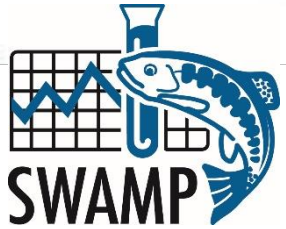
Surface Water Ambient Monitoring Program



Bioassessment Program Quality Assurance Project Plan

SEPTEMBER 2019

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Surface Water Ambient Monitoring Program

Bioassessment Program Quality Assurance Project Plan

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A. PROJECT MANAGEMENT

A.1 Title and Approvals

Project Title:	SWAMP Bioassessment Program (SBP) Quality Assurance Project Plan: Perennial Streams Assessment (PSA) and Reference Condition Management Program (RCMP)
Lead Organization:	Surface Water Ambient Monitoring Program 1001 I Street Sacramento, CA 95814 (916) 341-5556
Primary Contact:	Peter Ode, Program Manager Aquatic Bioassessment Laboratory Department of Fish & Wildlife 2005 Nimbus Road Rancho Cordova, CA 95670 (916) 358-0316
Effective Date:	This Quality Assurance Project Plan (Project Plan) is effective September 2019 to September 2022 unless otherwise revised, approved and distributed accordingly at an earlier date.
Version:	1.0
Cite as:	State Water Resources Control Board. 2019. Statewide Bioassessment Program: Quality Assurance Project Plan. Sacramento, CA: Surface Water Ambient Monitoring Program.

Preface:
This Quality Assurance Project Plan (Project Plan or QAPP) establishes the requirements for collecting data as part of the Surface Water Ambient Monitoring Program (SWAMP) Bioassessment Program (SBP), and provides guidance for programs seeking to generate SWAMP-comparable data. The purpose of the Project Plan is to establish quality assurance (QA) and quality control (QC) standards and procedures to be applied to the SBP in order to produce data that are scientifically valid and defensible, and to document their quality. This QAPP is focused on the two primary monitoring projects of the SBP: The Perennial Streams Assessment (PSA) program and the Reference Condition Management Program (RCMP). However, this QAPP is intended to apply to other programs associated with the SBP, such as the Stormwater Monitoring Coalition (SMC) in southern coastal California and the Regional Monitoring Coalition (RMC) in the San Francisco Bay Area. The QAPP also applies to certain data components collected at

National Aquatic Resources Survey (NARS) sites that are not funded by that program, but rather are data augments funded by the SBP (specifically, taxonomic analysis of soft-bodied algae samples, diatom samples and the California Rapid Assessment Method [CRAM]). The format and elements of this Project Plan are in accordance with United States Environmental Protection Agency (US EPA) Guidance for Quality Assurance Project Plans (US EPA QA/G5, December 2002).

The approvals of signatories below were submitted separately and thus are not included in this signature block. Originals are kept on file by the State Water Resources Control Board (State Board).

Peter Ode
Program Manager and SWAMP Bioassessment Program Lead Scientist
California Department of Fish and Wildlife

Daniel Pickard
SWAMP Bioassessment Program Administrative Manager
California State University, Chico, Research Foundation

Rosalina Stancheva Hristova
Senior Scientist, Primary Algae Laboratory
California State University, San Marcos

Ali Dunn
Surface Water Ambient Monitoring Program Coordinator

Tessa Fojut
Surface Water Ambient Monitoring Program Quality Assurance Officer

Renee Spears
State Water Resources Control Board Quality Assurance Officer

Daniel Pickard
SWAMP Bioassessment Program Quality Assurance Officer

Rosalina Stancheva Hristova
CSUSM Algae Lab Quality Assurance Officer

Lisa Underwood
EcoAnalysts, Inc. Algae Lab Quality Assurance Officer

Timea Majoros
Delta Environmental Laboratory Quality Assurance Officer

A.2 Table of Contents

Contents

TABLES

FIGURES

A.3 Distribution List

Table 1. Distribution List

Position	Name	Responsibilities
Region 9 EPA Surface Water Standards Coordinator	Terrence Fleming	Oversight of SWAMP federal funding, synchronization with SWAMP Program objectives.
State Board Management – Office of Information Management and Analysis (OIMA)	Greg Gearheart (OIMA) Melissa Morris (OIMA) Ali Dunn (OIMA)	Program planning and oversight; project budget allocation and reconciliation with program objectives.
Water Boards Contract Manager	Chad Fearing (OIMA)	Approval of invoices.
SBP Manager (SBPM or Program Manager), Lead Scientist	Peter Ode (Aquatic Bioassessment Laboratory, CDFW)	Oversees design of program and coordination with State Board management to promote effective integration of SBP within SWAMP. Oversees SBP project management staff, who oversee coordination and implementation activities of the program and ensure that those activities are carried out according to the plan. Program Manager will oversee QAPP development and updates.
SBP Administrative Manager (SBPAM)	Daniel Pickard (Aquatic Bioassessment Laboratory, CSU Chico Research Foundation)	Manages administrative functions of the SBP, including coordinating with the Program Manager to develop budgets, coordinating and tracking the status of sampling and samples among the labs that process samples for the SBP and coordinating with Water Boards Contract Manager to reconcile tasks with contracts and invoices.
SBP Senior Scientists	Andrew Rehn (Aquatic Bioassessment Laboratory, CDFW)	Conducts and oversees development of the technical elements of the program, including: project design, data management, data analysis and interpretation and reporting and

Position	Name	Responsibilities
	Raphael Mazor (SCCWRP)	coordination within the program and its collaborators.
SMC Coordinator	Raphael Mazor (SCCWRP)	Coordinates Stormwater Monitoring Coalition (SMC) sampling in Regional Boards 4, 8 and 9 with the SBP.
Field Coordinator	Shawn McBride (Aquatic Bioassessment Laboratory, CDFW)	Coordinates field sampling for primary SBP projects (PSA and RCMP), assuring compliance with QAPP.
SBP Algae Program, Scientific Lead	Susanna Theroux (SCCWRP)	Oversees development and implementation of SBP algae plan.
State Board Quality Assurance Officer (QAO)	Renee Spears (OIMA)	Approves QAPP; reports to US EPA and State Board management.
SWAMP QAO	Tessa Fojut (OIMA-SWAMP Information Management and Quality Assurance Unit [SWAMP IQ])	Reviews and approves QAPP; oversees Data Quality Managers; establishes program-level quality objectives and requirements for project; reports to US EPA and State Board management and coordinates with State Board QAO.
SBP QAO	Daniel Pickard (Aquatic Bioassessment Laboratory, CSU Chico Research Foundation)	The SBP QAO reports to the SBP Program Manager and is independent of the field, laboratory, data, and reporting staff.
BMI Sample Coordinator	Douglas Post (DFW-ABL)	Receives benthic invertebrate samples, checks against sampling plan, checks for preservative levels, logs samples into SWAMP database and distributes to taxonomists.
BMI Lab QAO	Joe Slusark (Aquatic Bioassessment Laboratory, CSU Chico Research Foundation)	Conducts and oversees benthic macroinvertebrate analyses, ensures proper QA/QC measures are employed.

Position	Name	Responsibilities
Chemistry Laboratory QAO (water chemistry)	Timea Majoros Delta Environmental	Conducts water chemistry analysis, ensures proper QA/QC measures are employed.
Algae Laboratory QAO—CSUSM (soft-bodied algae and diatoms)	Rosalina Stancheva Hristova, CSU San Marcos	Conducts soft-bodied algae and diatom analyses, ensures proper QA/QC measures are employed for algae taxonomy. Provides external harmonization and QC for algae taxonomy data produced by other labs (i.e., EcoAnalysts, Inc).
Algae Laboratory QAO—EcoAnalysts Inc. (diatoms)	Lisa Underwood	Conducts diatom analysis, ensures proper QA/QC measures are employed.
SWAMP Coordinator	Ali Dunn (OIMA)	Oversees the integration of the SBP into the SWAMP program's overarching goals.

A.4 Project Organization

Involved Parties and Roles

The SWAMP Bioassessment Program Manager (SBPM), Peter Ode of the California Department of Fish and Wildlife (CDFW) Aquatic Bioassessment Laboratory, serves as Lead Scientist for the SBP and oversees the development and implementation, including the coordination of annual bioassessment workplans. Coordination duties entail overseeing the design and implementation of statewide condition assessments and reference site management plans; development and revision of bioassessment data analysis tools; and integration of SBP activities with other bioassessment efforts within the Water Boards and with other state and federal agencies, including the Water Boards combined biointegrity-biostimulatory project. The SBPM will also advise and participate in the development and revision of bioassessment quality assurance and database elements. The SBPM will assist Water Board staff with bioassessment questions and/or issues.

Daniel Pickard, SBP Administrative Manager (SBPAM), is responsible for managing administrative functions of the SBP, including coordinating with the SBPM to develop budgets, coordinating and tracking the status of sampling and samples among the labs that process samples for the SBP and coordinating with the Water Boards Contract Manager to reconcile tasks with contracts and invoices. The SBPAM will ensure that laboratory Standard Operating Procedures (SOPs) and Quality Control procedures are

followed when benthic macroinvertebrate (BMI) sample shipments arrive at the laboratory for processing and that Chain of Custody (COC) documents stay with each sample. The SBPAM will also ensure that data is returned to the SBPM, in the proper format with a Lab QA report and report all findings to the SBPM, including all requests for corrective action.

The SBP Senior Scientists, Andrew Rehn (CDFW-ABL) and Raphael Mazor (SCCWRP), are the primary scientific advisors to the SBPM; scientific managers have primary responsibility for conducting the technical elements of the program, including project design, data management, data analysis and interpretation and reporting and coordination within the program and collaborators. SBP Senior Scientists will assist the SBPM and the SBPAM with statewide project planning and logistical coordination as needed.

The SMC coordinator, Raphael Mazor, will manage site selection, program coordination and data coordination and interpretation for the SMC bioassessment survey in Regions 4, 8 and 9. The SMC program is comprised of several regulatory and stormwater management agencies, providing the SBP with a direct link to watershed managers in the Regional Boards and in the regulated community. The SBPM will coordinate with the SMC coordinator to ensure compatible data collection and take advantage of synergies between the two programs.

The Field Coordinator, Shawn McBride, will coordinate and/or oversee the field staff collecting SBP data, who will conduct site access/reconnaissance evaluations for statewide field collection of samples, collect field samples, complete COC documents, sample processing and sample transport or shipping to laboratory. The Field Coordinator will coordinate with the SBPM, Senior Scientists and SBPAM, hold planning meetings and participate in kick off meetings prior to project commencement.

Algae Program Scientific Lead, Susanna Theroux, will lead the implementation of the SBP Algae Plan, which is the program's strategy for developing the infrastructure needed to use algae as a second indicator of ecological condition. The algae lead will be responsible for guiding development and implementation of field and laboratory data protocols and will coordinate with the SBPM and Senior Scientists to develop tools for interpretation and quantification of ecological condition from benthic algal data.

The SWAMP Quality Assurance Officer, Tessa Fojut, will review quality assurance and quality control procedures found in this Project Plan as part of the program's design and supervision. The SWAMP QAO will ensure program compliance with this Project Plan and with state guidelines.

The SWAMP Coordinator, Ali Dunn, will coordinate with the SBPM and SBP staff to help ensure that SBP projects and products are aligned with the goals and objectives of SWAMP. The SWAMP Coordinator is responsible for reviewing and commenting on reports and posting them to the SWAMP website.

The Water Boards Contract Manager, Chad Fearing will manage the SBP contract, invoices, and deliverables.

The SBP QAO, Daniel Pickard, monitors QC activities to determine conformance with this SBP QAPP, distributes quality related information, trains personnel on QC requirements and procedures, reviews QA/QC plans for completeness and notes inconsistencies, and signs the QAPP and reports.

The Laboratory QAOs fulfill the functions and authority of a SBP QAO. The role of the Laboratory QAOs is to ensure that quality control for sample processing and data analysis procedures described in this QAPP are maintained throughout the project. All laboratory requirements within the SWAMP QAPrP will be followed. The Laboratory QAOs will review and assess all procedures during the life of this project against QAPP requirements and assess whether the procedures are performed according to protocol. The Laboratory QAOs will report all findings (including qualified data) to the SBPM, including all requests for corrective actions. The Laboratory and SBP QAOs have the authority to stop all actions if there are significant deviations from required procedures or evidence of a systematic failure.

The Benthic Macroinvertebrate QAO, Joe Slusark, will ensure that laboratory SOPs and Quality Control procedures are followed when BMI samples arrive at the laboratory for processing and that COC documents stay with each sample. They will also ensure that data is returned to the SBPM, in the proper format with an Analysis Authorization (AA) form. The QA Officer will report all findings to the SBPM, including all requests for corrective action.

The CSUSM Algae Lab QAO, Chief Scientist, Rosalina Stancheva Hristova, will ensure that laboratory SOPs and Quality Control procedures are followed when algae shipments arrive at the laboratory for processing and that COC documents stay with each sample. They will also ensure that data is returned to the SBPM, in the proper format with an AA form. The QAO will report all findings to the SBPM, including all requests for corrective action.

EcoAnalysts, Inc. Algae Lab QAO, Lisa Underwood, will ensure that laboratory SOPs and Quality Control procedures are followed when diatom shipments arrive at the laboratory for processing and that COC documents stay with each sample. They will also ensure that data is returned to the SBPM, in the proper format with an AA form. The QAO will report all findings to the SBPM, including all requests for corrective action.

The Chemistry Laboratory QAO (water chemistry), Timea Majoros, will oversee all activities to ensure accurate and reliable data is reported. They will ensure that laboratory SOPs and Quality Control procedures are followed when chemistry shipments arrive at the laboratory for processing and that COC documents stay with each sample. They will also ensure that data is returned to the SBPM, in the proper format. The QA Officer will report all findings to the SBPM, including all requests for corrective action.

Project Coordinators are lead staff, at Regional Boards or other environmental programs, that are responsible for planning, organizing and managing all aspects of bioassessment projects.

Project Organization

Figure 1 depicts the structure of the SBP. Management responsibilities extend downward, while the flow of data moves upwards from the bottom of the chart. Major tasks and responsibilities are described in Table 2. This Project Plan will be revisited annually for review and necessary updates.

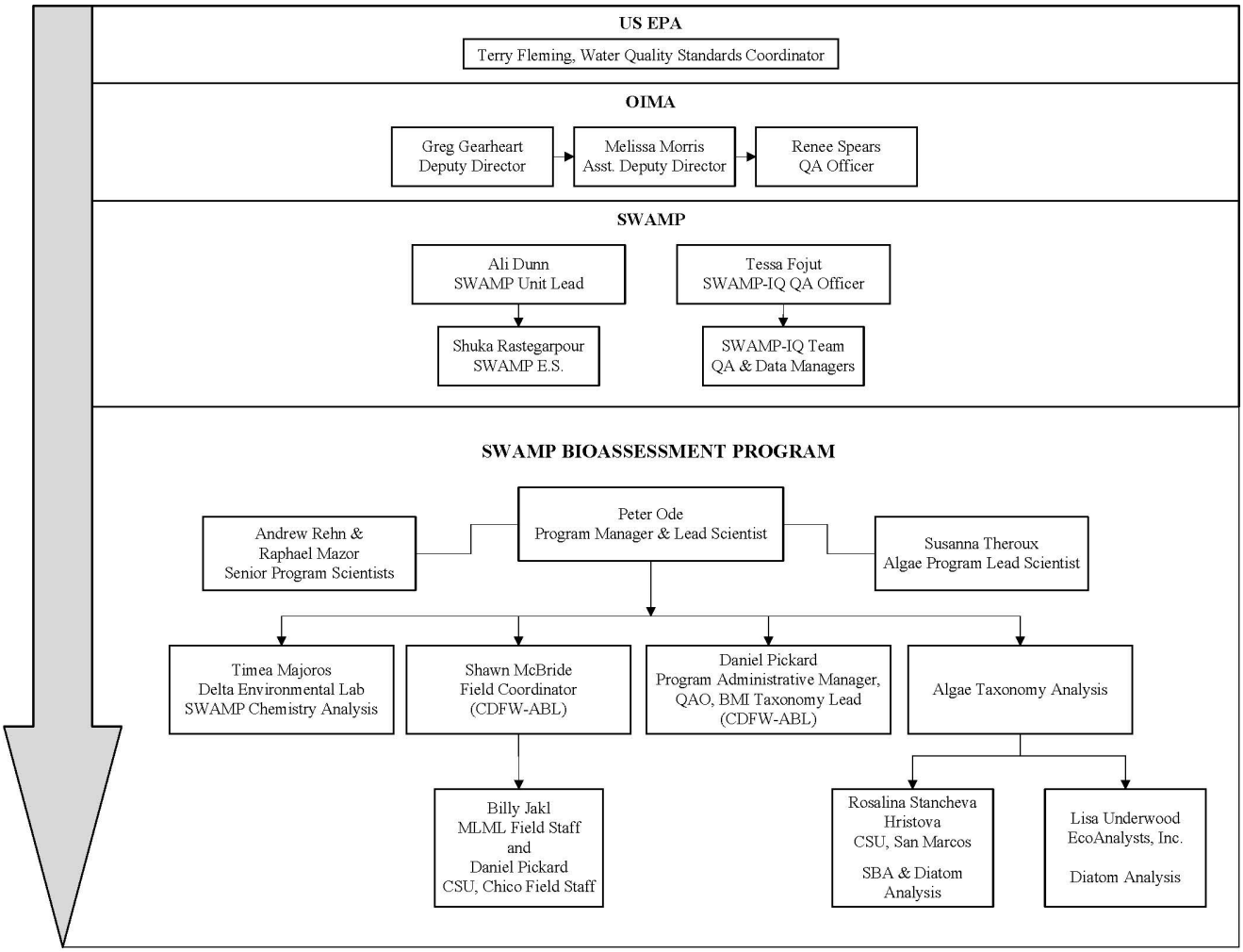

Figure 1. General organization of the SBP, showing lines of responsibility and oversight for key QAQC components of the program.

Table 2. PSA and RCMP Schedule of Primary Tasks

Responsible Party	Task	Time Frame
SBPM/Lead Scientist	Develop a sampling workplan for the field season	Annually, one month prior to sampling
SBPM/Lead Scientist	Coordinate with the SWAMP program and EPA Region 9 staff to develop the Sampling and Analysis plan	Annually in May
Field Coordinator	Determine candidate site locations for PSA and RCMP annually	Prior to kickoff meeting-before sampling begins
SBP Administrative Manager	After site reconnaissance, the Administrative Manager will provide a list of proposed site locations for PSA and RCMP to the State Water Board	Annually, one month prior to sampling
Field Coordinator	Kickoff meeting	One month prior to commencement of sampling
Field Crews	Collect field measurements and biological sampling	Sampling during the index period, typically April through October annually
Field Crews	Send samples to appropriate laboratories	Within holding times
BMI and Algae Laboratory Staff	Identify and enumerate algal and BMI samples for PSA and RCMP; send data to SWAMP IQ	Annually in July following the sampling year
Chemistry Laboratory Staff	Analyze water chemistry samples; send data to SWAMP IQ	In accordance with the contract
Field Crews	Enter field data into the most current SWAMP templates or data entry shell for submission to SWAMP IQ	Annually in November

Responsible Party	Task	Time Frame
Lab QA Officers	Interim data report for PSA and RCMP	Annually in September following each sampling year
SBP Senior Scientists	Prepare SWAMP style management information memos (fact sheet, technical reports) for PSA and RCMP	As needed by SWAMP coordinator
BMI sample coordinator	Sample logging and updating of lookup values (e.g., station codes)	Annually, during the sampling season

A.5 Project Background and Overview

SWAMP Bioassessment Program Objectives

The goal of the SWAMP Bioassessment Program (SBP) is to develop the State Water Board's capacity to monitor the ecological condition of California's wadeable freshwater streams and rivers through the evaluation of biological data (i.e., bioassessment). The SBP provides monitoring results to the Water Board and other managers to improve the protection and restoration of the state's freshwater streams and their watersheds.

In pursuing these objectives, the SBP undertakes several activities, including:

- Generating bioassessment data through its core monitoring programs and through leveraging complementary programs
- Standardizing sampling and lab protocols to produce comparable bioassessment data
- Developing analytical tools (e.g., indices) to interpret bioassessment data
- Outreach, training, and facilitation to support use of bioassessment data in programs within and outside of the Water Boards.

These activities are described below.

Generating data

Core monitoring programs

Perennial Streams Assessment

The PSA is an ongoing, long-term statewide probabilistic survey of the ecological condition of wadeable streams and rivers throughout California that was based on the design developed and used by the US EPA for its Environmental Monitoring and Assessment Program (EMAP) and National Aquatic Resources Survey (NARS) surveys.

The PSA estimates ecological stream health by assessing biological indicators (benthic macroinvertebrates, algae), chemical constituents (nutrients, major ions, etc.), and habitat assessments in streams (both for in-stream and riparian corridor conditions). In order to make statistically valid inferences about the condition of waters over time, a multi-year design has been implemented to account for temporal variability in conditions.

In probability survey designs, sampling locations are randomly selected and represent a known proportion of the total resource of interest (e.g., percent of total stream length) with known statistical confidence. These designs permit the inference of resource conditions for large geographic regions with a relatively small investment in sampling (Ringold et al., 1996, Olsen et al., 1999, Stevens and Olsen 2004). Their products establish an objective context for interpreting targeted monitoring data and facilitate inter-regional comparisons, thus providing critical perspective and a sound foundation for monitoring programs (Stevens and Olsen 2004, Southerland et al., 2008). These designs are now used widely throughout the US and serve as the basis for national condition assessments for several major waterbody types (e.g., coastal waters, lakes, streams and rivers, wetlands; Ode et al., 2011).

For the purposes of design and reporting, the PSA has divided the state into six “PSA regions” which reflect ecoregional, hydrological, and jurisdictional sub-regions of the state. Since 2009, the PSA has allocated resources towards sampling in five of these six regions. In the sixth region, the South Coast, sampling is accomplished through collaboration with the Stormwater Monitoring Coalition (SMC). Data collected by the SMC program in this region are shared with the PSA and incorporated into statewide reports. In exchange, the PSA provides funds to support algal analysis for samples collected by the SMC. As a result of this collaboration, data density in the South Coast is higher than in any other PSA region—in some years exceeding PSA sampling in all other regions combined.

Reference Condition Management Program

The RCMP is California’s program for establishing and maintaining a pool of stream sites that have low levels of human activity in the nearby and upstream watershed (i.e., reference sites) and using this pool to establish “reference conditions” for streams and rivers (Ode and Schiff 2009, Ode et al. 2016a). Reference sites managed by the RCMP are an integral part of a biological assessment program. Detailed knowledge about the biotic and abiotic conditions are necessary for: (1) setting objective and defensible benchmarks for attainment of ecological condition objectives, (2) accounting for natural variation in expected biological assemblages in different physical settings across the state, and (3) identifying high quality watersheds to prioritize protection efforts. Reference program data can also be used to help define physical habitat expectations and thus, help separate physical habitat impairment from other sources of impairment. Long term datasets at reference sites also provide an objective basis for monitoring the impacts of climate change on California’s aquatic resources.

The RCMP attempts to implement a “minimally disturbed” definition of reference (Stoddard et al. 2006), by which reference sites are characterized by low levels of

disturbance. For the RCMP, disturbance is measured as human activity in the watershed or near the sampling reach. In general, direct measures of stress, such as water quality, are not used as criteria to identify reference sites if they may vary from natural as well as anthropogenic causes. Natural factors (such as wildfire) are understood to affect the biological composition of reference sites, but these are not criteria to determine if a site is reference.

The RCMP has been conducted in two phases, described in the SBP's reference condition planning document (Ode and Schiff 2009). In the first phase, the SBP identified and sampled reference sites throughout the state to create a network of reference sites that represent different regions' environmental settings in the state. This effort identified approximately 600 sites in California that serve as a benchmark for establishing expectations of biological, chemical and physical conditions in healthy streams and rivers across the state (Ode et al. 2016a). Since then, the SBP has continued to add sites that pass screening criteria to the pool, focusing on underrepresented regions or settings (e.g., the interior chaparral). The reference site network now comprises approximately 800 sites. Now in its second phase, the RCMP samples two sets of sites each year: 1) a set of sites throughout the state randomly selected from this network, and 2) a set of sites selected for long-term monitoring every year.

Other Monitoring Programs

As mentioned above, the SBP partners with several other monitoring programs to leverage data collection. These programs each have their own objectives and design considerations, but they either use this QAPP directly, or use QAPPs that produce comparable data to the SBP. Some programs are spearheaded by federal partners, such as the US Forest Service, US EPA, or US Geological Survey. Others are led by state agencies, including other programs of the Water Boards. Local agencies and community groups also conduct monitoring programs that rely on this QAPP. The SBP collaborates with these programs by generating data for additional analytes (e.g., benthic algae, California Rapid Assessment Method [CRAM]) at sites these programs sample, or sampling sites that fulfill design requirements of both programs.

National Rivers and Streams Assessment (NRSA)

The National Rivers and Streams Assessment (NRSA) is the US EPA's nationwide assessment of stream condition, conducted over two of every five years (e.g., 2013-2014, 2018-2019). The PSA was designed to be compatible with the NRSA. In years when NRSA is sampling, the SBP replaces PSA sites with NRSA sites in the sampling schedule. Because NRSA protocols do not include all elements of the SBP's PSA protocols, PSA funds are used to augment the NRSA with additional analytes (e.g., benthic algae, CRAM). PSA usually samples a few non-NRSA sites in NRSA years.

Stormwater Monitoring Coalition (SMC)

The Stormwater Monitoring Coalition is a partnership of multiple state, federal, and local agencies that initiated a regional monitoring program in 2009 to assess the ecological condition of streams in southern California. Using multiple indicators of ecological health, including benthic macroinvertebrates, benthic algae, riparian wetland condition, water

chemistry, water column toxicity, and physical habitat, the SMC has led a large-scale comprehensive assessment of southern California's watersheds based on a probabilistic survey design that is compatible with the PSA. Through the reallocation of permit-required monitoring efforts, the SMC has developed a cooperative sampling program that is efficient and cost-effective for participants. The SMC serves multiple purposes; for regulated participants, participation in the program fulfills several permit requirements to conduct monitoring and provides regulatory participants with better regional context to evaluate permit compliance. In addition, data collected by the SMC serves as a regional intensification of the PSA survey. That is, the SMC replaces the need for the PSA to conduct sampling in the South Coast region. In exchange, the PSA supports the SMC by covering the costs of analytes of interest (e.g., algae taxonomy) or training and intercalibration activities.

Standardizing data collection and processing

The SBP plays a key role in creating standards for the collection of bioassessment data for most monitoring programs in California. As such, it has created and regularly updates guidance on the collection of bioassessment samples and physical habitat data (Ode et al. 2016b), taxonomic analysis (Woodard et al. 2012, Stancheva et al. 2015), and taxonomic quality assurance practices (Rehn et al. 2015). In addition, the SBP creates protocols and online calculators to support the standardized calculation of indices and other analytic tools described in the following section (e.g., Mazor et al. 2018, Rehn et al. 2015). Through partnerships with the State Water Board, the SBP supports training, intercalibration, and audits for field protocols.

Developing analytical tools

The complexity of bioassessment data is a major challenge preventing its use in aquatic resources management. Therefore, the development of standardized assessment tools, such as bioassessment indices, is a major activity of the SBP. Major achievements in this area are described below.

Assessment indices

The California Stream Condition Index (CSCI)

The CSCI is a biological scoring tool that provides a numeric measure of the ability of a stream to support aquatic life based on the composition of benthic macroinvertebrate (BMI) samples. The CSCI was designed to account for the tremendous diversity of natural stream types found in California. First, it was developed from a large reference data set that represented most major natural gradients in the state. Second, it uses statistical models to set site-specific biological benchmarks appropriate for each stream's unique environmental setting. Third, it combines two separate types of indices, each of which provides complementary information about the biological condition of the stream: a multi-metric index (MMI) that measures ecological structure and function, and an observed-to-expected (O/E) index that measures taxonomic completeness. The development and performance of the CSCI is described in Mazor et al. (2016), as well as in a brief technical

memo (Rehn et al. 2015) and a CSCI fact sheet. A protocol describing calculation of the CSCI has also been developed (Mazor et al. 2018).

The Algal Stream Condition Indices (ASCIs)

Like the CSCI, the ASCIs are biological scoring tools that measure the condition of streams in California. There are three versions of the ASCI: one based on benthic diatoms, one based on benthic soft-bodied algae, and a "hybrid" based on both assemblages. Like the CSCI, the ASCIs were calibrated for statewide application. They differ from the CSCI in that they do not include an O/E component, and the MMI sets a single statewide expectation (vs. site-specific benchmarks). Evaluations of the ASCIs' performance show that, despite these differences, they have consistent performance statewide. The ASCIs are intended to be used in concert with the CSCI, providing a more broad-based evaluation of stream condition. In general, the ASCIs are slightly more sensitive to degraded water quality, whereas the CSCI is slightly more sensitive to habitat degradation; however, both indices can reflect impacts to both habitat and water quality.

The Index of Physical-habitat Integrity (IPI)

The IPI provides a quantitative measure of physical habitat condition by evaluating deviation in five habitat metrics from their expected values under undisturbed condition. These components include: percent sands and fines, riparian vegetation cover, in-stream habitat complexity, flow-microhabitat complexity, and diversity of stream substrate composition. As with the CSCI, several of these components are assessed with site-specific benchmarks.

Facilitation and outreach to support uses of bioassessment data

Bioassessment data supports a wide range of programs in the Water Boards and other entities that manage ecological resources. The protection of biological integrity is a major goal of several federal, state, and local agencies, and they rely on tools and data produced by the SBP to create a technical foundation for their programs. To support their aims, the SBP produces technical reports and journal articles, conducts workshops, and coordinates with agency staff to support the use of bioassessment data in managing ecological resources.

Supporting the development of plans or policies

Data and tools generated by the SBP provide a technical foundation that may be used to support the development of a plan or policy regarding the protection of the biological integrity of surface waters. For example, the SBP provides standardized tools to measure biointegrity (i.e., the CSCI and ASCIs). For the most current information, check the Water Boards program website for Biostimulatory Substances Objective and Program to Implement Biological Integrity.

Integrated Report

Bioassessment data provide a line of evidence about stream condition in the biennial California Integrated Report, as directed by the State Water Board's Listing Policy. Analysis of CSCI scores (and eventually, ASCI scores) help identify impaired lotic

waterbodies for listing under the Clean Water Act section 303(d), as well as the listing of waterbodies that support beneficial uses in the section 305(b) report (i.e., Category 1). IPI and CRAM scores provide ancillary lines of evidence that help determine if impairments may be related to habitat degradation.

Assessment staff recommend listing or not delisting a waterbody-pollutant combination if adequate data exist to show that any of the following statements were true (pertaining specifically to biological assessments):

- Adverse biological response is observed as differences between observed biological assemblages and assemblages expected under reference conditions, and the impacts are associated with water or sediment concentrations of pollutants;
- Significant degradation of biological assemblages is exhibited as compared to reference sites;
- The weight of evidence demonstrates that a water quality standard is not attained.

The 2014-2016 Integrated Report marked the first systematic use of CSCI scores in identifying impaired streams. In that report, scores below the 10th percentile of reference (i.e., <0.79) were considered to indicate possible impairment when associated with the criteria described above.

The 2014-2016 Integrated Report also marked a change in the definition of Category 1 streams: All assessed beneficial uses are supported and no beneficial uses are known to be impaired. These recent modifications meet the need to identify and document waterbodies that support assessed beneficial uses. These minimally disturbed sites were identified, using data from SBP and other programs, in the development of the CSCI. To be considered for Category 1 in the 305(b) list, a stream had to meet reference criteria as described in Ode et al. (2016) and have a CSCI score greater than the 30th percentile of reference (i.e., ≥0.92).

A.6 Project/Task Description

Sampling Schedule for PSA and RCMP

Bioassessment samples are collected within normal index periods, usually starting in southern California in early spring and working toward northern sites as the summer progresses (Figure 2). These index periods are intended as generalized guidance for typical climate conditions only and should never overrule local and/or annual weather conditions. For example, in drought years, xeric regions of southern coastal California may need to be sampled earlier than May before flows become insufficient for completion of standardized field protocols. In addition, recently scoured streams should be avoided until sufficient time for recovery has elapsed, as should streams with partially dried reaches.

Figure 2. Index periods by ecoregion used as general guidelines for when to conduct bioassessment sampling. Local and/or annual weather conditions may be a sufficient reason to sample outside of the suggested date ranges (see text).

Geographic Locations

The PSA survey divides California into six main regions that are defined based on a combination of Omernik Level III ecoregional boundaries and Regional Water Board boundaries (Figure 3): North Coast, South Coast, Chaparral (includes interior and coastal sub-regions), Sierra Nevada (includes western Sierra and central Lahontan subregions), Central Valley and Desert-Modoc (Modoc Plateau and southern Deserts). CDFW field staff collect bioassessment data from approximately 35 PSA sites per year from locations throughout all regions except the South Coast, as documented in the Sampling and Analysis Plan. Monitoring of the South Coast Region is conducted in collaboration with the SMC, which conducts a probability survey that nests within the overall PSA design; the SMC collects data from approximately 60 to 90 sites per year, with the PSA funding analysis of benthic algae samples collected by the SMC.

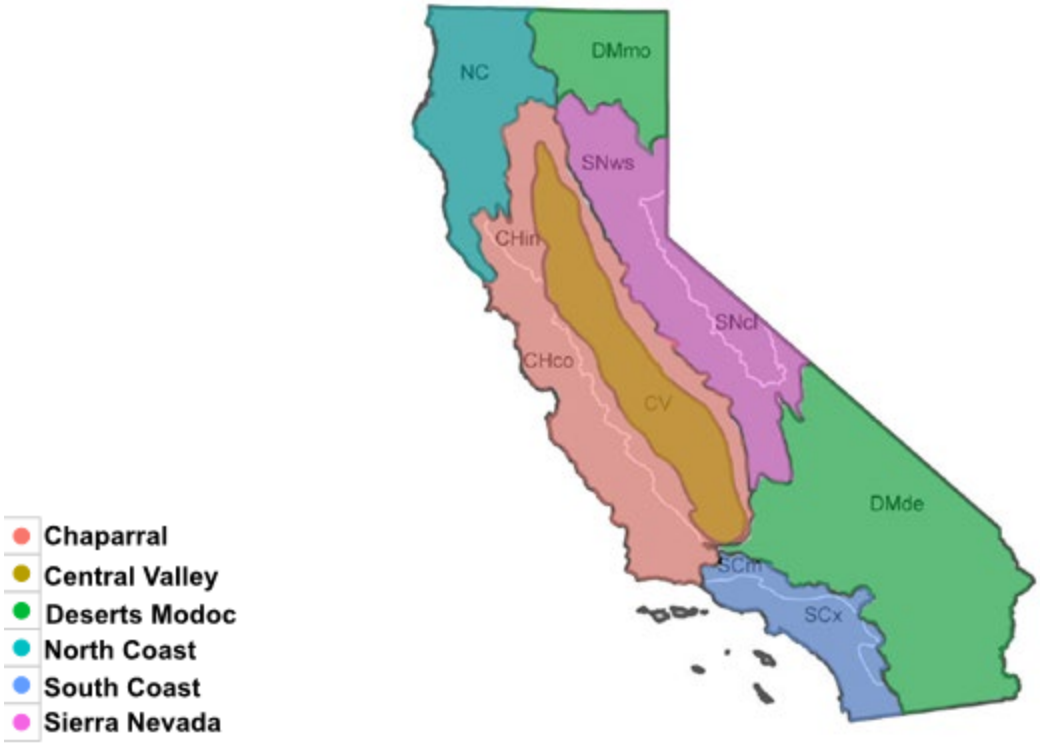

Figure 3. Perennial Streams Assessment ecological subregions

Sites in the RCMP reference pool were screened from data from more than 20 federal, state and regional biological monitoring programs (Ode et al. 2016a) resulting in a pool of more than 700 reference sites that are representative of the broad diversity of natural stream types found across California (Figure 4). There are two major components to managing the reference pools: (1) evaluation of the regional representation of natural gradients and (2) periodic review of sites to evaluate changes to their suitability (e.g., their continued reference status). Approximately 50 sites are sampled each year out of the pool of sites for California; new sites likely to meet reference criteria are also included in sampling efforts.

Figure 4. Location of reference sites used in the development of the CSCI (Ode et al. 2016a)

Measurements, Observations and Samples to be Collected

At each site for both PSA and RCMP, the following analytes are measured:

Water chemistry (lab)

- Chloride
- Hardness as $CaCO_3$
- Organic Carbon (dissolved)
- Silica as SiO_2 (dissolved)
- Sulfate
- Nutrients
    - Ammonia-N
    - Nitrate + Nitrite-N
    - Total N
    - Orthophosphate-P
    - Total P

Field water quality (probes)

- Alkalinity
- Dissolved Oxygen
- pH
- Salinity
- Specific Conductance
- Turbidity
- Velocity and discharge
- Water temperature

Solids (lab)

- Suspended sediment concentration
- Total suspended solids

Algae biomass

- Benthic chlorophyll *a*
- Benthic ash-free dry mass

Taxonomy

- Benthic macroinvertebrates
- Benthic diatoms
- Benthic soft-bodied algae
- eDNA samples for metagenomic analysis

Physical Habitat

- Wetted width, depth, and bankfull dimensions
- Substrate size

- Slope
- Sinuosity
- Flow microhabitats
- Instream habitat complexity
- Canopy cover (shading)
- Riparian vegetation cover
- Riparian human disturbance
- Cover of macroalgae, microalgae, and macrophytes
- Microalgae thickness
- Coarse particulate organic matter
- Site photographs
- Notable field conditions
- California Rapid Assessment Method (CRAM)

These analytes may vary based on guidance from the SWAMP Coordinator.

Constraints

Several factors constrain sampling within the SBP.

Sampling should be completed during the designated index period, generally late spring to early fall, for each designated eco-region. Index periods identify the appropriate estimated time periods for when bioassessment sampling is optimal within a designated eco-region. These index periods generally designate periods when benthic flora and fauna can be collected reliably and consistently. Note, however, that sampling may occur outside of the designated index period if conditions require adjustments (e.g., in a very wet or dry year).

The primary constraint in drier parts of California is the lack of streams with flows sufficient to execute normal bioassessment protocols. Most of California has a semi-arid, Mediterranean climate that is naturally dry for a majority of the year. This condition becomes exacerbated during years of low rainfall. This constraint can be overcome by two factors: (1) extensive site reconnaissance and (2) limiting the sampling index period to late spring/early summer, which excludes streams with short-duration flows.

Extreme wet weather could also affect sampling because streams must be wadeable for sampling to be conducted. Freezing weather could cause conditions that adversely affect the parameters being measured and could prevent access to some of the areas where sampling is needed.

If some areas that are planned to be monitored are not accessible because of legal restrictions, there will be some gaps that could affect some of the conclusions drawn from the data.

Other constraints include streams where currently available bioassessment protocols do not work or do not provide meaningful information about ecological condition, such as tidally influenced streams, or water conveyances that fall outside the purview of watershed management. Streams that are converted to other waterbody types (e.g., reservoirs) should be assessed with appropriate tools.

In addition to the constraints affecting the PSA, the RCMP has several additional constraints related to disturbance. Conditions within stream reaches and in their upstream drainages can change over time (e.g., timber harvest, conversion of natural landscapes to agricultural or urban/suburban/exurban uses). Furthermore, sources of anthropogenic stress that were unknown when sites were initially added to the reference pools (e.g., point source discharges, mines, flow withdrawals/diversions, small-scale mining, etc.) may be discovered upon visiting a site. Sites that fall into this category may be monitored to measure the impacts of these stressors, but they should be removed from the reference site pools.

In contrast, natural disturbances (e.g., forest fires, catastrophic flooding or landslides) can also alter the biological condition at sites and they should be excluded for sampling temporarily, but should remain in the reference site pool, even if their origin is anthropogenic (e.g., arson). The SBP is developing a strategy for defining objective criteria for these cases, how to use the information and how to ensure that the strategy is implemented correctly

A.7 Quality Objectives and Data Quality Indicators

Data Quality Objectives

Data from the SBP are used to assess the ecological status of California water bodies through the calculation of stream health scores. The data produced by PSA are used to produce long-term average estimates of stream conditions and ecological status, statewide and for each of the six major ecological subregions of the state. The data produced by RCMP is used to predict the expected natural composition of lotic freshwater organisms in streams throughout California. This information is also used to support the development and testing of indices (e.g., CSCI, ASCI, IPI).

Data from RCMP are also used in setting assessment thresholds by which stream health can be measured. By placing high quality sites in Category 1 in the Integrated Report, this has aided in development of the Biostimulatory Substances Objective and Program to Implement Biological Integrity. Maintaining data on relatively undisturbed reference sites also acts as a baseline to assess the effects of drought and climate change and characterize “reference conditions” (i.e., conditions at minimally disturbed sites) to track the effects of climate change, and support the development of water quality objectives to include biological expectations and in-stream flow requirements.

A major use of SBP data is the 303(d) and 305(b) Integrated Report. Therefore, most of the data collected under the SBP must meet the applicable quality objectives for this

purpose. As an exception, data collected under experimental methods development may not have applicable objectives. Data must be collected under the requirements and standard operating procedures outlined in this QAPP. Field personnel must be trained to collect the data and data must be collected the same way every time. Measurement quality objectives (MQOs) for biological, chemistry and field analytes must be adhered to. Laboratory external QC measurement quality objectives are utilized to ensure scientifically defensible BMI and algae data. Corrective actions are used to resolve issues between laboratories.

Data Quality Indicators

The Measurement Quality Objectives for these Data Quality Indicators are addressed in Section B5 and in Table 3.

Representativeness

Representativeness is the degree to which measurements correctly represent the environmental condition, target organism population, and/or watershed to be studied (US EPA QA/G-5, 2002). Representativeness touches on how well the site and sample collection represent the study area and analyte of interest, and whether or not the sample represents the conditions in the field at the time of analysis. The SBP aims for good representativeness through survey design, field practices, and lab practices (as described in SOPs).

Representativeness in study design

The PSA seeks to represent the population of wadeable streams in California, covering the range of both natural and anthropogenic settings found within the state. This representativeness is achieved through a probabilistic, spatially balanced sample design, wherein each site represents a known proportion of the total sample frame. The PSA sample draw was stratified by six PSA regions (North Coast, Chaparral, South Coast, Central Valley, Sierra Nevada, and Desert-Modoc), and treats four stream-order classes (1, 2, 3, and 4+) and three land-use classes (urban, agricultural, and forest/other) as subpopulations within each stratum. PSA land-use classes were determined by evaluating local land-use around each site in the sample draw. The SMC, which is nested within the PSA design stratifies by 15 watersheds (Ventura, Santa Clara, Calleguas, Santa Monica Bay, Los Angeles, San Gabriel, Lower Santa Ana, Middle Santa Ana, Upper Santa Ana, San Jacinto, San Juan, Northern San Diego, Central San Diego, Mission Bay-San Diego River, and Southern San Diego), and treats four stream-order classes (1-2, 3, 4, and 5+), and three land use classes (urban, agricultural, and open) as subpopulations within each stratum. SMC land-use classes were determined by evaluating land use within a 250-m buffer around each stream segment in the sample frame. For both the PSA and SMC, sites are evaluated for sampling within each stratum in the order of its site number in the original sample draw. If a site is rejected from sampling (e.g., no access or the site is too dry to sample), the next lowest-numbered site within the same stratum is evaluated for sampling.

The RCMP seeks to represent the population of minimally disturbed wadeable streams in California, covering the range of natural settings while excluding streams that have been

influenced by human activity. In previous efforts (documented in Ode et al. 2016a), the SBP identified a network of over 600 sites that met reference definitions. Each year, a subset of these sites in each region are revisited (one subset visited each year, and another subset randomly picked from this network).

The ability of the RCMP reference network to represent the state at large was evaluated in Ode et al. (2016a) by comparing the distribution of values of key natural gradients (e.g., mean annual rainfall) at reference sites with the true distribution at streams across the state, as inferred from PSA data (e.g., Figure 5).

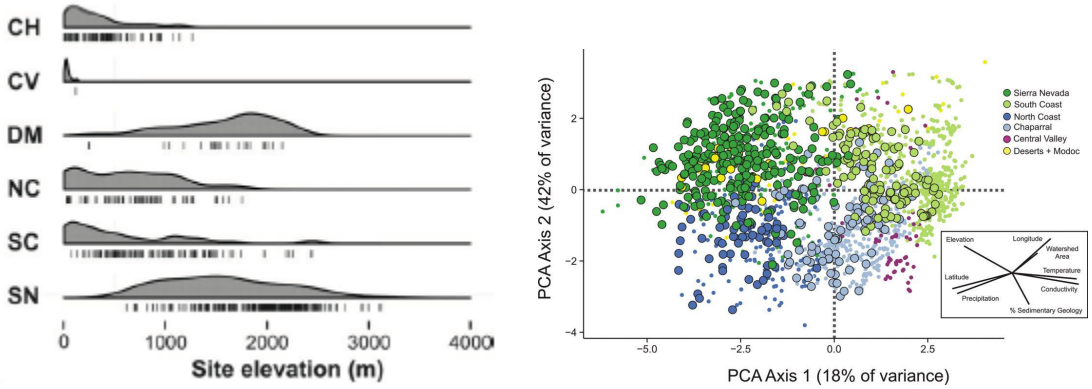

Figure 5. LEFT: Comparison of a single natural gradient (specifically, elevation) at reference sites (shown as tick marks) compared to the statewide distribution inferred from the PSA (shown as density curves). CH: Chaparral. CV: Central Valley. DM: Desert-Modoc. NC: North Coast. SC: South Coast. SN: Sierra Nevada. RIGHT: Multivariate comparison of natural gradients in the reference data set (large symbols) with ambient conditions inferred from PSA (small symbols). PCA: Principal components analysis. The extent of overlap between the two data sets indicates the representativeness of the reference data set. From Ode et al. (2016a).

Representativeness in field practices

Field practices improve representativeness by keeping sites within 300 m of targeted coordinates, and by collecting data from multiple locations throughout a reach. Most data (e.g., benthic macroinvertebrates) are collected at 11 equidistant transects, ensuring that local conditions and microhabitats are represented in the sample in proportion to their abundance in the reach. Representativeness of algal samples is further improved by subdividing the liquid fraction of the composite sample (which gets homogenized by light shaking) and macroalgal clumps separately when dividing aliquots. Representativeness of chemistry samples is improved by avoiding stagnant areas or backwaters when collecting samples.

Representativeness in lab practices

Lab practices improve representativeness by sorting samples to completion, or by ensuring that subsamples represent the entire sample (e.g., through randomization). For BMI, the representativeness of subsamples is assessed by ensuring that a minimum number of subsamples (i.e., "grids") are analyzed. For algae, representativeness is improved by homogenization of the sample (specifically, diatoms and soft bodied algae (SBA) microalgal fraction) before analysis. For SBA macroalgal fractions, representativeness is ensured by identifying all taxa in the fraction.

Completeness

Completeness refers to the comparison between the amount of valid data originally planned to be collected, and the actual quantity collected (US EPA QA/G-5, 2002). Completeness is commonly expressed as percentage of the number of reported measurements that meet Data Quality Objectives (DQOs), compared with the number of projected quality measurements. Completeness for PSA and RCMP are evaluated in several ways, including percent of sites sampled and percent of analytes measured, i.e., a full suite of physical habitat measurements are collected and 90% or greater of sites, for a project, are successfully sampled.

The completeness of taxonomic analyses of biological samples may be assessed by re-evaluating the remnant from picked and sorted samples (or subsamples). For BMI samples, 100% of the remnants from picked and sorted samples (or subsamples) are re-evaluated by a second sorter to ensure that few organisms were missed in the picking process. For algae samples, completeness is ensured by maintaining a minimum count (600 diatom valves or 300 SBA entities), or until the sample is entirely analyzed.

Sensitivity

Analytical sensitivity is most commonly defined as the lowest value an instrument or method can measure with reasonable statistical certainty. Resolution refers to the capability of a method or instrument to recognize small differences between values. These two terms are often used to assess if an instrument or method is useful to a study. Sensitivity and resolution can also be applied to taxonomic identifications, where organisms are identified to a specific rank in the hierarchy of classification of biological organisms based on project goals, analytical needs, availability of taxonomic keys and current taxonomic knowledge. This level of identification is referred to as Standard Taxonomic Effort (STE; Stribling 2003). Sensitivity is improved in BMI taxonomy by identifying all organisms to taxonomic names and STE levels defined by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT). The SBP and related programs use SAFIT Level 2 for BMIs (i.e., most taxa identified to species, with Chironomidae identified to genus, see Richards and Rogers [2011] available at safit.org).

The STE for algae taxonomy varies depending on whether live cultures from qualitative samples are used to assist SBA identification. Prior to the STE being formally adopted, SBP algal taxonomists consistently strived for the best achievable resolution. The STE is available on the SWAMP IQ Bioassessment webpage.

In biological samples, sensitivity is assessed through external QC, in which a subset of samples (10%) are sent to an external QC lab (QC) for re-evaluation. Sensitivity of BMI analyses is evaluated as taxonomic resolution error rate: that is, the percent of individuals in a sample where the original lab (OR) did not achieve the same taxonomic resolution as the QC lab. Sensitivity of algal analyses is evaluated by taxonomic similarity indices, and results are harmonized using photomicrographs when the OR and QC taxonomists are in disagreement.

Precision

The precision of a measurement system describes how close the agreement is between multiple measurements. If the two values are close together, then the measurement is said to have a high degree of precision. Precision is evaluated and achieved in the PSA and RCMP by using the same field protocol for every sample collected, collection of field duplicates for BMIs, benthic algae, and water chemistry at 10% of sites, and through the taxonomic QC process where, for example, error rates should be less than 10% for BMI taxonomic identifications, taxonomic resolution and organism counts (see Table 18 below). For chemistry measurements, precision may additionally be estimated as the variability among replicates split from the same sample but analyzed separately in the lab (i.e., lab replicates from 10% of samples).

Biological data can sometimes exhibit a high degree of natural variability among duplicate samples. Thus, although field replicates are collected and have been used to coarsely estimate precision of field protocols, variation among these replicates may indicate natural variability rather than poor data quality or failure to adhere to protocols, and establishment of MQOs for duplicate biological samples is inappropriate. Instead, the precision of biological analyses is evaluated through re-analysis of a subset (10%) of samples by an external QC lab. For BMI, precision is measured as differences in the identification and count of organisms between the two efforts. For algal data, precision is measured as similarity in composition of data produced by the OR and QC taxonomists.

It is not practical to directly assess the precision of many field-measured habitat variables, such as those derived from visual estimates of site conditions. Precision of these measurements is improved by annual intercalibration events where multiple crews participate and identify potential sources of disagreement among practitioners. Routine auditing of field crews also improves precision. Precision of field measurements derived from probes is ensured by inspecting equipment and calibrating as per manufacturers' instructions.

Accuracy

Accuracy is the assessment of the closeness of agreement between a measured or determined value and the true value. Bias is the quantitative measure of the difference between those values (NDT, 2016). Accuracy is ensured for PSA and RCMP by having all projects follow the same standardized field protocol and through the sorting process in the laboratory by separating all BMI to taxonomic order for later taxonomic identification. To ensure accuracy in BMI and algal taxonomy, taxonomists must be up-to-date on taxonomic literature and resources. Maintaining current knowledge of the taxonomy of

regional BMI fauna and algal flora is critical to ensuring data quality. Accuracy of taxonomic analyses is evaluated through external QC, which is measured as the rate of agreement in the identification of individuals or taxa (for BMI) or by similarity of community composition (for algae) between the OR and QC labs. The accuracy of chemical analyses is ensured through the evaluation of matrix spikes and/or reference material. The accuracy of probe-based field measurements is ensured through proper calibration of instruments. The accuracy of field measurements derived from visual observation is ensured through training, participation in annual intercalibration events, and routine auditing.

Comparability

Comparability expresses the measure of confidence that one dataset can be compared to and combined with another for a decision(s) to be made (US EPA QA/G-5, 2002). Data from multiple projects can be combined for decision-making purposes when projects use similar methodology, data reporting and units, have similar expectations for the level of quality needed, and document and provide similar amounts of metadata and quality assurance information. The PSA and RCMP projects maintain comparability through the fulfillment of the requirements within this plan. All sample collection, analyses, and reporting will be carried out with procedures and methodologies consistent with past biological data collection efforts for PSA, RCMP and SWAMP.

Table 3. MQOs and quality assurance practices for major elements of the SBP

Analyte or program element	**Completeness**	**Precision**	**Accuracy**	**Sensitivity**	**Representativeness**
PSA design	At least 95% of target sites sampled	Actual coordinates within 300 m of target coordinate	NA	NA	Generalized Random-Tessellation Stratified design with stratification
RCMP design	At least 95% of target sites sampled	Actual coordinates within 300 m of target coordinate	NA	NA	80% of sites in each region sampled
BMI taxonomy	Sorting efficiency >90%	Absolute recount error rate < 10%	Taxa ID and individual error rates < 10%	Lower taxonomic resolution error rate (count and individuals) < 10%	At least 8 transects sampled within a reach At least 3 grids, but possibly 100% of sample volume sorted
Diatom taxonomy	At least 600 valves are counted, or sample is completely evaluated	Bray-Curtis similarity ≥ 70%.	Bray-Curtis similarity ≥ 70%.	Reconciliation on all species identifications using photomicrographs if a sample fails the MQO	At least 8 transects sampled within a reach
Algae taxonomy – SBA	At least 300 entities are counted, or sample is completely evaluated	Bray-Curtis similarity ≥ 70%.	Sørensen similarity ≥ 80%	Reconciliation on all species identifications using photomicrographs if a sample fails the MQO	At least 8 transects sampled within a reach

A.8 Special Training/Certifications

Specialized Training and Safety Requirements

Field Crew

It is strongly recommended that field crews consist of at least two adults qualified to work in the State of California. However, larger crews may be preferable because PSA measures several indicators at each site (e.g., physical habitat, BMI and benthic algae communities, water chemistry and CRAM). If smaller crews are used, conducting CRAM assessments on a separate day, independent of sampling other indicators, may be acceptable. 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. (SMC QAPP, 2009)

The Field Coordinator will be responsible for ensuring that field crews are fully trained in field safety, applicable SWAMP-approved QA Plans, SWAMP SOPs, and SWAMP sample collection and handling guidelines. The Field Coordinator will maintain records of staff training and make those records available for inspection at the request of the Water Boards Contract Manager, or SWAMP QA Officer.

Monitoring and Measurements Bioassessment Courses

The monitoring and measurements bioassessment courses are offered by the State Water Board yearly through the Training Academy, College of Water Informatics. These courses teach the standardized techniques for measuring the condition of California streams and rivers using benthic macroinvertebrates, algae and physical habitat measures. Field sampling training for bioassessment and algae can also be provided by an agency similar to CDFW. These courses are a prerequisite to obtaining a scientific collecting permit.

Field Calibration Exercises

Each year, before field sampling starts, multiple bioassessment crews assemble for a one-day exercise to discuss invertebrate and algae sampling and processing procedures and to perform habitat measurements on a shortened stream reach. After a brief pre-exercise discussion of event activities, the crews are encouraged to present questions or concerns from the previous year's sampling for group discussion. Invertebrate and algae sampling methods are discussed and demonstrated and then the crews perform the physical habitat (PHab) exercises separately with minimal interaction recording the data on handwritten forms that are designed for the exercise. After the crews complete the exercise the groups get together to discuss the results and present any questions or concerns that came up while performing the exercise.

Field Audits

Regular (e.g., yearly) field audits of sampling crews, conducted by an individual that is highly experienced (e.g., at least 3 years of experience at more than 20 sampling events per year) in conducting all procedures described in the SOP are required, with additional training and follow-up auditing carried out as necessary depending upon audit outcomes. At the request of the Water Boards Contract Manager or SWAMP QA Officer, the SBPM will permit observation of field procedures, and inspection of equipment, including calibration logs.

Taxonomy

Laboratory analysis requires specialized training, years of experience and mentoring by a qualified taxonomist. It is strongly recommended that all BMI taxonomists become a member of Southwest Association of Freshwater Invertebrate Taxonomists (www.SAFIT.org), a taxonomist group for benthic macroinvertebrates. Although membership is not required, participation in a trade organization for freshwater taxonomists promotes taxonomic education, training, and communication. 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. (SMC QAPP, 2009)

The algal taxonomist laboratory must have at least one person (preferably two) with experience in identification and enumeration of all taxonomic groups of stream soft-bodied algae and/or diatoms. This experience can only be obtained by hands-on algal studies from a variety of freshwater habitats (preferably from streams) with algal identifications corroborated by experts. This experience should also include knowledge of and ability to use detailed taxonomic references. In order to remain current with changing algal systematics and nomenclature, the experienced taxonomist(s) must maintain contact with other taxonomists through professional societies and other interactions and must remain current with taxonomic literature related to local algal flora. (Stancheva et al., 2015)

California Rapid Assessment Method (CRAM)

The California Rapid Assessment Method provides a measure of stream and wetland condition. This assessment tool can be used independently or in the context of other assessment tools, such as PHab and Indices of Biological Indicators. Practice of CRAM as part of SWAMP's Bioassessment Program, including the CDFW-led PSA and RCMP surveys, should be conducted in accordance with the *CRAM Data Quality Assurance Plan*. This plan provides guidance for all aspects of CRAM, including method development and maintenance, training, data collection, and data reporting.

Practitioners (i.e., field data collectors) must be trained according to methods approved by the California Wetland Monitoring Workgroup (CWMW). CRAM data collection requires no fewer than two trained practitioners. More information about CRAM, including training opportunities, method documentation, and data stewardship is available at www.cramwetlands.org.

Note that new information and updates periodically arise, including module revisions, technical bulletin updates, and clarifications of existing module guidance. Practitioners are encouraged to subscribe to the CRAM newsletter to receive updates on the latest developments and upcoming trainings. Enroll at: www.cramwetlands.org/contact-us

More information on the CWMW is available at:
http://www.mywaterquality.ca.gov/monitoring_council/wetland_workgroup/index.html

Personnel Responsible for Ensuring Training

The SBPM and Field Coordinator are responsible for ensuring that training requirements are met by participating field crews and laboratories.

Training Safety and Certification Documentation

The SBPM and Field Coordinator are responsible for ensuring that staff are fully trained in field safety, applicable SWAMP-approved QA Plans, SWAMP SOPs, and SWAMP sample collection and handling guidelines. All agencies, contractors, and participating laboratories will maintain records of their training. These records will be made available upon request from the SWAMP QA Officer or SBPM. Lab QA officers are responsible for maintaining records and safety trainings in their respective labs.

Scientific Collecting Permit

A CDFW Scientific Collecting Permit is required to collect invertebrates for scientific, education, and non-commercial propagation purposes. A valid CDFW Scientific Collecting Permit must be issued to at least one member of the sampling crew in advance of sampling. To obtain a scientific collecting permit for BMI and algae, one must complete all the Monitoring and Measurements Bioassessment courses (mentioned above). Information on how to apply for a Scientific Collecting Permit is on the California Department of Fish and Wildlife website. Note: CDFW staff are exempt from this requirement.

A.9 Documentation and Records Requirements

Planning Documents

Water Boards staff will send an electronic copy of this QAPP to the SBPM, who will then distribute to all parties directly involved in this project listed in Table 1. Any future amendments to this QAPP will be distributed in the same fashion. Each version of this QAPP will be retained at the State Board.

Sample Collection and Handling Records

The PSA and RCMP Monitoring Plans detailing the sampling scheme employed for the current (i.e., just completed) year will be submitted to the Water Boards Contract Manager in an electronic format by the SBP Administrative Manager at the end of the sampling season (i.e., by end of November).

Original field sheets (Appendix VI) will be retained in a logbook, and copies of the COC (Appendix V) will be kept by each receiving laboratory. The field logbook will include the following elements: equipment inventory, instrument calibration dates and results, sensor/probe accuracy and precision check results and dates performed, personnel training records, a log of corrective actions, and any other items relating to the field sampling being conducted. The Field Coordinator will maintain the field logbook, store it on site, and make it available for review upon request of the Water Boards. An electronic copy of the COC will be provided to the SBPM, Water Boards Contract Manager, and the SWAMP Information Management and Quality Assurance Unit (SWAMP IQ) at the Water Boards (OIMA-Helpdesk@waterboards.ca.gov) within 10 business days of submission of samples to the laboratory. SWAMP AA forms (Appendix VII) will also accompany algal samples sent to the laboratory. The field crews will keep original copies of the field sheets, calibration logs and data generated for PSA and RCMP stored for 10 years. These documents will be made available to the Water Boards upon request.

Analytical Records

Contract laboratories will maintain logs measuring routine inspections, calibrations, and measurements for the items listed, as well as parameters required for the Water Boards Environmental Laboratory Accreditation Program (ELAP) certification. All equipment logs and data sheets will be retained at their respective laboratories for a minimum of 10 years from the contract's cessation (if applicable) and provided to Water Boards staff upon request.

Lab Reports

Sample information is entered into SWAMP Data Templates, data entry shells, or into Laboratory Information Management Systems (LIMS). Laboratory-generated data are entered from bench sheets or downloaded from the LIMS into SWAMP Data Templates.

Original bench sheets and lab reports must be retained for no less than five years or per the terms within the contract. Electronic scans or photocopies of those records will be made available to the Water Boards Contract Manager and SWAMP QA Officer upon request.

Electronic Data Deliverables (EDD)

The laboratories are responsible for the entry or export of analytical and quality control results into the most current Excel data templates or data entry shells provided by the SWAMP IQ. They will ensure that records are complete and accurate, and meet the most current SWAMP Formatting and Business Rules. Laboratories will include, and appropriately report, the applicable quality control samples required per batch or per

project to establish and verify compliance with the applicable MQOs. EDDs will be delivered to the SWAMP IQ within forty (40) business days of the analysis date. Should more time be required, a deadline extension must be requested from the Water Boards Contract Manager.

The laboratories will complete submission of EDDs through the SWAMP Online Data Checker, or via data entry shell submission through the SWAMP FTP site.
SWAMP IQ staff will review EDDs submitted to the SWAMP IQ for required formatting and accuracy. SWAMP IQ staff will return EDDs that are formatted incorrectly or are inaccurate. In the event that an EDD is returned to the laboratory for correction, the laboratory will resubmit the EDD through the SWAMP Online Data Checker with corrections within ten (10) business days of receiving a request for correction. Should the laboratory require more time to make the required corrections, the laboratory will request a deadline extension from with the Water Boards Contract Manager.

Corrective and Preventative Action Reports (CPAR)

Corrective actions are documented in the laboratory record. If a failure is not resolved it is conveyed to the Lab QAO who determines if the failure compromised associated results. The nature and disposition of the problem will be documented in the data report sent to the SBPM and the SWAMP QAO.

B. DATA GENERATION AND ACQUISITION

B.1 Sampling Process Design

Perennial Streams Assessment

The PSA is a status and trends program based on a probabilistic survey design of perennial wadeable streams in California. The PSA sample draw was stratified by six PSA regions (North Coast, Chaparral, South Coast, Central Valley, Sierra Nevada, and Desert-Modoc), and treats four stream-order classes (1, 2, 3, and 4+) and three land-use classes (urban, agricultural, and forest/other) as subpopulations within each stratum. PSA land-use classes were determined by evaluating local land-use around each site in the sample draw. Sites are evaluated for sampling within each stratum in the order of its site number in the original sample draw. If a site is rejected from sampling (e.g., no access or the site is too dry to sample), the next lowest-numbered site within the same stratum is evaluated for sampling. Reasons for rejecting sites for sampling are listed in Table 4.

Table 4. Site evaluation criteria for the PSA

Site evaluation criteria	Description
Waterbody status	The target coordinates must be within 300 m of a sampleable stream. Sites on other waterbody types (e.g., tidal waterbodies, pipelines) or not near any waterbody (e.g., map errors) cannot be sampled.
Flow status	A stream must be flowing at the time of sampling. Such streams are presumed to be perennial in certain analyses.
Wadeability status	A stream must be wadeable (i.e., < 1 m deep for at least 50% of the reach) at the time of sampling. As an exception, certain affiliated programs (e.g., NRSA) employ alternative protocols for non-wadeable (a.k.a., boatable) rivers)
Physical access status	A stream must be physically accessible. That is, a crew must be able to safely reach the site, sample it, and return to the vehicle in a single day.
Landowner permission status	Landowners must grant permission for site access

The PSA estimates ecological stream health by assessing biological indicators (benthic macroinvertebrates, algae), chemical constituents (nutrients, major ions, etc.), and habitat assessments (both for in-stream and riparian corridor conditions) and using the properties of the survey design to extrapolate to the population of perennial wadeable streams in the state. The weight of each site in these estimates is calculated by counting the total stream-length within major strata (e.g., combinations of region, stream order, and land use) associated with the PSA and associated surveys and dividing by the number of sampled sites. To estimate the extent of resources (e.g., extent of perennial vs. nonperennial streams), the total stream-length is divided by the number of sites evaluated (not just the number of sites sampled).

Reference Condition Management Program

The RCMP has been conducted in two phases, described in the SBP's reference condition planning document (Ode and Schiff 2009). In the first phase, the SBP identified and sampled reference sites throughout the state to create a network of reference sites that represent different regions' environmental settings in the state. This effort identified approximately 600 sites in California that serve as a benchmark for establishing expectations of biological, chemical and physical conditions in healthy streams and rivers across the state (Ode et al. 2016a). Since then, the SBP has continued to add sites that pass screening criteria to the pool, focusing on underrepresented regions or settings (e.g., the interior chaparral). The reference site network now comprises approximately 800 sites. Now in its second phase, the RCMP samples two sets of sites each year: (1) a set of sites throughout the state randomly selected from this network, and (2) a set of sites selected for long-term monitoring every year.

B.2 Sampling Procedures and Requirements

Sample/Data Collection Procedures

Field

Field crews will adhere to the following existing SWAMP and CDFW SOPs to sample field data for BMIs, algae, water chemistry associated with biotic assemblage samples, associated PHab (Ode et al. 2016b), and CRAM. The SOPs that field crews will follow are:

- Collection of Field Data for Bioassessments of CA Wadeable Streams: Benthic Macroinvertebrates, Algae and Physical Habitat.
- Marine Pollution Studies Laboratory Standard Operating Procedure: Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California. Version 1.1
- CRAM Data Quality Assurance Plan, methods and field data sheets.

Laboratory

Laboratory personnel will follow associated SOPs and this QA Project Plan, including guidance on Standard Taxonomic Effort (STE), for all BMI and algae analyses performed in the laboratory.

- Standard Operating Procedures for Laboratory Processing and Identification of Benthic Macroinvertebrates in California (Woodard et al. 2012).
- Standard Operating Procedures for External Quality Control of Benthic Macroinvertebrate Taxonomy Data Collected for Stream Bioassessment in California (Rehn et al., 2015).
- List of Freshwater Macroinvertebrate Taxa from California and Adjacent States Including Standard Taxonomic Effort Levels (Richards and Rogers 2011)
- Standard Operating Procedures for Laboratory Processing, Identification, and Enumeration of Stream Algae (Stancheva et al., 2015).
- Standard Operating Procedures for Internal and External Quality Control of Laboratory Processing, Identification, and Enumeration of Stream Algae in California (Stancheva and Sheath 2019) is available on the SWAMP IQ Bioassessment webpage).
- Standard Taxonomic Effort (STE) for algae is available on the SWAMP IQ Bioassessment webpage.

Equipment/ Supplies

Sampling equipment

Table 5. Testing, inspection and maintenance for sampling equipment and analytical instruments to be conducted by field crews.

Equipment Item
Analytical instruments. Inspect condition before each sampling event and calibrate as per field measurement MQOs in Tables 13 and 14.
• Conductivity probe • Dissolved oxygen probe • Flow Meter • pH Meter • Salinity probe • Turbidity meter
Consumable items. Ensure adequate supply before each day of sampling.
• Alkalinity kit • Flagging • Pencils/Permanent markers • Waterproof paper • Wide-mouth plastic jars (for BMI samples) • 50 mL centrifuge tubes, glass fiber filters (47 mm, 0.7 µm pore size), whirl-pak bags, and tinfoil (for algae samples) • Decontaminants, if necessary • Paper data sheets • Ice • Appropriate size and type pre-cleaned water chemistry sample jars (see Sample Handling Tables in Section B3). • Fixatives (ethanol for BMI, glutaraldehyde for SBA, and formalin)
Durable items. Inspect condition before each sampling event.
• Auto-level or clinometer • Compass • Densiometer • D-shaped Kick Net (0.5mm mesh) • Forceps • Gridded White Enameled Pan • Measuring Tape (50 meter) • Standard Size 35 Sieve (0.5 mm) • Wading rod (metric) • Thermometer • Ice chest

- Algae sampling gear: ABS delimiter, rubber delimiter, syringe scrubber, masonry trowel, knife, squirt bottle, collection bucket, 500-mL graduated cylinder, and vacuum pump.
- Personal protective equipment (PPE) when working with Glutaraldehyde: eye protection (chemical splash goggles or safety glasses with face shield), hand protection (nitrile or vinyl gloves), and body protection (lab coat with polypropylene splash apron that cover the arms)
- Digital data entry tablet

Cleaning/Decontamination

Sampling crews must take appropriate precautions to ensure that invasive species and pathogens are not transferred between sampling sites. Organisms of concern in the U.S. include, but may not be limited to, Eurasian watermilfoil (*Myriophyllum spicatum*), New Zealand mud snail (*Potamopyrgus antipodarum*), zebra mussel and quagga mussel (*Dreissena polymorpha and D. bugensis*), *Myxobolus cerebralis* (the sporozoan parasite that causes salmonid whirling disease), and *Batrachochytrium dendrobatidis* (a chytrid fungus that threatens amphibian populations). Crews should make every attempt to be apprised of the most up-to-date information regarding the emergence of new species of concern, as well as new advances in approaches to hygiene and decontamination to prevent the spread of all such organisms (e.g., Schisler et al. 2008). Decontamination techniques are also found in Supplemental Guidance for the SWAMP Bioassessment Field Protocol (2016).

B.3 Sample Handling, Custody Procedures, and Documentation

Sample Handling

Sample handling requirements vary with the assemblage being studied in the survey. For most biological assessments, the minimum sample size needed to fulfill the data quality objective for representativeness should be incorporated into the sampling design so that sampling produces minimal environmental impact. For those samples that will be analyzed in the laboratory, the organisms are sacrificed and field preservation, labeling, and transport protocols must be followed (USEPA, 1995).

Sample Documentation

The SWAMP Bioassessment Field Data Sheets with Algae (in PDF), is required when conducting bioassessment in the field or when a program is required to follow SWAMP protocol to conduct bioassessment. The form contains fields that correspond with the SWAMP database. This PDF form, found on the SWAMP website, contains SWAMP's Bioassessment full version data sheets used for physical habitat, benthic macroinvertebrate, algae, and water quality sampling.

Example sample labels are shown in Appendix IV.

Algae taxonomy results reporting forms (called algae Analysis Authorization (AA) forms; Appendix VII) must be provided to algae labs for all samples to be analyzed. The reporting form contains pertinent sample/collection data that is used by labs to calculate and enter results data; it is also required by labs to facilitate the submission of algae taxonomy data to SWAMP. Note: The current process (***subject to change***) for supplying reporting forms to algae labs is as follows:

1. Project coordinators must submit to SWAMP IQ via OIMA-Helpdesk@waterboards.ca.gov a complete set of sample and benthic collection data for each project as soon as possible after collecting the data, and notify the SWAMP IQ Algae Taxonomy liaison that the data is available;
2. SWAMP IQ staff will query out the dataset(s) and transfer the data into a reporting form template;
3. SWAMP IQ will send the completed forms to the lab (and project coordinator) via email.

Chain of Custody

Project COC procedures require that possession of samples is traceable from the time they are collected until completion and submittal of analytical results. Therefore, a complete COC form will accompany the transfer of samples to each analyzing laboratory. All samples will be handled, prepared, transported, and stored in a manner so as to minimize bulk loss, analyte loss, contamination, or biological degradation, according to the applicable MQOs and the SOPs in Appendix II. The receiving laboratory has a sample custodian who examines the samples for proper documentation, preservation, and holding times. Contract laboratories will follow the COC procedures outlined in their respective QA Plans (available upon request).

The Field Coordinator will be responsible for ensuring that each field sampling team adheres to proper custody and documentation procedures. A master sample logbook of field data sheets will be maintained for all samples collected during each sampling event. A COC form (Appendix V) must be completed after sample collection to document control, transfer, and analysis of samples.

An electronic copy of the COC will be provided to the SBPM, Water Boards Contract Manager, and the SWAMP IQ (OIMA-Helpdesk@waterboards.ca.gov) within 10 business days of submission of samples to the laboratory.

Sample Handling Requirements

The sample handling requirements for PSA and RCMP analytes are listed in Table 6 through Table 10. These requirements were excerpted from SWAMP's MQOs for Conventional Parameters in Fresh and Marine Water; Nutrients in Fresh and Marine Water; Solid Parameters in Fresh and Marine Water; and Algal and Benthic Macroinvertebrates Analysis.

Following sample handling guidelines ensures sample integrity from collection to analysis. Samples should be properly prepared according to guidelines and for laboratory analysis.

It is the shipper's responsibility to assure that samples are properly sealed and packaged. All persons shipping samples must adhere to Department of Transportation (DOT) and other shipping regulations.

Table 6. Sample Handling: Conventional analytes in Fresh and Marine Water.

Analyte	Recommended Container	Recommended Preservation[1,2]	Required Holding Time[3]	Notes
Alkalinity (as $CaCO_3$)[5]	Polyethylene	Cool to ≤6° Celsius	14 days	Marine Samples for alkalinity may be cooled to ≤6°C for maximum of 24 hours
Chloride	Polyethylene	None required	28 days	
Hardness (as $CaCO_3$)	Polyethylene	Cool to ≤6° Celsius; HNO_3 or H_2SO_4 to pH<2	6 months	
Organic Carbon (Dissolved)	Glass	Filter and preserve to pH <2 within 48 hours of collection; Cool to ≤6° Celsius	28 days	
Silica	Polyethylene	Cool to ≤6° Celsius; HNO_3 to pH<2	28 days; 6 months if acidified	
Specific Conductance	Polyethylene	Cool to ≤6° Celsius; if analysis is not completed within 24 hours of sample collection, sample should be filtered through a 0.45-micron filter and stored at ≤6° Celsius	28 days	

Analyte	Recommended Container	Recommended Preservation[1,2]	Required Holding Time[3]	Notes
Sulfate	Polyethylene	Cool to ≤6° Celsius	28 days	
Turbidity	Polyethylene	Cool to ≤6° Celsius	48 hours	

[1] Per the draft National Coastal Assessment Quality Assurance Project Plan (August 2009), marine waters in plastic containers may be ultra-frozen

[2] Per 40 CFR 136.3, aqueous samples must be preserved at ≤6 °C and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity is maintained on file and accepted as valid by the regulatory authority. The preservation temperature does not apply to samples that are analyzed immediately (less than 15 minutes).

[3] Each "Required Holding Time" is based on the assumption that the "Recommended Preservation" (or method-mandated alternative) has been employed. If a "Required Holding Time" for filtration, preservation, preparation, or analysis is not met, the Program Manager and SWAMP Quality Assurance Officer must be notified. Regardless of preservation technique, data not meeting the “Required Holding Time” will be appropriately flagged in the SWAMP database.

Table 7. Sample Handling: Nutrients in Fresh and Marine Water.

Analyte	Recommended Container	Recommended Preservation[1]	Required Holding Time[2]
Ammonia (as N)	Polyethylene	Cool to ≤6°C; samples may be preserved with 2 mL of H_2SO_4 per L	48 hours; 28 days if acidified
Nitrate + Nitrite (as N)	Polyethylene	Cool to ≤6°C; H_2SO_4 to pH <2	48 hours; 28 days if acidified
Orthophosphate (Dissolved, as P; Soluble Reactive Phosphorus)	Polyethylene	Filter within 15 minutes of collection[3] Cool to ≤6°C	48 hours
Phosphorus (Total, as P)	Polyethylene	Cool to ≤6°C; H_2SO_4 to pH <2	28 days

[2] Per 40 CFR 136.3, aqueous samples must be preserved at ≤6 °C and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity is maintained on file and accepted as valid by the regulatory authority. The preservation temperature does not apply to samples that are analyzed immediately (less than 15 minutes).
[3] Each "Required Holding Time" is based on the assumption that the "Recommended Preservation" (or a method-mandated alternative) has been employed. If a "Required Holding Time" for filtration, preservation, preparation, or analysis is not met, the Program Manager and SWAMP Quality Assurance Officer must be notified. Regardless of preservation technique, data not meeting the "Required Holding Time" will be appropriately flagged in the SWAMP database.
[4] Per 40 CFR 136.3, the immediate filtration requirement in orthophosphate measurement is to assess the dissolved or bioavailable form of orthophosphorus (i.e., that which passes through a 0.45-micron filter), hence the requirement to filter the sample immediately upon collection (i.e., within 15 minutes of collection).

Table 8. Sample Handling: Solid Parameters in Fresh and Marine Water.

Analyte	Recommended Container	Recommended Preservation[1]	Required Holding Time[2]
Suspended Sediment concentration	Glass or Polyethylene	Cool to ≤6°C	7 days
Total Suspended Solids	Glass or Polyethylene	Cool to ≤6°C	7 days

[1] Per 40 CFR 136.3, aqueous samples must be preserved at ≤6 °C and should not be frozen unless data demonstrating that sample freezing does not adversely impact sample integrity is maintained on file and accepted as valid by the regulatory authority. The preservation temperature does not apply to samples that are analyzed immediately (less than 15 minutes).
[2] Each "Required Holding Time" is based on the assumption that the "Recommended Preservation" (or a method-mandated alternative) has been employed. If a "Required Holding Time" for filtration, preservation, preparation, or analysis is not met, the Program Manager and SWAMP Quality Assurance Officer must be notified. Regardless of preservation technique, data not meeting the "Required Holding Time" will be appropriately flagged in the SWAMP database.

Table 9. Sample Handling: Algae.

Analyte	Container	Preservation	Temperature & Holding Time
Chlorophyll *a*	Glass-fiber filter	No additives	Filter, wrap in foil, store on wet ice in the field, but freeze (pref. -80ºC) within 4 h of collection; analyze within 28 d
Ash Free Dry Mass (AFDM)	Glass-fiber filter (pre-combusted)	No additives	Filter, wrap in foil, store on wet ice in the field, but freeze (pref. -80ºC) within 4 h of collection; analyze within 28 d
Soft-bodied algae quantitative sample	50 mL centrifuge tube	Add glutaraldehyde (to a 2% final concentration) under a fume hood, as soon as possible, but no later than 96 hours after sampling. Samples can arrive to the lab preserved, or unpreserved if received the day after sampling and lab is alerted in advance	Keep samples in dark on wet (not dry) ice. Keep at 0-4°C; do not freeze. After fixing, refrigerate (0-4°C) and keep in dark; fixed samples can be stored for at least 2 years
Soft-bodied algae qualitative sample	100 mL Whirl-Pak™ bag	No additives	Keep fresh sample on wet ice (or refrigerated) and in the dark. Keep at 0-4°C; do not freeze. Send so that sample is received within 2 weeks of sample collection

Analyte	Container	Preservation	Temperature & Holding Time
Diatom sample	50 mL centrifuge tube	Add 5% formalin for a 1% final concentration immediately after collection. Formalin does not need to be buffered, but if it is, use phosphate buffer, not borax. Samples should be fixed before shipment to lab. Note: glutaraldehyde is an acceptable alternative to formalin.	Keep sample in dark and away from heat; fixed samples can be stored at 0-4°C for at least 2 years
DNA sample	Not applicable	Between 5-50 ml of algae composite sample is filtered onto a 0.45 µm nitrocellulose filter. Filter is submerged in lysis buffer preservation solution and stored in microcentrifuge tube.	Sample is kept in the dark and on ice until transfer to a -20°F (or -80°F if available) freezer. Fixed samples can be stored frozen for 2 years.

Table 10. Sample Handling: Benthic Macroinvertebrates.

Analyte	Bottle Type/Size	Preservative	Maximum Holding Time
Benthic macroinvertebrate field samples	Plastic wide-mouth bottles with screw top lids, 0.5 L (minimum). Additional containers can be used as needed.	95% ethanol, diluted to a final concentration no less than 70% ethanol	Not applicable
Benthic macroinvertebrates (identified)	Glass or shell vials	70% ethanol	Not applicable

Sample Retention and Disposal

All samples will be retained for the entire duration of their required holding times and analysis. Any samples remaining after successful completion of analyses will be properly disposed of after verbal confirmation stating that the data have been received, reviewed and verified has been obtained from the Water Boards Contract Manager. Biological samples shall be retained as per Table 11. It is the responsibility of the personnel of each analytical laboratory to ensure that all applicable regulations are followed in the disposal of samples or chemicals.

Table 11. Minimum retention times for biological samples.

Benthic macroinvertebrate

Analyte	Bottle Type/Size	Preservative	Minimum Retention Time
Field samples	Plastic wide-mouth bottles with screw top lids, 0.5 L (minimum). Additional containers can be used as needed.	95% ethanol for < 30 days, place samples in an ice chest designated for BMI samples with alcohol only to avoid contamination of other water chemistry or algae samples.	5 years from date of sample
Sorted specimens	Glass containers, variable size depending on volume	70% ethanol	5 years from date of sample
Sorted subsample residue	Plastic wide mouth with screw top lids. Variable size depending on volume	70% ethanol	1 year from date of sample
Unsorted sample	Plastic wide mouth with screw top lids. Variable size depending on volume	70% ethanol	2 years from date of sample

Algae

Analyte	Bottle Type/Size	Preservative	Minimum Retention Time
SBA qualitative sample	20-40 mL plastic scintillation vial	2% glutaraldehyde	2 years
SBA quantitative macroalgal fraction	15 or 50 mL centrifuge tube	2% glutaraldehyde	2 years
SBA quantitative microalgal fraction slides	Sealed glass slides	None	2 years
SBA quantitative microalgal fraction remainder	15 or 50 mL centrifuge tube	2% glutaraldehyde	2 years
Diatom quantitative sample remainder	50 mL centrifuge tube	1% formalin	2 years
Cleaned, fixed diatom samples	Plastic scintillation vial	50% ethanol	2 years
Permanent diatom slides	Glass slides	None	5 years

B.4 Analytical Methods Requirements

The standardized test methods used to measure the analytes of interest to the PSA/RCMP programs are listed in Table 12, along with the reporting limits and appropriate reference.

Reporting limits (RLs) represent the lowest quantifiable concentration in a sample, based on the proper application of all method-based analytical procedures and the absence of any matrix interferences and dilutions. For instrumentation methods that use multi-point calibration techniques, the laboratories will ensure that the RLs represent the lowest standard in the calibration curve that meets calibration criteria for that specific analytical technique. For instrumentation that does not require multi-point calibration such as inductively coupled plasma (ICP) or inductively coupled plasma mass spectrometer (ICPMS), the laboratories will run a low-level check standard at the RL.

The laboratories will document method capability prior to performance of a method. Method capability is defined as performance of a method detection limit study (MDL) and an initial precision and recovery (IPR) study. The laboratories will make the method capability of an analysis available for review upon request from the SBPM, or the SWAMP QAO.

At a minimum, the laboratories will achieve specified RLs. Laboratories will notify the SBPM, SWAMP QAO, and Water Boards Contract Manager before proceeding with an analysis that will not achieve RLs and will obtain permission from the SBPM before proceeding with the analysis.

Table 12. Project Analytical Methods

Matrix	Method	Analytes	Unit	RL	MDL	Reference
Water	SM 4500-P E	Orthophosphate as P (dissolved)	mg/L	0.0100	0.00500	Standard Methods
Water	EPA 365.1M	Phosphorus as P (total; TPHOS) - typical	mg/L	0.00100	0.00900	NEMI
Water	SM 4500-NO3 F	Nitrate/Nitrite as N (NO3/NO2)	mg/L	0.00500	0.00200	Standard Methods

Matrix	Method	Analytes	Unit	RL	MDL	Reference
Water	SM 4500-NO3 F	Nitrite as N (NO2)	mg/L	0.00500	0.00200	Standard Methods
Water	SM 4500-N CM v21	Nitrogen, Total	mg/L	0.0100	0.00500	Standard Methods
Water	SM 4500-NH3 D v20, v21	Ammonia as N (NH3)	mg/L	0.0400	0.00300	Standard Methods
Water	EPA 300.0	Chloride (CL)	mg/L	0.0400	0.0230	NEMI
Water	EPA 300.0	Sulfate (SO4)	mg/L	0.0200	0.0110	NEMI
Water	SM 2340 B or EPA 130.1	Hardness as $CaCO_3$ (HARD;) (Total)	mg/L	2.50	1.00	Standard Methods NEMI
Water	SM 10200 H-2b	Chlorophyll *a* (CHL; syringe-filtered)	mg/m2	1.08	1.08	Standard Methods
Water	WRS 73A.3	Ash Free Dry Mass (AFDM)	g/m2	0.010	0.005	WRS
Water	SM 2540 D	Total Suspended Solids	mg/L	1.00	0.500	Standard Methods
Water	ASTM D3977	Suspended Sediment Concentration (SSC)	mg/L	4	2	ASTM
Water	EPA 200.7	Silica as SiO2	mg/L	0.02	0.01	NEMI

Matrix	Method	Analytes	Unit	RL	MDL	Reference
Water	EPA 415.1M	Dissolved Organic Carbon (DOC)	mg/L	0.20	0.10	NEMI

B.5 Quality Control Requirements

The chemistry laboratories participating in the SBP employ multiple approaches to quality control in order to identify possible contamination problem(s), matrix interference, and evaluate the ability to duplicate results.

Field Measurements Quality Control

Field QC definitions and requirements are listed in the SWAMP QAPrP. Laboratory QC results must meet the error limits and frequency detailed in the applicable MQOs. Field QC results must meet the limits of error and frequency requirements detailed in the applicable SWAMP Programmatic MQOs. These MQOs are shown in Table 13 and Table 14.

QC of habitat measures is attained through training, annual intercalibration events with multiple experienced field crews, and routine auditing.

Table 13. Field Measurements for In-Situ Water Quality Monitoring in Fresh and Marine Water - Instrument requirements for Accuracy, Precision, and Resolution

Water Quality Parameter	Unit	Accuracy (Unit or Percent)	Precision (Unit or RPD)[1]	Resolution[2]
pH	pH	±0.2	±0.2	±0.1
Specific Conductivity	uS/cm; mS/cm	±2	±2 or + ±10%	±1
Dissolved oxygen	mg/L; µmol/L	±0.5	±0.5 or ±10%	±0.1
Temperature	°C	±0.2	±1 or ±10%	±0.1
Turbidity	NTU; FNU	±1	±1 or ±10%	±0.1
Velocity	ft/sec	NA	±0.2 or ±10%	±0.1
Flow	m^3/s	NA	±0.2 or ±10%	±0.1
Total Chlorophyll	µg/L; RFU	±1	±1 or ±10%	±1

[1] Relative Percent Difference (RPD) is the difference between two repeated measurements expressed as a percentage of their average. *%RPD = (sample result - duplicate result) * 100*
[2] Resolution refers to the capability of a method or instrument to recognize small differences between values. This term is often used to assess if an instrument or method is useful to a study and is provided by the manufacturer.

Table 14. Field calibration and accuracy checks in Fresh and Marine Water

Parameter	Instrument Name or Type	Frequency of Calibration & Accuracy Checks[1, 2, 3]	Frequency of Repeated Measurements (Precision)[4]
Dissolved Oxygen	DO electrode (meter) or probe[5]	Daily, pre-sampling one-point calibration within 24 hours before event.	2 per trip
Temperature	Bulb thermometer	Periodic accuracy check halfway through the duration of project timeline, examine capillary daily (quarterly to annually)	2 per trip
Temperature	Temperature probe (with multimeter or DO meter)	Periodic accuracy check halfway through the duration of project timeline	2 per trip
Specific Conductivity	EC meter	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	2 per trip
Specific Conductivity	Conductivity probe	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	2 per trip
pH	pH meter (dry electrode) or probe	Daily, pre-sampling two-point calibration within 24 hours before event.	2 per trip
Turbidity	Nephelometer or turbidimeter	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	1 per trip

Parameter	Instrument Name or Type	Frequency of Calibration & Accuracy Checks[1, 2, 3]	Frequency of Repeated Measurements (Precision)[4]
Velocity	Electromagnetic	Periodic accuracy check and calibration adjustment halfway through the duration of project timeline	1 per trip
Total Chlorophyll	Optical fluorescence probe	Periodic accuracy check and two-point calibration adjustment halfway through the duration of project timeline[6]	1 per trip

[1] Unless manufacturer specifies more stringent requirements.
[2] SWAMP requires daily pre- and post- (within 24 hours after event) sampling accuracy checks when the manufacturer or documented procedure (e.g., standard operating procedure) do not provide instruction.
[3] For ongoing (e.g., trend monitoring) projects, accuracy checks and calibration adjustments should happen no less than every three months. All instruments will be checked for accuracy and calibrated before the first measurement of any project. Pre-project calibration date is reported with dataset.
[4] Repeat a field measurement at least twice by removing the probe from the water, re-submerging the probe and allowing the probe to stabilize. After the instrument stabilizes, record the reading and calculate the relative percent difference between the readings. If the relative percent difference exceeds the MQO, perform the test again to ensure that the required stabilization period is adhered to. If the instrument continues to provide measurements that exceed the MQO, the instrument must be re-calibrated.
[5] For elevation change of ≥ 500 m, conduct pre-transit and post-transit accuracy checks between sites with anticipated elevation difference. Depending on results from comparing accuracy checks, field calibration may be necessary.
[6] Refer to manufacturer's instructions to ensure that the meter is not being checked too infrequently.

Laboratory Measurements Quality Controls for Chemical Analysis

For laboratory chemical analysis terms and QC requirements carried out by the testing laboratory during sample preparation and chemical analysis see the SWAMP QAPrP. Laboratory QC results must meet the error limits and frequency detailed in the applicable MQOs, which are shown in
Table 16. 5 through 17.

Laboratory Quality Control	**Frequency of Analysis**	**Measurement Quality Objective1**
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Calibration Verification	Per 10 analytical runs	90-110% 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	90-110% 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	80-120% recovery; RPD <25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD <25% (NA if native concentration of either sample <RL)
Field Quality Control	Frequency of Analysis	Measurement Quality Objective1
Field Duplicate	5% of total project sample count	RPD <25% (NA if native concentration of either sample <RL)
Field Blank	Per method	<RL for target analyte
Travel Blank	Per method	<RL for target analyte
Equipment Blank	Per method	<RL for target analyte

Table 15. Lab MQOs: Conventional Parameters in Fresh and Marine Water

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective[1]
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Calibration Verification	Per 10 analytical runs	80-120% recovery

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective[1]
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	80-120% recovery; RPD <25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD <25% (NA 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[1]
Field Duplicate[2]	5% of total project sample count	RPD <25% (N/A if native concentration of either sample <RL)
Travel Blank, Equipment Blank	Per method	<RL for target analyte

[1] Unless manufacturer specifies more stringent requirement
[2] Field duplicate relative percent differences are not calculated for chlorophyll *a* analyses for bioassessment

Table 16. Lab MQOs: Nutrients in Fresh and Marine Water.

Laboratory Quality Control	**Frequency of Analysis**	**Measurement Quality Objective[1]**
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Calibration Verification	Per 10 analytical runs	90-110% 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	90-110% 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	80-120% recovery; RPD <25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD <25% (NA if native concentration of either sample <RL)
Field Quality Control	Frequency of Analysis	Measurement Quality Objective[1]
Field Duplicate	5% of total project sample count	RPD <25% (NA if native concentration of either sample <RL)
Field Blank	Per method	<RL for target analyte
Travel Blank	Per method	<RL for target analyte
Equipment Blank	Per method	<RL for target analyte

[1] Unless manufacturer specifies more stringent requirement

Table 17. Lab MQOs: Solid Parameters in Fresh and Marine Water.

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective[1]
Laboratory Blank[2]	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Laboratory Duplicate[3]	Per 20 samples or per analytical batch, whichever is more frequent	RPD <25% (NA if native concentration of either sample <RL)
Field Quality Control	Frequency of Analysis	Measurement Quality Objective[1]
Field Duplicate	5% of total project sample count	RPD <25% (NA if native concentration of either sample <RL)
Field Blank	Per method	<RL for target analyte
Travel Blank	Per method	<RL for target analyte
Equipment Blank	Per method	<RL for target analyte

[1] Unless method specifies more stringent requirements
[2] Not applicable to volatile suspended solids
[3] Applicable only to total suspended solids, total dissolved solids, and ash-free dry mass

Laboratory Quality Controls for Taxonomic Analyses

For terms relating to benthic macroinvertebrate, soft algae and diatom samples and the processes carried out in the laboratory, see the SWAMP QAPrP. Laboratory QC results must meet the error limits and frequency detailed in the applicable MQOs. QC practices require that some or all samples in a project be re-evaluated by a second (typically more experienced) practitioner in the lab (i.e., internal QC), and a subset be re-evaluated by an external lab (external QC). The MQOs for laboratory QC for taxonomic analyses are shown in Table 18 and Table 19.

When control limits are exceeded, the Laboratory QAO will determine the cause(s) by reviewing SOPs and identifying, documenting, and correcting any deficiencies. The Laboratory QAO will follow the corrective actions set forth by the applicable MQOs assigned by the project. The Laboratory QAO will also respond to requests for verification of corrective action follow-through, or requests to perform corrective actions from the SWAMP QAO, SBPM, or Water Boards Contract Manager. In addition, the Laboratory QAO or SBPM will conduct any corrective actions required, including requests for investigation, retraining of field staff, and audits of field protocols, or any other actions required to ensure sample integrity. The Laboratory QAO will document the applied corrective actions in a SWAMP Corrective and Preventative Action Report (CPAR), and provide this report at the request of the SBPM, SWAMP QAO, or Water Boards Contract Manager within twenty (20) business days of the request. The SWAMP QAO will review the report and may request additional information of actions to be taken. The Laboratory QAO will respond with an amended CPAR within twenty (20) business days of the

additional request. Should the Laboratory QAO require more time to complete or respond to comments on a CPAR, the Laboratory QAO will request a deadline extension from the Water Boards Contract Manager.

Table 18. Lab MQOs for Benthic Macroinvertebrate Taxonomic Analysis. Definitions: OR = Original lab, QC = Quality Control (external) lab.

External QC Assessment MQOs. Samples are re-evaluated by an external (QC) lab.

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Absolute recount error rate	10% of samples in project	$\sum \frac{\lvert QC\ lab\ count - OR\ lab\ count \rvert}{QC\ lab\ count} < 10\%$	Precision
Taxa ID error rate	10% of samples in project	$\frac{Number\ of\ FinalIDs\ misidentified\ by\ OR}{Number\ of\ FinalIDs\ identified\ by\ QC} < 10\%$	Accuracy
Individual ID error rate	10% of samples in project	$\frac{Number\ of\ individuals\ misidentified\ by\ QC\ lab}{Number\ of\ individuals\ identified\ by\ QC\ lab} < 10\%$	Accuracy
Lower taxonomic resolution individual error rate	10% of samples in project	$\frac{Number\ of\ specimens\ where\ QC\ lab\ FinalID\ achieved\ higher\ resolution\ than\ OR\ lab\ FinalID}{Total\ number\ of\ specimens\ in\ sample\ by\ QC\ lab} < 10\%$	Sensitivity
Lower taxonomic resolution count error rate	10% of samples in project	$\frac{Number\ of\ FinalIDs\ where\ the\ QC\ lab\ acheived\ higher\ resolution\ than\ the\ OR\ lab}{Number\ of\ FinalIDs\ identified\ by\ QC\ lab} < 10\%$	Sensitivity

External QC Descriptive MQOs (no thresholds). Samples are re-evaluated by an external (QC) lab.

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Recount accuracy	10% of samples in project	$\frac{Number\ of\ specimens\ in\ smaller\ count}{Number\ of\ specimens\ in\ larger\ count}$	Precision
Taxa count error rate	10% of samples in project	$\frac{\lvert Number\ of\ FinalIDs\ per\ QC\ lab\ -\ Number\ of\ FinalIDs\ per\ OR\ lab\rvert}{Number\ of\ FinalIDs\ per\ QC\ lab}$	Accuracy
Higher taxonomic resolution individual error rate	10% of samples in project	$\frac{Number\ of\ individuals\ where\ the\ QC\ lab\ acheived\ lower\ resolution\ than\ the\ OR\ lab}{Number\ of\ individuals\ identified\ by\ QC\ lab}$	Sensitivity
Higher taxonomic resolution count error rate	10% of samples in project	$\frac{Number\ of\ FinalIDs\ where\ the\ QC\ lab\ acheived\ lower\ resolution\ than\ the\ OR\ lab}{Number\ of\ FinalIDs\ identified\ by\ QC\ lab}$	Sensitivity

Taxonomy - Internal Quality Control. Samples are re-evaluated by a second practitioner in the lab.

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Recount accuracy	10% of samples	$\frac{Number\ of\ specimens\ in\ smaller\ count}{Number\ of\ specimens\ in\ larger\ count} \geq 95\%$	Precision
Taxa ID error rate	10% of samples in project	$\frac{Number\ of\ misidentified\ FinalIDs}{Number\ of\ FinalIDs} < 10\%$	Accuracy

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Individual ID error rate	10% of samples in project	$\frac{\text{Number of misidentified individuals}}{\text{Number of identified individuals}} < 10\%$	Accuracy
Lower taxonomic resolution individual error rate	10% of samples in project	$\frac{\text{Number of individuals with inadequate resolution}}{\text{Number of individuals adequate resolution}} < 10\%$	Sensitivity
Lower taxonomic resolution count error rate	10% of samples in project	$\frac{\text{Number of FinalIDs with inadequate resolution}}{\text{Number of FinalIDs with adequate resolution}} < 10\%$	Sensitivity

Sample Processing

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Sample integrity and preservation check	10% of samples in a project	Ensure that all sample jars are intact and have no more than 50% (by volume) of sample material. All hydrometer-checked samples must contain a minimum of 70% ethanol.	Representativeness
Subsampling	100% of samples	At least 3 grids analyzed, and up to 100% of sample volume analyzed if required to achieve target number of organisms (n = 600).	Representativeness

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Remnant jar quality control check	100% of samples	Ensure all organisms are removed from remaining material from initial sort. Record any differences from first sorting process. This internal process is used to quantify the picking effectiveness of the laboratory. $\frac{Number\ of\ specimens\ in\ inital\ sort}{Number\ of\ specimens\ after\ second\ sort} \geq 90\%$	Representativeness
Sorting process	Every sample	Separate BMIs to taxonomic Order for later taxonomic identification. Identified BMIs are labeled and placed in a separate vial per taxonomic Order.	Accuracy
Processing efficiency	100% of samples	$\frac{Total\ number\ of\ completely\ sorted\ samples}{Total\ number\ of\ samples} \geq 99\%$	Completeness
Taxonomic identification	100% of samples in a project	100% of all sorted samples are processed.	Completeness

Table 19. Lab MQOs for Algal Taxonomic Analysis

(Definitions: OR = Original lab, QC = Quality Control (external) lab)

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Similarity of diatom composition	10% of samples in project	Bray-Curtis similarity: $\sum min(QC_i, OR_i) \geq 70\%$ Where QC_i is the percent abundance of taxon *i* reported by the QCT, and OR_i is the percent abundance of taxon *i* reported by the ORT.	Precision, accuracy
Similarity of SBA composition	10% of samples in project	Sørensen similarity: $\frac{2 \times N_{COM}}{N_{OR} + N_{QC}} \times 100 \geq 80\%$ Where N_{COM} is the number of taxa common for both taxonomists, N_{OR} is the number of taxa reported by the ORT, and N_{QC} is the number of taxa reported by the QCT. 80% similarity should be achieved individually for each SBA sample type (i.e. qualitative-macroalgae, quantitative – macroalgae, epiphytes, microalgae).	Precision, accuracy
Photomicrograph agreement	SBA quantitative sample epiphytes and top 5 microalgal SBA taxa	At last 80% Sørensen similarity between ORT and QCT algae identifications based on review of the photomicrographs, submitted by ORT.	Accuracy, sensitivity

Lab Quality Control	Frequency of Analysis	Measurement Quality Objective	Purpose
Sampling efficiency	100% of samples in a project	At least 600 diatom valves/300 SBA natural counting entities (NCE) are evaluated. If the sample is very sparse 300 diatom valves/150 SBA NCE are counted allowing 4 hours for sample analysis.	Completeness
Taxonomic Identification	100% of samples in a project	100% of all collected and sorted samples are processed.	Completeness
Sample homogenization	100% of samples in a project	SBA macroalgal clumps are manually extracted from the composite algae sample. Diatoms and SBA quantitative liquid fraction remaining after macroalgae removal are well homogenized prior to processing and analysis of microalgae fraction.	Representativeness

Table 20. Field Quality Control for Bioassessment (PHab, BMI and Algae)

Field Quality Control[1]	Frequency of Analysis	Measurement Quality Objective	Data Quality Indicator or Reasoning
Field Protocol[2]	Every sampling event	All bioassessment studies shall follow standardized field protocols. For SWAMP statewide projects and targeted regional supplemental sites, the most current SOP is required.	Comparability, Accuracy, Precision, and Representativeness
Physical Habitat Measurements[3,4]	Every sampling event	SWAMP bioassessment studies shall include the "Full" suite of physical habitat measurements detailed in the most current SOP.	Completeness, Comparability
Scientific Collecting Permit[5]	Every project	Prior to the onset of field work, a Scientific Collecting Permit (for sampling of stream biota) must be acquired from California Department of Fish and Wildlife for at least one member of the field crew. For a permit to be acquired, College of Water Informatics courses, provided by State Water Board, must be successfully completed. Does not apply to CDFW employees.	Compliance with State Law
Index Period[6]	Every project	All SWAMP-funded bioassessments shall include sampling during the most appropriate index period (i.e., time of year that samples are collected).	Representativeness

Field Quality Control[1]	Frequency of Analysis	Measurement Quality Objective	Data Quality Indicator or Reasoning
Field Duplicates	10% of study sites	Collect field duplicates at a randomly selected set of sites, when both assemblages (BMI and algae) are being sampled together. BMI and algae replicates may be collected at different sites, but it is preferred that they be collected at the same sites.	Precision (includes natural variability for biological samples)
GPS Coordinates	Every site location	Record coordinates at Transect A, before entering stream to sample biota or collect PHab data. For probability sites, the sampling location can be moved up or downstream as much as 300 m from targeted Lat/Long for reasons such as avoiding obstacles or mitigating issues regarding safety or permission access.	Representativeness, Sensitivity, and Accuracy
Sample Completeness	≥90% successful collection at all sites for probabilistic designs	It is expected that 90% of all sites for a project will be sampled. This MQO accounts for adverse weather conditions, safety concerns, and equipment problems.	Completeness

[1] The requirements listed must be met by projects receiving SWAMP funding or wishing to produce SWAMP-comparable data. Refer to Standard Operating Procedures for Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae and Physical Habitat (2016) for more information.
[2] The project coordinator must have the approval of the SWAMP Bioassessment Program Lead Scientist and the SWAMP Quality Assurance Officer before the use of alternative methods that deviate from the SOP. See memorandum in Supplemental Guidance Document for the SWAMP Bioassessment Field Protocol (2016).
[3] Participation in Annual Field Audits of sampling crews is strongly recommended for SWAMP/SWAMP-comparable projects.
[4] Participation in Annual Intercalibration event for field crews is strongly recommended for SWAMP/SWAMP-comparable projects.
[5] All agencies, contractors, and participating laboratories shall maintain records of their training. These records shall be made available upon request from the SBP QAO or SBPM.

[6] SWAMP Lead and Senior Scientists, in association with project coordinators, may deviate from traditional index periods for special studies (e.g., bioassessment of nonperennial streams or evaluation of index periods themselves) or in response to annual climatic fluctuations such as drought.

Corrective Actions

Corrective actions are a necessary response when MQOs are not met. Typical corrective actions are summarized in Tables 21 through 26 and are more thoroughly described in the supporting SOPs listed in Appendix II, especially those for BMI and algae sample processing. Additional or different corrective actions may be determined to be necessary by the SBPM or SBP QAO.

Table 21. Corrective Action: Field Measurements in Fresh and Marine Water.

Field Corrective Action
The field crew 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 shall 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 are entered into the SWAMP database and flagged accordingly. Calibration adjustments will be required of any sensor failing accuracy checks in accordance with the framework established herein.

Table 22. Corrective Action: Conventionals and Nutrients in Fresh and Marine Water.

Laboratory Quality Control	Corrective Action
Calibration Standard	Recalibrate the instrument. Affected samples and associated quality control must be reanalyzed following successful instrument recalibration
Calibration Verification	Reanalyze the calibration verification to confirm the result. If the problem continues, halt analysis and investigate the source of the instrument drift. The analyst should determine if the instrument must be recalibrated before the analysis can continue. All samples not bracketed by acceptable calibration verification must be reanalyzed.
Laboratory Blank	Reanalyze the blank to confirm the result. Investigate the source of contamination. If the source of the contamination is isolated to the sample preparation, the entire batch of samples, along with the new laboratory blanks and associated QC samples, should be prepared and/or re-extracted and analyzed. If the source of contamination is isolated to the analysis procedures, reanalyze the entire batch of samples. If reanalysis is not possible, the associated sample results must be flagged to indicate the potential presence of contamination
Reference Material	Reanalyze the reference material to confirm the result. Compare this to the matrix spike/matrix spike duplicate recovery data. If adverse trends are noted, reprocess all the samples associated with the batch.
Matrix Spike	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike to confirm the result. Review the recovery obtained for the matrix spike duplicate. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery
Matrix Spike Duplicate	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike duplicate to confirm the result. Review the recovery obtained for the matrix spike. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.

Laboratory Quality Control	Corrective Action
Laboratory Duplicate	Reanalyze the duplicate samples to confirm the results. Visually inspect the samples to determine if a high RPD between the results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity.
Internal Standard	Check the response of the internal standards. If the instrument continues to generate poor results, terminate the analytical run and investigate the cause of the instrument drift

Field Quality Control	Recommended Corrective Action
Field Duplicate	Visually inspect the samples to determine if a high RPD between results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity. 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	Investigate the source of contamination. Potential sources of contamination include sampling equipment, protocols, and handling. The laboratory should report evidence of field contamination as soon as possible so corrective actions can be implemented. Samples collected in the presence of field contamination should be flagged.

Table 23. Corrective Action: Solid Parameters in Fresh and Marine Water.

Laboratory Quality Control	Corrective Action
Laboratory Blank	Reanalyze the blank to confirm the result. Investigate the source of contamination. If the source of the contamination is isolated to the sample preparation, the entire batch of samples, along with the new laboratory blanks and associated QC samples, should be prepared and/or re-extracted and analyzed. If the source of contamination is isolated to the analysis procedures, reanalyze the entire batch of samples. If reanalysis is not possible, the associated sample results must be flagged to indicate the potential presence of the contamination.
Laboratory Duplicate	Reanalyze the duplicate samples to confirm the results. Visually inspect the samples to determine if a high RPD between the results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity.
Field Quality Control	Corrective Action
Field Duplicate	Visually inspect the samples to determine if a high RPD between results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Equipment Blank	Investigate the source of contamination. Potential sources of contamination include sampling equipment, protocols, and handling. The laboratory should report evidence of field contamination as soon as possible so corrective actions can be implemented. Samples collected in the presence of field contamination should be flagged.

Table 24. Laboratory Quality Control Corrective Actions for Algae Analysis (Diatom and Soft-bodied algae).

Lab Quality Control	Corrective Action
Diatom Quantitative Sample Integrity Check	If sample is not preserved in formalin prior to receipt, it must be noted in the COC and the sample should be fixed immediately upon receipt. If the integrity of the sample upon receipt is in question, the taxonomist must inspect the sample to determine the extent of sample degradation and document these findings on the COC, and in comments section of AA taxa form. Results must be flagged if the hold time is missed. If a vial is cracked or leaking it must be transferred to a new vial according to the procedures outlined in Section 2.2.4 of Stancheva et al., 2015. If the sample is field-preserved but has a total volume less than 50 mL (40 mL sample and 10 mL formalin preservative), results must be flagged to indicate the reduced total sample volume.
Taxonomic Nomenclature	If taxonomic nomenclature is different from that in the SWAMP Master list, taxa names must undergo external taxonomic harmonization in order to be submitted as new records to the SWAMP Master List.
Photographic Documentation of Algae	If photomicrographs are absent for newly recorded species, the vouchered samples should be re-examined and photographs taken of the species in question by the taxonomist that recorded said species. If the quality standards are not met for the photomicrographs, multiple images should be collected until satisfactory image quality is achieved.
Standard Taxonomic Effort (STE)	The STE provides guidance on the assignment of taxonomic identity for ambiguous taxa. This guidance includes the aggregation to genus level for morphospecies of certain routinely problematic genera.
External Taxonomic Harmonization (for SWAMP projects)	Taxonomic identification of new records for SWAMP Master Lists should be approved by harmonizing taxonomist. The discussion between the OR taxonomist and the harmonizing taxonomist should continue until identification is settled. ● If additional photomicrographs need to be taken for newly recorded species, key aspects of vegetative and reproductive morphology should be documented and provided to harmonizing taxonomist. ● Voucher specimens should be sent upon request if photomicrographs are insufficient.
Internal taxonomic QC	Taxonomic disagreement between both taxonomists should be resolved and SBA and diatom taxonomy and enumeration should be corrected as needed in all project samples affected. For instance, if a name is confirmed to be systematically misapplied, all the samples from the project should be revisited, and the name should be corrected by the ORT and verified by the QCT. This step should be done internally before reporting the results, which improves the quality of the data.
Soft-bodied algae quantitative sample processing -	If macroalgae or other solid particles are observed in any of the original 50 mL centrifuge tubes checked by QCT after macroalgae processing, all samples from the project should be reexamined for

Lab Quality Control	Corrective Action
Macroalgal fraction separation check	potentially omitted macroalgae. All remaining macroalgae should be added to the tube with the macroalgal fraction, and the total volume of macroalgae should be corrected accordingly.
External taxonomic QC	All samples that fail the MQO thresholds must undergo taxonomy reconciliation. The reconciliation process is conducted by the QCT in dispute with the ORT. All problematic taxa listed in SBA/Diatom QC Summary Tab in SBA/Diatom QC Submittal Data Template should be resolved for all QC samples to pass the MQO thresholds. Discrepancies are clarified by comparing the photomicrographs of questionable taxa with existing literature and established SWAMP photomicrograph records available in the California Online Algae Identification Resource Tools website. Additional algal material from the same sample may be examined to correct identifications. In case the MQO failures are due to misidentifications by ORT of common and abundant taxa based on feedback from the QCT, the project coordinator should choose corrective action, consisting of additional external QC of 10% of samples, when the data for a certain project are finally generated by ORT. However, this corrective action is possible for quantitative diatom and SBA samples, but not for qualitative SBA samples. The project coordinator selects another random 10% of samples to submit for a second round of QC. Samples that underwent QC in Round 1 should not be selected for Round 2 and subsequent rounds. If an additional round of QC is needed, all steps in the process are performed again, including submittal of an Excel Algae QC Submittal Data Template with data from the second set of samples, except that round would equal 2. The process continues until the OR lab, QC lab and project coordinator agree the data meet QC requirements, discrepancies have been resolved and data are finalized. Enforcement of corrective actions is the responsibility of the project coordinator, not the QC lab.

Table 25. Laboratory Quality Control Corrective Actions for Benthic Macroinvertebrates Analysis.

Sample Processing

Lab Quality Control	Recommended Corrective Action
Sample integrity and preservation check	If samples are found to not meet the minimum concentration of ethanol, then the entire batch must be checked. Any sample not meeting the requirement must have fresh preservative placed in the container immediately, and any associated data must be flagged by the laboratory. Project coordinator and field crew must be notified about inadequate preservation.
Subsampling	Corrective action for this MQO is to retrain and supervise pickers.
Remnant jar quality control check	Corrective action for this MQO is to increase training and supervision of sorter according to lab protocol, and to continue sorting residue until the MQO is achieved (that is, ≤10% of the total number organisms are discovered in the sorted residue). Because 100% of samples are subjected to these MQOs, data do not need to be qualified.
Sorting process	Corrective action for this MQO is to retrain and supervise pickers.
Processing efficiency	Corrective action for this MQO is to locate missing samples and document failures.
Taxonomic identification	Corrective action for this MQO is to locate missing samples and document failures.

Taxonomy

Lab Quality Control	Recommended Corrective Action
Standard taxonomic effort	The Standard Taxonomic Effort for BMIs will be reviewed and updated as needed based on discovery of new taxa, published taxonomic revisions that result in nomenclatural changes, workshops that provide better understanding of existing taxonomic keys, etc. Typically, these changes and updates are presented and discussed at the annual meeting of SAFIT.
Taxonomic identification and enumeration (internal and external QC)	Corrective action for these MQOs is to train and supervise taxonomists, and to update data for analysis based on the following process: In the case of MQO failures, the OR taxonomist goes back through all original samples from a given project and corrects identifications as necessary based on feedback from the QC taxonomist. The project coordinator then randomly selects another 10% of samples to submit for a second round of QC. Samples

Lab Quality Control	Recommended Corrective Action
	that underwent QC in Round 1 should not be selected for Round 2 and subsequent rounds. If an additional round of QC is needed, all steps in the process are performed again, including submittal of an Excel "BMI QC Submittal Data Template" with data from the second set of samples, except that Round would equal 2. Additional lots shall be submitted by the OR lab until a lot passes quality assurance checks or until all samples have been submitted to a QC lab for quality assurance checks. Enforcement of corrective actions is the responsibility of the project coordinator, not the QC lab. If the original lab disputes the QC lab identification, specimens can be sent to a third lab for verification at the discretion of the project coordinator.

Table 26. Field Quality Control Corrective Actions for Bioassessment (PHab, BMI and Algae).

Field Quality Control	Corrective Action
Field Protocol	If a site has been sampled that modifies the SOP (e.g., skips dry transects, shortens transects) a comment shall be entered in the comments section of the database. If a site is sampled where flow is too low to measure, a comment shall be entered in the comments section of the database. Data from sampling events that stray too far from protocols may be entirely excluded from data submission and analysis at the discretion of the SBPM.
Physical Habitat Measurements	Field crews shall, where practical, revisit sites to execute missing or erroneously measured portions of the protocol.
Index Period	If a site is sampled within 4 weeks of a storm event (sufficient to cause bed scour), or if there is evidence of recent scour, a comment shall be entered.
Field Duplicates	If sampling for the project is not yet complete, field crews shall collect duplicate samples at the next opportunity. If sampling is complete, field crews may, where practical, revisit sites to collect a duplicate.
GPS coordinates	If a site is sampled more than ~ 300 m from target coordinates, a comment shall be entered in the geometry entry table in the database. At the discretion of the SBPM, a new or alternative station name and code may be generated.
Sample Completeness	If practical, field crews shall sample additional sites.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Laboratory instruments are inspected and maintained in accordance with laboratory SOPs, which include those specified by the manufacturer and those specified by the method. These SOPs have been reviewed by each respective Laboratory QAO and found to be in compliance with SWAMP criteria. Analysts are responsible for equipment testing, inspection, and maintenance.

The manufacturer's instructions for the laboratory equipment used in the SBP will be followed as a minimum requirement. The results of equipment tests, inspections, maintenance, and repairs will be documented in the appropriate logbook. If an instrument fails to meet the accuracy and/or precision criteria after maintenance has been performed, the manufacturer will be contacted.

B.7 Instrument/ Equipment Calibration and Frequency

Laboratory instruments are calibrated, standardized, and maintained according to the analytical method and the manufacturer's specifications. Analytical instruments that fail to meet performance requirements will be checked according to their respective SOP and recalibrated. If the instrument still does not meet specifications, it will be repaired and retested until performance criteria are achieved. In addition, all maintenance activities will be recorded into the instrument's log. If sample analytical information is in question due to instrument performance, the SBPM will be contacted regarding the proper course of action.

At a minimum, all calibration procedures will meet the requirements specified in the US EPA-approved methods of analysis. The means and frequency of calibration recommended by the manufacturer of the equipment or devices, as well as any instruction given specifically for an analytical method, will be followed. When such information is not specified by the method, instrument calibration will be performed at least once daily, and continuing calibration will be performed on a 10% basis thereafter (with the exception of analysis by GC/MS). It is also required that records of calibration be kept by the person performing the calibration and be accessible for verification during either a laboratory or field audit. At the request of the Water Boards Contract Manager or SWAMP QAO, the SBPM will permit observation of inspection of equipment and including calibration logs.

B.8: Inspection/Acceptance of Supplies and Consumables

All supplies will be examined for damage as they are received. Laboratory personnel will review all supplies as they arrive to ensure the shipment is complete and intact. All chemicals are logged into the appropriate logbook and dated upon receipt. All supplies are stored appropriately and are discarded upon expiration date. If items are not found to be in compliance with accuracy, precision, and contamination criteria, they will be returned to the manufacturer.

B.9: Non-direct Measurements

Data will not be used from non-direct measures in this study.

B.10 Data Management

Field Data Entry

Field data is either entered from paper forms to templates or a database entry shell or directly from digital field forms to a database entry shell (preferred). Field crews complete submission through the SWAMP Online Data Checker, or via database entry shell submission through the SWAMP FTP site. Applicable sample and/or collection comments will be included when conditions exist that may affect analytical results, or when a collection that was expected to be completed is not completed (due to site or collection conditions). Chain of Custody forms are completed for all samples collected. A copy of the COC is forwarded to the analyzing laboratory in advance of sample receipt. An electronic copy of the COC will be provided to the Water Boards Contract Manager and SWAMP IQ within 10 business days of submission of samples to the laboratory. SWAMP AA forms will also accompany samples sent to each laboratory (Appendix VII). Original copies of the field sheets, calibrations logs, lab logs, and data generated for PSA/RCMP will be stored by the SBPM for 10 years.

The field crews will complete the entry of field records and will submit the EDD to the SWAMP IQ within the following timeframes:

i. Conventional Water/Sediment/Toxicity Collection Only: twenty (20) business days following a site visit.
ii. Collections with Bioassessment Physical Habitat: forty (40) business days following the end of the field season.

Should the field crews require more time to enter data for a site visit, they will request a deadline extension from the Water Boards Contract Manager.

Laboratory LIMS, Data Entry

Laboratory data will be entered in the applicable SWAMP template by laboratory staff and submitted to SWAMP's Online Data Checker to ensure compliance with formatting and business rules. Upon approval, the data template will then be submitted via email to the OIMA Helpdesk inbox for the SWAMP IQ Data Managers to verify.

When all data results are entered for the project, the data are verified, put through completeness checks, and loaded to the database. Once finalized data is loaded to the SWAMP database, it is then transferred to the California Environmental Data Exchange Network (CEDEN).

C. ASSESSMENTS

C.1 Assessments and Response Actions

Project Kickoff (Readiness Review)

At least one month prior to the start of each sampling season, the SBPM will arrange a teleconference or web conference with the laboratory Quality Assurance Officers from each of the participating laboratories, applicable SWAMP IQ Data Managers, project coordinators, field crews, and the Water Boards Contract Manager. These meetings will facilitate coordination of project planning and logistics, and should address the following: project field sampling methodology, field sheets, COC forms, AA Forms, sample collection timing, sample handling (shipping), QA/QC procedures, laboratory analysis, holding times, laboratory turnaround times, and any other topics required to ensure success of the project.

Real-Time Data Audits

Data will be reviewed by each Laboratory QAO prior to submission of each batch to the SBPM or SWAMP IQ. Field crew audits will be conducted once per sampling season, and a review of sampling procedures will be made by the Field Coordinator and the SBPM should problems arise. As SOPs are updated and refined, additional reviews will be made. Each laboratory data technician is responsible for flagging data that does not meet established QA/QC criteria.

If a reviewer discovers any discrepancy, the Laboratory QAO will discuss it with the personnel responsible for the activity. The discussion will include the accuracy of the information, potential factors leading to the deviation, how the deviation might impact data quality, and the corrective actions that might be considered. If the discrepancy is not resolved, the Laboratory QAO will issue a stop work order until the problem is fixed.

Assessments by the Laboratory QAO will be oral; if no discrepancies are noted and corrective action is not required, additional records will not be required. If discrepancies are observed, the details of the discrepancy and any corrective action will be reported.

Field Procedures

The Field Coordinator will conduct field procedure audits to ensure adherence to the SOPs, field health and safety requirements, and sample handling and custody procedures.

Lab Procedures

The Water Chemistry Laboratory Director or QA Officer will conduct laboratory systems audits per the Laboratory Quality Management Plan.

Deviations and Corrective Actions

Analyses are conducted according to procedures and conditions recommended by the US EPA, and described in laboratory SOPs, with the exception of those reported herein. Beyond those identified, deviations from these recommended conditions are reported to the Laboratory QAO. The SBPM and SBP QAO will also be notified within 48 hours of a deviation.

In the event of an SOP/QAPP deviation or corrective action, a Corrective and Preventative Action Report will be prepared, completed, and signed, and the SBPM and SBP QAO will both be notified. Best professional judgment will be used in interpretation of results obtained when deviations in the test conditions have occurred. All deviations and associated interpretations will be reported in interim and final reports. Protocol amendments will be submitted to the Laboratory QAO, SBP QAO, and SBPM. Upon approval, protocol amendments will be employed.

Data Quality Assessment

A data quality assessment is conducted at the end of each sampling season and includes the following:

- Initial review of analytical and field data for complete and accurate documentation, COC procedures, compliance with analytical holding times, and required frequency of laboratory QA samples;
- Review of data verification results;
- Reconciliation with corrective actions; and
- Discussion of any remaining issues and potential improvements for the following sampling season.

A summary of the data quality assessment will be developed and included with the final project report.

C.2: Reports to Management

Corrective and Preventative Action Reports (CPAR)

Analyses are conducted according to procedures and conditions recommended by the US EPA, and described in laboratory SOPs, with the exception of those reported herein. Beyond those identified, deviations from these recommended conditions are reported to the Laboratory QAO. The SBPM and SBP QAO will also be notified of a deviation. In the event of an SOP/QAPP deviation or corrective action, a Corrective and Preventative Action Report will be prepared, completed, and signed, and the SBPM and SBP QAO will both be notified. Best professional judgment will be used in interpretation of results obtained when deviations in the test conditions have occurred. All deviations and associated interpretations will be reported in interim and final reports. Protocol

amendments will be submitted to the Laboratory QAO, SBP QAO, and SBPM. Upon approval, protocol amendments will be employed.

Trend and Status Reports

Under the guidance of the SWAMP Coordinator, the Lead Scientists shall prepare reports summarizing data from the SBP to characterize status or trends in condition. These reports may be written technical reports, memos, journal articles, or oral reports delivered through SWAMP's bioassessment workgroup.

D. REVIEW, EVALUATION OF USABILITY AND REPORTING REQUIREMENTS

D.1 Data Review, Verification and Validation Requirements

All data reported for PSA/RCMP will be checked for errors in transcription, calculation, and computer input by the Laboratory Director, Sample Manager, and/or Laboratory QAO. Additionally, the Laboratory QAO will review sample logs and data forms to ensure that requirements for sample preservation, sample integrity, data quality assessments, and equipment calibration have been met. Data that do not meet these requirements will either not be reported or will be reported with qualifiers that serve as an explanation of any necessary considerations.

All raw and statistically analyzed data are subject to a 100% check for accuracy by the SBPM, Laboratory QA Officers, and SWAMP IQ. Data are reviewed for accuracy and checked against the QAPP and applicable MQOs before being uploaded into the SWAMP database. See section D.1 for more information.

D.2 Verification and Validation Methods

Field Data

Field data are submitted electronically to the SWAMP database through data entry shells. If data were recorded on paper forms, field crews will check the entered data for typos and errors. Field data is loaded to the SWAMP database and verified by SWAMP IQ staff to ensure proper flagging for equipment failures and impossible values. Discrepancies in flagged data, noted during the data verification process, will be communicated to the Field Crews, SBP QAO, Laboratory QAO, and SBPM prior to finalizing records.

Every year (by December 31), CRAM data will be re-evaluated to ensure consistency with data in the SWAMP database (with respect to station and project codes).

Laboratory Data

Laboratory data will be sent electronically to SWAMP IQ for verification and inclusion in the SWAMP database. SWAMP IQ Data Managers will follow the applicable Data Management Plans for verification of data. Discrepancies in flagged data, noted during the data verification process, will be communicated to the SBP QAO, Laboratory QAO, and SBPM prior to loading and finalizing records.

Data are entered using SWAMP Business Rules for data reporting and formatting. The laboratory staff will review 100% of the laboratory data entry records against the original bench sheets (if used) to detect and correct typographical errors, as well as confirm that all records have been entered. If a LIMS is used, laboratory staff will verify 10% of the electronic data reports to ensure accuracy and completeness. If errors are detected during the 10% check, then 100% verification is required since the last successful verification check was completed. The laboratory data verifier will also ensure that the correct result qualifier and QA codes are applied to the results, where applicable.

Laboratory staff will include and appropriately report the applicable quality control samples required per batch or per project to establish and verify compliance with the applicable MQOs. Lab staff will evaluate the results of the quality control samples and apply appropriate qualifications to results that do not meet the applicable MQOs and will apply qualifications to the records following the SWAMP formatting business rules. Laboratory staff will ensure result and/or batch comments include any applicable information about the result.

Prior to submittal of a Laboratory Data Template to SWAMP IQ, data will be run through the SWAMP Data Checker. The data checker is an online tool that checks for lookup list values and adherence to SWAMP database business rules. Format issues that are found by the checker must be corrected prior to submission.

D.3 Reconciliation with User Requirements

Bioassessment data is collected yearly for the PSA and RCMP programs. When a reach is visited, BMI, algae (soft-bodied, diatoms), chemistry, and PHab data are collected and recorded. The BMI samples are sent to a laboratory where identifications and enumerations take place according to SAFIT STE rules. CSCI scores are calculated from the raw data that is provided. Algae samples are also sent to a laboratory where identifications and enumerations take place. If organisms are identified that are new to the SWAMP Master List of algae IDs, those organisms must undergo a process called harmonization prior to being added to the Master List. ASCI calculations are used to provide a score for algae (in southern California) similar to CSCI.

Reconciliation with the DQOs involves reviewing the data to determine whether the DQOs have been attained and that the data are adequate for their intended use. For SWAMP, both the existing MQOs and data need to be reconciled with the programmatic intended data uses. At the project level, reconciliation occurs during the Data Quality Assessment. Data quality assessment is the process of using the results of the verification and validation steps in conjunction with any other information known about the data collection to determine overall data usability (EPA R9QA/03.2). Data assessment in SWAMP will be performed by the SBPM, Lead Scientist, or designated project staff.

The reconciliation process for BMI and algae is conducted by the QC taxonomist in dispute with the OR lab. For each sample, the type of error for incorrect identification and enumeration should be evaluated. Differences between the two taxonomists should be

resolved by comparing to the best available literature or online resources and verified using vouchered representative specimens with confirmed identifications.

For BMI, when an MQO has failed, a reconciliation between the QC laboratory and OR laboratory will take place. Data reconciliation is done for each algal QC sample.

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APPENDICES

Appendix I: Glossary and Acronyms

Acronym/Term	Description
AA	Analysis Authorization form
ASCI	Algal Stream Condition Indices
BMI	Benthic Macroinvertebrate
CDFW	California Department of Fish and Wildlife
CDFW-ABL	CDFW Aquatic Bioassessment Laboratory
CSUSM	CSU, San Marcos
CSUCRF	CSU, Chico Research Foundation
COC	Chain of Custody
CPAR	Corrective and Preventative Action Report
CRAM	California Rapid Assessment Method
EMAP	Environmental Monitoring and Assessment Program
NA	Not applicable
NARS	National Aquatic Resources Survey
NRSA	National Rivers and Streams Assessment
OIMA	Office of Information Management and Analysis
OR	Original Lab
ORT	Original Taxonomist
PPE	Personal Protective Equipment
PHab	Physical Habitat
PSA	Perennial Streams Assessment
QAPP	Quality Assurance Project Plan
QC	Quality Control or Quality Control Lab
QCT	Quality Control Taxonomist
RCMP	Reference Condition Management Program
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SBA	Soft Bodied Algae
SBP	SWAMP Bioassessment Program
SBPAM	SWAMP Bioassessment Program Administrative Manager
SBPM	SWAMP Bioassessment Program Manager
SOP	Standard Operating Procedure
SMC	Stormwater Monitoring Coalition
STE	Standard Taxonomic Effort
SWAMP	Surface Water Ambient Monitoring Program
SWAMP IQ	SWAMP Information Management and Quality Assurance Unit

Appendix II: List of Associated Field and Laboratory SOPs

California Rapid Assessment Method (CRAM) for Wetlands, Riverine Wetlands Field Book ver.6.1 January 2013.

California Rapid Assessment Method (CRAM)_Riverine datasheet_v.6.1.pdf

Delta Environmental Laboratories Quality Assurance Program Manual Rev#12. 2018
Environmental Laboratory Accreditation Program (ELAP) Certification Number 1857.

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The following chemistry SOPs are available upon request

Chlorophyll *a* - Method 62018
Ammonia (NH3)-Method SM 4500-NH3 D
Nitrite- Method SM 4500 NO2- B
Acid Digestion and ICP Measurements of Waters for Silica Determination- Method EPA 200.7
Total Nitrogen- Method SM 4500 N
Total Phosphate, Ortho, Phosphorus (Colorimetric, ascorbic Acid, Two Reagent)- Method EPA 365.3 (1978)
Total Suspended Solids (TSS)- Method SM 2540 D
Total Dissolved Solids (TDS)- Method SM 2540 D

Appendix III: List of Supplies

This list of supplies was copied from The Supplemental Guidance Document for the SWAMP Bioassessment Field Protocol. (Ode et al., 2016)
The first column indicates what task(s) in the SOP the item is needed for: "G" = general; "W" = water quality measurements; "P" = PHab data collection; "B" = BMI sampling; "D" = diatom sampling; "S" = soft-bodied algae sampling; "C" = chlorophyll *a* sampling; "A" = AFDM sampling

List of Supplies

Needed for:	Item	Quantity / Site	Specifications, Comments
G	Sampling SOP (this document)	1/person	
G	Equipment decontamination supplies		See Guidance Document
G	Hip or chest waders, or wading boots/shoes (not felt-soled)	at least 1 pair/person	
G	Full set of datasheets printed on waterproof paper (e.g., Rite-in-the-Rain™)	1 full set (and spare set recommended)	
G	Fine-tipped and thick-tipped waterproof/alcohol-proof pens and markers	2 to 3, each	
G	Pencils	2 to 3, each	
G	Clipboard	2 to 3	

Needed for:	Item	Quantity / Site	Specifications, Comments
G	Site dossier containing site maps, aerials, etc.	1	Add a 150-m scale line to aerials adjacent to stream
G	Thomas Guide, regional maps, topographic maps	as needed	
G	First aid kit	1	
W	Centigrade thermometer	1	
W	pH meter	1	
W	DO meter and spare membrane	1	
W	Conductivity meter	1	
W	Turbidimeter and vial(s) (optional)	1	
W	Field alkalinity meter or test kit (e.g., Hach)	1	
W	Water chemistry containers	as needed	
W	Calibration standards	1 set	
W	Spare batteries, user's manuals, and spare parts for meters	as needed	
P	Digital camera & spare batteries	1	
P	GPS receiver & spare batteries	1	
P	Measuring tape; 150 m	1	

Needed for:	Item	Quantity / Site	Specifications, Comments
P	Lengths of rope (7.5 m and 12.5 m)	1 each	For measuring distance between main and inter-transects in delineating the monitoring reach
P	Digital watch/stopwatch & spare batteries	1	For timing duration of float for NBO stream velocity measure; also can be used to generate random number for selecting locations to place net for TRC sampling
P	10-sided die or random number table (if no digital watch available)	1	For selecting locations to place net for TRC sampling
P	Stadia rod	1	
P	Marked ski pole (or waterproof meter stick)	1	Mark pole with cm graduations to measure water depth during pebble count
P	Clinometer	1	
P	Autolevel and tripod	1	Required for slopes <1%

Needed for:	Item	Quantity / Site	Specifications, Comments
P	Hand level (optional)	1	
P	Current velocity meter & top-setting rod	1	Examples: Swoffer Instruments propeller-type flow meter; Marsh-McBirney inductive probe flow meter; check battery and calibration as needed
P	Flagging tape	1 strip	To determine direction of stream flow for proper angling of the current velocity meter probe
P	Convex spherical densiometer	1	Taped to expose only 17 intersections of the grid
P	Transect flags; or large, heavy washers each tied with a strip of flagging tape	21 total	Two colors; label with main transect (11 ct.) and inter-transect (10 ct.) names
P	Small/slender rod with 1, 5, and 20 mm marks	1	For measuring microalgal thickness
P	Rangefinder & spare batteries	1	

Needed for:	Item	Quantity / Site	Specifications, Comments
P	Fresh orange peel OR plastic film canister partially full of water OR ice cube	1	Use as neutrally buoyant object
P	Small metric ruler or gravelometer for substrate measurements	1	See Guidance Document
P, S	Algae viewing bucket (optional)	1	
B	D-frame kick net (fitted with 500-µm mesh bag)	1	
B	Standard #35 sieve (500- µm mesh)	1	
B	Wide mouth 500-mL or 1000-mL plastic jars	several	
B	White sorting pan (enamel or plastic; optional)	1	
B	95% EtOH	1 gallon	
B	Fine-tipped forceps or soft forceps	1	
B	Waterproof paper and tape for attaching labels	as needed	
B	Large spill tray	1	Used when transferring the BMIs from the D-frame net to the sample jar in order to avoid any

Needed for:	Item	Quantity / Site	Specifications, Comments
			loss of sample material
B	Preprinted waterproof labels (e.g., on Rite-in-the-Rain™ paper)	as needed	It is recommended that the label be printed on a laser printer using alcohol-proof ink
B	Disposable gloves/elbow length insulated gloves		
D, S, C, A	White dish tub, rectangular, plastic, 11.5 qt, OR white plastic 5-gallon bucket with lid, 5L	1	Must be white, to avoid potential interference of pigmented shards from the tub or bucket in the chlorophyll *a* analysis
D, S, C, A	Scrubbing brush or scouring pad to clean dish tub or bucket, etc.	1	
D, S, C, A	Composite sample receiving bottle (wide-mouth HDPE jar with cap, 1 L)	1	Fisher 05-719-239
D, S, C, A	Graduated cylinder, 1L, 500 mL, 100 mL, and 25 mL, plastic	1 each	e.g., Fisher 03-007-42 & 03-007-39
D, S, C, A	Bottle brush to clean graduated cylinders, etc.	1 sm, 1 lg	

Needed for:	Item	Quantity / Site	Specifications, Comments
D, S, C, A	PVC delimiter, 12.6 cm^2 area	1	
D, S, C, A	Masonry trowel (flat, pointed, with a surface area > 12.6 cm^2)	1	
D, S, C, A	Rubber delimiter, 12.6 cm^2 area	1	
D, S, C, A	Toothbrush, firm-bristled	1	
D, S, C, A	Syringe scrubber, 60 mL syringe, 5.3 cm^2 area	1	
D, S, C, A	White (non-pigmented) scrubbing-pad circles	11 per replicate	
D, S, C, A	Tally meter (optional)	1	Ben Meadows 9JB-102385
D, S, C, A	Scissors	1	
D, S, C, A	Wash bottles	2	Label bottles with “stream water”, and “DI water”
D, S, C, A	Exacto™ or Swiss-army-style knife	1	
D, S, C, A	Sample labels (printed on waterproof paper)	4 per replicate	

Needed for:	Item	Quantity / Site	Specifications, Comments
D, S, C, A	Clear plastic tape, 5 cm wide	Length of ~20 cm per replicate	
D, S, C, A	Ice chest with wet ice	1 (2 preferred if multiple sites to be sampled)	
D, S, C, A	Fisherman's vest (optional)	1	
D, S, C, A	Tarp, plastic, clean	1	To cover the ground at the algae processing station
D, C, A	Wide-mouthed measuring cup with a broad pouring spout	1	For pouring homogenate sample into the diatom sample vial, and for preparation of biomass filters
D, S	Centrifuge tubes, 50 mL, plastic	2 per replicate	Cole Parmer 06344-27
D, S	Rack for 50 mL centrifuge tubes	1	
D	5% formalin solution	10 mL per replicate	
D	Formalin-resistant gloves	1 pair	
D	Safety goggles or face shield	1	
D	Small syringe or bulb pipette	1	

Needed for:	Item	Quantity / Site	Specifications, Comments
D	Vermiculite packing material	as needed	
S	Turkey baster	1	
S (see note)	20% glutaraldehyde solution (to be dispensed by trained individual using a laboratory fume hood, and wearing appropriate safety gear)	5 mL per replicate	Note: glutaraldehyde could be added by taxonomy lab, with prior notification
S	Calculator	1	
S	Small metric ruler (waterproof)	1	
S	Small Ziploc bag	1	
S, C, A	Whirl-Pak™ bag, 100 mL	3 per replicate	Cole Parmer 06498-00
S, C	Umbrella	1	To shade processing station when shade is not available at site
C, A	Filter forceps	1	Fisher 0975350
C, A	Pointed forceps	1	Fisher 08-900
C, A	Filtering chamber/tower, 47 mm, plastic	1	Hach 2254400
C, A	Hand vacuum pump	1	Fisher 13-874-612B
C, A	Deionized water	500 mL	

Needed for:	Item	Quantity / Site	Specifications, Comments
C, A	Dry ice (if not returning to lab immediately following the day's fieldwork)	10 lbs	
C, A	Snapping Petri dish, 47 mm	2 per replicate	Fisher 08-757-105
C	Glass fiber filter, 47 mm, 0.7 µm pore size	1 per replicate	Fisher 09804142H
C	Aluminum foil	~100 cm^2 per replicate	
A	Glass fiber filter, 47 mm, 0.7 µm pore size; pre-combusted	1 per replicate	Check with analytical laboratory ahead of time; they should be able to supply these

Appendix IV: Labeling

Algae Samples

Double bag the qualitative samples and slip a filled-out (with pencil) label printed on waterproof paper into the outer bag (see below). Store in the cooler on wet ice (not dry ice). Be careful not to place the bags right up against ice (or 'blue-ice" packs), because this could cause the algae to freeze and thus destroy the sample. Unlike with the quantitative samples, do not add glutaraldehyde (or any other fixative) to these qualitative samples.

Contract/ Billing Code: _____ **qualitative (soft)**
Project: _____ Date: _____ Time:_____
Site Code: _____Sample ID: _____
Bag # _____ of _____
Site Name: _____
NO FIXATIVE *IS ADDED TO THE QUALITATIVE*
Stream Name: _____
County: _____ Collector: _____

Figure 6 Label for soft-bodied algae qualitative sample

Recorded on each sample label are the volume of the composite sample (see below), as well as the volume aliquoted (for the taxonomic ID samples) or filtered (for the chl *a* and AFDM samples). All of these volumes are recorded on the field forms, as well, under the "Algae Samples" section. On the sample labels, the sample type: "chl *a*", "AFDM", "diatoms", or "soft" is circled, and all the remaining information on each label (Station Code, Date, stream name, etc.) is filled out.

Contract/ Billing Code: _____ circle one: **diatoms soft**
Project: _____ Date: _____ Time:_____
Site Code: _____Sample ID: _____
Repl #: _____ Vol Aliquotted (mL): _____
Composite Vol (mL): _____
Delimiter Grabs (Rub.+ABS): ☐ # Syringe: ☐
Fixative Added (*buffered?*): _____
Stream Name: _____
County: _____ Collector: _____
Sampling method (circle one): **RWB / MCM**

Contract/ Billing Code: _____ circle one: **chl *a* AFDM**
Project: _____ Date: _____ Time:_____
Site Code: _____Sample ID: _____
Repl #: _____ Vol Filtered (mL): _____
Composite Vol (mL): _____
Delimiter Grabs (Rub.+ ABS): ☐ # Syringe: ☐
Stream Name: _____
County: _____ Collector: _____
Sampling method (circle one): **RWB / MCM**

Figure 7 Labels for algae quantitative taxonomic identification (left) and biomass samples (right).

Benthic Macroinvertebrate Samples

Place a completed date/locality label on the inside of the jar (use pencil, only, as most "permanent" inks dissolve in ethanol) and completely fill with 95% ethanol.
Place a second waterproof label on the outside of the jar. It is recommended that the label for the outside of the jar be printed with a laser printer (with alcohol-proof toner); otherwise, fill the label out by hand in pencil. Tape the label with a transparent tape strip. Make sure all samples have both internal and external labels. (Ode et al., 2016)

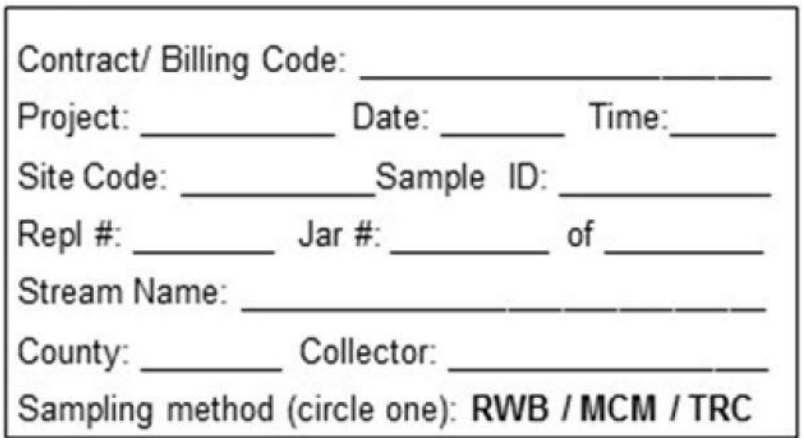

Figure 8 Date/ Locality label for BMI samples

Appendix V: SWAMP Chain of Custody Forms

Delta Environmental Lab Chain of Custody Forms

(https://sites.google.com/site/swampwikihomepage/project-lead-tool-kit)

Appendix VI: Bioassessment Field Sheet

SWAMP Field Sheet - Stream Habitat Characterization Form

(https://drive.google.com/file/d/0B40pxPC5g-D0RDVxQlJsQlU0cnM/view)

Appendix VII: SWAMP Analysis of Authorization (AA) forms

Algae Reporting (AA) form

(https://drive.google.com/file/d/0B40pxPC5g-D0X2Y0OC1FYWRpYm8/view)

Appendix VIII: Corrective and Preventative Action Report (CPAR) Template

Date:

Reporting Party:

Involved Party:

Subject:

Project:

Matrix:

Analysis:

Problem Type:

Problem Description:

Proposed Corrective Action:

Impact on Data:

Sample Results:

Follow Up:

FOR INTERNAL USE:	
Resolution Date:	
SWAMP Quality Assurance Officer (QAO) name:	
SWAMP QAO Signature:	Date:
Water Boards Contract Manager:	Date:
Water Boards Contract#	