BASMAA

Regional Monitoring Coalition

Creek Status Monitoring Program
Quality Assurance Project Plan

Prepared for:

The Bay Area Stormwater Management Agencies Association (BASMAA)

Prepared 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

Armand Ruby Consulting
on behalf of the Contra Costa Clean Water Program

Final Draft February 1, 2012
(Version 1.0)

1. (A1) Title and Approval Sheet

Program Title Regional Monitoring Coalition Creek Status Monitoring Program

Lead Organization Bay Area Stormwater Management Agencies Association (BASMAA)
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Primary Contact

Effective Date

Revision Number Version 1.0

1.1. Approval Signatures:

Table 1-1. Managing Organization:

Title	Name	Signature	Date
Program Manager			
Central QA Officer			
Central Information Management Coordinator			
Creek Status Monitoring Coordinator			

2. (A2) Table of Contents

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List of Acronyms

ASTM	American Society for Testing and Materials
BASMAA	Bay Area Stormwater Management Agencies Association
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
CIMCC	Central Information Management Coordinator
CQAO	Central Quality Assurance Officer
CWA	Clean Water Act
CWP	Clean Water Program of Alameda County
DMT	Data Management Team
DOC	Dissolved Organic Carbon
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency (U.S.)
FC	Field Crew
FSURMP	Fairfield-Suisun Urban Runoff Management Program
IATA	International Air Transport Association
IDL	Instrument Detection Limits
IDW	Investigation-Derived Waste
IMC	Information Management Coordinator
LIMC	Local Information Management Coordinator
LPM	Laboratory Project Manager
LQAO	Local Quality Assurance Officer
MCC	Creek Status Monitoring Coordinator
MDL	Method Detection Limit
MPC	Monitoring and Pollutants of Concern Committee
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
NPDES	National Pollutant Discharge Elimination System
OC	Organochlorine
OERR	Office of Emergency and Remedial Response
PAH	Polycyclic Aromatic Hydrocarbon
PBDE	Polybrominated Diphenyl Ether
PCB	Polychlorinated Biphenyl
PM	Program Manager
PML	Stormwater Program Local Project Managers
PPE	Personal Protective Equipment
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Method Reporting Limit
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in the San Francisco Estuary
RP	Report Preparer
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SMSTOPPP	San Mateo Countywide Stormwater Pollution Prevention Program
SOP	Standard Operating Procedure
SSC	Suspended Sediment Concentration
SWAMP	California Surface Water Ambient Monitoring Program

TOC	Total Organic Carbon
TMDL	Total Maximum Daily Load
USA	Unified Stream Assessment
VSFCD	Vallejo Sanitation and Flood Control District

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3. (A3) Distribution List and Contact Information

The RMC QAPP was developed by the RMC to be comparable with the SWAMP Quality Assurance Program Plan (QAPrP), Version 1.0 (SWAMP 2008).

Table 3-1. RMC QAPP Distribution List

Title	Name and Affiliation	Telephone No.	QAPP #
Program Manager	Name	555-555-5555	1
Central QA Officer	Name		2
Central Information Mgmt Coordinator			3
Creek Status Monitoring Coordinator	Name		4
Local Program Project Mgr	Arleen Feng, CWP		5
Local Program Project Mgr	Jamison Crosby, CCCWP		6
Local Program Project Mgr	Kevin Cullen, FSURMP		7
Local Program Project Mgr	Chris Sommers, SCVURPPP		8
Local Program Project Mgr	Jon Konnan, SMCWPPP		9
Local Program Project Mgr	?, VSFCD		10
RWQCB Representative	Jan O'Hara		11
RWQCB Representative	Kevin Lunde		12
Lab PM			13
Lab PM			14
Lab PM			15
Report Preparer			16

4. (A4) Program Organization

4.1. Involved Parties and Roles

The Bay Area Stormwater Management Agencies Association (BASMAA) is a 501(c)(3) non-profit organization comprised of the municipal stormwater programs in the San Francisco Bay Area. The BASMAA programs supporting implementation of the Municipal Regional Stormwater NPDES Permit No. CAS612008 (MRP) include all 76 identified MRP municipalities and special districts, the Alameda Countywide Clean Water Program (ACCWP), Contra Costa Clean Water Program (CCCWP), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), the Fairfield-Suisun Urban Runoff Management Program (FSURMP), the City of Vallejo and the Vallejo Sanitation and Flood Control District (VSFCD) (Table 4-1). Additionally, for the purposes of projects managed under this QAPP, the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP, have voluntarily elected to participate in MRP-related regional activities with the expectation that regionally coordinated activities undertaken by the Contra Costa Clean Water Program and other BASMAA partners will fulfill requirements that will be established by the Central Valley Regional Water Quality Control Board through its separate NPDES permit regulating stormwater discharges from eastern Contra Costa County.

To address requirements of water quality monitoring associated with implementation of the MRP, the above-mentioned parties formed the Regional Monitoring Coalition (RMC), a collaboration of San Francisco Bay Area stormwater programs and associated Permittees focused on effectively and efficiently developing and implementing a regionally coordinated water quality monitoring program that will improve stormwater management in the region. The goals of the RMC are to:

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

Through its implementation, the RMC allows Permittees and the Water Board to effectively modify their existing creek monitoring programs, which improves their ability to collectively answer core management questions in a cost effective and scientifically rigorous way. Participation in the RMC is coordinated by stormwater program and or Permittee representatives (or equivalent), and facilitated through the BASMAA Monitoring and Pollutants of Concern Committee (MPC). The RMC implementation area is shown in Figure 4-1.

While more than seventy MRP Permittees are participating in the in the RMC, the majority of effort expended to manage the monitoring efforts is anticipated to be performed at the countywide or other regional organization level. For the purposes of this document, the term “Stormwater Program” will be used herein to refer to these organizing levels.

Table 4-1. San Francisco Bay Area Stormwater Programs and Associated MRP Permittees Participating in the BASMAA Regional Monitoring Coalition (RMC).

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
Clean Water Program of Alameda County	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)[1]	Cities of Antioch, Brentwood, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, Oakley, Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Sanitation and Flood Control District

[1] The Cities of Antioch, Brentwood and Oakley, and portions of Unincorporated Contra Costa County are subject to an NDPES Permit issued by the Central Valley Regional Water Quality Control Board (as opposed to the MRP). Monitoring requirements in this Permit are similar to those in the MRP and therefore these Permitees have agreed to participate in the RMC.

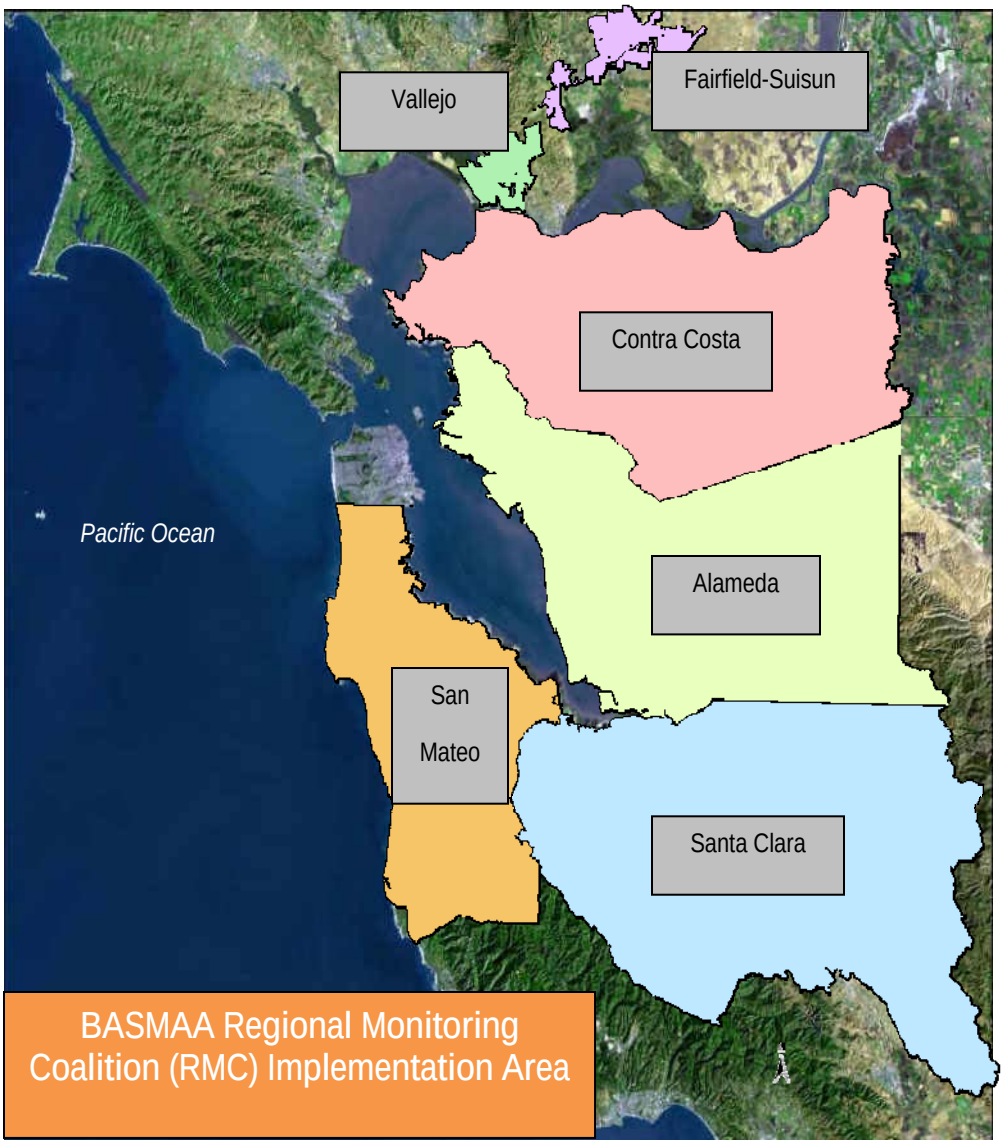
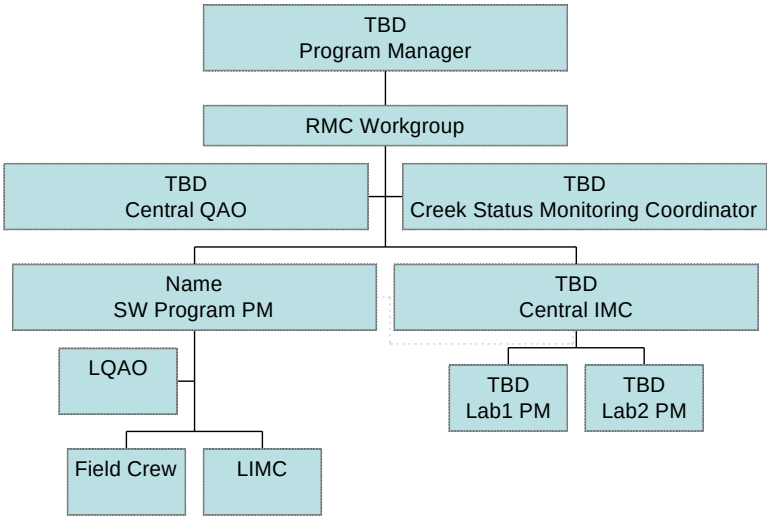


Figure 4-1. BASMAA Regional Monitoring Coalition (RMC) Implementation Area.

A general organization chart for managing dataflow within the RMC is depicted in Figure 4-2. Additional information regarding dataflow roles, responsibilities and access are provided in the RMC Information Management System .

Figure 4-2. RMC Dataflow Diagram.



4.2. Program Manager Role

The Program Manager (PM) will be responsible for oversight of RMC management level activities, including budgeting, reporting, and updating of the QAPP when appropriate. In addition, the Program Manager will coordinate with the Program partners and key regional agencies, including the California Regional Water Quality Control Board (Water Board), and oversee preparation of required reports to the Water Board.

4.3. RMC Work Group

The PM will be assisted in design and implementation of RMC Creek Status Monitoring activities by a project management team consisting of representatives from BASMAA member agencies, the RMC Workgroup (Workgroup). Workgroup members will provide guidance for the overall RMC effort (e.g., centralized reporting, identifying modifications to the RMC, and contracting with laboratories).

4.4. Central Quality Assurance Officer Role

The role of the RMC Central Quality Assurance Officer (CQAO) is to provide independent oversight and review of the quality of the data being generated by the Program with respect to the quality that is required. Thus, the CQAO will be independent from those generating all Program information and will not report to the proposed Program Manager or to any of the proposed technical staff. In this role, the

CQAO has the responsibility to require data that is of insufficient quality to be flagged, or not used, or for work to be redone as necessary so that the data meets specified quality measurements.

The CQAO will be responsible for overall Program quality assurance, but due to the size of the effort and number of participating agencies, will not be responsible for day-to-day quality assurance efforts that are the responsibility of the individual Stormwater Programs. As such, the CQAO will ensure that appropriate measures are in place within the QAPP to ensure data quality and monitor that actions required through the QAPP are undertaken by those with these responsibilities (e.g., Local QAOs).

4.5. Central Information Management Coordinator Role

The RMC Creek Status Central Information Management Coordinator (CIMC) is responsible for ensuring laboratory program compliance with the QAPP. The CIMC will also ensure that raw data is available to LIMCs for transfer to SFEI annually for input into CEDEN.

4.6. Creek Status Monitoring Coordinator Role

The Creek Status Monitoring Coordinator (MCC) will oversee the technical conduct of the field related components of the Creek Status Monitoring Program, including ensuring field program compliance with the QAPP for tasks overseen at the programmatic level. As required, the MCC will consult with the CQAO to make proposals to the Workgroup to initiate changes to the RMC (e.g., identifying potential modifications to SOPs or QAPP) or address questions posed by RMC participants.

4.7. Local Project Managers

Individual Stormwater Program Local Project Managers (PMLs) will be responsible for the day-to-day operations associated with implementation of the Creek Status monitoring component of the MRP. It will be their responsibility to ensure that data generated and reported through implementation of the Creek Status Monitoring program meet data quality objectives and work with the CQAO as required to resolve any uncertainties or discrepancies.

4.8. Local Program Local Information Management Coordinator

The Stormwater Program Local Information Management Coordinator (LIMC) will serve as the primary contact for communication with contract laboratory(ies), field crews, and the CIMC. Also, the LIMC will be responsible for management of all data not managed by the CIMC. LIMCs will be responsible for reviewing field datasheets prepared by FCs and, as applicable, ensuring correction of errors and providing feedback to FCs. LIMCs will also receive and store laboratory electronic data deliverables (EDDs) at the local stormwater program level.

4.9. Local Program Quality Assurance Officer

The role of the Local Quality Assurance Officer (LQAO) is to provide independent oversight and review of the quality of the data being generated by the individual Stormwater Program producing that data and, as applicable, transferring to the Program level. Thus, the LQAO will be independent from those generating all information and will not report to the proposed PML or to any of the proposed technical staff. In this role, the CQAO has the responsibility to require data that is of insufficient quality to be flagged, or not used, or for work to be redone as necessary so that the data meets specified quality

measurements. The LQAO will also be responsible for ensuring that all required local QA activities are being conducted (e.g., field calibrations, field audits, etc.), and will forward this information along to the CQAO for compilation.

4.10. Local Program Field Crew Role

The Stormwater Program Field Crews (FCs) will be responsible for conducting all monitoring- and reporting-related activities, including completion of field datasheets, chain of custodies, and collection of field measurements and field samples, consistent with the QAPP and Standard Operating Procedures (SOPs).

4.11. Laboratory Project Manager

The Laboratory Project Manager (LPM) at the selected analytical laboratory(ies) will be responsible for ensuring that the laboratory's quality assurance program and standard operating procedures are consistent with this QAPP, and that laboratory analyses meet all applicable requirements or explain any deviations. The LPM will also be responsible for coordinating with the CQAO and CIMC as required for the project.

4.12. Report Preparer

The Report Preparer (RP) will be responsible for developing and submitting regional reporting activities as outlined in the QAPP and MRP. Specific deliverables will include development of the draft versions of the regional creek status portion, the regional POC loads monitoring portion.

Titles and contact information for the RMC personnel responsibilities at central and local levels are provided in Tables 4-2 and 4-3

Table 4-2. RMC Personnel Responsibilities at Central Level

Name	Organizational Affiliation	Title	Contact Information (Name; Phone / Fax; email)
	RMC	Program Manager	555.555.5555 name@domain.org
	RMC	Central Information Management Coordinator	555.555.5555 name@domain.org
	RMC	Central QA Officer	555.555.5555 name@domain.org
	RMC	Monitoring Coordinator	555.555.5555 name@domain.org

Table 4-3. RMC Personnel Responsibilities at Local Level

Name	Organizational Affiliation	Title	Contact Information (Name; Phone / Fax; email)
	SW Program	Local Project Manager	555.555.5555 name@domain.org
	SW Program	Local Information Management Coordinator	555.555.5555 name@domain.org
	SW Program	Local QA Officer	555.555.5555 name@domain.org
	SW Program	Local Field Crew	555.555.5555 name@domain.org

5. (A5) Problem Definition/Background

5.1. Problem Statement

This QAPP was developed to assist in conducting the monitoring required in Provision C.8 of the MRP, adopted Oct. 2009 (RWQCB 2009).

5.2. Decisions or Outcomes

RMC Status and trends monitoring in local creeks/rivers is intended to answer the following core management questions:

1. Are conditions in local creeks supportive of or likely to be supportive of beneficial uses?
2. Are conditions in local creeks getting better or worse over time?
3. Are water quality objectives, both numeric and narrative, being met?
4. What are the long-term trends in pollutant concentrations and toxicity in receiving waters and sediment?

The Program will provide information about creek status through multiple lines of inquiry, including monitoring of biological community and physical habitat, general water quality, water chemistry, water toxicity, sediment chemistry, sediment toxicity, and pathogen indicators.

5.3. Water Quality or Regulatory Criteria

This Program will yield data through many related monitoring efforts. This data will be reported by RMC agencies and may be used by the Permittees and Water Board for status reporting, comparison to Basin Plan water quality objectives (and 303d listing or de-listing), comparison with triggers identified within the MRP Attachment H, and watershed assessments. Results that exceed identified triggers may results in a required Stressor / Source Identification Monitoring Project to be conducted as identified within MRP Provision C.8.d.i.

6. (A6) Program/Task Description

6.1. Work Statement and Produced Products

Cumulative, the Creek Status Monitoring Program will include water quality measurements and also collection of individual samples for analysis of chemical analytes and/or organisms in water, sediment, and tissue as described in MRP Table 8.1. Sampling and measurements will be made during both wet and dry weather conditions. Station types sampled may include: rivers, streams and/or creeks, sampled at varying frequencies depending on parameter and jurisdiction.

Results will be discussed relative to prior conditions, beneficial uses, and applicable water quality standards as described in the Basin Plan, the Ocean Plan (CSWRCB 2005), or the California toxics Rule (Federal Register 1997), or other applicable water quality control plans. Where appropriate, hypotheses will be developed to investigate potential pollutant sources, trends, and BMP effectiveness. Reports will identify and prioritize water quality problems, sources of water quality problems, describe follow-up actions and any additional management actions needed to address water quality problems, and evaluate the effectiveness of existing control measures.

In compliance with MRP provision C.8.g monitoring results will be analyzed and synthesized into regional and local assessment reports annually to address the RMC management questions as described below. Reports will summarize monitoring conducted during the foregoing October 1 – September 30 period and will be submitted to the Regional Board by March 15 following this period. The initial reports for RMC participants will be on March 15, 2013.

6.2. Sampling Detail

The Creek Status Monitoring Program entails a wide variety of sample collection, water quality measurements, and field assessments designed to comply with Provisions C.8.c and C.8.e of the MRP. Table 6-1 lists the parameters that will be monitored, their sampling frequency and the associated monitoring design. Sampling design is summarized in Section B2 of this report and in greater detail within the RMC Creek Status and Long-Term Monitoring Plan (BASMAA 2011).

Table 6-1. Summary of RMC Monitoring Parameters, Designs, and Reporting.

Parameter	RMP Required # of Annual Sites/Miles[1]	Monitoring Design	
		Regional Condition Status (Probabilistic)	Targeted
Bioassessment, PHAB, Water Quality, Nutrients	20/10/4	X	
General Water Quality (sondes)	Spring 3/2/1 Dry 3/2/1		X (Spring and Dry)
Chlorine	Spring 20/10/2 Dry 3/2/1	X (Spring and Dry)	
Temperature (Hobos)	8/4/1		X
Water Toxicity	Dry 3/2/1 Storm 3/2/1	X	*TBD*
Sediment Toxicity	3/2/1	X	*TBD*
Sediment Chemistry	3/2/1	X	*TBD*
Bacteria	5/5/*		X
Stream Survey	9/6/3 (miles)		X

[1] The number of sampling sites shown is based on the relative population in each Regional Stormwater Countywide Program and is listed in this order: Santa Clara & Alameda Countywide / Contra Costa & San Mateo Countywide / Vallejo & Fairfield-Suisun Programs.

Sampling parameters associated with probabilistic and targeted creek status monitoring designs are discussed in more detail below. Methods used to measure these parameters are provided in Section B3 of this report and in the RMC Monitoring Plan

6.2.1. Probabilistic Monitoring Design Parameters

The following parameters will be measured at sites that are selected using a probabilistic monitoring design: biological assessments (including physical habitat assessments), general water quality, nutrients, chloride, sediment toxicity and chemistry and water toxicity.

6.2.1.1. Biological Assessments

Bioassessments will be conducted one time each year during spring index period (approximately April 15 – July 15), with the goal of assessing all sites within a two month period each year. To the extent practical, the RMC will conduct sampling approximately 30 days following any significant storm event that occurs during the index period or prior to the start of the index period.

Bioassessments will consist of the collection of benthic macroinvertebrate and algae samples and the measurement of physical parameters related to biological habitat. Physical water quality measurements are measured synoptically with bioassessments. Measurements will include (1) dissolved oxygen; (2) temperature, (3) conductivity, and (4) pH. Water samples will also be collected during bioassessments and analyzed for nutrients and other constituents listed below:

- Total Phosphorus (as P)
- Dissolved Orthophosphate (as P)
- Total Kjeldahl Nitrogen (TKN)

- Nitrate (as N)
- Nitrite (as N)
- Total Nitrogen (calculated as a sum of TKN, Nitrate and Nitrite)
- Ammonia (as N)
- Silica
- Chloride (total and free)
- Organic Carbon (Dissolved)
- Suspended Sediment Concentration

6.2.1.2. Aquatic Toxicity Monitoring

Twice per year, field crews will collect appropriate volumes of water to support aquatic toxicity testing. One sample will be collected during a storm event, and a second during dry season sampling. Sampling will be conducted at pre-determined number of site(s) (Table 6-1) that were selected using a probabilistic design for bioassessment monitoring.

Acute toxicity tests are short-term tests that measure the effects of exposure of a test organism to relatively high concentrations of chemicals in a given media. The measurement endpoint generally reflects the extent of lethality. In comparison, chronic toxicity tests generally are longer-term tests that measure the effects of exposure to relatively lower, less toxic concentrations. For a chronic toxicity test, the measurement endpoint concerns a sublethal effect (e.g., reproduction, growth) or both lethal and sublethal effects (USEPA 1994a). The following aquatic toxicity tests will be performed as part of the RMC effort:

- *Selenastrum capricornutum* (sublethal endpoint)
  The chronic algal growth test performed on *Selenastrum capriconutum* identifies both biostimulatory and chronic toxic effects of a sample to a one-celled freshwater alga (USEPA 1994b). The test uses the static design and lasts 96 hours, to a growth endpoint.

- *Ceriodaphnia dubia* (lethal and sublethal endpoints)
  The *Ceriodaphnia dubia* survival and reproduction test estimates chronic toxicity of a sample to *Ceriodaphnia dubia*, a water flea. The test uses the static-renewal design, will run for 96 hours, and monitors survival and reproduction of test organisms as endpoint.

- *Pimephales promelas* (lethal and sublethal endpoints)
  Acute and chronic tests extending 7 days in duration are performed on *Pimephales promelas*, the fathead minnow, under static conditions. Toxicity tests are performed on *P. promelas* larvae, to a growth and survival endpoint.

- *Hyalella azteca* (lethal endpoint)
  Acute tests extending 10 days in duration are performed on *Hyalella azteca*, an amphipod, under static conditions. The endpoint for acute tests is survival.

6.2.1.3. Sediment Toxicity Sampling

Once per year during the dry season, field crews will collect samples for analysis of sediment toxicity. Sampling will be conducted at pre-determined number of site(s) (Table 6-1) that were selected using a probabilistic design for bioassessment monitoring. Samples will be collected by direct removal of

surficial sediments from depositional areas within the wetted perimeter of creeks, homogenized on-site, aliquotted into appropriate containers, and handled appropriate for the designated analyses. The collected samples will be analyzed at a contracted laboratory for sediment toxicity using the 10-Day *Hyalella azteca* sediment toxicity test, with endpoint of survival.

6.2.1.4. Sediment Chemistry Sampling

Concurrent with sediment toxicity sampling described above, sediment chemistry samples will be collected for analysis of the following:

- grain size
- TOC
- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc)
- Organochlorine pesticides (DDTs, chlordane, dieldrin, endrin, heptachlor epoxide, and lindane (gamma-HCH))
- PAHs (acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b) fluoranthene, benzo(e) pyrene, benzo(g,h,i) perylene, benzo(k) fluoranthene, biphenyl, chrysene, dibenz(a,h) anthracene, dibenzo-thiophene, 2,6-dimethyl-naphthalene, fluoranthene, fluorene, indeno(1,2,3-c,d) pyrene, 1-methyl-naphthalene, 2-methyl-naphthalene, 2-methyl-phenanthrene, naphthalene, perylene, phenanthrene, and pyrene)
- pyrethroids bifenthrin, cyfluthrin, total cypermethrin, total deltamethrin, total esfenvalerate/ fenvalerate, total lambda-cyhalothrin, total cis-permethrin, trans-permethrin).

Samples for analysis of sediment chemistry will be aliquotted from the same homogenate prepared for analysis of sediment toxicity.

6.2.2. Targeted Monitoring Design Parameters

6.2.2.1. General Water Quality Measurements

Field parameters under targeted monitoring design include continuous measurements of dissolved oxygen, specific conductivity, pH, and temperature. These parameters will be measured twice per year, once during the spring and during the August – September timeframe. Monitoring equipment will be placed in the field so that measurements of each of the target parameters will be recorded at fifteen-minute intervals of the course of a one- to two-week deployment.

6.2.2.2. Continuous Temperature Monitoring

Field crews will deploy digital temperature loggers at selected sites within Stormwater Program jurisdictions. The loggers will be deployed for the period April through September, and will be programmed to record temperature data at sixty-minute intervals

6.2.2.3. Pathogens Indicators Sampling

Once per year, during the dry season, field crews will collect water samples for analysis of pathogen indicators. Sampling techniques will include direct filling of containers, preservation in the field (as required), and immediate transfer of samples to analytical laboratories within specified hold time requirements. The following analytes will be measured: (1) *E. coli*, and (2) fecal coliform.

6.2.2.4. Stream Surveys

Once per year, field crews will conduct stream surveys using a modified Unified Stream Assessment (USA) approach (CWP 2005) or equivalent method.

6.3. Project Schedule

The proposed schedule for monitoring activities and deliverables is summarized in Table 6-2 below. The sampling schedule below is based upon the MRP monitoring requirements for those Programs with the most extensive required level of effort. The sampling schedule below is based on the MRP monitoring requirements for those Programs with the most extensive required level of effort. Note that successive sampling years follow the same schedule.

Table 6-2. Program Schedule Timeline.

Activity	Date of Initiation	Date of Completion	Deliverable	Due Date
Preparation for monitoring	10/19/10	08/15/11	Approved QAPP Monitoring Plan	10/01/11
Aquatic Toxicity, Storm Event	10/01/11	04/30/12	Lab results	See below
Continuous Temperature Recording	04/01/12	09/30/12	60-minute interval data April through Sept	See below
Biological Assessment[1], WQ Field Measurements, Nutrients & Chlorine	04/15/12	07/15/12	BMI community analysis, WQ measurements	See below
Continuous WQ Monitoring	04/15/12	07/15/12	15-minute data, 1 to 2 weeks	See below
Aquatic Toxicity, Dry Season	07/01/12	09/30/12	Lab results	See below
Pathogen Indicators	07/01/12	09/30/12	Lab results	See below
Sediment Toxicity & Chemistry	07/01/12	09/30/12	Lab results	See below
Stream Survey	07/01/12	09/30/12	Survey results	See below
Continuous WQ Monitoring	08/01/12	09/30/12	15-minute data, 1 to 2 weeks	See below
Status & Trends Electronic Reporting	10/01/12	01/15/13	SWAMP comparable data report forwarded to Water Board and SFEI for input to CEDEN	01/15/13
Urban Creeks Monitoring Report(s)	10/01/12	01/15/13	Summary and interpretation	03/15/13

[1] RMC goal will be to conduct all bioassessments within a two month period within the 3 month index period each year.

The sampling trips will be conducted at varying frequencies and times dependent on project needs and MRP requirements; exact timing will be determined based on flow, weather and water quality conditions,

and anticipated activities. Laboratory analyses will follow specific status monitoring efforts and the final analytical report will be finished by March 15th of each successive monitoring year.

6.4. Geographical Setting

The RMC Ambient Status Monitoring Program applies to all non-tidally influenced perennial and non-perennial creeks in Alameda, Contra Costa, San Mateo, Santa Clara and Solano Counties that are within Water Board Region 2 boundary and the eastern portion of Contra Costa County that are within Water Board Region 5 boundary (Figure 6-1).

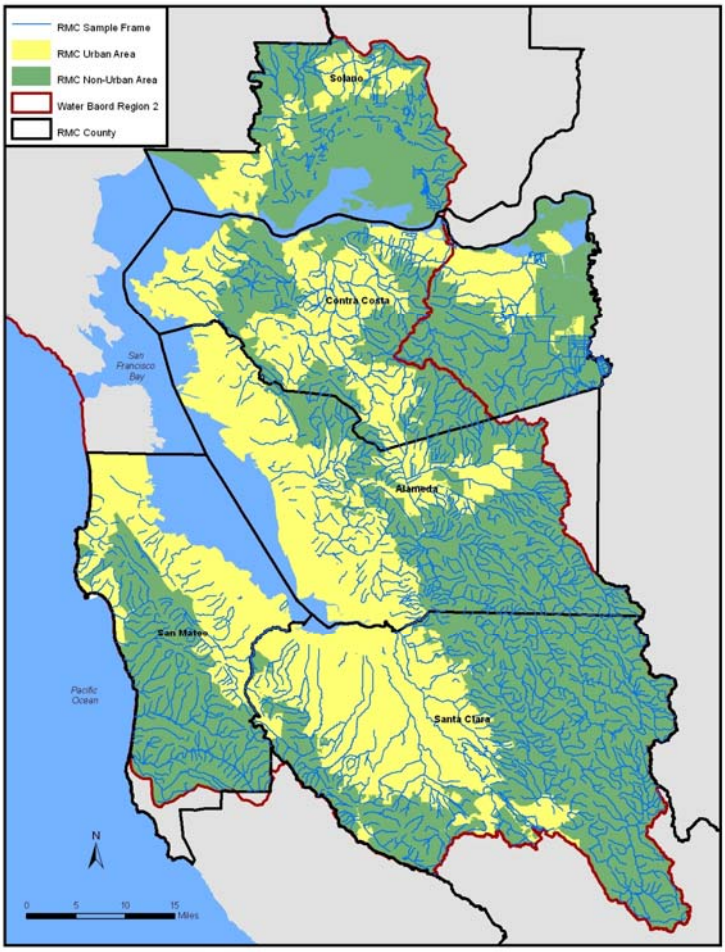


Figure 6-1. RMC Geographical Area

6.5. Constraints

Extreme wet weather may pose a safety hazard to sampling personnel and may therefore impact planned storm event sampling. Extreme dry weather may limit or prevent representative sampling due to low flow and/or harsh conditions that would adversely affect the parameters being monitored. If some planned sampling sites are not accessible because of legal restrictions, then there will be some gaps that could affect some of the conclusions drawn from the data. Budget constraints caused by unexpected problems in accessing the planned monitoring locations or unanticipated analytical difficulties (such as interferences requiring selection of other methods, accepting higher detection levels, or requiring additional clean up of

samples prior to their analysis) could result in fewer locations or samples. Lower measurement quality would result in lowering data quality objectives for the Program.

7. (A7) Quality Objectives and Criteria for Measurement Data

The quantitative measurements that estimate the true value or concentration of a physical or chemical property always involve some level of uncertainty. The uncertainty associated with a measurement generally results from one or more of several areas: (1) natural variability of a sample; (2) sample handling conditions and operations; (3) spatial and temporal variation; and (4) variations in collection or analytical procedures. Stringent QA and QC procedures are essential for obtaining unbiased, precise, and representative measurements and for maintaining the integrity of the sample during collection, handling, and analysis, as well and for measuring elements of variability that cannot be controlled. Stringent procedures also must be applied to data management to assure that accuracy of the data is maintained.

Data Quality Objectives (DQOs) are established to ensure that data collected are sufficient and of 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, and the quantitative goals include completeness, sensitivity (detection and quantization limits), precision, accuracy, and contamination.

DQOs for the non-biological laboratory analytical components of the RMC are described in narrative form in sections below. Specific DQOs for the Program will be based on Measurement Quality Objectives (MQOs) for each analyte. Data acquisition activities will include both field measurements and laboratory analyses, which are specified in Appendix A for RMC Analytes.

Approaches used for data quality assurance for water chemistry do not have the same application to biological data. Instead of using the repeatable physical and chemical properties of target constituents to assess accuracy and precision, biological data are quantified using trained taxonomists relying on organism morphological features. Even for highly trained and experienced taxonomists, if organisms are immature, damaged, or otherwise indistinct, accurate identification can be difficult. Moreover, phylogenies can and do change over time based on increases in taxonomic understanding.

Compounding the challenge between chemistry and biology is the inherent small-scale spatial and temporal variability in biological data. Unlike chemical data where replicate sampling and analysis of samples are expected to be similar, no such expectation exists for biological data. Hence, MQOs in this QAPP have a strong emphasis on training and oversight. In addition, chemical approaches that focus on accuracy do not apply to biological samples. For example, matrix spikes used for chemistry have no parallel in biological samples. Thus, a new approach using independent third party verification through a reference laboratory becomes the primary mechanism for assuring accuracy.

The MQOs in this plan, developed by SWAMP (SCCWRP 2009), focus on five aspects of biological data quality: representativeness, completeness, sensitivity, precision and accuracy. Specifically, these MQOs address the sampling, sorting, and identification phases for producing benthic macroinvertebrate data. The overarching objectives of the MQOs for BMI bioassessment data is to first validate the taxonomic data and ensure that the final data have an overall error ≤10%, and to provide constructive feedback

concerning errors that occurred during identification to the taxonomist with the purpose of allowing them to prevent the errors from occurring in the data in the future. The BMI MQOs and data production processes are summarized in Appendix B.

In general, MQOs were set at levels found in the survey of other BMI bioassessment programs. MQOs were set at 99% for objectives where perfect compliance was a reasonable expectation (e.g., most completeness MQOs). Where perfect compliance was not a reasonable expectation, the MQOs were set at 90%. However, where available data supported more stringent thresholds, MQOs were set at 95%. It is expected that, as data become available, these MQOs will change to reflect the most stringent threshold that can be reasonably attained.

Data quality objectives for benthic algae are not addressed in this version of the RMC Bioassessment QAPP. The SWAMP bioassessment group is currently developing guidelines for quality assurance and quality control for algae data, including the development of laboratory SOPs, on-line identification tools, master taxonomic list, and a standard taxonomic level of effort (similar to what SAFIT develops for BMIs). It is anticipated that SWAMP will incorporate forthcoming tools and documentation into a statewide QAPP for benthic algae. The RMC will update this QAPP to include MQOs for algae as they become available.

There are no SWAMP data quality objectives for physical habitat data that is collected synoptically with benthic macroinvertebrate and algae data. Similar to algae, the RMC will update this QAPP to include MQOs for physical habitat as they become available. Until a statewide SWAMP QAPP is developed that addresses both algae and physical habitat, the RMC will place strong emphasis on training and oversight for both field and laboratory personnel to ensure highest data quality (Section 8).

Quality objectives associated with representativeness, comparability, completeness, sensitivity, precision and accuracy in narrative form for both chemical and biological data are presented below.

7.1. Representativeness

7.1.1 Chemical Data

The representativeness of data is the ability of the sampling locations and the sampling procedures to adequately represent the true condition of the sample sites. Field personnel will strictly adhere to the field sampling protocols to ensure the collection of representative, uncontaminated samples. The most important aspects of quality control associated with chemistry sample collection are as follows:

- Field personnel will be thoroughly trained in the proper use of sample collection equipment and will be able to distinguish acceptable versus unacceptable samples in accordance with pre-established criteria.

- Field personnel are trained to recognize and avoid potential sources of sample contamination (e.g., dirty hands, insufficient field cleaning).

- Samplers and utensils that come in direct contact with the sample will be made of non-contaminating materials, and will be thoroughly cleaned between sampling stations.

- Separate samples will be collected for each analysis, thus avoiding the need for sub-sampling and sample splitting between labs.

- Sample containers will be pre-cleaned and of the recommended type.

7.1.1 Biological Data

There are three scales of representativeness for biological sampling including watershed, reach, and sample scales. In probabilistic studies, representativeness is ensured at the watershed scale by a spatially-balanced random sampling design, where there is a known probability of inclusion for all sites in the study. This representativeness is ensured by evaluating random sites in order for sampling or rejection. For the RMC, sites are evaluated in order within each management unit.

Representativeness of the sampling event is ensured by sampling within the **nominal targets**—that is, sampling occurs at the intended place and time. The MQOs for sampling event representativeness are measured by proximity to the nominal coordinates (i.e., within 300 m or 10 seconds latitude and longitude, as determined by a global positioning system), within the nominal index period (i.e., 4 to 12 weeks after the last major rainfall, or April 15 to July 15), and within the nominal stratum (i.e., the correct stream order and land use). Corrective action for this MQO is to flag samples that are collected more than 10 seconds from the nominal coordinates, and to reject samples collected outside the index period or nominal stratum.

At the reach scale, representativeness is ensured through the use of reach-wide sampling, which is assumed to sample microhabitats in proportion to their abundance at a reach.

At the sample scale, representativeness is ensured through the sample **homogenization** and **subsampling** procedures that give each individual organism an equal probability of selection during the sorting phase. Samples are subsampled into aliquots by evenly spreading the sample onto gridded trays, and grids are randomly assigned a picking order. Sample depth should be no greater than 0.5 inches. For the first subsample, one-eighth of the grid is transferred to a tray or Petri dish for sorting under a dissecting microscope. Organisms overlapping multiple grids (or portions of grids) are selected if the majority (i.e., >50%) of their body is within the grid to be sorted. If <20 organisms are taken from the first grid, then larger portions (i.e., one-quarter, one-half, or a whole grid) of subsequent grids are to be sorted. A minimum of three grids or 25% of the total sample volume must be selected for sorting, and all selected grids are sorted to completion. Sorting is completed when both of the following conditions are met: 1) At least 600 organisms are picked from a sample; and 2) At least three grids are sorted *or* at least 25% of the total sample volume is sorted. For samples with very high densities of organisms, it is possible to pick more than 600 individuals before processing the minimum three grids or 25% of the total sample volume. In these cases, data are flagged, but are still considered valid for analysis and assessment. Corrective action for this MQO include flagging data as potentially not representative.

Representativeness of taxonomic identifications is ensured by identifying all the organisms that were sorted.

Example lab benchsheets for sorting and identification are provided in Appendix C.

7.2. Comparability

Comparability is the degree to which data can be compared directly to other relevant studies. All data collected through implementation of the RMC will also be performed in a manner so that data is comparable with California Surface Water Ambient Monitoring Program (SWAMP) protocols.

7.3. Completeness

7.3.1. Chemical Data

Completeness is defined as the percentage of valid data collected and analyzed compared to the total expected to being obtained under normal operating conditions. Overall completeness accounts for both sampling (in the field) and analysis (in the laboratory). Valid samples include those for analytes in which the concentration is determined to be below detection limits.

Completeness is expressed as overall completeness for a given parameter for each component of the RMC. Under ideal circumstances, the objective is to collect 100 percent of all field samples desired, with successful laboratory analyses on 100% of measurements (including QC samples). However, circumstances surrounding sample collections and subsequent laboratory analysis are influenced by numerous factors, including weather, shipping damage or delays, sampling crew or lab analyst error, and QC samples failing DQOs. An overall completeness of greater than 90% is considered acceptable for the Program.

7.3.2. Biological Data

Completeness describes the success of sample collection and laboratory analysis (both sorting and taxonomic identification), which should be sufficient to fulfill the statistical criteria of the project (Appendix B).

7.3.2.1. Sampling Completeness

Completeness of sampling is measured as the percent of sites sampled and percent of variables measured.

In all biological surveys, all sites selected for sampling must be evaluated in order to achieve the intended statistical power. Therefore, this MQO measures how completely a program fulfills its sampling goals. It is expected that 95% of all sites will be sampled. This MQO accounts for adverse weather conditions, safety concerns, and equipment problems. A loss of 5% of the samples in this study would represent a minimal loss in statistical power to address the study objectives. Corrective action for this DQO is to collect additional samples within the index period, if possible.

All variables must be measured at each site. This MQO ensures that a complete suite of indicators and supporting data are collected at each site in the survey. It is expected that 95% of all variables will be sampled. This MQO applies to biological samples (including macroinvertebrates and benthic algae), all components of physical habitat (e.g., gradient, pebble counts, etc.). This MQO accounts for adverse weather conditions, safety concerns, and equipment problems. A loss of 5% of the samples in this study would represent a minimal loss in statistical power to address the study objectives. Corrective action for this MQO is to revisit sites and measure missing variables within the index period, if possible. In certain cases, the LQAO may require that additional variables be re-measured if synoptic data are required (e.g., resampling water chemistry if toxicity samples are required).

7.3.2.2. Sorting Completeness

There are two MQOs for completeness of sorting activities**: sorting efficiency** and **processing efficiency**.

Sorting efficiency measures how complete the sorting of a sample is, and it is evaluated by resorting the residue of sample aliquots to ensure that no benthic macroinvertebrates remain. Sorted residue is checked by a person different from the original sorter for any remaining organisms, which are then added to the final, sorted sample. If a second sorting technician is not available and a taxonomist performs sorting activities, the same taxonomist may re-sort the remnant for evaluating sorting accuracy. The second sorter, or taxonomist, will check the sorted residue for 10% of the original processing time. Sorting efficiency is calculated as follows:

$$\frac{\textit{Total number of organisms in initial sort}}{\textit{Total number of organisms after resort}}$$

The frequency of sorting efficiency evaluation shall be 100%, and shall be equal to or greater than 95%. Corrective action for this MQO is to train and supervise sorters, and to continue sorting residue until the MQO is achieved (that is, ≤5% of the total number organisms are discovered in the sorted residue).

Processing efficiency is the ability of a taxonomy lab to sort all samples to completion. Processing efficiency is measured as the ability of a lab to obtain adequate numbers of organisms (i.e. ≥600) from all samples or, if <600 organisms are in a sample, that 100% of sample volume has been sorted. Processing efficiency is calculated as follows:

$$\frac{\textit{Total number of completely sorted samples}}{\textit{Total number of samples}}$$

The number of completely sorted samples include all samples containing ≥600 organisms, or samples for which 100% of the material has been sorted. The frequency of processing efficiency evaluation shall be 100%, and shall be equal to or greater than 99%. Corrective action for this MQO is to locate missing samples and document failures.

7.3.2.3. Taxonomic Identification Completeness

The MQO for completeness of taxonomic identifications is greater than or equal to 99% of all samples submitted to the taxonomist. This MQO accounts for loss of samples during shipping and processing. Corrective action for this MQO is to locate missing samples and document failures.

Example lab bench sheets for sorting and identification are provided in Appendix C.

7.4. Sensitivity

7.4.1. Chemical Data

Different indicators of the sensitivity of an analytical method to measure a target parameter are often used including instrument detection limits (IDLs), method detection limits (MDLs), and reporting limits (RLs). Each of these indicators is described below:

The IDL is the lowest concentration of analyte that an analytical instrument can detect that is statistically different from the response obtained from the background instrumental noise. The IDL indicates the absolute sensitivity of the analytical technique or instrument. It is established by adding the analyte to reagent blank water or solvent to give a concentration within a few times the estimated IDL and by calculating the standard deviation for seven or more replicate measurements. The IDL should be determined at least on a quarterly basis for all analyses, or more frequently as specified by laboratory SOPs. For some analytical methods, IDL is dynamically determined through analysis of the background noise during each analytical run.

The MDL is the lowest concentration of analyte in distilled water, solvent, or another appropriate clean matrix that a method can detect reliably and that is statistically different from a blank carried through the complete method, including extraction and pretreatment of the sample. The MDL is specified based on replicate analyses of seven or more measurements with a specified confidence level and defined as three times the standard deviation of replicate analyses of a sample that is 1 to 5 times the estimated detection limit for the analyte of concern. The MDL should be determined at a minimum on an annual basis.

The RL, or practical quantification limit (PQL), is the lowest level at which measurements become quantitatively meaningful and which are achievable on a routine day-to-day basis. The RL is defined as approximately three to four times the MDL or ten times the IDL, or may be defined as the concentration for the minimum calibration point (expressed in concentration units equivalent to those for field samples). Analytical measurements above the MDL but below the RL should be reported as measured, but may be qualified by the laboratory as estimated or detected but not quantified (DNQ).

For the RMC, RL is the measurement of primary interest, consistent with SWAMP Quality Assurance Project Plan (SWAMP QAT, 2008). Target RLs for this study are listed in Appendix B. In some cases, analytical laboratories may not be able to achieve SWAMP targets due to possible interferences present in media sampled.

7.4.2. Biological Data

Sensitivity represents the reporting level that can be expected for each measurement. For field sampling, sensitivity should be to the nearest second for latitude and longitude. For taxonomic identification, taxonomists shall use Level I of the standard taxonomic effort (STE) established by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). SAFIT is a regional, professional, not for profit organization of bioassessment taxonomists. The STE can be found at http://www.safit.org/ste.html.

7.5. Precision

7.5.1. Chemical Data

Precision is used to measure the degree of mutual agreement among individual measurements of the same property under prescribed similar conditions. Overall precision usually refers to the degree of agreement for the entire sampling, operational, and analysis system. It is derived from reanalysis of individual samples (laboratory replicates) or multiple collocated samples (field replicates) analyzed on equivalent instruments and expressed as the relative percent difference (RPD) or relative standard deviation (RSD). Analytical precision can be determined from duplicate analyses of field samples, laboratory matrix spikes, and/or reference material samples. The analytical precision of duplicate measurements of samples or spikes will serve as the overall precision for the Program.

Analytical precision is expressed as the RPD for duplicate measurements.

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

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

In cases where more than one replicate is measured from a single sample or taken from a given site (on a scale presumed to be homogenous), rather than deriving RPDs for each pairwise combination, RSD can instead be calculated:

$$RSD = [stdev (X,,X2 ,..XN)] / [average (X,, X2 , ..XN)]$$

Where: X1 = the first sample result
XN = each successive sample result

If the laboratory-reported RPD (or RSD) exceeds the target for over 30% of the parameters in an analysis, the analysis is rerun. If after rerunning the analysis, RPD (or RSD) for a substantial number of analytes still exceeds the target, the problem is further investigated to identify whether potential problems originate in field sampling or laboratory handling and analysis. Additional corrective actions including flagging of data or reanalysis of samples are taken where possible and as needed.

In cases where there is insufficient field sample to analyze both lab duplicates and matrix spike duplicates, a duplicate of the unspiked sample is generally preferred, due to the possibility of spiking too high, resulting in precision measurement for a concentration range not found in typical samples. Analyzing a laboratory replicate for a field sample different from that used for matrix spikes can alleviate a problem of insufficient sample material. In extreme cases where there is sufficient material for only a single analysis of each sample from the Program, other samples such as blank spikes, reference materials, or samples from another project may be used to evaluate analytical precision, again with caveats on the relevance of evaluations for samples with much higher concentrations.

7.5.2. Biological Data

Although conventional approaches to quality assurance assess precision using replicate measurements, biological data require a different approach. Replicate field samples are of little use to assessing precision because there is no reasonable expectation that replicates will produce identical data. Several classic papers in benthic ecology has shown that even within very small spatial scales (e.g., <1 m), habitats and benthic communities can vary significantly (e.g., Needham and Usinger 1956, Chutter 1972). This variability in community structure can affect assessment indices, such as IBIs. Therefore, it is not possible to determine whether differences in BMI communities are attributable to natural variability or sampling error. Unlike replicates of water chemistry samples, replicate biological samples do not provide a valid estimate of precision in the sampling method.

7.5.2.1. Estimates of variability

Field replicates can be evaluated to assess the intrinsic variability arising from small scale spatial and temporal heterogeneity. These evaluations will be reported as **standard deviations** and **coefficients of variation** for quantitative data (e.g., species richness, IBI, Coleoptera richness, EPT richness, predator taxa, % collector individuals, % intolerant individuals, % non-insect taxa, and % tolerant taxa).

7.5.2.2. Random Error Rate

Random errors are defined as misidentifications that are made inconsistently within a taxon, and decrease the precision of bioassessments. They are usually indicative of sub-optimal working conditions for the taxonomist, rather than the lack of taxonomic expertise.

Random errors occur in two ways: 1) the original lab mistakenly identifies a single taxon as multiple taxa; and 2) the original lab mistakenly identifies multiple taxa as a single taxon The first precision DQO for taxonomic identification is the number of random errors in identifications determined by a re-identification of samples by expert taxonomists at a reference laboratory. The frequency of re-identification shall be at least 10% of all samples or one sample per lab per project, whichever is greater. It is expected that the same reference lab and samples used for quality assurance checks of taxonomic identification accuracy will be used to assess identification precision. The error rates shall be calculated as follows:

[(# of taxa identified as multiple taxa by original lab) + (# taxa identified by original lab consisting of multiple taxa)]/(# of taxa identified by the reference lab).

This MQO is calculated for an entire batch of samples submitted for quality assurance check, and not for individual samples. Examples of calculations of this MQO are provided in Appendix D.

All random errors are corrected before data are submitted to the database. An error rate <10% is considered acceptable. If a higher error rate is observed, an additional 10% of all samples shall be submitted for external re-identification. This quality control check will be repeated until a sample lot has acceptable error rates or all samples have been checked by the reference lab.

Additional corrective actions for this MQO include training and supervision of the taxonomist, and an internal re-identification of samples not submitted for external review.

7.5.2.3. Systemic Error Rate

The second precision DQO will be assessed shall be **systemic errors**, which occurs when a specific taxon is consistently misidentified. Systemic errors are the result of errors that are made consistently, and are usually indicative of a taxonomist lacking up-to-date knowledge of particular taxa.

Systemic errors are calculated as the number of common taxa (i.e., those occurring at least 5 times in a batch of samples submitted for quality assurance checks) consistently misidentified as the incorrect taxon (i.e., all individuals were given the same, but incorrect, identification), as a proportion of all the common taxa identified in a batch.

(# of common taxa consistently misidentified)/(# of common taxa identified by the reference lab).

This MQO is calculated for an entire batch of samples submitted for quality assurance check, and not for individual samples. Examples of calculations of this MQO are provided in Appendix D.

All systemic errors are corrected before data are submitted to the database. An error rate <10% is considered acceptable. If a higher error rate is observed, an additional 10% of all samples shall be submitted for external re-identification. This quality control check will be repeated until a sample lot has acceptable error rates or all samples have been checked by the reference lab.

The original lab is expected to correct systemic errors in all samples prior to submitting data.

Additional corrective actions for this MQO include training and supervision of the taxonomist, and an internal re-identification of all samples containing the erroneously identified taxa.

7.5.2.4. Taxonomic Resolution Error Rate

Taxonomic resolution errors occur when the original lab does not identify taxa to the correct taxonomic level. Poor taxonomic resolution reduces precision of bioassessments. Taxonomic resolution errors may occur in two ways: (1) **Low resolution errors**, where the lab may leave the identification at too coarse a level when a more fine determination is possible; and (2) **High resolution errors**, where the lab makes an identification at a finer level than the condition of the specimens or the STE will support.

Error rates for low resolution errors and high resolution errors are calculated separately, and added to estimate the overall error rate for taxonomic resolution.

The low resolution error rate is calculated as follows:

$$\frac{\text{\# of individuals with lower than appropriate resolution}}{\text{Total \# of individuals}}$$

The high resolution error rate is calculated as follows:

$$\frac{\text{\# of individuals with higher than appropriate resolution}}{\text{Total \# of individuals}}$$

The total taxonomic resolution error rate is the sum of the high and low resolution error rates:

$$\text{Low resolution error rate} + \text{High resolution error rate}$$

Examples of calculations of this MQO are provided in Appendix D.

All taxonomic resolution errors are corrected before data are submitted to the database. A total error rate <10% is considered acceptable. If a higher error rate is observed, an additional 10% of all samples shall be submitted for external re-identification. This quality control check will be repeated until a sample lot has acceptable error rates or all samples have been checked by the reference lab.

This quality control check will be repeated until a sample lot has acceptable error rates or all samples have been checked by the reference lab.

The original lab is expected to correct taxonomic resolution errors in all samples prior to submitting data.

Additional corrective actions for this MQO include training and supervision of the taxonomist, and an internal re-identification of all samples containing the erroneously identified taxa.

7.6. Accuracy

7.6.1. Chemical Data

Accuracy describes the degree of agreement between a measurement (or the average of measurements of the same quantity) and an acceptable reference or true value. The "true" values of the parameters measured in the Program are unknown and the overall accuracy (including representativeness) cannot be assessed. However, accuracy of certain portions of a measurement process can be evaluated. For the Study, analytical accuracy, characterized through the use of reference samples and laboratory matrix spikes in the laboratory operation, is considered acceptable for the overall accuracy of the Program. Accuracy is expressed as percent recovery for reference materials:

$$\% \text{ Recovery} = MV / EV$$

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

For matrix spikes, recovery is calculated from the original sample result, the expected value (EV = native + spike concentration), and the measured value with the spike (MV):

$$\% \text{ Recovery} = (MV-N) \times 100\% \, (EV-N)$$

Where: MV = the measured value
EV = the true expected (reference) value
N = the native, unspiked result

Surrogate standards are also spiked into samples for some analytical methods and used to correct for losses in the analytical process. Although recoveries on surrogates are to be reported, control limits for surrogates are method and laboratory specific, and no project specific recovery targets for surrogates are specified, so long as overall recovery targets for accuracy (with matrix spikes and reference materials) are achieved. Where applicable, data will be reported as surrogate-corrected values.

Recovery targets for RMC analytes are shown in Appendix A. If a laboratory's reported recovery falls outside of this range for over 30% of reported parameters in analysis of reference materials, the problems need to be identified, corrected, and the instrument re-calibrated, and samples in that batch rerun if possible. If the recovery for a matrix spike/duplicate falls outside of target range, possible causes must be investigated, and the analysis needs to be rerun where possible. If the spike continues to fall outside of the target range, the analysis will be rerun if sufficient material is available, and/or other corrective actions such as data flagging may be taken in consultation with CIMC.

No individual analyte value shall exceed the target limits more than once in consecutive analyses without appropriate documentation and consultation with the CIMC and/or CQAO. Additional leeway may be granted for analytes with reference but not certified values, or for those with 95% confidence intervals already outside the recovery targets. Due to the inherent variability in analyses near the method detection

limit, control limit criteria for relative accuracy only apply to analytes with true values that are greater than three (3) times the MDL established by the laboratory.

In cases where Program field samples have insufficient material, the laboratory may instead spike a similar blank matrix (e.g., sand for sediment) or samples from other projects with similar expected concentrations. Spikes should be at least double the native concentrations in samples to allow quantitative assessment, but less than 100 times higher. If spiking concentrations are found too high in the first analyzed batch, additions in later analysis batches must be reduced. If expected native concentrations are unknown, spikes should be made at approximately 100 times the MDL or 10 times the quantification limit, and adjusted upward in later batches as needed.

7.6.2. Biological Data

7.6.2.1. Sampling Accuracy

Sampling accuracy measures how close field measurements are to the true value. For bioassessment sampling, it is not possible to assess accuracy because the true value is not known. However, the accuracy of several components of field sampling can be assessed, as described below.

There is no direct way to assess the accuracy of other components of physical habitat assessments that accompany bioassessment because true values are typically not known. Instead, data quality is assured through **assessments** (described in Section 20) conducted by the Project QAO at least once per crew per sampling season. According to his or her professional judgment, the LQAO may require additional assessments or trainings of crews whose performance does not comply with established protocols.

7.6.2.2. Sorting Accuracy

Sorting accuracy shall also be assessed as **recount accuracy**. Recount accuracy is evaluated by an independent recount of the number of organisms in a sample. The frequency of recount accuracy shall be at least 10% of all samples or one sample per lab per project (whichever is greater) each year. Recount accuracy shall be conducted at a designated reference laboratory. For the RMC, the designated reference laboratory is the Aquatic Bioassessment Lab (ABL).Recount accuracy is calculated as follows:

$$\frac{\textit{Number of identified organisms in the smaller of the two counts}}{\textit{Number of identified organisms in the larger of the two counts}}$$

Recount accuracy shall be equal to or greater than 95%. Examples of calculations of this MQO are provided in Appendix D. Corrective action for this MQO is to train and supervise sorters.

7.6.2.3. Taxonomic Identification Accuracy

Taxonomic identification accuracy shall be assessed through the independent **re-identification** of samples by expert taxonomists at a reference laboratory. The frequency of re-identification shall be at least 10% of all samples or one sample per lab per project (whichever is greater) each year. It is expected that the same lab and samples used to assess sorting accuracy will be used to assess identification accuracy. The designated reference laboratory is the Aquatic Bioassessment Lab (ABL) of the California Department of Fish and Game.

Identification accuracy shall be assessed as error rate using the following three calculations:

Taxa count error rate:

$$\frac{|(\#\ Taxa\ in\ Final\ ID - \#\ Taxa\ in\ Initial\ ID)|}{\#\ Taxa\ in\ Final\ ID}$$

Taxa ID error rate:

$$\frac{\#\ Taxa\ misidentified}{\#\ Taxa\ in\ Final\ ID}$$

Individual ID error rate:

$$\frac{\#\ Individuals\ misidentified}{\#\ Individuals}$$

These three DQOs were selected because each provides different sensitivities to different types of errors.

Taxa count error rate measures the accuracy of richness estimates provided by the original lab. Richness metrics are the basis of many metrics used in IBIS, as well as RIVPACS-type O/E scores, and this MQO is a broad-stroke measure of the impact of taxonomic identification errors on bioassessment indices. This MQO is robust to errors that do not affect richness (e.g., multiple errors that balance each other out, or do not affect all the individuals within a taxon).

Taxonomic ID error rate provides greater sensitivity than taxa count error rate by measuring the number of misidentified taxa as a portion of the total number of taxa in a sample. Thus, errors that do not affect total richness can be assessed by this MQO. However, it does not differentiate between errors affecting common taxa and those affecting rare taxa.

Individual ID error rate is a measure of the number of incorrectly identified individuals in a sample, and is the most sensitive of these three MQOs. Unlike taxa count error rate and taxa ID error rate, it is based on the number of misidentified individuals, and is therefore more sensitive to errors affecting common taxa than to those affecting rare taxa.

The re-identification error rate will be less than 10% by any of these measures.

Example lab benchsheets for sorting and identification are provided in Appendix C. Examples of calculations of these MQOs are provided in Appendix D. Corrective action for these MQOs is to train and supervise taxonomists, and to update data for analysis.

This quality control check will be repeated until a sample lot has acceptable error rates or all samples have been checked by the reference lab. Identifications determined by the reference lab shall be used to substitute identifications made by the original lab. In the case that the original lab disputes the identifications made by reference labs, specimens may be sent to designated third lab or outside experts. If the reference lab encounters labeling errors (e.g., labels for two taxa are switched), the errors are noted

in the QA report, but the reference lab can, at their discretion, contact the original lab to verify the error, and proceed with the QA check with correct labeling.

7.7. Contamination

Collected samples may inadvertently be contaminated with target analytes at many points in the sampling and analytical process, from the materials shipped for field sampling, to the air supply in the analytical laboratory. Blank samples evaluated at multiple points in the process chain help assure that pollutants measured in samples actually originated from the target matrix in the sampled environment and are not artifacts of the collection or analytical process.

Method blanks (also called laboratory reagent blanks, extraction blanks, procedural blanks, or preparation blanks) are used to assess laboratory contamination during all stages of sample preparation and analysis. The method blank will be processed through the entire analytical procedure in a manner identical to the samples. Method blanks should be less than the MDL or not exceed a concentration of 10% of the lowest reported sample concentration. A method blank concentration greater than two times the MDL or 10% of the lowest reported sample concentration will require corrective action to identify and eliminate the source(s) of contamination before proceeding with sample analysis. If eliminating the blank contamination is not possible, all impacted analytes in the analytical batch shall be flagged. In addition, a detailed description of the likely contamination source(s) and the steps taken to eliminate/minimize the contaminants shall be included in narrative of the data report. If supporting data is presented demonstrating sufficient precision in blank measurement that the 99% confidence interval around the average blank value is less than MDL or 10% of the lowest measured sample concentration, then the average blank value may be subtracted.

Equipment blanks are generated by the personnel responsible for cleaning sampling equipment. Equipment blanks must be analyzed before the equipment is shipped to the sampling site. In order to accommodate any necessary corrective action, equipment blank results should be available well in advance of the sampling event. To ensure that sampling equipment is contaminant-free, water known to be low in the target analyte(s) must be processed though the equipment as during sample collection. The specific type of water used for blanks is selected based on the information contained in the relevant sampling or analysis methods. The water must be collected in an appropriate sample container, preserved, and analyzed for the target analytes (in other words, treated as an actual sample). The inclusion of field blanks is dependent on the requirements specified in the relevant MQO tables, or in the sampling method or SOP. Typically, equipment blanks are collected when new equipment, equipment that has been cleaned after use at a contaminated site, or equipment that is not dedicated for surface water sampling is used. An equipment blank must be prepared for dissolved metals in water samples whenever a new lot of filters is used.

A field blank is collected to assess potential sample contamination levels that occur during field sampling activities. Field blanks are taken to the field, transferred to the appropriate container, preserved (if required by the method), and treated the same as the corresponding sample type during the course of a sampling event. The inclusion of field blanks is dependent on the requirements specified in the relevant MQO tables or in the sampling method or SOP. Field blanks for other media and analytes should be conducted upon initiation of sampling. If field blank performance is acceptable, further collection and analysis of field blanks should be performed on an as-needed basis.

8. (A8) Special Training Needs / Certification

8.1. Specialized Training or Certification

All field crew will be required to take training in sampling procedures described in both BMI and Algae Bioassessment SOPs (see Section 11). It is strongly recommended that crews contain no fewer than three members because the RMC measures several indicators at each site (i.e., BMI and benthic algae communities, physical habitat and water chemistry). Inadequate staffing of field crews is one of the most common sources of data errors, and may result in costly corrective actions or data deficiencies. Bioassessment training is offered several times each year by the California Department of Fish and Game (CDFG). Crew chiefs are responsible for ensuring the safety of the crew and must use his or her discretion to end sampling if conditions become unsafe.

Analytical laboratories are to be certified for the analyses conducted at each laboratory by ELAP, NELAP, or an equivalent accreditation program as approved by the PM.

Biological laboratory analysis requires years of experience and mentoring by a qualified taxonomist. It is strongly recommended that all benthic macroinvertebrates taxonomists become a member of the Southwest Association of Freshwater Invertebrate Taxonomists (www.SAFIT.org). Membership in organizations like SAFIT offers several benefits to project participants, such as opportunities for continuing education, taxonomic workshops, reviews of current literature, and intercalibration exercises. Taxonomists are expected to participate in at least one taxonomic workshop focusing on benthic macroinvertebrates per year. Similar requirements for training will be applied to RMC contracted algal taxonomists when laboratory protocols and training workshops become available.

All agencies, contractors, and participating laboratories must maintain rigorous field and laboratory training programs based on written, oral and performance-based guidelines. Training and performance are also evaluated on an ongoing basis based, in part, on the QA parameters defined in this plan. Standard Operating Procedures (SOPs) for field, laboratory, and data management tasks have been developed and shall be updated on a regular basis in order to maintain procedural consistency. The maintenance of an SOP Manual will provide project personnel with a reference guide for training new personnel as well as a standardized information source that personnel can access.

To ensure consistent and comparable field techniques, this project shall include presurvey field training and *in-situ* field assessments. The presurvey training will focus on sampling methods and field logistics including compositing and netting patterns. *In-situ* assessments will consist of equipment checks, good sampling practices, record-keeping, and health and safety. Assessments are conducted annually, once for each crew, although more frequent assessments may be conducted at the LQAO's discretion.

8.2. Training and Certification Documents

All training materials, handouts, class rosters, and certification records related to the RMC will be kept at office of the Creek Status Monitoring Coordinator. All laboratories contracted through this Program are required to maintain their own training documents and certification records, and to make these available to RMC representatives as requested.

9. (A9) Documents and Records

The PM will also ensure that all field measurements and laboratory analytical data are submitted to the Water Board no later than January 15 of each year, reporting on all data collected during the foregoing October 1 through September 30 period. Electronic Status & Trends Data Reports shall be in a format compatible with the SWAMP database. In order to accomplish this, key parts of the information management system employed by the RMC will be standardized throughout the central and local levels implementing the field operations, laboratory analyses, and data management process. A discussion of some of the key parts of the documentation process is shown below.

9.1. Field Documentation

9.1.1. Sampling Plans, COCs, and Sampling Reports

PMLs will be responsible for development and submission of field sampling plans and sampling reports to the PM. Field sampling crews will collect records for sample collection, and will be responsible for maintaining these records in an accessible manner. Samples sent to analytical laboratories will include standard Chain of Custody (COC) procedures (see SOP FS-9, Sample Collection, Handling, and Chain of Custody Procedures) and forms; field crews will maintain a copy of originating COCs at their individual Stormwater Program headquarters. Analytical laboratories will collect records for sample receipt and storage, analyses, and reporting. All records, except lab records, generated by this Program will be stored at the office of the PML for the local program conducting the monitoring. All laboratory records pertinent to this Program will be maintained either at the office of the CIMC or LIMC per the reference IMS.

9.1.2. Data Sheets

All field data gathered by this Program will be recorded on standardized SWAMP field data entry forms, as described in more detail in Element 19 Data Management and RMC SOP FS-10, Completion and Processing of Field Datasheets.

9.1.3. Field Logbooks

In addition to completing field data sheets, sampling personnel may record relevant information in bound logbooks. All information should be recorded in permanent ink. Any changes made to recorded information will be made using single strike-through and will be initialed and dated by the person making the change.

9.1.4. Photographic Documentation

Photographic documentation is an important part of sampling procedures. An associated photo log will be maintained documenting sites and subjects associated with photos. If an option, the date function on the camera shall be turned on. A copy of all photographs should be provided to the LIMC, preferably on CD-ROM, at the conclusion of sampling efforts and maintained for project duration.

9.2. Laboratory Documentation

The RMC Creek Status Monitoring Program requires specific actions to be taken by contract laboratories, including requirements for data deliverables, quality control, and on-site archival of project-specific information. Each of these aspects is described below.

9.2.1. Data Reporting Format

Each laboratory will deliver data in electronic formats to one RMC recipient at both the central and local level, the CIMC and LIMC, respectively. Each will be responsible for storage and safekeeping of these records at their respective level. Each will maintain at least two back-up copies on compact disc or off-site storage. In addition, each laboratory will deliver hardcopy data to the LIMC for use in data QA and for long-term storage.

The analytical laboratory will report the analytical data to the CIMC and LIMC via an analytical report consisting of, at a minimum:

1. Letter of transmittal
2. Chain of custody information
3. Analytical results for field and quality control samples
4. Case narrative
5. Copies of all raw data.

The LQAO or CQAO will review the data deliverables provided by the laboratory for review of QA/QC. In addition to the laboratory's standard reporting format, all results meeting data quality objectives and results having satisfactory explanations for deviations from objectives shall be reported in tabular format on electronic media, in a format consistent with RMC templates and standard business rules (see relevant SOPs, Data Management). The specific format and any needed templates for this electronic data deliverable (EDD) are to be agreed upon by the CIMC and each LPM prior to onset of any sampling activities related to that laboratory.

As they become available, and after internal laboratory QA/QC review, draft data produced from laboratory analyses are sent in electronic format. These draft data are not for distribution or application in any manner, other than for the initial review by RMC staff. Upon completion of their preliminary review of the draft data, RMC staff will provide any concerns/comments (if any) in writing to the respective laboratory and the Program Manager. RMC staff will notify the lab if it approves of this draft data in its current format. If there are any concerns regarding the draft data, the concerns must be addressed in writing by the analytical lab. After the concerns are addressed and corrective actions taken (such as reviewing for transcription errors, reanalysis, and data flagging), data will be resubmitted as draft data for re-review. After RMC staff concerns have been addressed, they will notify the laboratory and approve the data as final.

Documentation for analytical data is kept on file at the laboratories, or may be submitted with analytical results. These may be reviewed during external audits of the Program, as needed. These records include the analyst's comments on the condition of the sample and progress of the analysis, raw data, instrument printouts, and results of calibration and QC checks. Paper or electronic copies of all analytical data, field data forms and field notebooks, raw and condensed data for analysis performed on-site, and field instrument calibration notebooks are kept as part of the Program archives for a minimum period of eight years.

9.2.2. Other Laboratory QA/QC Documentation

All laboratories will have the latest version of the RMC QAPP in electronic format. In addition, the following documents and information from the laboratories will be current, and they will be available to all laboratory personnel participating in the processing of RMC samples:

1. Laboratory QA plan: Clearly defines policies and protocols specific to a particular laboratory, including personnel responsibilities, laboratory acceptance criteria, and corrective actions to be applied to the affected analytical batches, qualification of data, and procedures for determining the acceptability of results.

2. Laboratory SOPs: Contain instructions for performing routine laboratory procedures, describing exactly how a method is implemented in the laboratory for a particular analytical procedure. Where published standard methods allow alternatives at various steps in the process, those approaches chosen by the laboratory in their implementation (either in general or in specific analytical batches) are to be noted in the data report, and any deviations from the standard method are to be noted and described.

3. Instrument performance information: Contains information on instrument baseline noise, calibration standard response, analytical precision and bias data, detection limits, scheduled maintenance, etc.

4. Control charts: Control charts are developed and maintained throughout the Program for all appropriate analyses and measurements for purposes of determining sources of an analytical problem or in monitoring an unstable process subject to drift. Control charts serve as internal evaluations of laboratory procedures and methodology and are helpful in identifying and correcting systematic error sources. Control limits for the laboratory quality control samples are ±3 standard deviations from the certified or theoretical concentration for any given analyte.

Records of all quality control data, maintained in a bound notebook at each workstation, are signed and dated by the analyst. Quality control data include documentation of standard calibrations, instrument maintenance and tests, and analyses of CRMs. Control charts of the data are generated by the analysts monthly or for analyses done infrequently, with each analysis batch. The laboratory quality assurance specialist will review all QA/QC records with each data submission, and will provide QA/QC reports to the LIMC with each batch of submitted field sample data.

9.3. Program Management Documentation

The CIMC and LIMCs are responsible for managing key parts of the RMC information management systems. These efforts are described below.

9.3.1. QAPP

All original QAPPs will be held by LIMC. This QAPP and its revisions will be distributed to all parties involved with the Program, including PMLs and Water Board representative(s). Copies will also be sent to the each participating analytical laboratory's Project Manager for internal distribution.

Associated with each update to the QAPP, the PM will notify PMLs and Water Board representative of the updated QAPP, with a cover memo compiling changes made. After appropriate distributions are made

to affected parties, these approved updates will be filed and maintained by the CQAO for the Program. Upon revision, the replaced QAPPs will be discarded.

9.3.2. Program Information Archival

The PM will oversee the actions of all personnel with records retention responsibilities, and will arbitrate any issues relative to records retention and any decisions to discard records. Each analytical laboratory will archive all analytical records generated for this Program. Each LIMC will be responsible for archiving all other records associated with implementation of the Program within their jurisdiction. The RMC Program Manager will be responsible for archiving all management-level records.

Persons responsible for maintaining records for this Program are shown in Table 9-1.

Table 9-1 - Document and Record Retention, Archival, and Disposition

Type	Retention	Archival	Disposition
Field Datasheets	8	LIMC	Maintain indefinitely
Chain of Custody Forms	8	LIMC	Maintain indefinitely
Calibration Logs	8	LIMC	Maintain indefinitely
Raw Analytical Data	8	LIMC, CIMC	Recycling
Lab QC Records	8	LIMC, CIMC	Recycling
Electronic data deliverables	8	LIMC, CIMC	Maintain indefinitely
Reports	8	PM	Maintain indefinitely
Field Audits	8	LQAO, CQAO	Maintain indefinitely

The PM will oversee the actions of all personnel with records retention responsibilities, and will arbitrate any issues relative to records retention and any decisions to discard records. As discussed previously, each analytical laboratory will archive all analytical records generated for this Program. Each PML will be responsible for archiving all other records associated with implementation of the RMC within their jurisdiction. The PM will be responsible for archiving all management-level records.

The PM will also ensure that all field measurements and laboratory analytical data are compiled in a format compatible with the SWAMP protocols. In order to accomplish this, individual LIMCs will submit field measurement data in electronic templates designed and distributed by the CIMC. All field operation records will be entered into electronic formats and maintained in a dedicated directory managed by each individual LIMC. Each file will also have at least two back-up copies on compact disc or off-site storage.

10. (B1) Sampling Process Design

The RMC Creek Status Monitoring Program includes both probabilistic and targeted creek status monitoring designs to comply with the MRP C.8.c[2] and C.8.e provisions. A summary of the probabilistic and targeted creek status monitoring designs is presented below. Both sample designs are discussed in greater detail in the RMC Creek Status and Long-Term Trends Monitoring Plan (RMC Monitoring Plan) (BASMAA 2011).

10.1. Probabilistic Design

The probabilistic survey design utilizes the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Service (USEPA) and the University of Oregon (Stevens and Olson 2004). Sample sites will be selected using the GRTS approach from a sample frame that consists of a stream network geographic information system (GIS) data set within the RMC boundary. The RMC sampling frame includes non-tidally influenced perennial and non-perennial creeks within five management units that are located in the San Francisco Bay Area. The management units represent the area within five counties (Alameda, Contra Costa, Santa Clara, San Mateo and Solano) that occur within the Water Board Region 2 boundary, with the exception of Contra Costa, which also includes the eastern portion of the county that is a part of Water Board Region 5. These areas together represent the sample frame universe for the probabilistic design (Figure 10-1). These management units represent areas managed by storm water programs associated with the RMC.

Sample sites are stratified by management unit and weighed by land use (i.e., urban versus non-urban). The stratification was done to ensure that a predetermined number of sites will be sampled in each management unit corresponding to requirements described in Table 8.1 of the MRP. The sampling frame was weighed so approximately 80% of sites would occur in urban land use and 20% of sites in non-urban land use. Urban land use was defined as the area occurring within Census 2000 Urban Area and/or within city boundaries within the five counties (Figure 10-1). The exception was Solano County, where urban area was defined as only the area within Cities of Vallejo, Suisun City and Fairfield. The number and frequency of sample sites for each management unit is described in RMC Monitoring Plan.

10.2. Targeted Monitoring Design

The targeted monitoring stations and timing of monitoring will be selected with the intent of meeting permit performance standards. The study reaches, sampling stations within each reach, and seasonality of sampling will all be selected using the directed sampling design principle.[3]

[2] 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?".

[3] The sampling design principles used can be defined as follows: Systematic - A deterministic approach in which points are selected deliberately at fixed intervals of area, length, or time; Directed - 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." Random (stratified) - A probabilistic approach in which points are deliberately selected at random at random from a given population of "eligible" points that all have the same chance of being selected. Points are often grouped, or "stratified" by specific attributes of interest. Non-deliberate - none of the above; points are selected anecdotally, or opportunistically, or as dictated by given constraint, or in response to spills, etc.

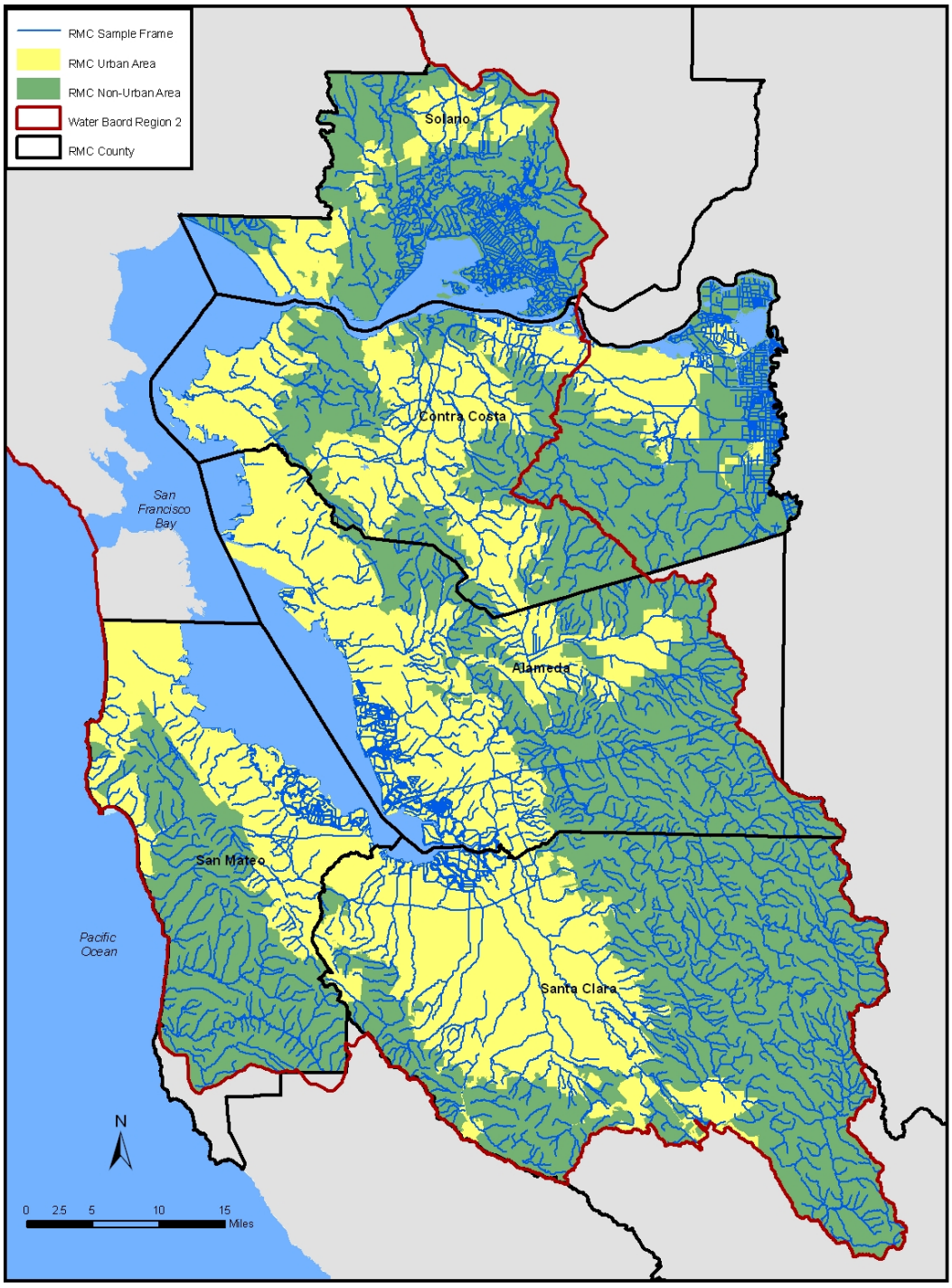


Figure 10-1. The RMC Sample Frame Universe

The total number of site visits will vary depending on the status monitoring parameter (MRP Table 8.1). Stations will be visited at a frequency of one to two times per year, depending on Status Monitoring Parameter type. The planned interval between visits is seasonal. Individual monitoring aspects are described in more detail in the following.

Each SW Program will be responsible for developing sampling and analysis plans in association with conduct of specific field monitoring efforts.

10.3. Sampling Uncertainty

There are multiple sources of potential sampling uncertainty associated with the Creek Status Monitoring Project, including: (1) measurement error; (2) natural (inherent) variability; (3) sample misrepresentation (or poor representativeness); and (4) sampling bias (statistical meaning). Measures incorporated to address these areas of uncertainty are discussed below:

(1) Measurement error combines all sources of error related to the entire sampling and analysis process (i.e., to the measurement system). All aspects of dealing with uncertainty due to measurement error have been described elsewhere within this QAPP.

(2) Natural (inherent) variability occurs in any environment monitored, and is often much wider than the measurement error. Prior work conducted by the Stormwater Programs and others in the field of stormwater management have demonstrated the high degree of variability in environmental media, which will be taken into consideration when interpreting results of the various lines of inquiry.

(3) Sample misrepresentation happens at the level of an individual sample or field measurement where an individual sample collected is a poor representative for overall conditions encountered. To address this situation, the RMC will be developing and implementing a number of QA-related measures, including development of Standard Operating Procedures (SOPs) and auditing of field crews to ensure their proper implementation.

(4) Sampling bias relates to the sampling design employed and whether the appropriate statistical design is employed to allow for appropriate understanding of environmental conditions. To a large degree, the sampling design required by the MRP for Creek Status Monitoring is judgmental, which will therefore incorporate an unknown degree of sampling bias into the Program. There are small measures that have been built into the sampling design to combat this effect (e.g., homogenization of sediments for chemistry and toxicity analyses), but overall this bias will need to be taken into consideration when interpreting results of the various investigations.

11. (B2) Sampling Methods

The RMC Creek Status Monitoring Program targeted sampling involves the collection of samples for a variety of analytes in water, sediment, tissue, and biota. Collections are conducted by multiple organizations (Stormwater Programs) using a variety of sampling protocols, depending on the media and parameter monitored. A brief summary of relevant methods is presented below, with detailed descriptions provided in associated SOPs (Table 11-1).

Table 11-1. List of Relevant SOPs Governing Methods Employed for RMC Creek Status Monitoring Program.

SOP #	SOP	Source
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements	RMC
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity	RMC
FS-3	Field Measurements, Manual	RMC
FS-4	Field Measurements, Continuous General Water Quality	RMC
FS-5	Temperature, Automated, Digital Logger	RMC
FS-6	Collection of Bedded Sediment Samples for Chemical Analysis and Toxicity	RMC
FS-7	Field Equipment Cleaning Procedures	RMC
FS-8	Field Equipment Decontamination Procedures	RMC
FS-9	Sample Container, Handling, and Chain of Custody Procedures	RMC
FS-10	Completion and Processing of Field Datasheets	RMC
FS-11	Site and Sample Naming Convention	RMC
FS-12	Site Evaluation Guidance	RMC
N/A	Unified Stream Assessment: A User's Manual, v2.0	CWP (2005)

11.1. Biological Sampling

Biological sampling methods applied by the RMC are summarized in FS-1 BMI and Algae Bioassessments and Physcial Habitat Assessments. BMI and algae samples are collected at 11evenly spaced transects at each monitoring site using the Reachwide Benthos (RWB) method. Sampling positions within each transect is alternated between the left, center and right positions along each transect (25%, 50% and 75% of the wetted width, respectively). BMI samples are collected using a D-shaped kick net and algae samples are collected using three different methods corresponding to type of substrate found at the sample location. The 11 subsamples for both BMI and algae are composited into a single "reachwide" sample. One composited BMI sample, and four algae samples (subsampled from composite sample) consisting of soft-bodied algae, diatoms, chlorophyll a, and ash-free dry mass) are collected from each site.

Physical habitat assessments (PHAB) incorporate quantitative and qualitative measurements taken at each of the 11 transects and 10 inter-transects. RMC will collect PHAB measurements following procedures defined in the BASIC level of effort (Ode 2007), with the following exceptions as defined in the FULL level of effort (as prescribed in the MRP): stream depth and pebble count + CPOM, cobble embeddedness, discharge measurements and in-stream habitat score. In addition, the percent algal cover (measured during point intercept with pebble count), will be measured at each transect and inter-transect.

11.2. Automated Measurements of General Water Quality and Temperature

The RMC will implement standard methods associated with continuous measurement of water quality and temperature that are identified in RMC SOPs FS-4 and FS-5, respectively. Methods associated with the continuous water quality monitoring include procedures for the maintenance, calibration, deployment, post-deployment and data evaluation of multi-probe instrument (sonde) YSI 6600 series or equivalent. Methods used for automated temperature monitoring include accuracy checks, deployment and data evaluation for temperature data loggers. Automated monitoring equipment will be record measurements using internal power source (i.e., batteries). Deployment sites will be carefully considered to ensure data collected will meet monitoring objectives and equipment is properly installed to reduce potential for theft and vandalism. Field staff will conduct proper checks of equipment to ensure data meets MQOs for precision and accuracy.

11.3. Water Sampling

The RMC will implement standard methods associated with water quality sampling and toxicity testing that is identified in RMC SOPs FS-2. Field Crews will collect water samples in the field in a way that neither contaminates, loses, or changes the chemical form of the analytes of interest. The samples will be collected in the field into pre-cleaned sample bottles of a material appropriate to the analysis to be conducted. Pre-cleaned sampling equipment is used for each site, whenever possible and/or when necessary. Appropriate sampling technique and measurement equipment may vary depending on the location, sample type, sampling objective, and weather. Water chemistry and bacteriological samples, as required, are collected at the same location. Water samples are best collected before any other work is done at the site. If other work (i.e., sediment sample collection, flow measurement or biological/habitat sample collection or assessment) is done prior to the collection of water samples, it might be difficult to collect representative samples for water chemistry and bacteriology from the disturbed stream. Care must be taken, though, to not disturb sediment collection sites when taking water samples.

11.3.1. Summary of Typical Procedure for Collection of Water Samples for Analyzing Trace Metals, Organics, Conventional Constituents, and for Toxicity Testing

All samples collected for analysis of trace metals, organics, conventional constituents, and for toxicity testing in water will be collected using clean techniques that minimize sample contamination. Sampling methods will generally conform to EPA "clean" sampling methodology described in Method 1669: Sampling Ambient Water for Trace Metals (USEPA 1996). Samples will generally be collected from shore in wadeable waters, in most cases by using a near-surface grab sample, as peristaltic pump and Teflon tubing setups are not required for MRP parameters. Grab samples will be collected into appropriate pre-cleaned containers and aliquoted into glass, polyethylene, or Teflon sample containers appropriate for the analyses to be performed (see Sample Handling Requirements Tables in Section B3, Element 12), or will be collected directly into the sample containers, if appropriate. After collection, field-collected samples will be stored at between 0 and 6°C until arrival at the contract laboratory.

11.4. Sediment Sampling

The RMC will implement standard methods associated with the collection of bedded sediment sampling and toxicity testing that is identified in RMC SOPs FS-6. RMC sampling personnel will collect sediment samples in the field in a way that neither contaminates, loses, or changes the chemical form of the analytes of interest. The samples will be collected in the field into previously cleaned and tested (if

necessary) sample bottles of a material appropriate to the analysis to be conducted. Pre-cleaned sampling equipment is used for each site, whenever possible and/or when necessary. Appropriate sampling technique and measuring equipment may vary depending on the location, sample type, sampling objective, and weather.

Bed sediment samples are collected after any water samples have been collected. Care must be taken not to sample sediments that have been disturbed in any manner by field personnel collecting water or other samples. Sediment samples are collected into a composite container, where they are thoroughly homogenized in the field, and then aliquoted into separate jars for chemical or biological analysis. Sediment samples for metals and organics are submitted to the respective analytical laboratories in separate glass jars, which have been pre-cleaned according to laboratory protocol.

Many of the chemical constituents of concern are adsorbed onto fine particles. One of the major objectives in selecting a sample site, and in actually collecting the sample while on site, is to obtain recently deposited fine sediment, to the extent possible. Samplers should avoid hard clay, bank deposits, gravel, and disturbed and/or filled areas. Any sediment that resists being scooped is probably not recently deposited fine sediment material. In following this guidance, the collection of sediment is purposefully being biased for fine materials, which must be discussed thoroughly in any subsequent interpretive reporting of the data, in regards to representativeness of the collected sample to the environment from which it was collected. Quiescent areas are conducive to the settling of finer materials. Choose a sampling site with lower hydrologic energy, such as the inner (depositional) side of bends or eddies where the water movement may be slower.

11.5. Field Preparation

Samples will be prepared in the field as needed to conform to USEPA and/or SWAMP requirements, to ensure sample integrity from time of sample collection to delivery at the analytical laboratory. Detailed information on sample containers, required preservation, holding times, and sample volumes is shown in Table 12-1 of Element 12.

11.6. Sampling Containers

The RMC will implement standard methods associated with sample container, handling and chain of custody procedures that is identified in RMC SOPs FS-9. Collection of pathogens in water requires the use of sterilized sample containers. Containers will be provided by contracted laboratories pre-sterilized. Individual laboratories will be responsible for the integrity of containers provided. No other containers required for collection of RMC Creek Status Monitoring samples will require sterile containers.

All sampling containers used for the RMC sampling for water quality and sediment quality analysis will be provided pre-cleaned by contracted analytical laboratories. The individual laboratories will be responsible for ensuring integrity of the containers. Should sampling containers lose their integrity during the sampling process, then they will be discarded and replaced with a pre-cleaned container. A list of sampling containers required for RMC implementation is compiled in SOP FS-9, Sample Container, Handling, and Chain of Custody Procedures.

11.7. Sample ID Numbers

Every sample must have a unique sample number so that the analytical results from each sample can be differentiated from every other sample. This information should follow the sample through the COC, analytical, and interpretation and reporting processes. As described in SOP FS-11, Site and Sample Naming Convention, samples collected under the probabilistic design will adopt a naming convention that is consistent with the SWAMP Perennial Streams Assessment and the Stormwater Monitoring Coalition. RMC sampling sites associated with targeted monitoring design will adopt the Region 2 SWAMP site naming convention.

11.8. Sample Equipment Cleaning

Cleaning techniques required for sampling equipment will vary depending on the media sampled and analyte measured. Cleaning techniques to be used are described in SOP FS-7, Equipment Cleaning Procedures, and individual SOPs associated with the relevant type of sampling to be conducted.

11.9. WASTE DISPOSAL

Proper disposal of all waste is an important component of field activities. At no time will any waste be disposed of improperly. The proper methods of waste disposal are outlined below:

11.9.1. Routine Garbage

Regular garbage (paper towels, paper cups, etc.) is collected by sampling personnel in garbage bags or similar. It can then be disposed of properly at appropriate intervals.

11.9.2. Detergent Washes

Any detergents used or detergent wash water should be collected in the field in a water-tight container and disposed of appropriately.

11.9.3. Chemicals

Solvents, acids, and formalin are hazardous materials and should be disposed of by following all appropriate regulations. They should always be collected when sampling and never be disposed in the field.

11.10. Responsibility and Corrective Actions

If monitoring equipment fails, sampling personnel will report the problem in the comments section of their field notes and will not record data values for the variables in question. Actions will be taken to replace or repair broken equipment prior to the next field use. Under no condition will data be entered into the SWAMP database that were known to be collected with faulty equipment.

12. (B3) Sample Handling and Custody

Each RMC Stormwater Program Project Manager will be responsible for overall quality assurance associated with field sampling conducted within their jurisdiction. As such, Project Managers are responsible for identifying and ensuring appropriate qualifications and training for all sampling personnel.

One member of each sampling team will be identified as "Team Lead", and will be responsible for overall collection and custody of samples during field sampling. Field crews will keep a field log, which will consist of sampling forms for each sampling event. SOPs for Field Sample Collection, identified in Table 11-1 will be followed, and include instruction for field documentation. In the field log, the following items will be recorded: time of sample collection, sample identification numbers, results of any field measurements and the time that they were made, qualitative descriptions of relevant water and weather conditions at the time of sample collection, and a description of any unusual occurrences associated with the sampling event (especially those that could affect sample or data quality).

The field crews will have custody of samples during field sampling and chain-of-custody (COC) forms will accompany all samples to the analyzing laboratory. COC procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. A detailed description of COC procedures is included in SOP FS-9, Sample Container, Handling, and Chain of Custody Procedures. Each contracted analytical laboratory will maintain custody logs sufficient to track each sample submitted and to analyze or preserve each sample within specified holding times. Each analytical laboratory has a sample custodian who examines the samples for correct documentation, proper preservation and holding times. Each laboratory will follow sample custody procedures as outlined in its QA plans.

In general, all non-biological samples will be packed in wet ice during shipment, so that they will be kept at approximately 6º C. When used (e.g., analysis of trace metals), wet ice will be double bagged in Zip-top bags to prevent contamination via meltwater. Where appropriate, samples may be frozen to prevent biological degradation. If samples are to be shipped frozen on dry ice, then appropriate handling procedures will be followed, including ensuring use of appropriate packaging materials and appropriate training for shipping personnel.

BMI and algae samples collected for taxonomic identification will be fixed in the field and stored in a cool, dark place. Algae samples collected for chlorophyll a and ash free dry weight analysis will be placed on ice during transport and stored in a freezer at the laboratory, or placed on dry ice for extended periods until laboratory freezer space is available.

Additional detail on sample handling procedures is presented in Table 12-1 and in SOP FS-9.

12.1. Shipping Containers

All samples will be handled, prepared, transported, and stored in a manner so as to minimize bulk loss, analyte loss, contamination, or biological degradation. Sample containers will be clearly labeled with an indelible marker. All caps and lids will be checked for tightness prior to shipping. Ice chests will be sealed with packing tape before shipping. Samples will be placed in the ice chest with enough ice or frozen ice packs to completely fill the ice chest. COC forms will be placed in a zip-top bag and placed

inside of the ice chest. Additional detail on sample handling is included in SOP FS-9, Sample Container, Handling, and Chain of Custody Procedures.

12.2. Commercial Vehicle Transport

Transport of samples to the contracted laboratories will be by commercial carriers. As required, pickup will be pre-arranged with the carrier and all required shipping forms will be completed prior to sample pickup by the commercial carrier.

12.3. Sample Hold Times

Information on sampling containers, preservation techniques, and hold times are shown in SOP FS-9, Sample Container, Handling, and Chain of Custody Procedures.

13. (B4) Method Selection

13.1. Method Reporting Limits

Target method reporting limits (MRLs), or Reporting Limits (RLs), applicable for RMC sampling are presented in Appendix E. It is understood that all targets may not be achievable by laboratories in each media, especially in most urbanized areas where interferences present may elevate MRLs.

13.2. In Situ Monitoring

In-situ monitoring will be conducted at selected stations for the RMC Creek Status Monitoring Program. The sampling stations may have aquatic plants, trash, and other materials that either float on the surface of the water or that may be below the water surface and this may cause fouling of the in-situ measuring instruments. RMC Sampling Personnel will protect these instruments, or instrument intakes, from fouling with a screen through which water can flow but the fouling materials cannot easily penetrate.

13.3. Continuous Monitoring

Sonde measurements for general water quality will be evaluated by comparing field measurements with pre and post deployment calibration measurements. The accuracy of sonde probe readings are checked against calibration standard solutions. Calibration of these probes to these standards must be performed prior to initial deployment, during interruptions in the deployment (if readings drift significantly or if batteries are changed) and after the sonde is retrieved. The post-run calibration allows the data collected to be checked for accuracy and flagged as not meeting measurement quality objectives if necessary.

13.4. Performance Based Measurement System

Multiple analytical laboratories will provide analytical services. Contracted laboratories used for the RMC sampling and analysis program will be encouraged to use a Performance Based Measurement System (PBMS). A performance-based approach permits the use of any scientifically appropriate method that demonstrates the ability to meet established method performance criteria (e.g., accuracy, sensitivity, bias, precision) and complies with specified data quality needs or requirements. Using PBMS the data quality needs, mandates, or limitations of the program or project are specified. These will serve as criteria for selecting measurement processes (i.e, methods), which will meet those needs in a cost-effective manner, rather than the use of a mandated method.

13.5. PBMS Methods Validation

Each analytical laboratory should adhere to its individual QA program for method validation techniques for specific methods. Individual QA plans should be maintained on-site and be made available to RMC representatives upon request. When using the PBMS for the RMC, the labs will have to follow all PBMS procedures related to obtaining quality data, but the labs are not required to submit the results to anyone except upon request. The results are to be kept on file by each individual lab.

13.6. Method Failures

The RMC Program Manager will be responsible for any corrective actions that may be needed in the event that methods fail to produce SWAMP-comparable data. If a method fails to provide SWAMP-

comparable data for any reason, including analyte or matrix interferences, instrument failures, etc., then the involved samples will be analyzed again if possible. The laboratory in question's SOP for handling these types of problems will be followed. When a method fails to provide SWAMP-comparable data, then the laboratory's SOP for documenting method failures will be used to document the problem and what was done to rectify it.

Corrective actions for biological data are taken when an analysis is deemed suspect for some reason. These reasons include exceeding accuracy ranges and/or problems with sorting and identification. The corrective action will vary on a case-by-case basis, but at a minimum involves the following:

- A check of procedures.
- A review of documents and calculations to identify possible errors.
- Correction of errors based on discussions among taxonomists.
- A complete re-identification of the sample.

The field and laboratory coordinators shall have systems in place to document problems and make corrective actions. All corrective actions will be documented to the Project Director.

When specific MQOs associated with taxonomic analyses are not met, the following corrective actions are required (See Section 7 for additional details):

- Reasons for failure to complete sampling should be documented, and plans to ensure future success shall be made. When possible, efforts should be made to resample. For example, additional sites could be visited if there is time remaining within the index period. Incomplete site evaluations should either be resampled or a new site selected.

- If sorting efficiency or processing efficiency does not meet specified MQOs, then training and supervision of that sorter shall increase according to laboratory protocols. The corrected data shall be confirmed in the project database. Because 100% of samples are subjected to these MQOs, data do not need to be qualified. All organisms recovered during the sorting completeness check (i.e., sorting efficiency) are added to the final count and identified.

- If a sample does not meet the MQOs for taxonomic identifications (i.e., random or systemic error rates), then corrective actions shall include submitting additional sample lots (10% of all samples processed by a lab for a particular project) for further quality assurance checks by a reference lab. Additional lots shall be submitted until a lot passes quality assurance checks or until all samples have been submitted to a reference lab for quality assurance checks. The taxonomist should gain additional training for problematic taxa.

- If a sample does not meet MQOs for recount accuracy or poor accuracy in taxonomic identifications (i.e., excessive taxa count error rate, taxa ID error rate, individual ID error rate), then corrective actions shall include submitting additional sample lots (10% of all samples processed by a lab for each project) for further quality assurance checks by a reference lab. Additional lots shall be submitted until a lot passes quality assurance checks or until all samples have been submitted to a reference lab for quality assurance checks. The taxonomist should gain additional training for problematic taxa.

- All taxonomic errors, whether they are above or below the thresholds established in Table 27-1, Appendix B, shall be resolved through the following process:

  - Reference labs will inform the original lab of errors. The original lab is responsible for correcting the data set with the revised taxonomic identification from the reference lab.
  - If the original lab disputes the reference lab identification, then taxa can be sent to a third lab for verification. The original lab is responsible for correcting the data set with the revised taxonomic identification from the third lab.

- If a site is sampled more than 10 seconds (~ 300 m) from nominal coordinates, the data from this site shall be flagged in the project database. However, samples collected outside the nominal stratum or outside the index period shall be rejected.

13.7. Sample Disposal

After analysis of the RMC samples have been completed by the laboratory and results have been accepted by CIMC, they will be disposed by each laboratory of in compliance with all federal, state, and local regulations. The laboratory has standard procedures for disposing of its waste, including left over sample materials

13.8. Laboratory Sample Processing

Field samples sent to the laboratories will be processed within their recommended hold time (Table 12-1) using methods agreed upon method between CQAO and LPMs. Each sample may be assigned unique laboratory sample identification (ID) numbers for tracking processing and analyses of samples within the laboratory. This laboratory sample ID (if differing from the field team sample ID) must be included in the data submission, within a lookup table linking the field sample ID to that assigned by the lab.

Samples arriving at the laboratory are to be stored under conditions appropriate for the planned analytical procedure(s), unless they are processed for analysis immediately upon receipt. Samples to be analyzed should only be removed from storage when laboratory staff are ready to proceed.

13.9. Field Measurements

The RMC will implement standard methods associated with manual and continuous water quality measurements and water samples as described in RMC SOP FS-2. The RMC will implement standard methods described in FS-3, FS-4 and FS-5 to utilize water quality equipment and test kits to measure target analytes in water (Table 13-1).

Table 13-1. Field Measurements for RMC Analytes

Water Quality Analyte	Instrument Type	Model	Range and Units
Temperature (continuous)	Digital temperature logger	HOBO Water Temp Pro V2 (or equivalent)	-40º to 50º C
Temperature, DO, pH, Conductivity	Multi-parameter probe	YSI 6600 or 6920 (or equivalent)	See below, by parameter
Temperature	Multi-parameter probe	6560 sensor	-5º to 50º C
DO	Multi-parameter probe	6562 rapid pulse sensor	0 to 50 mg/L
pH	Multi-parameter probe	6561 sensor	0 to 14 units
Conductivity	Multi-parameter probe	6560 sensor	0 to 100 mS/cm
Chlorine, Free and Total, mid-range	Chemetrics Test Kit	Catalog No. K-2511	0 to 0.2 ppm (mg/L) Cl_2
Chlorine, Free and Total, high-range	Chemetrics Test Kit	Catalog No. K-2504	0 to 5 ppm (mg/L) Cl_2

14. (B5) Quality Control

Concentrations of pollutants in environmental samples are often low. Therefore, a quality-assurance program for the chemical analysis of samples requires stringent laboratory conditions and careful control over all aspects of the analyses. Each step in the analytical process is a potential source of contamination and must be consistently monitored to ensure that the final measurement is not adversely affected by any processing steps. Various aspects of the RMC quality control program are summarized below.

14.1. Laboratory Quality Control for Non-Biological Data

Laboratories providing analytical support to the RMC will have the appropriate facilities to store, prepare, and process samples in an ultra-clean environment, and will have appropriate instrumentation and staff to perform analyses and provide data of the required quality within the time period dictated by the Program. The laboratories are expected to satisfy the following:

1. Demonstrate capability through pertinent certification and satisfactory performance in inter-laboratory comparison exercises.
2. Provide qualification statements regarding their facility and personnel.
3. Maintain a program of scheduled maintenance of analytical balances, laboratory equipment and instrumentation.
4. Conduct routine checking of analytical balances using a set of standard reference weights (American Society of Testing and Materials Class 3, NIST Class S-1, or equivalents). Analytical balances are serviced at six-month intervals or when test weight values are not within the manufacturer's instrument specifications, whichever occurs first.
5. Conduct routine checking and recording the composition of fresh calibration standards against the previous lot. Acceptable comparisons are within 2% of the precious value.
6. Record all analytical data in bound (where possible) logbooks, with all entries in ink, or electronically.
7. Monitor and document the temperatures of cold storage areas and freezer units on a continuous basis.

8. Verify the efficiency of fume/exhaust hoods.
9. Have a source of reagent water meeting specifications described in Section 8.0 available in sufficient quantity to support analytical operations.
10. Label all containers used in the laboratory with date prepared, contents, initials of the individual who prepared the contents, and other information as appropriate.
11. Date and safely store all chemicals upon receipt. Proper disposal of chemicals when the expiration date has passed.
12. Have QAPP, SOPs, analytical methods manuals, and safety plans readily available to staff.
13. Have raw analytical data readily accessible so that they are available upon request.

In addition, laboratories involved in the RMC are required to demonstrate capability continuously through the following protocols:

1. Strict adherence to routine QA/QC procedures.
2. Routine analysis of CRMs, if available.
3. Regular participation in annual certification programs.
4. Satisfactory performance at least annually in the analysis of blind Performance Evaluation Samples and/or participation in inter-laboratory comparison exercises.

Laboratory QC samples must satisfy SWAMP measurement quality objectives (MQOs) and frequency requirements. MQOs are specified in Appendix A. Frequency requirements are provided on an analytical batch level. The RMC defines an analytical batch as 20 or fewer samples and associated quality control that are processed by the same instrument within a 24-hour period (unless otherwise specified by method). Details regarding sample preparation are method- or laboratory SOP-specific, and may consist of extraction, digestion, or other techniques.

14.2. Laboratory Quality Contol for Biological Data

Sorting efficiency is used to quantify the sorting accuracy of the laboratory. Once samples are sorted, a second technician will re-sort the remnants of sorted aliquots for 10% of the original processing time to recover organisms missed by the primary sorter and to assess sorting accuracy. The acceptable accuracy limit is 95%. If a second sorting technician is not available and a taxonomist performs sorting activities, the same taxonomist may re-sort the remnant for evaluating sorting accuracy.

Precision of sorting shall be assessed as processing efficiency. Processing efficiency is the ability to obtain adequate numbers of organisms (i.e. ≥600) from all samples, or to sort 100% of sample volume. Samples with fewer than 600 organisms removed shall be sorted until this number has been achieved, or there is no sample left to sort.

Recount accuracy is used to quantify the sorting accuracy of the laboratory. A subset of samples (10%, or one per lab per project each year, whichever is greater) that have been sorted and identified are sent to a reference laboratory. At the reference lab, the number of benthic macroinvertebrates is enumerated by new sorters or taxonomists. The acceptable recount accuracy limit is 95%.

Sample re-identification is used to quantify the identification accuracy of the laboratory. A subset of samples (10%, or one sample per lab per project each year, whichever is greater) analyzed by a second

taxonomist at the reference lab will re-identify the sample to ensure that all organisms have been accurately identified and enumerated. The acceptable accuracy limits are shown in Table 4. Identification accuracy is calculated using the following metrics: Acceptable error rates for taxa count error, taxa ID error, and individual ID error are less than or equal to 10%.

Precision will also be assessed as bias through the re-identification process. Bias is defined as systemic errors, arising when a specific taxon is consistently misidentified. Only common taxa (i.e., those appearing at least 5 times in all the samples submitted for quality assurance checks) will count towards the calculation of systemic errors. Acceptable systemic error rates are ≤10% of all common taxa in a batch submitted for QA check.

Precision of identifications will also be assessed through the re-identification process. Random errors are inconsistent misidentifications in which different specimens of a single taxon are identified as belonging to multiple taxa or specimens of multiple taxa are identified as the same taxon. Acceptable random error rates are ≤10% of all taxa in a batch submitted for QA check.

Precision of identifications will also be assessed as taxonomic resolution errors. Taxonomic resolution errors occur when specimens are not identified to a taxonomic level supported by the condition of the specimen, or by the STE. Acceptable taxonomic resolution error rates are ≤10% of all individuals in a sample.

14.3. Calibration and Working Standards

All calibration standards must be traceable to a certified standard obtained from a recognized organization. If traceable standards are not available, procedures must be implemented to standardize the utilized calibration solutions (e.g., comparison to a certified reference material (CRM – see below). Standardization of calibration solutions must be thoroughly documented, and is only acceptable when pre-certified standard solutions are not available. Working standards are dilutions of stock standards prepared for daily use in the laboratory. Working standards are used to calibrate instruments or prepare matrix spikes, and may be prepared at several different dilutions from a common stock standard. Working standards are diluted with solutions that ensure the stability of the target analyte. Preparation of the working standard must be thoroughly documented such that each working standard is traceable back to its original stock standard. Finally, the concentration of all working standards must be verified by analysis prior to use in the laboratory.

14.4. Instrument Calibration

Prior to sample analysis, utilized instruments must be calibrated following the procedures outlined in the relevant analytical method or laboratory SOP. Each method or SOP must specify acceptance criteria that demonstrate instrument stability and an acceptable calibration. If instrument calibration does not meet the specified acceptance criteria, the analytical process is not in control and must be halted. The instrument must be successfully recalibrated before samples may be analyzed.

Calibration curves will be established for each analyte covering the range of expected sample concentrations. Only data that result from quantification within the demonstrated working calibration range may be reported unflagged by the laboratory. Quantification based upon extrapolation is not

acceptable. Data reported outside of the calibration range must be flagged as "Detected not Quantified". Alternatively, if the instrumentation is linear over the concentration ranges to be measured in the samples, the use of a calibration blank and one single standard that is higher in concentration than the samples may be appropriate. Samples outside the calibration range will be diluted or concentrated, as appropriate, and reanalyzed.

14.5. Initial Calibration Verification

The initial calibration verification (ICV) is a mid-level standard analyzed immediately following the calibration curve. The source of the standards used to calibrate the instrument and the source of the standard used to perform the ICV must be independent of one another. This is usually achieved by the purchase of standards from separate vendors. Since the standards are obtained from independent sources and both are traceable, analyses of the ICV functions as a check on the accuracy of the standards used to calibrate the instrument. The ICV is not a requirement of all SOPs or methods, particularly if other checks on analytical accuracy are present in the sample batch.

14.6. Continuing Calibration Verification

Continuing calibration verification (CCV) standards are mid-level standards analyzed at specified intervals during the course of the analytical run. CCVs are used to monitor sensitivity changes in the instrument during analysis. In order to properly assess these sensitivity changes, the standards used to perform CCVs must be from the same set of working standards used to calibrate the instrument. Use of a second source standard is not necessary for CCV standards, since other QC samples are designed to assess the accuracy of the calibration standards. Analysis of CCVs using the calibration standards limits this QC sample to assessing only instrument sensitivity changes. The acceptance criterion and required frequency for CCVs are detailed in Appendix A, Measurement Quality Objectives. If a CCV falls outside the acceptance limits, the analytical system is not in control, and immediate corrective action must be taken.

Data obtained while the instrument is out of control is not reportable, and all samples analyzed during this period must be reanalyzed. If reanalysis is not an option, the original data must be flagged with the appropriate qualifier and reported. A narrative must be submitted listing the results that were generated while the instrument was out of control, in addition to corrective actions that were applied.

14.7. Laboratory Blanks

Laboratory blanks (also called extraction blanks, procedural blanks, or method blanks) are used to assess the background level of target analyte resulting from sample preparation and analysis. Laboratory blanks are carried through precisely the same procedures as the field samples. For both organic and inorganic analyses, a minimum of at least one laboratory blank must be prepared and analyzed in every analytical batch. Some methods may require more than one laboratory blank with each analytical run. Acceptance criteria for laboratory blanks are detailed in Appendix A, Measurement Quality Objectives. Blanks that are too high require corrective action to bring the concentrations down to acceptable levels. This may involve changing reagents, cleaning equipment, or even modifying the utilized methods or SOPs. Although acceptable laboratory blanks are important for obtaining results for low-level samples, improvements in analytical sensitivity have pushed detection limits down to the point where some amount

of analyte will be detected in even the cleanest laboratory blanks. The magnitude of the blanks must be evaluated against the concentrations of the samples being analyzed and against Program objectives.

14.8. Reference Materials and Demonstration of Laboratory Accuracy

Evaluation of the accuracy of laboratory procedures is achieved through the preparation and analysis of reference materials with each analytical batch. Ideally, the reference materials selected are similar in matrix and concentration range to the samples being prepared and analyzed. The acceptance criteria for reference materials are listed in Appendix A, Measurement Quality Objectives. The accuracy of an analytical method can be assessed using CRMs only when certified values are provided for the target analytes. When possible, reference materials that have certified values for the target analytes should be used. This is not always possible, and often times certified reference values are not available for all target analytes. Many reference materials have both certified and non-certified (or reference) values listed on the certificate of analysis. Certified reference values are clearly distinguished from the non-certified reference values on the certificate of analysis.

14.9. Reference Materials vs. Certified Reference Materials

The distinction between a reference material and a certified reference material does not involve how the two are prepared, rather with the way that the reference values were established. Certified values are determined through replicate analyses using two independent measurement techniques for verification. The certifying agency may also provide "non-certified or "reference" values for other target analytes. Such values are determined using a single measurement technique that may introduce bias. When available, it is preferable to use reference materials that have certified values for all target analytes. This is not always an option, and therefore it is acceptable to use materials that have reference values for these analytes. Note: Standard Reference Materials (SRMs) are essentially the same as CRMs. The term "Standard Reference Material" has been trademarked by the National Institute of Standards and Technology (NIST), and is therefore used only for reference materials distributed by NIST.

14.10. Laboratory Control Samples

While reference materials are not available for all analytes, a way of assessing the accuracy of an analytical method is still required. Laboratory control samples (LCSs) provide an alternate method of assessing accuracy. An LCS is a specimen of known composition prepared using contaminant-free reagent water or an inert solid spiked with the target analyte at the midpoint of the calibration curve or at the level of concern. The LCS must be analyzed using the same preparation, reagents, and analytical methods employed for regular samples. If an LCS needs to be substituted for a reference material, the acceptance criteria are the same as those for the analysis of reference materials. These are detailed in Appendix A, Measurement Quality Objectives.

14.11. Prioritizing Certified Reference Materials, Reference Materials, and Laboratory Control Samples

Certified reference materials, reference materials, and laboratory control samples all provide a method to assess the accuracy at the mid-range of the analytical process. However, this does not mean that they can be used interchangeably in all situations. When available, RMC Creek Status Monitoring requires the analysis of one certified reference material per analytical batch. Certified values are not always available

for all target analytes. If no certified reference material exists, reference values may be used. If no reference material exists for the target analyte, an LCS must be prepared and analyzed with the sample batch as a means of assessing accuracy. The hierarchy is as follows: analysis of a CRM is favored over the analysis of a reference material, and analysis of a reference material is preferable to the analysis of an LCS. Substitution of an LCS is not acceptable if a certified reference material or reference material is available.

14.12. Matrix Spikes

A matrix spike (MS) is prepared by adding a known concentration of the target analyte to a field sample, which is then subjected to the entire analytical procedure. Matrix spikes are analyzed in order to assess the magnitude of matrix interference and bias present. Because matrix spikes are analyzed in pairs, the second spike is called the matrix spike duplicate (MSD). The MSD provides information regarding the precision of the matrix effects. Both the MS and MSD are split from the same original field sample. In order to properly assess the degree of matrix interference and potential bias, the spiking level should be approximately 2-5x the ambient concentration of the spiked sample. To establish spiking levels prior to sample analysis, laboratories should review any relevant historical data. In many instances, the laboratory will be spiking samples blind and will not meet a spiking level of 2-5x the ambient concentration. In addition to the recoveries, the relative percent difference (RPD) between the MS and MSD is calculated to evaluate how matrix affects precision. The MQO for the RPD between the MS and MSD is the same regardless of the method of calculation. These are detailed in Appendix A: *Measurement Quality Objectives*. Recovery data for matrix spikes provides a basis for determining the prevalence of matrix effects in the samples collected and analyzed for SWAMP. If the percent recovery for any analyte in the MS or MSD is outside of the limits specified in Appendix A, Measurement Quality Objectives, the chromatograms (in the case of trace organic analyses) and raw data quantitation reports should be reviewed. Data should be scrutinized for evidence of sensitivity shifts (indicated by the results of the CCVs) or other potential problems with the analytical process. If associated QC samples (reference materials or LCSs) are in control, matrix effects may be the source of the problem. If the standard used to spike the samples is different from the standard used to calibrate the instrument, it must be checked for accuracy prior to attributing poor recoveries to matrix effects.

14.13. Laboratory Duplicates

In order to evaluate the precision of an analytical process, a field sample is selected and prepared in duplicate. Specific requirements pertaining to the analysis of laboratory duplicates vary depending on the type of analysis. The acceptance criteria for laboratory duplicates are specified in Appendix A, Measurement Quality Objectives.

14.14. Laboratory Duplicates vs. Matrix Spike Duplicates

Although the laboratory duplicate and matrix spike duplicate both provide information regarding precision, they are unique measurements. Laboratory duplicates provide information regarding the precision of laboratory procedures. The matrix spike duplicate provides information regarding how the matrix of the sample affects both the precision and bias associated with the results. It also determines whether or not the matrix affects the results in a reproducible manner. Because the two concepts cannot

be used interchangeably, it is unacceptable to analyze only an MS/MSD when a laboratory duplicate is required.

14.15. Replicate Analyses

The RMC will adopt the same terminology as SWAMP in defining replicate samples, wherein replicate analyses are distinguished from duplicate analyses based simply on the number of involved analyses. Duplicate analyses refer to two sample preparations, while replicate analyses refer to three or more. Analysis of replicate samples is not explicitly required.

14.16. Surrogates

Surrogate compounds accompany organic measurements in order to estimate target analyte losses during sample extraction and analysis. The selected surrogate compounds behave similarly to the target analytes, and therefore any loss of the surrogate compound during preparation and analysis is presumed to coincide with a similar loss of the target analyte. Surrogate compounds must be added to field and QC samples prior to extraction, or according to the utilized method or SOP. Surrogate recovery data is to be carefully monitored. If possible, isotopically labeled analogs of the analytes are to be used as surrogates.

14.17. Internal Standards

To optimize gas chromatography mass spectrometry (GC-MS) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analyses, internal standards (also referred to as "injection internal standards") may be added to field and QC sample extracts prior to injection. Use of internal standards is particularly important for analysis of complex extracts subject to retention time shifts relative to the analysis of standards. The internal standards can also be used to detect and correct for problems in the GC injection port or other parts of the instrument. The analyst must monitor internal standard retention times and recoveries to determine if instrument maintenance or repair or changes in analytical procedures are indicated. Corrective action is initiated based on the judgment of the analyst. Instrument problems that affect the data or result in reanalysis must be documented properly in logbooks and internal data reports, and used by the laboratory personnel to take appropriate corrective action. Performance criteria for internal standards are established by the method or laboratory SOP.

14.18. Dual-Column Confirmation

Due to the high probability of false positives from single-column analyses, dual column confirmation should be applied to all gas chromatography and liquid chromatography methods that do not provide definitive identifications. It should not be restricted to instruments with electron capture detection (ECD).

14.19. Dilution of Samples

Final reported results must be corrected for dilution carried out during the process of analysis. In order to evaluate the QC analyses associated with an analytical batch, corresponding batch QC samples must be analyzed at the same dilution factor. For example, the results used to calculate the results of matrix spikes must be derived from results for the native sample, matrix spike, and matrix spike duplicate analyzed at the same dilution. Results derived from samples analyzed at different dilution factors must not be used to calculate QC results.

14.20. Laboratory Corrective Action

Failures in laboratory measurement systems include, but are not limited to: instrument malfunction, calibration failure, sample container breakage, contamination, and QC sample failure. If the failure can be corrected, the analyst must document it and its associated corrective actions in the laboratory record and complete the analysis. If the failure is not resolved, it is conveyed to the respective supervisor who should determine if the analytical failure compromised associated results. The nature and disposition of the problem must be documented in the data report that is sent to the RMC Program Manager. SWAMP comparable corrective actions are detailed in Appendix C.

14.21. Field Quality Control

Field QC results must meet the MQOs and frequency requirements specified in Appendix A, Measurement Quality Objectives, where frequency requirements are provided on a sample batch level. RMC defines a sample batch as 20 or fewer field samples prepared and analyzed with a common set of QC samples. Specific field quality control samples may also be required by the method or SOP selected for sample collection and analysis. If RMC MQOs conflict with those prescribed in the utilized method or SOP, the more rigorous of the objectives must be met.

14.22. Travel Blanks

Travel blanks are used to determine if there is any cross-contamination of volatile constituents between sample containers during shipment from the field to the laboratory. One volatile organic analysis (VOA) sample vial with reagent water known to be free of volatile contaminants is transported to the site with the empty sample containers. The list of volatile organic compounds (VOCs) includes methyl tert-butyl ether (MTBE); and benzene, toluene, ethylbenzene, and xylenes (BTEX). This vial must be handled like a sample (but never opened) and returned to the laboratory with the other samples. Travel blanks are not required (unless explicitly required by the utilized method or SOP), but are encouraged as possible and appropriate. At the current time, there are no analyses of volatile constituents associated with RMC Creek Status Monitoring.

14.23. Equipment Blanks

Equipment blanks are generated by the personnel responsible for cleaning sampling equipment. Equipment blanks must be analyzed before the equipment is shipped to the sampling site. In order to accommodate any necessary corrective action, equipment blank results should be available well in advance of the sampling event. To ensure that sampling equipment is contaminant-free, water known to be low in the target analyte(s) must be processed though the equipment as during sample collection. The specific type of water used for blanks is selected based on the information contained in the relevant sampling or analysis methods. The water must be collected in an appropriate sample container, preserved, and analyzed for the target analytes (in other words, treated as an actual sample). The inclusion of field blanks is dependent on the requirements specified in the relevant MQO tables, or in the sampling method or SOP. Typically, equipment blanks are collected when new equipment, equipment that has been cleaned after use at a contaminated site, or equipment that is not dedicated for surface water sampling is used. An equipment blank must be prepared for dissolved metals in water samples whenever a new lot of filters is used.

14.24. Field Blanks

A field blank is collected to assess potential sample contamination levels that occur during field sampling activities. Field blanks are taken to the field, transferred to the appropriate container, preserved (if required by the method), and treated the same as the corresponding sample type during the course of a sampling event. The inclusion of field blanks is dependent on the requirements specified in the relevant MQO tables or in the sampling method or SOP. Field blanks for other media and analytes should be conducted upon initiation of sampling. If field blank performance is acceptable, further collection and analysis of field blanks should be performed on an as-needed basis. Acceptable levels for field blanks are specified in Appendix A, Measurement Quality Objectives. The water used for field blanks must be free of target analyte(s) and appropriate for the analysis being conducted.

14.25. Field Duplicates

Field samples collected in duplicate provide precision information as it pertains to the sampling process. The duplicate sample must be collected in the same manner and as close in time as possible to the original sample. This effort is to attempt to examine field homogeneity as well as sample handling, within the limits and constraints of the situation.

Bioassessment field duplicates help quantify intrinsic variability associated with sampling activities. Bioassessment field duplicates are comprised of a second sample taken at 10% of all sampling sites. There are no specific criteria for field duplicate variability, but these data are evaluated in the data analysis/assessment process for small-scale spatial variability.

14.26. Field Corrective Action

The field organization is responsible for responding to failures in their sampling and field measurement systems. If monitoring equipment fails, personnel are to record the problem according to their documentation protocols. Failing equipment must be replaced or repaired prior to subsequent sampling events. It is the combined responsibility of all members of the field organization to determine if the performance requirements of the specific sampling method have been met, and to collect additional samples if necessary. Associated data is entered into the SWAMP Information Management System (IMS) and flagged accordingly. Specific field corrective actions are detailed in Appendix C.

14.27. Collection of Background Samples

Background samples provide a comparison between the concentrations or levels of the target parameters in the Program's environmental samples with samples from a nearby location that is known or believed to be uncontaminated (i.e., to contain the target parameters at "natural" concentrations or levels. This is necessary in order to differentiate between the project on-site contribution and the off-site natural contribution to the parameter's concentrations or levels. Background samples will not be required for measurements and analyses covered within this QAPP.

14.28. Field Sampling Representativeness

Field sampling accuracy is ensured by evaluating if the sample event occurred at the nominal coordinates, within the index period, and within the nominal stratum. Site location shall be measured by global

positioning system and must be within 10 seconds (~300 m) of the nominal latitude and longitude. All samples must be collected within the established index period and within the nominal stratum.

15. (B6) Instrument/Equipment Testing, Inspection and Maintenance

15.1. RMC Field Equipment

Field measurement equipment will be checked for operation in accordance with manufacturer's specifications. This includes battery checks and routine replacement and/or cleaning of parts as specified by the manufacturer. All equipment will be inspected for damage when first employed and again when returned from use. Maintenance logs will be kept and each piece of equipment will have its own log that documents the dates and description of any problems, the action(s) taken to correct problem(s), maintenance procedures, system checks, follow-up maintenance dates, and the person responsible for maintaining the equipment. A list of anticipated field measurement equipment to be used for RMC monitoring is shown in Table 15-1. The RMC will implement standard methods associated with calibration and equipment maintenance as described in RMS SOPs FS-3, FS-4, and FS-5.

15.1. Laboratory Equipment

All laboratories providing analytical support for chemical or biological analyses will have the appropriate facilities to store, prepare, and process samples. Moreover, appropriate instrumentation and staff to provide data of the required quality within the schedule required by the program are also required. Laboratory operations must include the following procedures:

- A program of scheduled maintenance of analytical balances, microscopes, laboratory equipment, and instrumentation.
- Routine checking of analytical balances using a set of standard reference weights (American Society of Testing and Materials (ASTM) Class 3, NIST Class S-1, or equivalents).
- Checking and recording the composition of fresh calibration standards against the previous lot, wherever possible. Acceptable comparisons are < 2% of the previous value.
- Recording all analytical data in bound (where possible) logbooks, with all entries in ink, or electronic format.
- Monitoring and documenting the temperatures of cold storage areas and freezer units once per week.
- Verifying the efficiency of fume hoods.
- Having a source of reagent water meeting ASTM Type I specifications (ASTM, 1984) available in sufficient quantity to support analytical operations. The conductivity of the reagent water will not exceed 18 megaohms at 25°C. Alternately, the resistivity of the reagent water will exceed 10 mmhos/cm.
- Labeling all containers used in the laboratory with date prepared, contents, initials of the individual who prepared the contents, and other information, as appropriate.
- Dating and safely storing all chemicals upon receipt. Proper disposal of chemicals when the expiration date has passed.
- Having QAPP, SOPs, analytical methods manuals, and safety plans readily available to staff.
- Having raw analytical data, such as chromatograms, accessible so that they are available upon request.

Laboratories will maintain appropriate equipment per the requirements of individual laboratory SOPs and will be able to provide information documenting their ability to conduct the analyses with the required level of data quality. Such information might include results from interlaboratory comparison studies, control charts and summary data of internal QA/QC checks, and results from certified reference material analyses.

Table 15-1. Testing, Inspection and Maintenance of Sampling Equipment and Analytical Instruments

Instrument / Equipment	Test / Maintenance	Frequency of Checking	Responsible Person
YSI Multi-parameter probe (or similar)	Operation and battery life	Before and after each use	Local Program Field Lead
Digital Temperature Logger	Operation and battery life	Before and after each use	Local Program Field Lead

16. (B7) Instrument/Equipment Calibration and Frequency

16.1. Field Measurements

Equipment used for RMC Creek Status Monitoring shall be calibrated at frequencies as shown in Table 16-1. The RMC will implement standard methods associated with calibration and equipment maintenance as described in RMS SOPs FS-3, FS-4, and FS-5.

Table 16-1. Field Instrument Calibration and Quality Checks Frequency for RMC Water Quality Measurement Equipment

Analyte	Instrument Kind	Instrument Name or Type	Standard Material	Frequency of Calibration &Accuracy Checks
Temperature	Digital thermometer	Not specified	NIST-certified thermometer	Annually
Temperature	Digital temperature logger	HOBO Water Temp Pro V2 (or equivalent)	NIST-certified thermometer	Annually
DO, pH, Temperature, Conductivity	Multi-parameter probe	YSI 6600 V2 (or equivalent)	As appropriate for each probe	Before each monitoring event

16.2. Laboratory Analyses

16.2.1. In-house Analyses

There are no in-house laboratory-based analyses planned for this project.

16.2.2. Contract Laboratory Analyses

The procedures for and frequency of calibration will vary depending on the chemical parameters being determined. Equipment is maintained and checked according to the standard procedures specified in each laboratory's instrument operation instruction manual.

Upon initiation of an analytical run, after each major equipment disruption, and whenever on-going calibration checks do not meet recommended DQOs (see Appendix A), analytical systems will be calibrated with a full range of analytical standards. Immediately after this procedure, the initial calibration must be verified through the analysis of a standard obtained from a different source than the standards used to calibrate the instrumentation and prepared in an independent manner and ideally having certified concentrations of target analytes of a CRM or certified solution. Frequently, calibration standards are included as part of an analytical run, interspersed with actual samples.

Calibration curves will be established for each analyte and batch analysis from a calibration blank and a minimum of three analytical standards of increasing concentration, covering the range of expected sample concentrations. Only those data resulting from quantification within the demonstrated working calibration range may be reported by the laboratory. Alternatively, if the instrumentation is linear over the concentration ranges to be measured in the samples, the use of a calibration blank and one single standard

that is higher in concentration than the samples may be appropriate. Samples outside the calibration range will be diluted or concentrated, as appropriate, and reanalyzed.

The calibration standards will be prepared from reference materials available from the EPA repository, or from available commercial sources. The source, lot number, identification, and purity of each reference material will be recorded. Neat compounds will be prepared weight/volume using a calibrated analytical balance and Class A volumetric flasks. Reference solutions will be diluted using Class A volumetric glassware. Individual stock standards for each analyte will be prepared. Combination working standards will be prepared by volumetric dilution of the stock standards. The calibration standards will be stored at -20º C. Newly prepared standards will be compared with existing standards prior to their use. All solvents used will be commercially available, distilled in glass, and judged suitable for analysis of selected chemicals. Stock standards and intermediate standards are prepared on an annual basis and working standards are prepared every three months.

Sampling and analytical logbooks will be kept to record inspections, calibrations, standard identification numbers, the results of calibrations, and corrective action taken. Equipment logs will document instrument usage, maintenance, repair and performance checks. Daily calibration data will be stored with the raw sample data.

16.3. Biological Measurements

There are no SWAMP requirements for instrument/equipment calibration and frequency for bacteria. The guidance provided in Standard Methods (20th edition) section 9020 will be followed.

17. (B8) Inspection/Acceptance for Supplies and Consumables

Each sampling event conducted for the RMC Creek Status Monitoring Program will require use of appropriate consumables to reduce likelihood of sample contamination (e.g., solvents for field cleaning sampling equipment, trace metal clean sample containers for mercury analysis). Field Leads will be responsible for ensuring that all supplies are appropriate prior to their use. Inspection requirements for sampling consumables and supplies are summarized in Table 17-1.

Table 17-1. Inspection / Acceptance Testing Requirements for Consumables and Supplies

Project-related Supplies	Inspection / Testing Specifications	Acceptance Criteria	Frequency	Responsible Person Sampling Containers
Chemetrics test kits	Visual	Appropriateness; no evident contamination or damage; reagents within expiration date	Each purchase	Local Program Field Lead
Sampling supplies	Visual	Appropriateness; no evident contamination or damage; within expiration date	Each purchase	Local Program Field Lead

18. (B9) Non Direct Measurements, Existing Data

No data from external sources are planned to be used with this project.

19. (B10) Data Management

As previously discussed, RMC Creek Status Monitoring Program data management will conform to protocols dictated by relevant SOPs (Table 11-1). A summary of specific data management aspects is provided below.

19.1. Field Data Management

SOP number DM-1, Field Measurements Data Management, is the SOP that will be used for managing field data for the RMC Creek Status Monitoring Program. This SOP describes standardized record-keeping and tracking practices, and the document control system. It thus provides a standardized approach for data management from field to final use and storage for all field data. The SOP identifies all data handling equipment/procedures that should be used to process, compile, analyze, and transmit field data reliably and accurately. The SOP describes how field measurements will be formatted, entered, and uploaded into the SWAMP Information Management System. The RMC will use these protocols to produce SWAMP-comparable field measurement data for inclusion in the SWAMP database. The SOP describes the SWAMP documentation for producing field data sheets, and these protocols will be followed so that SWAMP-comparable data will be produced. Each LIMC will be responsible for field measurement data management for their individual SW Program.

19.2. Continuous Monitoring Data Management

SOP number DM-2, Continuous Monitoring Data Management, is the SOP that will be used for managing continuous monitoring analytical data with the proposed project. This SOP describes standardized record-keeping and tracking practices, and the document control system. It thus provides a standardized approach for data management from field to final use and storage for all continuous monitoring data. The SOP identifies all data handling equipment/procedures that should be used to process, compile, analyze, and transmit continuous monitoring analytical data reliably and accurately. The SOP describes how continuous monitoring data will be formatted, entered, and uploaded into the SWAMP Information Management System. The RMC will use these protocols to produce SWAMP-comparable continuous monitoring data for inclusion in the SWAMP database. The SOP describes the SWAMP documentation for producing continuous monitoring data sheets and these protocols will be followed so that SWAMP-comparable data will be produced. Each LIMC will be responsible for continuous monitoring data management.

19.3. Laboratory Data Management

SOP number DM-3, Laboratory Data Management, is the SOP that will be used for managing laboratory analytical data with the proposed project. This SOP describes standardized record-keeping and tracking practices, and the document control system. It thus provides a standardized approach for data management from field to final use and storage for all laboratory data. The SOP identifies all data handling equipment/procedures that should be used to process, compile, analyze, and transmit laboratory analytical data reliably and accurately. The SOP describes how laboratory analytical data will be formatted, entered, and uploaded into the SWAMP Information Management System. We will use the Excel template for laboratories that is provided by the SWAMP Data Management Team for formatting laboratory data in a manner that can easily be loaded into the SWAMP Database. The SOP describes documentation for using SWAMP's standardized list of analytes and these protocols will be followed so

that SWAMP-comparable data will be produced. This SOP describes how the RMC will manage data involving analysis of chemicals and bacteria as well as for toxicity analyses. The SOP references the chemical and biological analytical template as well as the toxicity analytical template. Each LIMC will be responsible for laboratory analytical data management.

The above-mentioned SOPs reference the SWAMP station template that will be used to generate SWAMP-comparable data. These SOPs reference the SWAMP file and batch naming convention that will be used for all data management so that the data will be comparable for loading into the SWAMP Information Management System. These SOPs also reference the need for data comparability, and by following these guidelines, the SWAMP Information Management System requirements for specified fields for database comparability will be followed.

20. (C1) Assessments and Response Actions

20.1. Readiness Reviews

PMLs, or their designee, will review all field equipment, instruments, containers, and paperwork to ensure that everything is ready prior to each sampling event (see SOP R-1, Reports to RMC Program Managers). All sampling personnel will be given a brief review of the goals and objectives of the sampling event and the sampling procedures and equipment that will be used to achieve them. It is important that all field equipment be clean and ready to use when it is needed. Therefore, prior to using all sampling and/or field measurement equipment, each piece of equipment will be checked to make sure that it is in proper working order. Equipment maintenance records will be checked to ensure that all field instruments have been properly maintained and that they are ready for use. Adequate supplies of all preservatives, bottles, labels, waterproof pens, etc. will be checked before each field event to make sure that there are sufficient supplies to successfully support each sampling event, and, as applicable, are within their expiration dates. It is important to make sure that all field activities and measurements are properly recorded in the field. Therefore, prior to starting each field event, necessary paperwork such as logbooks, chain of custody record forms, etc. will be checked to ensure that sufficient amounts are available during the field event. In the event that a problem is discovered during a readiness review it will be noted in the field log book and corrected before the field crew is deployed. The actions taken to correct the problem will also be documented with the problem in the field log book. This information will be communicated by the PML to the LQAO prior to conducting relevant sampling. The LQAO will track corrective actions taken, and as appropriate, communicate this information to other Stormwater Programs for whom it may be relevant.

20.2. Field Activity Audits

The responsible LQAO will be responsible for conducting all field activity audits within their jurisdiction (see SOP R-1, Reports to RMC Program Managers). Any problems that are noted will be documented along with recommendations for correcting the problem. Field activity audits will be conducted on a rotating basis during the Program's various field sampling activities. The CQAO will determine the appropriate frequency of audits based upon the complexity of sampling and findings of previous audits. At a minimum, these audits will be conducted on a biennial basis.

Field activity audits will assess the sample collection methodologies, field measurement procedures, and record keeping of the field crew in order to ensure that the activities are being conducted as planned and as documented in this QAPP. In the event that a problem is discovered during a field audit, it will be corrected as soon as possible so that all subsequent samples and field measurements collected are valid. The problems and the actions taken to correct them will become a part of the field audit report. Any field sampling team member has authority to stop any sampling or field measurement activity that could potentially compromise data quality.

20.3. Post Sampling Event Reviews

PMLs, or their designee, will be responsible for post sampling event reviews (see SOP R-1, Reports to RMC Program Managers). Any problems that are noted will be documented along with recommendations for correcting the problem. Post sampling event reviews will be conducted following each sampling event

in order to ensure that all information is complete and any deviations from planned methodologies are documented. Post sampling event reviews will include field sampling activities and field measurement documentation in order to help ensure that all information is complete. The reports for each post sampling event will be used to identify areas that may be improved prior to the next sampling event. A combined post sampling event report, identifying any deficiencies and corrective actions taken, will be an integral part of the final report on this proposed project.

20.4. Laboratory Data Reviews

The LQAO or CQAO (incorporate info from IMS, R&R) will be responsible for reviewing the laboratory's data for completeness and accuracy. The data will also be checked to make sure that the appropriate methods were used and that all required QC data was provided with the sample analytical results. Laboratory data reviews will be conducted following receipt of each data package from a laboratory in order to ensure that all information is complete and any deviations from planned methodologies are either corrected or the reasons for change are documented. Any laboratory data that is discovered to be incorrect or missing will immediately be reported to the both the laboratory and LQAO/CQAO. The laboratory's QA manual details the procedures that will be followed by laboratory personnel to correct any invalid or missing data. The RMC PM and LQAO/CQAO have the authority to request re-testing if a review of any of the laboratory data is found to be invalid or if it would compromise the quality of the data and resulting conclusions from the proposed project.

Table 20-1. Type and Frequency of QA Reviews for RMC Creek Status Monitoring Program

Type of Review	Frequency	Person(s) Responsible for Report Preparation	Report Recipients
Readiness Review	Prior to each sampling event	PML	MCC
Field Activity Audit	Minimum biennial per field crew	LQAO	MCC
Post-sampling Reviews	Following each sampling event	PML	MCC
Laboratory Data Review	Per lab report	LQAO	CQAO

21. (C2) Reports to Management

21.1. Post Sampling Event Reports

PMLs will be responsible for submitting Post Sampling Event Reports to the PM at the conclusion of each monitoring component in a particular season. This report will follow that outlined in the SOP R-1, Reports to RMC Program Managers.

21.2. Water Quality Standard Exceedance Reports

When data collected through the RMC indicate that stormwater runoff or dry weather discharges are or may be causing or contributing to exceedance(s) of applicable water quality standards, the associated Stormwater Program shall notify the Water Board within no more than 30 days of such a determination and submit a follow-up report in accordance with MRP Provision C.1 requirements. This shall not apply to continuing or recurring exceedances of water quality standards previously reported to the Water Board or to exceedances of pollutants that are to be addressed pursuant to Provisions C.8 through C.14 of the MRP. Reports will follow the format outlined in the SOP R-2, Reports to RWQCB.

21.3. Status and Trend Electronic Data Reporting

Stormwater Programs shall submit an Electronic Status & Trends Data Report no later than January 15 of each year, reporting on all data collected during the foregoing October 1 through September 30 period. Electronic Status & Trends Data Reports shall be in a format compatible with the SWAMP database. Water Quality Objective exceedances shall be highlighted in the Report. Reports will follow the format outlined in the SOP R-2, Reports to RWQCB. Electronic data shall also be submitted during the same timeframe to SFEI for entry into the California Environmental Data Exchange Network (CEDEN).

21.4. Urban Creeks Monitoring Report

The RMC Program Manager shall submit a comprehensive Urban Creeks Monitoring Report to the Water Board no later than March 15 of each year, reporting on all data collected during the foregoing October 1 through September 30 period, with the initial report due March 15, 2013. Each Urban Creeks Monitoring Report shall contain summaries of information as identified in MRP Provision C.8.g.iii. Integrated Monitoring Report (see below). Reports will follow the format outlined in the SOP R-2, Reports to RWQCB.

21.1. Integrated Monitoring Report

No later than March 15, 2014, the RMC Program Manager shall prepare and submit an Integrated Monitoring Report to the Water Board on behalf of all participating Stormwater Programs, so that all monitoring conducted during the Permit term is reported. This report shall be in lieu of the Annual Urban Creeks Monitoring Report due on March 15, 2014. The report shall include, but not be limited to, a comprehensive analysis of all data collected pursuant to MRP Provision C.8, and may include other pertinent studies. The report shall include methods, data calculations, load estimates, and source estimates for each monitoring parameter. The report shall include a budget summary for each monitoring requirement and recommendations for future monitoring. Reports will follow the format outlined in the SOP R-2, Reports to RWQCB.

This information is additionally summarized in Table 21-1 below.

Table 21-1. Reports to Management

Type of Report	Frequency (daily; weekly; monthly; quarterly; annually; etc.)	Projected Delivery Dates(s)	Person(s) Responsible for Report Preparation	Report Recipients
Post Sampling Event Review	Event-based	Vary	PML	MCC
WQ Exceedance	Trigger-based	Vary	PML	PM
S&T Electronic Data	Annually	January 15	CIMC	WB, SFEI
Urban Creeks Monitoring	Annually	March 15	RP	WB
Integrated Monitoring	End of permit	March 15, 2014	RP	WB

22. (D1) Data Review, Verification, and Validation

Defining data review, verification, and validation procedures helps to ensure that Program data will be reviewed in an objective and consistent manner. Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. LIMCs will be responsible for initial data review for field forms and field measurements; CIMC will be responsible for doing so for data reported by analytical laboratories. This includes checking that all technical criteria have been met, documenting any problems that are observed and, if possible, ensuring that deficiencies noted in the data are corrected. This review process is summarized below and detailed in SOP DM-4, Verification and Validation of Data.

In-house examination of the data produced from the proposed Program will be conducted to check for typical types of errors. This includes checking to make sure that the data have been recorded, transmitted, and processed correctly. The kinds of checks that will be made will include checking for data entry errors, transcription errors, transformation errors, calculation errors, and errors of data omission.

Data generated by Program activities will be reviewed against method quality objectives (MQOs) that were developed and documented in Element 7. This will ensure that the data will be of acceptable quality and that it will be SWAMP-comparable with respect to minimum expected MQOs.

QA/QC requirements were developed and documented in Elements 14, 15, 16, and 17 and the data will be checked against this information. Checks will include evaluation of field and laboratory duplicate results, field and laboratory blank data, matrix spike recovery data, and laboratory control sample data pertinent to each method and analytical data set. This will ensure that the data will be SWAMP-comparable with respect to quality assurance and quality control procedures.

Field data consists of all information obtained during sample collection and field measurements, including that documented in field log books and/or recording equipment, photographs, and chain of custody forms. Checks of field data will be made to ensure that it is complete, consistent, and meets the data management requirements that were developed and documented in Element 19.

Lab data consists of all information obtained during sample analysis. Initial review of laboratory data will be performed by the laboratory QA/QC Officer in accordance with the lab's internal data review procedures. However, upon receipt of laboratory data, the CIMC will perform independent checks to ensure that it is complete, consistent, and meets the data management requirements that were developed and documented in Element 19. This review will include evaluation of field and laboratory QC data and also making sure that the data are reported in compliance with procedures developed and documented in Elements 12, 13, and 14.

Data verification is the process of evaluating the completeness, correctness, and conformance / compliance of a specific data set against the method, procedural, or contractural specifications. The RMC will conduct data verification, as described in Element 14 on Quality Control, in order to ensure that it is SWAMP-comparable with respect to completeness, correctness, and conformance with minimum requirements. LIMCs will be responsible for data verification at the local level, and CIMC will do so for laboratory data.

Data validation is an analyte- and sample-specific process that evaluates the information after the verification process (i.e., determination of method, procedural, or contractual compliance) to determine analytical quality and any limitations. The CIMC will conduct data validation in order to ensure that the data is SWAMP-comparable with respect to its end use as described in Element 5.2 (Decisions or Outcomes).

Data will be separated into three categories for use with making decisions based upon it. These categories are: (1) data that meets all acceptance requirements, (2) data that has been determined to be unacceptable for use, and (3) data that may be conditionally used and that is flagged as per US EPA specifications.

23. (D2) Verification and Validation Methods

Defining the methods for data verification and validation helps to ensure that Program data are evaluated objectively and consistently. For the proposed Program many of these methods have been described in Element 22. Additional information is provided below.

All data records for the proposed Program will be checked visually and will be recorded as checked by the checker's initials as well as with the dates on which the records were checked. CIMC will conduct all of these reviews. CIMC staff will perform an independent re-check of at least 10% of these records as the validation methodology.

All of the laboratory's data will be checked as part of the verification methodology process. Each contract laboratory's Project Analyst will conduct reviews of all laboratory data for verification of their accuracy. CIMC staff will perform independent re-checks of at least 10% of them as the validation methodology.

Any data that is discovered to be incorrect or missing during the verification or validation process will immediately be reported to the PM. If errors involve laboratory data then this information will also be reported to the laboratory's CQAO. Each laboratory's QA manual details the procedures that will be followed by laboratory personnel to correct any invalid or missing data. LIMCs will be responsible for reporting and correcting any errors that are found in the data during the verification and validation process.

If there are any data quality problems identified, the CQAO will try to identify whether the problem is a result of project design issues, sampling issues, analytical methodology issues, or QA/QC issues (from laboratory or non-laboratory sources). If the source of the problems can be traced to one or more of these basic activities then the person or people in charge of the areas where the issues lie will be contacted and efforts will be made to immediately resolve the problem. If the issues are too broad or severe to be easily corrected then the appropriate people involved will be assembled to discuss and try to resolve the issue(s) as a group. The CQAO has the final authority to resolve any issues that may be identified during the verification and validation process.

During the process of verification and validation the methods that will be used are described in the RMC SOP DM-3.

24. (D3) Reconciliation with User Requirements

The purpose of the RMC Creek Status Monitoring Program is to obtain chemical, bacterial, and biological data from San Francisco Bay Area tributaries in compliance with the MRP permit conditions. RMC status and trends monitoring in local creeks/rivers is intended to answer the following core management questions: (1) Are conditions in local creeks supportive of or likely to be supportive of beneficial uses?; (2) Are conditions in local creeks getting better or worse over time?

Information from field data reports (including field activities, post sampling events, corrective actions, and audits), laboratory data reviews (including errors involving data entry, transcriptions, omissions, and calculations and laboratory audit reports), reviews of data versus Measurement Quality Objectives (MQOs), reviews against Quality Assurance and Quality Control (QA/QC) requirements, data verification reports, data validation reports, independent data checking reports, and error handling reports will be used to determine whether or not the Program's objectives have been met. Data from monitoring measurements will not be statistically analyzed. Descriptions of the data will be made with no extrapolation to more general cases.

Data from all monitoring measurements will be summarized in tables. In addition, data used for trend analysis will be represented graphically, when appropriate. Additional data may also be represented graphically when it is deemed helpful for interpretation purposes.

RMC data is collected from a wide variety of sites with differing stream type, land use conditions, and other factors. As the Bay Area in general is highly urbanized, there is a good likelihood that matrix interfences within the runoff may affect ability of some analyses to achieve data quality objectives (e.g. elevated MRLs relative to SWAMP recommendations).

The proposed Program will provide SWAMP-comparable data for the selected analytes described in Element 6. Electronic data shall also be submitted during the same timeframe to SFEI for entry into the California Environmental Data Exchange Network (CEDEN).

The above evaluations will provide a comprehensive assessment of how well the Program meets its objectives. No other evaluations will be used. The RMC Program Manager will be responsible for reporting project reconciliation. This will include measurements of how well the project objectives were met and the degree to which the data is SWAMP-comparable.

25. References

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26. Appendix A. Measurement Quality Objectives for RMC Analytes

Table 26-1. Measurement Quality Objectives* - Conventional Analytes in Water

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs	80-120% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (chlorophyll: n/a)	80-120% recovery RPD<25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (chlorophyll: per method)	RPD<25% (n/a if native concentration of either sample<RL)
Internal Standard	Accompanying every analytical run as method appropriate	Per method
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	10% of total Project sample count	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Travel Blank, Field, Travel, Eqpt Blanks	Field Blanks required for DOC only at a rate of 5% of total Project sample count	<RL for target analyte

*Unless method specifies more stringent requirements

Table 26-2. Measurement Quality Objectives* – Conventional Analytes in Water – Solids

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% (n/a if native concentration of either sample<RL)
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	10% of total Project sample count	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Equipment Field, Eqpt Blanks	Not required for RMC analytes	<RL for target analyte

*Unless method specifies more stringent requirements

Table 26-3. Measurement Quality Objectives* – Conventional Analytes in Water - Pathogens

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration	Check temperatures in incubators twice daily with a minimum of 4 hours between each reading	Per analytical method or manufacturer's specifications
Filter Sterility Check	Perform one filter sterility check each day samples are analyzed	No growth on filter
Laboratory Blank	Per batch of bottles or reagents	No growth on filter
Filtration Blank	Per 20 samples or per analytical batch, whichever is more frequent	No growth on filter
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Positive Control	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Negative Control	Per 20 samples or per analytical batch, whichever is more frequent	No growth on filter
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% (n/a if native concentration of either sample<RL)
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count (coliforms: one per 25 tube dilution tests)	Coliforms: within 95% confidence interval as defined by IDEXX Laboratories)
Field Blank, Travel Blank, Field, Travel, Eqpt Blanks	Not required for RMC analytes	Blanks<RL for target analyte

*Unless method specifies more stringent requirements

Table 26-4. Measurement Quality Objectives* - Conventional Analytes in Sediments

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs (as applicable)	80-120% recovery
Laboratory Blank	TOC only: one per analytical batch (n/a for others)	<RL or <30% of lowest sample
Reference Material	TOC only: one per 20 samples or per analytical batch, whichever is more frequent (n/a for others)	80-120% recovery
Matrix Spike	n/a	n/a
Matrix Spike Duplicate	n/a	n/a
Laboratory Duplicate	One per analytical batch	RPD<25% (n/a if native concentration of either sample<RL)
Surrogate or Internal Standard	n/a	n/a
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Travel Blank, Field, Travel, Eqpt Blanks	Not required for RMC analytes	<RL or <30% of lowest sample

*Unless method specifies more stringent requirements

Table 26-5. Measurement Quality Objectives* – Inorganic Analytes in Water (Bioassessment Sites)

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs	80-120% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery (70-130% for MMHg)
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery (70-130% for MMHg)
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery (70-130% for MMHg); RPD<25%
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% (n/a if native concentration of either sample<RL)
Internal Standard	Accompanying every analytical run when method appropriate	60-125% recovery
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	10% of total Project sample count	RPD<25% (n/a if native concentration of either sample<RL), unless otherwise specified by method
Field Blank, Equipment Field, Eqpt Blanks	5% equipment (filter) blanks for orthophosphate	Blanks<RL for target analyte

*Unless method specifies more stringent requirements

Table 26-6. Measurement Quality Objectives* – Inorganic Analytes in Sediment

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs	80-120% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery (70-130% for MMHg)
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery (70-130% for MMHg)
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery (70-130% for MMHg); RPD<25%
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% (n/a if native concentration of either sample<RL)
Internal Standard	Accompanying every analytical run when method appropriate	60-125% recovery
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count	RPD<25% (n/a if native concentration of either sample<RL), unless otherwise specified by method
Field Blank, Equipment Field, Eqpt Blanks	Not required for RMC analytes	Blanks<RL for target analyte

*Unless method specifies more stringent requirements

Table 26-7. Measurement Quality Objectives* – Synthetic Organic Compounds in Water, Sediment and Tissue

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs	Water: 85-115% recovery Sediment: 85-115% recovery Tissue: 75-125%
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analytes
Reference Material	Method Validation: as many as required to assess accuracy and precision of method before routine analysis of samples; Routine Accuracy Assessment: per 20 samples or per analytical batch (preferably blind)	70-130% recovery if certified; otherwise, 50-150% recovery
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	50-150% recovery, or based on 3x the standard deviation of laboratory's actual method recoveries
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25%
Laboratory Duplicate	Per method	Water: RPD<25% (n/a if native concentration of either sample<RL) Sediment: Per method Tissue: Per method
Surrogate or Internal Standard	Per method	Per method
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count	Per method
Field Blank, Travel Field, Field, Travel, EqptBlanks	Not required for RMC analytes	<RL for target analytes

* Unless method specifies more stringent requirements. ELISA results must be assessed against kit requirements

Table 26-8. Measurement Quality Objectives* - Toxicity Testing (General)

Negative Controls	Frequency of Analysis	Control Limits
Laboratory Control Water	Laboratory Control Water consistent with Section 7 of the appropriate EPA method must be tested with each analytical batch.	Laboratory Control Water must meet all test acceptability criteria (Please refer to Section 7 of the EPA manuals) for the species of interest.
Conductivity Control Water	A conductivity control must be tested with each analytical batch when the conductivity of any freshwater ambient sample approaches the species' tolerance for conductivity per method.	Follow EPA guidance on interpreting data.
Additional Control Water	Additional method blanks are required whenever manipulations are performed on one or more of the ambient samples within each analytical batch (e.g. pH adjustments, continuous aeration, etc.).	No statistical difference between the laboratory control water and each additional control water within an analytical batch.
Sediment Control	Sediment Control consistent with those described in Section 7 of the EPA manual must be tested with each analytical batch of sediment toxicity tests.	Sediment Control must meet all data acceptability criteria (Please refer to Section 7 of the EPA manuals) for the species of interest.
Positive Controls	**Frequency of Analysis**	**Control Limits**
Reference Toxicant Tests	Reference Toxicant Tests must be conducted monthly for species that are raised within a laboratory. Reference Toxicant Test must be conducted per analytical batch for species from commercial supplier settings. Reference Toxicant Tests must be conducted concurrently for test species or broodstocks that are field collected.	Last plotted data point must be within 2 SD of the cumulative mean (n=20). (Reference toxicant tests that fall outside of recommended control chart limits are evaluated to determine the validity of associated effluent and receiving water tests. An out of control reference toxicant test result does not necessarily invalidate associated test results. More frequent and/or concurrent reference toxicant testing may be advantageous if recent problems have been identified in testing.)
Field Quality Control	**Frequency of Analysis**	**Control Limits**
Field Duplicate	5% of total project sample count	According to method
Field Blanks	Not required for RMC analytes	No statistical difference between the laboratory control water (or sediment control) and the field blank within an analytical batch
Equipment Blanks	Not required for RMC analytes	No statistical difference between the Laboratory Control Water and the Equipment Blank within an analytical batch

*Unless method specifies more stringent requirements.

The measurement quality objectives for water quality parameters (pH, dissolved oxygen, conductivity, temperature, unionized ammonia, salinity, alkalinity and hardness) are detailed in the Field Measurement and Conventional Analytes tables of this Appendix. In special cases where the criteria listed in the following tables cannot be met, EPA minimum criteria may be followed. The affected data should be qualified accordingly.Test data are reviewed to verify that the test acceptability criteria (TAC) requirements for a valid test have been met. Any test not meeting the minimum test acceptability criteria is considered invalid. All invalid tests must be repeated with the newly collected sample.

Deviations from the summary of recommended test conditions must be evaluated on a project specific basis to determine the validity of test results. Deviations from recommended conditions may or may not invalidate a test result depending on the degree of the departure and the objective of the test. The reviewer should consider the degree of the deviation and the potential or observed impact of the deviation on the test result before rejecting or accepting a test result is valid. For example, if dissolved oxygen is measured below 4.0 mg/L in one test chamber, the reviewer should consider whether any observed mortality in that test chamber corresponded with the drop in dissolved oxygen.

Table 26-9. Measurement Quality Objectives - 96-Hour *Selenastrum capricornutum* Chronic Aquatic Toxicity Test

Method Recommendation	
EPA/821/R-02/013 (Test Method 1003.0) or validated and SWAMP-approved alternative method	
Data Acceptability Requirements	
Parameter	*Criteria*
Test Acceptability Criteria*	Mean cell density of at least 1 X 10^6 cells/mL in the controls and variability (CV%) among control replicates less than or equal to 20% (non-EDTA: Mean cell density of at least 1 X 106 cells/mL in the controls; and variability (CV%) among control replicates less than or equal to 20% (required)
Data Qualification	
Test Conditions	*Required*
Test Type	Static non-renewal
Age at Test Initiation	4 - 7 days
Replication at Test Initiation	10,000 cells/mL (recommended)
Organisms/Replicate	>4
Food Source	n/a
Renewal Frequency	None
Test Duration	96 h
Endpoints	Growth
Test Conditions	*Recommended***
Temperature Range	25 ± 1 °C (+/- 3 °C required)
Light Intensity	86 ± 8.6 µE/m^2/s OR 400 ± 40 ft-c
Photoperiod	Continuous Illumination (“cool white” fluorescent lighting)
Test Chamber Size	125 mL or 250 mL
Replicate Volume	50 mL or 100 mL
Feeding Regime	None
Nutrient Media	Media prepared in accordance with EPA protocols
EDTA Addition	EDTA required per method
Laboratory Control Water	Moderately hard water prepared in accordance with EPA protocols
Minimum Sample Volume	1 L for one-time grab sample
Sensitivity	*Performance Criteria*
Minimum Significant Difference	<29% MSD If the percent minimum significant difference (PMSD) measured for the test exceeds the upper

	criterion and toxicity is found at the permitted receiving water concentration (RWC) based upon the value of the effect concentration estimate (NOEC or LOEC), then the test shall be accepted, unless other test review steps raise serious doubts about its validity. If toxicity is not found at the permitted RWC based upon the value of the effect concentration estimate (NOEC or LOEC) and the PMSD measured for the test exceeds the upper PMSD bound, then the test shall not be accepted, and a new test must be conducted promptly on a newly collected sample.
Water Chemistry	
Test Parameter	*Required Frequency*
Initial Water Chemistry	One DO, SC, pH, and temperature measurement per sample and per dilution
Initial Unionized Ammonia	One measurement per sample
Initial Hardness and Alkalinity	One measurement per sample
Daily Water Chemistry	One pH and one temperature measurement per sample
Final Water Chemistry	One DO, pH, and temperature measurement and per sample and per dilution (One DO per renewal)
Test Parameter	*Recommended Criteria*
Initial DO Range	4.0 - 8.6 mg/L
Initial pH Range	6.0 - 9.0
Conductivity Controls	Include appropriate controls when sample conductivities are <100 or >2000 µS/cm
Sample Handling/Collection	
Test Parameter	*Recommended Conditions*
Species' Conductivity Tolerance	<3000 µS/cm
Relevant Media	Water column
Sample Container Type	Amber glass
Sample Preservation	Wet or blue ice in field, 0 - 6 °C refrigeration in laboratory, dark at all times
Sample Receipt Temperature	0 - 6 °C
Holding Time	< 48 hours@ 0 - 6 °C; dark

*Test data are reviewed to verify that the test acceptability criteria (TAC) requirements for a valid test have been met. Any test not meeting the minimum test acceptability criteria is considered invalid. All invalid tests must be repeated with the newly collected sample.

**Deviations from the summary of recommended test conditions must be evaluated on a project-specific basis to determine the validity of test results. Deviations from recommended conditions may or may not invalidate a test result, depending on the degree of the departure and the objective of the test.

Table 26-10. Measurement Quality Objectives - 7-Day *Pimephales promelas* Acute and Chronic Toxicity Tests

Method Recommendation	
EPA/821/R-02/013 (Test Method 1000.0) or validated and SWAMP-approved alternative method	
Data Acceptability Requirements	
Parameter	*Criteria*
Test Acceptability Criteria*	80% or greater survival in controls and an average dry weight per surviving organism in control chambers equals or exceeds 0.25 mg
Data Qualification	
Test Conditions	*Required*
Test Type	Static renewal (required)
Age at Test Initiation	Newly-hatched larvae <24hoursold. If shipped, <48hours old with a 24-hour age range
Replication at Test Initiation	4 (minimum)
Organisms/Replicate	10 (minimum)
Food Source	Newly-hatched *Artemia* nauplii (<24hoursold)
Renewal Frequency	Daily
Test Duration	7 days
Endpoints	Survival and biomass
Test Conditions	*Recommended***
Temperature Range	25 ± 1.0 °C (+/- 3 °C required)
Light Intensity	10 – 20 µE/m^2/s or 50 – 100 ft-c
Photoperiod	16 hours of ambient laboratory light, 8 hours dark
Test Chamber Size	>500 mL or per method specific requirements
Replicate Volume	>250 mL or per method specific requirements
Feeding Regime	< 2 times per day
Laboratory Control Water	Moderately hard water prepared in accordance with EPA protocols
Minimum Sample Volume	7 L for one-time grab sample
Sensitivity	*Performance Criteria*
Minimum Significant Difference	<30% MSD If the percent minimum significant difference (PMSD) measured for the test exceeds the upper criterion and toxicity is found at the permitted receiving water concentration (RWC) based upon the value of the effect concentration estimate (NOEC or LOEC), then the test shall be accepted, unless other test review steps raise serious doubts about its validity. If toxicity is not found at the permitted RWC based upon the value of the effect concentration estimate (NOEC or LOEC) and

	the PMSD measured for the test exceeds the upper PMSD bound, then the test shall not be accepted, and a new test must be conducted promptly on a newly collected sample.
Water Chemistry	
Test Parameter	*Required Frequency*
Initial Water Chemistry	One DO, SC, pH, and temperature measurement per sample and per dilution
Initial Unionized Ammonia	One measurement per sample (recommended)
Initial Hardness and Alkalinity	One measurement per sample
Daily Water Chemistry	One DO and one pH measurement per sample
Final Water Chemistry	One DO, pH, and temperature measurement and per sample and per dilution (one DO per renewal)
Test Parameter	*Recommended Criteria*
Initial DO Range	4.0 - 8.6 mg/L
Initial pH Range	6.0 - 9.0
Conductivity Controls	Per method - recommend including appropriate controls when sample conductivities are below 100 or above 2500 µS/cm
Sample Handling/Collection	
Test Parameter	*Recommended Conditions*
Species' Conductivity Tolerance	<3000 µS/cm
Relevant Media	Water column
Sample Container Type	Amber glass or plastic (per method)
Sample Preservation	Wet or blue ice in field, 0 - 6 °C refrigeration in laboratory, dark at all times
Sample Receipt Temperature	0 - 6 °C
Holding Time	<48 hours@ 0 - 6 °C; dark

*Test data are reviewed to verify that the test acceptability criteria (TAC) requirements for a valid test have been met. Any test not meeting the minimum test acceptability criteria is considered invalid. All invalid tests must be repeated with the newly collected sample.

**Deviations from the summary of recommended test conditions must be evaluated on a project-specific basis to determine the validity of test results. Deviations from recommended conditions may or may not invalidate a test result, depending on the degree of the departure and the objective of the test.

Table 26-11. Measurement Quality Objectives –*Ceriodaphnia dubia* Acute and Chronic Aquatic Toxicity Tests

Method Recommendation	
EPA/821/R-02/013 (Test Method 1002.0) or validated and SWAMP-approved alternative method	
Data Acceptability Requirements	
Parameter	*Criteria*
Test Acceptability Criteria*	80% or greater survival of al control organisms and an average of 15 or more young per surviving female. 60% of the surviving control females must produce three broods.
Data Qualification	
Test Conditions	*Required*
Test Type	Static renewal (required)
Age at Test Initiation	<24 hours old and all released within an 8-h period
Replication at Test Initiation	>10
Organisms/Replicate	One (assigned using blocking by known parentage)
Food Source	YCT and *Selenastrum* or comparable food
Renewal Frequency	Daily
Test Duration	<8 days
Endpoints	Survival and reproduction
Test Conditions	*Recommended***
Temperature Range	25 ± 1.5 °C (+/- 3 °C required)
Light Intensity	10 – 20 µE/m^2/s OR 50 – 100 ft-c
Photoperiod	16 hours of ambient laboratory light, 8 hours dark
Test Chamber Size	20 - 40 mL
Replicate Volume	>15 mL
Feeding Regime	Daily
Laboratory Control Water	Moderately hard water prepared in accordance with EPA protocols
Minimum Sample Volume	2 L for one-time grab sample
Sensitivity	*Performance Criteria*
Minimum Significant Difference	<47% MSD If the percent minimum significant difference (PMSD) measured for the test exceeds the upper criterion and toxicity is found at the permitted receiving water concentration (RWC) based upon the value of the effect concentration estimate (NOEC or LOEC), then the test shall be accepted, unless other test review steps raise serious doubts about its validity. If toxicity is not found at the permitted RWC based upon the value of the effect concentration estimate (NOEC or LOEC) and

	the PMSD measured for the test exceeds the upper PMSD bound, then the test shall not be accepted, and a new test must be conducted promptly on a newly collected sample.
Water Chemistry	
Test Parameter	*Required Frequency*
Initial Water Chemistry	One DO, SC, pH, and temperature measurement per sample and per dilution
Initial Unionized Ammonia	One measurement per sample
Initial Hardness and Alkalinity	One measurement per sample
Daily Water Chemistry	Two DO , one pH and one temperature per 24-h period in one sample per concentration and in the control
Final Water Chemistry	One DO, pH, and temperature measurement per sample and per dilution (One DO per renewal)
Test Parameter	*Recommended Criteria*
Initial DO Range	4.0 - 8.6 mg/L
Initial pH Range	6.0 - 9.0
Conductivity Controls	Include appropriate controls when sample conductivities are <100 or >2000 µS/cm
Sample Handling/Collection	
Test Parameter	*Recommended Conditions*
Species' Conductivity Tolerance	2500 µS/cm
Relevant Media	Water column
Sample Container Type	Amber glass
Sample Preservation	Wet or blue ice in field, 0 - 6 °C refrigeration in laboratory, dark at all times
Sample Receipt Temperature	0 - 6 °C
Holding Time	<48 hours@ 0 - 6 °C; dark

*Test data are reviewed to verify that the test acceptability criteria (TAC) requirements for a valid test have been met. Any test not meeting the minimum test acceptability criteria is considered invalid. All invalid tests must be repeated with the newly collected sample.

**Deviations from the summary of recommended test conditions must be evaluated on a project-specific basis to determine the validity of test results. Deviations from recommended conditions may or may not invalidate a test result, depending on the degree of the departure and the objective of the test.

Table 26-12. Measurement Quality Objectives - 10-Day *Hyalella azteca* Acute Aquatic Toxicity Test

Method Recommendation	
EPA/821/R-02/013 (Test Method 1002.0) or validated and SWAMP-approved alternative method	
Data Acceptability Requirements	
Parameter	*Criteria*
Test Acceptability Criteria*	90% or greater survival in controls
Data Qualification	
Test Conditions	*Required*
Test Type	Static renewal
Age at Test Initiation	7 – 14 days old
Replication at Test Initiation	5
Organisms/Replicate	10
Food Source	YCT
Renewal Frequency	80% renewal on Day 5
Test Duration	10 days
Endpoints	Survival
Test Conditions	*Recommended***
Temperature Range	23 ± 1.0 °C
Light Intensity	500 - 1000 lux
Photoperiod	16 hours of ambient laboratory light, 8 hours dark
Test Chamber Size	300 mL
Replicate Volume	100 mL water
Feeding Regime	1.5 mL YCT every other day
Laboratory Control Water	Moderately hard water prepared in accordance with EPA protocols
Minimum Sample Volume	1L
Sensitivity	*Performance Criteria*
Minimum Significant Difference	No MSD available
Water Chemistry	
Test Parameter	*Required Frequency*
Initial Water Chemistry	One DO, SC, pH, and temperature measurement per sample and per dilution

Initial Unionized Ammonia	One measurement per sample
Initial Hardness and Alkalinity	One measurement per sample
Daily Water Chemistry	Temperature
Final Water Chemistry	One DO, EC, pH, and temperature measurement and per sample and per dilution (DO, EC, pH per renewal)
Test Parameter	*Recommended Criteria*
Initial DO Range	4.7 - 8.92 mg/L
Initial pH Range	6.0 - 9.0
Conductivity Controls	Include appropriate controls when sample conductivities are below or above levels in method
Sample Handling/Collection	
Test Parameter	*Recommended Conditions*
Species' Conductivity Tolerance	<15 ppt
Relevant Media	Water
Sample Container Type	Amber glass
Sample Preservation	Wet or blue ice in field; 0 - 6 °C refrigeration in laboratory; dark at all times
Sample Receipt Temperature	0 - 6 °C
Holding Time	<48 hours@ 0 - 6 °C; dark

*Test data are reviewed to verify that the test acceptability criteria (TAC) requirements for a valid test have been met. Any test not meeting the minimum test acceptability criteria is considered invalid. All invalid tests must be repeated with the newly collected sample.

**Deviations from the summary of recommended test conditions must be evaluated on a project-specific basis to determine the validity of test results. Deviations from recommended conditions may or may not invalidate a test result, depending on the degree of the departure and the objective of the test.

Table 26-13. Measurement Quality Objectives - 10-Day *Hyalella azteca* Acute Sediment Toxicity Test

Method Recommendation	
EPA/600/R-99/064 (Test Method 100.1) or validated and SWAMP-approved alternative method	
Data Acceptability Requirements	
Parameter	*Criteria*
Test Acceptability Criteria*	Mean control survival of >80%
Data Qualification	
Test Conditions	*Required*
Test Type	Whole sediment toxicity test with renewal of overlying water
Age at Test Initiation	7 – 14 days old
Replication at Test Initiation	8
Organisms/Replicate	10
Food Source	YCT
Renewal Frequency	Twice daily
Test Duration	10 days
Endpoints	Survival
Test Conditions	*Recommended***
Temperature Range	23 ± 1.0 °C
Light Intensity	500 - 1000 lux
Photoperiod	16 hours of ambient laboratory light, 8 hours dark
Test Chamber Size	300 mL
Replicate Volume	Sediment volume 100 mL; Overlying water volume 175 mL
Feeding Regime	Daily
Laboratory Control Water	Moderately hard water prepared in accordance with EPA protocols
Sediment Control	Control sediment as listed in method (Control sediment should follow EPA requirements for formulated sediments)
Minimum Sample Volume	6 L for one-time grab sample
Sensitivity	*Performance Criteria*
Minimum Significant Difference	No MSD available
Water Chemistry	

Test Parameter	*Required Frequency*
Initial Water Chemistry	One DO, SC, pH, and temperature measurement per sample
Initial Unionized Ammonia	One measurement per sample
Initial Hardness and Alkalinity	One measurement per sample
Daily Water Chemistry	One DO and one temperature measurement per sample
Final Water Chemistry	One DO, pH, and temperature measurement per sample
Test Parameter	*Recommended Criteria*
Initial DO Range	4.7 - 8.92 mg/L
Initial pH Range	6.0 - 9.0
Conductivity Controls	Include appropriate controls when sample conductivities are below or above levels listed in method
Sample Handling/Collection	
Test Parameter	*Recommended Conditions*
Species' Conductivity Tolerance	<15 ppt
Relevant Media	Sediment
Sample Container Type	Amber glass
Sample Preservation	Wet or blue ice in field, 0 - 6 °C refrigeration in laboratory, dark at all times
Sample Receipt Temperature	0 - 6 °C
Holding Time	< 14 days (recommended) or <8 weeks (required) @ 0 - 6 °C; dark; Do not freeze

*Test data are reviewed to verify that the test acceptability criteria (TAC) requirements for a valid test have been met. Any test not meeting the minimum test acceptability criteria is considered invalid. All invalid tests must be repeated with the newly collected sample.

**Deviations from the summary of recommended test conditions must be evaluated on a project-specific basis to determine the validity of test results. Deviations from recommended conditions may or may not invalidate a test result, depending on the degree of the departure and the objective of the test.

Table 26-14. Measurement Quality Objectives* - Field Measurements**

Water Quality Parameter	Recommended Device	Units	Resolution	Target Reporting Limit	"Electronic Specs" Accuracy**
Depth	Stadia Rod/Staff Gauge	m	0.01	0.02	n/a
Dissolved Oxygen	Polarographic or Luminescence Quenching	mg/L	0.1	0.2	± 0.2
pH	Electrode	None	0.1	n/a	± 0.2
Specific Conductivity	Conductivity Cell	µS/cm	1	2	± 2
Temperature	Thermistor or Bulb	°C	0.1 or 0.5	n/a	± 0.1
Turbidity	Portable Turbidimeter or Optical Probe	NTU	1	5	± 1
Velocity	Flow Meter	ft/s	0.05	0.1	Follow manufacturer's instructions

* Unless method specifies more stringent requirements

** This table may not include all field analyses. Please refer to method or manufacturer instructions for guidance

27. Appendix B. Benthic macroinvertebrate MQOs and Data Production Process

Table 27-1. Measurement Quality Objectives for Biological Measurements

Analyte	Completeness	Accuracy	Precision	Sensitivity	Representativeness
Sampling	• ≥95% successful collection at all sites for probabilistic designs	• NA	• Record coefficient of variation of biological measures for duplicate samples (no MQO), frequency of 10% or at least one per project each year.	• 1.0 seconds or 1/10,000th of a degree Lat/Long	• Probabilistic sites are evaluated in order within each panel and management unit. • ≤10 seconds of nominal Lat/Long (300 m radius)
Sorting	• Sorting efficiency ≥95%, 100 % frequency (internal) • Processing efficiency ≥99%, 100% frequency	• Recount accuracy ≥95%. 10% frequency (external reference lab)	• At least three grids or 25% of the total sample volume must be sorted.	• N/A	• ≥ 3 grids or ≥ 25% of the total sample volume is sorted
Taxonomic ID	• ≥99% successful analysis of all sorted samples	• Taxa count error ≤10%. 10% frequency (external reference lab) • Taxa ID error ≤10%. 10% frequency (external reference lab) • Individual ID error ≤10%. 10% frequency (external reference lab)	• Random errors ≤ 10% of taxa, 10% frequency (ref lab) • Systemic errors ≤ 10% of common taxa. 10% frequency (external reference lab) • Taxonomic resolution error rate ≤10%.	• SAFIT Level 1	• All sorted organisms are identified

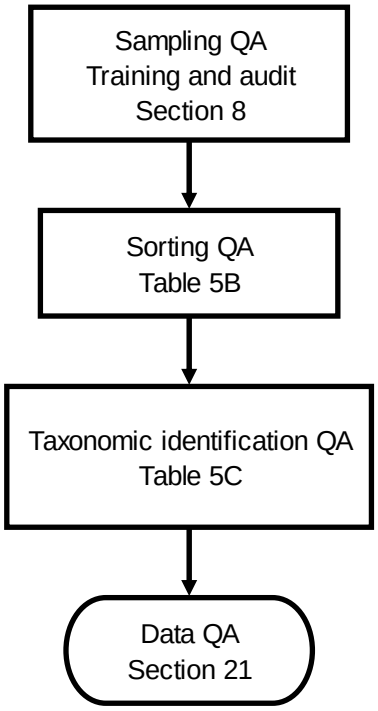

Figure 27-1. Overall Data Production Process Diagram

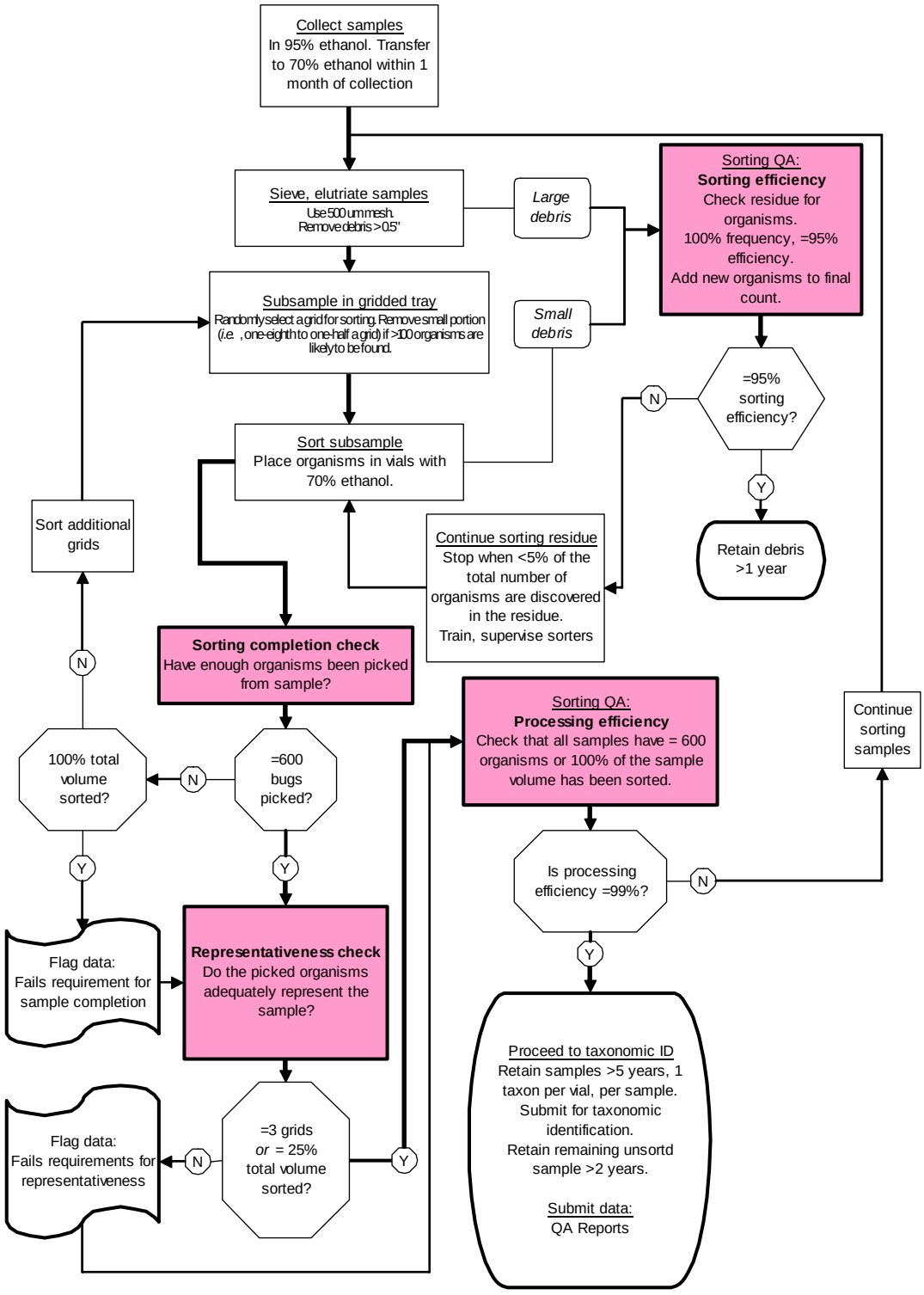

Figure 27-2. Sorting Process Diagram for Sorting

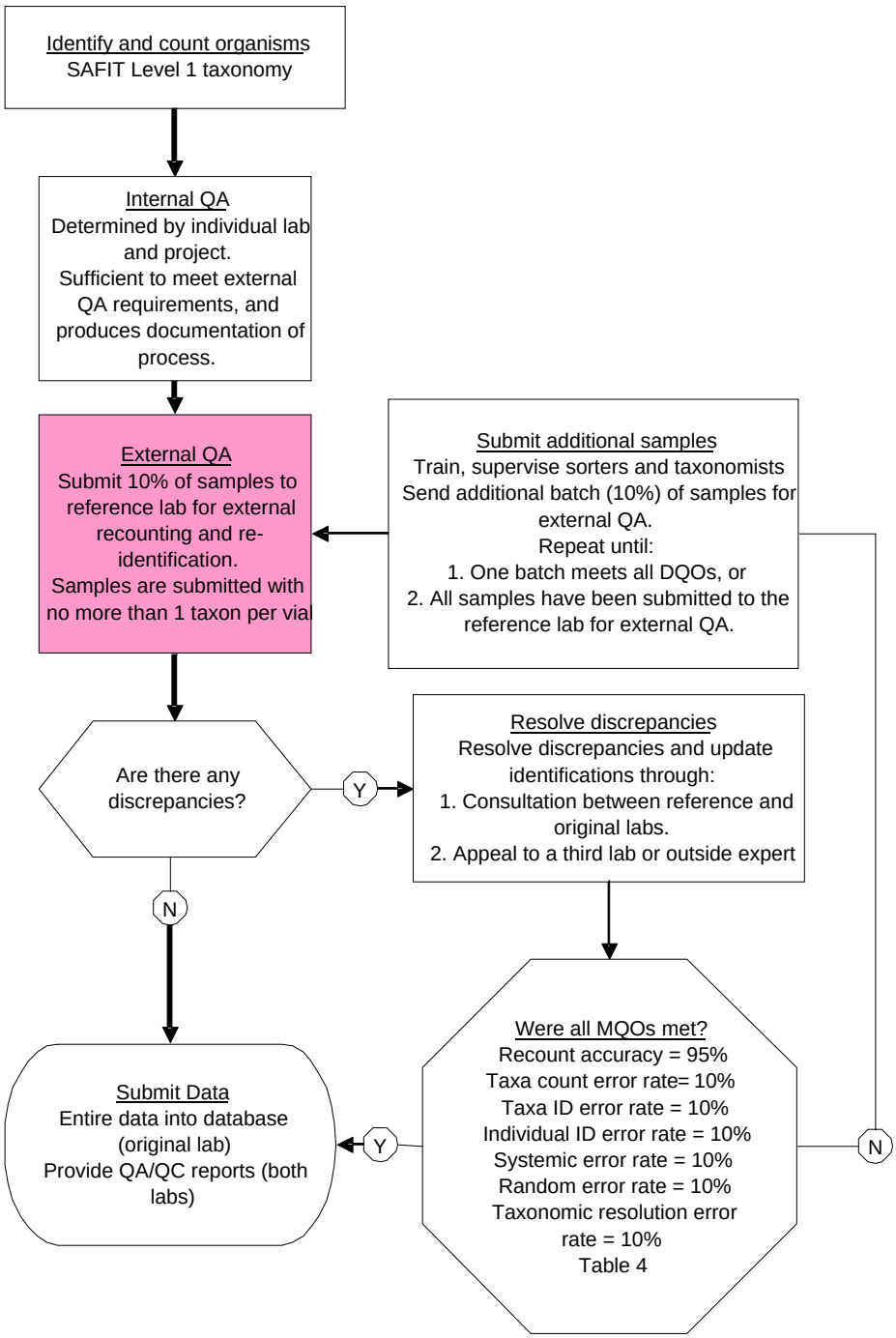

Figure 27-3. Taxonomic Identification Process Diagram

28. Appendix C. BMI Subsampling Worksheet and Sorting Sheet

BENTHIC MACROINVERTEBRATE SUBSAMPLING WORKSHEET

Project Name: _____ ***Project Code:*** _____ ***Object Code:*** _____

Lab Sample ID #:				**Date:**					**Technician Name:**											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
random grid #																				
half /whole grid																				
# per grid																				
cumulative #																				

Lab Sample ID #:				**Date:**					**Technician Name:**											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
random grid #																				
half /whole grid																				
# per grid																				
cumulative #																				

Lab Sample ID #:				**Date:**					**Technician Name:**											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
random grid #																				
half /whole grid																				
# per grid																				
cumulative #																				
Grids Picked: Total Grids: Count:									QC #: QC%:							Total Count:				
																Time: QC Initials:				

Benthic Macroinvertebrate

Sorting Worksheet

Project Code:		**Project Name:**							
Technician Name:		**Object Code:**				**Project Date:**			
	Lab Sample ID #		**Lab Sample ID #**		**Lab Sample ID #**		**Lab Sample ID #**		**Lab Sample ID #**
Taxon:	***#bugs***		***#bugs***		***#bugs***		***#bugs***		***#bugs***
Annelida(Hirudinea)									
Annelida(Oligochaeta)									
Annelida(Polychaeta)									
Chelicerata(Hydracarina)									
Coleoptera									
Crustacea(Amphipoda)									
Crustacea(Isopoda)									
Crustacea(Mysidacea)									
Crustacea(Ostracoda)									
Decapoda									
Diptera									
Diptera(Chironomidae)									
Ephemeroptera									
Hydra									
Hemiptera									
Lepidoptera									
Megaloptera									
Mollusca(Gastropoda)									
Mollusca(Pelecypoda)									
Nemertea									
Odonata									
Plecoptera									
Platyhelminthes									
Tardigrada									
Trichoptera									
Total Bugs Sorted:									
***Total Bugs Discarded:**									
Total:									
Bugs Picked:									
Time:									
Date:									

***Discards include exuvia, small (<0.5 mm), fragmented, decomposed, non-aquatic/benthic**

29. Appendix D. Example of MQO Calculations for Biological Data

Below are results from two hypothetical samples submitted to a reference lab as a batch for quality assurance checks. Calculations of the MQOs described in Section 7 are provided. Relevant MQOs are summarized in Table 29-1.

Table 29-1. Summary of MQOs for Biological Data

Sample-based MQO	Objective
Recount accuracy	≥95%
Taxa count error rate	≤10%
Taxa ID error rate	≤10%
Individual ID error rate	≤10%
Taxonomic resolution error rate	≤10%
Batch-based MQO	
Random error rate	≤10%
Systemic error rate	≤10%

Table 29-2 shows the results from Sample 1. Sample 1 contains several errors in counting as well as identification. For example, in Vial 1, *Diphetor hageni* is incorrectly identified as *Fallceon quilleri*, and the vial contains two specimens instead of one. Vial 6 and Vial 10 both show errors of taxonomic resolution, in which the original lab made an inappropriate determination than the specimens (and, in fact, the STE) could support.

Table 29-2. Results from Sample 1

Vial #	Original ID	Original count	Reference ID	Reference count	ID error	Count error
1	*Fallceon quilleri*	1	*Diphetor hageni*	2	Yes	Yes
2	*Baetis*	129	*Baetis*	129	No	No
3	*Hydroptila*	12	*Hydroptila*	12	No	No
4	*Hydropsyche*	67	*Hydropsyche*	67	No	No
			Prostoma	1	Yes	Yes
5	*Simulium*	46	*Simulium*	45	No	Yes
6	*Caloparyphus*	20	*Caloparyphus / Euparyphus*	20	Yes	No
7	*Sperchon*	5	*Sperchon*	5	No	No
8	*Argia*	12	*Argia*	12	No	No
9	*Hyalella*	3	*Hyalella*	3	No	No
10	*Corbicula fluminea*	6	*Corbicula*	6	Yes	No

Table 29-3 summarizes the count of individuals and taxa for Sample 1. These numbers are used in the calculation of several MQOs.

Table 29-3. Summary of Sample 1

	Original	Reference
Total richness	10	11
Total # individuals	301	302

Table 29-4 shows the calculation of MQOs for Sample 1. Although most objectives were met, the Taxa ID error rate exceeded the MQO because four of the 11 taxa (36.4%) were identified incorrectly.

Table 29-4. MQOs for Sample 1.

Sample-based MQOs	Calculation	Result	Meets objective?
Recount accuracy	=301/302*100	99.7%	Yes (≥95%)
Taxa count error rate	=|(11-10)|/11*100	9.1%	Yes (≤10%)
Taxa ID error rate	*Diphetor hageni* *Prostoma* *Caloparyphus/Euparyphus* *Corbicula* =4/11*100	36.4%	No (>10%)
Individual ID error rate	2 *Diphetor hageni* 1 *Prostoma* 20 *Caloparyphus/Euparyphus* 6 *Corbicula* =29/302*100	9.6%	Yes (≤10%)
High taxonomic resolution error rate	6 *Corbicula* 20 *Caloparyphus/Euparyphus* =26/302*100	8.6%	NA
Low taxonomic resolution error rate	None	0%	NA
Taxonomic resolution error rate	8.6% + 0%	8.6%	Yes (≤10%)

Table 29-5 shows the results from the second sample included in the QA batch. Table 29-6 shows its summary, and Table 29-7 shows the MQO calculations.

Table 29-5. Results for Sample 2.

Vial #	Original ID	Original count	Reference ID	Reference count	ID error	Count error
1	*Fallceon quilleri*	13	*Fallceon quilleri*	12	No	Yes
2	*Caenis*	2	*Caenis*	2	No	No
3	*Cheumatopsyche*	1	*Cheumatopsyche*	1	No	No
4	*Hydroptila*	1	*Hydroptila*	1	No	No
5	*Simulium*	128	*Simulium*	127	No	No
			Cheumatopsyche	1	Yes	No
6	Chironomidae	29	Chironomidae	28	No	Yes
			Mycetophilidae	1	Yes	No
7	*Trichocorixa*	1	*Trichocorixa*	1	No	No
8	Corixidae	2	Corixidae	2	No	No
9	*Sperchon*	2	*Sperchon*	2	No	No
10	*Argia*	24	*Argia*	22	No	Yes
11	Oligochaeta	35	Oligochaeta	9	No	Yes
12	Ostracoda	1	Ostracoda	1	No	No
13	*Hyalella*	41	*Hyalella*	41	No	No
14	*Corbicula fluminea*	6	*Corbicula*	6	Yes	No
15	*Pisidium*	11	*Pisidium*	11	No	No
16	*Turbellaria*	2	*Turbellaria*	2	No	No

Table 29-6. Summary of Sample 2

	Original	Reference
Total richness	16	17
Total # individuals	299	270

Table 29-7. MQOs for Sample 2

Sample-based MQOs	Calculation	Result	Meets objective?
Recount accuracy	=270/299*100	90.3%	No (≤95%)
Taxa count error rate	=|(17-16)|/17*100	5.9%	Yes (≤10%)
Taxa ID error rate	*Cheumatopsyche* Mycetophilidae *Corbicula* =3/17*100	17.6%	No (≥10%)
Individual ID error rate	1 *Cheumatopsyche* 1 Mycetophilidae 6 *Corbicula* =8/270*100	3.0%	Yes (≤10%)
High taxonomic resolution error rate	6 *Corbicula* =6/270*100	2.2%	NA
Low taxonomic resolution error rate	None	0%	NA
Taxonomic resolution error rate	=2.2% + 0%	2.2%	Yes (≤10%)

Sample 2 shows several additional errors. For example, the original lab counted a higher number of Oligochaeta than the reference lab found, presumably because the original lab counted organism fragments as individual specimens. However, this discrepancy was not so large as to cause a failure of the recount accuracy MQO.

Table 29-8 shows the summary of the entire QA batch, and Table D9 shows the calculation of batch-based MQOs. Table 29-9 shows that random and systemic error rates exceeded objectives.

Table 29-8. Summary of batch

	Original	Reference
Total richness	19	22
Total number of common taxa	13	13
Total # individuals	600	572

Table 29-9. Batch-based MQOs

MQO	Calculation	Result	Meets objective?
Random error rate	*Hydropsyche* identified as *Hydropsyche* and *Prostoma* (Sample 1, Vial 4) *Simulium* identified as *Simulium* and *Cheumatopsyche* (Sample 2, Vial 5 *Cheumatopsyche* identified as *Cheumatopsyche* and *Simulium* (Sample 2, Vials 3 and 5) Mycetophilidae identified as Chironomidae (Sample 2, Vial 6) =4/22*100	18.2%	No (≥10%)
Systemic error rate	*Caloparyphus/Euparyphus* identified as *Caloparyphus* *Corbicula* identified as *Corbicula fluminea* =2/13*100	15.4%	No (≥10%)

Note that some identification errors did not count towards the systemic error rate because the taxa appeared fewer than 5 times in the batch (e.g., *Diphetor hageni* identified as *Fallceon quilleri* in Sample 1 Vial 1, or *Prostoma* identified as *Hydropsyche* in Sample 1 Vial 4). Furthermore, some identification errors did not count towards the systemic error rate because the error was not made consistently (e.g., *Cheumatopsyche* identified as *Simulium* in Sample 2 Vial 5, but as *Cheumatopsyche* in Sample 2 Vial 3).

Sample 1 failed to meet one MQO, and Sample 2 failed to meet two. The batch failed both applicable. MQOs. Therefore, the original lab would be required to submit an additional two samples for quality assurance checks

30. Appendix E. RMC Target Method Reporting Limits

Table 30-1. Target MRLs for RMC Creek Status Monitoring Water Quality Parameters, Laboratory Analyses.

Analyte	MRL (mg/L)
Ammonia (as N)	0.1
Chloride	1
Total Kjeldahl Nitrogen	0.5
Nitrate (as N)	0.05
Nitrite (as N)	0.03
Organic Carbon (Dissolved)	0.6
Orthophosphate (as P)	0.01
Silica	1
Total Phosphorus (as P)	0.01
SSC	3

Table 30-2. Target MRLs for RMC Creek Status Monitoring Water Quality Parameters, Field Measurements.

Analyte	Units	MRL	Resolution
Chlorine, Free	mg/L	0.5	0.01
Chlorine, Total	mg/L	0.5	0.01
Temperature	º C	N/A	0.1
Dissolved Oxygen	mg/L	0.2	0.1
pH	pH units	N/A	0.1
Conductivity	mS/cm	2	1

Table 30-3. Target MRLs for RMC Creek Status Monitoring Pathogen Indicators.

Analyte	MRL (MPN/100 mL)
Pathogens – *E. coli*	2
Pathogens –Fecal Coliform	2

Table 30-4. Target MRLs for RMC Creek Status Monitoring Conventional Sediment Quality Parameters.

Analyte	MRL
Sediment Total Organic Carbon	0.01%
%Moisture	n/a
%Lipids	n/a

Table 30-5. Target MRLs for MRC Creek Status Monitoring Inorganic Sediment Quality Parameters.

Analyte	MRL (mg/kg)
Arsenic	0.3
Cadmium	0.01
Chromium	0.1
Copper	0.01
Lead	0.01
Mercury	0.03
Nickel	0.02
Zinc	0.1

Table 30-6. Target MRLs for RMC Creek Status Monitoring Organochlorine Pesticides in Sediment

Analyte	Sediment (ng/g)
cis-Chlordane	2
trans-Chlordane	2
DDD (o,p')	2
DDD (p,p')	2
DDE (o,p')	2
DDE (p,p')	2
DDT (o,p')	3
DDT (p,p')	5
Dieldrin	2
Endrin	2
Heptachlor epoxide	1
Lindane (gamma-HCH)	1

Table 30-7. Target MRLs for RMC Creek Status Monitoring PAHs in Sediment

Analyte	MRL (ng/g)
Acenaphthene	20
Acenaphthylene	20
Anthracene	20
Benz(a) anthracene	20
Benzo(a) pyrene	20
Benzo(b) fluoranthene	20
Benzo(e) pyrene	20
Benzo(g,h,i) perylene	20
Benzo(k) fluoranthene	20
Biphenyl	20
Chrysene	20
Dibenz(a,h) anthracene	20
Dibenzo-thiophene	20
2,6-Dimethyl-naphthalene	20

Analyte	MRL (ng/g)
Fluoranthene	20
Fluorene	20
Indeno(1,2,3-c,d) pyrene	20
1-Methyl-naphthalene	20
2-Methyl-naphthalene	20
1-Methyl-phenanthrene	20
Naphthalene	20
Perylene	20
Phenanthrene	20
Pyrene	20

Table 30-8. Target MRLs for RMC Creek Status Monitoring Pyrethroids in Sediment

Analyte	Sediment (ng/g)
Bifenthrin	0.33
Cyfluthrin	0.33
Total Cypermethrin	0.33
Total Deltamethrin	0.33
Total Esfenvalerate/ Fenvalerate	0.33
Total Lambda-cyhalothrin	0.33
Total cis-Permethrin	0.33
trans-Permethrin	0.33

Table 30-9. Size Distribution Categories and Target MRLs for CW4CB Analyte Grain Size in Soils / Sediment

Wentworth Size Category	Size	MRL
Clay	<0.0039 mm	1%
Silt	0.0039 mm to <0.0625 mm	1%
Sand, very fine	0.0625 mm to <0.125 mm	1%
Sand, fine	0.125 mm to <0.250 mm	1%
Sand, medium	0.250 mm to <0.5 mm	1%
Sand, coarse	0.5 mm to < 1.0 mm	1%
Sand, very coarse	1.0 mm to < 2 mm	1%
Gravel	2 mm and larger	1%

Table 30-10. Effort Level for Biological Assessments

Analyte	Method	MDL
Benthic macroinvertebrate sampling, identification and enumeration	Ode 2007	SAFIT Standard Taxonomic Effort Level 1
Benthic algae sampling, identification and enumeration	Fetscher et al. (2010)	TBD

31. Appendix F. Corrective Actions

Table 31-1. Corrective Action – Laboratory Analysis of Conventional Analytes (Water)

Laboratory Quality Control	Corrective Action
Calibration Standard	Affected samples and associated quality control must be reanalyzed following successful instrument recalibration.
Initial/Continuing Calibration Verification	The analysis must be halted, the problem investigated, and the instrument recalibrated. All samples after the last calibration verification must be reanalyzed.
Laboratory Blank	The sample analysis must be halted, the source of the contamination investigated, the samples along with a new laboratory blank prepared and/or re-extracted, and the sample batch and fresh laboratory blank reanalyzed. If reanalysis is not possible due to sample volume, flag associated samples as estimated.
Reference Material	Affected samples and associated quality control must be reanalyzed following instrument recalibration.
Matrix Spike	The spiking level should be approximately 2-5 times the ambient concentration of the spiked sample. Appropriately spiked results should be compared to the matrix spike duplicate to investigate matrix interference. If matrix interference is suspected, the matrix spike result must be qualified.
Matrix Spike Duplicate	The spiking level should be approximately 2-5 times the ambient concentration of the spiked sample. Appropriately spiked results should be compared to the matrix spike duplicate to investigate matrix interference. If matrix interference is suspected and reference material recoveries are acceptable, the matrix spike duplicate result must be qualified.
Laboratory Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. Other failures should be reanalyzed as sample volume allows.
Internal Standard	As method requires. The instrument must be flushed with rinse blank. If, after flushing, the responses of the internal standards remain unacceptable, the analysis must be terminated and the cause of drift investigated.
Field Quality Control	**Corrective Action**
Field Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Travel Blank, Equipment Blank	If contamination of the field blanks and associated samples is known or suspected, the laboratory should qualify the affected data, and notify the project coordinator, who in turn will follow the process detailed in the method.

Table 31-2. Corrective Action - Conventional Analytes (Total Solids, Suspended Sediment Concentration, and Percent Lipids)

Laboratory Quality Control	Corrective Action
Calibration Standard	n/a
Initial/Continuing Calibration Verification	n/a
Laboratory Blank	Please refer to method requirements.
Reference Material	Please refer to method requirements.
Matrix Spike	n/a
Matrix Spike Duplicate	n/a
Laboratory Duplicate*	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. Other failures should be reanalyzed as sample volume allows. A matrix spike duplicate may not be analyzed in place of a laboratory duplicate.
Internal Standard	n/a
Field Quality Control	**Corrective Action**
Field Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Travel Blank, Equipment Blank	n/a

*Not applicable to suspended sediment concentration analyses

Table 31-3. Corrective Action - Inorganic Chemistry

Laboratory Quality Control	Corrective Action
Calibration Standard	Affected samples and associated quality control must be reanalyzed following successful instrument recalibration
Initial/Continuing Calibration Verification	The analysis must be halted, the problem investigated, and the instrument recalibrated if necessary. If deemed appropriate, all samples after the last acceptable continuing calibration verification may be reanalyzed.
Laboratory Blank	The sample analysis must be halted, the source of the contamination investigated, the samples along with a new laboratory blank prepared and/or re-extracted, and the sample batch and fresh laboratory blank reanalyzed. If reanalysis is not possible due to sample volume, flag associated samples as estimated.
Reference Material	If deemed appropriate, affected samples and associated quality control may be reanalyzed following instrument recalibration.
Matrix Spike	The spiking level should be approximately 2-5 times the ambient concentration of the spiked sample. Appropriately spiked results should be compared to the matrix spike duplicate to investigate matrix interference. If matrix interference is suspected, the matrix spike result must be qualified.
Matrix Spike Duplicate	The spiking level should be approximately 2-5 times the ambient concentration of the spiked sample. Appropriately spiked results should be compared to the matrix spike duplicate to investigate matrix interference. If matrix interference is suspected and reference material recoveries are acceptable, the matrix spike duplicate result must be qualified.
Laboratory Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. Other failures should be reanalyzed as sample volume allows.
Internal Standard	As method requires. The instrument must be flushed with rinse blank. If, after flushing, the responses of the internal standards remain unacceptable, the analysis must be terminated and the cause of drift investigated.
Field Quality Control	**Corrective Action**
Field Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Equipment Blank	n/a

Table 31-4. Corrective Action - Organic Chemistry

Laboratory Quality Control	Corrective Action
Calibration Standard	Affected samples and associated quality control must be reanalyzed following successful instrument recalibration.
Initial/Continuing Calibration Verification	The analysis must be halted, the problem investigated, and the instrument recalibrated. All samples after the last acceptable continuing calibration verification must be reanalyzed.
Laboratory Blank	The sample analysis must be halted, the source of the contamination investigated, the samples along with a new laboratory blank prepared and/or re-extracted, and the sample batch and fresh laboratory blank reanalyzed. If reanalysis is not possible due to sample volume, flag associated samples as estimated.
Reference Material	Affected samples and associated quality control must be reanalyzed following instrument recalibration.
Matrix Spike	The spiking level should be approximately 2-5 times the ambient concentration of the spiked sample. Appropriately spiked results should be compared to the matrix spike duplicate to investigate matrix interference. If matrix interference is suspected, the matrix spike result must be qualified.
Matrix Spike Duplicate	The spiking level should be approximately 2-5 times the ambient concentration of the spiked sample. Appropriately spiked results should be compared to the matrix spike duplicate to investigate matrix interference. If matrix interference is suspected and reference material recoveries are acceptable, the matrix spike duplicate result must be qualified.
Laboratory Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. Other failures should be reanalyzed as sample volume allows.
Internal Standard	Analyze as appropriate per method. Troubleshoot as appropriate. If, after trouble-shooting, the responses of the internal standards remain unacceptable, the analysis must be terminated and the cause of drift investigated.
Surrogate	Analyze as appropriate per method. All affected results should be qualified. The analytical method or quality assurance project plan must detail procedures for updating surrogate measurement quality objectives.
Field Quality Control	**Corrective Action**
Field Duplicate	For duplicates with a heterogeneous matrix or ambient levels below the reporting limit, failed results may be qualified. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Travel Blank, Equipment Blank	n/a

Table 31-5. Corrective Action - Toxicity Testing

Negative Controls	Corrective Action
Laboratory Control Water	If tested with in-house cultures, affected samples and associated quality control must be retested within 24 hours of test failure. If commercial cultures are used, they must be ordered within 16 hours of test failure for earliest possible receipt, and retests must be initiated within 8 hours of receipt. The laboratory should try to determine the source of contamination, document the investigation, and document steps taken to prevent recurrence.
Conductivity Control Water	Affected samples and associated quality control must be qualified.
Additional Control Water	A water sample that has similar qualities to the test sample may be used as an additional control based on the objectives of the study. Results that show statistical differences from the laboratory control should be qualified. The laboratory should try to determine the source of contamination, document the investigation, and document steps taken to prevent recurrence. This is not applicable for TIE method blanks.
Laboratory Control Sediment	Affected samples and associated quality control must be re-tested within 24 hours of test failure if tested with in-house cultures. If commercial cultures are used, they must be ordered within 16 hours of test failure for earliest possible receipt, and re-tests must be initiated within 8 hours of receipt. The laboratory should try to determine the source of contamination, document the investigation, and document steps taken to prevent recurrence.
Additional Control Sediment	A sediment sample that has similar qualities to the test sample may be used as an additional control based on the objectives of the study. Results that show statistical differences from the laboratory control should be qualified. The laboratory should try to determine the source of contamination, document the investigation, and document steps taken to prevent recurrence.
Positive Controls	**Corrective Action**
Reference Toxicant Tests	If LC50 exceeds +/- two standard deviations of the running mean of the last 20 reference toxicant tests, the test should be qualified or repeated.
Field Quality Control	**Corrective Action**
Field Duplicate	For duplicates with a heterogeneous matrix, results that do not meet SWAMP criteria should be qualified. All field duplicate results that do not meet SWAMP criteria should be communicated to the project coordinator, who in turn will notify the sampling team so that the source of contamination can be identified and corrective measures taken prior to the next sampling event.
Field Blanks	If contamination of the field blanks and associated samples is known or suspected, the laboratory should qualify the affected data and notify the project coordinator, who in turn will notify the sampling team so that the source of contamination can be identified and corrective measures taken prior to the next sampling event.
Equipment Blanks	If contamination of the equipment blanks and associated samples is known or suspected, the laboratory should qualify the affected data and notify the project coordinator, who in turn will notify the sampling team so that the source of contamination can be identified and corrective measures taken prior to the next sampling event.

Table 31-6. Corrective Action - Field Measurements

Field Quality Control	Corrective Action
Depth, Dissolved Oxygen, pH, Salinity, Specific Conductance, Temperature, Turbidity, Velocity	The instrument should be recalibrated following its manufacturer's cleaning and maintenance procedures. If measurements continue to fail measurement quality objectives, affected data should not be reported and the instrument should be returned to the manufacturer for maintenance. All troubleshooting and corrective actions should be recorded in the calibration and field data logbooks.