot Ave Storm Drain | Santa Clara | 2015 | 1.84 | 79% | 24% | 123 | 19 | 14927 | 17 | 0.56 | 15 | 67 | 13 |
| Veterans Pump Station | San Mateo | 2015 | 0.522 | 67% | 7% | 121 | 20 | 3520 | 38 | 0.47 | 18 | 14 | 44 |
| Gateway Ave Storm Drain | San Mateo | 2015 | 0.356 | 69% | 52% | 117 | 21 | 5244 | 35 | 0.44 | 19 | 20 | 39 |
| Guadalupe River at Hwy 101 | Santa Clara | 2003-2006, 2010, 2012-2014 | 233 | 39% | 3% | 115 | 22 | 23736 | 13 | 3.60 | 2 | 603 | 1 |
| Runnymede Ditch | San Mateo | 2015 | 2.05 | 53% | 2% | 108 | 23 | 28549 | 11 | 0.19 | 36 | 52 | 21 |
| E. Gish Rd Storm Drain | Santa Clara | 2015 | 0.447 | 84% | 70% | 99 | 24 | 14365 | 18 | 0.59 | 12 | 85 | 9 |
| Line 3A-M-1 at Industrial Pump Station | Alameda | 2015 | 3.44 | 78% | 26% | 96 | 25 | 8923 | 25 | 0.34 | 26 | 31 | 33 |
| Zone 4 Line A | Alameda | 2007-2010 | 4.17 | 68% | 12% | 82 | 26 | 18442 | 16 | 0.17 | 39 | 30 | 34 |
| Storm Drain near Cooley Landing | San Mateo | 2015 | 0.108 | 73% | 39% | 79 | 27 | 6473 | 32 | 0.43 | 20 | 35 | 31 |
| San Leandro Creek | Alameda | 2011-2014 | 8.94 | 38% | 0% | 66 | 28 | 8614 | 28 | 0.86 | 8 | 117 | 5 |
| Oddstad Pump Station | San Mateo | 2015 | 0.280 | 74% | 11% | 62 | 29 | 9204 | 24 | 0.37 | 23 | 55 | 18 |
| Line 4-B-1 | Alameda | 2015 | 0.963 | 85% | 28% | 57 | 30 | 8674 | 27 | 0.28 | 29 | 43 | 26 |
| Fremont Osgood Road Bioretention Influent | Alameda | 2012, 2013 | 0.000804 | 76% | 0% | 45 | 31 | 2906 | 40 | 0.12 | 43 | 10 | 45 |
| Gellert Park Daly City Library Bioretention Influent | San Mateo | 2009 | 0.0153 | 40% | 0% | 36 | 32 | 725 | 44 | 1.01 | 6 | 22 | 38 |
| Lower Coyote Creek | Santa Clara | 2005 | 327 | 22% | 1% | 30 | 33 | 4576 | 36 | 0.24 | 31 | 34 | 32 |

| Watershed/ Catchment | County | Water Year sampled | Area ($km^2$) | Impervious cover (%) | Old Industrial land use (%) | Polychlorinated biphenyls (PCBs) | | | | Total Mercury (HgT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Particle Ratio | | Composite /mean water concentration | | Particle Ratio | Rank (HgT PR) | Composite /mean water concentration | |
| | | | | | | (ng/g) | Rank | (pg/L) | Rank | (µg/g) | Rank | (ng/L) | Rank |
| Calabazas Creek | Santa Clara | 2011 | 50.1 | 44% | 3% | 29 | 34 | 11493 | 22 | 0.15 | 42 | 59 | 15 |
| San Lorenzo Creek | Alameda | 2011 | 125 | 13% | 0% | 25 | 35 | 12870 | 21 | 0.18 | 38 | 41 | 27 |
| Stevens Creek | Santa Clara | 2011 | 26.0 | 38% | 1% | 23 | 36 | 8160 | 30 | 0.22 | 33 | 77 | 10 |
| Guadalupe River at Foxworthy Road/ Almaden Expressway | Santa Clara | 2010 | 107 | 22% | 0% | 19 | 37 | 3120 | 39 | 4.09 | 1 | 529 | 2 |
| Lower Penitencia Creek | Santa Clara | 2011, 2015 | 11.5 | 65% | 2% | 16 | 38 | 1588 | 42 | 0.16 | 41 | 17 | 41 |
| Borel Creek | San Mateo | 2011 | 3.23 | 31% | 0% | 15 | 39 | 6129 | 33 | 0.16 | 40 | 58 | 17 |
| San Tomas Creek | Santa Clara | 2011 | 108 | 33% | 0% | 14 | 40 | 2825 | 41 | 0.28 | 28 | 59 | 16 |
| Zone 5 Line M | Alameda | 2011 | 8.05 | 34% | 5% | 13 | 41 | 21120 | 14 | 0.57 | 13 | 505 | 3 |
| Belmont Creek | San Mateo | 2011 | 7.22 | 27% | 0% | 13 | 42 | 3599 | 37 | 0.22 | 32 | 53 | 20 |
| Walnut Creek | Contra Costa | 2011 | 232 | 15% | 0% | 7 | 43 | 8830 | 26 | 0.07 | 45 | 94 | 6 |
| Lower Marsh Creek | Contra Costa | 2011-2014 | 83.6 | 10% | 0% | 3 | 44 | 1445 | 43 | 0.11 | 44 | 44 | 25 |
| San Pedro Storm Drain | Santa Clara | 2006 | 1.27 | 72% | 16% | No data | | | | 1.12 | 5 | 160 | 4 |

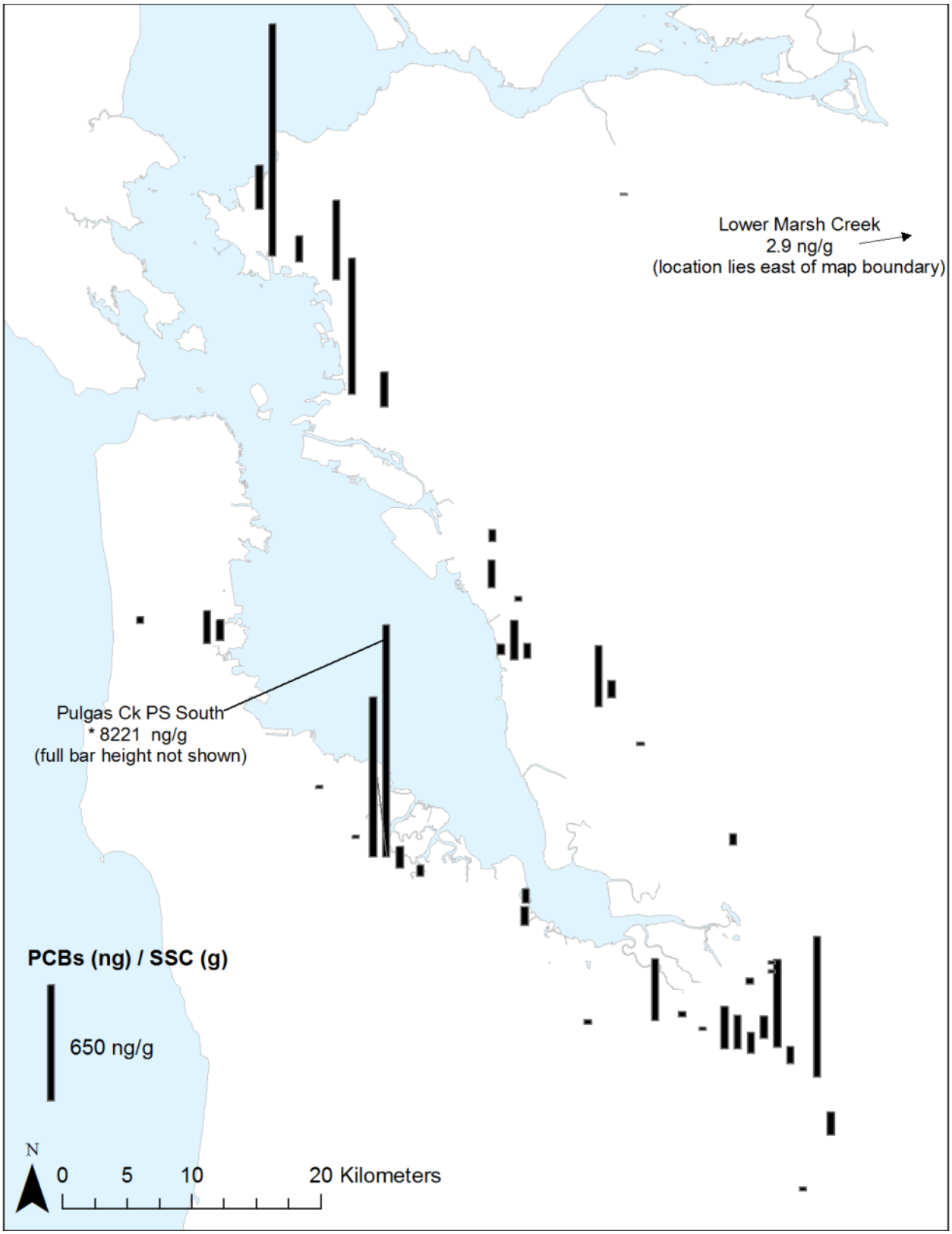


Figure 5. Regional distribution of particle ratios of polychlorinated biphenyl (PCB) in stormwater samples collected to date.

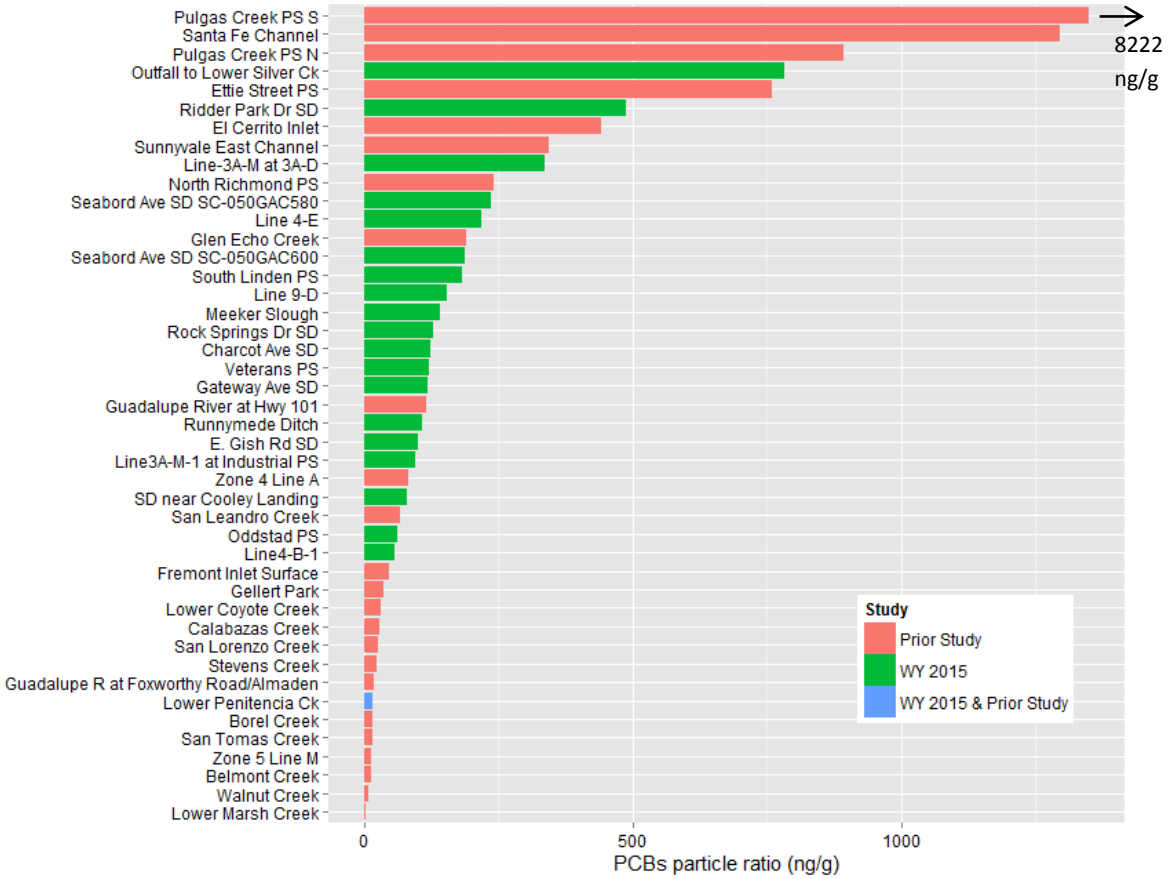


Figure 6. All watershed sampling locations measured to date ranked using PCB particle ratios. Note Pulgas Creek Pump Station-South is beyond the extent of this graph at 8,222 ng/g.

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. 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) and WY 2015 (a slightly drier than average year).

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 Creek Pump Station-South, Santa Fe Channel, Sunnyvale East Channel, Pulgas Creek Pump Station-North, Ettie Street Pump Station, Ridder Park Dr Storm Drain, Outfall to Lower Silver Creek, Line4-E , Glen Echo Creek, and Runnymede Ditch (Figure 6). Using PCB particle ratios, the ten most polluted sites appear to be: Pulgas Creek Pump Station-South, Santa Fe Channel, Pulgas Creek Pump Station-North, Outfall to Lower Silver Ck, Ettie Street Pump Station, Ridder Park Dr Storm Drain, Sunnyvale East Channel, Line-3A-M at 3A-D, North Richmond Pump

Station and Seabord Ave Storm Drain. Seven of these locations were similarly selected based on water concentrations but three of the sites with elevated water concentrations dropped to lower rank due to high sediment production and three new sites were ranked in the top ten based on the relative nature of PCB mass in the water and lower suspended sediment mass (Line-3A-M at 3A-D, North Richmond Pump Station, and Seabord Ave Storm Drain). In addition to identification of four new top-10 ranked PCB particle ratio sites, the WY 2015 stormwater sampling effort also identified a large number of sites with moderate particle ratios (Figure 6). 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.

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 a larger watershed, but in a small watershed, when coupled with low suspended sediment concentrations, it would indicate sediment is not the dominant vector for transport and that PCB emulsions are possibly in transport. Conversely, a lower ranking for concentration coupled with a higher ranking for particle ratio can indicate erosion of highly contaminated particles. If this occurs in a smaller watershed, this would indicate sediment transport is the main vector. Therefore, at smaller site scales, these hints could be instructive for helping to consider main source areas and release processes.

There are a number of watersheds that appear to show relatively low Hg concentrations. In contrast to PCBs, 26 out of 45 sampling locations have composite averaged HgT water concentrations less than 53 ng/L (Table 8), 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[14]); the lowest observation so far has been Walnut Creek at 0.073 µg/g (0.07 mg/kg) (Table 8; Figure 7). But 16 sites measured to-date (Line9-D , Lower Coyote Creek, Belmont Creek, Stevens Creek, Glen Echo Creek, Sunnyvale East Channel, Runnymede Ditch, El Cerrito Inlet, San Lorenzo Creek, Zone 4 Line A Storm Drain, Fremont tree Well Filter Inlet, Borel Creek, Lower Penitencia Creek, Calabazas Creek, Lower Marsh Creek, and Walnut Creek) do have particle ratios <0.25 µg/g that, given 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) (SFRWQCB, 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

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

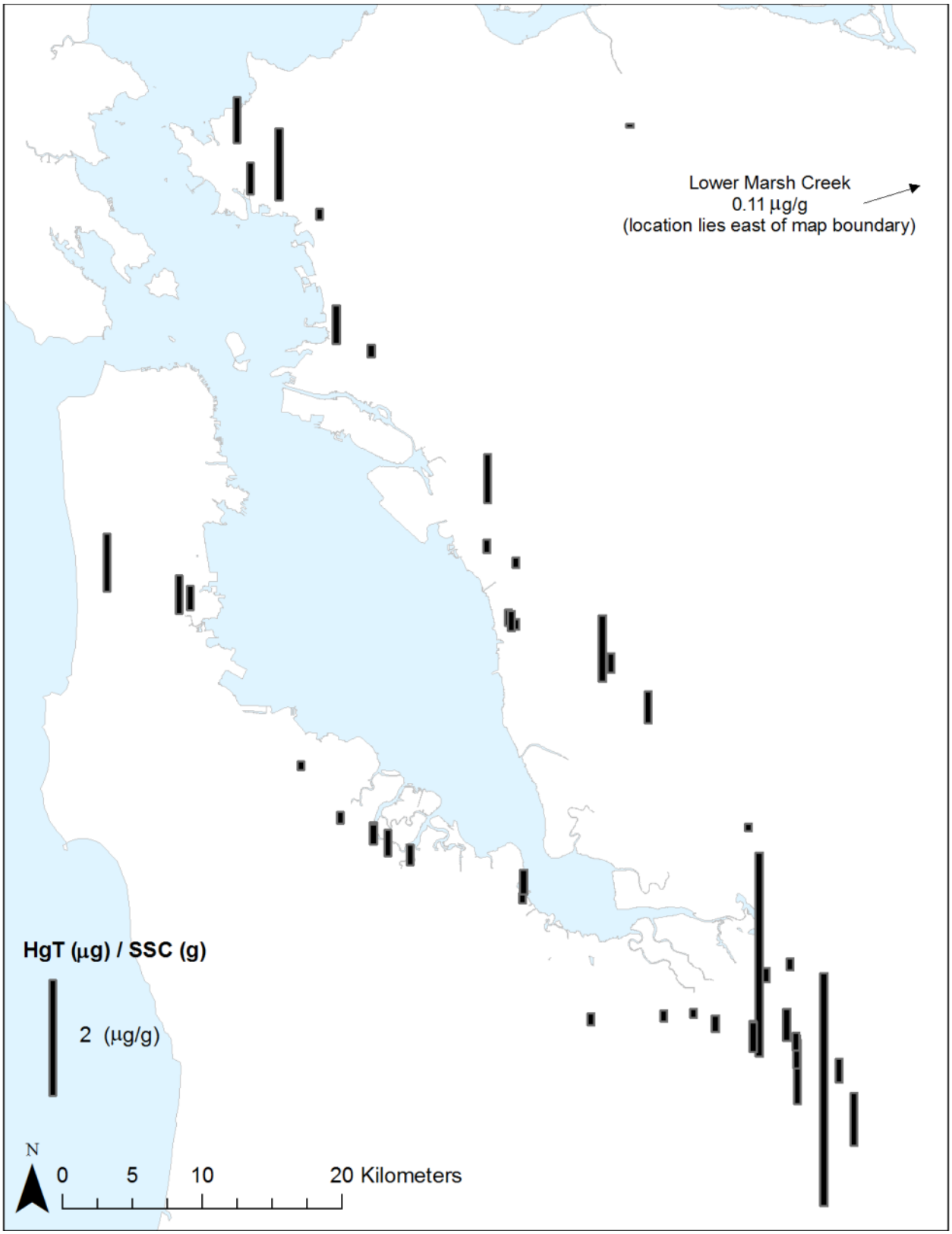


Figure 7. Regional distribution of sites and particle ratios of total mercury (HgT) in stormwater samples collected to date.

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 8). Based on composite averaged HgT water concentrations, the ten most polluted sites (ranked in order from high to lower) would include the Guadalupe River mainstem, Zone 5 Line M, San Pedro Storm Drain, San Leandro Creek, Walnut Creek, Santa Fe Channel (also ranked high for PCB concentrations in composite averaged stormwater), Line-3A-M at 3A-D, E. Gish Rd SD, Stevens Creek, and Meeker Slough.

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 5$^{th}$ highest in terms of stormwater composite averaged concentrations but lowest (45$^{th}$ out of 45 watershed locations) in terms of particle ratios. 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 calibration of the RWSM based on the hydrology where a better calibration for PCBs than for Hg has been achieved (Wu et al., 2016); 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) Meeker Slough, Line-3A-M at 3A-D, San Pedro Storm Drain, Gellert Park bioretention inlet, Rock Springs Dr Storm Drain, San Leandro Creek, North Richmond Pump Station, Ettie Street Pump Station, South Linden Pump Station, and E. Gish Rd Storm Drain (Table 8; Figure 8). Management in these watersheds might be most cost effective for HgT. The Daly City library bioretention demonstration project 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

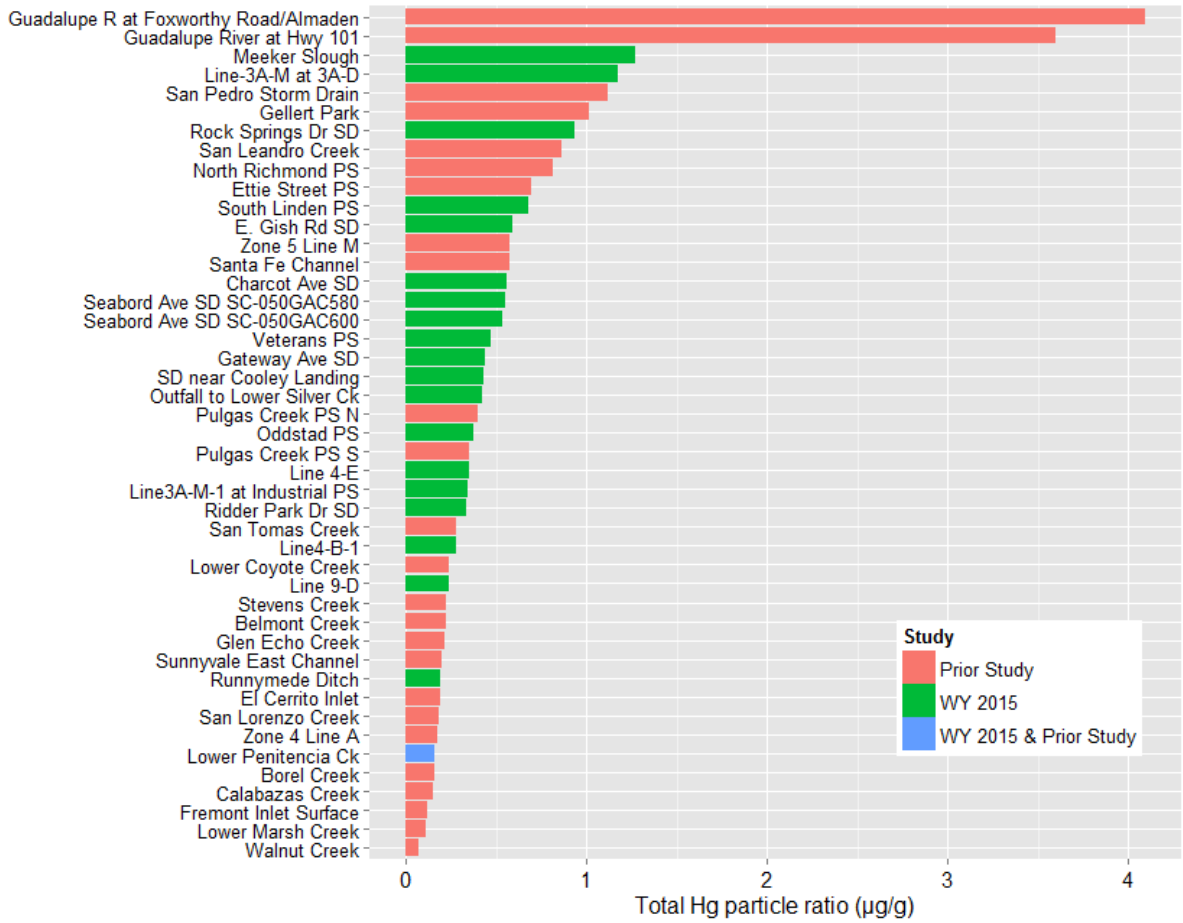


Figure 8. All watershed sampling locations measured to data ranked using total mercury (HgT) particle ratios.

concerns about methylmercury production (David et al., 2015). Three of these locations were also identified as elevated for PCB particle ratios (Ettie Street Pump Station, Line-3A-M at 3A-D, North Richmond Pump Station) 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.

## 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 Creek 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 WY 2015, trace element data were collected at an additional 20 locations (See Table 6 earlier in this report). All these data (n=30 sites for Cu; n=24 for Cd, Pb, and Zn; n=23 for As) 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 9). In the case of Guadalupe River, the HgT data were removed from the analysis due the historic mining influence in that watershed[15]. 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.

A variety of relationships have been found but 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 with impervious cover and old industrial land use but the larger role of atmospheric recirculation in the mercury cycle. PCBs appear to inversely correlate with all the trace metals analyzed (As, Cu, Cd, Pb, and Zn) since these also inversely correlate with impervious cover and old industrial land use. Total mercury does not appear to correlate with any of the other trace metals and shows similar but weaker relationships to impervious cover, old industrial land use, and watershed area than does PCBs. In contrast, the trace metals all appear to correlate with each other more generally. The strongest correlations appear to be between Cu and Zn perhaps because they are both vehicular related (see discussion in McKee et al., 2012) and between Pb and Cd perhaps because of the strong atmospheric pathway of these two metals (Davis et al., 2001). Overall, based on this analysis using the available pooled data, there is no support for the use of these trace metals as a tracer for either PCB or HgT pollution sources.

## 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. A total of 45 sites have been sampled for PCBs and HgT during various field sampling efforts since WY

[15] 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 9. Spearman Rank correlation matrix based on stormwater samples collected in the Bay Area since WY 2003 (see text for data source and exclusions).

| | *PCBs (ng/g)* | *HgT (µg/g)* | *Arsenic (µg/mg)* | *Cadmium (µg/mg)* | *Copper (µg/mg)* | *Lead (µg/mg)* | *Zinc (µg/mg)* | *Area (km²)* | *% Impervious cover* | *% Old Industrial land use* | *% Clay (<0.004 mm)* | *% Silt (0.004 to <0.0625 mm)* | *% Sands (0.0625 to <2.0 mm)* | *TOC (mg/mg)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCBs (ng/g) | 1.00 | | | | | | | | | | | | | |
| HgT (µg/g) | 0.44 | 1.00 | | | | | | | | | | | | |
| Arsenic (µg/mg) | -0.61 | -0.13 | 1.00 | | | | | | | | | | | |
| Cadmium (µg/mg) | -0.38 | 0.12 | 0.75 | 1.00 | | | | | | | | | | |
| Copper (µg/mg) | -0.15 | 0.05 | 0.71 | 0.67 | 1.00 | | | | | | | | | |
| Lead (µg/mg) | -0.37 | 0.04 | 0.73 | 0.89 | 0.60 | 1.00 | | | | | | | | |
| Zinc (µg/mg) | -0.37 | 0.19 | 0.47 | 0.65 | 0.88 | 0.55 | 1.00 | | | | | | | |
| Area (km²) | -0.47 | -0.38 | 0.06 | -0.06 | -0.33 | 0.17 | -0.26 | 1.00 | | | | | | |
| % Impervious cover | 0.64 | 0.36 | -0.28 | -0.13 | 0.10 | -0.27 | 0.18 | -0.71 | 1.00 | | | | | |
| % Old Industrial land use | 0.58 | 0.40 | -0.34 | -0.28 | -0.29 | -0.41 | -0.14 | -0.43 | 0.75 | 1.00 | | | | |
| % Clay (<0.004 mm) | 0.47 | 0.16 | -0.28 | -0.05 | -0.40 | -0.16 | -0.40 | -0.31 | 0.11 | 0.41 | 1.00 | | | |
| % Silt (0.004 to <0.0625 mm) | -0.03 | 0.22 | -0.04 | -0.12 | 0.39 | 0.03 | 0.36 | 0.29 | -0.12 | -0.19 | -0.02 | 1.00 | | |
| % Sands (0.0625 to <2.0 mm) | 0.06 | 0.08 | 0.17 | -0.07 | -0.10 | 0.06 | 0.06 | -0.21 | 0.36 | 0.35 | -0.80 | -0.34 | 1.00 | |
| TOC (mg/mg) | 0.28 | 0.32 | 0.59 | 0.44 | 0.86 | 0.30 | 0.66 | -0.48 | 0.45 | 0.26 | -0.50 | 0.31 | 0.28 | 1.00 |

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, 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 19.2% 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 (where 61% of this land use has been sampled), followed by Alameda County (17%), San Mateo County (9%), and Contra Costa County (3%). 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, 48% of it lies within 1 km of the Bay and 65% 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 22 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% of the runoff within the calibration watersheds and were present in <10 of the 22 watersheds (Wu et al., 2016). Based on the extended dataset (now 45 watersheds), the number of watersheds where these types of source areas are present has increased (Table 10) compared to data available mainly reported by McKee et al., (2010). For example, waste-recycle was present in just nine watersheds, auto-recycle was present in just 10 watersheds, and metals recycle was present in just 5 watersheds within the 22 sample sites previously available for model calibration; these numbers have now increased to 16, 19, and 11 respectively (Table 10). In addition, many of the new watersheds characterized in WY 2015 (described for the first time in this current report) are much smaller in size (0.108-7.34 $km^2$) compared to previous characterization or loading based sampling efforts (0.552-327 $km^2$) and as such are less heterogeneous in relation to land uses and source areas. This may also help the model to calibrate better by placing stronger constraints on the calibration process for key source areas. 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 use of the data is for improving the calibration of the RWSM and by extension improved estimates of regional scale watershed loads.

Table 10. Land uses and source areas sampled in relation to potential use for calibration of the Regional Watershed Spreadsheet Model (RWSM) (Wu et al., 2016).

| Land use or source area | % volume contribution | Number of watersheds | Conceptual largest influence (Combined rank) | Potential use in the RWSM |
|---|---|---|---|---|
| LU Open | 36% | 33 | 1189 | Likely high calibration influence. Can likely be used as either a single or group parameter |
| LU Old Transportation | 20% | 38 | 750 | |
| LU Old Residential | 15% | 35 | 540 | |
| LU Old Commercial | 9.6% | 37 | 354 | |
| LU Old Industrial | 2.8% | 33 | 93 | |
| LU New Industrial | 2.5% | 35 | 87 | |
| LU New Transportation | 4.9% | 16 | 79 | |
| SA TranspRail | 1.8% | 29 | 51 | |
| LU New Residential | 4.3% | 11 | 48 | |
| LU New Commercial | 2.4% | 15 | 37 | |
| SA RecycWaste | 1.2% | 16 | 19 | Likely moderate calibration influence. Can best be used in a grouped parameter |
| LU Agriculture | 1.7% | 8 | 13 | |
| SA ManufMetals | 0.2% | 21 | 5.2 | |
| SA RecycAuto | 0.2% | 19 | 4.3 | |
| SA ElectricTransf | 0.1% | 16 | 0.94 | Likely low calibration influence but could be grouped with other source areas as part of a global parameter that would not influence the calibration but could influence the regional loads estimates |
| SA RecycMetals | 0.1% | 11 | 0.81 | |
| SA TranspAir | 0.3% | 2 | 0.59 | |
| SA ElectricPower | 0.1% | 3 | 0.25 | |
| SA RecycDrums | 0.0% | 3 | 0.024 | |
| SA Military | 0.0% | 1 | 0.0016 | |

# Summary and Recommendations for Improved Sampling Design

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. At these sites, 20 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 three of these locations, simultaneous samples were also collected using a Hamlin remote suspended sediment sampler and at one site 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 relative to tides, some success even occurred at tidal sties, but overall, tidal sites remain the most challenging to sample. Although optimism remains about future applications, the remote suspended sediment samplers that were trialed showed mixed results and need further testing.

Based on the WY 2015 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 areas 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 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.
- Continue to trial both the Hamlin and Walling remote suspended sediment samplers to amass a full dataset of 12 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.

# References

BASMAA, 2011. Small Tributaries Loading Strategy Multi-Year Plan (MYP) Version 2011. A document developed collaboratively by the Small Tributaries Loading Strategy Work Group of the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP): Lester McKee, Alicia Gilbreath, Ben Greenfield, Jennifer Hunt, Michelle Lent, Aroon Melwani (SFEI), Arleen Feng (ACCWP) and Chris Sommers (EOA/SCVURPPP) for BASMAA, and Richard Looker and Tom Mumley (SFRWQCB). Submitted to the Regional Water Board, September 2011, in support of compliance with the Municipal Regional Stormwater Permit, provision C.8.e. http://www.swrcb.ca.gov/rwqcb2/water_issues/programs/stormwater/MRP/2011_AR/BASMAA/B2_2010-11_MRP_AR.pdf

BASMAA, 2012. Small Tributaries Loading Strategy Multi-Year Plan (MYP) Version 2012A. A document developed collaboratively by the Small Tributaries Loading Strategy Work Group of the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP): Lester McKee, Alicia Gilbreath, Ben Greenfield, Jennifer Hunt, Michelle Lent, Aroon Melwani (SFEI), Arleen Feng (ACCWP) and Chris Sommers (EOA/SCVURPPP) for BASMAA, and Richard Looker and Tom Mumley (SFRWQCB). Submitted to the Regional Water Board, September 2011, in support of compliance with the Municipal Regional Stormwater Permit, provision C.8.e. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/MRP/2012_AR/BASMAA/BASMAA_2011-12_MRP_AR_POC_APPENDIX_B4.pdf

David, N., Leatherbarrow, J.E, Yee, D., and McKee, L.J, 2015. Removal Efficiencies of a Bioretention System for Trace Metals, PCBs, PAHs, and Dioxins in a Semi-arid Environment. J. of Environmental Engineering, 141(6).

Gilbreath, A., Yee, D., McKee, L.J., 2012a. Concentrations and loads of trace contaminants in a small urban tributary, San Francisco Bay, California. A Technical Report of the Sources Pathways and Loading Work Group of the Regional Monitoring Program for Water Quality: Contribution No. 650. San Francisco Estuary Institute, Richmond, California. 40pp. http://www.sfei.org/documents/concentrations-and-loads-trace-contaminants-small-urban-tributary-san-francisco-bay

Gilbreath, A. N., Pearce, S.A., and McKee, L. J., 2012b. Monitoring and Results for El Cerrito Rain Gardens. Contribution No. 683. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/sites/default/files/El%20Cerrito%20Rain%20Garden_FINALReport.pdf

Gilbreath, A.N., Gluchowski, D.C., Wu, J., Hunt, J.A., and McKee, L.J., 2014. Pollutants of concern (POC) loads monitoring data progress report, water year (WYs) 2012 and 2013. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 708. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/pollutants-concern-poc-loads-monitoring-data-progress-report-water-years-wys-2012-and-2013

Gilbreath, A.N., Hunt, J.A., Wu, J., Kim, P.S., and McKee, L.J., 2015a (in SPLWG review). Pollutants of concern (POC) loads monitoring progress report, water years (WYs) 2012, 2013, and 2014. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 741. San Francisco Estuary Institute, Richmond, California.

Gilbreath, A.N., Hunt, J.A., and McKee, L.J., 2015b. Hydrological response and pollutant removal by tree-well filter bioretention, Fremont, CA. A technical report of the Clean Water Program. SFEI Contribution No. xxx. San Francisco Estuary Institute, Richmond, CA.

Greenfield, B., Klatt, M., Leatherbarrow, J.E., and McKee, L.J., 2010. Exploratory categorization of watersheds for potential stormwater monitoring in San Francisco Bay. A technical memo for the Sources Pathways and Loading Workgroup of the Regional Monitoring Program for Water Quality. San Francisco Estuary Institute, Oakland, CA. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/MRP/2011_AR/BASMAA/B2d_2010-11_MRP_AR.pdf

Hunt, J.A., Gluchowski, D., Gilbreath, A., and McKee, L.J., 2012. Pollutant Monitoring in the North Richmond Pump Station: A Pilot Study for Potential Dry Flow and Seasonal First Flush Diversion for Wastewater Treatment. A report for the Contra Costa County Watershed Program. Funded by a grant from the US Environmental Protection Agency, administered by the San Francisco Estuary Project. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/sites/default/files/NorthRichmondPumpStation_Final_19112012_ToCCCWP.pdf

McKee, L.J., Leatherbarrow, J., and Oram, J., 2005. Concentrations and loads of mercury, PCBs, and OC pesticides in the lower Guadalupe River, San Jose, California: Water Years 2003 and 2004. A Technical Report of the Regional Watershed Program: SFEI Contribution 409. San Francisco Estuary Institute, Oakland, CA. 72pp. http://www.sfei.org/documents/concentrations-and-loads-mercury-pcbs-and-oc-pesticides-lower-guadalupe-river-san

McKee, L.J., Oram, J., Leatherbarrow, J., Bonnema, A., Heim, W., and Stephenson, M., 2006. Concentrations and loads of mercury, PCBs, and PBDEs in the lower Guadalupe River, San Jose, California: Water Years 2003, 2004, and 2005. A Technical Report of the Regional Watershed Program: SFEI Contribution 424. San

Francisco Estuary Institute, Oakland, CA. 47pp + Appendix A and B. http://www.sfei.org/documents/concentrations-and-loads-mercury-pcbs-and-pbdes-lower-guadalupe-river-san-jose-california

McKee, L.J., Gilbreath, A.N., Hunt, J.A., and Greenfield, B.K., 2012. Pollutants of concern (POC) loads monitoring data, Water Year (WY) 2011. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Small Tributaries Loading Strategy (STLS). Contribution No. 680. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/documents/pollutants-concern-poc-loads-monitoring-data-water-year-wy-2011

McKee, L.J., Gilbreath, A.N., Wu, J., Kunze, M.S., Hunt, J.A., 2014. Estimating Regional Pollutant Loads for San Francisco Bay Area Tributaries using the Regional Watershed Spreadsheet Model (RWSM): Year's 3 and 4 Progress Report. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 737. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/sites/default/files/737%20RWSM%20Progress%20Report%20Y3_4%20for%20the%20WEB.pdf

McKee, L.J. Gilbreath, N., Hunt, J.A., Wu, J., and Yee, D., 2015 (in review). Sources, Pathways and Loadings: Multi-Year Synthesis with a focus on PCBs and Hg. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. 773. San Francisco Estuary Institute, Richmond, Ca.

Melwani, A., Lent, M., Greenfield, B., and McKee, L.J., 2010. Optimizing sampling methods for pollutant loads and trends in San Francisco Bay urban stormwater monitoring. A technical report for the Sources Pathways and Loading Workgroup of the Regional Monitoring Program for Water Quality. San Francisco Estuary Institute, Oakland, CA. Final Draft. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/MRP/2011_AR/BASMAA/B2c_2010-11_MRP_AR.pdf

SFEI, 2009. RMP Small Tributaries Loading Strategy. A report prepared by the strategy team (L McKee, A Feng, C Sommers, R Looker) for the Regional Monitoring Program for Water Quality. SFEI Contribution #585. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/rmp/stls

SFRWQCB, 2006. Mercury in San Francisco Bay: Proposed Basin Plan Amendment and Staff Report for Revised Total Maximum Daily Load (TMDL) and Proposed Mercury Water Quality Objectives. California Regional Water Quality Control Board San Francisco Bay Region, August 1st, 2006. 116pp. http://www.waterboards.ca.gov/sanfranciscobay/TMDL/SFBayMercury/sr080906.pdf

SFRWQCB, 2007. Total Maximum Daily Load for PCBs in San Francisco Bay Proposed Basin Plan Amendment and Staff Report. San Francisco Bay Regional Water Quality Control Board. Oakland, CA. December 4th, 2007. 178pp. http://www.waterboards.ca.gov/sanfranciscobay/TMDL/SFBayPCBs/PCBsSR1207rev.pdf

SFRWQCB, 2008. Guadalupe River Watershed Mercury Total Maximum Daily Load (TMDL) Project BASIN PLAN AMENDMENT. California Regional Water Quality Control Board San Francisco Bay Region October 8, 2008. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/guadalupe_river_mercury/Guad_Hg_TMDL_BPA_final_EOcorrSB_clean.pdf

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/index.shtml

SFRWQCB, 2011. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. Revised November 28, 2011 http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/Municipal/R2-2009-0074_Revised.pdf

SPLWG, 2014. Regional Monitoring Program for Water Quality (RMP), Sources, Pathways and Loadings Workgroup (SPLWG) meeting. May 2014. San Francisco Estuary Institute, Richmond, California. http://www.sfei.org/events/rmp-sources-pathways-and-loading-workgroup-meeting

Steding, D. J. and Flegal, A. R. 2002. Mercury concentrations in coastal California precipitation: evidence of local and trans-Pacific fluxes of mercury to North America. Journal of Geophysical Research. pp.11-1.

Tsai, P., and Hoenicke, R., 2001. San Francisco Bay atmospheric deposition pilot study Part 1: Mercury. San Francisco Estuary Institute, Oakland Ca, July, 2001. 45pp. http://www.sfei.org/rmp/reports/air_dep/mercury_airdep/ADHg_FinalReport.pdf

Wu, J., Gilbreath, A.N., and McKee, L.J., 2016 (in review). Regional Watershed Spreadsheet Model (RWSM): Year 5 Progress Report. A technical report prepared for the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP), Sources, Pathways and Loadings Workgroup (SPLWG), Small Tributaries Loading Strategy (STLS). Contribution No. xxx. San Francisco Estuary Institute, Richmond, Ca.

Yee, D., and McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg in soils, sediments and water in the urbanized Bay Area: Implications for best management. A technical report of the Watershed Program. SFEI Contribution 608. San Francisco Estuary Institute, Oakland CA 94621. 36 pp. + appendix. http://www.sfei.org/sites/default/files/Concentrations%20of%20Hg%20PCBs%20in%20soils%20sediment%20and%20water%20in%20the%20urbanized%20Bay%20Area_0.pdf

Yee, D., Franz, A., Jabusch, T., Wong, A., Ross, J., 2015. Quality Assurance Program Plan for the Regional Monitoring Program for Water Quality in San Francisco Bay. San Francisco Estuary Institute, Richmond, Ca. http://www.sfei.org/documents/quality-assurance-program-plan-regional-monitoring-program-water-quality-san-francisco-b-0

# Appendices

## Appendix A – Detailed QA information

Table A1: Summary of QA data at all sites.

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| SSC | mg/L | - | 0.5-0.5; 0.5 | 1 | NA | 5.16-5.16; 5.16 | NA | NA |
| DOC | µg/L | 0 | 52-520; 256 | NA | 0.00-6.02; 1.91 | 0.00-10.13; 3.97 | NA | 100.00-112.50; 107.18 |
| TOC | mg/L | 0.00289 | 0.096-0.48; 0.129 | NA | 0.00-3.93; 2.16 | 0.00-35.79; 11.89 | NA | 100.00-141.25; 107.49 |
| Total Arsenic | µg/L | 0.00358 | 0.013-0.013; 0.013 | 0.032 | 2.74-2.74; 2.74 | 1.81-4.04; 2.89 | 96.32-101.76; 98.32 | 91.56-102.34; 93.65 |
| Total Cadmium | µg/L | 0 | 0.007-0.037; 0.0118 | 0.0344 | 1.89-4.29; 3.09 | 0.93-8.00; 3.74 | 99.90-105.59; 102.66 | 80.27-101.05; 95.83 |
| Total Cu | µg/L | 0 | 0.042-0.211; 0.116 | 0.349 | 0.87-1.04; 0.95 | 0.75-1.36; 1.06 | 100.28-104.55; 103.00 | 91.83-103.60; 95.98 |
| Total Hg | µg/L | 0.000129 | 0.00253-0.00263; 0.00258 | 0.0103 | NA | 16.66-16.66; 16.66 | 100.58-103.34; 101.77 | 93.75-103.82; 98.54 |
| Total Lead | µg/L | 0 | 0.006-0.032; 0.0174 | 0.0726 | 0.00-1.75; 0.82 | 0.00-7.85; 2.93 | 99.00-104.12; 101.92 | 97.21-101.10; 99.33 |
| Total Zinc | µg/L | 0 | 0.06-0.32; 0.174 | 0.58 | 0.31-0.59; 0.48 | 0.05-2.64; 0.97 | 101.11-108.34; 105.43 | 86.35-101.14; 92.89 |

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| Dissolved PCB 008 | ng/L | - | 0.000814-0.000814; 0.000814 | NA | NA | NA | NA | NA |
| Dissolved PCB 018 | ng/L | - | 0.000528-0.000528; 0.000528 | NA | NA | NA | NA | NA |
| Dissolved PCB 028 | ng/L | - | 0.00599-0.00599; 0.00599 | NA | NA | NA | NA | NA |
| Dissolved PCB 031 | ng/L | - | 0.00535-0.00535; 0.00535 | NA | NA | NA | NA | NA |
| Dissolved PCB 033 | ng/L | - | 0.00546-0.00546; 0.00546 | NA | NA | NA | NA | NA |
| Dissolved PCB 044 | ng/L | - | 0.000907-0.000907; 0.000907 | NA | NA | NA | NA | NA |
| Dissolved PCB 049 | ng/L | - | 0.000823-0.000823; 0.000823 | NA | NA | NA | NA | NA |
| Dissolved PCB 052 | ng/L | - | 0.00102-0.00102; 0.00102 | NA | NA | NA | NA | NA |
| Dissolved PCB 056 | ng/L | - | 0.0084-0.0084; 0.0084 | NA | NA | NA | NA | NA |
| Dissolved PCB 060 | ng/L | - | 0.0083-0.0083; 0.0083 | NA | NA | NA | NA | NA |
| Dissolved PCB 066 | ng/L | - | 0.00759-0.00759; 0.00759 | NA | NA | NA | NA | NA |
| Dissolved PCB 070 | ng/L | - | 0.00776-0.00776; 0.00776 | NA | NA | NA | NA | NA |
| Dissolved PCB 087 | ng/L | - | 0.00236-0.00236; 0.00236 | NA | NA | NA | NA | NA |

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| Dissolved PCB 095 | ng/L | - | 0.00267-0.00267; 0.00267 | NA | NA | NA | NA | NA |
| Dissolved PCB 099 | ng/L | - | 0.00291-0.00291; 0.00291 | NA | NA | NA | NA | NA |
| Dissolved PCB 101 | ng/L | - | 0.00238-0.00238; 0.00238 | NA | NA | NA | NA | NA |
| Dissolved PCB 105 | ng/L | - | 0.0311-0.0311; 0.0311 | NA | NA | NA | NA | NA |
| Dissolved PCB 110 | ng/L | - | 0.00196-0.00196; 0.00196 | NA | NA | NA | NA | NA |
| Dissolved PCB 118 | ng/L | - | 0.0238-0.0238; 0.0238 | NA | NA | NA | NA | NA |
| Dissolved PCB 128 | ng/L | - | 0.0152-0.0152; 0.0152 | NA | NA | NA | NA | NA |
| Dissolved PCB 132 | ng/L | - | 0.0198-0.0198; 0.0198 | NA | NA | NA | NA | NA |
| Dissolved PCB 138 | ng/L | - | 0.0152-0.0152; 0.0152 | NA | NA | NA | NA | NA |
| Dissolved PCB 141 | ng/L | - | 0.0171-0.0171; 0.0171 | NA | NA | NA | NA | NA |
| Dissolved PCB 149 | ng/L | - | 0.0172-0.0172; 0.0172 | NA | NA | NA | NA | NA |
| Dissolved PCB 151 | ng/L | - | 0.000869-0.000869; 0.000869 | NA | NA | NA | NA | NA |
| Dissolved PCB 153 | ng/L | - | 0.014-0.014; 0.014 | NA | NA | NA | NA | NA |

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| Dissolved PCB 156 | ng/L | - | 0.0138-0.0138; 0.0138 | NA | NA | NA | NA | NA |
| Dissolved PCB 158 | ng/L | - | 0.0118-0.0118; 0.0118 | NA | NA | NA | NA | NA |
| Dissolved PCB 170 | ng/L | - | 0.00157-0.00157; 0.00157 | NA | NA | NA | NA | NA |
| Dissolved PCB 174 | ng/L | - | 0.0013-0.0013; 0.0013 | NA | NA | NA | NA | NA |
| Dissolved PCB 177 | ng/L | - | 0.00143-0.00143; 0.00143 | NA | NA | NA | NA | NA |
| Dissolved PCB 180 | ng/L | - | 0.00117-0.00117; 0.00117 | NA | NA | NA | NA | NA |
| Dissolved PCB 183 | ng/L | - | 0.00138-0.00138; 0.00138 | NA | NA | NA | NA | NA |
| Dissolved PCB 187 | ng/L | - | 0.00131-0.00131; 0.00131 | NA | NA | NA | NA | NA |
| Dissolved PCB 194 | ng/L | - | 0.00327-0.00327; 0.00327 | NA | NA | NA | NA | NA |
| Dissolved PCB 195 | ng/L | - | 0.0036-0.0036; 0.0036 | NA | NA | NA | NA | NA |
| Dissolved PCB 201 | ng/L | - | 0.000686-0.000686; 0.000686 | NA | NA | NA | NA | NA |
| Dissolved PCB 203 | ng/L | - | 0.000843-0.000843; 0.000843 | NA | NA | NA | NA | NA |
| Total PCB 008 | ng/L | 0.00248 | 0.000282-0.00212; 0.000883 | NA | NA | NA | NA | NA |

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| Total PCB 018 | ng/L | 0.0022 | 0.000282-0.000782; 0.000447 | NA | NA | NA | NA | NA |
| Total PCB 028 | ng/L | 0.00389 | 0.000319-0.0323; 0.00212 | NA | NA | NA | NA | NA |
| Total PCB 031 | ng/L | 0.00206 | 0.000319-0.03; 0.00198 | NA | NA | NA | NA | NA |
| Total PCB 033 | ng/L | 0.000879 | 0.000319-0.0302; 0.00201 | NA | NA | NA | NA | NA |
| Total PCB 044 | ng/L | 0.00221 | 0.000282-0.00215; 0.00055 | NA | NA | NA | NA | NA |
| Total PCB 049 | ng/L | 0.00149 | 0.000282-0.00196; 0.000524 | NA | NA | NA | NA | NA |
| Total PCB 052 | ng/L | 0.00831 | 0.000282-0.00225; 0.000558 | NA | NA | NA | NA | NA |
| Total PCB 056 | ng/L | 0 | 0.000319-0.0846; 0.00644 | NA | NA | NA | NA | NA |
| Total PCB 060 | ng/L | 0 | 0.000319-0.085; 0.00646 | NA | NA | NA | NA | NA |
| Total PCB 066 | ng/L | 0.000589 | 0.000319-0.0824; 0.00623 | NA | NA | NA | NA | NA |
| Total PCB 070 | ng/L | 0.00319 | 0.000319-0.157; 0.00916 | NA | NA | NA | NA | NA |
| Total PCB 087 | ng/L | 0.00097 | 0.000319-0.0511; 0.00466 | NA | NA | NA | NA | NA |
| Total PCB 095 | ng/L | 0.00353 | 0.000344-0.0391; 0.00447 | NA | NA | NA | NA | NA |

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| Total PCB 099 | ng/L | 0.000725 | 0.000354-0.0425; 0.0048 | NA | NA | NA | NA | NA |
| Total PCB 101 | ng/L | 0.00122 | 0.000319-0.0533; 0.0048 | NA | NA | NA | NA | NA |
| Total PCB 105 | ng/L | 0.00128 | 0.000601-0.63; 0.0362 | NA | NA | NA | NA | NA |
| Total PCB 110 | ng/L | 0.00123 | 0.000319-0.0442; 0.004 | NA | NA | NA | NA | NA |
| Total PCB 118 | ng/L | 0.00135 | 0.000555-0.554; 0.0321 | NA | NA | NA | NA | NA |
| Total PCB 128 | ng/L | 0.000236 | 0.000475-0.29; 0.0241 | NA | NA | NA | NA | NA |
| Total PCB 132 | ng/L | 0 | 0.000608-0.365; 0.0303 | NA | NA | NA | NA | NA |
| Total PCB 138 | ng/L | 0.00116 | 0.000476-0.317; 0.0252 | NA | NA | NA | NA | NA |
| Total PCB 141 | ng/L | 0.000241 | 0.00054-0.328; 0.0272 | NA | NA | NA | NA | NA |
| Total PCB 149 | ng/L | 0.00226 | 0.000528-0.313; 0.0259 | NA | NA | NA | NA | NA |
| Total PCB 151 | ng/L | 0.000853 | 0.000282-0.00454; 0.000844 | NA | NA | NA | NA | NA |
| Total PCB 153 | ng/L | 0.000882 | 0.000426-0.259; 0.0214 | NA | NA | NA | NA | NA |
| Total PCB 156 | ng/L | 0 | 0.000517-0.301; 0.0243 | NA | NA | NA | NA | NA |

| Analyte | Unit | Average Lab Blank | Detection Limit (MDL) (range; mean) | Average Reporting Limit (RL) | RSD of Lab Duplicates (% range; % mean) | RSD of Field Duplicates (% range; % mean) | Percent Recovery of CRM (% range; % mean) | Percent Recovery of Matrix Spike (% range; % mean) |
|---|---|---|---|---|---|---|---|---|
| Total PCB 158 | ng/L | 0 | 0.000373-0.226; 0.0188 | NA | NA | NA | NA | NA |
| Total PCB 170 | ng/L | 0 | 0.000299-0.00696; 0.00124 | NA | NA | NA | NA | NA |
| Total PCB 174 | ng/L | 0 | 0.000302-0.00624; 0.00112 | NA | NA | NA | NA | NA |
| Total PCB 177 | ng/L | 0 | 0.000311-0.00651; 0.00117 | NA | NA | NA | NA | NA |
| Total PCB 180 | ng/L | 0.000357 | 0.000282-0.00549; 0.00099 | NA | NA | NA | NA | NA |
| Total PCB 183 | ng/L | 0 | 0.00029-0.00608; 0.00109 | NA | NA | NA | NA | NA |
| Total PCB 187 | ng/L | 0.000353 | 0.000282-0.0058; 0.00104 | NA | NA | NA | NA | NA |
| Total PCB 194 | ng/L | 0 | 0.000446-0.013; 0.00176 | NA | NA | NA | NA | NA |
| Total PCB 195 | ng/L | 0 | 0.000483-0.0141; 0.00189 | NA | NA | NA | NA | NA |
| Total PCB 201 | ng/L | 0 | 0.000282-0.00211; 0.000657 | NA | NA | NA | NA | NA |
| Total PCB 203 | ng/L | 0 | 0.000282-0.00277; 0.000885 | NA | NA | NA | NA | NA |

Table A2: Field blank data from all sites.

| Analyte | Unit | Average MDL | RL | Minimum Field Blank | Maximum Field Blank | Average Field Blank |
|---|---|---|---|---|---|---|
| Total As | µg/L | 0.013 | 0.032 | ND | ND | ND |
| Total Cd | µg/L | 0.007 | 0.021 | ND | ND | ND |
| Total Cu | µg/L | 0.211 | 0.632 | ND | ND | ND |
| Total Hg | µg/L | 0.0001 | 4E-04 | ND | ND | ND |
| Total Pb | µg/L | 0.006 | 0.026 | ND | ND | ND |
| Total Zn | µg/L | 0.32 | 1.05 | ND | ND | ND |
| PCB 008 | ng/L | 0.000185 | - | 0.00304 | 0.00304 | 0.00304 |
| PCB 018 | ng/L | 0.000185 | - | 0.00251 | 0.00251 | 0.00251 |
| PCB 028 | ng/L | 0.000185 | - | 0.00514 | 0.00514 | 0.00514 |
| PCB 031 | ng/L | 0.000185 | - | 0.00394 | 0.00394 | 0.00394 |
| PCB 033 | ng/L | 0.000185 | - | 0.00274 | 0.00274 | 0.00274 |
| PCB 044 | ng/L | 0.000185 | - | 0.00352 | 0.00352 | 0.00352 |
| PCB 049 | ng/L | 0.000185 | - | 0.00152 | 0.00152 | 0.00152 |
| PCB 052 | ng/L | 0.000185 | - | 0.00677 | 0.00677 | 0.00677 |
| PCB 056 | ng/L | 0.000185 | - | 0.00159 | 0.00159 | 0.00159 |
| PCB 060 | ng/L | 0.000185 | - | 0.000579 | 0.000579 | 0.000579 |
| PCB 066 | ng/L | 0.000185 | - | 0.00175 | 0.00175 | 0.00175 |
| PCB 070 | ng/L | 0.000185 | - | 0.00344 | 0.00344 | 0.00344 |
| PCB 087 | ng/L | 0.000229 | - | 0.00216 | 0.00216 | 0.00216 |
| PCB 095 | ng/L | 0.000259 | - | 0.00283 | 0.00283 | 0.00283 |
| PCB 099 | ng/L | 0.000268 | - | 0.00124 | 0.00124 | 0.00124 |
| PCB 101 | ng/L | 0.000232 | - | 0.00262 | 0.00262 | 0.00262 |
| PCB 105 | ng/L | 0.000213 | - | 0.00124 | 0.00124 | 0.00124 |
| PCB 110 | ng/L | 0.000197 | - | 0.00341 | 0.00341 | 0.00341 |
| PCB 118 | ng/L | 0.000227 | - | 0.0023 | 0.0023 | 0.0023 |
| PCB 128 | ng/L | 0.000185 | - | 0.00111 | 0.00111 | 0.00111 |

Table A2 (continued): Field blank data from all sites.

| Analyte | Unit | Average MDL | RL | Minimum Field Blank | Maximum Field Blank | Average Field Blank |
|---|---|---|---|---|---|---|
| PCB 132 | ng/L | 0.000218 | - | 0.00222 | 0.00222 | 0.00222 |
| PCB 138 | ng/L | 0.000185 | - | 0.00435 | 0.00435 | 0.00435 |
| PCB 141 | ng/L | 0.000188 | - | 0.000699 | 0.000699 | 0.000699 |
| PCB 149 | ng/L | 0.000188 | - | 0.00294 | 0.00294 | 0.00294 |
| PCB 151 | ng/L | 0.000185 | - | 0.0012 | 0.0012 | 0.0012 |
| PCB 153 | ng/L | 0.000185 | - | 0.00202 | 0.00202 | 0.00202 |
| PCB 156 | ng/L | 0.000185 | - | 0.000417 | 0.000417 | 0.000417 |
| PCB 158 | ng/L | 0.000185 | - | 0.000391 | 0.000391 | 0.000391 |
| PCB 170 | ng/L | 0.000185 | - | 0.000938 | 0.000938 | 0.000938 |
| PCB 174 | ng/L | 0.000185 | - | 0.0011 | 0.0011 | 0.0011 |
| PCB 177 | ng/L | 0.000185 | - | 0.000651 | 0.000651 | 0.000651 |
| PCB 180 | ng/L | 0.000185 | - | 0.0015 | 0.0015 | 0.0015 |
| PCB 183 | ng/L | 0.000185 | - | 0.000699 | 0.000699 | 0.000699 |
| PCB 187 | ng/L | 0.000185 | - | 0.00113 | 0.00113 | 0.00113 |
| PCB 194 | ng/L | 0.000458 | - | ND | ND | ND |
| PCB 195 | ng/L | 0.000303 | - | ND | ND | ND |
| PCB 201 | ng/L | 0.000185 | - | ND | ND | ND |
| PCB 203 | ng/L | 0.000678 | - | ND | ND | ND |

Table A3: Average RSD of field and lab duplicates at each site.

| | Charcot Avenue SD SC-051CTC275 | | SD near Cooley Landing SM-72 | | Line 3A-M-1 at Industrial PS | | Line 4-B-1 | | Line 4-E | |
|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | RSD Lab | RSD Field | RSD Lab | RSD Field | RSD Lab | RSD Field | RSD Lab | RSD Field | RSD Lab | RSD Field |
| SSC | - | - | - | - | - | - | - | - | - | - |
| DOC | - | - | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | - | - |
| TOC | - | - | 0.00% | 0.00% | - | - | - | - | 3.90% | 3.90% |
| Total As | - | - | - | - | - | - | - | - | - | - |
| Total Cd | 4.30% | 4.30% | - | - | - | - | 1.90% | 1.90% | - | - |
| Total Cu | - | 0.70% | - | - | - | - | 1.00% | 1.00% | - | - |
| Total Hg | - | - | - | - | - | - | - | - | - | - |
| Total Pb | 0.00% | 0.00% | - | - | - | - | 0.70% | 0.70% | - | - |
| Total Zn | 0.30% | 0.30% | - | - | - | - | 0.60% | 0.60% | - | - |
| PCB 008 | - | - | - | - | - | - | - | - | - | - |
| PCB 018 | - | - | - | - | - | - | - | - | - | - |
| PCB 028 | - | - | - | - | - | - | - | - | - | - |
| PCB 031 | - | - | - | - | - | - | - | - | - | - |
| PCB 033 | - | - | - | - | - | - | - | - | - | - |
| PCB 044 | - | - | - | - | - | - | - | - | - | - |
| PCB 049 | - | - | - | - | - | - | - | - | - | - |
| PCB 052 | - | - | - | - | - | - | - | - | - | - |
| PCB 056 | - | - | - | - | - | - | - | - | - | - |
| PCB 060 | - | - | - | - | - | - | - | - | - | - |
| PCB 066 | - | - | - | - | - | - | - | - | - | - |
| PCB 070 | - | - | - | - | - | - | - | - | - | - |
| PCB 087 | - | - | - | - | - | - | - | - | - | - |
| PCB 095 | - | - | - | - | - | - | - | - | - | - |
| PCB 099 | - | - | - | - | - | - | - | - | - | - |
| PCB 101 | - | - | - | - | - | - | - | - | - | - |
| PCB 105 | - | - | - | - | - | - | - | - | - | - |
| PCB 110 | - | - | - | - | - | - | - | - | - | - |
| PCB 118 | - | - | - | - | - | - | - | - | - | - |
| PCB 128 | - | - | - | - | - | - | - | - | - | - |
| PCB 132 | - | - | - | - | - | - | - | - | - | - |
| PCB 138 | - | - | - | - | - | - | - | - | - | - |
| PCB 141 | - | - | - | - | - | - | - | - | - | - |
| PCB 149 | - | - | - | - | - | - | - | - | - | - |
| PCB 151 | - | - | - | - | - | - | - | - | - | - |
| PCB 153 | - | - | - | - | - | - | - | - | - | - |
| PCB 156 | - | - | - | - | - | - | - | - | - | - |
| PCB 158 | - | - | - | - | - | - | - | - | - | - |
| PCB 170 | - | - | - | - | - | - | - | - | - | - |
| PCB 174 | - | - | - | - | - | - | - | - | - | - |
| PCB 177 | - | - | - | - | - | - | - | - | - | - |
| PCB 180 | - | - | - | - | - | - | - | - | - | - |
| PCB 183 | - | - | - | - | - | - | - | - | - | - |
| PCB 187 | - | - | - | - | - | - | - | - | - | - |
| PCB 194 | - | - | - | - | - | - | - | - | - | - |
| PCB 195 | - | - | - | - | - | - | - | - | - | - |
| PCB 201 | - | - | - | - | - | - | - | - | - | - |
| PCB 203 | - | - | - | - | - | - | - | - | - | - |

Table A3 (continued): Average RSD of field and lab duplicates at each site.

| | Line 9-D | | Outfall to Lower Silver | | Meeker Slough | | Oddstad PS SM-267 | | Rock Springs Dr SD | |
|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | RSD Lab | RSD Field | RSD Lab | RSD Field | RSD Lab | RSD Field | RSD Lab | RSD Field | RSD Lab | RSD Field |
| SSC | - | 5.20% | - | - | - | - | - | - | - | - |
| DOC | 6.00% | 10.10% | - | - | - | - | 3.50% | 3.50% | - | - |
| TOC | 1.30% | 35.80% | 3.90% | 3.90% | 0.00% | 0.00% | - | - | - | - |
| Total As | - | 1.80% | - | - | - | 4.00% | - | - | 2.70% | 2.70% |
| Total Cd | - | 8.00% | - | - | - | 0.90% | - | - | - | 2.90% |
| Total Cu | - | 1.40% | - | - | - | 1.20% | - | - | 0.90% | 0.90% |
| Total Hg | - | 16.70% | - | - | - | - | - | - | - | - |
| Total Pb | - | 7.90% | - | - | - | 1.20% | - | - | 1.70% | 1.70% |
| Total Zn | - | 2.60% | - | - | - | 0.00% | - | - | 0.50% | 0.50% |
| PCB 008 | - | 6.50% | - | - | - | - | - | - | - | - |
| PCB 018 | - | 5.30% | - | - | - | - | - | - | - | - |
| PCB 028 | - | 9.00% | - | - | - | - | - | - | - | - |
| PCB 031 | - | 7.10% | - | - | - | - | - | - | - | - |
| PCB 033 | - | 7.40% | - | - | - | - | - | - | - | - |
| PCB 044 | - | 2.90% | - | - | - | - | - | - | - | - |
| PCB 049 | - | 3.40% | - | - | - | - | - | - | - | - |
| PCB 052 | - | 5.50% | - | - | - | - | - | - | - | - |
| PCB 056 | - | 7.70% | - | - | - | - | - | - | - | - |
| PCB 060 | - | 8.60% | - | - | - | - | - | - | - | - |
| PCB 066 | - | 4.50% | - | - | - | - | - | - | - | - |
| PCB 070 | - | 2.40% | - | - | - | - | - | - | - | - |
| PCB 087 | - | 4.20% | - | - | - | - | - | - | - | - |
| PCB 095 | - | 10.80% | - | - | - | - | - | - | - | - |
| PCB 099 | - | 9.00% | - | - | - | - | - | - | - | - |
| PCB 101 | - | 9.40% | - | - | - | - | - | - | - | - |
| PCB 105 | - | 9.60% | - | - | - | - | - | - | - | - |
| PCB 110 | - | 8.80% | - | - | - | - | - | - | - | - |
| PCB 118 | - | 11.30% | - | - | - | - | - | - | - | - |
| PCB 128 | - | 17.50% | - | - | - | - | - | - | - | - |
| PCB 132 | - | 5.60% | - | - | - | - | - | - | - | - |
| PCB 138 | - | 3.90% | - | - | - | - | - | - | - | - |
| PCB 141 | - | 2.80% | - | - | - | - | - | - | - | - |
| PCB 149 | - | 2.30% | - | - | - | - | - | - | - | - |
| PCB 151 | - | 0.80% | - | - | - | - | - | - | - | - |
| PCB 153 | - | 1.20% | - | - | - | - | - | - | - | - |
| PCB 156 | - | 5.70% | - | - | - | - | - | - | - | - |
| PCB 158 | - | 6.10% | - | - | - | - | - | - | - | - |
| PCB 170 | - | 4.60% | - | - | - | - | - | - | - | - |
| PCB 174 | - | 6.10% | - | - | - | - | - | - | - | - |
| PCB 177 | - | 6.80% | - | - | - | - | - | - | - | - |
| PCB 180 | - | 4.90% | - | - | - | - | - | - | - | - |
| PCB 183 | - | 9.70% | - | - | - | - | - | - | - | - |
| PCB 187 | - | 7.70% | - | - | - | - | - | - | - | - |
| PCB 194 | - | 4.70% | - | - | - | - | - | - | - | - |
| PCB 195 | - | 3.80% | - | - | - | - | - | - | - | - |
| PCB 201 | - | 10.80% | - | - | - | - | - | - | - | - |
| PCB 203 | - | 7.90% | - | - | - | - | - | - | - | - |

# Appendix B – Additional data results

Table B1. PCB congener results data appendix.

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Charcot Ave SD | PCB 008 | Dissolved | 649 | pg/L |
| Charcot Ave SD | PCB 018 | Dissolved | 1630 | pg/L |
| Charcot Ave SD | PCB 028 | Dissolved | 3170 | pg/L |
| Charcot Ave SD | PCB 031 | Dissolved | 2490 | pg/L |
| Charcot Ave SD | PCB 033 | Dissolved | 1630 | pg/L |
| Charcot Ave SD | PCB 044 | Dissolved | 3070 | pg/L |
| Charcot Ave SD | PCB 049 | Dissolved | 1770 | pg/L |
| Charcot Ave SD | PCB 052 | Dissolved | 3460 | pg/L |
| Charcot Ave SD | PCB 056 | Dissolved | 715 | pg/L |
| Charcot Ave SD | PCB 060 | Dissolved | 373 | pg/L |
| Charcot Ave SD | PCB 066 | Dissolved | 1410 | pg/L |
| Charcot Ave SD | PCB 070 | Dissolved | 2930 | pg/L |
| Charcot Ave SD | PCB 087 | Dissolved | 2340 | pg/L |
| Charcot Ave SD | PCB 095 | Dissolved | 2990 | pg/L |
| Charcot Ave SD | PCB 099 | Dissolved | 1610 | pg/L |
| Charcot Ave SD | PCB 101 | Dissolved | 3030 | pg/L |
| Charcot Ave SD | PCB 105 | Dissolved | 1240 | pg/L |
| Charcot Ave SD | PCB 110 | Dissolved | 3870 | pg/L |
| Charcot Ave SD | PCB 118 | Dissolved | 2490 | pg/L |
| Charcot Ave SD | PCB 128 | Dissolved | 747 | pg/L |
| Charcot Ave SD | PCB 132 | Dissolved | 2080 | pg/L |
| Charcot Ave SD | PCB 138 | Dissolved | 5900 | pg/L |
| Charcot Ave SD | PCB 141 | Dissolved | 1170 | pg/L |
| Charcot Ave SD | PCB 149 | Dissolved | 4890 | pg/L |
| Charcot Ave SD | PCB 151 | Dissolved | 2130 | pg/L |
| Charcot Ave SD | PCB 153 | Dissolved | 4710 | pg/L |
| Charcot Ave SD | PCB 156 | Dissolved | 566 | pg/L |
| Charcot Ave SD | PCB 158 | Dissolved | 607 | pg/L |
| Charcot Ave SD | PCB 170 | Dissolved | 2290 | pg/L |
| Charcot Ave SD | PCB 174 | Dissolved | 2740 | pg/L |
| Charcot Ave SD | PCB 177 | Dissolved | 1470 | pg/L |
| Charcot Ave SD | PCB 180 | Dissolved | 5840 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Charcot Ave SD | PCB 183 | Dissolved | 2060 | pg/L |
| Charcot Ave SD | PCB 187 | Dissolved | 2900 | pg/L |
| Charcot Ave SD | PCB 194 | Dissolved | 1880 | pg/L |
| Charcot Ave SD | PCB 195 | Dissolved | 701 | pg/L |
| Charcot Ave SD | PCB 201 | Dissolved | 348 | pg/L |
| Charcot Ave SD | PCB 203 | Dissolved | 1810 | pg/L |
| Charcot Ave SD | PCB 008 | Total | 167 | pg/L |
| Charcot Ave SD | PCB 018 | Total | 307 | pg/L |
| Charcot Ave SD | PCB 028 | Total | 600 | pg/L |
| Charcot Ave SD | PCB 031 | Total | 495 | pg/L |
| Charcot Ave SD | PCB 033 | Total | 332 | pg/L |
| Charcot Ave SD | PCB 044 | Total | 492 | pg/L |
| Charcot Ave SD | PCB 049 | Total | 277 | pg/L |
| Charcot Ave SD | PCB 052 | Total | 552 | pg/L |
| Charcot Ave SD | PCB 056 | Total | 163 | pg/L |
| Charcot Ave SD | PCB 060 | Total | 86.8 | pg/L |
| Charcot Ave SD | PCB 066 | Total | 286 | pg/L |
| Charcot Ave SD | PCB 070 | Total | 614 | pg/L |
| Charcot Ave SD | PCB 087 | Total | 516 | pg/L |
| Charcot Ave SD | PCB 095 | Total | 500 | pg/L |
| Charcot Ave SD | PCB 099 | Total | 298 | pg/L |
| Charcot Ave SD | PCB 101 | Total | 592 | pg/L |
| Charcot Ave SD | PCB 105 | Total | 292 | pg/L |
| Charcot Ave SD | PCB 110 | Total | 805 | pg/L |
| Charcot Ave SD | PCB 118 | Total | 588 | pg/L |
| Charcot Ave SD | PCB 128 | Total | 138 | pg/L |
| Charcot Ave SD | PCB 132 | Total | 359 | pg/L |
| Charcot Ave SD | PCB 138 | Total | 1100 | pg/L |
| Charcot Ave SD | PCB 141 | Total | 212 | pg/L |
| Charcot Ave SD | PCB 149 | Total | 779 | pg/L |
| Charcot Ave SD | PCB 151 | Total | 322 | pg/L |
| Charcot Ave SD | PCB 153 | Total | 834 | pg/L |
| Charcot Ave SD | PCB 156 | Total | 110 | pg/L |
| Charcot Ave SD | PCB 158 | Total | 109 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Charcot Ave SD | PCB 170 | Total | 332 | pg/L |
| Charcot Ave SD | PCB 174 | Total | 431 | pg/L |
| Charcot Ave SD | PCB 177 | Total | 212 | pg/L |
| Charcot Ave SD | PCB 180 | Total | 834 | pg/L |
| Charcot Ave SD | PCB 183 | Total | 260 | pg/L |
| Charcot Ave SD | PCB 187 | Total | 371 | pg/L |
| Charcot Ave SD | PCB 194 | Total | 238 | pg/L |
| Charcot Ave SD | PCB 195 | Total | 80.7 | pg/L |
| Charcot Ave SD | PCB 201 | Total | 38 | pg/L |
| Charcot Ave SD | PCB 203 | Total | 204 | pg/L |
| E. Gish Rd SD | PCB 008 | Total | 62.3 | pg/L |
| E. Gish Rd SD | PCB 018 | Total | 154 | pg/L |
| E. Gish Rd SD | PCB 028 | Total | 269 | pg/L |
| E. Gish Rd SD | PCB 031 | Total | 228 | pg/L |
| E. Gish Rd SD | PCB 033 | Total | 155 | pg/L |
| E. Gish Rd SD | PCB 044 | Total | 292 | pg/L |
| E. Gish Rd SD | PCB 049 | Total | 158 | pg/L |
| E. Gish Rd SD | PCB 052 | Total | 378 | pg/L |
| E. Gish Rd SD | PCB 056 | Total | 101 | pg/L |
| E. Gish Rd SD | PCB 060 | Total | 55 | pg/L |
| E. Gish Rd SD | PCB 066 | Total | 183 | pg/L |
| E. Gish Rd SD | PCB 070 | Total | 429 | pg/L |
| E. Gish Rd SD | PCB 087 | Total | 550 | pg/L |
| E. Gish Rd SD | PCB 095 | Total | 586 | pg/L |
| E. Gish Rd SD | PCB 099 | Total | 294 | pg/L |
| E. Gish Rd SD | PCB 101 | Total | 658 | pg/L |
| E. Gish Rd SD | PCB 105 | Total | 255 | pg/L |
| E. Gish Rd SD | PCB 110 | Total | 846 | pg/L |
| E. Gish Rd SD | PCB 118 | Total | 543 | pg/L |
| E. Gish Rd SD | PCB 128 | Total | 167 | pg/L |
| E. Gish Rd SD | PCB 132 | Total | 389 | pg/L |
| E. Gish Rd SD | PCB 138 | Total | 1140 | pg/L |
| E. Gish Rd SD | PCB 141 | Total | 243 | pg/L |
| E. Gish Rd SD | PCB 149 | Total | 910 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| E. Gish Rd SD | PCB 151 | Total | 407 | pg/L |
| E. Gish Rd SD | PCB 153 | Total | 936 | pg/L |
| E. Gish Rd SD | PCB 156 | Total | 122 | pg/L |
| E. Gish Rd SD | PCB 158 | Total | 114 | pg/L |
| E. Gish Rd SD | PCB 170 | Total | 360 | pg/L |
| E. Gish Rd SD | PCB 174 | Total | 463 | pg/L |
| E. Gish Rd SD | PCB 177 | Total | 239 | pg/L |
| E. Gish Rd SD | PCB 180 | Total | 1000 | pg/L |
| E. Gish Rd SD | PCB 183 | Total | 337 | pg/L |
| E. Gish Rd SD | PCB 187 | Total | 498 | pg/L |
| E. Gish Rd SD | PCB 194 | Total | 336 | pg/L |
| E. Gish Rd SD | PCB 195 | Total | 115 | pg/L |
| E. Gish Rd SD | PCB 201 | Total | 60.8 | pg/L |
| E. Gish Rd SD | PCB 203 | Total | 332 | pg/L |
| Gateway Ave SD | PCB 018 | Total | 27.5 | pg/L |
| Gateway Ave SD | PCB 028 | Total | 64.9 | pg/L |
| Gateway Ave SD | PCB 031 | Total | 48.4 | pg/L |
| Gateway Ave SD | PCB 033 | Total | 33.6 | pg/L |
| Gateway Ave SD | PCB 044 | Total | 86.9 | pg/L |
| Gateway Ave SD | PCB 049 | Total | 45.3 | pg/L |
| Gateway Ave SD | PCB 052 | Total | 126 | pg/L |
| Gateway Ave SD | PCB 056 | Total | 42.5 | pg/L |
| Gateway Ave SD | PCB 060 | Total | 22.8 | pg/L |
| Gateway Ave SD | PCB 066 | Total | 87.8 | pg/L |
| Gateway Ave SD | PCB 070 | Total | 175 | pg/L |
| Gateway Ave SD | PCB 087 | Total | 208 | pg/L |
| Gateway Ave SD | PCB 095 | Total | 214 | pg/L |
| Gateway Ave SD | PCB 099 | Total | 143 | pg/L |
| Gateway Ave SD | PCB 101 | Total | 276 | pg/L |
| Gateway Ave SD | PCB 105 | Total | 136 | pg/L |
| Gateway Ave SD | PCB 110 | Total | 386 | pg/L |
| Gateway Ave SD | PCB 118 | Total | 285 | pg/L |
| Gateway Ave SD | PCB 128 | Total | 91.5 | pg/L |
| Gateway Ave SD | PCB 132 | Total | 173 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Gateway Ave SD | PCB 138 | Total | 526 | pg/L |
| Gateway Ave SD | PCB 141 | Total | 95.9 | pg/L |
| Gateway Ave SD | PCB 149 | Total | 341 | pg/L |
| Gateway Ave SD | PCB 151 | Total | 127 | pg/L |
| Gateway Ave SD | PCB 153 | Total | 367 | pg/L |
| Gateway Ave SD | PCB 156 | Total | 61.1 | pg/L |
| Gateway Ave SD | PCB 158 | Total | 54.5 | pg/L |
| Gateway Ave SD | PCB 170 | Total | 113 | pg/L |
| Gateway Ave SD | PCB 174 | Total | 124 | pg/L |
| Gateway Ave SD | PCB 177 | Total | 66.9 | pg/L |
| Gateway Ave SD | PCB 180 | Total | 274 | pg/L |
| Gateway Ave SD | PCB 183 | Total | 86.8 | pg/L |
| Gateway Ave SD | PCB 187 | Total | 153 | pg/L |
| Gateway Ave SD | PCB 194 | Total | 80.7 | pg/L |
| Gateway Ave SD | PCB 195 | Total | 26.9 | pg/L |
| Gateway Ave SD | PCB 201 | Total | 12.5 | pg/L |
| Gateway Ave SD | PCB 203 | Total | 60.9 | pg/L |
| Line-3A-M at 3A-D | PCB 008 | Total | 145 | pg/L |
| Line-3A-M at 3A-D | PCB 018 | Total | 620 | pg/L |
| Line-3A-M at 3A-D | PCB 028 | Total | 842 | pg/L |
| Line-3A-M at 3A-D | PCB 031 | Total | 634 | pg/L |
| Line-3A-M at 3A-D | PCB 033 | Total | 386 | pg/L |
| Line-3A-M at 3A-D | PCB 044 | Total | 801 | pg/L |
| Line-3A-M at 3A-D | PCB 049 | Total | 421 | pg/L |
| Line-3A-M at 3A-D | PCB 052 | Total | 1070 | pg/L |
| Line-3A-M at 3A-D | PCB 056 | Total | 274 | pg/L |
| Line-3A-M at 3A-D | PCB 060 | Total | 156 | pg/L |
| Line-3A-M at 3A-D | PCB 066 | Total | 490 | pg/L |
| Line-3A-M at 3A-D | PCB 070 | Total | 1210 | pg/L |
| Line-3A-M at 3A-D | PCB 087 | Total | 1200 | pg/L |
| Line-3A-M at 3A-D | PCB 095 | Total | 1300 | pg/L |
| Line-3A-M at 3A-D | PCB 099 | Total | 755 | pg/L |
| Line-3A-M at 3A-D | PCB 101 | Total | 1560 | pg/L |
| Line-3A-M at 3A-D | PCB 105 | Total | 659 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Line-3A-M at 3A-D | PCB 110 | Total | 1950 | pg/L |
| Line-3A-M at 3A-D | PCB 118 | Total | 1460 | pg/L |
| Line-3A-M at 3A-D | PCB 128 | Total | 342 | pg/L |
| Line-3A-M at 3A-D | PCB 132 | Total | 670 | pg/L |
| Line-3A-M at 3A-D | PCB 138 | Total | 1920 | pg/L |
| Line-3A-M at 3A-D | PCB 141 | Total | 327 | pg/L |
| Line-3A-M at 3A-D | PCB 149 | Total | 1160 | pg/L |
| Line-3A-M at 3A-D | PCB 151 | Total | 397 | pg/L |
| Line-3A-M at 3A-D | PCB 153 | Total | 1240 | pg/L |
| Line-3A-M at 3A-D | PCB 156 | Total | 254 | pg/L |
| Line-3A-M at 3A-D | PCB 158 | Total | 210 | pg/L |
| Line-3A-M at 3A-D | PCB 170 | Total | 322 | pg/L |
| Line-3A-M at 3A-D | PCB 174 | Total | 281 | pg/L |
| Line-3A-M at 3A-D | PCB 177 | Total | 159 | pg/L |
| Line-3A-M at 3A-D | PCB 180 | Total | 663 | pg/L |
| Line-3A-M at 3A-D | PCB 183 | Total | 197 | pg/L |
| Line-3A-M at 3A-D | PCB 187 | Total | 303 | pg/L |
| Line-3A-M at 3A-D | PCB 194 | Total | 181 | pg/L |
| Line-3A-M at 3A-D | PCB 195 | Total | 58.2 | pg/L |
| Line-3A-M at 3A-D | PCB 201 | Total | 25.5 | pg/L |
| Line-3A-M at 3A-D | PCB 203 | Total | 148 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 008 | Total | 150 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 018 | Total | 368 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 028 | Total | 559 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 031 | Total | 453 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 033 | Total | 299 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 044 | Total | 542 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 049 | Total | 297 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 052 | Total | 528 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 056 | Total | 143 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 060 | Total | 78.1 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 066 | Total | 267 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 070 | Total | 514 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 087 | Total | 297 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Line3A-M-1 at Industrial PS | PCB 095 | Total | 321 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 099 | Total | 191 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 101 | Total | 354 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 105 | Total | 159 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 110 | Total | 496 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 118 | Total | 318 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 128 | Total | 85.3 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 132 | Total | 164 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 138 | Total | 484 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 141 | Total | 86.2 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 149 | Total | 309 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 151 | Total | 117 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 153 | Total | 329 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 156 | Total | 60.1 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 158 | Total | 52.2 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 170 | Total | 105 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 174 | Total | 106 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 177 | Total | 58.1 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 180 | Total | 250 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 183 | Total | 73.5 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 187 | Total | 131 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 194 | Total | 79.1 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 195 | Total | 25.1 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 201 | Total | 11.1 | pg/L |
| Line3A-M-1 at Industrial PS | PCB 203 | Total | 63.4 | pg/L |
| Line4-B-1 | PCB 008 | Total | 14.7 | pg/L |
| Line4-B-1 | PCB 018 | Total | 37.2 | pg/L |
| Line4-B-1 | PCB 028 | Total | 71.5 | pg/L |
| Line4-B-1 | PCB 031 | Total | 53.2 | pg/L |
| Line4-B-1 | PCB 033 | Total | 32.7 | pg/L |
| Line4-B-1 | PCB 044 | Total | 126 | pg/L |
| Line4-B-1 | PCB 049 | Total | 63 | pg/L |
| Line4-B-1 | PCB 052 | Total | 189 | pg/L |
| Line4-B-1 | PCB 056 | Total | 60.7 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Line4-B-1 | PCB 060 | Total | 30 | pg/L |
| Line4-B-1 | PCB 066 | Total | 105 | pg/L |
| Line4-B-1 | PCB 070 | Total | 242 | pg/L |
| Line4-B-1 | PCB 087 | Total | 339 | pg/L |
| Line4-B-1 | PCB 095 | Total | 370 | pg/L |
| Line4-B-1 | PCB 099 | Total | 217 | pg/L |
| Line4-B-1 | PCB 101 | Total | 444 | pg/L |
| Line4-B-1 | PCB 105 | Total | 192 | pg/L |
| Line4-B-1 | PCB 110 | Total | 619 | pg/L |
| Line4-B-1 | PCB 118 | Total | 412 | pg/L |
| Line4-B-1 | PCB 128 | Total | 140 | pg/L |
| Line4-B-1 | PCB 132 | Total | 285 | pg/L |
| Line4-B-1 | PCB 138 | Total | 846 | pg/L |
| Line4-B-1 | PCB 141 | Total | 164 | pg/L |
| Line4-B-1 | PCB 149 | Total | 630 | pg/L |
| Line4-B-1 | PCB 151 | Total | 248 | pg/L |
| Line4-B-1 | PCB 153 | Total | 629 | pg/L |
| Line4-B-1 | PCB 156 | Total | 90.5 | pg/L |
| Line4-B-1 | PCB 158 | Total | 84.6 | pg/L |
| Line4-B-1 | PCB 170 | Total | 215 | pg/L |
| Line4-B-1 | PCB 174 | Total | 245 | pg/L |
| Line4-B-1 | PCB 177 | Total | 142 | pg/L |
| Line4-B-1 | PCB 180 | Total | 524 | pg/L |
| Line4-B-1 | PCB 183 | Total | 173 | pg/L |
| Line4-B-1 | PCB 187 | Total | 311 | pg/L |
| Line4-B-1 | PCB 194 | Total | 133 | pg/L |
| Line4-B-1 | PCB 195 | Total | 46.9 | pg/L |
| Line4-B-1 | PCB 201 | Total | 23.3 | pg/L |
| Line4-B-1 | PCB 203 | Total | 126 | pg/L |
| Line4-E | PCB 008 | Total | 41.1 | pg/L |
| Line4-E | PCB 018 | Total | 109 | pg/L |
| Line4-E | PCB 028 | Total | 294 | pg/L |
| Line4-E | PCB 031 | Total | 106 | pg/L |
| Line4-E | PCB 033 | Total | 53.7 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Line4-E | PCB 044 | Total | 490 | pg/L |
| Line4-E | PCB 049 | Total | 282 | pg/L |
| Line4-E | PCB 052 | Total | 445 | pg/L |
| Line4-E | PCB 056 | Total | 100 | pg/L |
| Line4-E | PCB 060 | Total | 44.8 | pg/L |
| Line4-E | PCB 066 | Total | 238 | pg/L |
| Line4-E | PCB 070 | Total | 433 | pg/L |
| Line4-E | PCB 087 | Total | 508 | pg/L |
| Line4-E | PCB 095 | Total | 870 | pg/L |
| Line4-E | PCB 099 | Total | 407 | pg/L |
| Line4-E | PCB 101 | Total | 1060 | pg/L |
| Line4-E | PCB 105 | Total | 277 | pg/L |
| Line4-E | PCB 110 | Total | 975 | pg/L |
| Line4-E | PCB 118 | Total | 666 | pg/L |
| Line4-E | PCB 128 | Total | 387 | pg/L |
| Line4-E | PCB 132 | Total | 1100 | pg/L |
| Line4-E | PCB 138 | Total | 3930 | pg/L |
| Line4-E | PCB 141 | Total | 967 | pg/L |
| Line4-E | PCB 149 | Total | 3080 | pg/L |
| Line4-E | PCB 151 | Total | 1300 | pg/L |
| Line4-E | PCB 153 | Total | 3870 | pg/L |
| Line4-E | PCB 156 | Total | 281 | pg/L |
| Line4-E | PCB 158 | Total | 339 | pg/L |
| Line4-E | PCB 170 | Total | 1920 | pg/L |
| Line4-E | PCB 174 | Total | 1860 | pg/L |
| Line4-E | PCB 177 | Total | 1130 | pg/L |
| Line4-E | PCB 180 | Total | 4610 | pg/L |
| Line4-E | PCB 183 | Total | 1280 | pg/L |
| Line4-E | PCB 187 | Total | 1780 | pg/L |
| Line4-E | PCB 194 | Total | 1030 | pg/L |
| Line4-E | PCB 195 | Total | 388 | pg/L |
| Line4-E | PCB 201 | Total | 120 | pg/L |
| Line4-E | PCB 203 | Total | 578 | pg/L |
| Line9-D | PCB 008 | Total | 34.9 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Line9-D | PCB 018 | Total | 52.45 | pg/L |
| Line9-D | PCB 028 | Total | 133.5 | pg/L |
| Line9-D | PCB 031 | Total | 102.85 | pg/L |
| Line9-D | PCB 033 | Total | 78.85 | pg/L |
| Line9-D | PCB 044 | Total | 147 | pg/L |
| Line9-D | PCB 049 | Total | 74.1 | pg/L |
| Line9-D | PCB 052 | Total | 194.5 | pg/L |
| Line9-D | PCB 056 | Total | 76.25 | pg/L |
| Line9-D | PCB 060 | Total | 41.75 | pg/L |
| Line9-D | PCB 066 | Total | 127 | pg/L |
| Line9-D | PCB 070 | Total | 297 | pg/L |
| Line9-D | PCB 087 | Total | 424.5 | pg/L |
| Line9-D | PCB 095 | Total | 301 | pg/L |
| Line9-D | PCB 099 | Total | 195.5 | pg/L |
| Line9-D | PCB 101 | Total | 399.5 | pg/L |
| Line9-D | PCB 105 | Total | 183.5 | pg/L |
| Line9-D | PCB 110 | Total | 519.5 | pg/L |
| Line9-D | PCB 118 | Total | 392.5 | pg/L |
| Line9-D | PCB 128 | Total | 121 | pg/L |
| Line9-D | PCB 132 | Total | 280 | pg/L |
| Line9-D | PCB 138 | Total | 933 | pg/L |
| Line9-D | PCB 141 | Total | 203 | pg/L |
| Line9-D | PCB 149 | Total | 636.5 | pg/L |
| Line9-D | PCB 151 | Total | 258.5 | pg/L |
| Line9-D | PCB 153 | Total | 763.5 | pg/L |
| Line9-D | PCB 156 | Total | 84.8 | pg/L |
| Line9-D | PCB 158 | Total | 89.8 | pg/L |
| Line9-D | PCB 170 | Total | 380.5 | pg/L |
| Line9-D | PCB 174 | Total | 460 | pg/L |
| Line9-D | PCB 177 | Total | 237.5 | pg/L |
| Line9-D | PCB 180 | Total | 932 | pg/L |
| Line9-D | PCB 183 | Total | 263 | pg/L |
| Line9-D | PCB 187 | Total | 467.5 | pg/L |
| Line9-D | PCB 194 | Total | 253.5 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Line9-D | PCB 195 | Total | 87.85 | pg/L |
| Line9-D | PCB 201 | Total | 34.55 | pg/L |
| Line9-D | PCB 203 | Total | 188.5 | pg/L |
| Lower Penitencia Ck | PCB 008 | Total | 4.36 | pg/L |
| Lower Penitencia Ck | PCB 018 | Total | 11.3 | pg/L |
| Lower Penitencia Ck | PCB 028 | Total | 18.3 | pg/L |
| Lower Penitencia Ck | PCB 031 | Total | 13.5 | pg/L |
| Lower Penitencia Ck | PCB 033 | Total | 8.58 | pg/L |
| Lower Penitencia Ck | PCB 044 | Total | 30.4 | pg/L |
| Lower Penitencia Ck | PCB 049 | Total | 15.2 | pg/L |
| Lower Penitencia Ck | PCB 052 | Total | 43.9 | pg/L |
| Lower Penitencia Ck | PCB 056 | Total | 12 | pg/L |
| Lower Penitencia Ck | PCB 060 | Total | 6.12 | pg/L |
| Lower Penitencia Ck | PCB 066 | Total | 22 | pg/L |
| Lower Penitencia Ck | PCB 070 | Total | 50.1 | pg/L |
| Lower Penitencia Ck | PCB 087 | Total | 79.9 | pg/L |
| Lower Penitencia Ck | PCB 095 | Total | 91.5 | pg/L |
| Lower Penitencia Ck | PCB 099 | Total | 49.8 | pg/L |
| Lower Penitencia Ck | PCB 101 | Total | 106 | pg/L |
| Lower Penitencia Ck | PCB 105 | Total | 46.6 | pg/L |
| Lower Penitencia Ck | PCB 110 | Total | 152 | pg/L |
| Lower Penitencia Ck | PCB 118 | Total | 96.4 | pg/L |
| Lower Penitencia Ck | PCB 128 | Total | 35.6 | pg/L |
| Lower Penitencia Ck | PCB 132 | Total | 67.4 | pg/L |
| Lower Penitencia Ck | PCB 138 | Total | 203 | pg/L |
| Lower Penitencia Ck | PCB 141 | Total | 37 | pg/L |
| Lower Penitencia Ck | PCB 149 | Total | 140 | pg/L |
| Lower Penitencia Ck | PCB 151 | Total | 52.1 | pg/L |
| Lower Penitencia Ck | PCB 153 | Total | 142 | pg/L |
| Lower Penitencia Ck | PCB 156 | Total | 23 | pg/L |
| Lower Penitencia Ck | PCB 158 | Total | 21.6 | pg/L |
| Lower Penitencia Ck | PCB 170 | Total | 53.5 | pg/L |
| Lower Penitencia Ck | PCB 174 | Total | 54.7 | pg/L |
| Lower Penitencia Ck | PCB 177 | Total | 30.2 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Lower Penitencia Ck | PCB 180 | Total | 128 | pg/L |
| Lower Penitencia Ck | PCB 183 | Total | 36 | pg/L |
| Lower Penitencia Ck | PCB 187 | Total | 63 | pg/L |
| Lower Penitencia Ck | PCB 194 | Total | 37.9 | pg/L |
| Lower Penitencia Ck | PCB 195 | Total | 14 | pg/L |
| Lower Penitencia Ck | PCB 201 | Total | 4.97 | pg/L |
| Lower Penitencia Ck | PCB 203 | Total | 31.3 | pg/L |
| Meeker Slough | PCB 008 | Total | 7.26 | pg/L |
| Meeker Slough | PCB 018 | Total | 26.6 | pg/L |
| Meeker Slough | PCB 028 | Total | 64.8 | pg/L |
| Meeker Slough | PCB 031 | Total | 47.3 | pg/L |
| Meeker Slough | PCB 033 | Total | 23.8 | pg/L |
| Meeker Slough | PCB 044 | Total | 105 | pg/L |
| Meeker Slough | PCB 049 | Total | 56 | pg/L |
| Meeker Slough | PCB 052 | Total | 178 | pg/L |
| Meeker Slough | PCB 056 | Total | 53.6 | pg/L |
| Meeker Slough | PCB 060 | Total | 27.5 | pg/L |
| Meeker Slough | PCB 066 | Total | 95.4 | pg/L |
| Meeker Slough | PCB 070 | Total | 245 | pg/L |
| Meeker Slough | PCB 087 | Total | 349 | pg/L |
| Meeker Slough | PCB 095 | Total | 360 | pg/L |
| Meeker Slough | PCB 099 | Total | 242 | pg/L |
| Meeker Slough | PCB 101 | Total | 463 | pg/L |
| Meeker Slough | PCB 105 | Total | 244 | pg/L |
| Meeker Slough | PCB 110 | Total | 661 | pg/L |
| Meeker Slough | PCB 118 | Total | 512 | pg/L |
| Meeker Slough | PCB 128 | Total | 166 | pg/L |
| Meeker Slough | PCB 132 | Total | 280 | pg/L |
| Meeker Slough | PCB 138 | Total | 928 | pg/L |
| Meeker Slough | PCB 141 | Total | 165 | pg/L |
| Meeker Slough | PCB 149 | Total | 540 | pg/L |
| Meeker Slough | PCB 151 | Total | 189 | pg/L |
| Meeker Slough | PCB 153 | Total | 663 | pg/L |
| Meeker Slough | PCB 156 | Total | 113 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Meeker Slough | PCB 158 | Total | 94 | pg/L |
| Meeker Slough | PCB 170 | Total | 203 | pg/L |
| Meeker Slough | PCB 174 | Total | 194 | pg/L |
| Meeker Slough | PCB 177 | Total | 108 | pg/L |
| Meeker Slough | PCB 180 | Total | 487 | pg/L |
| Meeker Slough | PCB 183 | Total | 135 | pg/L |
| Meeker Slough | PCB 187 | Total | 215 | pg/L |
| Meeker Slough | PCB 194 | Total | 146 | pg/L |
| Meeker Slough | PCB 195 | Total | 45.7 | pg/L |
| Meeker Slough | PCB 201 | Total | 19.8 | pg/L |
| Meeker Slough | PCB 203 | Total | 107 | pg/L |
| Oddstad PS | PCB 008 | Total | 15 | pg/L |
| Oddstad PS | PCB 018 | Total | 42.4 | pg/L |
| Oddstad PS | PCB 028 | Total | 89.6 | pg/L |
| Oddstad PS | PCB 031 | Total | 48.2 | pg/L |
| Oddstad PS | PCB 033 | Total | 23.4 | pg/L |
| Oddstad PS | PCB 044 | Total | 156 | pg/L |
| Oddstad PS | PCB 049 | Total | 87.6 | pg/L |
| Oddstad PS | PCB 052 | Total | 198 | pg/L |
| Oddstad PS | PCB 056 | Total | 66.5 | pg/L |
| Oddstad PS | PCB 060 | Total | 33.3 | pg/L |
| Oddstad PS | PCB 066 | Total | 117 | pg/L |
| Oddstad PS | PCB 070 | Total | 201 | pg/L |
| Oddstad PS | PCB 087 | Total | 288 | pg/L |
| Oddstad PS | PCB 095 | Total | 398 | pg/L |
| Oddstad PS | PCB 099 | Total | 213 | pg/L |
| Oddstad PS | PCB 101 | Total | 411 | pg/L |
| Oddstad PS | PCB 105 | Total | 139 | pg/L |
| Oddstad PS | PCB 110 | Total | 533 | pg/L |
| Oddstad PS | PCB 118 | Total | 289 | pg/L |
| Oddstad PS | PCB 128 | Total | 115 | pg/L |
| Oddstad PS | PCB 132 | Total | 241 | pg/L |
| Oddstad PS | PCB 138 | Total | 722 | pg/L |
| Oddstad PS | PCB 141 | Total | 149 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Oddstad PS | PCB 149 | Total | 677 | pg/L |
| Oddstad PS | PCB 151 | Total | 295 | pg/L |
| Oddstad PS | PCB 153 | Total | 624 | pg/L |
| Oddstad PS | PCB 156 | Total | 66.7 | pg/L |
| Oddstad PS | PCB 158 | Total | 66.6 | pg/L |
| Oddstad PS | PCB 170 | Total | 238 | pg/L |
| Oddstad PS | PCB 174 | Total | 334 | pg/L |
| Oddstad PS | PCB 177 | Total | 174 | pg/L |
| Oddstad PS | PCB 180 | Total | 754 | pg/L |
| Oddstad PS | PCB 183 | Total | 239 | pg/L |
| Oddstad PS | PCB 187 | Total | 470 | pg/L |
| Oddstad PS | PCB 194 | Total | 289 | pg/L |
| Oddstad PS | PCB 195 | Total | 88.3 | pg/L |
| Oddstad PS | PCB 201 | Total | 45.9 | pg/L |
| Oddstad PS | PCB 203 | Total | 266 | pg/L |
| Outfall to Lower Silver Ck | PCB 008 | Total | 68.6 | pg/L |
| Outfall to Lower Silver Ck | PCB 008 | Total | 2020 | pg/L |
| Outfall to Lower Silver Ck | PCB 008 | Total | 63.8 | pg/L |
| Outfall to Lower Silver Ck | PCB 018 | Total | 105 | pg/L |
| Outfall to Lower Silver Ck | PCB 018 | Total | 3980 | pg/L |
| Outfall to Lower Silver Ck | PCB 018 | Total | 195 | pg/L |
| Outfall to Lower Silver Ck | PCB 028 | Total | 308 | pg/L |
| Outfall to Lower Silver Ck | PCB 028 | Total | 21500 | pg/L |
| Outfall to Lower Silver Ck | PCB 028 | Total | 782 | pg/L |
| Outfall to Lower Silver Ck | PCB 031 | Total | 217 | pg/L |
| Outfall to Lower Silver Ck | PCB 031 | Total | 13500 | pg/L |
| Outfall to Lower Silver Ck | PCB 031 | Total | 572 | pg/L |
| Outfall to Lower Silver Ck | PCB 033 | Total | 168 | pg/L |
| Outfall to Lower Silver Ck | PCB 033 | Total | 9340 | pg/L |
| Outfall to Lower Silver Ck | PCB 033 | Total | 429 | pg/L |
| Outfall to Lower Silver Ck | PCB 044 | Total | 516 | pg/L |
| Outfall to Lower Silver Ck | PCB 044 | Total | 56700 | pg/L |
| Outfall to Lower Silver Ck | PCB 044 | Total | 1900 | pg/L |
| Outfall to Lower Silver Ck | PCB 049 | Total | 250 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Outfall to Lower Silver Ck | PCB 049 | Total | 28000 | pg/L |
| Outfall to Lower Silver Ck | PCB 049 | Total | 901 | pg/L |
| Outfall to Lower Silver Ck | PCB 052 | Total | 720 | pg/L |
| Outfall to Lower Silver Ck | PCB 052 | Total | 86300 | pg/L |
| Outfall to Lower Silver Ck | PCB 052 | Total | 2970 | pg/L |
| Outfall to Lower Silver Ck | PCB 056 | Total | 498 | pg/L |
| Outfall to Lower Silver Ck | PCB 056 | Total | 44200 | pg/L |
| Outfall to Lower Silver Ck | PCB 056 | Total | 1520 | pg/L |
| Outfall to Lower Silver Ck | PCB 060 | Total | 267 | pg/L |
| Outfall to Lower Silver Ck | PCB 060 | Total | 18300 | pg/L |
| Outfall to Lower Silver Ck | PCB 060 | Total | 741 | pg/L |
| Outfall to Lower Silver Ck | PCB 066 | Total | 840 | pg/L |
| Outfall to Lower Silver Ck | PCB 066 | Total | 77400 | pg/L |
| Outfall to Lower Silver Ck | PCB 066 | Total | 2660 | pg/L |
| Outfall to Lower Silver Ck | PCB 070 | Total | 1560 | pg/L |
| Outfall to Lower Silver Ck | PCB 070 | Total | 155000 | pg/L |
| Outfall to Lower Silver Ck | PCB 070 | Total | 5660 | pg/L |
| Outfall to Lower Silver Ck | PCB 087 | Total | 2130 | pg/L |
| Outfall to Lower Silver Ck | PCB 087 | Total | 240000 | pg/L |
| Outfall to Lower Silver Ck | PCB 087 | Total | 8260 | pg/L |
| Outfall to Lower Silver Ck | PCB 095 | Total | 1570 | pg/L |
| Outfall to Lower Silver Ck | PCB 095 | Total | 187000 | pg/L |
| Outfall to Lower Silver Ck | PCB 095 | Total | 6920 | pg/L |
| Outfall to Lower Silver Ck | PCB 099 | Total | 1170 | pg/L |
| Outfall to Lower Silver Ck | PCB 099 | Total | 144000 | pg/L |
| Outfall to Lower Silver Ck | PCB 099 | Total | 4990 | pg/L |
| Outfall to Lower Silver Ck | PCB 101 | Total | 2630 | pg/L |
| Outfall to Lower Silver Ck | PCB 101 | Total | 315000 | pg/L |
| Outfall to Lower Silver Ck | PCB 101 | Total | 10600 | pg/L |
| Outfall to Lower Silver Ck | PCB 105 | Total | 1760 | pg/L |
| Outfall to Lower Silver Ck | PCB 105 | Total | 147000 | pg/L |
| Outfall to Lower Silver Ck | PCB 105 | Total | 5970 | pg/L |
| Outfall to Lower Silver Ck | PCB 110 | Total | 3800 | pg/L |
| Outfall to Lower Silver Ck | PCB 110 | Total | 417000 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Outfall to Lower Silver Ck | PCB 110 | Total | 14300 | pg/L |
| Outfall to Lower Silver Ck | PCB 118 | Total | 3570 | pg/L |
| Outfall to Lower Silver Ck | PCB 118 | Total | 316000 | pg/L |
| Outfall to Lower Silver Ck | PCB 118 | Total | 12300 | pg/L |
| Outfall to Lower Silver Ck | PCB 128 | Total | 967 | pg/L |
| Outfall to Lower Silver Ck | PCB 128 | Total | 70700 | pg/L |
| Outfall to Lower Silver Ck | PCB 128 | Total | 2800 | pg/L |
| Outfall to Lower Silver Ck | PCB 132 | Total | 1600 | pg/L |
| Outfall to Lower Silver Ck | PCB 132 | Total | 142000 | pg/L |
| Outfall to Lower Silver Ck | PCB 132 | Total | 6000 | pg/L |
| Outfall to Lower Silver Ck | PCB 138 | Total | 5310 | pg/L |
| Outfall to Lower Silver Ck | PCB 138 | Total | 466000 | pg/L |
| Outfall to Lower Silver Ck | PCB 138 | Total | 17500 | pg/L |
| Outfall to Lower Silver Ck | PCB 141 | Total | 865 | pg/L |
| Outfall to Lower Silver Ck | PCB 141 | Total | 70800 | pg/L |
| Outfall to Lower Silver Ck | PCB 141 | Total | 3020 | pg/L |
| Outfall to Lower Silver Ck | PCB 149 | Total | 2690 | pg/L |
| Outfall to Lower Silver Ck | PCB 149 | Total | 230000 | pg/L |
| Outfall to Lower Silver Ck | PCB 149 | Total | 9890 | pg/L |
| Outfall to Lower Silver Ck | PCB 151 | Total | 874 | pg/L |
| Outfall to Lower Silver Ck | PCB 151 | Total | 85700 | pg/L |
| Outfall to Lower Silver Ck | PCB 151 | Total | 3490 | pg/L |
| Outfall to Lower Silver Ck | PCB 153 | Total | 3230 | pg/L |
| Outfall to Lower Silver Ck | PCB 153 | Total | 250000 | pg/L |
| Outfall to Lower Silver Ck | PCB 153 | Total | 11300 | pg/L |
| Outfall to Lower Silver Ck | PCB 156 | Total | 659 | pg/L |
| Outfall to Lower Silver Ck | PCB 156 | Total | 55700 | pg/L |
| Outfall to Lower Silver Ck | PCB 156 | Total | 2290 | pg/L |
| Outfall to Lower Silver Ck | PCB 158 | Total | 596 | pg/L |
| Outfall to Lower Silver Ck | PCB 158 | Total | 48000 | pg/L |
| Outfall to Lower Silver Ck | PCB 158 | Total | 1900 | pg/L |
| Outfall to Lower Silver Ck | PCB 170 | Total | 852 | pg/L |
| Outfall to Lower Silver Ck | PCB 170 | Total | 55500 | pg/L |
| Outfall to Lower Silver Ck | PCB 170 | Total | 2740 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Outfall to Lower Silver Ck | PCB 174 | Total | 735 | pg/L |
| Outfall to Lower Silver Ck | PCB 174 | Total | 50200 | pg/L |
| Outfall to Lower Silver Ck | PCB 174 | Total | 2500 | pg/L |
| Outfall to Lower Silver Ck | PCB 177 | Total | 426 | pg/L |
| Outfall to Lower Silver Ck | PCB 177 | Total | 28800 | pg/L |
| Outfall to Lower Silver Ck | PCB 177 | Total | 1400 | pg/L |
| Outfall to Lower Silver Ck | PCB 180 | Total | 1710 | pg/L |
| Outfall to Lower Silver Ck | PCB 180 | Total | 102000 | pg/L |
| Outfall to Lower Silver Ck | PCB 180 | Total | 5350 | pg/L |
| Outfall to Lower Silver Ck | PCB 183 | Total | 490 | pg/L |
| Outfall to Lower Silver Ck | PCB 183 | Total | 33300 | pg/L |
| Outfall to Lower Silver Ck | PCB 183 | Total | 1650 | pg/L |
| Outfall to Lower Silver Ck | PCB 187 | Total | 782 | pg/L |
| Outfall to Lower Silver Ck | PCB 187 | Total | 45400 | pg/L |
| Outfall to Lower Silver Ck | PCB 187 | Total | 2140 | pg/L |
| Outfall to Lower Silver Ck | PCB 194 | Total | 362 | pg/L |
| Outfall to Lower Silver Ck | PCB 194 | Total | 17900 | pg/L |
| Outfall to Lower Silver Ck | PCB 194 | Total | 963 | pg/L |
| Outfall to Lower Silver Ck | PCB 195 | Total | 127 | pg/L |
| Outfall to Lower Silver Ck | PCB 195 | Total | 6140 | pg/L |
| Outfall to Lower Silver Ck | PCB 195 | Total | 336 | pg/L |
| Outfall to Lower Silver Ck | PCB 201 | Total | 34.5 | pg/L |
| Outfall to Lower Silver Ck | PCB 201 | Total | 2310 | pg/L |
| Outfall to Lower Silver Ck | PCB 201 | Total | 128 | pg/L |
| Outfall to Lower Silver Ck | PCB 203 | Total | 186 | pg/L |
| Outfall to Lower Silver Ck | PCB 203 | Total | 9710 | pg/L |
| Outfall to Lower Silver Ck | PCB 203 | Total | 556 | pg/L |
| Ridder Park Dr SD | PCB 008 | Total | 8.91 | pg/L |
| Ridder Park Dr SD | PCB 018 | Total | 33.9 | pg/L |
| Ridder Park Dr SD | PCB 028 | Total | 82.8 | pg/L |
| Ridder Park Dr SD | PCB 031 | Total | 62.2 | pg/L |
| Ridder Park Dr SD | PCB 033 | Total | 32.6 | pg/L |
| Ridder Park Dr SD | PCB 044 | Total | 205 | pg/L |
| Ridder Park Dr SD | PCB 049 | Total | 98.1 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Ridder Park Dr SD | PCB 052 | Total | 336 | pg/L |
| Ridder Park Dr SD | PCB 056 | Total | 114 | pg/L |
| Ridder Park Dr SD | PCB 060 | Total | 58.5 | pg/L |
| Ridder Park Dr SD | PCB 066 | Total | 201 | pg/L |
| Ridder Park Dr SD | PCB 070 | Total | 432 | pg/L |
| Ridder Park Dr SD | PCB 087 | Total | 684 | pg/L |
| Ridder Park Dr SD | PCB 095 | Total | 1610 | pg/L |
| Ridder Park Dr SD | PCB 099 | Total | 341 | pg/L |
| Ridder Park Dr SD | PCB 101 | Total | 1860 | pg/L |
| Ridder Park Dr SD | PCB 105 | Total | 355 | pg/L |
| Ridder Park Dr SD | PCB 110 | Total | 1530 | pg/L |
| Ridder Park Dr SD | PCB 118 | Total | 865 | pg/L |
| Ridder Park Dr SD | PCB 128 | Total | 552 | pg/L |
| Ridder Park Dr SD | PCB 132 | Total | 1850 | pg/L |
| Ridder Park Dr SD | PCB 138 | Total | 5760 | pg/L |
| Ridder Park Dr SD | PCB 141 | Total | 1670 | pg/L |
| Ridder Park Dr SD | PCB 149 | Total | 5460 | pg/L |
| Ridder Park Dr SD | PCB 151 | Total | 2550 | pg/L |
| Ridder Park Dr SD | PCB 153 | Total | 5890 | pg/L |
| Ridder Park Dr SD | PCB 156 | Total | 388 | pg/L |
| Ridder Park Dr SD | PCB 158 | Total | 502 | pg/L |
| Ridder Park Dr SD | PCB 170 | Total | 2540 | pg/L |
| Ridder Park Dr SD | PCB 174 | Total | 3160 | pg/L |
| Ridder Park Dr SD | PCB 177 | Total | 1730 | pg/L |
| Ridder Park Dr SD | PCB 180 | Total | 6170 | pg/L |
| Ridder Park Dr SD | PCB 183 | Total | 2050 | pg/L |
| Ridder Park Dr SD | PCB 187 | Total | 3450 | pg/L |
| Ridder Park Dr SD | PCB 194 | Total | 1260 | pg/L |
| Ridder Park Dr SD | PCB 195 | Total | 510 | pg/L |
| Ridder Park Dr SD | PCB 201 | Total | 190 | pg/L |
| Ridder Park Dr SD | PCB 203 | Total | 911 | pg/L |
| Rock Springs Dr SD | PCB 008 | Total | 16.9 | pg/L |
| Rock Springs Dr SD | PCB 018 | Total | 22.4 | pg/L |
| Rock Springs Dr SD | PCB 028 | Total | 47.6 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Rock Springs Dr SD | PCB 031 | Total | 38.7 | pg/L |
| Rock Springs Dr SD | PCB 033 | Total | 27.8 | pg/L |
| Rock Springs Dr SD | PCB 044 | Total | 76.3 | pg/L |
| Rock Springs Dr SD | PCB 049 | Total | 34.7 | pg/L |
| Rock Springs Dr SD | PCB 052 | Total | 113 | pg/L |
| Rock Springs Dr SD | PCB 056 | Total | 33.1 | pg/L |
| Rock Springs Dr SD | PCB 060 | Total | 17.2 | pg/L |
| Rock Springs Dr SD | PCB 066 | Total | 60.3 | pg/L |
| Rock Springs Dr SD | PCB 070 | Total | 158 | pg/L |
| Rock Springs Dr SD | PCB 087 | Total | 295 | pg/L |
| Rock Springs Dr SD | PCB 095 | Total | 203 | pg/L |
| Rock Springs Dr SD | PCB 099 | Total | 153 | pg/L |
| Rock Springs Dr SD | PCB 101 | Total | 290 | pg/L |
| Rock Springs Dr SD | PCB 105 | Total | 203 | pg/L |
| Rock Springs Dr SD | PCB 110 | Total | 442 | pg/L |
| Rock Springs Dr SD | PCB 118 | Total | 406 | pg/L |
| Rock Springs Dr SD | PCB 128 | Total | 127 | pg/L |
| Rock Springs Dr SD | PCB 132 | Total | 190 | pg/L |
| Rock Springs Dr SD | PCB 138 | Total | 592 | pg/L |
| Rock Springs Dr SD | PCB 141 | Total | 95.4 | pg/L |
| Rock Springs Dr SD | PCB 149 | Total | 277 | pg/L |
| Rock Springs Dr SD | PCB 151 | Total | 107 | pg/L |
| Rock Springs Dr SD | PCB 153 | Total | 331 | pg/L |
| Rock Springs Dr SD | PCB 156 | Total | 79.1 | pg/L |
| Rock Springs Dr SD | PCB 158 | Total | 69 | pg/L |
| Rock Springs Dr SD | PCB 170 | Total | 97.1 | pg/L |
| Rock Springs Dr SD | PCB 174 | Total | 85.6 | pg/L |
| Rock Springs Dr SD | PCB 177 | Total | 48.6 | pg/L |
| Rock Springs Dr SD | PCB 180 | Total | 205 | pg/L |
| Rock Springs Dr SD | PCB 183 | Total | 59 | pg/L |
| Rock Springs Dr SD | PCB 187 | Total | 102 | pg/L |
| Rock Springs Dr SD | PCB 194 | Total | 68.8 | pg/L |
| Rock Springs Dr SD | PCB 195 | Total | 22.7 | pg/L |
| Rock Springs Dr SD | PCB 201 | Total | 8.34 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Rock Springs Dr SD | PCB 203 | Total | 49 | pg/L |
| Runnymede Ditch | PCB 008 | Total | 74.8 | pg/L |
| Runnymede Ditch | PCB 018 | Total | 177 | pg/L |
| Runnymede Ditch | PCB 028 | Total | 378 | pg/L |
| Runnymede Ditch | PCB 031 | Total | 284 | pg/L |
| Runnymede Ditch | PCB 033 | Total | 177 | pg/L |
| Runnymede Ditch | PCB 044 | Total | 586 | pg/L |
| Runnymede Ditch | PCB 049 | Total | 336 | pg/L |
| Runnymede Ditch | PCB 052 | Total | 865 | pg/L |
| Runnymede Ditch | PCB 056 | Total | 223 | pg/L |
| Runnymede Ditch | PCB 060 | Total | 113 | pg/L |
| Runnymede Ditch | PCB 066 | Total | 499 | pg/L |
| Runnymede Ditch | PCB 070 | Total | 1020 | pg/L |
| Runnymede Ditch | PCB 087 | Total | 1170 | pg/L |
| Runnymede Ditch | PCB 095 | Total | 1400 | pg/L |
| Runnymede Ditch | PCB 099 | Total | 884 | pg/L |
| Runnymede Ditch | PCB 101 | Total | 1630 | pg/L |
| Runnymede Ditch | PCB 105 | Total | 660 | pg/L |
| Runnymede Ditch | PCB 110 | Total | 2140 | pg/L |
| Runnymede Ditch | PCB 118 | Total | 1480 | pg/L |
| Runnymede Ditch | PCB 128 | Total | 425 | pg/L |
| Runnymede Ditch | PCB 132 | Total | 876 | pg/L |
| Runnymede Ditch | PCB 138 | Total | 2460 | pg/L |
| Runnymede Ditch | PCB 141 | Total | 431 | pg/L |
| Runnymede Ditch | PCB 149 | Total | 1760 | pg/L |
| Runnymede Ditch | PCB 151 | Total | 679 | pg/L |
| Runnymede Ditch | PCB 153 | Total | 1780 | pg/L |
| Runnymede Ditch | PCB 156 | Total | 268 | pg/L |
| Runnymede Ditch | PCB 158 | Total | 250 | pg/L |
| Runnymede Ditch | PCB 170 | Total | 490 | pg/L |
| Runnymede Ditch | PCB 174 | Total | 602 | pg/L |
| Runnymede Ditch | PCB 177 | Total | 315 | pg/L |
| Runnymede Ditch | PCB 180 | Total | 1430 | pg/L |
| Runnymede Ditch | PCB 183 | Total | 460 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Runnymede Ditch | PCB 187 | Total | 889 | pg/L |
| Runnymede Ditch | PCB 194 | Total | 537 | pg/L |
| Runnymede Ditch | PCB 195 | Total | 160 | pg/L |
| Runnymede Ditch | PCB 201 | Total | 98.4 | pg/L |
| Runnymede Ditch | PCB 203 | Total | 542 | pg/L |
| SD near Cooley Landing | PCB 008 | Total | 14.2 | pg/L |
| SD near Cooley Landing | PCB 008 | Total | 4590 | pg/L |
| SD near Cooley Landing | PCB 018 | Total | 32.2 | pg/L |
| SD near Cooley Landing | PCB 018 | Total | 5000 | pg/L |
| SD near Cooley Landing | PCB 028 | Total | 72.4 | pg/L |
| SD near Cooley Landing | PCB 028 | Total | 11400 | pg/L |
| SD near Cooley Landing | PCB 031 | Total | 51.6 | pg/L |
| SD near Cooley Landing | PCB 031 | Total | 8850 | pg/L |
| SD near Cooley Landing | PCB 033 | Total | 31.8 | pg/L |
| SD near Cooley Landing | PCB 033 | Total | 6190 | pg/L |
| SD near Cooley Landing | PCB 044 | Total | 78.7 | pg/L |
| SD near Cooley Landing | PCB 044 | Total | 15200 | pg/L |
| SD near Cooley Landing | PCB 049 | Total | 41.7 | pg/L |
| SD near Cooley Landing | PCB 049 | Total | 6970 | pg/L |
| SD near Cooley Landing | PCB 052 | Total | 105 | pg/L |
| SD near Cooley Landing | PCB 052 | Total | 22100 | pg/L |
| SD near Cooley Landing | PCB 056 | Total | 40.4 | pg/L |
| SD near Cooley Landing | PCB 056 | Total | 6840 | pg/L |
| SD near Cooley Landing | PCB 060 | Total | 20.7 | pg/L |
| SD near Cooley Landing | PCB 060 | Total | 3620 | pg/L |
| SD near Cooley Landing | PCB 066 | Total | 85.4 | pg/L |
| SD near Cooley Landing | PCB 066 | Total | 14800 | pg/L |
| SD near Cooley Landing | PCB 070 | Total | 156 | pg/L |
| SD near Cooley Landing | PCB 070 | Total | 29100 | pg/L |
| SD near Cooley Landing | PCB 087 | Total | 192 | pg/L |
| SD near Cooley Landing | PCB 087 | Total | 40300 | pg/L |
| SD near Cooley Landing | PCB 095 | Total | 225 | pg/L |
| SD near Cooley Landing | PCB 095 | Total | 56000 | pg/L |
| SD near Cooley Landing | PCB 099 | Total | 130 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| SD near Cooley Landing | PCB 099 | Total | 27100 | pg/L |
| SD near Cooley Landing | PCB 101 | Total | 258 | pg/L |
| SD near Cooley Landing | PCB 101 | Total | 54900 | pg/L |
| SD near Cooley Landing | PCB 105 | Total | 132 | pg/L |
| SD near Cooley Landing | PCB 105 | Total | 26300 | pg/L |
| SD near Cooley Landing | PCB 110 | Total | 419 | pg/L |
| SD near Cooley Landing | PCB 110 | Total | 89600 | pg/L |
| SD near Cooley Landing | PCB 118 | Total | 281 | pg/L |
| SD near Cooley Landing | PCB 118 | Total | 57500 | pg/L |
| SD near Cooley Landing | PCB 128 | Total | 112 | pg/L |
| SD near Cooley Landing | PCB 128 | Total | 29300 | pg/L |
| SD near Cooley Landing | PCB 132 | Total | 215 | pg/L |
| SD near Cooley Landing | PCB 132 | Total | 56800 | pg/L |
| SD near Cooley Landing | PCB 138 | Total | 703 | pg/L |
| SD near Cooley Landing | PCB 138 | Total | 190000 | pg/L |
| SD near Cooley Landing | PCB 141 | Total | 126 | pg/L |
| SD near Cooley Landing | PCB 141 | Total | 38000 | pg/L |
| SD near Cooley Landing | PCB 149 | Total | 479 | pg/L |
| SD near Cooley Landing | PCB 149 | Total | 131000 | pg/L |
| SD near Cooley Landing | PCB 151 | Total | 178 | pg/L |
| SD near Cooley Landing | PCB 151 | Total | 54200 | pg/L |
| SD near Cooley Landing | PCB 153 | Total | 479 | pg/L |
| SD near Cooley Landing | PCB 153 | Total | 146000 | pg/L |
| SD near Cooley Landing | PCB 156 | Total | 66.5 | pg/L |
| SD near Cooley Landing | PCB 156 | Total | 16300 | pg/L |
| SD near Cooley Landing | PCB 158 | Total | 72.6 | pg/L |
| SD near Cooley Landing | PCB 158 | Total | 18800 | pg/L |
| SD near Cooley Landing | PCB 170 | Total | 184 | pg/L |
| SD near Cooley Landing | PCB 170 | Total | 63900 | pg/L |
| SD near Cooley Landing | PCB 174 | Total | 205 | pg/L |
| SD near Cooley Landing | PCB 174 | Total | 72300 | pg/L |
| SD near Cooley Landing | PCB 177 | Total | 110 | pg/L |
| SD near Cooley Landing | PCB 177 | Total | 41000 | pg/L |
| SD near Cooley Landing | PCB 180 | Total | 473 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| SD near Cooley Landing | PCB 180 | Total | 144000 | pg/L |
| SD near Cooley Landing | PCB 183 | Total | 148 | pg/L |
| SD near Cooley Landing | PCB 183 | Total | 46600 | pg/L |
| SD near Cooley Landing | PCB 187 | Total | 262 | pg/L |
| SD near Cooley Landing | PCB 187 | Total | 88800 | pg/L |
| SD near Cooley Landing | PCB 194 | Total | 138 | pg/L |
| SD near Cooley Landing | PCB 194 | Total | 41900 | pg/L |
| SD near Cooley Landing | PCB 195 | Total | 44.8 | pg/L |
| SD near Cooley Landing | PCB 195 | Total | 15100 | pg/L |
| SD near Cooley Landing | PCB 201 | Total | 18.5 | pg/L |
| SD near Cooley Landing | PCB 201 | Total | 6010 | pg/L |
| SD near Cooley Landing | PCB 203 | Total | 91.7 | pg/L |
| SD near Cooley Landing | PCB 203 | Total | 28800 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 008 | Total | 98.9 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 018 | Total | 206 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 028 | Total | 283 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 031 | Total | 231 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 033 | Total | 169 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 044 | Total | 895 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 049 | Total | 401 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 052 | Total | 392 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 056 | Total | 141 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 060 | Total | 81.6 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 066 | Total | 238 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 070 | Total | 460 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 087 | Total | 498 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 095 | Total | 734 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 099 | Total | 335 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 101 | Total | 845 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 105 | Total | 234 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 110 | Total | 733 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 118 | Total | 438 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 128 | Total | 195 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 132 | Total | 520 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Seabord Ave SD SC-050GAC580 | PCB 138 | Total | 1610 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 141 | Total | 349 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 149 | Total | 1570 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 151 | Total | 811 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 153 | Total | 1380 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 156 | Total | 127 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 158 | Total | 143 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 170 | Total | 658 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 174 | Total | 762 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 177 | Total | 430 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 180 | Total | 1620 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 183 | Total | 488 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 187 | Total | 831 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 194 | Total | 456 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 195 | Total | 180 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 201 | Total | 63.7 | pg/L |
| Seabord Ave SD SC-050GAC580 | PCB 203 | Total | 308 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 008 | Total | 26.9 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 018 | Total | 48.4 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 028 | Total | 96.6 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 031 | Total | 75.5 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 033 | Total | 47.7 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 044 | Total | 252 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 049 | Total | 150 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 052 | Total | 386 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 056 | Total | 73.6 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 060 | Total | 33.5 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 066 | Total | 161 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 070 | Total | 380 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 087 | Total | 555 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 095 | Total | 630 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 099 | Total | 365 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 101 | Total | 728 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 105 | Total | 295 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Seabord Ave SD SC-050GAC600 | PCB 110 | Total | 959 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 118 | Total | 649 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 128 | Total | 193 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 132 | Total | 404 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 138 | Total | 1190 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 141 | Total | 245 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 149 | Total | 872 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 151 | Total | 348 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 153 | Total | 936 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 156 | Total | 127 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 158 | Total | 123 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 170 | Total | 315 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 174 | Total | 417 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 177 | Total | 216 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 180 | Total | 833 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 183 | Total | 291 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 187 | Total | 529 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 194 | Total | 211 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 195 | Total | 77.3 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 201 | Total | 40.4 | pg/L |
| Seabord Ave SD SC-050GAC600 | PCB 203 | Total | 192 | pg/L |
| South Linden PS | PCB 018 | Total | 21.7 | pg/L |
| South Linden PS | PCB 028 | Total | 48.5 | pg/L |
| South Linden PS | PCB 031 | Total | 38.8 | pg/L |
| South Linden PS | PCB 033 | Total | 17.5 | pg/L |
| South Linden PS | PCB 044 | Total | 73.2 | pg/L |
| South Linden PS | PCB 049 | Total | 35.3 | pg/L |
| South Linden PS | PCB 052 | Total | 107 | pg/L |
| South Linden PS | PCB 056 | Total | 39.4 | pg/L |
| South Linden PS | PCB 060 | Total | 22 | pg/L |
| South Linden PS | PCB 066 | Total | 76.1 | pg/L |
| South Linden PS | PCB 070 | Total | 165 | pg/L |
| South Linden PS | PCB 087 | Total | 207 | pg/L |
| South Linden PS | PCB 095 | Total | 200 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| South Linden PS | PCB 099 | Total | 122 | pg/L |
| South Linden PS | PCB 101 | Total | 257 | pg/L |
| South Linden PS | PCB 105 | Total | 131 | pg/L |
| South Linden PS | PCB 110 | Total | 360 | pg/L |
| South Linden PS | PCB 118 | Total | 276 | pg/L |
| South Linden PS | PCB 128 | Total | 110 | pg/L |
| South Linden PS | PCB 132 | Total | 156 | pg/L |
| South Linden PS | PCB 138 | Total | 539 | pg/L |
| South Linden PS | PCB 141 | Total | 105 | pg/L |
| South Linden PS | PCB 149 | Total | 362 | pg/L |
| South Linden PS | PCB 151 | Total | 145 | pg/L |
| South Linden PS | PCB 153 | Total | 431 | pg/L |
| South Linden PS | PCB 156 | Total | 52.8 | pg/L |
| South Linden PS | PCB 158 | Total | 58.5 | pg/L |
| South Linden PS | PCB 170 | Total | 142 | pg/L |
| South Linden PS | PCB 174 | Total | 214 | pg/L |
| South Linden PS | PCB 177 | Total | 105 | pg/L |
| South Linden PS | PCB 180 | Total | 721 | pg/L |
| South Linden PS | PCB 183 | Total | 202 | pg/L |
| South Linden PS | PCB 187 | Total | 583 | pg/L |
| South Linden PS | PCB 194 | Total | 682 | pg/L |
| South Linden PS | PCB 195 | Total | 90.5 | pg/L |
| South Linden PS | PCB 201 | Total | 93.4 | pg/L |
| South Linden PS | PCB 203 | Total | 824 | pg/L |
| Veterans PS | PCB 008 | Total | 3.98 | pg/L |
| Veterans PS | PCB 018 | Total | 17.1 | pg/L |
| Veterans PS | PCB 028 | Total | 27 | pg/L |
| Veterans PS | PCB 031 | Total | 20.4 | pg/L |
| Veterans PS | PCB 033 | Total | 8.94 | pg/L |
| Veterans PS | PCB 044 | Total | 36.2 | pg/L |
| Veterans PS | PCB 049 | Total | 23 | pg/L |
| Veterans PS | PCB 052 | Total | 61.5 | pg/L |
| Veterans PS | PCB 056 | Total | 17.3 | pg/L |
| Veterans PS | PCB 060 | Total | 9.45 | pg/L |

| Sampling Location | Analyte Name | Fraction Name | Result | Unit |
|---|---|---|---|---|
| Veterans PS | PCB 066 | Total | 33.5 | pg/L |
| Veterans PS | PCB 070 | Total | 77 | pg/L |
| Veterans PS | PCB 087 | Total | 112 | pg/L |
| Veterans PS | PCB 095 | Total | 118 | pg/L |
| Veterans PS | PCB 099 | Total | 91.3 | pg/L |
| Veterans PS | PCB 101 | Total | 160 | pg/L |
| Veterans PS | PCB 105 | Total | 78.4 | pg/L |
| Veterans PS | PCB 110 | Total | 227 | pg/L |
| Veterans PS | PCB 118 | Total | 164 | pg/L |
| Veterans PS | PCB 128 | Total | 60.2 | pg/L |
| Veterans PS | PCB 132 | Total | 94.2 | pg/L |
| Veterans PS | PCB 138 | Total | 379 | pg/L |
| Veterans PS | PCB 141 | Total | 66.1 | pg/L |
| Veterans PS | PCB 149 | Total | 210 | pg/L |
| Veterans PS | PCB 151 | Total | 83.8 | pg/L |
| Veterans PS | PCB 153 | Total | 316 | pg/L |
| Veterans PS | PCB 156 | Total | 42.8 | pg/L |
| Veterans PS | PCB 158 | Total | 31.5 | pg/L |
| Veterans PS | PCB 170 | Total | 97.9 | pg/L |
| Veterans PS | PCB 174 | Total | 97.3 | pg/L |
| Veterans PS | PCB 177 | Total | 54.6 | pg/L |
| Veterans PS | PCB 180 | Total | 287 | pg/L |
| Veterans PS | PCB 183 | Total | 73.5 | pg/L |
| Veterans PS | PCB 187 | Total | 140 | pg/L |
| Veterans PS | PCB 194 | Total | 86.6 | pg/L |
| Veterans PS | PCB 195 | Total | 25 | pg/L |
| Veterans PS | PCB 201 | Total | 13.4 | pg/L |
| Veterans PS | PCB 203 | Total | 74.7 | pg/L |

## Table B2. Grain size results data appendix.

| Sampling Location | <0.0039 mm | 0.0039 to <0.0625 mm | <0.0625 mm | 0.0625 to <2.0 mm | 2.0 to <64 mm | V. Fine 0.0625 to <0.125 mm | Fine 0.125 to <0.25 mm | Medium 0.25 to <0.5 mm | Coarse 0.5 to <1.0 mm | V. Coarse 1.0 to <2.0 mm |
|---|---|---|---|---|---|---|---|---|---|---|
| Charcot Ave SD | 11.2 | 29.2 | 40.4 | 7.03 | 0.000 | 4.12 | 1.34 | 1.22 | 0.341 | 0.000 |
| Ridder Park Dr SD | 39.3 | 26.4 | 65.7 | 1.36 | 0.000 | 0.194 | 0.682 | 0.428 | 0.0537 | 0.000 |
| E. Gish Rd SD | 23.5 | 34.7 | 58.1 | 0.345 | 0.000 | 0.345 | 0.000 | 0.000 | 0.000 | 0.000 |
| Seabord Ave SD SC-050GAC580 | 10.3 | 16.0 | 26.3 | 0.0633 | 0.000 | 0.0633 | 0.000 | 0.000 | 0.000 | 0.000 |
| Seabord Ave SD SC-050GAC600 | 1.89 | 3.35 | 5.24 | 0.107 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Line-3A-M at 3A-D | 16.7 | 7.82 | 24.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Line4-B-1 | 37.5 | 68.5 | 106.0 | 16.3 | 0.000 | 10.5 | 5.18 | 0.646 | 0.000 | 0.000 |
| Line4-E | 36.0 | 54.2 | 90.2 | 0.117 | 0.000 | 0.117 | 0.000 | 0.000 | 0.000 | 0.000 |
| Line3A-M-1 at Industrial PS | 13.0 | 22.0 | 35.0 | 7.88 | 0.000 | 3.25 | 3.37 | 1.26 | 0.000 | 0.000 |
| SD near Cooley Landing | 17.3 | 23.9 | 41.3 | 0.0260 | 0.000 | 0.0260 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rock Springs Dr SD | 1.17 | 2.19 | 3.36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gateway Ave SD | 0.380 | 0.681 | 1.06 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Lower Penitencia Ck | 37.5 | 58.8 | 96.3 | 2.02 | 0.000 | 1.11 | 0.904 | 0.00727 | 0.000 | 0.000 |
| Outfall to Lower Silver Ck | 7.34 | 7.52 | 14.9 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Meeker Slough | 4.85 | 9.77 | 14.6 | 0.437 | 0.000 | 0.437 | 0.000 | 0.000 | 0.000 | 0.000 |
| Oddstad PS | 9.89 | 17.0 | 26.9 | 84.1 | 0.000 | 10.0 | 17.0 | 21.0 | 26.3 | 9.78 |
| Runnymede Ditch | 57.7 | 111 | 169 | 4.89 | 0.000 | 4.87 | 0.0243 | 0.000 | 0.000 | 0.000 |
| Line9-D | 3.39 | 5.25 | 8.64 | 2.10 | 0.000 | 0.621 | 0.914 | 0.325 | 0.244 | 0.000 |
| South Linden PS | 2.64 | 3.97 | 6.61 | 0.00927 | 0.000 | 0.00927 | 0.000 | 0.000 | 0.000 | 0.000 |
| Veterans PS | 0.0348 | 0.0503 | 0.0851 | 6.98 | 0.000 | 0.229 | 2.52 | 4.23 | 0.000 | 0.000 |

# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# STRESSOR / SOURCE IDENTIFICATION PROJECT: DUBLIN CREEK BIOLOGICAL COMMUNITY AND SEDIMENT QUALITY

## WATER YEAR 2015 PROGRESS REPORT

## URBAN CREEKS MONITORING REPORT, APPENDIX A.4A


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, 2016

Protecting Alameda County Creeks, Wetlands & the Bay

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

# 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 | Municipal Regional Stormwater Permit |
| 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 2009, 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. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a and 2014a) and Standard Operating Procedures (SOPs, BASMAA 2012b and 2014b) 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 |
| N/A | Unified Stream Assessment: A User's Manual, v2.0 |

[1]The MRP was reissued on November 19, 2015 (MRP 2.0) and contains 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 MRP (SFBRWQCB 2009)

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 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

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

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.

The MRP 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.

ACCWP (2014) describes the first two years of an SSID study of sediment quality in the Dublin Creek watershed. This report documents further project activities through December 2015, and activities planned to complete the project in 2016.

[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 MRP 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:<br>• PAHs - slightly elevated,<br>• Pesticides (organochlorine) all somewhat elevated<br>• 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).

## 2.3 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

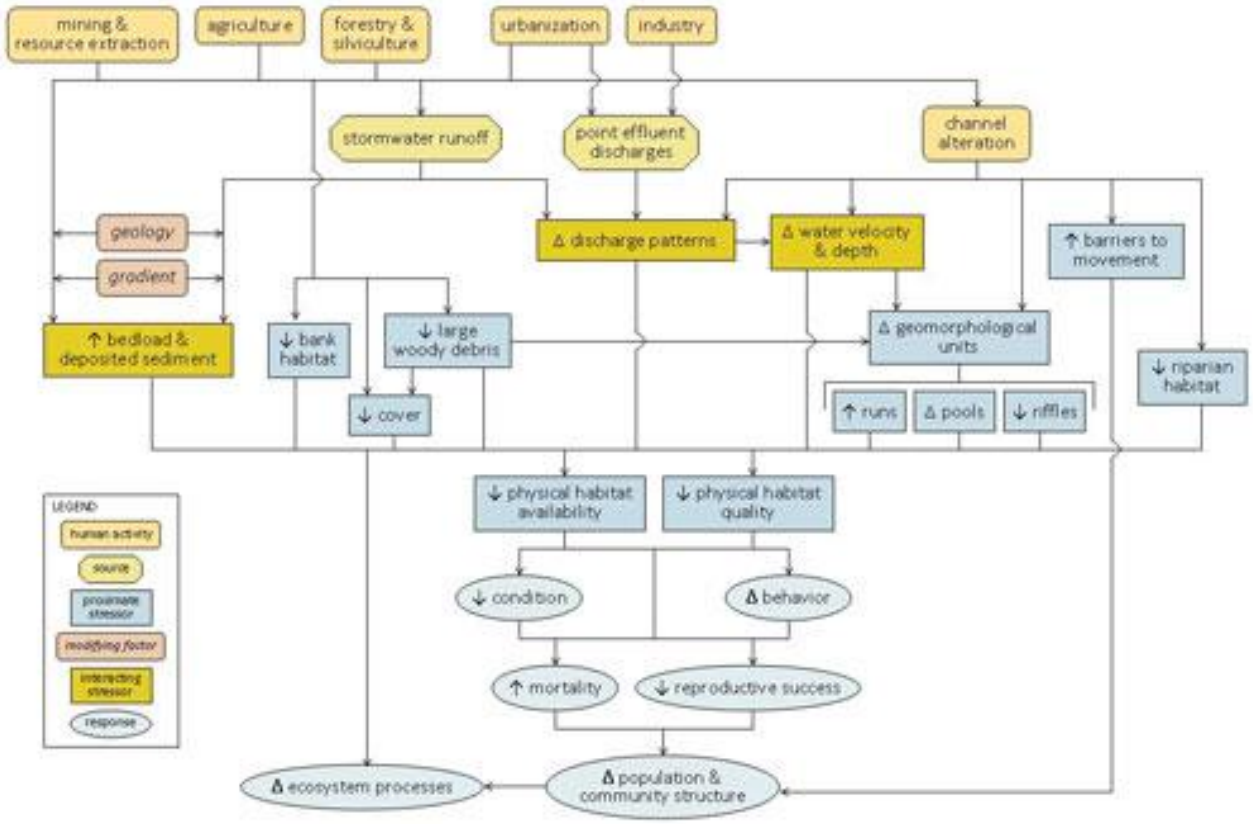


**Figure 2-1. Conceptual diagram illustrating causal pathways, from sources to impairments, related to physical habitat (USEPA 2010).**

# 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.

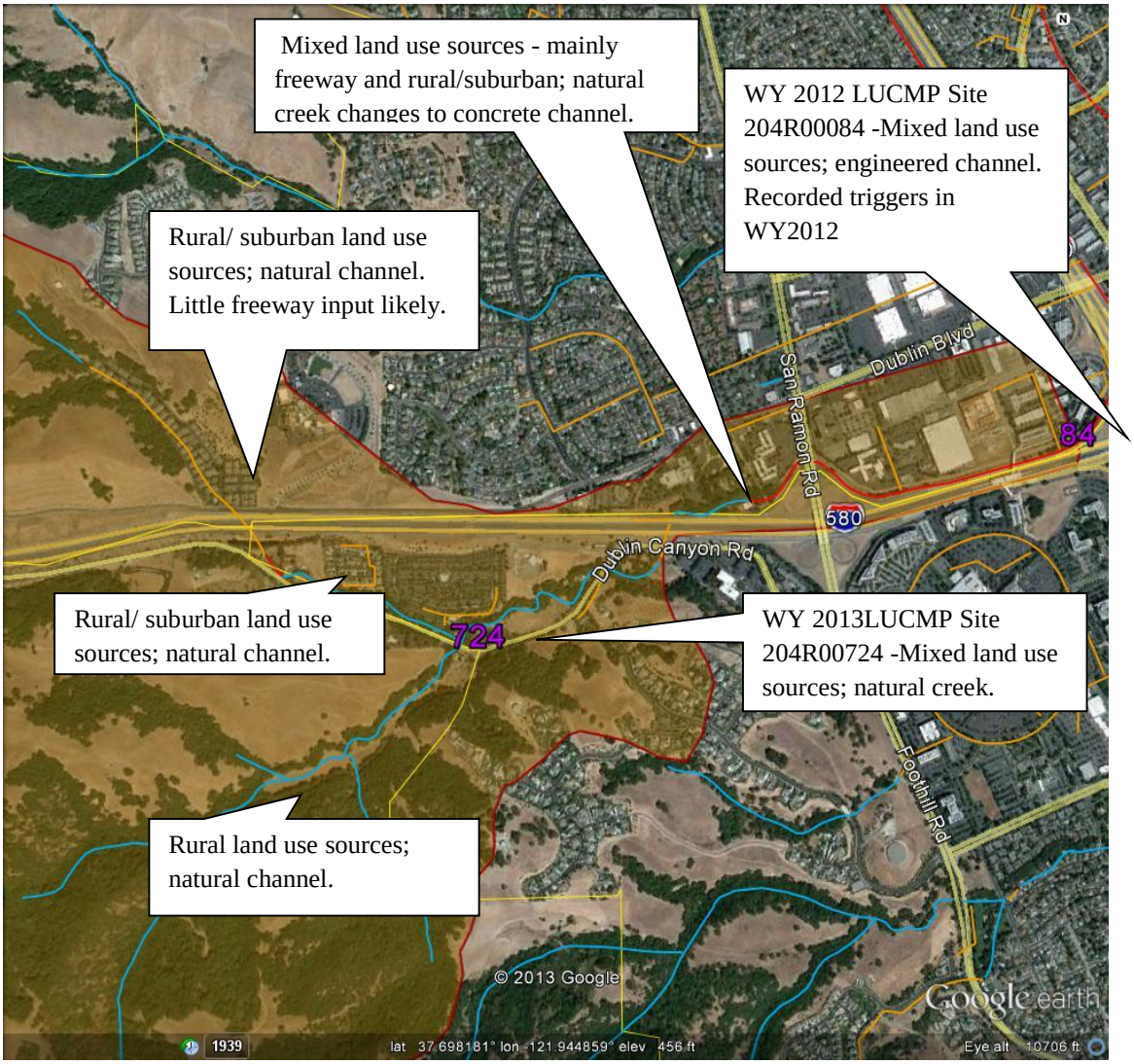


**Figure 3-1. Conceptual Model of Candidate Causal Stressors in the Dublin Creek Watershed**

The sampling locations and sampling strategies for SSID monitoring in the Dublin Creek Watershed in WY2013 are presented in Table 3-1 and Table 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. WY 2013 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 | | |

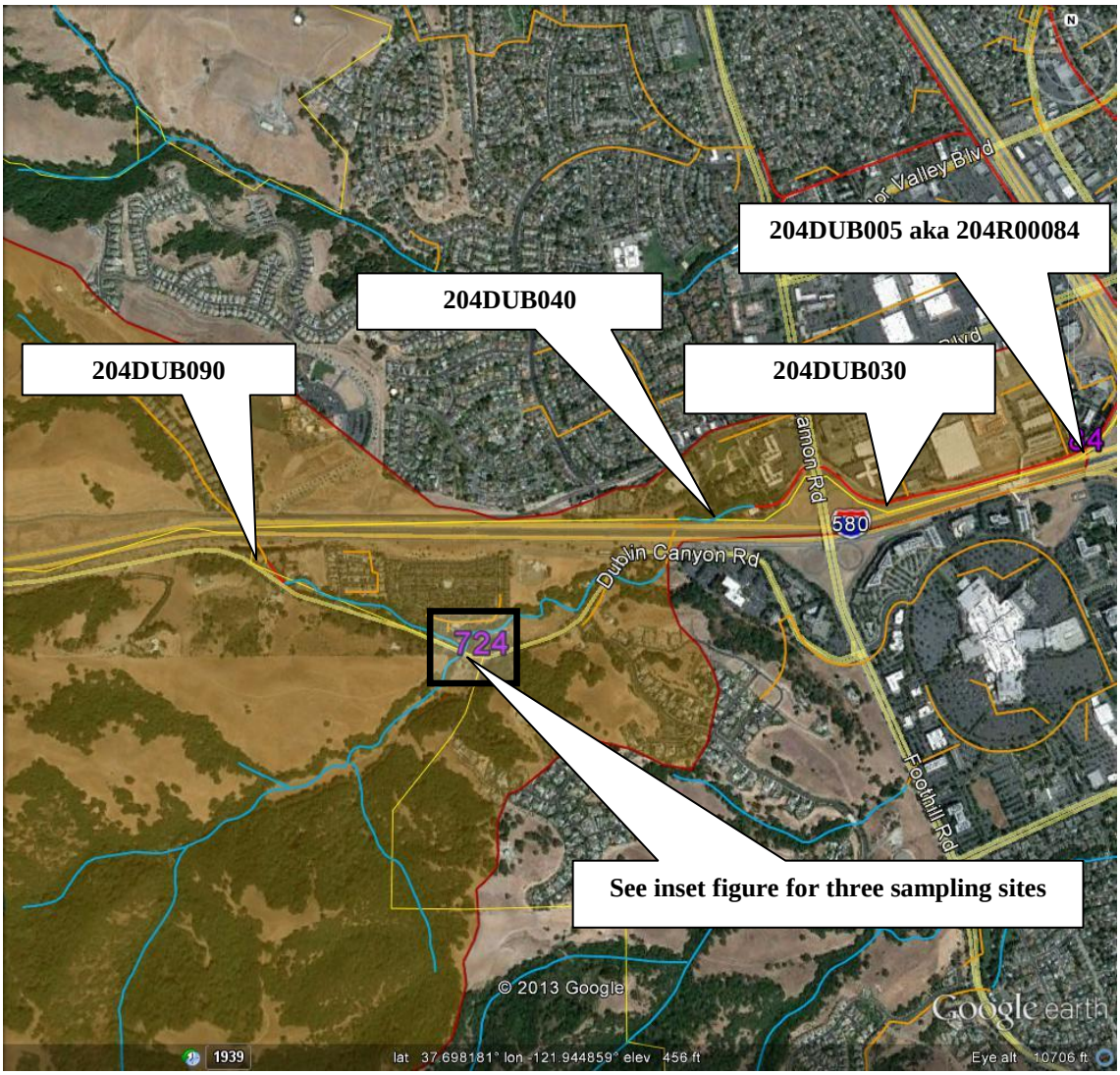


**Figure 3-2. WY 2013 Monitoring Locations in the Dublin Creek Watershed**

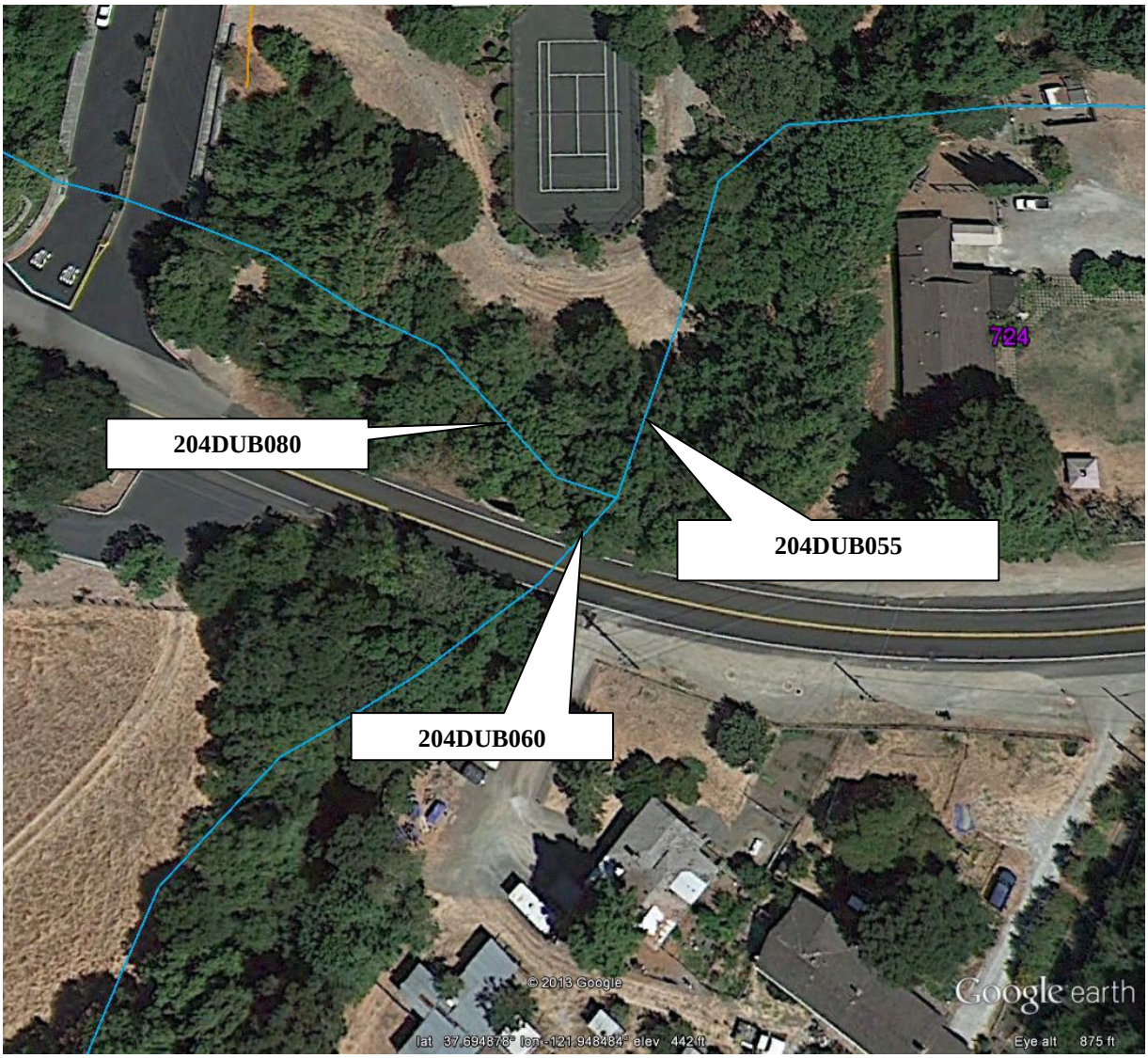


**Figure 3-3. Inset Monitoring Locations for 204DUB055, 204DUB060 and 204DUB080**

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.

## 4.1 Next Steps

Further technical studies may be useful at a regional level, or SSID projects conducted in other systems that specifically focus on stressors or sources to macroinvertebrate communities.

ACCWP will also work with City of Dublin staff to review longer-term inspection records from the watershed in an attempt to further identify potential specific sources of pollutants.

# 5 References

ACCWP, 2014. Stressor / Source Identification Project: Dublin Creek Site 204R00084 – Biological Community and Sediment Quality- Water Year 2013 Progress Report. Integrated Monitoring Report, Part A: Appendix A.4A. March 13, 2014.

Anderson BS, Phillips BM, Siegler K, Voorhees, J. 2012. Initial Trends in Chemical Contamination, Toxicity and Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program. Second Technical Report - Field Years 2009-2010. California State Water Resources Control Board, Sacramento, CA. 92 pp (with appendices).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.

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.

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.

Caltrans. 2003a. A Review of the Contaminants and Toxicity Associated with Particles in Stormwater Runoff. http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-03-059.pdf.Accessed on October 17, 2013

Caltrans.2003b. Discharge Characterization Study Report.http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-03-065.pdf.Accessed on Oct 17, 2013

Coleman, D., C. MacRae and E.D. Stein. 2005. Effect of increases in peak flows and imperviousness on the morphology of southern California streams. Technical Report 450. Southern California Coastal Water Research Project. Westminster, CA.

Hunt JW, Phillips B, Anderson B, Siegler K, Lamerdin C, Sigala M, Fairey R, Swenson S, Ichikawa G, Bonnema A, Crane D. 2012. Statewide perspective on chemicals of concern and connections between stream water quality and land use. Surface Water Ambient Monitoring Program – Stream Pollution Trends (SPoT) Program. California State Water Resources Control Board. Sacramento, CA.

MacDonald, D.D., G.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology 39(1):20-31.

SFBRWQCB. 2009. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074 NPDES Permit No. CAS612008, October 14, 2009.

SFBRWQCB. 2012. The Reference Site Study and the Urban Gradient Study Conducted in Selected San Francisco Bay Region Watersheds in2008-2010 (Years 8 to 10). Surface Water Ambient Monitoring Program, San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

SFBRWQCB. 2015. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015.

SFBRWQCB. 2015b. California Regional Water Quality Control Board, San Francisco Bay Region, San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). Incorporating all amendments approved by the Office of Administrative Law as of March 20, 2015. http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

Schuler, T. 2004. Urban Subwatershed Restoration Manual Series, No. 1: An integrated Framework to Restore Small Urban Watersheds. Version 1.0. Center for Watershed Protection. Ellicott City, Maryland. March 2004.

TDC Environmental, LLC. 2010. Pesticides in Urban Runoff, Wastewater, and Surface Water. Annual Urban Pesticide Use Report 2010. Available at: http://www.up3project.org/documents/UP3Use2010_Final.pdf

U.S. EPA (U.S. Environmental Protection Agency). 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Office of Research and Development, Washington, DC. Available online at https://www.epa.gov/caddis. Last updated September 23, 2010.

Weston, D.P., Holmes, R.W., You, J., and Lydy, M.J., 2005, Aquatic toxicity due to residential use of pyrethroid insecticides: Environmental Science and Technology 39(24): 9778-9784.

# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# STRESSOR SOURCE IDENTIFICATION PROJECT: CASTRO VALLEYCREEK SEDIMENT QUALITY

## WATER YEAR 2015 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, 2016

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 | Municipal Regional Stormwater Permit |
| NPDES | National PollutantDischarge 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, SFBRWQCB 2009, 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. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a and 2014a) and Standard Operating Procedures (SOPs, BASMAA 2012b and 2014b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see **Error! Reference source not found.**.

**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 |
| N/A | Unified Stream Assessment: A User's Manual, v2.0 |

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 reissued on November 19, 2015 (MRP 2.0) and contains 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 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.

The MRP 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 reissiued 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.

ACCWP (2014) describes the first two years of an SSID study of sediment quality in the Castro Valley Creek watershed. This report documents further project activities through December 2015, and activities planned to complete the project in 2016.

# 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 metersupstream ofSite 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.

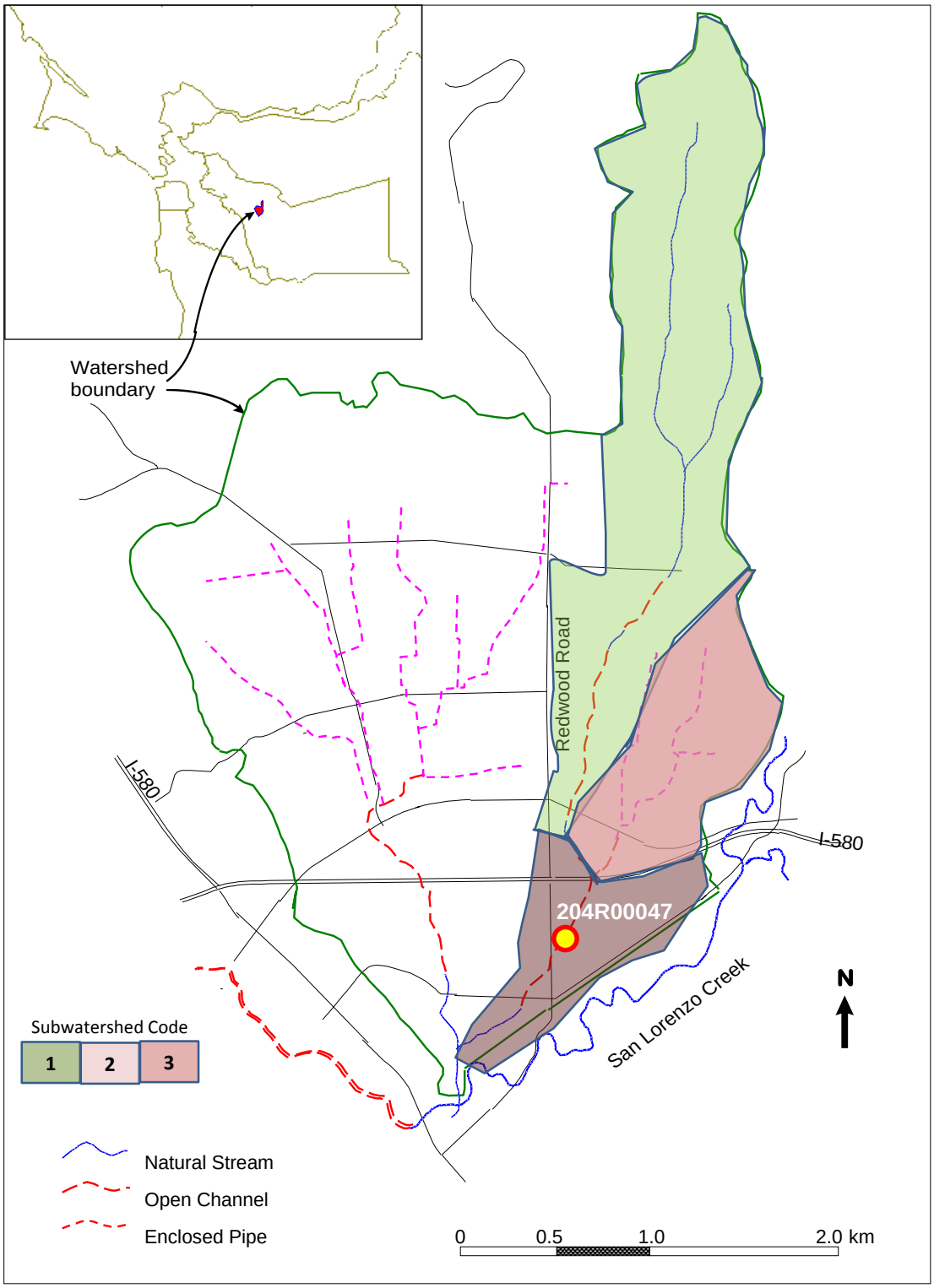


**Figure 2-1.Map of the Castro Valley Creek Watershed and Targeted Subwatersheds Tributary to Site 204R00047.**

## 2.2 Problem Statement

### 2.2.1 Water Quality Triggers

Comparison of W2012 sampling results at site 204R00047 with MRP 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:<br>• PAHs - somewhat elevated<br>• Pesticides (organochlorine) all significantly elevated<br>• 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).

### 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
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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

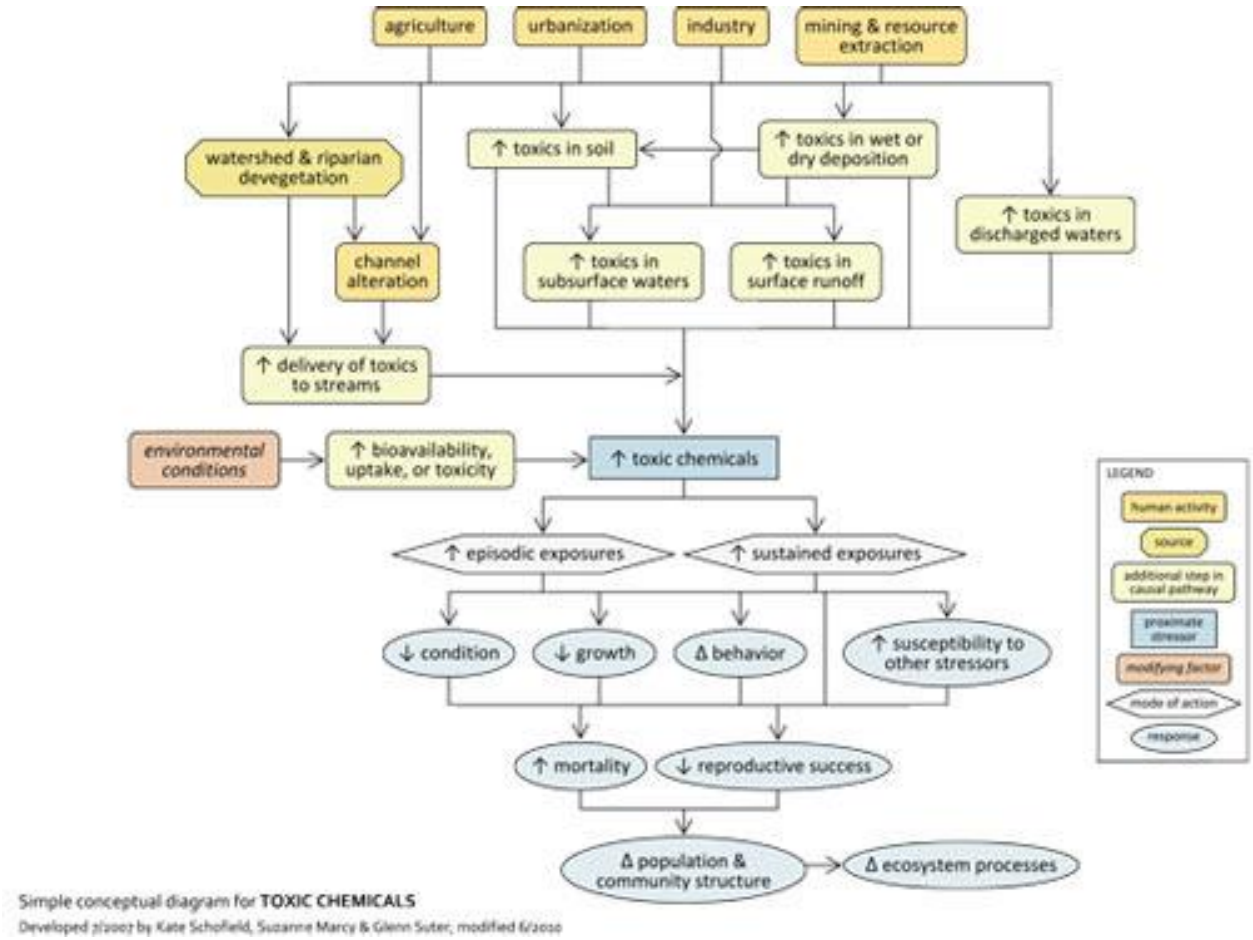


**Figure 2-2. Conceptual diagram illustrating causal pathways, from sources to impairments, related to unspecified toxic chemicals (USEPA 2010).**

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.

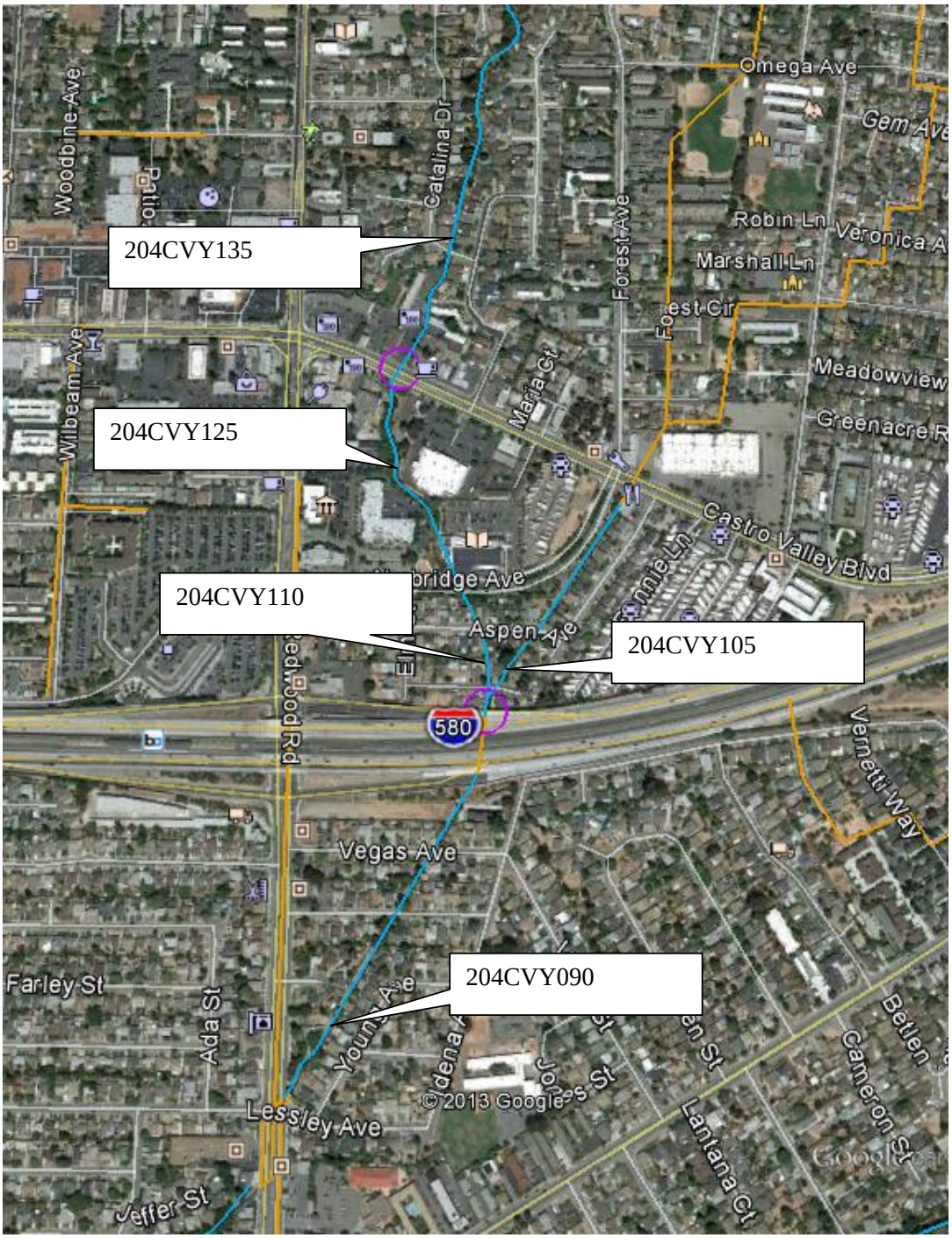


**Figure 3-1. WY 2013 Monitoring Locations) for Source Identification in the Castro Valley Creek Watershed**

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.

# 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). Thus the trigger criteria may 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 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

ACCWP will work with Alameda County staff to review longer-term inspection records from the watershed in an attempt to further identify potential specific sources of pollutants. Although toxicity has not been regularly associated with the sediment chemistry, the Program will assist the County in reviewing Best Management Practices currently being implemented and looking for opportunities to improve their effectiveness.

# 5 References

ACCWP. 2002. 2000-01 Alameda County Watershed Sediment Sampling Program: Two-Year Summary and Analysis. 37pp (with appendices).

ACCWP, 2014. Stressor Source Identification Project: Castro Valley Creek Site 204R00047 – Sediment Quality - Water Year 2013 Progress Report. Integrated Monitoring Report, Part A: Appendix A.4B. March 13, 2014.

Anderson BS, Phillips BM, Siegler K, Voorhees, J. 2012.Initial Trends in Chemical Contamination, Toxicityand Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program. Second Technical Report - Field Years 2009-2010. California State Water Resources Control Board, Sacramento, CA. 92pp (with appendices).

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.

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.

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.

Hunt JW, Phillips B, Anderson B, Siegler K, Lamerdin C, Sigala M, Fairey R, Swenson S, Ichikawa G, Bonnema A, Crane D. 2012. Statewide perspective on chemicals of concern and connections between stream water quality and land use. Surface Water Ambient Monitoring Program – Stream Pollution Trends (SPoT) Program. California State Water Resources Control Board. Sacramento, CA.

Ensminger, MP., R. Budd, K. Kelley and K. Goh. 2012. Pesticide Occurrence and Aquatic Benchmark Exceedances in Urban Surface Waters and Sediments in Three Urban Areas of California, USA, 2008-2011.

Kinnetic Laboratories Inc and EOA, Inc. 2002. Joint Stormwater Agency Project to Study Urban Sources of Mercury, PCBs and Organochlorine Pesticides. pp 75. Accessed

at:http://www.scvurppp-w2k.com/pdfs/0102/Joint_Stormwater_Agency_Project_to_Study_Urban_Sources_of_Mercury-PCBs_and_Organochlorine_Pesticides_(Year%202).pdf

San Francisco Regional Water Quality Control Board (SFRWQCB). 2009. Municipal Regional Stormwater NPDES Permit. Order R2-2009-0074, NPDES Permit No. CAS612008. 125 pp plus appendices.

SFBRWQCB. 2015. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015.

SFBRWQCB. 2015b. California Regional Water Quality Control Board, San Francisco Bay Region, San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). Incorporating all amendments approved by the Office of Administrative Law as of March 20, 2015. http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

Scanlin, J. and A.Y Feng. 1997. Characterization of the Presence and Sources of Diazinon in the Castro Valley Creek Watershed. Alameda Countywide Clean Water Program and Alameda County Flood Control and Water Conservation District.Accessed at:http://www.cleanwaterprogram.org/components/com_files/download.php?f=cvc diazinon characterization.pdf

Surface Water Ambient Monitoring Program(SWAMP) Quality Assurance Project Plan (QAPP). September 1, 2008. http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf. Viewed on December 17, 2012

TDC Environmental, LLC. 2010a. Pesticides in Urban Runoff, Wastewater, and Surface Water. Annual Urban Pesticide Use Report 2010. Available at: http://www.up3project.org/documents/UP3Use2010_Final.pdf

TDC Environmental, LLC. 2010b. Pesticides in Urban Runoff, Wastewater, and Surface Water. Annual Review of New Scientific Findings 2010. Available at: http://www.up3project.org/documents/UP3ScienceReport2010Final.pdf

U.S. EPA. 2000. Stressor Identification Guidance Document. Office of Water-Office of Research and Development. EPA-822-B-00-025. December 2000.

U.S. EPA (U.S. Environmental Protection Agency). 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Office of Research and Development, Washington, DC. Available online at https://www.epa.gov/caddis. Last updated September 23, 2010.

Weston, D.P., Holmes, R.W., You, J., and Lydy, M.J., 2005, Aquatic toxicity due to residential use of pyrethroid insecticides: Environmental Science and Technology 39(24): 9778-9784.

Zhang, X. 2010. Detections of Pyrethroid Insecticides in Surface Waters from Urban Areas of California, 1993-2010. Department of Pesticide Regulation. Accessed at: http://www.cdpr.ca.gov/docs/emon/surfwtr/swanalysismemo/memo_zhang_urban%20py%20report_dec310.pdf

# ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

# STRESSOR / SOURCE IDENTIFICATION PROJECT: CROW CREEK LOW DISSOLVED OXYGEN

## WATER YEAR 2015 PROGRESS 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

FINAL

MARCH 31, 2016

# Acknowledgements

Dr. Matthew Cover contributed substantially to this report in preparation of the continuous monitoring data review and development of the monitoring work plan.

# 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 | Municipal Regional Stormwater Permit |
| 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 Stormwater Permit (MRP, SFBRWQCB 2009, 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. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a and 2014a) and Standard Operating Procedures (SOPs, BASMAA 2012b and 2014b) 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 |
| N/A | Unified Stream Assessment: A User's Manual, v2.0 |

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 reissued on November 19, 2015 (MRP 2.0) and contains 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 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 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.

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

The MRP 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.

ACCWP (2014) describes the first two years of an SSID study of low dissolved oxygen in the Crow Creek watershed. This report documents further project activities through December 2015, and outlines a workplan for continuing work in 2016.

[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 20$^{th}$ 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.

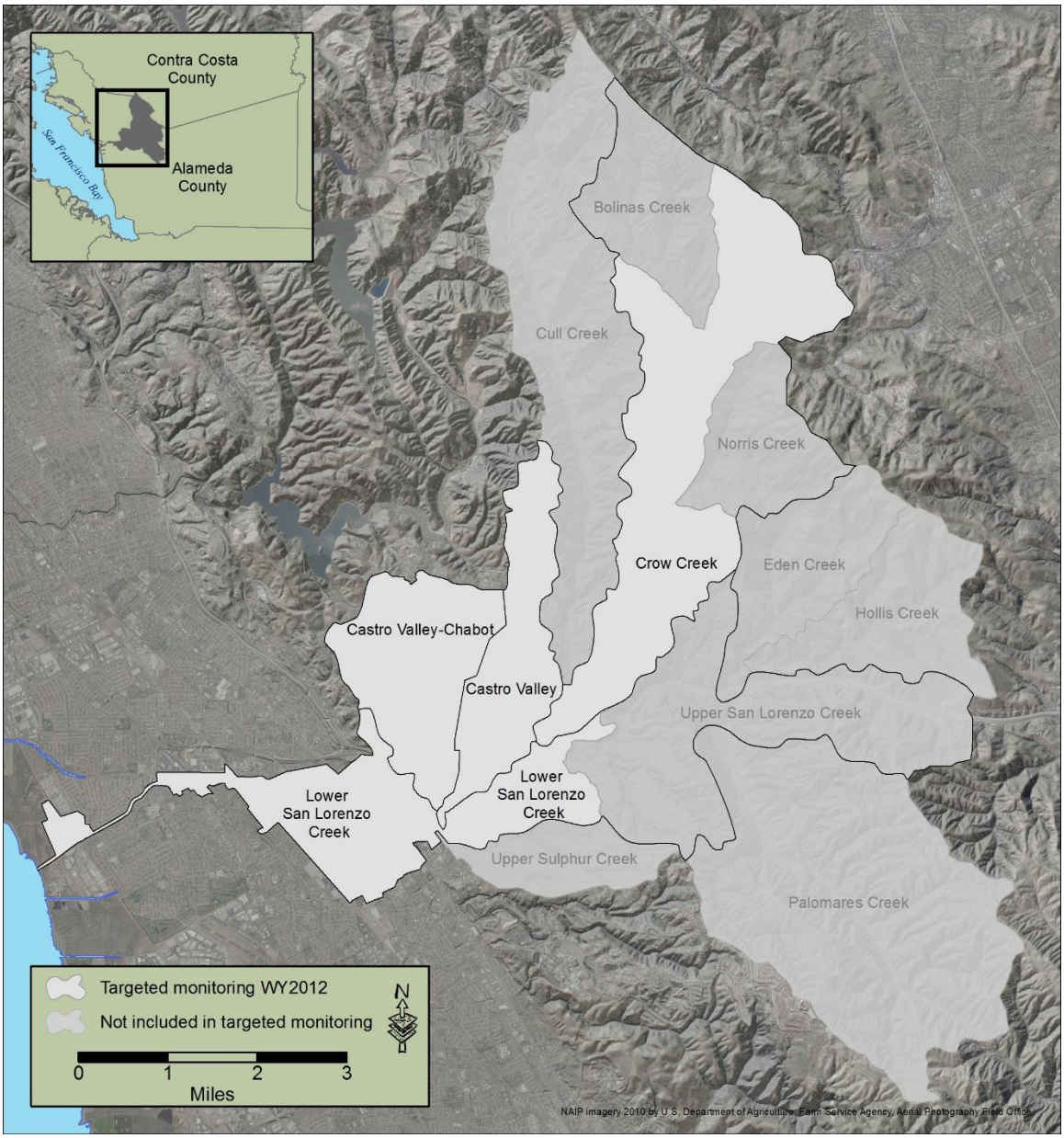



**Figure 2-1.Map of the San Lorenzo Creek Watershed and Major Subwatersheds.**

### 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.**).

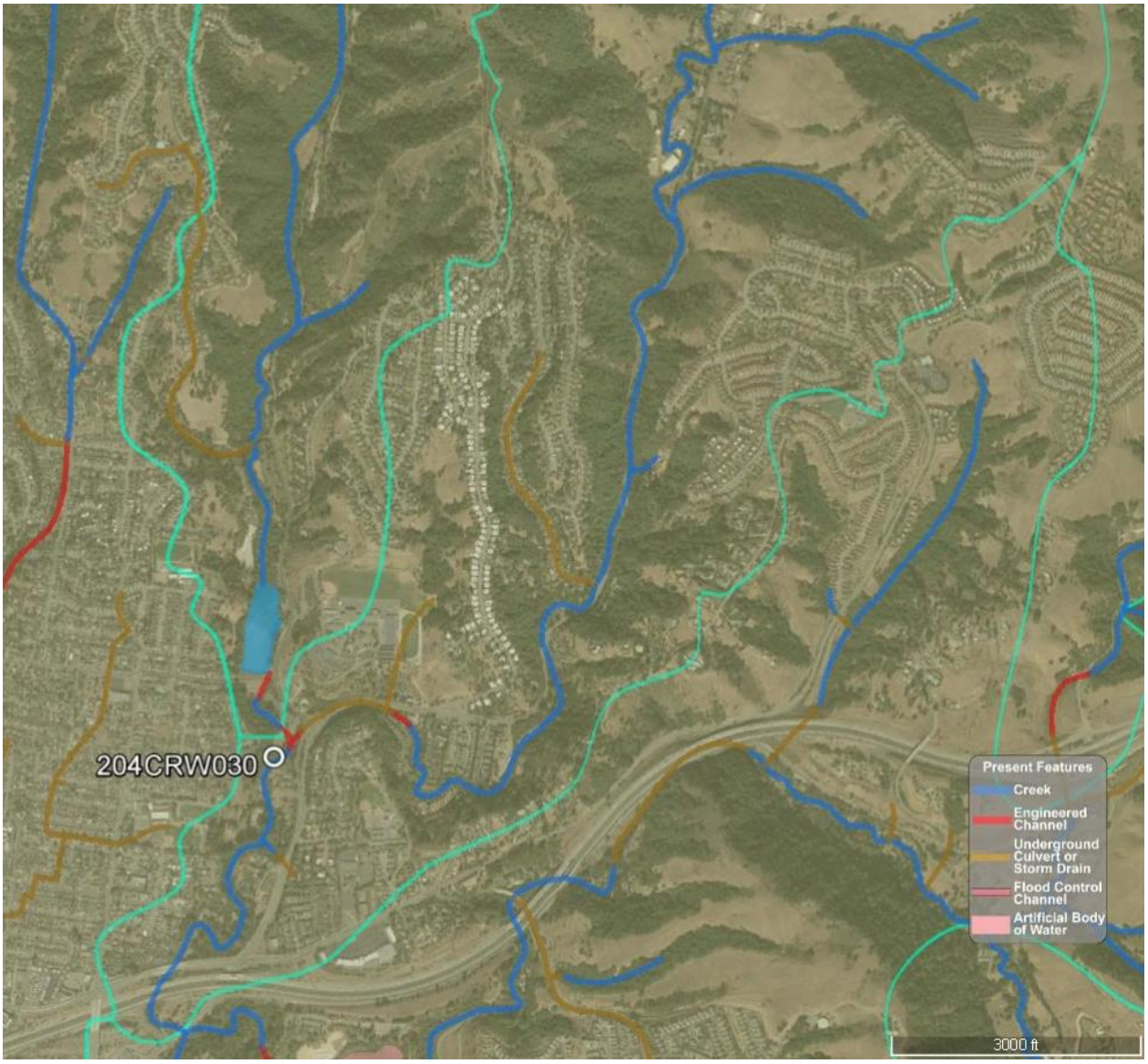



**Figure 2-2. Study Area in Lower Crow Creek and Cull Creek Watersheds**

## 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 MRP Table 8.1 in comparison to available Creek Status monitoring data in

**Table 2-1. Review of Trigger Types and Significance at Crow Creek Site 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 between 20th – 25th September, 2012 |
| General WQ - other | Not triggered | |
| Temperature | Not triggered | |
| Pathogen Indicators | Not sampled | |

### 2.2.2 Potential Sources and Activities Contributing to Low Dissolved Oxygen

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

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) evaluated for relevance to the DO observations in Crow Creek.

- 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 2012 at 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 alluviual 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 2-3 shows 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

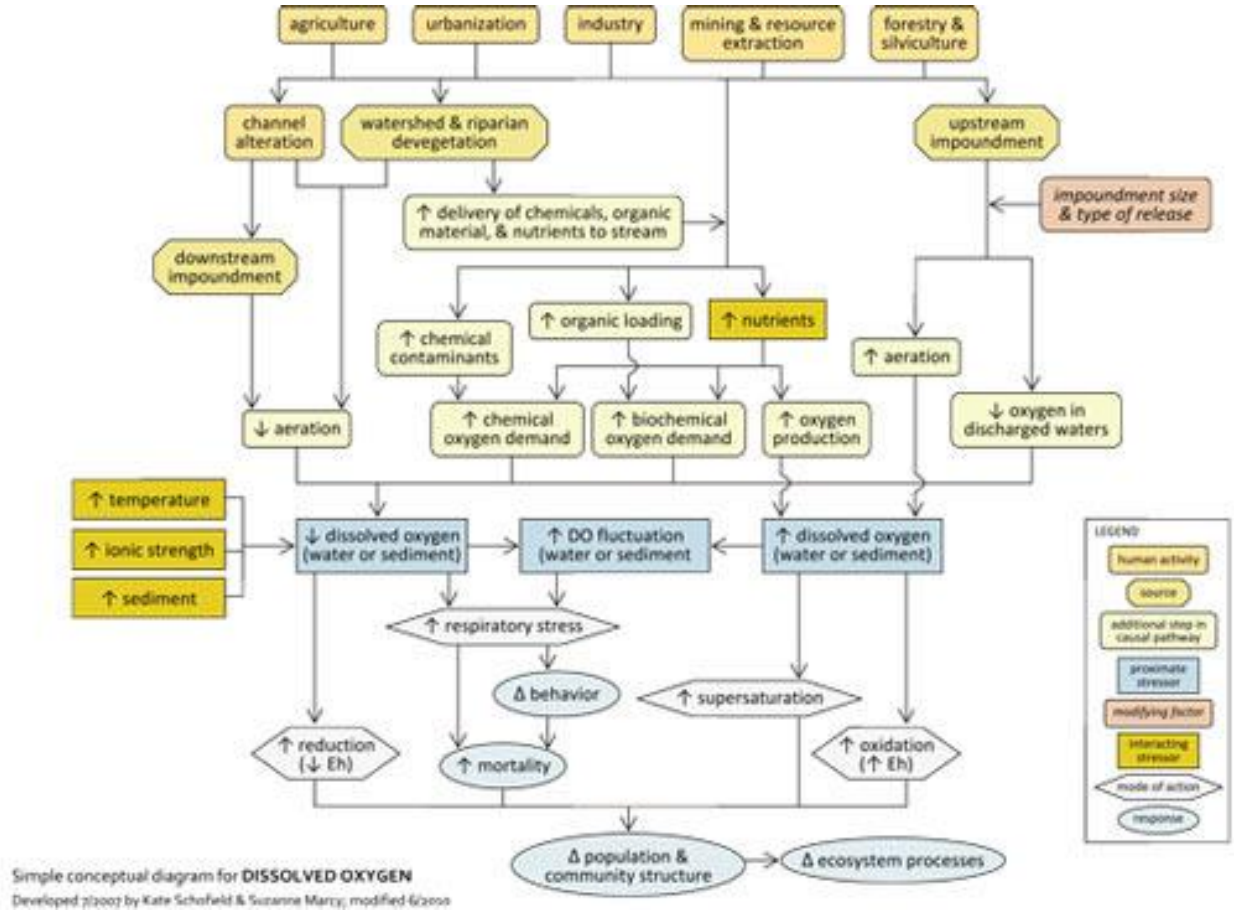



**Figure 2-3. Conceptual diagram illustrating causal pathways, from sources to impairments, related to dissolved oxygen (USEPA 2010).**

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:

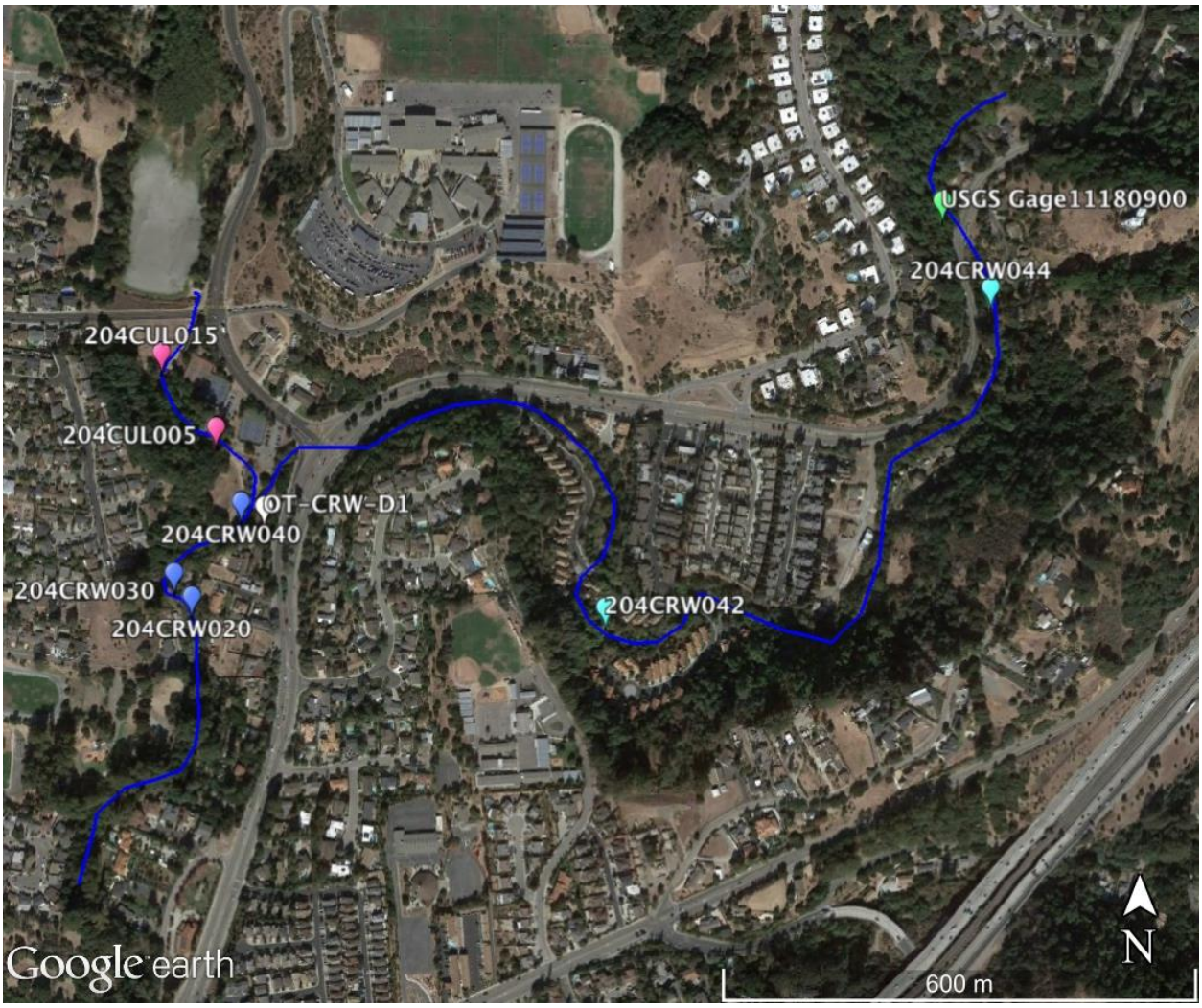



**Figure 2-4. Location map of Crow Creek SSID study sites WYs 2012-2015.**

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.

# 3. Review of SSID Project General Water Quality Data

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. Weekly rolling values less than the 7 mg/L cold-water benchmark in 5 out of 15 deployment periods (Table 3-1). 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 3-1. Percentage of weekly (7-day average) rolling average D.O. less than the 7 mg/ benchmark for COLD beneficial use during each deployment period (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.

## 3.1 Individual Site Monitoring Results

### 204CRW030

Weekly average DO concentrations were above the 7 mg/L benchmark in 1 out of 4 sampling periods (Table 3-1). DO concentrations were consistently above the 7 mg/L cold-water benchmark in May 2012. However, DO was frequently <7 mg/L during summer sampling in 2012 and 2013), and weekly averages were well below this threshold in 2013 (Figure 3-1[4]). Daily minimum values during summer were consistently below the benchmarks for aquatic life beneficial uses.

[4] In all boxplots the boxes represent the 3rd and 1st quartiles (75th and 25th percentiles) and the whiskers extend beyond the quartiles by 1.5 times the interquartile range.

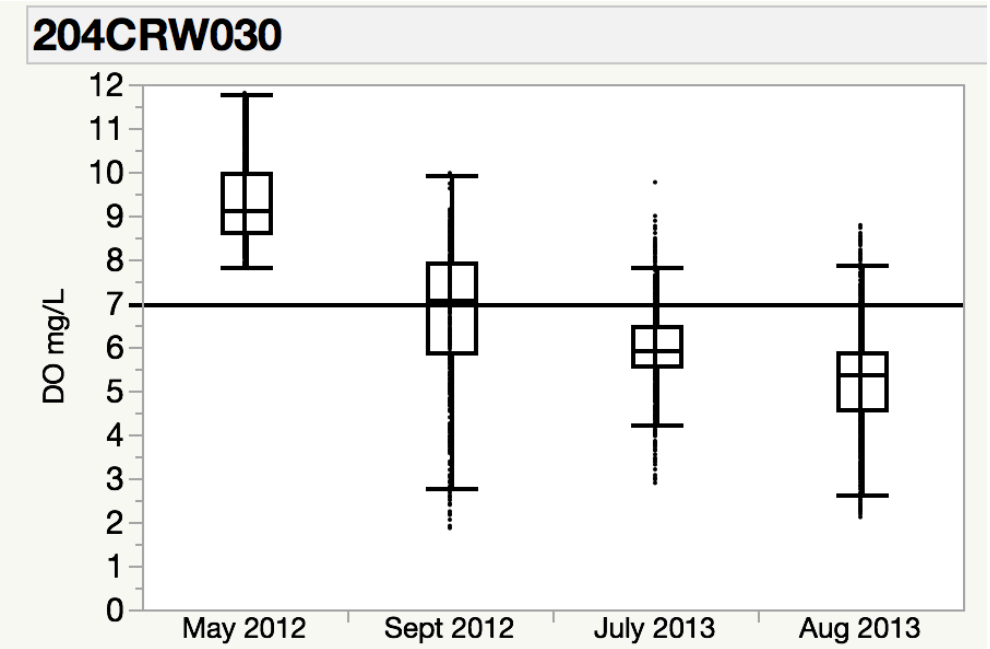



**Figure 3-1. Box plots of DO measurements at 204CRW030.**

**204CRW040**

Weekly average DO concentrations were above the 7 mg/L benchmark in 4 out of 5 sampling periods (Table 3-1). However, minimum DO concentrations were <5 mg/L in 4 out of 5 deployments, and the average concentration in September 2014 was ~5 mg/L (Figure 3-2). Additionally, excessively high DO concentrations (>12 mg/L, and as high as 20 mg/L) were observed in August 2013, May 2015, and August 2015, indicative of potentially eutrophic conditions at this site.

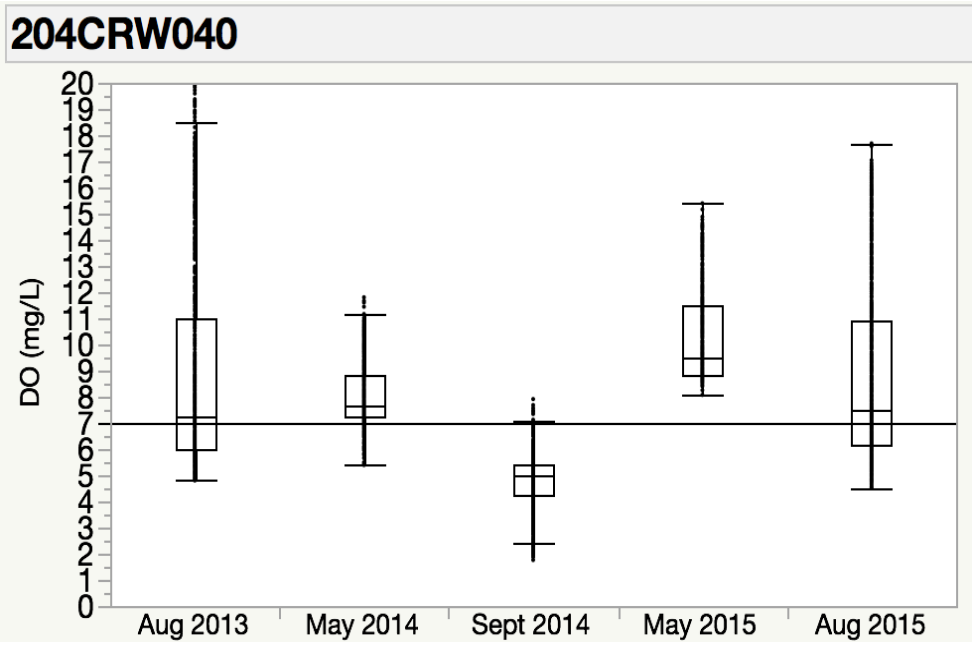



**Figure 3-2. Box plots of DO measurements at 204CRW040.**

**204CRW042**

Weekly average DO concentrations were above the 7 mg/L benchmark in 3 out of 3 deployments (Table 3-1). (DO data is not presented for summer 2015 because data quality objectives were not met.) The median DO concentration in August 2015 was 6.86 mg/L, however, and the minimum value was 5.42 mg/L (Figure 3-3).

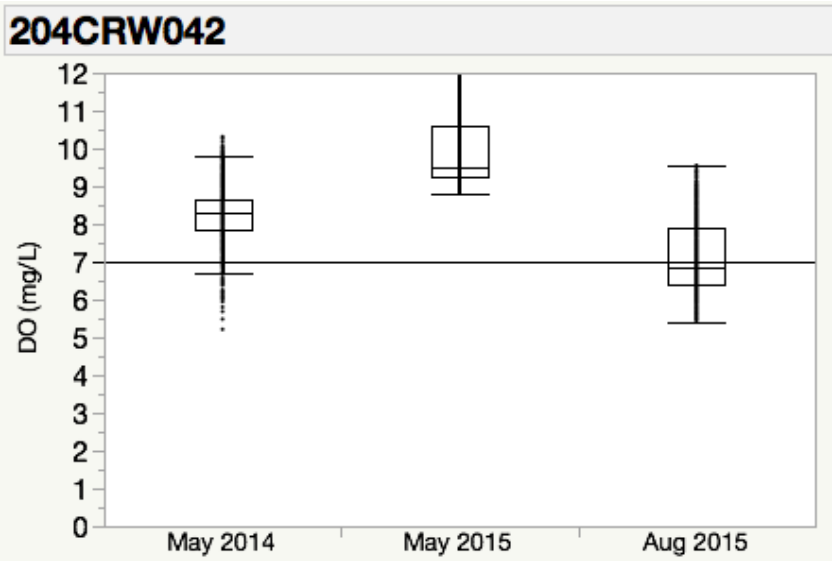



**Figure 3-3. Box plots of DO measurements at 204CRW042. (Data from summer 2014 not shown—see text).**

**204CRW044**

Weekly average DO concentrations were above the 7 mg/L benchmark in 2 out of 2 deployments (Table 3-1). The minimum DO concentration measured during the August 2015 deployment was 5.71 mg/L, and over 90% of all measurements were >7 mg/L (Figure 3-4).

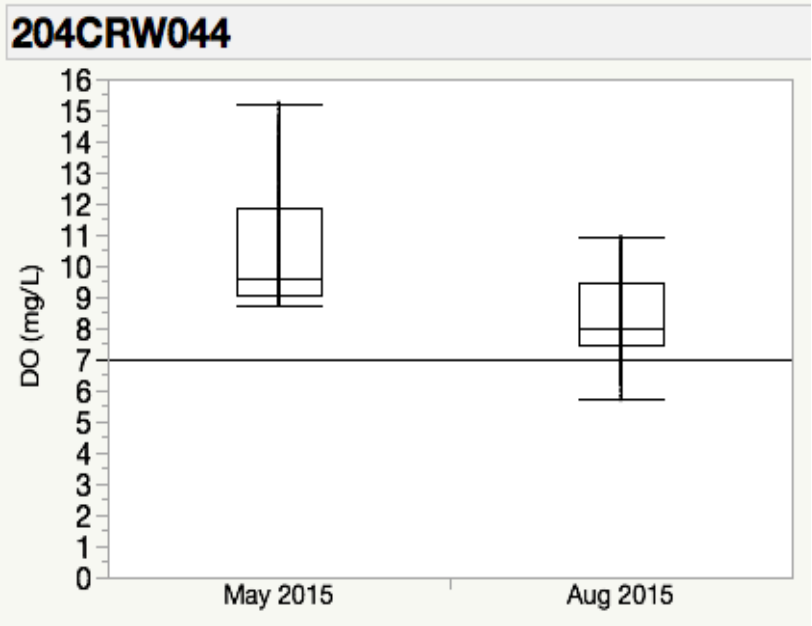
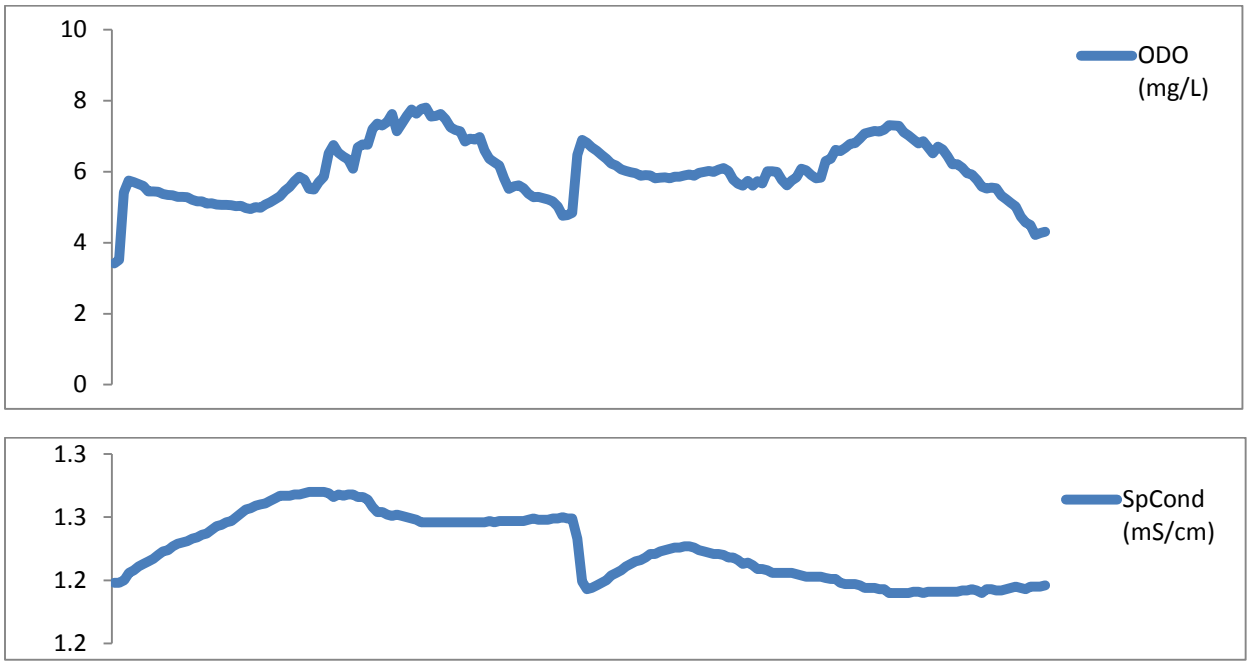


**Figure 3-4. Box plots of DO measurements at 204CRW042.**

## 3.2 Discussion of Continuous Water Quality Monitoring Data Patterns

Daily minimum dissolved oxygen concentrations at 204CRW030 during September 2012 and July and August 2013 were consistently <4 mg/L, and daily averages were often<7 mg/L and occasionally <5 mg/L. In addition to these low concentrations, DO curves exhibited unusual patterns, including rapid rises and falls over 15 minute time periods at unusual times of day. These sudden changes in DO are often simultaneous with sudden changes in conductivity, suggesting that discharges into the stream via the storm drain system may be affecting both parameters. For example, the July 2013 deployment period was characterized on most days by steady declines in DO during the night hours, punctuated by a sudden rise in DO just after midnight coincident with a sudden drop in conductivity (Figure 3-5[5]).




[5] Note that water depth is measured using an unvented system and has not been corrected for changes in atmospheric pressure.

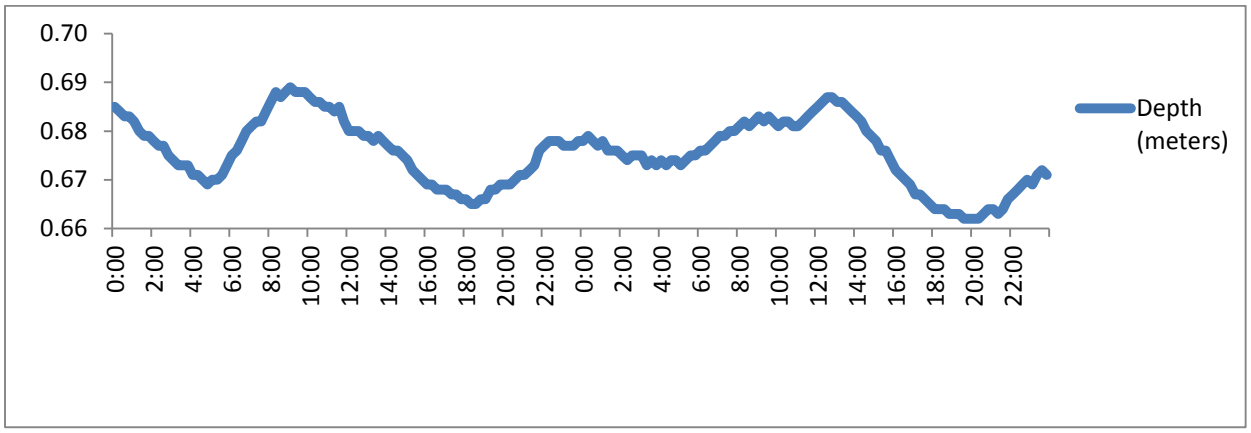
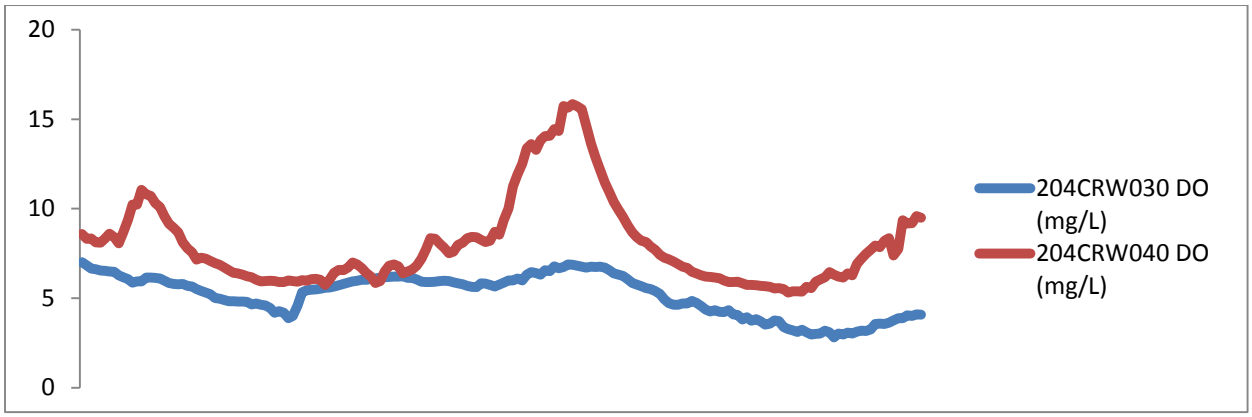



**Figure 3-5. Dissolved oxygen, specific conductivity, and water depth recorded at 204CRW030 during July 11-12, 2013.**

There were often substantial differences in water quality conditions measured simultaneously at nearby sites. For example, site 204CRW040 exhibited large diel variation in DO concentrations, with daytime values >15 mg/L, while a site ~150 m downstream, 204CRW030, exhibited a negligible increase in DO during the day (Figure 3-6). At the same time, specific conductivity values were often higher at 204CRW030 than 204CRW040, although conductivity was more variable at 204CRW040. This high degree of variation among nearby sites suggests that local hydrologic and biological conditions may vary at very small spatial scales.



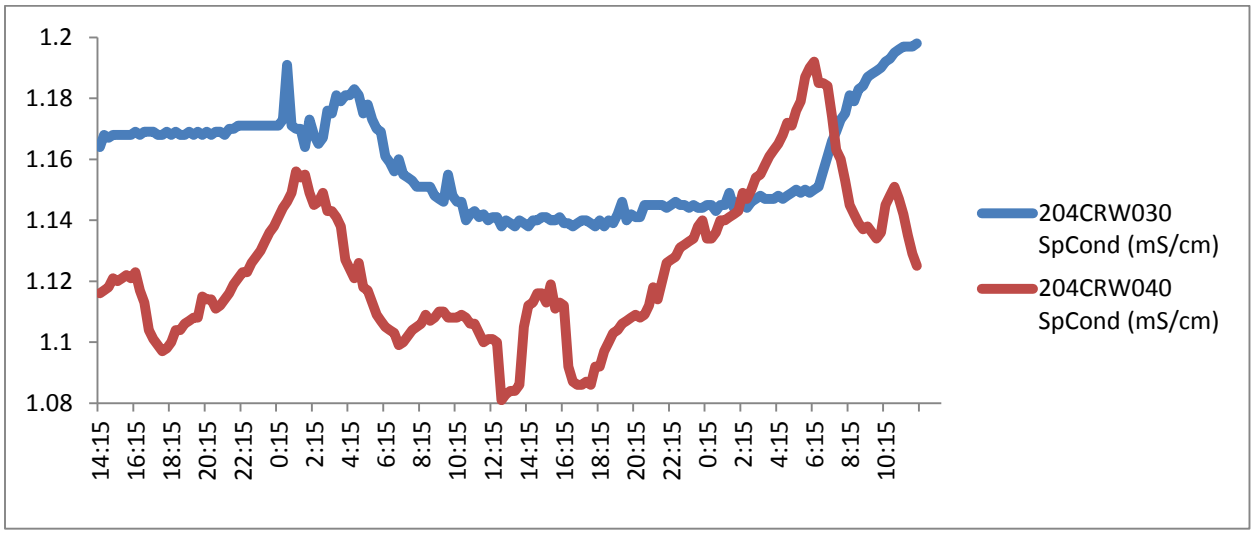



**Figure 3-6. Dissolved oxygen and specific conductivity recorded at 204CRW030 and 204CRW040 during a 45 hour period in August 2013.**

Dissolved oxygen patterns from summer 2014 at both 204CRW040 and 204CRW042 exhibit a troubling trend of continuing declines in DO during night-time hours to near anoxic conditions, suggesting excessive biological oxygen demand (BOD) not associated with respiration by algae and plants. For example, dissolved oxygen at 204CRW040 on August 27 gradually declined from 4.13 mg/L at 20:30 (i.e., dusk, when primary productivity ceases) to 1.98 mg/L at 2:30 (Figure 3-7). Over the next 30 minutes, however, DO increased to 4.18 mg/L and conductivity dropped from 1.573 to 1.560 mS/cm. Conductivity dropped further over the next few hours of the early morning, reaching a minimum of 1.551 mS/cm, while DO increased to 4.82 mg/L by 5am. This increase in DO took place prior to sunrise, and thus was not associated with in-stream photosynthesis. Instead, these patterns may represent a shift from higher conductivity water with high BOD to lower conductivity water via contributions from an intermittent source.

**Figure 3-7. Dissolved oxygen and specific conductivity recorded at 204CRW040 during Aug. 27-28, 2014.**

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.

# 4. Monitoring Work Plan for WY2016

## 4.1 Approach and Methods

Unusual fluctuations in specific conductivity have been frequently observed during the summer season in Crow Creek, especially at sites downstream of the confluence with Cull Creek (204CRW040, 204CRW030) where low DO concentrations have been frequently measured during the summer season. The timing and magnitude of these fluctuations suggest that localized discharges via the storm drain system, as opposed to natural hydrological processes, may be contributing to these patterns. Substantial variation in basic water quality conditions between nearby sites further suggests that localized discharges and/or small-scale variation in stream channel characteristics may play an important role in DO dynamics.

To further characterize potential sources of dissolved oxygen stressors in Crow Creek, spatially-intensive spot sampling of dissolved oxygen and specific conductivity could be used 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) will be 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 will follow the procedures in RMC SOP FS-4.

Additionally, synchronous continuous monitoring of dissolved oxygen at the ends of the study reach during the summer season (i.e., July-September) in Crow Creek (1) downstream of the confluence with Cull Creek (i.e., 204CRW030) and (2) near the USGS gage site (i.e., 204CRW044) will enable characterization of differences in water quality conditions between the urbanized and rural portions of the watershed.

## 4.2 Monitoring Locations

Planned WY 2016 monitoring locations are shown in figure xxx and described along with the planned monitoring types in Table 4-1.

**Figure 4-1. Planned Crow Creek SSID Monitoring Locations for WY2016 and Storm Drainage Features.**

**Table 4-1.Monitoring Locations and Methods for WY 2016 Crow Creek SSID.**

| Site Code | Description | Types | Season |
|---|---|---|---|
| 204CRW040 | Crow Creek 5 m downstream of Crow Creek/Cull Creek confluence at transition from concrete channel to natural creek | HOBO U24 | April-Sept |
| | | YSI Sonde | 1-2 week deployments in spring, midsummer and late summer |
| 204CRW041A | Inside Crow Creek box culvert approximately 75 m upstream of Crow Creek/Cull Creek confluence | HOBO U24 | April-Sept |
| 204CRW041C | Inside Crow Creek box culvert approx.. 30- m below upstream end, downstream of large outfall located under entrance to Crow Creek Rd. | HOBO U24 | April-Sept |
| 204CRW041D | Crow Creek upstream of box culvert, between 2 large outfalls approximately 30 m upstream of entrance to Crow Creek Rd. | HOBO U24 | April-Sept |
| 204CRW041E | Crow Creek upstream of box culvert, upstream of second large outfall approximately 100 m upstream of entrance to Crow Creek Rd. | HOBO U24 | April-Sept |
| | | (YSI Sonde) | (back-up site if water depth is insufficient at 204CRW042) |
| 204CRW042 | Crow Creek 50 m upstream of first bridge on Crow Creek Road | HOBO U24 | April-Sept |
| | | YSI Sonde | 1-2 week deployments in spring, midsummer and late summer |

# 5. References

ACCWP, 2014a. Creek Status Monitoring Report -Targeted Parameters, Water Years 2012 and 2013. Integrated Monitoring Report, Part A - Appendix A.3. March 14, 2014.

ACCWP, 2014b. Stressor Source Identification Project: Crow Creek Site 204CRW030- Low Dissolved Oxygen -Water Year 2013 Progress Report. Integrated Monitoring Report, Part A: Appendix A.4C. March 13, 2014.- Low Dissolved Oxygen -

Water Year 2013 Progress Report. Integrated Monitoring Report, Part A: Appendix A.4C. March 13, 2014.

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.

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.

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.

SFBRWQCB. 2009. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074 NPDES Permit No. CAS612008, October 14, 2009.

SFRWQCB.2011. San Francisco Bay Basin (Region 2) Water Quality Control Plan.(Basin Plan).

SFBRWQCB. 2015. California Regional Water Quality Control Board, San Francisco Bay Region, Municipal Regional Stormwater NPDES Permit, Order R2-2015-0049 NPDES Permit No. CAS612008, November 19, 2015.

U.S. EPA (U.S. Environmental Protection Agency). 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Office of Research and Development, Washington, DC. Available online at https://www.epa.gov/caddis. Last updated September 23, 2010.

Surface Water Ambient Monitoring Program(SWAMP) Quality Assurance Project Plan (QAPP). September 1, 2008. http://www.waterboards.ca.gov/water_issues/programs/ swamp/docs/qapp/swamp_qapp_master090108a.pdf. Viewed on December 17, 2012

United States Geological Service (USGS). 2013. Historical flow reports for Cull reservoir http://wdr.water.usgs.gov/wy2012/pdfs/11180960.2012.pdf. Viewed on October 1, 2013U.S. EPA (U.S. Environmental Protection Agency). 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Office of Research and Development, Washington, DC. Available online at https://www.epa.gov/caddis. Last updated September 23, 2010.