Delta Regional Monitoring Program

Quality Assurance Project Plan

for Fiscal Year 2019–2020 Monitoring

Version 5
August 29, 2019

Prepared by
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1. Title and Approval

For

PROJECT NAME: Delta Regional Monitoring Program, Fiscal Year 2019-2020

Date: August 29, 2019

NAME OF RESPONSIBLE ORGANIZATION: San Francisco Estuary Institute – Aquatic Science Center (SFEI-ASC)

1.1 Approval Signatures

Signatures on file

Title:	Name:	Signature:	Signature Date:
SFEI-ASC Program Manager / Contract Manager	Matthew Heberger		
SFEI-ASC QA Officer	Don Yee		
SFEI-ASC Data Manager	Amy Franz		
Assistant Deputy Director SWRCB Office of Information Management and Analysis	Melissa Morris		
SWAMP QA Officer	Tessa Fojut		
MPSL Project Manager	Wes Heim		
SRiNCS Principal Investigator	Lisa Thompson		
MPSL QA Officer	Autumn Bonnema		
USGS Project Chief (pesticides)	Jim Orlando		
Delta RMP Steering Committee co-Chair	Adam Laputz		
Delta RMP Steering Committee co-Chair	Debbie Webster		

2. Table of Contents

Appendices

2.1 List of Tables

Links are to online tables in Google docs. Tables are also attached at the end of the PDF version of this document.

2.2. List of Figures

2.3 Acronyms and Abbreviations

Acronyms and abbreviations used in this document are listed in Table 2.1.

3. Distribution List

The organizations and persons listed in Table 3.1 will receive a copy of the approved Quality Assurance Project Plan (QAPP) and any subsequent revisions.

In addition, copies of the QAPP will be posted on the Delta Regional Monitoring Program (Delta RMP) website and made publicly available via the internet at http://sfei.org/DeltaRMP/.

Previous versions of this document, covering monitoring conducted from 2014 - 2019, can be found on the project website, http://sfei.org/DeltaRMP/.

4. Project Task/Organization

This Quality Assurance Project Plan (QAPP) has been prepared for the monitoring of surface water quality in the Sacramento-San Joaquin River Delta (the Delta) by the Delta Regional Monitoring Program (Delta RMP). This section of the QA Project Plan describes how the project will be managed, organized and implemented.

The responsible agency for this surface water monitoring program is the San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC), acting as the fiscal agent and implementing entity to the Delta RMP. The program is managed by a Steering Committee and advised by a Technical Advisory Committee. SFEI-ASC staff contracts with, and partners with, several agencies and laboratories to carry out monitoring activities. Roles and responsibilities are shown in Figure 4.1 and described in more detail in the following sections.

Figure 4.1 Delta Regional Monitoring Program organization chart.

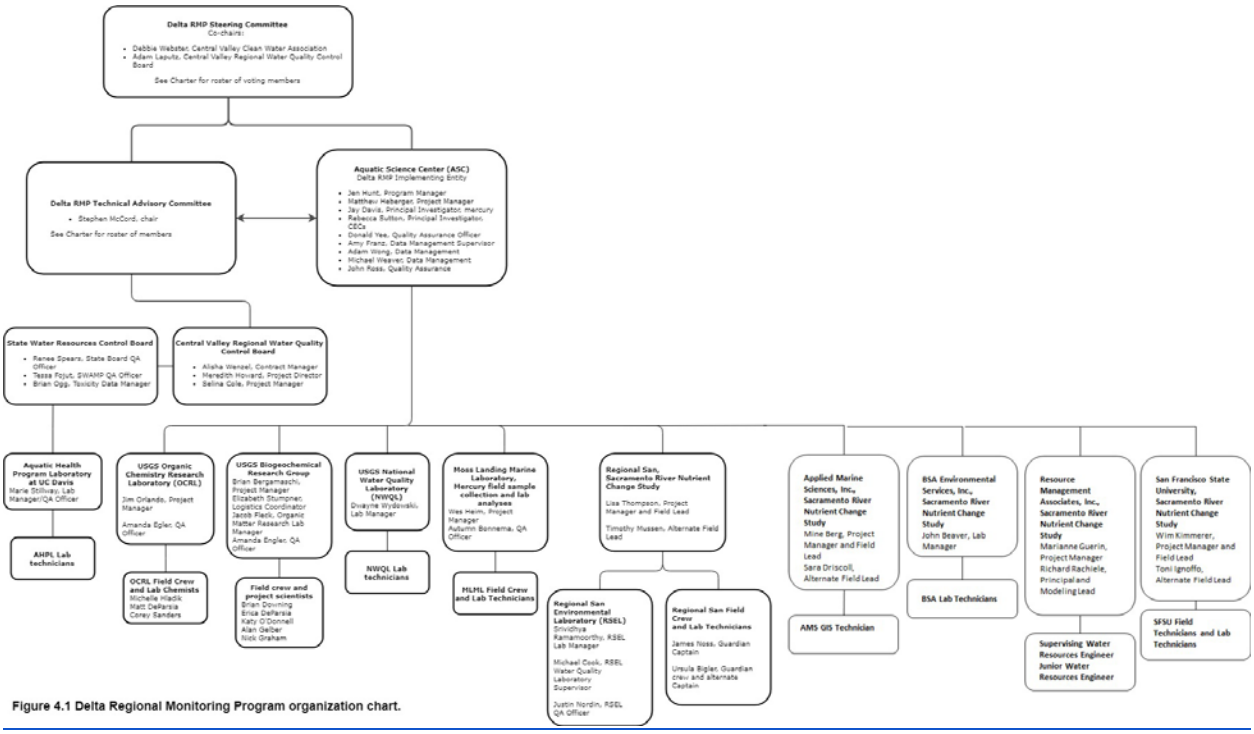


Figure 4.1 Delta Regional Monitoring Program organization chart.

See high-resolution image here.

4.1. Principal Data Users and Stakeholders

Principal data users include internal (program participants) and external stakeholders (other Delta managers and policymakers, local scientists and the scientific community at large, and the public). Participants include regulatory agencies, resource agencies, water supply, coordinated monitoring programs, wastewater treatment plants, stormwater municipalities, irrigated agriculture coalitions, and dredgers (Appendix A).

Funding for the Delta RMP is provided by the wastewater treatment plants, stormwater municipalities, irrigated agriculture coalitions, and dredgers listed in Appendix A. Funding also includes in-kind support from the Central Valley Regional Water Quality Control Board via funding from the Surface Water Ambient Monitoring Program (SWAMP).

4.2. Project Team

An organizational chart, with monitoring responsibilities noted, is provided in Figure 4.1. An abridged description of the Delta RMP staff and leadership is provided here. Detailed information on the governance of the Delta RMP, along with a roster of voting members, can be found in the program's Charter.

4.2.1. Program Leadership

The Delta RMP Steering Committee is the decision-making body of the Delta RMP. The Steering Committee is responsible for establishing the Delta RMP's strategic direction and the policies and procedures that govern its operation. The Steering Committee may direct Delta RMP staff and advisory committees to assist in meeting program objectives and may delegate day-to-day functions of the Delta RMP to the Delta RMP's implementing entity. The Steering Committee is made up of representatives from both the regulated and regulatory community, including organizations and agencies involved in agriculture, dredging, wastewater treatment, stormwater, water supply, and flood control and habitat restoration. An up-to-date list of Steering Committee members can be found online as an appendix to the Delta RMP Charter.

The Steering Committee authorizes the implementation of agreements among the participating members and, specifically:

1. Directs the fiscal/operating agent to request and receive federal, state, local, and private funds from any source and to expend those funds to accomplish the Delta RMP's goals.
2. Approves budgets and expenditures.
3. Directs the fiscal/operating agent to enter into partnerships, contracts, and other legal agreements on behalf of the Delta RMP, as necessary to fulfill the Delta RMP's mission.

4. Approves Delta RMP work products and any other plans, products, or resolutions of the Delta RMP.
5. Sets priorities and oversee the activities of the Technical Advisory Committee.
6. Establishes and oversees the implementation of policies and procedures necessary to the day-to-day functioning of the Delta RMP.

Under the direction of the Steering Committee, the Technical Advisory Committee (TAC) provides technical oversight of the Delta RMP. The TAC also has a number of technical subcommittees representing different focus areas, such as pesticides, nutrients, and mercury. An up-to-date roster of TAC members can be found online as an appendix to the Delta RMP Charter.

4.2.2. Implementing Entity

The San Francisco Estuary Institute – Aquatic Science Center (SFEI-ASC) manages and operates the program. The SFEI-ASC Program Manager (Matthew Heberger) is responsible for coordinating monitoring components of this project including the organization of field sampling, interactions with the contract laboratories, and managing laboratory subcontracts. The SFEI-ASC Program Manager reports directly to the Delta RMP Steering Committee.

The SFEI-ASC Regional Data Center Manager (Amy Franz) coordinates the SFEI-ASC Data Services Team, which performs data review and validation to ensure that data submitted by subcontractor labs are timely, complete, and properly incorporated into the Regional Data Center database.

SFEI-ASC's Quality Assurance Officer (QAO, Don Yee) role is to provide Quality Assurance oversight and to review and approve the quality assurance and quality control (QA/QC) procedures found in this QAPP, which include field and laboratory activities. The SFEI QAO will work with the Quality Assurance Officers for contracted analytical laboratories, reviewing and communicating all QA/QC issues contained in this QAPP to the laboratories.

The project QA officer position is independent of data generation.

4.2.3. Field Crews and Laboratories

Laboratories contracted by SFEI-ASC provide analytical services and will act as a technical resource to SFEI-ASC staff and management. Laboratories are listed in Table 4.3.

Mercury

The Marine Pollution Studies Lab (MPSL) at Moss Landing Marine Laboratory (MLML) will analyze tissue, sediment, and water for the mercury component.

Autumn Bonnema will serve as the MPSL Project Coordinator (PC). She will 1) review, evaluate, and document project reports, and 2) verify the completeness of all tasks. She may also assist field crew in preparation and logistics.

Billy Jakl of MPSL is in charge of directing fish, water, and sediment collection for mercury monitoring. He will 1) oversee preparation for sampling, including vehicle maintenance, and 2) oversee sample and field data collection.

Stephen Martenuk is the MPSL laboratory manager. His duties will be to ensure that laboratory technicians have processing instructions and that all laboratory activities are completed within the proper timelines. He is also responsible for sample storage and custody at MPSL.

Wes Heim will serve as the project manager for the MPSL component of this project. His specific duties will be to 1) review and approve the QAPP, 2) provide oversight for mercury analyses to be done for this project, 3) ensure that all MPSL activities are completed within the proper timelines, and 4) oversee data validation, management, and reporting.

Nutrients

In 2018 the nutrient monitoring effort involved a high frequency water quality boat mapping project conducted by the USGS. The analysis of the results of this 2018 project is ongoing. In 2019 a new nutrients special project is being added, called the Sacramento River Nutrient Change Study (SRiNCS). This new project incorporates a new high frequency water quality boat mapping project, again conducted by the same USGS personnel as in 2018 but with water quality mapping efforts focused on the SRiNCS study area within the Delta. Because the high frequency mapping methods to be used for the 2019 mapping effort are the same as those methods used in 2018, and have already been approved by the QAPP signatories, the relevant sections have been retained in this version of the QAPP.

Brian Bergamaschi is project manager and field lead for the USGS high frequency water quality mapping, Bryan Downing and Elizabeth Stumpner are alternate field leads. The USGS boat crew for all three days will include any of the following members of the Biogeochemistry (BGC) group: Brian Bergamaschi, Bryan Downing, Katy O'Donnell, Nick Graham, Jessa Rego, Liz Stumpner.

Liz Stumpner is the point of contact for the USGS National Water Quality Laboratory (NWQL). Sharon Gosselink and Annie Quratulain will complete laboratory processing and shipment to the USGS NWQL and any other labs.

Jacob Fleck is the USGS Organic Matter Research Laboratory (OMRL) laboratory manager and Duane Wydoski is the USGS-NWQL laboratory manager. Their duties will be to ensure that laboratory technicians have processing instructions and that all laboratory activities are completed within the proper timelines. They are also responsible for sample storage and custody at their labs.

For the FY19-20 SRiNCS project, the project manager and field lead will be Lisa Thompson, Chief Scientist at Sacramento Regional County Sanitation District (for which the preferred short name is Regional San). She will also conduct the zooplankton sampling for general enumeration. Timothy Mussen, Regional San Scientist II, is the alternate field lead. He will also conduct the clam trawl sampling. He and a Regional San intern (to be determined) will conduct clam enumerations (counts and biomass), and use these data to calculate clam grazing rates.

James Noss is Senior Environmental Laboratory Analyst at the Regional San Environmental Laboratory (RSEL). He will be the captain of the Guardian research vessel and the point of contact for RSEL. As point of contact for RSEL, he will oversee the collection of water quality samples and their transport to RSEL, and transport of phytoplankton and zooplankton samples to BSA Environmental Services, Inc. (BSA). A second RSEL staff person (to be determined) will assist with water quality sample collection and crewing the Guardian.

Srividhya Ramamoorthy is the RSEL Lab Manager and will oversee all laboratory activities. Michael Cook is RSEL Water Quality Laboratory Supervisor. He will ensure that laboratory technicians have processing instructions and that all laboratory activities are completed following established guidelines. Justin Nordin is RSEL QA Officer. He will review the RSEL analytical results for Quality Assurance/Quality Control (QA/QC) purposes.

John Beaver, Ph.D. is the owner and manager of BSA Environmental Services, Inc. (BSA). He will oversee the enumeration analyses of phytoplankton and zooplankton samples collected as part of the SRiNCS.

Mine Berg, Ph.D. of Applied Marine Sciences (AMS) is project manager and field lead for the phytoplankton growth studies part of the SRiNCS. Sara Driscoll is the alternate field lead for the phytoplankton collection and growth studies. They will conduct the phytoplankton growth experiments on board the Guardian, including vertical profiles of photosynthetically active radiation (PAR), variable fluorescence (F_v/F_m), and carbon (C) uptake.

Wim Kimmerer, Ph.D. of San Francisco State University (SFSU) is project manager and field lead for the zooplankton growth studies part of the SRiNCS. Toni Ignoffo is the alternate field lead for zooplankton sample collection and growth studies. SFSU staff will conduct zooplankton sampling onboard the Guardian boat.

SFSU staff will conduct zooplankton enumerations (one replicate sample per station), incubation growth rate experiments (at SFSU), volume determination using a FlowCam, and relate abundance, growth, reproduction, and mortality to environmental conditions. They will

also collect and analyze samples for molecular identification of foods consumed by the zooplankton. In addition, they will collect zooplankton and particulate matter at the growth-rate stations and freeze them for later analysis using High-Throughput Sequencing.

Marianne Guerin, Ph.D., of Resource Management Associates (RMA) is project manager for the modeling part of the SRiNCS. She will coordinate with the field leads from SRCSD to ensure that field calibration transect data are collected at the required locations. Richard Rachiele is an RMA Principal and modeling lead and will use the field transect data in model calibrations.

Pesticides

Jim Orlando is the project manager at the USGS Organic Chemistry Research Laboratory (OCRL). His duties will be to ensure that all project elements meet the guidelines established in the QAPP and project contract. He is responsible for the final review of all project analytical results produced by the OCRL. He serves as the primary contact between the Delta RMP and the OCRL and provides project updates to the cooperator.

Michelle Hladik is the Chief Chemist at the USGS OCRL and supervises all laboratory activities. Her duties will be to ensure that laboratory technicians have processing instructions and that all laboratory activities are completed following established guidelines (project specific QAPP and OCRL Standard Operating Procedures [SOPs]). She is responsible for sample analysis, initial review of the data, and provides data to the USGS project manager for review.

Corey Sanders is the chemist/database manager for the USGS OCRL. His duties will be to ensure that all sample collection information and analytical results are entered into the OCRL internal database and that this information is subsequently formatted and transferred to the USGS National Water Information System (NWIS) database. He is also responsible for sample storage and custody at OCRL.

Matt DeParsia is the OCRL field technical lead for the project. His duties will be to ensure that water quality sampling is conducted following documented procedures (as described in the USGS *National Field Manual*, and this project-specific QAPP). He is also responsible for the initial processing of water samples at the OCRL and for shipping samples to the USGS National Water Quality Laboratory in Denver for additional chemical analyses that are not performed at the OCRL in Sacramento.

Toxicity

Marie Stillway is the Laboratory Manager of the Aquatic Health Program Laboratory (AHPL) at UC Davis. Her duties will be to ensure that aquatic toxicity testing is conducted following documented procedures outlined in this document, SWAMP Measurement Quality Objectives (MQOs), and laboratory-specific SOPs. Ms. Stillway is also responsible for overseeing calculation and compilation of the toxicity data and providing these data to the data managers

at the State Water Resources Control Board's Information Management & Quality Assurance Center unit (SWAMP IQ). Additionally, Ms. Stillway will provide additional reporting data (such as copies of bench sheets and reference toxicity control charts) to the program manager for sharing with the Delta RMP Technical Advisory Committee.

The SWAMP IQ unit will assume all data management responsibilities for Delta RMP toxicity data. This includes data processing, QA/QC review, and uploading the data to the California Environmental Data Exchange Network (CEDEN). Responsible parties include Brian Ogg, Environmental Scientist, and Tessa Fojut, SWAMP QA Officer.

Because SWAMP is funding the toxicity analyses and managing these data, SWAMP IQ will upload the Delta RMP toxicity data to CEDEN and make the data publicly available without going through the same review and approval steps that govern the release of other Delta RMP datasets as outlined in the Communications Plan.

In the event that there are changes to the data *after* it has been published, changes will be communicated to data users in a timely manner. This is particularly important to members of the agricultural community who need it to fulfill the requirements of the Irrigated Lands Regulatory Program. ASC has set up an email listserv to communicate any changes or updates to Delta RMP toxicity data. If State Water Board staff makes any changes to the data after it has been published, Board staff should let ASC know so that staff can send out a notice to this group.

4.3. Persons Responsible for QAPP Update and Maintenance

Changes and updates to this QAPP may be made by SFEI-ASC's Program Manager and SFEI-ASC's Quality Assurance Officer (QAO), after they review the evidence for change, and with the concurrence of the Delta RMP Technical Advisory Committee (TAC). SFEI-ASC's QAO will be responsible for making the changes, submitting drafts for review, preparing a final copy, and submitting the final QAPP for signatures. The project plan will be reviewed on an annual basis. Changes are expected year to year in the early years of Delta RMP implementation.

5. Problem Definition/Background

The Delta RMP was initiated in 2008 by the Central Valley Regional Water Quality Control Board (Regional Water Board) with the primary goal of tracking and documenting the effectiveness of beneficial use protection and restoration efforts through comprehensive monitoring of water quality constituents and their effects in the Delta. The development of the Delta RMP was initially prompted by the collapse of the populations of several species of fish in the early 2000s, an event that triggered new inquiries into the potential role of contaminants in what is now termed the Pelagic Organism Decline (POD). However, these inquiries highlighted shortcomings of existing monitoring efforts to address questions at the scale of the Delta. The recognition that data from current monitoring programs were inadequate in coverage, could not

easily be combined, and did not support a rigorous analysis of the role of contaminants in the POD, persuaded regulatory agencies to improve coordination across multiple monitoring programs.

In addition, the Delta RMP reflects an increasing desire among water quality and resource managers throughout the state for more integrated information about patterns and trends in ambient conditions across watersheds and regions. Many stressors to beneficial uses are interrelated and must be addressed more holistically. The Delta RMP complements existing larger-scale collaborative monitoring efforts throughout the state that attempt to address questions and concerns about regional conditions and trends (e.g., San Francisco Bay RMP, Southern California Bight Monitoring Program, Surface Water Ambient Monitoring Program).

The Delta RMP Steering Committee decided at its December 3, 2012 meeting that the initial Delta RMP would focus on mercury, nutrients, pathogens, and pesticides, since these constituents represent high priority issues for management that are shared concerns of represented participant groups. The TAC subsequently developed monitoring designs for these priorities that would address the Delta RMP management questions (Appendix B) and priority assessment questions for each constituent (Appendix C).

Pesticides monitoring began in 2015 to provide information on spatial and temporal variability of pesticides and toxicity.

Mercury monitoring began in 2016 in order to address the highest priority information needs related to implementation of the Methylmercury Total Maximum Daily Load (TMDL).

Nutrients are associated with excessive growth of nuisance aquatic vegetation that interferes with navigation and recreation, and can block water supply intakes. It is also suspected to contribute to harmful algal blooms (HABs) that can produce toxins that kill fish, wildlife, and domestic animals, and are detrimental to drinking water quality and human health. Finally, nutrients play an important role in ecosystem health, for example by affecting the primary productivity of algae which form the base of the food chain. Water managers seek to better understand these factors in order to better manage ecosystems and craft more effective plans for the conservation and recovery of threatened and endangered species in the Delta. Nutrient monitoring began in 2017 with a one-year special study to assess spatial variability of nutrients and related water quality constituents in the Delta at the landscape scale.

5.1. Core Management Questions

5.1.1. Pesticides and Aquatic Toxicity

A better understanding of the effects of contaminants in the apparent decline of Delta ecosystems is a priority for regulators and stakeholders. Pesticide use in the Delta and Central Valley is one of the potential drivers of these effects. Constantly changing pesticide use presents

a challenge for environmental scientists, resource managers, and policy makers trying to understand whether these contaminants are impacting aquatic systems and if so, which pesticides appear to be the biggest problem. Less than half of the pesticides currently applied in the Central Valley are routinely analyzed in monitoring studies and new pesticides are continually being registered for use. Therefore, baseline monitoring of ambient surface water for both aquatic toxicity and a broad list of current use pesticides is needed to understand whether current use pesticides contribute to observed toxicity in the Delta.

The monitoring is intended to provide useful information to state and federal water quality regulators. Important regulatory drivers are described below.

***Water Quality Control Plan for the Sacramento River and San Joaquin River Basin* (Basin Plan, link)**

According to the State Water Board, the Basin Plan is "the Board's master water quality control planning document. It designates beneficial uses and water quality objectives for waters of the State, including surface waters and groundwater. It also includes programs of implementation to achieve water quality objectives."

The Central Valley's Basin Plan states that, "in addition to numerical water quality objectives for toxicity, the Basin Plan contains a narrative water quality objective that requires all surface waters to '...be maintained free of toxic substances in concentrations that are toxic to or that produce detrimental physiological responses to human, plant, animal, and aquatic life.' To check for compliance with this objective, the Regional Water Board initiated a biotoxicity monitoring program to assess toxic impacts from point and nonpoint sources in Fiscal Years 1986 - 1987" (CVRWQCB 2016, IV-32.08). The plan states that the Regional Board "will continue to impose toxicity testing monitoring requirements in NPDES [National Pollutant Discharge Elimination System] permits. The focus of ambient toxicity testing will continue to be the Delta and major tributaries." In other words, the Board is interested in verifying that there are "no toxics in toxic amounts" in waterways, and will continue to require aquatic toxicity testing as a key means of making this determination.

Organophosphate TMDL

In 2006, the Central Valley Regional Water Quality Control Board (CVRWQCB) identified Delta waterways as impaired under the federal Clean Water Act Section 303(d) due to elevated concentrations of the organophosphate pesticides, diazinon and chlorpyrifos, and created a plan for their allowable discharge to the Delta referred to as the Total Maximum Daily Load (TMDL). Under this plan (CVRWQCB 2006), the board put in place a number of new rules and requirements. One of these stated that new discharge permits (or WDRs) for runoff from fields and orchards draining to Delta Waterways must include monitoring to meet a number of goals, the most relevant being:

- Determine attainment of the diazinon and chlorpyrifos water quality objectives and Load Allocations (additivity target).
- Determine whether alternatives to diazinon and chlorpyrifos are causing surface water quality impacts.
- Determine whether the discharge causes or contributes to a toxicity impairment due to additive or synergistic effects of multiple pollutants

In addition are nearly identical requirements for agricultural dischargers to the Sacramento and San Joaquin River under those TMDLs (Daniel McClure, personal communication).

Control Program for Diazinon and Chlorpyrifos

In 2014, the Central Valley Water Board published an additional amendment to the Basin Plan containing a control program for discharges of diazinon and chlorpyrifos (CVRWQCB 2014). The control plan created new pollution control requirements for waterways designated as supporting both warm and cold freshwater habitats. Under these requirements, agricultural, municipal stormwater, and wastewater dischargers in the Sacramento and San Joaquin River basins below major reservoirs are required to monitor in order to:

- Determine compliance with established water quality objectives applicable to diazinon and/or chlorpyrifos.
- Determine whether alternatives to diazinon and/or chlorpyrifos are being discharged at concentrations which have the potential to cause or contribute to exceedances of applicable water quality objectives.

In addition, agricultural dischargers are also required to monitor water quality in order to:

- Determine whether the discharge causes or contributes to a toxicity impairment due to additive or synergistic effects of multiple pollutants

Pyrethroids Basin Plan Amendment

In 2017, the regional board determined that more than a dozen waterways are impaired due to elevated concentrations of pyrethroid pesticides under the Clean Water Act, section 303(d). In response, the regional board adopted a Basin Plan Amendment (CVRWQCB 2017) which includes a pyrethroid pesticide control program for the Sacramento and San Joaquin River Basins. This Basin Plan Amendment was adopted by the regional board in June 2017 and it is expected to be fully approved by Stater Water Board, the Office of Administrative Law, and EPA by the end of 2018.

The amendment contains requirements for monitoring of pyrethroids, pyrethroid alternatives, and aquatic toxicity to the invertebrate *Hyalella* in discharges and/or receiving water in order to:

- Determine if the pyrethroid concentration goals are being attained through monitoring pyrethroids either in discharges (monitoring requirements apply to wastewater treatment plants or publicly-owned treatment works, POTWs) or in receiving waters (monitoring requirements apply to municipal separate storm sewer systems [MS4s] and agricultural dischargers).
- Determine whether pyrethroid pesticides are causing or contributing to exceedances of the narrative water quality objectives for toxicity – through toxicity testing with *Hyalella* in water column of receiving waters (POTWs, MS4s, and agricultural dischargers) or receiving waters water column and bed sediments (agricultural dischargers and MS4s)

This monitoring must be completed two years from the effective date of the Basin Plan Amendment (BPA), expected December 2018. In the long term after that two-year period, dischargers will also be required to monitor for alternative insecticides that could be having water quality impacts.

Assessment Questions Addressed

The study of pesticides and toxicity is designed to help begin answering the core Delta RMP Management and Assessment Questions,

> Is water quality currently or trending towards adversely affecting beneficial uses of the Delta?
>
> **Status & Trends (S&T) Assessment Questions**
>
> S&T 1 - To what extent do current use pesticides contribute to observed toxicity in the Delta?
>
> S&T 1.1 - If samples are toxic, do detected pesticides explain the toxicity?
>
> S&T 1.2 - What are the spatial and temporal extent of lethal and sublethal aquatic and sediment toxicity observed in the Delta?
>
> S&T 2 - What are the spatial/temporal distributions of concentrations of currently used pesticides identified as possible causes of observed toxicity?

The study objectives are to:

- Collect water samples from a variety of locations across Delta subregions and analyze them for a broad suite of current use pesticides, and for toxicity to aquatic organisms.
- Test whether pesticides in ambient water samples exceed aquatic life benchmarks.
- Test for the co-occurrence of pesticides and observed aquatic toxicity.

Example Information Applications

The examples below show ways that information from the Delta RMP study of pesticides and toxicity could be used by scientists, water managers, and regulators. Examples information applications include, but are not limited to:

- The Delta RMP can use this information to determine what percentage of Delta waters exhibit toxicity to aquatic organisms or have concentrations of pesticides that exceed thresholds.
- State water quality regulators may use this information to help evaluate if waterways should be classified as impaired under Section 303(d) of the Clean Water Act. Regulators will be able to evaluate particular stream segments and parameters for signs of impairment, and, after several years of monitoring, may be able to track changes in impairment over time.
- If certain compounds are found to be having adverse impacts on the aquatic environment that prevent the attainment of beneficial uses, regulators may require the development of a management plan to prevent or mitigate pesticide contamination of waterways or, when warranted, adopt restrictions to further protect surface water from contamination.

5.1.2. Mercury

The Delta Methylmercury TMDL is the embodiment of management decisions for methylmercury in the Delta, establishing goals for cleanup and calling for a variety of control studies and actions. With providing information to support TMDL implementation in mind, the Mercury Subcommittee carefully considered the assessment questions articulated by the Steering Committee and Technical Advisory Committee for mercury.

The Delta RMP management and assessment questions addressed by each of the methylmercury monitoring elements are indicated in Table 5.1. In addition, the combination of water and fish monitoring addresses a critical data need for management that is not captured in the current set of questions for the Program: data to strengthen the linkage analysis that is a key component of the technical foundation for the TMDL.

Monitoring of subregional trends in bass is addressing questions relating to Status and Trends, Forecasting, and Effectiveness Tracking. Status and Trends Question 1A is a high priority for managers that relates to the TMDL, and is a primary driver of the sampling design for subregional bass trend monitoring. Annual monitoring of bass mercury is urgently needed to 1) firmly establish a baseline for each Delta subregion and 2) to characterize the degree of interannual variation, which is essential to designing an efficient monitoring program for detection of long-term trends. In addition to addressing status and trends, this monitoring will provide an essential foundation for Forecasting Scenarios (past trends are a starting point for projecting future conditions) and Effectiveness Tracking (evaluating whether water quality is improving at the subregional scale as a result of management actions).

Monitoring of subregional trends in water is addressing all of the major categories of Delta RMP management questions (Status and Trends; Sources, Pathways, Loadings, and Processes [SPLP]; Forecasting Scenarios; and Effectiveness Tracking). Data on concentrations of methylmercury in water are valuable as an indicator of Status and Trends as they can be compared to the TMDL implementation goal of 0.06 ng/L of unfiltered aqueous methylmercury. The use of water data to update the mass budget addresses SPLP Question 1A and is a key element of the TMDL. Aqueous methylmercury concentrations are essential input and validation data for the models that DWR and USGS are developing for the Delta that will elucidate the processes affecting methylmercury patterns and allow forecasting and testing of various water management scenarios. Water concentration data will also be valuable in Effectiveness Tracking, allowing assessment of status relative to the implementation goal and of changes in loading in the context of the overall mass budget for the Delta.

Monitoring of subregional trends in bass and water will also provide information on the influence of climate, hydrology, and ecology. For example, the first two years of monitoring have already spanned the end of a prolonged drought and a high flow year, providing an

opportunity to examine the impact of extreme variation in flow on methylmercury concentrations in fish and water.

Restoration monitoring will address questions relating to SPLP, Forecasting Scenarios, and Effectiveness Tracking. The basic concern with restoration projects is that they may enhance net methylmercury production within the Delta ecosystem, and represent an internal source that increases as the projects proceed (SPLP Question 1B) – restoration monitoring will track whether this occurs or not. Restoration monitoring will yield insights into which types of projects, if any, impact net methylmercury production and food web accumulation (Forecasting Scenarios Question 1) and whether internal loadings change and ambient water quality shows net improvement as a result of restoration projects (Effectiveness Tracking).

5.1.3. Nutrients

The information gathered will provide important baseline information to help stakeholders engaged in the Delta Nutrient Research Plan to determine whether nutrient concentrations cause or contribute to water quality problems and to evaluate how nutrient conditions respond to future management actions.

Assessment Questions Addressed

Status and Trends

ST1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?

ST1.A. Are trends similar or different across subregions of the Delta?

ST1.B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? Study relates nutrient demand to landscape elements.

Sources, Pathways, Loadings & Processes (SPLP)

SPLP1. Which sources, pathways, and processes contribute most to observed levels of nutrients?

SPLP1.F. What are the types of nutrient sources and sinks within the Delta?

Forecasting Scenarios

FS1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes? Study provides baseline data against which to evaluate change.

The primary objective of the 2018 high frequency mapping project is to document the spatial variability of nutrients (Question ST1) for the purpose of evaluating longitudinal transformation in nutrient concentrations, forms and ratios in different zones within the Delta (Question ST1.A). The goal is to identify "hot spots" of nutrient transformation and to locate internal sources and sinks for nutrients within the Delta (Question SPLP1.F). The study is expected to provide initial data to begin addressing Questions ST1.B and FS1.

The SRiNCS project is a short-term field study (to be conducted over one week in September 2019) that will assess the spatial variation of nutrients and their transformations along the Sacramento River, Georgiana Slough, the North Fork Mokelumne River, and South Fork Mokelumne River during the summer low flow period (Question ST1.B). The project will assess the current status of the Delta ecosystem as influenced by nutrients by determining the state of phytoplankton biomass and growth in the noted rivers and slough (Question ST2.A). The project will assess how nutrient source control (temporarily halting nutrient discharge from the Sacramento Regional Wastewater Treatment Plant) changes ambient nutrient levels and nutrient-associated parameters such as phytoplankton biomass and growth in the noted rivers and slough (Question SPLP1.A). The SRiNCS project will provide baseline data to assess how ambient water quality conditions will respond to a planned future source action, the decrease in nutrient loading from the Sacramento Regional Wastewater Treatment Plant by 2021 (Question FS1). The SRiNCS project also addresses key scientific uncertainties and fills important information gaps identified in the Delta Nutrient Research Plan. Specifically, this project will address, in part, six management sub-questions posed in the Delta Nutrient Research Plan (Table 1, pages 23-24).

1. What are the main factors affecting potential nutrient-related effects and how does the relative importance of these factors vary with space and time?
2. What are the important processes that transform nutrients in the Delta and what are the rates at which these processes occur?
3. Can nutrient management in the northern Delta (e.g., Yolo Bypass, Sacramento River, and Sacramento Deep Water Ship Channel) increase abundance or nutritional quality of pelagic phytoplankton?
4. What is the level and type of change in nutrients needed to affect change in HABS, macrophytes, or phytoplankton abundance?
5. What are the most likely alterations in nutrient conditions due to climate change, Delta habitat restoration, and changes in nitrogen forms and loads?
6. What nutrient levels are needed to support adequate primary productions and a healthy food web, particularly for endangered fish species?

5.2 Beneficial Uses and Water Quality Goals

Two water quality control plans apply to the Sacramento-San Joaquin Delta: the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (CVRWQCB, 2011.) This is frequently referred to as the *Central Valley Basin Plan* or simply, the *Basin Plan*. The *Basin Plan* is the Central Valley Regional Water Quality Control Board's regulatory reference for meeting the state and federal requirements for water quality control established under the federal *Clean Water Act* and California's Porter-Cologne Water Quality Control Act. The *Basin Plan* establishes numeric and narrative objectives for water quality aimed at protecting beneficial uses of water in the Sacramento River and San Joaquin River Basins, including the Sacramento-San Joaquin River Delta (Chapter III: Water Quality Objectives).

The second water quality control plan that applies to the Delta is the *Bay-Delta Water Quality Control Plan* (SWRCB 2006), commonly referred to as the *Bay-Delta Plan*. The State Water Resources Control Board adopted the Bay-Delta Plan to establish water quality objectives for the Bay-Delta Estuary related to flow and water project operations.

Table 5.2 provides an overview of beneficial uses that are relevant to the prioritized assessment questions of each of the individual monitoring elements. The full list of Delta RMP assessment questions can be found in Appendix B.

Table 5.3 summarizes existing numeric water quality criteria and aquatic life benchmarks for target analytes of pesticide monitoring. This information is useful for determining whether the lab's analytical methods are sensitive enough to detect pesticides at relevant concentrations. We make this determination by comparing the lab's detection limits to relevant thresholds. For the majority of the pesticide analytes, there are no regulatory thresholds. Exceptions are chlorpyrifos and diazinon, for which water quality objectives (WQOs) were set by the Central Valley Regional Water Quality Control Board. Other thresholds are drawn from the literature. In order to determine whether contaminants are present in waterways at concentrations that are ecologically relevant, i.e., those which may cause harm to aquatic biota, scientists compare observed concentrations with thresholds for aquatic toxicity gathered from the literature. The presence of a compound above a threshold is not necessarily evidence that harm is taking place, but rather it is a first step in a process for interpreting the data and evaluating relative ecological risk

The thresholds listed in Table 5.3 include:

- Water Quality Objectives for California's Central Valley (Central Valley Water Board 1998, 2007)
- EPA Office of Water (OW) Aquatic Life Ambient Water Quality Criteria (EPA 2000, 2015a, 2015b, website link)
- EPA Office of Pesticide Programs (OPP) Aquatic Life Benchmarks (link).

- California Department of Pesticide Regulation's Aquatic Life Benchmark Alternatives (Luo et al. 2013)

Table 5.4 lists the water quality objectives for methylmercury that will be used in evaluations of Delta RMP data. In addition to these water quality objectives, the Methylmercury TMDL includes implementation goals for largemouth bass (0.24 mg/kg in 350 mm largemouth bass) and unfiltered methylmercury in water (0.06 ng/L).

The Central Valley Regional Water Quality Control Board is developing a Nutrient Research Plan to identify research and modeling needed to determine whether further regulation and management of nutrients will help address water quality problems of low primary productivity, harmful algal blooms, invasive aquatic plants, and low dissolved oxygen. The Regional Board will make a decision about numeric nutrient water quality objectives at some point in the future. However, the Basin Plan currently establishes a narrative objective for "biostimulatory substances" that applies to nutrients. There are also numeric water quality objectives for dissolved oxygen. The water quality objectives for biostimulatory substances and dissolved oxygen are listed in Table 5.4.

6. Project Tasks Description

6.1 Water Quality Monitoring Overview

The Delta RMP is one of several ongoing water-quality monitoring programs in the Delta. In terms of budgets, it represents less than 10% of all Delta monitoring (Jabusch and Gilbreath, 2009). Therefore, the program seeks to complement existing programs and address gaps in existing monitoring, rather than to comprehensively address every water quality challenge described above.

The Delta RMP collects water quality data to address high-priority management decisions identified in Section 5.1. The current Delta RMP monitoring design is predominantly aimed at understanding the status and trends of three classes of pollutants. The Delta RMP will conduct water quality monitoring of (1) pesticides and aquatic toxicity, (2) mercury in water and fish tissue, and (3) nutrients (nitrogen and phosphorus) in water.

The pesticides monitoring element includes chemical analyses and toxicity testing. The chemical analyte groups for this monitoring element include several classes of chemicals that are referred to throughout this document as pesticides, including insecticides, herbicides, fungicides, and other compounds in products that are licensed and sold to farmers and residents in California.

Mercury monitoring consists of discrete sample collection and addresses the highest priority information needs related to the implementation of the Methylmercury TMDL.

Nutrient monitoring consists of a high-resolution water quality mapping project to assess spatial variability of nutrients and related water quality constituents in the Delta at the

landscape scale. Table 6.1 provides a complete list of target constituents for the current implementation of the Delta RMP.

6.2. Constituents to be Monitored and Reported

Table 6.1 lists the water quality constituents that will be measured by Delta RMP monitoring and special studies.

Some pesticides that the program monitored from 2015–2017 have been *dropped* from our analyte list from October 2018 onward. The Organic Chemistry Research Laboratory (OCRL) decided to remove several compounds from their methods list that had not been detected in any of their monitoring in the past 3 years, and which are not present in actively registered products with EPA within the last 3 years. The following 13 compounds were removed before Water Year 2019 monitoring began. (This list includes the Chemical Abstracts Service Registry Number, or CASRN, for reference).

1. Alachlor, CASRN: 15972-60-8
2. Azinphos methyl, CASRN: 86-50-0
3. Azinphos methyl oxon, CASRN: none
4. Bromuconazole, CASRN: 116255-48-2
5. Butylate, CASRN: 2008-41-5
6. Fenarimol, CASRN: 60168-88-9
7. Fenthion, CASRN: 55-38-9
8. Flusilazole, CASRN: 85509-19-9
9. Methidathion, CASRN: 950-37-8
10. Molinate, CASRN: 2212-67-1
11. Pebulate, CASRN: 1114-71-2
12. Tetradifon, CASRN: 116-29-0
13. Thiazopyr, CASRN: 117718-60-2

We have kept these old analytes in Table 5.3 as a reference to the data developed by the program.

The OCRL has also *added* new analytical capabilities beginning in Water Year 2019. The lab has added 20 new analytes to the list. These represent current use pesticides that are permitted for use nationally and in California, and which have been regularly applied in the last 3 years, according to the California Department of Pesticide Regulation's Public Use Reporting (PUR) database. The *new* analytes include the following (see Table 5.3 for ecotoxicological thresholds and Table 7.3(b) for detection limits and methods):

1. Acetochlor, CASRN: 34256-82-1
2. Benzovindiflupyr, CASRN: 1072957-71-1
3. Carboxin, CASRN: 5234-68-4

4. Chlorfenapyr, CASRN: 122453-73-0
5. Dichlorvos, CASRN: 62-73-7
6. Etoxazole, CASRN: 153233-91-1
7. Flubendiamide, CASRN: 272451-65-7
8. Fluopyram, CASRN: 658066-35-4
9. Flupyradifurone, CASRN: 951659-40-8
10. Imidacloprid urea, CASRN: 120868-66-8
11. Indaziflam, CASRN: 950782-86-2
12. Isofetamid, CASRN: 875915-78-9
13. Oxathiapiprolin, CASRN: 1003318-67-9
14. Penthiopyrad, CASRN: 183675-82-3
15. Pyriproxyfen, CASRN: 95737-68-1
16. Sulfoxaflor, CASRN: 946578-00-3
17. Tebufenozide, CASRN: 112410-23-8
18. Thiamethoxam Degradate (CGA-355190), CASRN: 902493-06-5
19. Thiamethoxam Degradate (NOA-407475), CASRN: NONE
20. Tricyclazole, CASRN: 41814-78-2

6.3. Geographical and Temporal Setting

The geographic scope of the Delta RMP encompasses the legal Delta (as defined by Section 12220 of the Water Code), as well as water bodies that directly drain into the Delta, the Yolo Bypass, and Suisun Bay (Figure 6.1). The Delta Primary Zone encompasses approximately 500,000 acres of waterways, levees, and farmed lands, including the Yolo Bypass. Most of Yolo Bypass is located within the Primary Zone. The Secondary Zone includes approximately 250,000 acres that are surrounding the Primary Zone and are subject to increasing urban and suburban development. Suisun Marsh on the northern side of Suisun Bay consists of approximately 110,000 acres of managed wetlands. The southern side of the Suisun Bay shoreline encompasses additional tidal wetlands as well as urban, suburban, and industrial areas.

Water dynamics in the Delta and Suisun Bay are governed by inflows from the Sacramento and San Joaquin watershed, tidal exchange with the Pacific Ocean, and water withdrawals for municipal and agricultural use. The main tributaries are the Sacramento River and the San Joaquin River. Additional tributaries include the Mokelumne River, Cosumnes River, Calaveras River, Bear Creek, Marsh Creek, Cache Creek, Putah Creek, and Ulatis Creek. Flows from the Sacramento River, San Joaquin River, and other tributaries are transported across the Delta through a complex network of rivers, channels, and flooded islands, before entering Suisun Bay or the intakes of the federal and state water projects. Flows in the Delta are highly seasonal and peak in the spring and early summer when snowmelt waters from the upper watersheds arrive.

Important human activity and land use impacts in the Delta and Suisun Bay include the presence of urban and agricultural contaminants throughout the system, habitat loss, and alterations to the amount, duration, direction, and timing of water flows. In addition, more than 200 intentionally or accidentally introduced non-native species are residing in the project area.

6.3.1. Delta Subregions for Pesticides and Toxicity Sampling

For monitoring of pesticides and aquatic toxicity, all samples will be collected from within the legal boundaries of the Delta (Figure 6.1).

Previous efforts by both the Delta RMP and the Central Valley Regional Water Quality Control Board (CVRWQCB) have divided the Delta into roughly similar subregions based on hydrology and management practices. The Delta RMP has divided the Delta into 6 subregions based on the contribution of source waters, as described in the 2018 report *Modeling to Assist Identification of Temporal and Spatial Data Gaps for Nutrient Monitoring* (Jabusch, Trowbridge, Heberger, and Guerin 2018). The rotating basin monitoring design for pesticides and toxicity includes monitoring random points selected within waterways in each of the 6 subregions shown in Figure 6.2. Geographic data files (shapefiles) of the subregions are available upon request to the program manager, Matthew Heberger, matth@sfei.org.

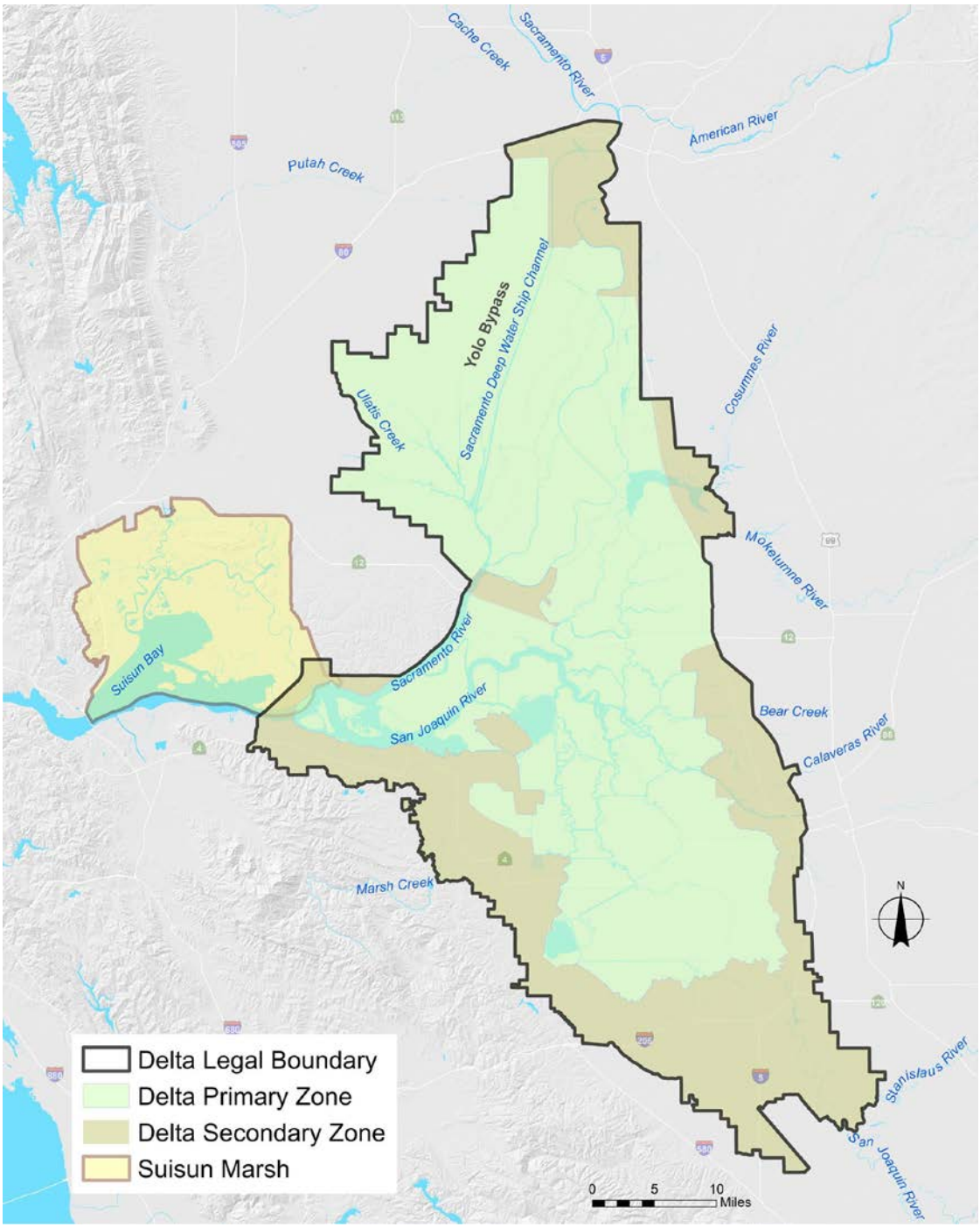


Figure 6.1 The geographic scope of the Delta RMP encompasses the legal Delta (as defined by section 12220 of the Water Code), including water bodies that directly drain into the Delta, Yolo Bypass, and Suisun Bay.

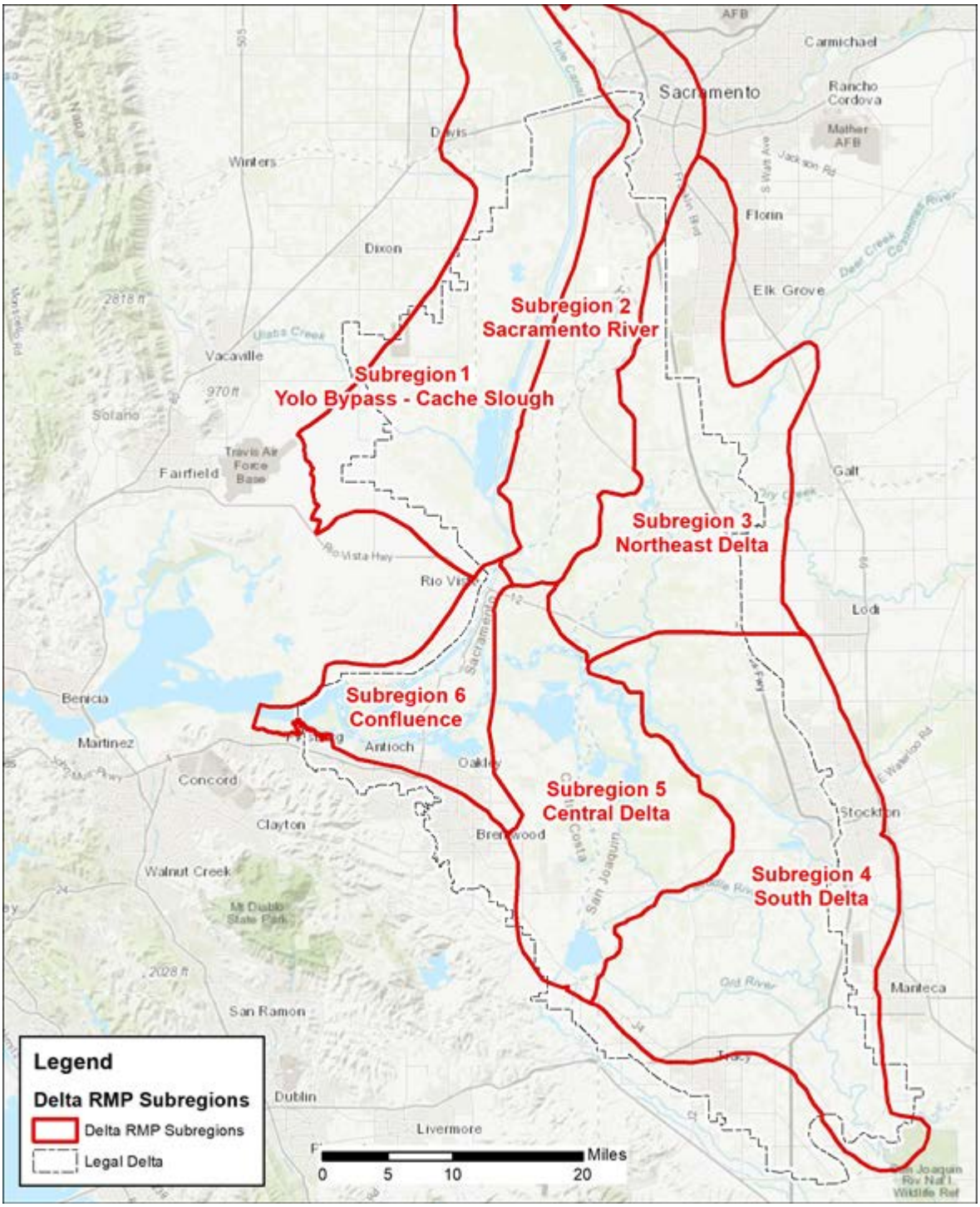


Figure 6.2 Map of Delta RMP Subregions for pesticides and toxicity sampling

6.3.2. Temporal Scope

Delta RMP Status & Trends monitoring is ongoing. Budgets are approved annually by the Steering Committee. A first phase of monitoring of mercury in sport fish and water is planned through 2019, in order to inform a re-opening of the Methylmercury TMDL. Phase two will include continued monitoring of mercury in largemouth bass, continued monitoring of water but at a lower level of effort than phase one, and will add monitoring the impacts of wetland restoration projects on accumulation of mercury in prey fish and largemouth bass.

The monitoring design for pesticides and toxicity is planned for 4 years with year 1 beginning in October 2018 and ending in September 2019.

The surface water samples for pesticide analyses are collected for 6 sampling events during each water year. Samples will be collected over the course of 2 to 3 days during 6 planned monitoring events which represent times of interest such as high agricultural and/or urban irrigation. Other sampling will occur during periods of high flow or following storms when pollutants are flushed from land surfaces into waterways via overland flow and drains. The specific timing for sampling events for pesticides and toxicity has been planned in collaboration with Delta RMP Pesticides Subcommittee and our science advisors and is documented in Section 6.4.3.

6.4. Monitoring Design

Delta RMP monitoring includes separate "projects" covering (1) mercury, (2) nutrients, and (3) pesticides and toxicity. The monitoring design for each constituent group is described below.

6.4.1. Mercury

The sport fish samples for mercury analyses are collected annually from fixed sites that represent different subareas of the Delta. Surface water samples for mercury analyses are collected from fixed sites that align with the Delta RMP sport fish monitoring sites. The schedule and frequency for water and sediment monitoring has varied from one year to the next based on budgets and priorities, as shown in Table 6.2(b) and Table 6.2(c).

The Central Valley Regional Water Quality Control Board has divided the Delta into eight subregions for assessing and managing methylmercury impairment (shown in Figure 6.3). The sampling design was developed with consideration given to distributing stations throughout these subregions, and comparing trends across the subregions.

Planned mercury sampling sites are shown in Figure 6.3 and listed in Table 6.2(a). The mercury monitoring element includes fish sampling and water sampling. The chemical analyte groups for this monitoring element include mercury and methylmercury and ancillary parameters such as chlorophyll *a*, dissolved organic carbon (DOC), total suspended solids, and volatile suspended solids.

In Fiscal Year 2019 - 2020 (FY19-20), 7 sites will be sampled for sport fish. A list of the targeted fish species is included in Section 11.1.2.3.

Sediment will not be sampled in FY19-20.

There will be 8 sampling events for water. The sampling schedule is shown in Table 6.2(a) through (c). Field crews will collect water samples at 8 sampling sites during 4 sampling events between July and October 2019. In the second half of FY19-20, field crews will collect water samples at 6 sampling sites during 4 sampling events between March and June 2020.

Sampling dates -- Scientists at Moss Landing shall choose the dates for water sampling in collaboration with ASC Principal Investigator Dr. Jay Davis and the Delta RMP Mercury Subcommittee. Any changes to planned sample dates shall be communicated to ASC staff in a timely manner.

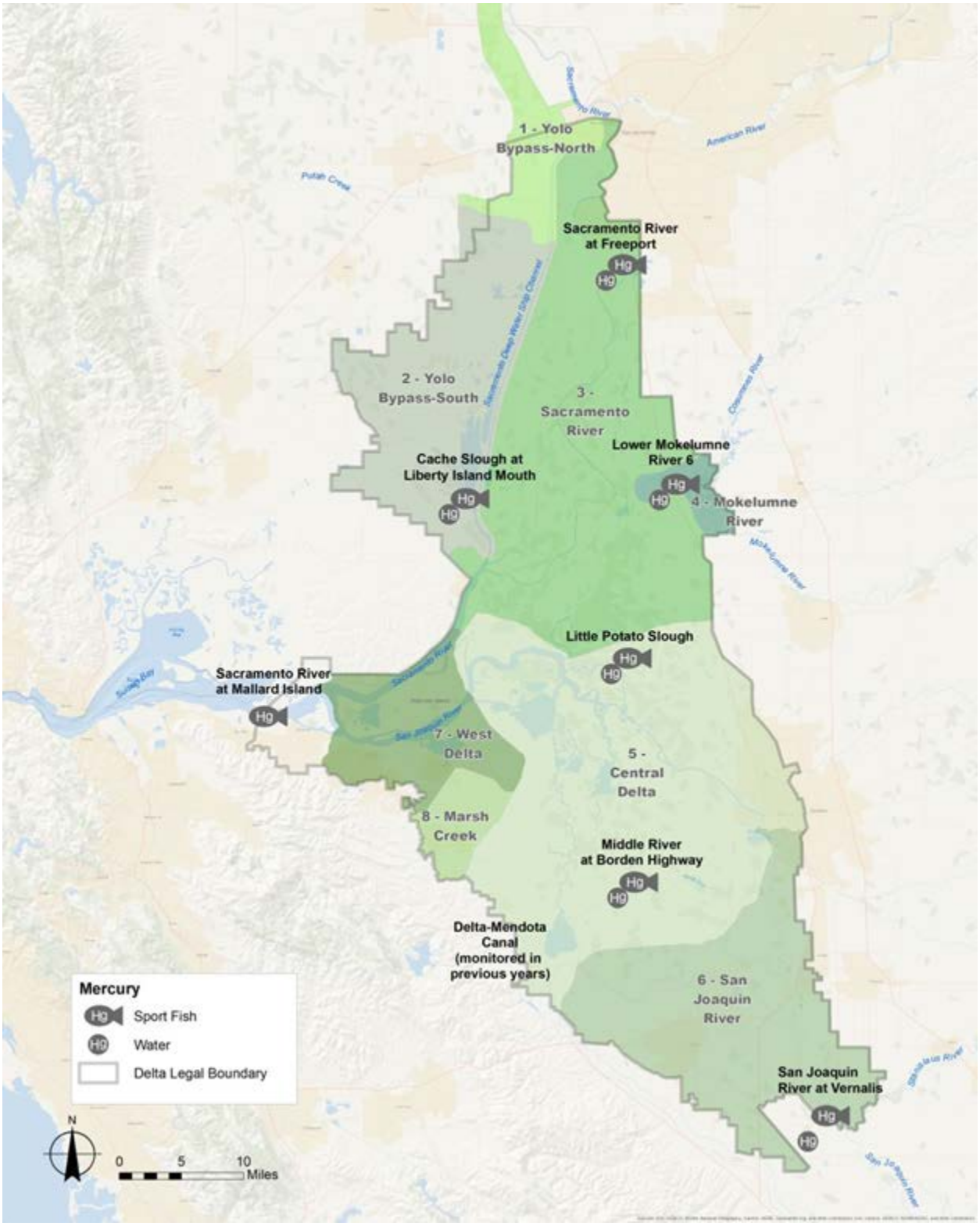


Figure 6.3 Map of mercury monitoring sites.

6.4.2. Nutrients - SRiNCS Project

The SRiNCS project will track the effects of changes in nutrient loading resulting from short-term wastewater holds at the Sacramento River Wastewater Treatment Plant. In the summer of 2019, scheduled wastewater effluent diversions will occur during the Effluent Valve Replacement project, part of the EchoWater Project upgrade at the Sacramento River Wastewater Treatment Plant. During an Effluent Valve Replacement diversion, no treated effluent will enter the Sacramento River for a period of up to 48 hours. Based on prior research (Kraus et al. 2017) this should create a parcel of effluent-free river water over six miles long in the Sacramento River. The SRiNCS project will compare samples collected from the effluent-free river water with the regular Sacramento River Wastewater Treatment Plant operations occurring just prior to the Effluent Valve Replacement hold. The magnitudes and impacts of short-term changes in nutrient loading to the river will be tracked within parcels of water as they move downstream in the Sacramento River and channels in the eastern Delta.

The project consists of a week-long river sampling campaign, field measurements and laboratory analyses. The project will use a range of methods, including high frequency fixed stations for water quality, mobile high frequency boat sampling of water quality, "grab" sampling of water quality, phytoplankton biomass, zooplankton biomass, and clam biomass, and phytoplankton carbon uptake (to determine growth rates). Data will be collected to study the response of phytoplankton to a range of nutrient loads and forms, as well as environmental factors including light, turbidity, water residence time, and grazing by zooplankton and clams. Numerical modeling will be used to describe proportions of water at sampling locations from various upstream sources, mixing, and water residence time. The model outputs will be used to interpret changes in nutrients, phytoplankton, and other water parameters observed in the study.

Timeline for the SRiNCS project -- Nutrient sampling for the SRiNCS project is scheduled to be conducted during one week-long period in late September 2019. Clams will be collected at each location sampled for nutrients during the subsequent field experiments. Clam trawl transects will be conducted within one month of nutrient sampling, to reduce the likelihood of clam movements or population biomass changes due to growth or mortality. Additional lab work (phytoplankton enumeration, estimation of phytoplankton growth rates) will be conducted in the weeks following the field sample collection. Numerical modeling will be conducted from approximately October 2019 to September 2020. Expected dates for project deliverables are as follows:

- Modeling results, Jun 30, 2020
- Particle-tracking products, Jun 30, 2020
- Draft report/manuscript, Nov 5, 2020
- Final report/manuscript, Dec 31, 2020

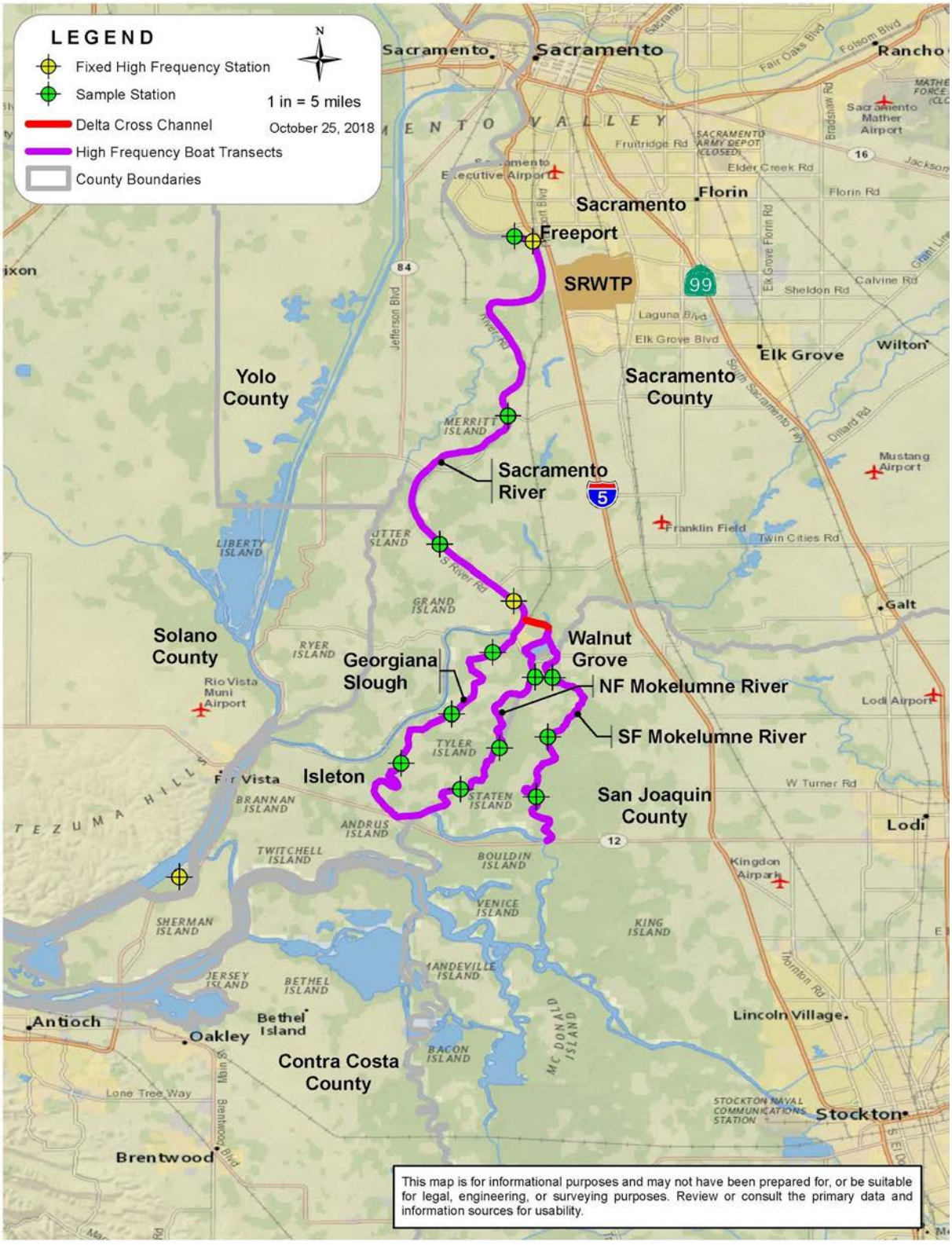


Figure 6.4 Study area for the Sacramento River Nutrient Change Study (SRiNCS) project.

6.4.3. Pesticides and Aquatic Toxicity

A "rotating basin" probabilistic monitoring design was chosen for the purpose of understanding the spatial extent of toxicity and pesticide concentrations (Table 6.3). In this instance, the "basins" are 6 Delta subregions. Under the rotating basin monitoring design, crews shall collect enough samples in each subregion to adequately characterize the mean and variance of pesticide concentrations and toxicity in each subregion. Samples will be collected by boat at randomly-selected locations within each subregion. The locations and timing of sampling are described in more detail below.

Environmental water samples will be analyzed for a suite of current-use pesticides and for chronic toxicity to 5 organisms as shown in Table 6.1. For each sample, all 5 organisms will be tested. In 2019, staff and the Technical Advisory Committee may consider creating a set of decision rules for which organisms to test based on water quality conditions. For example, invertebrates such as *Ceriodaphnia* and *Hyalella* are known to survive and reproduce well in a relatively narrow range of salinity and hardness. When environmental samples are outside of these ranges, test results are difficult to interpret, and it may be best to save money rather than running these tests.

In addition, the monitoring design calls for continued monitoring 6 times per year at two fixed sites. Both sites, Ulatis Creek at Brown Road and San Joaquin River at Buckley Cove, are locations where aquatic toxicity has been observed by Delta RMP monitoring in the past (see locator map in Figure 6.5). For more information on the first year of Delta RMP pesticides monitoring, see recent reports by the USGS (De Parsia et al. 2018) and SFEI-ASC (Jabusch, Trowbridge, Heberger, Orlando, et al. 2018). Fixed site monitoring allows us to detect temporal trends at these two sites and to analyze the correlation between observed pesticide concentrations and aquatic toxicity. By sampling at the same location repeatedly, it holds a greater number of factors constant in comparison to the rotating basin component of the monitoring design. This may provide additional opportunities to test for an association between pesticides and toxicity at these locations.

The monitoring design involves collecting 48 ambient surface water samples in each water year from 2019 to 2022. This monitoring design will result in 24 samples being collected from each of the 6 Delta subregions after 4 years of monitoring. This allows project scientists to make inferences about water quality conditions across the Delta, as well as to detect differences among the subregions. If the monitoring design is continued in the future, scientists may be able to draw inferences about trends or changes over time. However, trend detection is not an emphasis of the rotating basin component of the design.

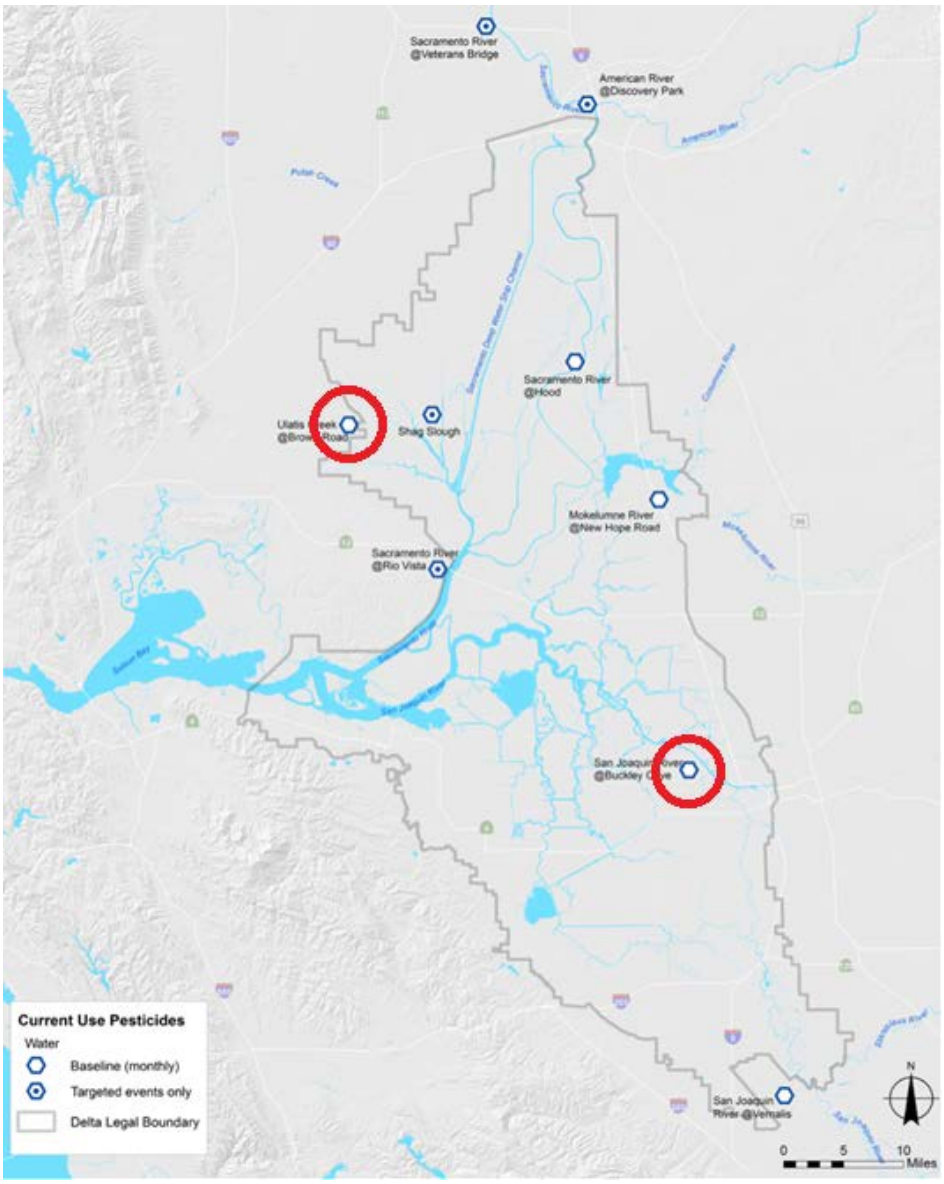


Figure 6.5 Map of Delta RMP "integrator" sites monitored for pesticides and aquatic toxicity from 2015 to 2017, highlighting the two fixed stations selected for continued sampling in Water Year 2019.

Sampling Locations

Table 6.4 contains information about the sampling locations, such as the siteID (a unique identifier assigned to each location), subregion, and latitude and longitude coordinates. If a site is inaccessible, field crews will cross this site off the list, and sample the next "oversample" site on the list. Field crews should communicate this to the program manager.

These sampling points were created by performing 5 Generalized Random Tessellation Stratified (GRTS) draws using the R software. The project team selected draw #3, which looked the most "reasonable;" with points reasonably spaced, and no samples appearing too close to one another. Further, it included sample points in waterways that our technical advisors deemed important such as Discovery Bay, Miner Slough, Steamboat Slough, and the Stairstep.

Before sampling, the field crew chief will inspect each point against aerial photos, and make sure it can be safely reached by boat. If in doubt, the field crew should reject the site and choose the next site on the "oversample" list.

The order of visiting sampling sites during each sampling event does matter. Field crews should aim to collect all samples in one day, or on two consecutive days, to minimize the hold times and to ensure that the toxicity tests can all be initiated in a single batch. The field crew may sample sites in the order that is most efficient in terms of time, fuel, and other logistical factors.

If the field crew determines that a sampling site is inaccessible or unsafe, a sample should be taken within 100 meters if possible and only if there is not some obvious change in the environment, such as moving downstream of an outfall, a change in water clarity, etc. If not possible to sample within 100 m, the crew should choose the next site on the "oversample" list shown in Table 6.4.

The monitoring design calls for sampling in 2 subregions each year. Sampling shall begin in regions 1 and 2 in Water Year 2019: (1) Yolo Bypass-Cache Slough, and (2) Sacramento River. Afterwards, sampling will be done in 2 subregions in each year.

As described above, in Water Year 2019, field crews will collect a total of 24 samples in the first subregion, and 12 samples in the second subregion. In other words, the second subregions will be sampled at "half intensity," with sampling split across two consecutive years. After four years, crews will have collected the desired number of samples (n = 24) in each of the 6 subregions. The detailed plan for how many samples to collect in each subregion is outlined in Table 6.5.

For subregions sampled at an intensity of n = 12 each year, crews will collect 2 samples during each of the 6 sampling events described in the following section.

Field crews will collect one-sixth of the total samples during each event. For subregions being sampled at full intensity, 4 samples will be collected during each event. For subregions being sampled at half intensity, 2 samples will be collected during each event. The number of samples collected during each event is detailed in Table 6.6. This table shows the number of regular environmental samples of ambient water to be collected.

In addition, field crews should collect field blanks and field duplicate samples at a rate of 1 per 20 samples, as prescribed in Table 14.2. As the study design calls for 48 samples per year, this

translates to 3 field duplicates collected during 6 events. The suggested schedule for field duplicates is as follows:

- 1 at a GRTS site during Event 1
- 1 at San Joaquin River at Buckley Cove during sampling Event 3
- 1 at Ulatis Creek during sampling event 5.

Adaptive management of the monitoring design is an important component of Delta RMP monitoring. While a 4-year plan is described here, to date, the Delta RMP Steering Committee has only allocated funding for Water Year 2019. Changes to the schedule described here may be made based on budgets, evolving priorities, or lessons learned from our sampling and data analysis. Changes may be made by the program manager, in consultation with the Pesticides Subcommittee. Major changes shall be subject to review by the Technical Advisory Committee and approval by the Steering Committee. Significant changes shall be documented as an amendment to, or revision of this document.

Sampling Events

Sampling for pesticides and aquatic toxicity will be conducted over 6 events during the water year, designed to capture a range of hydrologic conditions and periods of the agricultural calendar. Among the 6 planned events, 3 are for storm sampling, and 3 for dry weather / irrigation season. It is necessary to space sampling events by at least 2 weeks so the labs can process all the samples from the previous round.

Samples will be taken on the ebb tide, if possible.

Planned timing of sampling events is shown in Table 6.7. This table shows how the six events have been designed to capture a variety of hydrologic conditions throughout the year. The timing of sampling events shall be planned by the field crews and scientists at the Organic Chemistry Research Laboratory (OCRL), in collaboration with staff of the Aquatic Health Program Laboratory at UC Davis (toxicity lab), to ensure that the lab is ready to accept water samples and initiate the toxicity tests. The sampling triggers for storm sampling in Table 6.7 are guidelines and may be adjusted by the project scientists based on their best professional judgment. Scheduling of sampling events and changes to the schedule shall be communicated with ASC staff in a timely manner.

Staff also maintain an online spreadsheet "dashboard" that documents the planned and actual monitoring dates as they are established.

6.5. Constraints

There is a constraint related to the timing of sampling for pesticides and toxicity due to the operations of the toxicity testing lab. The monitoring design calls for collecting "split" samples at the same place and time, and sending a portion of the sample for pesticides chemical analysis, and the other portion to the toxicity testing lab. This sample design is intended to determine whether there is a relationship between pesticides in Delta waterways and harm to aquatic ecosystems. Because of the way the lab is staffed and operated, field crews can only collect samples on Monday through Thursday because of timing of getting test organisms into the lab and getting the tests set up.

The ability to measure some of the target compounds at the ultra-trace levels found in the ambient environment may be constrained by the detection limits routinely achievable by analytical laboratories. Target detection limits in this document represent those achieved by laboratories contracted by the Delta RMP or levels needed to obtain quantitative measurements of ambient concentrations in a majority of samples.

Another constraint is that discrete samples represent only a moment in time and may therefore not always represent conditions during other time periods.

6.6. Evaluation of Monitoring Data

Data analysis and interpretation in the Delta RMP provide answers to the assessment questions, and ultimately, the management questions (see Section 5.1).

Program participants develop the interpretation collectively in a science-based and collaborative process. With oversight by the TAC, program staff and contracted independent scientists conduct the relevant analyses by evaluating the data against the specific monitoring questions and benchmarks.

6.6.1. Mercury

The specific monitoring questions for mercury are listed in Section 5.1.2 and Table 5.1. Mercury concentrations in largemouth bass will be evaluated for trends in time series and compared to the TMDL implementation goal of 0.24 mg/kg in 350 mm largemouth bass. Water concentrations for total methylmercury will be compared to the TMDL implementation goal of 0.06 ng/L. Water concentrations for total and filtered methylmercury and mercury will be compared to past data to evaluate trends. Observed concentrations in water will also be related to concentrations in fish and sediment, in order to update the TMDL linkage analysis. A better understanding of the linkage, or relationship, between aqueous mercury and the concentration in fish tissue is an important goal of this study, in order to inform management

Restoration monitoring with prey fish will allow comparison of mercury bioaccumulation between stations in restoration projects and at reference locations, comparisons between years in the early stages of monitoring, comparisons to historic data at nearby stations, and in the long-term evaluation of trends at a decadal scale.

6.6.2. Nutrients - SRiNCS Project

The high-resolution nutrient monitoring part of the SRiNCS project is designed to document the spatial variability of nutrients for the purpose of evaluating longitudinal transformation in nutrient concentrations, forms, and ratios in different zones within the study area. Analysis of spatial variation will evaluate statistically significant variations in nutrient concentrations that exceed uncertainty. Descriptive statistics and multivariate classification of both the laboratory and in situ optical measurements will be obtained using parallel factor analysis (PARAFAC), principal component analysis (PCA), and/or discriminant analysis (DA) to obtain significant variation over spatial and temporal scales. The goal is to identify "hot spots" of nutrient transformation and to locate internal sources and sinks for nutrients within the Delta.

Using the field and laboratory data generated during the SRiNCS project, longitudinal, time series, and regression plots will be generated to examine general patterns in the flow, water quality, phytoplankton, and zooplankton data; these patterns will in turn guide further analyses. Graphical analyses will be conducted to expose any broad trends along the river segments, and between different nutrient loading conditions (with and without wastewater effluent). Curves will be fitted to trends along the river, for variables including nutrient concentrations, Chl-a, plankton biomass, plankton growth rates, zooplankton and clam grazing rates, and these curves will be compared for statistical differences between nutrient loading conditions. Comparative methods will include regression analysis along river gradients, and Analysis of Covariance (ANCOVA) comparisons of phytoplankton biomass and growth among the nutrient loading conditions. In addition, RMA staff will use their numerical modeling applications RMA2, RMA11 and RMATRK to provide hydrodynamic, transport and particle tracking modeling analyses, respectively, of the study area before and during the Effluent Valve Replacement diversion period to support analysis of the sampling data.

6.6.3. Pesticides and Aquatic Toxicity

A better understanding of the effects of contaminants in the apparent decline of Delta ecosystems is a priority for regulators and stakeholders. Pesticide use in the Delta and Central Valley is one of the potential drivers of these effects. One of the goals of toxicity testing is to determine whether Delta waterways contain toxic substances in toxic amounts that are impairing the attainment of beneficial uses such as fish and wildlife habitat or municipal water supply.

The overall objectives of the Delta Regional Monitoring Program's (Delta RMP's) Current Use Pesticide (CUP) monitoring program are to collect ambient surface water samples to answer the program's Management and Assessment Questions (Appendix B and Appendix C). The management and assessment questions are broad and the Delta is large, so addressing them will require a correspondingly large effort over the course of several years. The study design was developed to make the best use of available funding to answer the highest priority Management and Assessment Questions in an initial effort to characterize the status and trends of pesticide concentrations and toxicity in the Delta.

6.7. Products and Reporting

Table 6.8 provides a summary of key products of the Delta RMP. Data from Status and Trends monitoring efforts will be made available annually for download via:

- SFEI's Contaminant Data, Display and Download tool (CD3)
- The California Environmental Data Exchange Network (CEDEN)
- The California Estuaries web portal (link)

Data will be reported in annual data reports, constituent-specific technical reports (every 2-3 years).

The *Pulse of the Delta* will be the main interpretive reporting vehicle for Delta RMP results. The audience of this report will be local, state, and federal decision-makers, and the interested public. The data will be interpreted to answer Delta RMP management and assessment questions, based on the most appropriate statistical analyses to be used for evaluating the data in relation to a question, as guided by the TAC. The *Pulse of the Delta* will be prepared by ASC and external authors that will be identified by staff and the Steering Committee. Both the TAC and the SC will provide review of the Pulse of the Delta. Prior to release of the Pulse of the Delta, SFEI-ASC will provide basic annual data reports (Annual Monitoring Reports) for review by the TAC and SC.

Technical reports will provide a more in-depth evaluation of monitoring and special study results. Technical reports will facilitate technical review of Delta RMP studies and are targeted to a technical audience. The annual reports and 3-year interpretive technical report for mercury will be prepared by staff from ASC and MPSL. The technical report for the 1-year nutrient study will be prepared by USGS. Technical reports for mercury and nutrients will be submitted first to the Mercury and Nutrient Subcommittees and then to the TAC for technical review. The technical report for the SRiNCS will be prepared by overall project manager Lisa Thompson, with chapters developed by the principal investigators for each sub-component of the project. When the technical review is completed, the TAC will make a recommendation to submit the reports to the SC for approval.

Monitoring results will be one of the main decision factors for adaptive changes to the monitoring program. An annual SC planning meeting/workshop will identify adaptations needed to the monitoring program and will be informed by monitoring results. In addition, the TAC will have access to preliminary data through the TAC workspace website maintained by ASC. On this website, provisional data and draft reports are available to SC, TAC, and subcommittee members via password-protected pages.

6.7.1. QA Summary Report

The Project QA officer or designee shall write a report for each dataset outlining the quality of the data. This report highlights any issues that were addressed by the laboratory, project manager, or data management staff. The QA Summary Report includes the following details:

- Lab
- Matrix
- Analyte
- Reporting Issues for Lab to Review
- Formatting Issues for Data Manager to Review
- QA Review:
    - Dataset completeness
    - Overall acceptability
    - MDLs sensitivity
    - Blank sample averages (procedural, field blank)
    - Average precision from replicate field sample
    - Accuracy (using a variety of standard reference materials or matrix spike quality assurance recoveries)
    - Comparison of dissolved and total phases
    - Comparison of results to previous year's observations

The QA summary report will be reviewed and approved by the QAO and program manager, and is typically included in a year-end data report as an appendix. These reports are reviewed by the Delta RMP Technical Advisory Committee and approved by the Steering Committee prior to being published.

Annual data reports are planned for each of the focus areas (pesticides, mercury, etc.).

7. Quality Objectives and Criteria

7.1. Data Quality Objectives

Data Quality Objectives (DQOs) aim to support defensible conclusions that address the management questions and assessment questions in Appendix B and Appendix C.

7.1.1. Pesticides

The overall objectives of the Delta RMP's Current Use Pesticide (CUP) monitoring program are to collect ambient surface water samples to answer the Program's Management and Assessment Questions. The management and assessment questions are broad and the Delta is large, so addressing them will require a correspondingly large effort over the course of several years. The study design was developed to make the best use of available funding to answer the highest priority Management and Assessment Questions in an initial effort to characterize the status and trends of pesticide concentrations and toxicity in the Delta.

The priority question driving the design for the CUP study is:

ST1. To what extent do current use pesticides contribute to observed toxicity in the Delta?

ST1.1 - If samples are toxic, do detected pesticides explain the toxicity?

ST1.2 - What are the spatial and temporal extent of lethal and sublethal aquatic and sediment toxicity observed in the Delta?

ST2 - What are the spatial/temporal distributions of concentrations of currently used pesticides identified as possible causes of observed toxicity?

Data quality objectives (DQOs) for the pesticides and toxicity monitoring program are shown in Table 7.1. The decision rules in Table 7.1 anticipate that parametric statistical methods will be used. If data are non-normally distributed or regression residuals are non-normal, there may be a need to use nonparametric statistical analysis methods. Non-parametric methods may require larger sample sizes to answer the assessment questions listed in Table 7.1. The table shows tolerable limits on decision errors (referred to by statisticians as *alpha* and *beta*) based on commonly used assumptions in similar scientific studies. The planned study calls for a statistical significance level (alpha) of 0.05 for a one-tailed hypothesis test. For example, suppose you are testing whether more than 1% of river miles have a pesticide concentration exceeding a threshold. With alpha = 0.05, there is a 5% chance of a false positive with hypothesis testing (incorrectly concluding that concentrations in these river miles exceeds the threshold.) The choice of beta of 0.2 is the probability of a false negative. Statistical power is 1 – beta or 0.8. This means, for example, that you have a 20% chance of incorrectly concluding that a predicted pesticide concentration does not exceed a threshold.

Water quality thresholds – The simplest and most straightforward way of determining whether a chemical may be causing an adverse impact on a waterway is to compare observed concentrations to a water quality threshold or benchmark. When a threshold has the force of law, it is referred to as a standard, or in California, a water quality objective. However, state and federal regulators have written standards for only a few current use pesticides. For example, the Central Valley Regional Water Quality Control Board has established water quality objectives for chlorpyrifos and diazinon that cover much of the Central Valley including the Delta.[1] For the hundreds of other current use pesticides, there are neither national water quality criteria recommended by the EPA, nor are there state water quality objectives.

Comparing ambient concentrations to benchmarks is a useful first step in the process for interpreting pesticide data and evaluating relative risk. The choice of a threshold is important. If our monitoring shows that concentrations exceed a threshold, the implication is that there is a problem. Yet, the choice of a threshold is a complicated technical question. *Project scientists have not have not explicitly defined thresholds for pesticides*, in part because this work is ongoing, as part of an analysis of pesticides and toxicity data contracted by the Delta RMP to the firm Deltares.

Options for setting thresholds include aquatic life (AL) benchmarks published by the US EPA Office of Pesticide Programs (OPP). OPP benchmarks were developed by the EPA for use in the agency's risk assessments conducted as part of the decision-making process for pesticide registration. The OPP benchmark values are based on the most sensitive species tested within taxonomic groups (fish, invertebrates, vascular and non-vascular plants). They represent the lowest toxicity values available from peer-reviewed data with transparent data quality standards. OPP benchmarks may or may not be useful for interpreting Delta RMP toxicity data. However, these thresholds are broadly relevant to protecting aquatic life. It has also been suggested by TAC members that it may be appropriate to divide OPP aquatic life benchmarks by a safety factor of 5 or 10. This would be in line with the precautionary principle, and consistent with the CVRWQCB's Basin Plan, which states that standards will be based on the lowest LC50 divided by 10.[2]

Handling of non-detects – In the first two years of pesticide monitoring by the Delta RMP, many of the pesticide chemistry results were non-detects. Statistical methods should be chosen

[1] See *Amendments to the 1994 Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Central Valley Regional Water Quality Control Board, 2016), Table III-2A, Specific Pesticide Objectives, on page III-6.01. Chronic toxicity is based on the average concentration over a 4-day period.

[2] See Amendments to the 1994 Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (2016), page IV-35: "Where valid testing has developed 96 hour LC50 values for aquatic organisms (the concentration that kills one half of the test organisms in 96 hours), the Board will consider one tenth of this value for the most sensitive species tested as the upper limit (daily maximum) for the protection of aquatic life. Other available technical information on the pesticide (such as Lowest Observed Effect Concentrations and No Observed Effect Levels), the water bodies and the organisms involved will be evaluated to determine if lower concentrations are required to meet the narrative objectives."

carefully for handling "censored data" (Helsel 2010). Common methods used in the past, such as substitution of zero or one-half the detection limit for non-detects, are known to introduce bias in data analyses. One of our science advisors has recommended the use of the "Nondetects and Data Analysis (NADA)" package in R created by D. Helsel (USGS). Staff anticipate that useful guidance will also be developed as a part of the Delta RMP-funded interpretive report underway by Deltares. The Delta RMP TAC will continue to evaluate non-detect analysis options and provide guidance for future use of non-detect data in interpretative reports and annual summaries. All non-detects will be coded in CEDEN as less than the MDL.

7.1.2. Aquatic Toxicity

For the Delta RMP, the primary goal of toxicity testing is to determine whether pesticides are potentially causing significant aquatic toxicity in the Delta. Toxicity testing is an integrative tool because it evaluates the combined effects from multiple constituents on biota concurrently in site media, and provides an environmentally relevant understanding of the potential for beneficial use impairment. Chemical analyses are also important for understanding trends and can be compared with paired sample toxicity test data to identify which pesticides (or other parameter) might be contributing to observed effects.

Toxicity Identification Evaluations (TIEs) are an investigative tool that can be used to identify the cause of toxicity. The primary goal of Delta RMP TIE testing is to determine if pesticides (or degradates, or any of the inert ingredients in the formulated product), are contributing to observed effects.

Appendix I describes the protocol the Delta RMP will follow for deciding whether to initiate a TIE. TIEs are planned for Delta RMP samples when there is a $\geq$ 50 percent adverse effect observed (for *either* chronic and acute tests, at *any* point during the test, and for *all* test organisms and *all* endpoints).

TIEs should be initiated within 48 hours of the observation of the TIE trigger being met in the initial sample screening. The primary goal of Delta RMP TIE testing is to identify whether pesticides are causing or contributing to observed toxicity, and if so, which pesticides (or degradates, or any of the inert ingredients in the formulated product) are the drivers. Potential toxicity drivers may be elucidated (via weight of evidence) from the TIE, paired chemistry data, and/or with more advanced TIEs. A secondary goal is to identify other factors (i.e., water quality conditions or other toxicants) contributing to reduced survival, growth, or reproduction.

Table 14.3 and Table 14.4 outline the data quality indicators and MQOs for toxicity testing and water quality measurements associated with the toxicity testing procedures**.** Test Acceptability Criteria shall follow SWAMP guidance (most recent version dated August 22, 2018).[3] Test

[3] https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/chronic_freshwater_tox_mqo_082218.pdf

results will be rejected when test acceptability criteria are not met. However, a sample may be retested and qualified as having exceeded the recommended hold time if the SWAMP contract manager and the AHPL laboratory manager agree on the need for additional testing/retesting.

7.1.3. Mercury

The Delta Methylmercury TMDL uses a tissue-based implementation goal of 0.24 ppm in 350 mm largemouth bass to determine impairment within Delta subregions. Monitoring of mercury concentrations in sport fish tissue as an index of mercury impairment in the Delta and as a performance measure for the TMDL was identified by the Delta RMP as a priority data need.

The priority question driving the design for the initial phase of methylmercury monitoring is:

ST1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?

ST1.A. Do trends over time in methylmercury in sport fish vary among Delta subareas?

ST1.B. Do trends over time in methylmercury in water vary among Delta subareas?

The initial and preliminary data quality objective (DQO) for subregional bass trend monitoring is the ability to detect a trend of mercury in 350 mm largemouth bass of 0.040 ppm/yr. This DQO can be refined when additional data are available. MQOs are identical to those used in other mercury studies throughout the state for determinations of impairment and trend detection. These MQOs generally call for indices of accuracy and precision to be within 30% of expected values.

The Delta Methylmercury TMDL describes a statistically significant relationship between the annual average concentration of methylmercury in unfiltered water and average mercury in 350 mm largemouth bass, when data are organized by subarea. The linkage of aqueous methylmercury concentration to fish mercury concentration provides a connection between methylmercury inputs from various in-Delta pathways (e.g., municipal wastewater, municipal stormwater, agricultural drainage, and wetlands) and impairment of beneficial uses. Because of this linkage, the Delta Methylmercury TMDL established an implementation goal of 0.06 ng/L of unfiltered aqueous methylmercury[4,5]. Monitoring of fish mercury and aqueous

[4] For methylmercury, aqueous samples should be analyzed using USEPA method 1630 with a method detection limit of 0.02 ng/L or less. For total recoverable mercury, aqueous samples should be analyzed with a method detection limit of 0.2 ng/l or less.

[5] The preferred method for total mercury is USEPA Method 1631 Revision E. If quality control objectives are not being met (for example, recoveries in matrix spike samples are outside of expected limits) and matrix interferences are suspected as the cause,

methylmercury is needed to: better quantify the fish-water linkage that is the foundation of the TMDL; support development of a mercury model for the Delta; support evaluation of the fish data by providing information on processes and trends; and provide mass balance data for re-evaluation of the Delta Methylmercury TMDL, when it is updated in 2020.

For restoration monitoring with prey fish to answer sub-questions calling for comparisons among stations over time and space, based on data collected for the same target species with the same design in the North Bay Biosentinel Project, ANOVAs to detect differences in means across groups of stations will have high power (> 0.99), and pairwise comparisons will have 80% power to detect a difference of 0.023 between stations or time intervals.

7.1.4. Nutrients - Sacramento River Nutrient Change Study

The priority DRMP questions driving the design for the SRiNCS project are:

ST1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?

ST1.A. B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology?

2. ST2. What is the current status of the Delta ecosystem as influenced by nutrients?

ST1.A. ST2. A. What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?

3. SPLP1. Which sources, pathways, and processes contribute most to observed levels of nutrients?

ST1.A. SPLP1.A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters?

4. FS1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?

The DQOs for each of the components of the SRiNCS project (high frequency mapping, water quality, phytoplankton and zooplankton enumerations, water flow modeling, phytoplankton growth assays, zooplankton growth assays, and clam biomass sampling) are described in the sub-sections below. The DQOs are designed to provide sufficient levels of accuracy and precision to allow the assessment of the spatial variation of nutrients and their transformations

USEPA Method 245.7 may be used, if detectable concentrations are within the range of the method's calibration and quality control criteria.

along the Sacramento River, Georgiana Slough, the North Fork Mokelumne River, and South Fork Mokelumne River during the summer low flow period.

In addition, the DQOs are expected to allow assessment of the current status of the Delta ecosystem as influenced by nutrients in terms of the state of phytoplankton biomass and growth in the noted rivers and slough. Furthermore, the DQOs have been designed to allow an assessment of how nutrient source control (temporarily halting nutrient discharge from the Sacramento Regional Wastewater Treatment Plant) changes ambient nutrient levels and nutrient-associated parameters such as phytoplankton biomass and growth in the noted rivers and slough.

Further, the DQOs of the SRiNCS project components will provide adequate baseline data to assess how ambient water quality conditions will respond to a planned future source action, the decrease in nutrient loading from the Sacramento Regional Wastewater Treatment Plant by 2021. The locations, frequency, and replication of sampling events is designed to support the planned statistical evaluation of the monitoring data, as previously described in Section 6.6.2.

7.1.4.1. SRiNCS High Frequency Mapping

For the high frequency water quality mapping part of the SRiNCS project, the DQO used is the ability to assess the statistical significance of spatial variation with a defined threshold of $p < 0.001$, based on cumulative uncertainty. To meet the DQO, performance criteria require accuracy of laboratory measurements to within 5% of the measured value at 3 times the method reporting limit and of underway instruments to < 2% of the full-scale value. The performance criteria also require that the underway paths are representative of the complexity of the Delta and its tributaries. Uncertainty due to analytical errors in underway instrumentation is included in the replication inherent in high frequency sampling and reported together with natural variation as standard deviation across averaging periods.

Underway instrument performance will be validated against laboratory values and the uncertainty published in the report. Analysis of spatial variation will use this uncertainty to only highlight statistically significant variations that exceed uncertainty. The cumulative uncertainty will be estimated in quadrature or using Monte Carlo simulations over the domain of the uncertainty of the individual measurements.

7.1.4.2. SRiNCS Water Quality

The Regional San Environmental Laboratory is certified by the California Environmental Laboratory Accreditation Program (ELAP). Data quality objectives for this project will measure both completeness and correctness. An acceptable completeness goal for this project will be 90% completeness and will include both collection and transport of sample and the laboratory

analysis completeness. Completeness is assessed based on the number of samples successfully obtained and validated for use in this study and the proportion of quality control samples that are within acceptance criteria.

Correctness will include using the appropriate analytical method, sampling technique, preservation and all the required Quality Control (QC) for the type of analysis performed (for more detail, see Section 14.2 and Table 14.2) . Data quality objectives for accuracy, precision, recovery, and contamination are determined through a combination of instrument calibration and the analysis of duplicates, blanks, and spikes. Accuracy, precision, and recovery are assessed through the use of QC samples by the laboratories. Laboratory spikes and matrix spikes are used to assess accuracy and recovery, and duplicates are used to assess precision. All of the sampling and analysis performed for this project will comply with the appropriate laboratory or method required QC. When analysis is not in compliance with these established method criteria the lab will notify the program manager (Lisa Thompson) and the contract manager (Matt Heberger) and will include a narrative/qualifier in the draft final report.

7.1.4.3. SRiNCS Phytoplankton and Zooplankton Enumerations

The QA/QC that BSA uses for its analyses of phytoplankton and zooplankton samples is as follows. All phytoplankton and zooplankton samples will be processed at the BSA laboratory using side-by-side, identically calibrated microscopes with confirmation of all taxonomic designations by another taxonomist. Ten percent of the zooplankton, phytoplankton and diatom samples will be enumerated by a second taxonomist for quality control/quality assurance if required, with results meeting the performance criteria of 90% percent similarity by using the following formula for the Percent Similarity of Community (PSC):

$$PSC = 1 - 0.5 \sum_{i=1}^{k} |a - b|$$

If percent similarity is less than 90% for any sample, reasons for the discrepancy between analysts will be discussed within the laboratory and documented within the data and the cover letter accompanying the data submittal. If the laboratory technical lead identifies major differences in how analysts have been identifying organisms, samples may be recounted. BSA is certified by Abraxis, a manufacturer of the Enzyme-Linked Immunosorbent Assay (ELISA) test kit, and has participated in the testing of blind samples sent to BSA by Abraxis.

7.1.4.4. SRiNCS Water Flow Modeling

The QA/QC for the numerical modeling part of the SRiNCS project is as follows. RMA will gather boundary condition data for the project time period, QA/QC the data (i.e., compare flow values at sequential flow monitoring stations along a particular river to ensure that flow volume

is conserved, that is, that more/less flow does not appear at a downstream station for which no new flow inputs/exports could have occurred), run and document the flow model setup and results, and document the transport model setup and output for volumetric source water calculations.

Documentation will include boundary condition metadata, volumetric model output, graphics and associated calculations. Modeling results will include an estimate of the model's accuracy and variance (statistical power) for the computations. The localized upgrades to the existing grid (conversion from 1-D to 2-D will require a check on flow and stage calibration locally and at selected downstream locations. Documentation for the tracer study will include metadata for the tracer data and its use in various model calculations. Documentation for the particle tracking work will include a description of the particle tracking model set-up, and travel time estimates.

7.1.4.5. SRiNCS Phytoplankton Growth Assays

The QA/QC that AMS uses for phytoplankton growth assays is as follows. All sampling equipment used with the phytoplankton growth assays will be acid-cleaned and rinsed three times with ambient river water before being filled with sample water.

All uptake experiments will be started within 3 hours of each other, so that sampled phytoplankton will receive a similar amount of light.

Uptake determination bottles will be kept in a flow-through incubator which will have two layers of darkened neutral density netting (top and sides) to limit light intensity to 40% of surface irradiance to prevent excessive irradiation. Shadows should be kept off the incubator. Water temperature in the incubator will be monitored with a digital thermocouple thermometer. Incubator water temperature will be kept constant at a temperature close to the temperature of the river water (±2 ^{o}C) by various methods of water exchange coupled with cooling. Filtered uptake samples will be dried in a drying oven and stored in a desiccator until analysis to prevent degradation.

7.1.4.6. SRiNCS Zooplankton Growth Assays

The QA/QC that SFSU uses for zooplankton growth assays follows the SOPs of the Kimmerer Laboratory (see Appendix E for links to all SOP documents). There is no minimum or maximum growth rate necessary for a growth assay to be considered successful. Copepod zooplankton will be collected using net tows at a gentle tow speed (less than 1 m/s) to avoid damaging the organisms.

The bottom of the net will not be rinsed to avoid using individuals that have been stuck to the net and potentially damaged. The sizes of filters used will be chosen based on the species and life stage to be studied, to fractionate the sample into appropriate size/age classes. Sub-samples

of each zooplankton cohort will be counted under a microscope in order to determine the correct volume of sample is needed in order to have 100 to 150 individuals in each cubitainer.

River water and plankton samples will be transferred to the SFSU Kimmerer laboratory on the same day as they are collected so that growth incubations can begin the same day. Incubation chambers will incubated at temperatures as close to in situ as possible. Six replicate time zero samples will be taken and five replicate samples will be taken for each time period (usually 48 hours and 72 hours).

Records will be kept throughout the process, including incubation start time, filtering start times, and time of preservation.

7.1.4.7 SRiNCS Clam Biomass Sampling

The QA/QC that Regional San uses for clam collection is as follows. There is no minimum number of clams needed for a trawl pull to be considered successful. However, if the clam trawl becomes caught on the bottom, and noticeably slows the boats trawling speed, the transect will be repeated in a slightly different location of the river to avoid the snag. If a repeated trawls are necessary, only clams from the second trawl will be collected for analysis.

The clam trawl will be visually inspected by two investigators following each trawl to ensure that all clams are collected from the sample basket. During the shell sizing analysis in the laboratory, clam shells will be manually verified to contain tissue, so that shells filled with mud are excluded from the analysis. Sizing calipers will be tared to zero daily.

7.2. Data Quality Indicators

Data Quality Indicators (DQIs) are the quantitative measures and qualitative descriptors used to set limits of acceptable levels of data error. The principal data quality indicators are precision, accuracy/bias, comparability, completeness, and representativeness (SWRCB 2017).

- **Precision** describes how close the agreement is between multiple measurements (SWRCB 2017).
- **Accuracy (Bias)** 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).
- **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).
- **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).

- **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).
- **Sensitivity** is the ability of a measurement to detect small quantities and differences in concentration of the measured component.

7.3. Field Quality Control Measurements for Sensors and Sample Collection

7.3.1. Field Measurements

Precision of field measurements is determined by repeated measurement of the same parameter within a single sample, or samples taken in rapid succession (only when conditions are not dynamically variable). The project will address the precision of field measurements by performing replicate measures at the required intervals described in Section 14.1, Field Measurements.

Accuracy of field measurements is established by calibration and tested by periodic measurement of known standards. The project will perform instrument calibration prior to each sampling day or event for user-calibrated instruments (e.g. daily for handheld field meters), or at the manufacturer-specified interval for instruments requiring factory servicing or otherwise incapable of field calibration. All instruments undergo blank and calibration checks as described in Table 14.1. The flow-through system makes redundant measurements (e.g. two chlorophyll fluorimeters, two fDOM fluorimeters, two thermistors), which allows technical staff to check constituent measurement accuracy throughout the day.

Instruments will also be visually inspected for fouling at the checkpoints and cleaned if necessary. Fouling and drift of instruments may occur due to electrical, optical, and/or communication issues, but redundant measurements can distinguish such issues from environmental variability. Additionally, grab samples are collected for laboratory analysis to ground-truth environmental measurements. The Timberline ammonium analyzer requires a calibration curve at the start and end of each field day. The instrument is intermittently flushed with blank water to monitor drift and check standards are run over the course of the field day.

Completeness of field measurement is evaluated as the percentage of usable measurements out of the total number of measurements desired. The project will ensure that at least 90% of the planned field measurements are collected and are usable. If a lower percentage is achieved for any sampling event or time period, causes shall be investigated and fixed where possible, through instrument maintenance (e.g. defouling), recalibration, repair, or replacement (with the same or different instrument type) as needed. If completeness targets are not achieved, instrument choice, settings, deployment method, maintenance, and/or other activities shall be

adjusted to improve measurement reliability before the next sampling event or measurement period.

Comparability of field measurements will be ensured by using protocols (see Section 23) and QA standards that are comparable within the project and to similar monitoring projects in the study area.

Representativeness of field measurements will be ensured by utilizing standardized protocols (Section 23) and selecting representative monitoring sites and underway paths to support the project management questions (Section 5.1). Conditions that may influence the measurements will be noted in the database and measurements may be retaken if necessary.

Sensitivity is most commonly defined as the lowest value an instrument or method can measure with reasonable statistical certainty (SWRCB 2017) as well as the ability of the instrument to detect small changes. Where applicable, the desired sensitivity is expressed as a target detection limit (Section 6.2) and resolution of a deployed sensor. For this project, sensors will be used that meet the DQOs.

7.3.2. Field Sample Collection

Precision of the field sample collection will be evaluated by collecting field duplicates/replicates (for water and sediment samples). Duplicate or replicate samples account for variability in the field collection and laboratory analysis combined and are collected at the same time under the same conditions as the original sample. Minimum frequencies and target performance requirements for field duplicates/replicates are described in Table 14.2.

Accuracy. In the field, bias of field sample results can be introduced by contamination that occurs during field sample collection or by matrix interference. Field blanks (for water samples) account for all of the sources of contamination that might be introduced to a sample as well as those due to the immediate field environment, such as possible contamination sources in container and equipment preparation, transport, handling, and sampling methodology. Field blanks are generated under actual field conditions and are subjected to the same aspects of sample collection, field processing, preservation, transport, and laboratory handling as the environmental samples.

Travel/bottle blanks (for water samples) account for contaminants introduced during the transport process between the laboratory and field site, in addition to any contamination from the source solution and container. Equipment blanks (for water samples) account for contamination introduced by the field sampling equipment in addition to the above sources.

Neither Travel/bottle blanks **nor** equipment blanks are planned as part of this project at the present time, as ASC QA staff have found over several years of monitoring experience that these are of little use, as they have never shown any evidence of contamination. The QAO may

decide to reinstate these in the future, for example when an established procedure is changed or when contamination problems are identified.

Field duplicates and field blanks will be obtained for each sampling event. Minimum frequencies and target performance requirements for field blanks, travel/bottle blanks, and equipment blanks are described in Table 14.2.

The same equipment that is used for collecting and processing environmental samples is used for collecting and processing blanks and other types of quality-control samples; however, equipment-cleaning and -rinsing procedures differ somewhat.

When required, field crew will also collect matrix samples as described in Section 14.1 Field Measurements.

7.4. Laboratory Quality Control Measurements

The discussion in this section reviews the measurements and procedures expected to demonstrate the quality of reported data. Table 7.2 provides an overview of quality control (QC) sample types and their purpose. The quality assessment process that is used after the data have been collected to evaluate whether the Data Quality Objectives (DQOs) have been satisfied is described and illustrated in Section 22, Data Review, Verification, and Validation.

Prior to the initial analyses of samples for the project, each laboratory will demonstrate capability and proficiency for meeting MQOs for the Delta RMP. Performance-based measures for chemical analyses consist of two basic elements: initial demonstration of laboratory capability and on-going demonstration of capability during analysis of project samples. Initial demonstration includes documentation that sample analyses can be performed within the measurement quality objectives and method quality objectives listed in the QAPP (Table 14.2) as well as demonstrate ability to meet the project's required reporting levels. On-going demonstration of capability during analysis of project samples includes routine analyses (e.g., intercomparison studies) that ensure on a continual basis that MQOs and RLs listed in Table 7.3 are met.

7.4.1. Laboratory QC Measurements

Accuracy (Bias) is the assessment of the closeness of agreement between a measured or determined value and the true value. Blank spikes (laboratory control samples or LCSs), matrix spikes/matrix spike duplicates (MSs/MSDs), internal standards, surrogate recoveries, initial calibration, and calibration checks will be employed to ensure accuracy of results.

Sensitivity refers to the capability of a method or instrument to detect a given analyte at a given concentration and reliably quantitate the analyte at that concentration. This project will achieve the desired sensitivity by selecting appropriate analytical methods and the laboratory will demonstrate analytical capability to meet the project DQOs and reporting limits.

Precision is the reproducibility of an analytical measure. Field samples will be utilized to perform laboratory replicates.

Completeness is defined as "a measure of the amount of data collected from a measurement process compared to the amount that was expected to be obtained under the conditions of measurement" (Stanley and Verner 1985). The goal of the Delta RMP is to achieve >90% completeness for all analyses.

Completeness will be quantified as the total number of usable results divided by the total number of site visits, aggregated by all analytes of interest. However, additional factors may be considered on a case-by-case basis.

Contamination. Laboratory method blanks (also called extraction blanks, procedural blanks, or preparation blanks) are used to assess laboratory contamination during all stages of sample preparation and analysis.

Comparability. The Delta RMP adheres to the requirements specified in the SWAMP Quality Assurance Program Plan (QAPrP), for parameters covered by the SWAMP Quality Control and Sample Handling Tables, to facilitate coordination and data integration with other water quality monitoring efforts. Specifically, the Delta RMP adheres to SWAMP requirements for QC and holding times and to California Environmental Data Exchange Network (CEDEN) requirements for data submittal.

Table 7.3 summarizes the reporting limits (RL) and method detection limits (MDL) for all laboratory measurements. Table 7.3(a) lists the RL and MDL for conventional analytes, field parameters, trace metals, and nutrients. Table 7.3(b) lists the RL and MDL for current use pesticides analyzed by USGS Organic Chemistry Research Laboratory (OCRL).

Laboratory methods are referred to according to the following codes:

40 CFR Part 136, Table I B	US EPA. 2019. Code of Federal Regulations. Title 40—Protection of Environment, Chapter I—Environmental Protection Agency, Subchapter D – Water Programs, Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants. https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr136_main_02.tpl Note: RSEL follows 40 CFR guidelines for the appropriate version of *Standard Methods* to be referred to for any test that follows *Standard Methods*. The numbers and letters after "SM" refer to the method number in *Standard Methods*.
ASTM D888-09 C	ASTM International. 2018. ASTM D888 - 18. Standard Test Methods for Dissolved Oxygen in Water. https://www.astm.org/Standards/D888.htm
EPA 120.1	US EPA. 1982. Method 120.1 Conductance (Specific Conductance, µmhos 25°C) by Conductivity Meter . US Environmental Protection Agency, 1982. https://www.epa.gov/sites/production/files/2015-08/documents/method_120-1_1982.pdf

SESDPROC-103-R4	US EPA. 2017. Field Turbidity Measurement (103)_AF.R4, US EPA Science and Ecosystem Support Division Operating Procedure. https://www.epa.gov/sites/production/files/2017-07/documents/field_turbidity_measurement103_af.r4.pdf
EPA 200.8	Creed, J.T., C.A. Brockhoff, and T.D. Martin. 1994. Determination of Trace Elements in Waters and Wastes By Inductively Coupled Plasma - Mass Spectrometry. Method 200.8, Revision 5.4 (1994). Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. https://www.epa.gov/sites/production/files/2015-06/documents/epa-200.8.pdf
EPA 350.1	US EPA. 1993. Method 350.1: Nitrogen, Ammonia (Colorimetric, Automated Phenate), Revision 2.0. Cincinnati, OH. https://www.epa.gov/esam/epa-method-3501-determination-ammonia-nitrogen-semi-automated-colorimetry https://www.epa.gov/sites/production/files/2015-06/documents/epa-350.1.pdf
EPA 351.2	US EPA. 1993. Method 351.2, Revision 2.0: Determination of Total Kjeldahl Nitrogen by Semi-Automated Colorimetry. https://www.epa.gov/sites/production/files/2015-08/documents/method_351-2_1993.pdf
EPA 353.2	US EPA. 1993. Method 353.2, Revision 2.0: Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry. https://www.epa.gov/sites/production/files/2015-08/documents/method_353-2_1993.pdf
EPA 365.4	EPA 1974. Method 365.4: Phosphorous, Total (Colorimetric, Automated, Block Digester AA II) . https://www.epa.gov/sites/production/files/2015-08/documents/method_365-4_1974.pdf
EPA 440	Zimmerman, C. F., Keefe, C. W., Bashe, J. 1997. Method 440.0 Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/00. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309418
EPA 445	US EPA. 1997. Method 445.0 In Vitro Determination of Chlorophyll a and Pheophytin Ain Marine and Freshwater Algae by Fluorescence." US Environmental Protection Agency, 1997. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309417.
EPA 446	Arar, E.J. "Method 446.0: In Vitro Determination of Chlorophylls a, b, c + c and Pheopigments in Marine and Freshwater Algae by Visible Spectrophotometry." Washington, DC: US Environmental Protection Agency, 1997. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=309415.

Hladik et al. 2008 — Hladik, M.L., Smalling, K.L., and Kuivila, K.M., 2008, A multi-residue method for the analysis of pesticides and pesticide degradates in water using Oasis HLB solid phase extraction and gas chromatography-ion trap mass spectrometry: *Bulletin of Environmental Contamination and Toxicology*, v. 80, p. 139–144. [Download link]

NFM-A6 — Chapter A6, *Field Measurements* in: Wilde, F. D., D. B. Radtke, Jacob Gibs, and R. T. Iwatsubo. *National Field Manual for the Collection of Water-Quality Data: US Geological Survey Techniques of Water-Resources Investigations*. Handbooks for Water-Resources Investigations, Book 9. Reston, VA: U.S. Geological Survey, 2005. https://water.usgs.gov/owq/FieldManual/.

OFR-92-480 — Brenton, R.W., Arnett, T.L. 1993. Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of dissolved organic carbon by UV-promoted persulfate oxidation and infrared spectrometry: U.S. Geological Survey Open-File Report 92-480, 12 p. https://nwql.usgs.gov/rpt.shtml?OFR-92-480

SESDPROC-103-R4 — US EPA. 2017. Field Turbidity Measurement (103)_AF.R4, US EPA Science and Ecosystem Support Division Operating Procedure. https://www.epa.gov/sites/production/files/2017-07/documents/field_turbidity_measurement103_af.r4.pdf

SIR-2012-5206 — Hladik, M.L., and Calhoun, D.L., 2012, Analysis of the herbicide diuron, three diuron degradates, and six neonicotinoid insecticides in water—Method details and application to two Georgia streams: U.S. Geological Survey Scientific Investigations Report 2012–5206, 10 p. https://pubs.usgs.gov/sir/2012/5206/pdf/sir20125206.pdf

SM […]* — Rice, E.W., R.B. Baird, A.D. Eaton, and L.S. Clesceri. *Standard Methods for the Examination of Water and Wastewater*. Water Environmental Federation, American Water Works Association, American Public Health Association, 2005. https://www.standardmethods.org/

*The numbers and letters after "SM" refer to the method number in *Standard Methods*. Readers are referred to either the print edition, or individual chapters can be purchased online.

TM-5-C2 — Hladik, M.L., Smalling, K.L., and Kuivila, K.M., 2009, Methods of analysis—Determination of pyrethroid insecticides in water and sediment using gas chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods 5–C2, 18 p. https://pubs.usgs.gov/tm/tm5c2/tm5c2.pdf

TM-5-C3 — Hladik, M.L., and McWayne, M.M., 2012, Methods of analysis—Determination of pesticides in sediment using gas chromatography/mass spectrometry: U.S. Geological Survey Techniques and Methods 5–C3, 18 p. Available at http://pubs.usgs.gov/tm/tm5c3

TM-5-B1	Garbarino, J.R., Kanagy, L.K., Cree, M.E. 2006. Determination of Elements in Natural Water, Biota, Sediment and Soil Samples Using Collision/Reaction Cell Inductively Coupled Plasma-Mass Spectrometry, U.S. Geological Survey Techniques and Methods, 88p. (Book 5, Sec. B, Chap.1). https://pubs.usgs.gov/tm/2006/tm5b1/
TM O-1122-92	R.W. Brenton and T.L. Arnett, 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of dissolved organic carbon by UV-promoted persulfate oxidation and infrared spectrometry: U.S. Geological Survey Open-File Report 92-480. https://pubs.er.usgs.gov/publication/ofr92480
I-2525-89	Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, p. 119 - 124. https://nwql.usgs.gov/rpt.shtml?OFR-93-125

7.4.2. Laboratory QC Samples

Data from OCRL (Pesticides chemistry) and MLML (mercury and related parameters) shall include at least the following QC data:

1. Surrogate recovery (for all environmental and QC samples, where applicable)
2. Method blank
3. Matrix spike recovery (where applicable)
4. Laboratory replicate precision (environmental samples or CRM, matrix spike, blank matrix spike samples when applicable)
5. Certified/lab reference material (CRM/LRM) recovery (where applicable)

Method blanks shall be run at a minimum frequency of one per 20 field samples. Results for laboratory method blanks, combined with those for field blanks, can help identify whether probable causes of sample contamination originated in the field or in laboratory analyses. If both field and lab method blanks have similar levels of contamination, it is likely caused primarily in lab procedures. If field blanks have higher contamination, sample collection methods are likely the cause. Results for method blanks shall be reported.

Matrix spikes (MS) shall be run at a minimum frequency of one per 20 samples. Matrix spike results are to be reported, along with the expected result (unspiked sample concentration + spike concentration), and a recovery estimate. The spiking concentrations should be sufficiently high to quantify recovery (at least 3× the unspiked sample concentration) but also low enough to be a relevant accuracy indicator in the concentration range of field samples (3 - 10x the unspiked sample concentration). In cases where analytes are mostly not detected in unspiked samples, a concentration range of 10× to 100× over the MDL may be appropriate to use instead.

Precision can be determined with all sample types analyzed and reported in replicate. Lab replicates (split and analyzed in the laboratory) of field samples are generally the preferred indicator of precision for typical field samples, as the target analyte concentration range, matrix, and interferences are most similar to previous analyzed samples or samples from nearby sites. However, sometimes field sample concentrations are below detection limits for many analytes and replicate results for CRMs, LRMs, MS/MSDs, or blank spikes (LCSs) may be needed to obtain quantitative precision estimates. These alternative sample types, in particular blank spikes (LCSs), should not serve as the primary or exclusive indicator of measurement precision without prior approval by the Program Manager and QAO. LCSs are often created from a clean laboratory matrix and are likely not representative of the measurement precision routinely achievable in more complex matrices of real field-originated samples. The relative percent difference (RPD) should be calculated as described in Section 7.4.3 and reported for all samples analyzed in replicate.

A laboratory control sample (LCS) shall be run at a minimum frequency of one per analytical batch [6](for analytical batches consisting of up to 20 field samples). Results shall be reported along with the expected values and recoveries (as a percentage of the expected value), where available for target analytes in appropriate matrices.

For the SRiNCS project, measurement quality objectives, including methods blanks, matrix spikes, matrix spike duplicates, reporting limit checks, laboratory control samples and duplicates are summarized in Table 14.2.

7.4.3. Precision

Precision measurements will be determined on field and/or laboratory replicates. If samples other than environmental samples are used to evaluate lab precision, target concentrations should be at least high enough to be quantitative but less than 100 times those in environmental samples, as precision in high concentration samples is not likely representative for much lower ambient samples. When using MS/MSD, samples of a similar matrix are most relevant and thus preferred for evaluating precision.

A minimum of one field duplicate per 20 samples, or no less than 5%, of environmental samples will be collected, processed, and analyzed for precision. In addition, a minimum of one

[6] A *batch* is a set of samples that are processed together. It does *not* refer to samples that arrived or were delivered together. Each lab should determine what defines a batch, keeping in mind the factors that lead to significant differences in the analysis. For example, in some processes, it is the extraction that may be more critical than the instrument run/start/stop in terms of defining the method performance. Other factors could include which lab personnel perform sample preparation, temperature of the extraction, which batch of solvent, or who spiked the internal standards or prepped the calibration samples. For certain "finicky" lab instruments, stopping and restarting the instrument may make a difference; in this case, labs should define a batch that way.

environmental sample (or alternative sample type such as a MS, where sample material is insufficient or target analytes are largely not detected in field samples) per batch of samples submitted to the laboratory (minimum one per 20, or 5%, in large batches) will be processed and analyzed in replicate for precision.[7] Previously analyzed material (e.g. from the same project in prior years, or from other projects) may also be analyzed as replicates to help ensure that results are in a quantifiable range. The RPD among replicate samples should be less than the MQO listed in Table 14.2 for each analyte of interest. RPD is calculated as:

$$RPD = \frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2}\right)} \times 100$$

where X_1 and X_2 are independent measurements of the replicate samples.

When more than two replicate samples are collected, the relative standard deviation (RSD) shall be used as a basis of comparison against the MQOs:

RSD = STDEV (all replicate samples) x 100/Average (all replicate samples)

For the SRiNCS project, at each sample station, triplicate samples will be collected for water quality, phytoplankton enumeration, zooplankton enumeration, and clam biomass. Phytoplankton growth assays will be conducted in triplicate at each station. Due to time and logistical constraints, duplicate or triplicate samples at each station are not feasible for the zooplankton growth assays. Single replicates of these experiments will be conducted focusing on the more downstream locations where changes in zooplankton growth will have had more time to occur.

7.4.4. Accuracy

Accuracy is the closeness of a measured result to an accepted reference value. Accuracy shall be measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples (LCS), spiked samples (matrix spikes and matrix spike duplicates), internal standards, surrogate recoveries, initial calibration, and calibration checks. The accuracy of lab measurements will be evaluated based on measurement quality objectives (Table 14.2).

For a matrix spike, a known quantity of an analyte added to a sample to test whether the response to a sample is the same as that expected from a calibration curve. These samples are useful for determining whether elements of the matrix (the remainder of the sample other than the analyte) influence the results of the measurement. The percent recovery for spiked samples is calculated using the equation:

[7] For example, if there were 61 samples, 4 environmental samples would be processed and analyzed in replicate for precision.

$$\%\ recovery = \frac{\left(C_{spiked\ sample} - C_{unspiked\ sample}\right)}{C_{added}} \times 100$$

The percent recovery for LCS and surrogates is calculated using the equation

$$\%\ recovery = \frac{analyzed\ concentration\ of\ LCS\ or\ surrogate}{certified\ concentration\ of\ LCS\ or\ surrogate} \times 100$$

Table 7.4 lists recovery surrogate standards used for pesticide analyses and associated measurement quality objectives.

7.4.5. Contamination

For laboratory analyses, at least one laboratory method blank will be run at a minimum rate of one for each 20 field samples. The method blank will be processed throughout the entire analytical procedure in a manner identical to the samples (i.e., using the same reagents and equipment). The result for a method blanks should be that the analyte concentration is less than the method detection limit (MDL).

A method blank with a measured concentration greater than the MDL for any analyte of interest will require corrective action (e.g., checking of reagents, re-cleaning and re-checking of equipment) to identify and eliminate the source(s) of contamination before proceeding with sample analysis.

If eliminating the blank contamination and reanalysis is not possible, results for all impacted analytes in the analytical batch shall be flagged. In addition, a detailed description of the contamination sources and the steps taken to identify and eliminate/minimize them shall be included in the transmittal letter. The analytical lab may or may not "blank correct" the reported results, depending on the guidelines in the method and/or laboratory SOP. Blank correction involves subtracting the result of the lab method blank from all results. A "LabBatch" comment shall be included in the tabulated data, indicating whether the sample results in that batch are blank corrected or not.

8. Special Training or Certifications

Laboratories must have a designated on-site QA Officer for the particular analytical component(s) performed at that laboratory. This individual will serve as the point of contact for the SFEI-ASC QA staff in identifying and resolving issues related to data quality.

To ensure that the samples are analyzed in a consistent manner throughout the duration of the program, key laboratory personnel will participate in an orientation session conducted during an initial site visit or via communications with SFEI-ASC staff. The purpose of the orientation session is to familiarize key laboratory personnel with this QAPP and the Delta RMP QA/QC program. Participating laboratories will be required to demonstrate acceptable performance

before analysis of samples can proceed. Laboratory operations will be evaluated on a continuous basis through technical systems audits and by participation in laboratory intercomparison programs. For the SRiNCS study, a trial-study will be performed in late August 2019 to ensure that all personnel are trained and knowledgeable of QAPP QA/QC standards for this study.

Personnel in any laboratory performing analyses will be well versed in good laboratory practices (GLPs), including standard safety procedures. It is the responsibility of the analytical laboratory manager and/or safety staff to ensure that all laboratory personnel are properly trained. Each laboratory is responsible for maintaining a current safety manual in compliance with Occupational Safety and Health Administration (OSHA) or equivalent state or local regulations. The safety manual will be readily available to laboratory personnel. Proper procedures for safe storage, handling, and disposal of chemicals will be followed at all times. Each chemical will be treated as a potential health hazard and good laboratory practices (GLPs) will be implemented accordingly.

Personnel collecting samples will be trained in the field sampling methods described in the QAPP.

For mercury monitoring, the MPSL project coordinator will be responsible for training the MPSL field staff.

For pesticides monitoring and analysis, the USGS Organic Chemistry Research Laboratory (OCRL) principal investigators will be responsible for training field and laboratory staff.

For aquatic toxicity testing, the Aquatic Health Program Laboratory at UC Davis (AHPL) principal investigators will be responsible for training of laboratory staff.

For nutrient monitoring, the USGS Biogeochemical Group principal investigators will be responsible for training the USGS field staff.

For the SRiNCS project, the project managers from Regional San, AMS, SFSU, and USGS will be responsible for the training of all field leads. In turn, field leads will be responsible for the training of all staff working on their respective research components. Regional San's RSEL staff performing water quality laboratory analyses will have California Environmental Laboratory Accreditation Program (ELAP) certification for the specific chemical analyses which they perform.

Staff shall maintain a record of field training given. Information will include trainer, trainees, and dates of training. The sign-in sheet of the training can be the documentation of the training.

8.1. Training Certification and Documentation

Contractors performing sampling are responsible for providing training to their staff and maintaining records of all trainings. Those records can be obtained if needed from contractors through their respective QA or Safety Officers.

8.2. Training Personnel

Each contract laboratory's QA Officer and Safety Officer shall provide and/or designate staff to provide training to their respective personnel. All personnel responsible for sampling will be trained in field sample collection and safety prior to the first day they are scheduled to sample for the Delta RMP.

9. Documentation and Records

The main information products and reports planned by the Delta RMP are described in Section 6.7. These include annual data reports, annual QA reports, occasional interpretive reports, and the *Pulse of the Delta* every 2 to 3 years.

All Delta RMP documents will be provided to the Steering Committee, which includes the Central Valley Regional Water Quality Control Board.

SFEI-ASC will collect records for sample collection, field analyses, and laboratory chemical analyses. Samples sent to analytical laboratories will include a Chain-of-Custody (COC) form. The analytical laboratories will maintain records of sample receipt and storage, analyses, and reported results.

SFEI-ASC will maintain hard copy or scanned files of field notes and measurements as well as documentation and results submitted by laboratories at the SFEI-ASC main office. The SFEI-ASC Data Manager will be responsible for the storage and organization of information.

Contract laboratories will be responsible for maintaining copies of project documentation originating from their respective laboratories, with backup archival storage offsite where possible. All SOPs used for the Delta RMP will be stored indefinitely, in case future review is necessary.

For water quality analyses performed by the RSEL, documentation will be maintained in the lab's Laboratory Information Management System (LIMS). The RSEL's LIMS is Horizon version 12.6 (made by Chemware). The lab's document retention policy calls for records to be kept for 10 years. For clam collections, the field notes (sampling locations, dates, and times), clam counts, shell width measurements, clam biomass calculations, and clam grazing rate calculations will be maintained by Regional San. Scanned copies of all SRiNCS field sampling datasheets and laboratory output for water quality, phytoplankton and zooplankton enumeration and growth, and clam samples will be stored on Regional San's network servers,

which are backed up on a daily basis. Further details of the data management plan for the SRiNCS nutrients project are presented in section 19.3 of this document.

9.1. Quality Assurance Documentation

All laboratories will have the latest revision of the Delta RMP QAPP. In addition, the following documents and information will be current and available to all laboratory personnel participating in the processing of project samples and to SFEI-ASC program staff:

1. **Field Standard Operating Procedures** (SOPs): Containing instructions for fieldwork activities, including procedures for conducting field observations, field measurements, and environmental sample collection. Describes requirements for sample containers, volume, preservation, and storage.
2. **Laboratory Quality Management Plan:** clearly defined policies and protocols specific to a particular laboratory, including policies and objectives, organizational authority, personnel responsibilities, and internal performance measures.
3. **Laboratory Standard Operating Procedures** (SOPs): containing instructions for performing routine laboratory procedures (such as logging, labelling, and storage of samples; cleaning of equipment; checking of reagents) that are not necessarily part of any analytical methodology for specific analytes or analyte types.
4. **Laboratory Analytical Methods**: step-by-step instructions describing exactly how a method is implemented in the laboratory for a particular analytical procedure. Contains all analytical methods utilized in the particular laboratory for services provided to the Delta RMP.
5. **Instrument Performance Information**: information on instrument baseline noise, calibration standard response, analytical precision and bias data, detection limits, etc. This information shall be reported for the periods during which Delta RMP samples are analyzed.
6. **Control Charts**: control charts are useful in evaluating internal laboratory procedures and are helpful in identifying and correcting systematic error sources. Contract laboratories are encouraged to develop and maintain control charts whenever they may serve in determining sources of analytical problems.

Copies of laboratory methods, SOPs, and QA plans shall be available upon request from the SFEI-ASC QA Officer or Program Manager. Some laboratory methods and SOPs may be edited to exclude proprietary details about the analyses. Quality assurance documents are reviewed to assure conformance to program needs by the Delta RMP Program Manager and QAO or their designees.

Handwritten original field sheets, logs, and calibration records will be maintained by the field sample collection teams.

Copies of all records will be maintained at SFEI-ASC and at the laboratory for a **minimum of five years** after project completion, after which they may be discarded. This excludes electronic databases at SFEI-ASC, which will be maintained without discarding. All data will be backed up and secured at a remote location (i.e., separate from the SFEI-ASC office). As needed, data recovery can be initiated by contacting the back-up facility for restoration and this will be covered through SFEI-ASC overhead.

All participants listed in Table 3.1 will receive the most current version of the Delta RMP QAPP. The Delta RMP Program Manager will be responsible for sharing the latest version of the QAPP. The QAPP will also be posted publicly on the Delta RMP website.

For the SRiNCS project, the following data types will be entered into CEDEN: water quality, phytoplankton taxonomic analyses, zooplankton taxonomic analyses, and clam density and biomass. Records of phytoplankton growth bioassays will be maintained by AMS, Inc. with an electronic copy of these data to be stored on the Regional San server for 10 years.

9.2 Standard Operating Procedures (SOPs)

Standard Operating Procedure documents are listed in Appendix E in this QAPP. The QA Officer and Project Manager shall approve any changes in methods.

10. Sampling Process Design

10.1. Study Area and Period

Sample collection points and a justification for site selection and study areas for the different elements are described in the specific designs for each of the Delta RMP monitoring elements (Appendix D). Short Summaries of Delta RMP Monitoring Elements). Delta RMP monitoring occurs in, upstream, and downstream of the Delta.

The monitoring sites for mercury sampling represent different subareas of the Delta (Figure 6.3).

Cruise tracks for nutrient monitoring represent nutrient gradients and under-monitored areas in the Delta (Figure 6.4).

The sampling area for the SRiNCS project is the mainstem Sacramento River between Freeport and Walnut Grove, and in Georgiana Slough, the North Fork Mokelumne River, and the South Fork Mokelumne River (Figure 6.5).

Sampling timing and frequency varies for the different elements of the monitoring program:

- **Mercury monitoring** includes annual sport fish sampling at 7 sites, and monthly water sampling at 8 sites from July through October 2019, and 6 sites from March through June 2020. Both sport fish and water sampling started in 2016. Sediment sampling was conducted quarterly at 6 sites in FY17-18 and was discontinued in FY18-19.
- **USGS high frequency nutrient monitoring** will consist of research cruises along transects of the North, Central, and South Delta that will be conducted three times on three successive days in October of 2017 and May and August of 2018.
- **Nutrient sampling for the SRiNCS project** is scheduled to be conducted during one week-long period in September 2019. Clams will be collected at each location sampled for nutrients during the subsequent field experiments. Clam trawl transects will be conducted within one month of nutrient sampling, to reduce the likelihood of clam movements or population biomass changes due to growth or mortality. All clams collected in the trawl will be fixed for laboratory analysis within 48 hours. Clam commonly live in patchy distributions, but the clam trawl will cover a larger surface area of the river bottom (approximately 9 m^2), compared to a Ponar scoop sampler, which helps reduce sample variation.
- **Sampling for pesticides and aquatic toxicity** will be conducted over 6 events during the water year, designed to capture a range of hydrologic conditions and periods of the agricultural calendar. Among the 6 planned events, 3 are for storm sampling, and 3 for dry weather / irrigation season. It is necessary to space sampling events by at least 2 weeks so the labs can process all the samples from the previous round. Planned timing of sampling events is shown in Table 6.7. Samples will be taken on the outgoing, or ebb, tide, if possible.

The Delta is a highly dynamic and hydrologically complex system. Seasonal and temporal variability of target analytes within the system is shaped by numerous influencing factors, including the relative contributions of source waters and their chemical composition, seasonal and temporal variability in loads, biogeochemical processes within the system, seasonally-varying process rates, flow rates and flow routing, climate variability, and habitat-specific (local) factors. Therefore, study design and data evaluation should always take into consideration co-variance of and potential bias caused by influencing factors.

Collected data are used to evaluate future data needs and adjust the sampling and analysis plan as needed to optimize data collection in an adaptive manner. The program will be continually adjusted to optimize data collection. In addition to this document, monitoring designs are described in Annual Workplans on the project website: http://sfei.org/DeltaRMP/

10.2. Sampling Sites

Mercury monitoring

Table 10.1 summarizes information on sampling sites and schedule for the mercury monitoring project in Fiscal Year 2019-20. In the case that a site is inaccessible, the field team lead will inform the SFEI-ASC Program Manager. Alternative options will be discussed with the mercury and the TAC and decided by the SC.

Pesticides and aquatic toxicity

For pesticides sampling, occasionally, one of the randomly-selected sampling locations will not be accessible because it is unsafe, on private property, etc. In this case, a sample should be taken within 100 meters if possible and only if there is not some obvious change in the environment, such as moving downstream of an outfall, a change in water clarity, etc. If not possible to sample within 100 m, the crew should choose the next site on the "oversample" list shown in Table 6.4.

Nutrients - Sacramento River Nutrient Change Study

For the SRiNCS project approximately 12 locations will be sampled, with the actual number and their exact locations dependent upon river flow rates and the resulting velocity of the wastewater-free water parcel through the study area. Sampling locations are listed in Table 10.1(d). The number and type of samples to be collected are described in Section 11.1.8 below.

11. Sampling (Sample Collection) Methods

11.1. Field Sample Collection

11.1.1. Equipment Cleaning and Decontamination Procedures

Mercury Sampling

Equipment cleaning and decontamination procedures are documented in MPSL SOPs MPSL-102b, Section 7, and MPSL-111, Section 7. (See Appendix E for links to download all SOPs referenced in this document.) To avoid cross-contamination, all equipment used in sample collection will be thoroughly cleaned before each sample is processed. Before the next sample is processed, instruments will be washed with a detergent solution (Micro™), rinsed with ambient water, rinsed with a high-purity solvent (methanol or petroleum ether), and finally rinsed with Milli-Q® water. Waste detergent and solvent solutions must be collected and taken back to the laboratory. Boats, sampler, and personal protection equipment (PPE) will be pre-cleaned with 10% bleach to prevent introducing invasive species from one water body to another water body.

Nutrients Study - High-Frequency Monitoring - Underway Flow-through System

The flow-through system is rinsed thoroughly with organic free water (OFW) after each use (within 24 hours) and stored with OFW in the flow path between uses. A blank is collected before and after each field outing to verify cleanliness of the system and verify instrument offsets. If a blank fails, instruments are cleaned with lens paper, and if necessary, isopropyl alcohol.

The sample pump is thoroughly rinsed and scrubbed. Tubing is changed between uses.

The water quality sonde (YSI EXO) flow-through cup and pre-filter are cleaned with hot tap water and Liquinox® detergent, rinsed with deionized water (DI), and rinsed with OFW after each use.

Tubing that delivers water from manifold to instrumentation is replaced after each field use.

Chlorophyll *a* filter supplies (filter towers, filter pad holder, tweezers) undergo a hot Liquinox soak for a minimum of 24 hours. They are then thoroughly rinsed with hot tap water to remove Liquinox, followed by a DI rinse, and an OFW rinse. Filter towers are then rinsed with acetone. They are left in a fume hood overnight to allow acetone to evaporate off. They receive a final rinse with OFW before use. Materials are placed in plastic bags when stored (following EPA Method 445.0).

11.1.2. Mercury Sampling

The following sections describe collection of samples for analysis of mercury and methylmercury. For trace metals such as mercury, great care must be taken and special sampling methods to avoid contamination during sample collection, transport, and analysis. According to the US EPA (1996):

> Preventing ambient water samples from becoming contaminated during the sampling and analytical process is the greatest challenge faced in trace metals determinations. In recent years, it has been shown that much of the historical trace metals data collected in ambient water are erroneously high because the concentrations reflect contamination from sampling and analysis rather than ambient levels. Therefore, it is imperative that extreme care be taken to avoid contamination when collecting and analyzing ambient water samples for trace metals.
>
> There are numerous routes by which samples may become contaminated. Potential sources of trace metals contamination during sampling include metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents, and deionized water; improperly cleaned and stored equipment, labware, and reagents; and atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, bridges, wires, and poles. Even human contact can be a source of trace metals contamination. For example, it has been demonstrated that dental work (e.g., mercury amalgam fillings) in the mouths of laboratory personnel can contaminate samples that are directly exposed to exhalation.

Field crews and laboratory staff are experienced in ultra-trace methods. Further details about sampling methods for each matrix (water, fish tissue, sediment) are described below. To avoid contamination, all material that comes in contact with fish are prepared and cleaned as described in Method MPSL-101, *Sample Container Preparation for Organics and Trace Metals, Including Mercury and Methylmercury*. Sample handling protocols are described in more detail below.

11.1.2.1 Water Sampling

This section describes collection of water samples for analysis of mercury and methylmercury. Samples will be collected according to MPSL Field SOP v1.1 (see Appendix E for link) and standard trace metal clean-hands/dirty-hands collection methods (USEPA Method 1669) where appropriate to avoid sample contamination. A depth-integrated sample will be collected fusing a bucket sampler following methods described in the MPSL Field SOP v1.1 and MPSL-111).

Briefly, a web of clean C-Flex tubing is used to hold the bottle in place while sampling. Tubing will be replaced prior to each sampling event or sooner, if thought to have come in contact with surfaces known to be possible contamination sources, such as the boat deck. Plastic-covered

lead weights are fastened with plastic fasteners to the outside bottom of the bucket to allow sufficient weight to lower the sampler through the water column. A clean polypropylene line is attached to the bucket and used to lower and raise the sampler through the water column.

The sampling bucket and line will be kept clean by storing in new clean plastic bags between uses and not allowing contact with surfaces on the sampling platform that are known to be potential sources of contamination.

A depth-integrated sample will be collected by lowering and raising the 4L bottle through the water column at a sufficient rate so that the bottle is not completely filled upon retrieval. A new pre-cleaned 4L glass bottle (MPSL-101 *Sample Container Preparation for Organics and Trace Metals, including Mercury and Methylmercury*) will be used for each site.

Field sample handling and shipping procedures are described in Section 12. Further, Table 12.1 provides important information on storage and hold time requirements.

11.1.2.2. Sediment samples

This section describes collection of sediment samples for analysis of mercury, methylmercury, and sediment characteristics. Sediment samples for mercury monitoring were collected 4 times per year during the 2017 - 2018 fiscal year (FY17-18). Sediment monitoring is not planned after June 2018. However, information on sediment collection is kept in the document here for reference by data users. Further, the program is likely to begin sediment sampling for mercury again in the future.

Sediment will be collected in accordance with the SOP MPSL- 102b *Field Collection Procedures for Bed Sediment Samples*. The procedure for collecting the samples is described in the SOP sections 8.2 and 8.3. Sediment samples are to be collected at the same monitoring locations where water is collected, after water sample collection is complete. Additional procedures related to both water and sediment are detailed in MPSL Field SOP v1.1, *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California*. Sediment samples will be collected from the thalweg and the shoal at each site. Field crews will evaluate each site to determine the correct method to be employed. Samples will be rejected if certain criteria are not met, as described in MPSL Field SOP v1.1, "Rejection Criteria," page 59.

Only the top 2 cm of the collected material will be transferred to the sample containers using a pre-cleaned polyethylene scoop. Sediment for mercury and TOC analysis will be frozen immediately upon collection by placing them on dry ice. Sediment for grain size analysis will be stored on wet ice. Upon arrival at the analytical lab the temperature of the cooler is measured and recorded to verify samples were maintained at the appropriate temperature.

11.1.2.3. Collection of Fish Tissue for Analysis of Mercury and Methylmercury

Sport fish samples for mercury monitoring are collected annually. The appropriate sample collection method may vary by site and will be determined by the MPSL field sample collection team.

Links to Standard Operating Procedures (SOP) documents for fish sample collection are provided in Appendix E.

Fish will be collected in accordance with the SOP MPSL-102a, *Sampling Marine and Freshwater Bivalves, Fish and Crabs for Trace Metal and Synthetic Organic Analysis*. Because habitats may vary greatly, there is no one method of collection that is appropriate. Field crews will evaluate each fishing site to determine the correct method to be employed. Potential sampling methods include but are not limited to: electroshocking, seining, gill netting, and hook and line. Field crew will determine the appropriate collection method based on physical site parameters such as depth, width, flow, and accessibility. Field crew will indicate the collection method on data sheets. The project data sheet is shown in Appendix F.

For the mercury status and trends study, for annual sport fish monitoring, the targeted fish species is largemouth bass (*Micropterus salmoides*). The goal is to collect 16 individuals spanning a range of total length from 200 to greater than 407 mm at each site. The targeted size range is as follows:

3 × 200–249 mm

3 × 250–304 mm

7 × 305–407 mm

3 × 407+ mm

The target sizes span a wide range to support development of a length:mercury regression at each station, with a primary focus on fish in the legal range that is most commonly caught

Specimens of similar predator species may be collected, if the desired number of individuals of the primary target fish species in the desired size range cannot be collected at a site. Other acceptable sport fish species include, in order of preference:

1. spotted bass, *Micropterus punctulatus*
2. smallmouth bass, *Micropterus dolomieu*

For mercury monitoring at restoration sites, the target fish species is the Mississippi silverside, *Menidia beryllina*, formerly referred to as the inland silverside. The goal is to collect six composites in five 5 mm increments across the 45–70 mm size range. The other acceptable prey fish species is young-of-the-year largemouth bass, *Micropterus salmoides*. We will target young-of-the-year (YOY) largemouth in the 50-110 mm range, preparing six composites in 10 mm

increments across this range. Other species have not been extensively monitored and would not be useful for the study.

Section 12.3 provides more information on field sample handling and shipping procedures. Table 12.1 provides information about storage and hold time requirements for each parameter group.)

Fish will be processed according to MPSL- 102a *Sampling Marine and Freshwater Bivalves, Fish and Crabs for Trace Metal and Synthetic Organic Analysis;* except where noted here. Collected fish will be partially dissected in the field. At the dock, the fish is placed on a measuring board covered with clean aluminum foil or plastic. Fork and total length are recorded. Weight is recorded, if the fish is large enough for the scale. If the fish is too large to fit in the bag, it will then be placed on the covered cutting board, where the head, tail, and guts are removed using a clean cleaver (scrubbed with Micro™, rinsed with tap and deionized water). The fish cross-section is tagged with a unique numbered ID, wrapped in aluminum foil, and placed in a clean labeled bag. When possible, parasites and body anomalies are noted. The cleaver and cutting board are re-cleaned with Micro™, rinsed with tap and deionized water between fish species. The equipment cleaning procedures will be repeated at each sampling site.

[Sections 11.1.3 to 11.1.5 removed in this version]

11.1.6. Pesticides and Aquatic Toxicity Sampling

This section describes collection of water samples for pesticides and aquatic toxicity analysis. Samples for pesticides and toxicity monitoring shall be collected concurrently as grab samples 0.5 meters below the water surface. All grab samples shall be collected in accordance with the following methods described in the USGS *National Field Manual* (U.S. Geological Survey, variously dated). Relevant sections of the manual include the following chapters:

A1. Preparations for Water Sampling (Version 1.0, 11/2018)

A2. Selection of Equipment for Water Sampling (Version 3.1, 4/2014)

A3. Cleaning of Equipment for Water Sampling (Version 2.0, 4/2004)

A4. Collection of Water Samples (Version 2.0, 9/2006)

The USGS field manual is a dynamic document that has been in constant development since 1991 by the scientists and technicians at the USGS National Water-Quality Laboratory and National Research Program.

The study design calls for grab samples due to the large volume of water (approximately 45 liters or 8 gallons) required for collecting toxicity and pesticide samples concurrently, even in hydrologic conditions that might otherwise dictate integrated sampling techniques.

Samples shall be collected between the high and low tide, or on the ebb tide (for tidally influenced sites) by submerging narrow-mouthed bottles at mid-channel to a depth of 0.5 m. At the two fixed monitoring sites, during low flow conditions, samples may be collected by wading into streams and submerging handheld bottles. In high flow conditions or for sites with difficult bank access, samples shall be collected from bridges using weighted-bottle samplers.

At the probabilistic (random) sites chosen by GRTS, samples will be collected by boat using the weighted bottle sampler. Water samples for pesticide and toxicity analyses will be collected by submerging 1 L baked amber glass bottles (pesticides), 3 L Teflon (copper and dissolved organic carbon or DOC), and 4 L glass (toxicity) to a depth of 0.5 m using weighted bottle samplers. Samples will be collected on an ebb tide if logistically feasible. The sampling boat will be maintained on station at the GRTS site throughout the sample collection process.

Pesticide samples shall be collected in pre-cleaned, baked 1 L glass amber bottles and transported on ice to the USGS OCRL in Sacramento, California for processing and analysis using a combination of liquid chromatography tandem mass spectrometry (LC/MS/MS) and gas chromatography mass spectrometry (GC/MS). Samples for analysis at the USGS NWQL shall be collected in 3-L Teflon bottles, processed at the USGS California Water Science Center, and shipped on ice to the USGS NWQL in Denver, Colorado.

NWQL will analyze the following:

- Copper
- dissolved organic carbon (DOC)
- particulate inorganic carbon (PIC)
- particulate organic carbon (POC)
- total particulate carbon (TPC)
- total particulate nitrogen (TPN)

Toxicity samples shall be collected in pre-cleaned 4-L glass amber bottles provided by the Aquatic Health Program Laboratory at UC Davis. Bottles shall be triple rinsed with native water on-site before sample collection. Bottles shall be transported on ice to the AHPL for analysis.

Basic water-quality measurements (water temperature, specific conductance, dissolved oxygen, pH, and turbidity) shall be taken at a depth of 0.5m at mid-channel during each sample collection using a YSI 6920V2 multi-parameter meter. The meter shall be calibrated using appropriate procedures and standards prior to sample collection as described in the USGS National Field Manual (U.S. Geological Survey, variously dated).

11.1.7. Habitat Observations

The field crew collecting pesticides and toxicity water samples shall make a number of observations about the sampling location, and record these on a field sampling data sheet. These observations are somewhat confusingly referred to (by USGS, SWAMP and others) as

"habitat parameters," even though this project is not specifically monitoring wildlife habitat. Table 11.1 shows the elements to be recorded by field crews on the SWAMP field data sheet.[8]

In the past, Delta RMP pesticides monitoring visited the same 5 sites monthly, and therefore, each site was well known to us, and there was not much to be gained from these observations. However, as the project will be monitoring dozens of new, randomly-selected locations, it will be important to record conditions at each site, particularly anything out of the ordinary. These observations may be useful for interpreting the pesticide and toxicity results for that station.

11.1.8. Collection of Samples for the SRiNCS Project

11.1.8.1. Water column sampling and analyses

Methods for water column sampling and analyses will follow the protocols described in AMS (2017) with any exceptions noted below.

Sample collection will follow the protocols in Section 22 of the Regional San *Environmental Laboratory Quality Manual*, 2019 (available upon request).

At each station, a YSI model 6600 sonde (Xylem Instruments) will be deployed to collect vertical profiles of temperature (°C), pH, electrical conductivity (µS cm^{-1}), DO (mg L^{-1}) and depth (m).

At each station, surface water (~0.5 m depth) will be collected using an acid-cleaned plastic bucket.

Triplicate samples for determination of ammonium, nitrate, dissolved phosphorus, and dissolved organic carbon concentrations will be filtered through a 0.45 µm filter, preserved, and stored refrigerated until analysis using standard methods at the Regional San Environmental Laboratory.

Triplicate samples for turbidity will be measured at each site using a Hach 2100P turbidimeter. A LI-COR underwater quantum sensor (model LI-192SA) will be deployed to collect a vertical profile of photosynthetically active radiation (PAR, µmol photons m^{-2} s^{-1}).

Samples collected for Chl-*a* determinations will be analyzed at the RSEL following extraction with 90% acetone. Briefly, 20-100 mL water will be filtered onto Whatman Glass Microfiber Filters (GF/F) filters which will be placed in petri dishes, wrapped in foil and preserved frozen until analysis. The frozen filter containing the sampled phytoplankton cells will be placed into a grinding tube to which 90% acetone was added. The glass filter will be ground with a glass grinder (manufactured by Wheaton and made of Teflon or polytetrafluoroethylene [PTFE]) for 1-2 min. The ground filter will be rinsed with 90% acetone into a centrifuge tube and extracted

[8] Download the SWAMP Water Quality Field Data Sheet: https://drive.google.com/file/d/0B40pxPC5g-D0WTBmZlkzOHE0dnM/view

overnight in the refrigerator in the dark. Samples will be centrifuged and the supernatant analyzed at 750 nm using a spectrophotometer.

Whole water samples for phytoplankton identification and enumeration will be collected in brown high-density polyethylene (HDPE) bottles and preserved with acid Lugol's solution, a solution of iodine and potassium iodide, at a rate of 5 mL per 250 mL water sample. Samples will be filtered onto a 0.2 µm polycarbonate membrane (Nuclepore) and enumerated by BSA using a Leica compound microscope according to McNabb (1960) as described in Beaver et al. (2013). At least 400 natural units (colonies, filaments, and unicells) will be enumerated to the lowest possible taxonomic level from each sample. The abundance of common taxa will be estimated by random field counts. Rare taxa will be quantified by scanning a transect of the filter. In the case of rare, large taxa, half of the filter will be scanned and counted at a lower magnification. Cell volumes (biovolumes) will be estimated by applying the geometric shapes that most closely matched the cell shape (Hillebrand et al. 1999). Biovolume calculations will be based on measurements of 10 organisms per taxon for each sample where possible.

For picoplankton, 50 mL whole water will be preserved with glutaraldehyde (1 mL 50% glutaraldehyde addition per 25 mL water sample) and stored refrigerated. Picoplankton (typically < 2 µm) biovolume will be estimated using epifluorescence microscopy. Preserved samples will be filtered onto 0.2 µm polycarbonate membranes (Nuclepore), enumerated, and sized using an epifluorescence microscope.

If visual survey of a station indicates that potentially harmful algal species such as *Microcystis sp*. are present, the boat field crew will collect separate water samples for BSA to measure microcystin concentrations. The sample boats' crews will contain members from all the entities involved in field data collection (Regional San, AMS, SFSU, USGS). Any person from these organizations may observe *Microcystis* during their other tasks and may thus trigger the *Microcystis* sampling, following the SRiNCS *Microcystis* sampling SOP.

If field crews on boats observe visual evidence of *Microcystis* (e.g., green flakes of algae near the water surface) they will collect a surface grab sample for the microcystin toxin using a 250 mL PETG (polyethylene terephthalate, with a glycol modification) bottle, with the bottle filled only to the shoulder. Samples will be stored on ice in the field, then stored frozen at the RSEL. Samples will be shipped overnight to BSA on ice (blue ice packs). Shipping will commence on a Monday, Tuesday, or Wednesday to ensure that samples reach BSA in time to be analyzed during the same work week. BSA staff will analyze the samples using the Enzyme-Linked Immunosorbent Assay (ELISA).

BSA provides ELISA testing by USEPA approved Method 546 for the detection of microcystins. BSA uses ELISA kits provided by Abraxis and a Cyanotoxin Automated Assay System (CAAS), an automated, microtiter plate format analyzer for quantitative determination of microcystins. The analyzer is computer controlled and capable of automating all the steps of both ELISA

assays including fluid handling, plate mixing, incubation/timing, optical reading, calculations and reports. The CAAS system produces rapid, reliable, and consistent results, detecting microcystin values as low as 0.05 ppb.

11.1.8.2. Microzooplankton and macrozooplankton sampling and analysis

Methods for zooplankton sampling will follow the protocols described in AMS (2017) with the exception of the net diameter and mesh size noted below. At each station, we will collect triplicate vertical zooplankton samples with a 0.5 meter diameter, 50 micron mesh 3:1 Wisconsin-style zooplankton net. Samples will be transferred from the cod end to a 250 mL brown HDPE bottle after rinsing the net three times, and preserved with Lugol's solution (12.5 mL per 250 mL water sample). Analyses performed by BSA will follow BSA's internal SOPs. Zooplankton samples will be analyzed by BSA using the Utermohl technique with a minimum tally of 200 organisms. Dry weight biomass estimates will be based on length and length:width relationships and applied following methods described in Beaver et al. (2013).

11.1.8.3. Carbon Uptake (Phytoplankton Growth Assay)

Methods for carbon uptake will follow the methods described in AMS (2017). Briefly, whole water samples will be collected using an acid-cleaned plastic bucket that has been rinsed three times with ambient river water before being filled. Water will be poured from the bucket into acid-cleaned 250 mL polycarbonate square bottles (Nalgene) after each bottle has been rinsed three times. A set of three bottles for each station will receive ^{13}C-bicarbonate. Isotopes will be added at trace levels (approximately 10% of ambient concentrations). After the bottles have been spiked with tracer they will be placed into a flow-through incubator on deck, and shaded with multiple layers of darkened neutral density netting (top and sides) to 40% of surface irradiance. Uptake incubations will be terminated after 4 hours via vacuum filtration of 125-250 mL water onto combusted 25 mm Whatman glass fiber filters (GF/F). Following filtration, samples will be placed in sterile 2 mL Eppendorf micro-centrifuge tubes and dried in a drying oven at 50°C overnight. After drying, samples will be stored in a desiccator until processed for mass spectrometric analysis at a Stable Isotope Facility (to be determined). These incubations will produce three replicate measurements of bicarbonate uptake per station.

11.1.8.4. Zooplankton Growth Assays

These methods will follow the SOPs of the Kimmerer Laboratory at San Francisco State University (SFSU). At each monitoring station, field crews will collect one oblique zooplankton sample with a ½ meter net equipped with a flowmeter, and preserve with 10% Formalin solution. One sample will be analyzed for species, abundance, biomass, reproductive rate, and life-stage (for copepods) or size (for cladocerans) at SFSU.

Growth rate of zooplankton will be determined using a modification of the Artificial Cohort method (Kimmerer and McKinnon 1987). Field crews will collect live zooplankton by gentle subsurface tows with a 150 μm mesh net, resuspend the sample in water from the site, and size fractionate at selected mesh sizes using gentle reverse (upward) filtration. The selected size fraction will be diluted into ~18 L of surface water, subsampled to estimate the number of organisms, and mixed and subsampled with a beaker to obtain ~30-50 target organisms per subsample.

Subsamples will be poured alternately into 10 incubation containers and 5 jars whose contents will be preserved in 2% glutaraldehyde (Kimmerer and McKinnon 1986) and transported to the laboratory. After incubation for 1 and 2 days, contents of incubation containers are preserved similarly. We will incubate samples in 2-L polycarbonate bottles on a rotating wheel in a water bath at ambient temperature (± 0.2°C), which is simpler than incubating at a field site.

Optical measurements will be used to determine the volume of each copepod or cladoceran (Kimmerer et al. 2018) which will be calibrated to carbon mass. Volume will be determined using a FlowCam. Growth rate will be calculated as the time rate of change of the natural log of mass, and data from multiple time steps will be used to determine if growth rate changes during incubation (Kimmerer et al. 2018).

Samples preserved in the field will be repeatedly subsampled and organisms in subsamples will be identified and counted to obtain sufficient numbers for analysis. For copepods this means at least 20 adult females, and 30-50 of each pre-adult life stage. At least 100 cladocera will also be identified and measured. These data together with growth rates will be used to estimate mortality (Kimmerer 2015). Abundance, growth, reproduction, and mortality will be related to environmental conditions.

Field crews will also collect and analyze samples for molecular identification of foods consumed by the zooplankton. We will collect zooplankton and particulate matter at the growth-rate stations and freeze them for later analysis using High-Throughput Sequencing (Holmes 2018, Kimmerer et al. 2018).

11.8.1.5. Clam Biomass Estimation

Methods for clam sampling and analyses will follow the protocols described in AMS (2017). The study will sample clams from the surface of the river bottom using a custom-built, 35 cm wide, trawling dredge. Clams > 5 mm will be collected in a wire mesh basket at the back end of the dredge, which allows finer particles to pass through. At each location, 3 transects will be sampled parallel to the river banks, with transects spaced equally across the river's width. The dredge will be towed by a boat into the river's current for roughly 1 min at 1.8 km/h.

Distance traveled will be estimated from boat speed and time traveled, and verified by recording starting and ending GPS locations. All clams and other material will be removed from

the dredge before each transect pull starts. Time of day, water depth, and field notes will also be recorded. Clams will be stored on ice and transported to the laboratory, where they will be fixed, preserved, and measured with calipers to determine shell lengths following the protocols described in the project's clam measurement SOP.

11.8.1.6. Collection of Water Samples for Nutrient Analyses (USGS high frequency mapping cruises)

Samples for nutrient analyses (nitrate-nitrite, ammonium, and orthophosphate) will be collected at 0.5-m depth through Tygon brand flexible polymer tubing using the onboard diaphragm pump. The samples will be filtered using a 0.2-µm membrane filter before collection in clean glass bottles. Field crews shall follow the guidance for sample collection in the USGS *National Field Manual for the Collection of Water Quality Data* (USGS, variously dated).

Samples for chlorophyll-*a* analysis will be collected and field-filtered within 24 hours of collection using a syringe sample method (USEPA Method 445). Samples will be filtered by forcing water with a 60-mL syringe through an inline filter holder containing a 25-mm glass microfiber filter. The 60-mL syringe and inline filter holder are rinsed three times with ambient water before filtration. The syringe is then filled with 60 mL of ambient water. The filter holder is then removed and a 25-mm glass microfiber filter is placed inside. The filter holder is then screwed back onto the syringe and ambient water is flushed through the filter. The filter holder is removed every time more water needs to be drawn into the syringe.

The process will be repeated until the desired amount of chlorophyll *a* is present (usually 60 to 360 mL, depending on turbidity). When filtering is complete, the filter holder is opened and the filter is removed with tweezers without touching the filtrate. The filter is folded in half, then in quarters, with the chlorophyll *a* inside the folds. The folded filter is then wrapped in aluminum foil and placed in an envelope labeled with the site information and the volume filtered. The envelope is immediately placed on dry ice until transferred to USGS-OMRL. Upon arrival at the analytical lab, the temperature of the cooler is measured and recorded to verify samples were maintained at the appropriate temperature.

Samples for chlorophyll-*a* analysis in chlorophyll-containing particles > 5 µm in diameter will be identical to the total chlorophyll-*a* analysis described above except that a 5 µm membrane filter will be used.

11.2. Field Sample Collection Quality Control Samples and Measurement Quality Objectives

Required field sample collection QC samples include field blanks and field duplicates. All field sample collection QC samples will be collected at a rate of no less than 5% each. Field QC samples shall be planned and collected throughout the project to evaluate potential variability

sources in the field; including differing environmental conditions, geographic locations, sample collection personnel, and various field sampling protocols employed. Field blanks are required for water sample collection for analysis of mercury, methylmercury, current use pesticides, aquatic toxicity, total suspended solids (TSS), and volatile suspended solids (VSS). Field duplicates are required for all water and sediment samples. Field sample quality controls and measurement quality objectives are included in Table 14.1.

11.3. Field Sample Collection Corrective Actions

Table 11.3 lists typical corrective actions that may be taken by the project manager and/or QA Officer in response to issues that arise as a result of field sampling procedures. All necessary steps for corrective action will be documented on the field form and are entered into the electronic version of the Field Sampling Report that is maintained by SFEI-ASC. The individuals responsible for assuring that the field staff are properly trained and implement the Field Sampling SOPs are the Field Collection Coordinators (i.e., MPSL Project Coordinator and USGS Principal Investigators, OCRL Project Chief), SFEI-ASC Project Manager, and the QA Officer.

11.3.1. Field Sample Collection Corrective Actions for SRiNCS Project

Any issues that arise in relation to field sample collection during the SRiNCS project will be communicated to the overall project manager, Lisa Thompson, by the project managers for AMS, SFSU, and USGS Thompson will communicate said issues with SFEI Program Manager Matt Heberger, in conjunction with the relevant sub-project managers as appropriate.

In order to minimize the chance of such issues arising in the first place, Mr. Heberger, Dr. Thompson and the SRiNCS project team sub-project managers will conduct a monthly standing 30-minue conference call. The aims of these calls will be to keep SFEI/ASC and Delta RMP staff apprised of progress on field sample collection tasks. Should issues nevertheless arise, the project would be subject to the DRMP's corrective actions procedures, as described in Section 14.2.2 (note that there is planned a forthcoming DRMP formal procedure to document deviations from what is described in the Workplan, Sampling and Analysis Plan, and QAPP, and to document corrective actions).

12. Sample Handling and Custody

This section describes the sample handling and custody procedures from sample collection through transport and laboratory analysis.

Chain of custody (COC_ procedures shall be strictly adhered to during sample collection, transportation and laboratory handling to assure the identity of the samples. Proper sample and data handling and appropriate COC procedures help ensure that program data are credible and acceptable, in addition to considerations of accuracy and precision. COC documentation will document the processing of the sample from the time of collection to the time of analysis.

Table 12.1 provides information about storage and hold time requirements for each type of water quality measurement.

12.1. Pesticides

Sample containers will be labeled with the location, date, and time collected and packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets and chain-of-custody forms (COC) will be filled out by the USGS PFRG field crews at the time of collection and will include site ID, site description, collection date/time, container type, sample preservation, field water chemistry measurements, sampler(s) name and requested analyses. All forms will be included with the appropriate samples during shipping.

Samples for pesticide analysis will be delivered to the USGS OCRL laboratory in Sacramento California. If upon arrival at the OCRL samples are found to be warm (ice melted) or if sample containers are broken the Project Manager and Principal Investigator will be immediately notified. Ice chests are examined upon delivery to ensure that samples have been properly chilled (acceptable temperature range = 0 to 6 °C).

Water samples for pesticide analyses will generally be processed to extraction upon arrival at the OCRL. If this is not possible, the samples will be refrigerated at 0 to 6 °C in the dark for a period not to exceed the OCRL holding time requirement of 48 hours between sample collection and extraction. Upon arrival of samples, appropriate laboratory processing forms noting unique laboratory ID, site name, collection time and date, receiving technician's name, requested analysis, and date and time of receipt will be filled out. Signed copies of COCs will be maintained with the appropriate OCRL field and laboratory forms.

Samples for dissolved copper analysis and DOC/POC analysis will be processed at the USGS OCRL, within 24 hours of collection. Samples for dissolved copper analysis will be filtered using 0.45-micrometer (μm) filters and acidified to a pH less than 2 with 2 mL of 7.5N nitric acid. Samples for DOC analysis will be filtered using 0.7 μm pore size, pre-combusted glass-fiber filters, collected in 125-mL baked amber glass bottles, and acidified using 4.5N sulfuric acid. The 0.7 μm pore size filter holding the retained suspended material will be used for the POC analysis and will be wrapped in an aluminum foil square of appropriate size.

Samples for dissolved copper, DOC, and POC will be placed in a cooler on wet ice and shipped overnight to the USGS NWQL in Lakewood, Colorado.

Receipt temperature and sample condition (broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by receiving laboratories.

12.2. Toxicity Testing

Toxicity test samples will be delivered to the Aquatic Health Program Laboratory (AHPL) at UC Davis, California, within 24 hours of sample collection. Upon arrival at AHPL, toxicity testing samples will be immediately removed from the ice chests and the laboratory staff receiving the coolers will complete the accompanying Chain of Custody form (COC). The AHPL will initiate tests within 48 hours of sample collection, although under rare circumstances, this holding time may be extended to 120 hours for storm events, or when courier delivery schedules on weekends and holidays limit the availability of test organisms. This, however, is not in the MQOs and will result in a holding time flag. In these instances, AHPL staff will notify the SFEI-ASC QAO and Project Manager, and associated data will be flagged appropriately for hold time violation.

12.3. Trace Metals - Mercury

12.3.1. Sample Water

Sample containers will be labeled with the location, date, and time collected and packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets and chain-of-custody forms (COC) will be filled out at the time of collection and will include site code, site description, collection date/time, container type, sample preservation, field measurements, sampler(s) name, and requested analyses. All forms will be included with the appropriate samples during shipping. Samples will be delivered to MPSL in Moss Landing, CA. If upon arrival at the laboratory samples are found to be warm (ice melted), or if sample containers are broken, the Project Manager and Principal Investigator will be immediately notified. Ice chests are examined upon receipt to ensure that samples have been properly chilled (acceptable temperature range = 0° to 6° C).

Water samples will be delivered to MPSL within requisite holding times, where laboratory personnel will filter (if not field filtered) and preserve (if not field preserved) water samples following Table 12.1. Receipt temperature and sample condition (broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by receiving laboratories. Upon arrival of samples, appropriate laboratory processing forms noting unique laboratory ID, site name, collection time and date, receiving technician's name, requested analysis, and date and time of receipt will be filled out. Samples for dissolved mercury and dissolved methylmercury analysis will be filtered using 0.45-micrometer (μm) filters and acidified to 0.5% with pre-tested bromine monochloride, BrCl, or 12N hydrochloric acid, HCl, as appropriate within 48 hours of collection.

12.3.2. Fish Tissue

Fish samples will be wrapped in prepared aluminum foil, placed in zipper-closure bags and frozen on dry ice for transportation to the laboratory, where they will be stored at –20°C until dissection and homogenization. To avoid contamination, all material that comes in contact with fish are prepared and cleaned as described in Method MPSL-101, *Sample Container Preparation for Organics and Trace Metals, Including Mercury and Methylmercury*. Lab homogenates will be frozen until analysis is performed. Frozen tissue samples have a 12-month hold time from the date of collection. If a hold-time violation has occurred, data will be flagged appropriately in the final results. Holding times for each analyte can be found in Table 12.1.

12.3.3. Sediment

Sediment samples will be preserved by the sample collection crew following Table 12.1. At the end of each collection event, samples will be delivered to MPSL.

12.4. Nutrients

12.4.1. SRiNCS High Frequency Mapping Water Samples

Sample containers will be labeled with the location, date, and time collected and packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets and chain-of-custody forms (COC) will be filled out at the time of collection and will include site code, site description, collection date/time, container type, sample preservation, field water chemistry measurements, sampler(s) name and requested analyses. Regional San staff may use their own COC form or a version of the SFEI COC form in Appendix G.

Samples will be processed onboard, within 4 hours of collection. Samples for ammonium and nitrate + nitrite analysis will be acidified to a pH less than 2 with 2 mL of H_2SO_4 per L. Processed samples will be placed in a cooler on wet ice and shipped overnight to the USGS NWQL in Lakewood, CO. Receipt temperature and sample condition (e.g. broken/compromised containers, incorrect preservatives, holding time exceedance, etc.) will be recorded by NWQL.

12.4.2. SRiNCS Water Samples

Sample handling and custody will follow the protocols in Section 23 of the *Regional San Environmental Laboratory Quality Manual* (2019). Sample containers will be pre-labeled with the sample location and LIMS barcode. Date and time collected will be added to the label at the time of collection. Sample bottles will be packed in ice chests with sufficient wet ice to maintain sample transport criteria. Field sheets will be filled out at the time of collection and will include site code, site description, GPS location, collection date/time, field physical and water chemistry measurements, and sampler(s) name.

Water samples collected for analysis at the RSEL will be subject to the maximum holding times and sample collection preservation guidelines in the *Manual for the Certification of Laboratories Analyzing Drinking Water* 5th Edition, January 2005 and 40 CFR Parts 141.23.and 141.13. Details are provided in Table 12.1. Note that in the case of chlorophyll-a, the lab analysis method is based on" 10200 H. Spectrophotometric Determination of Chlorophyll" (in *Standard Methods for the Examination of Water and Wastewater - 20th edition*), but will be modified such that samples will be filtered within 12 hours of field collection, and that sample filters will be frozen for up to 6 months prior to analysis.

12.4.3. SRiNCS Phytoplankton and Zooplankton Enumeration Samples

Samples will be stored in a cool dry location at the RSEL prior to being shipped overnight to BSA in Ohio. Following analyses, samples will be stored at BSA until the final study report has been accepted by the Delta RMP.

12.4.4. SRiNCS Clam Samples

Clams will be transported and held on ice in coolers for up to 48 hours prior to fixation in buffered 10% formalin in labeled glass containers. After roughly 2 weeks, the clams will be transferred into 70% ethanol for long term preservation and can be stored at room temperature as long as needed.

12.5. Conventional Water Quality Parameters

12.5.1. SRiNCS High Frequency Mapping Water Samples - Chlorophyll

Samples for chlorophyll *a* analysis will be collected and field filtered using a syringe sample method and placed on dry ice until transfer to the lab. Samples will be filtered by forcing water with a 60-mL syringe through a filter holder containing a 25-mm glass microfiber filter. The 60-mL syringe and an inline filter holder are rinsed three times with the ambient water before filtration. The syringe is then filled with 60 mL of ambient water. The filter holder is then removed and a 25-mm glass microfiber filter is placed inside. The filter holder is then screwed onto the syringe and the ambient water is flushed through the filter. The filter holder is removed every time more water needs to be drawn into the syringe. The process is repeated until the desired amount of chlorophyll *a* is present (usually 60 to 360 mL depending on the water clarity). When filtering is complete, the filter holder is opened and the filter is removed with a forceps without touching the filtered material. The filter is then folded in half, then in quarters, with the chlorophyll *a* inside the folds. The folded filter is wrapped in aluminum foil and placed in an envelope labeled with the site information and the volume filtered. The envelope will be immediately placed on dry ice until transferred to MPSL.

12.5.2. SRiNCS High Frequency Mapping Water Samples - Dissolved Organic Carbon

DOC samples collected for the nutrient monitoring program will be field filtered using a syringe sample method. Samples will be filtered into a 125-mL amber glass bottle pre-preserved with phosphoric acid by forcing water with a 60-mL syringe through a filter holder containing a 25-mm diameter 0.45-µm sterile membrane filter. Sample bottles should be filled only to the shoulder to ensure a final pH less than one.

12.5.3. SRiNCS High Frequency Mapping Water Samples - Other Conventional Water Quality Parameters

TOC handling is covered in Section 12.3.3 Sediment. TSS/VSS have no special handling requirements and are covered in the second paragraph of Section 12.3.1, Sample Water.

13. Analytical Methods and Field Measurements

13.1. Field Measurements

The field collection teams will record measurements performed in the field on field sheets (electronic or paper), then enter them into a CEDEN template for subsequent entry in the Delta RMP database by SFEI-ASC. The master data logger is a Campbell Scientific CR6 (https://www.campbellsci.com/cr6). The data uploading is described in Section 19.3, Data storage/database. Reporting limits (RLs) and method detection limits (MDLs) for field measurements are shown in Table 7.3(a) where applicable.

13.1.1. SRiNCS Project - High Frequency Mapping - Underway Flow-through Instrumentation and Data Collection System

Underway measurements will be made using a powered watercraft (USGS R/V Landsteiner) with a sample collection system connected to two sensors to measure nitrate concentration, conductivity, turbidity, pH, dissolved oxygen, fDOM, chlorophyll-*a*, and phycocyanin. Mapping data is collected at speeds up to 10 m/s. For details on operation of the flow-through system see Downing et al. (2016). The USGS National Field Manual for the Collection of Water-Quality Samples (https://water.usgs.gov/owq/FieldManual/index.html) provides additional SOP guidance.

Briefly, data is recorded at 1 Hz and displayed in real time so the boat operator may slow down when rapid changes in constituents occur. Boat position and time are logged using a GPS (Garmin 16X-HVS) and speed is maintained below 10 m/s. Care to avoid navigational hazards, like shallow water and submersible aquatic vegetation, is taken to prevent clogging in the pickup water tube or in the flow through system.

The watercraft will be outfitted with a sample pick-up tube, assembled from ¾ inch diameter PVC pipe, attached to the keel at the stern, fixed 0.5 m below the water surface. Tygon tubing will be used to direct flow from the pick-up tube to a 12 volt DC, Viton diaphragm pump (SHURflo, Cypress, CA) fitted with a 178 micron inline strainer (Cole Parmer; EW-29595-47).

Oxygen de-bubblers will be used to prevent interference with optical measurements in the flow-through instrumentation system. Flow through instrumentation will be connected using Tygon tubing. All tubing will be new and, prior to use, all components of the flow-through system will be flushed with organic-free, deionized water.

The flow-through system will be divided into three flow paths after the pump. The first flowpath will be directed through a filter (Osmonics Memtrex, 25 cm length, 0.2 µm pore size; MNY921EGS; Osmonics, Inc.) and into a water sampler. The second flowpath will be directed into a 3-stage de-bubbler without filtration and then into a flow-through measurement system.

The measurement system comprises a Seabird model SB45 thermosalinograph (conductivity and temperature), Satlantic model ISUS V3 nitrate analyzer (NO_3-N mg/L), and a YSI EXO2. The YSI EXO2 will be fitted with sensors measuring conductivity, turbidity, pH, dissolved oxygen, fDOM, chlorophyll-*a*, and phycocyanin. A third flowpath will be used to compensate for changes in system pressure resulting from changes in boat speed. All instrumentation will be cleaned and calibrated prior to each use. Calibration samples for nutrients and chlorophyll-*a* are collected throughout the day.

13.1.2. SRiNCS Field Measurements of Water Quality, Phytoplankton Growth, Zooplankton Growth

The analytical methods and instruments used in the field measurements of water quality for the SRiNCS project are summarized in Table 13.1.

The descriptions of methods for the SRiNCS project repeat the text that in Section 11.1.8, *Collection of Samples for the SRiNCS Project*, as there is some overlap between sampling and field measurements, and for the sake of completeness.

13.1.2.1 SRiNCS Water Column Sampling and Analyses

Methods for water column sampling and analyses will follow the protocols described in AMS (2017) with any exceptions noted below. Sample collection will follow the protocols in Section 22 of the Regional San Environmental Laboratory Quality Manual (2019).

At each station, a YSI model 6600 sonde (Xylem Instruments) will be deployed to collect vertical profiles of temperature (°C), pH, electrical conductivity (µS cm^{-1}), DO (mg L^{-1}) and depth (m).

At each station, surface water (~0.5 m depth) will be collected using an acid-cleaned plastic bucket. Triplicate samples for determination of ammonium, nitrate, dissolved phosphorus, and dissolved organic carbon concentrations will be filtered through a 0.45 µm filter, preserved, and

stored refrigerated until analysis using standard methods at the Regional San Environmental Laboratory.

Triplicate samples for turbidity will be measured at each site using a Hach 2100P turbidimeter. A LI-COR underwater quantum sensor (model LI-192SA) will be deployed to collect a vertical profile of PAR (µmol photons m^{-2} s^{-1}).

Samples collected for chlorophyll *a* determinations will be analyzed at the RSEL following extraction with 90% acetone. Briefly, 20-100 mL water will be filtered onto Whatman GF/F filters which will be placed in petri dishes, wrapped in foil and preserved frozen until analysis. Frozen samples will be placed into a grinding tube to which 90% acetone was added. The sample will be ground with a PTFE (Teflon) glass grinder (Wheaton) for 1-2 min. The ground filter will be rinsed with 90% acetone into a centrifuge tube and extracted overnight in the refrigerator in the dark. Samples will be centrifuged and the supernatant analyzed at 750 nm using a spectrophotometer.

Whole water samples for phytoplankton identification and enumeration will be collected in brown HDPE bottles and preserved with acid Lugol's solution (5 mL per 250 mL water sample). Samples will be filtered onto a 0.2 µm polycarbonate membrane (Nuclepore) and enumerated by BSA using a Leica DMLB compound microscope according to McNabb (1960) as described in Beaver et al. (2013). At least 400 natural units (colonies, filaments, and unicells) will be enumerated to the lowest possible taxonomic level from each sample.

The abundance of common taxa will be estimated by random field counts. Rare taxa will be quantified by scanning a transect of the filter. In the case of rare, large taxa, half of the filter will be scanned and counted at a lower magnification. Cell volumes (biovolumes) will be estimated by applying the geometric shapes that most closely matched the cell shape (Hillebrand et al. 1999).

Biovolume calculations will be based on measurements of 10 organisms per taxon for each sample where possible. Picoplankton (typically < 2 µm) biovolume will be estimated using epifluorescence microscopy. Briefly, 50 mL whole water will be preserved with glutaraldehyde (1 mL 50% glutaraldehyde addition per 25 mL water sample) and stored refrigerated. Preserved samples will be filtered onto 0.2 µm polycarbonate membranes (Nuclepore), enumerated, and sized using an epifluorescence microscope.

If visual survey of a station indicates that potentially harmful algal species such as *Microcystis sp*. are present, we will collect separate water samples for BSA to measure microcystin concentrations. The sample boats' crews will contain members from all the entities involved in field data collection (Regional San, AMS, SFSU, USGS). Any person from these organizations may observe *Microcystis* during their other tasks and may thus trigger the *Microcystis* sampling.

If field crews observe visual evidence of *Microcystis* (e.g., green flakes of algae near the water surface) they will collect a surface grab sample for the microcystin toxin using a 250 mL PETG

(polyethylene terephthalate, with a glycol modification) bottle, with the bottle filled only to the shoulder. Samples will be stored on ice in the field, then stored frozen at the RSEL. Samples will be shipped overnight to BSA on ice (blue ice packs). Shipping will commence on a Monday, Tuesday, or Wednesday to ensure that samples reach BSA in time to be analyzed during the same work week. BSA staff will analyze the samples using the Enzyme-Linked Immunosorbent Assay (ELISA) method.

BSA provides ELISA testing by USEPA approved Standard Method 546 for the detection of microcystins . BSA uses ELISA kits provided by Abraxis and a Cyanotoxin Automated Assay System (CAAS), an automated, microtiter plate format analyzer for quantitative determination of microcystins. The analyzer is computer controlled and capable of automating all the steps of both ELISA assays including fluid handling, plate mixing, incubation/timing, optical reading, calculations and reports. The CAAS system produces rapid, reliable, and consistent results, detecting microcystin values as low as 0.05 ppb.

13.1.2.2. SRiNCS Microzooplankton and Macrozooplankton Sampling and Analysis

Methods for zooplankton sampling will follow the protocols described in AMS (2017) with any exceptions noted below. At each station, we will collect triplicate vertical zooplankton samples with a 0.5 meter diameter, 50 micron mesh 3:1 Wisconsin-style zooplankton net. Samples will be transferred from the cod end to a 250 mL brown HDPE bottle after rinsing the net three times, and preserved with Lugol's solution, a solution of iodine and potassium iodide, at a rate of 5 mL per 250 mL water sample. Analyses performed by BSA will follow BSA's internal SOPs.

Zooplankton samples will be analyzed by BSA using the Utermohl technique with a minimum tally of 200 organisms. Dry weight biomass estimates will be based on length and length/ width relationships and applied according to Beaver et al. (2013).

13.1.2.3. SRiNCS Carbon uptake (Phytoplankton Growth Assay)

Methods for carbon uptake will follow the methods described on pages 7 - 11 in the report *Spatial and Seasonal Patterns in Irradiance, Phytoplankton, and Grazers Along the Sacramento River, California* (AMS 2017). See Appendix E for a links to methods and SOP documents.

In brief, carbon uptake by phytoplankton will be quantified using the stable isotope tracer ^{13}C-bicarbonate. Whole water samples will be collected using an acid-cleaned plastic bucket that has been rinsed three times with ambient river water before being filled. Water will be poured from the bucket into acid-cleaned 250 mL polycarbonate square bottles (Nalgene) after each bottle has been rinsed three times. Each carbon source will be incubated in triplicate. A set of 3 bottles will receive ^{13}C-bicarbonate. Isotopes will be added at trace levels (approximately 10% of ambient concentrations).

After the bottles have been spiked with tracer they will be placed into a flow-through incubator on deck, and shaded with multiple layers of darkened neutral density netting (top and sides) to 40% of surface irradiance. Uptake incubations will be terminated after 4 hours via vacuum filtration of 125-250 mL water onto combusted 25 mm Whatman glass fiber filters (GF/F).

Following filtration, samples will be placed in sterile 2 mL Eppendorf micro-centrifuge tubes and dried in a drying oven at 50°C overnight. After drying, samples will be stored in a desiccator until processed for mass spectrometric analysis at the University of California at Davis Stable Isotope Facility. These incubations will produce three replicate measurements of bicarbonate uptake per station.

13.1.2.4. Zooplankton Growth Rate Assays

These methods will follow the SOPS of the Kimmerer Laboratory at SFSU. At each station, field crews will collect one oblique zooplankton sample with a ½ meter net equipped with a flowmeter, and the sample will be preserved with 10% Formalin solution.

One sample will be analyzed for species, abundance, biomass, reproductive rate, and life-stage (copepods) or size (cladocera) distributions (at SFSU). Growth rate of zooplankton will be determined using a modification of the "Artificial Cohort" method (Kimmerer and McKinnon 1987). Field crews will collect live zooplankton by gentle subsurface tows with a 150 μm mesh net, resuspend the sample in water from the site, and size fractionate at selected mesh sizes using gentle reverse (upward) filtration.

The selected size fraction will be diluted into ~18 L of surface water, subsampled to estimate the number of organisms, and mixed and subsampled with a beaker to obtain ~30-50 target organisms per subsample. Subsamples will be poured alternately into 10 incubation containers and 5 jars whose contents will be preserved in 2% glutaraldehyde (Kimmerer and McKinnon 1986) and transported to the laboratory. After incubation for 1 and 2 days, contents of incubation containers are preserved similarly. We will incubate samples in 2-L polycarbonate bottles on a rotating wheel in a water bath at ambient temperature (± 0.2°C), which is simpler than incubating at a field site. Optical measurements will be used to determine the volume of each copepod or cladoceran (Kimmerer et al. 2018) which will be calibrated to carbon mass. Volume will be determined using a FlowCam.

Growth rate will be calculated as the time rate of change of the natural log of mass, and data from multiple time steps will be used to determine if growth rate changes during incubation (Kimmerer et al. 2018). Samples preserved in the field will be repeatedly subsampled and organisms in subsamples will be identified and counted to obtain sufficient numbers for analysis. For copepods this means at least 20 adult females, and 30-50 of each pre-adult life stage. At least 100 cladocera will also be identified and measured.

These data together with growth rates will be used to estimate mortality (Kimmerer 2015). Abundance, growth, reproduction, and mortality will be related to environmental conditions. Field crews will also collect and analyze samples for molecular identification of foods consumed by the zooplankton. We will collect zooplankton and particulate matter at the growth-rate stations and freeze them for later analysis using high-throughput sequencing (Holmes 2018, Kimmerer et al. 2018.

13.1.2.5. Clam Sampling

A custom built clam trawl will be used to scrape clams from surface of the river benthos. The trawl will be deployed from the side of the boat while it is stationary in the water. The trawl will have a rope connected to a buoy on the basket end and a rope connected to the boat on the inlet end. After the boat moves about 10 m into the river's current, the trawl will be tied off and dragged behind the boat for roughly 1 min at a speed of approximately 0.7 m/s. The starting and ending locations, average river depth, trawl duration, and movement speed, and observational field notes will be recorded for each trawl.

The clam trawl will be lifted to the side of the boat and gently agitated to release fine particles. It will then be moved into the boat and its contents will be emptied into a plastic sorting tub. All living clams, including those attached to the trawls rake will be placed into labeled mesh storage bags and placed on ice in a cooler for transport to the laboratory. All other material will be returned to the river and the trawl will be visually inspected by two researchers to ensure that there are no remaining clams. Three transects will be conducted that are equally spaced across the river's width per location.

13.2. Laboratory Analysis

The following sections list the laboratory analytical methods that will be used in Delta RMP monitoring, and policies for sample archiving and disposal.

Reporting turnaround times for submission of results from sample analyses are generally 90 days or less, but may be specified in contracts with the analytical laboratories. Samples should be extracted and analyzed within the holding times specified for the analytical methods used (Table 12.1).

13.2.1. Analytical Methods

Table 13.1 provides a summary of analytical methods and instruments used by the Delta RMP. The analytical methods and instruments used in the laboratory analyses of water quality for the SRiNCS nutrients project are summarized in Table 13.1.

Reporting limits (RLs) and method detection limits (MDLs) are shown in Table 7.3 (a) for conventional analytes, field parameters, trace metals, and nutrients. Table 7.3(b) shows the RLs and MDLs for pesticide analytes.

All analytical method SOPs can be downloaded from the SFEI-ASC Google Drive. Appendix E provides a list and links to these SOPs.

Detailed descriptions of methods for analysis of pesticides can be found in these publications:

- *Delta Regional Monitoring Program Annual Monitoring Report for Fiscal Year 2015–16: Pesticides and Toxicity* (Jabusch, Trowbridge, Heberger, Orlando, et al. 2018)
- *Pesticide Inputs to the Sacramento-San Joaquin Delta, 2015-2016: Results from the Delta Regional Monitoring Program* (De Parsia et al. 2018)

13.2.2. Toxicity Testing Procedures

Staff of the Aquatic Health Program Laboratory (AHPL) at UC Davis shall perform aquatic toxicity testing following EPA methods, SWAMP MQOs, and the lab's SOPs as listed in Table 14.4. Additional project-specific requirements are listed below for 3 test species.

Any use of surrogate species must be approved by the SWAMP QA Officer. Furthermore, it should be discussed by the Pesticides subcommittee of the Delta RMP TAC and approved by the Steering Committee. Alternative protocols can be proposed to SWAMP and EPA, but tests shall be run per the method for this project.

Ceriodaphnia dubia

Toxicity testing according to SWAMP MQOs describes the recommendation for secondary conductivity controls when an ambient sample conductivity[9] is outside of the physiological range of the test organisms. These can be either high-conductivity controls (i.e., synthetic control waters salted up to match the highest conductivity of the ambient samples collected) or low-conductivity controls (i.e., synthetic control waters diluted with glass-distilled water to match the lowest conductivity of the ambient samples collected). The latter will include nutrients (i.e., biotin, sodium selenate, and vitamin B_{12}) added to match the target concentrations in culture water. Secondary controls will be tested as outlined below.

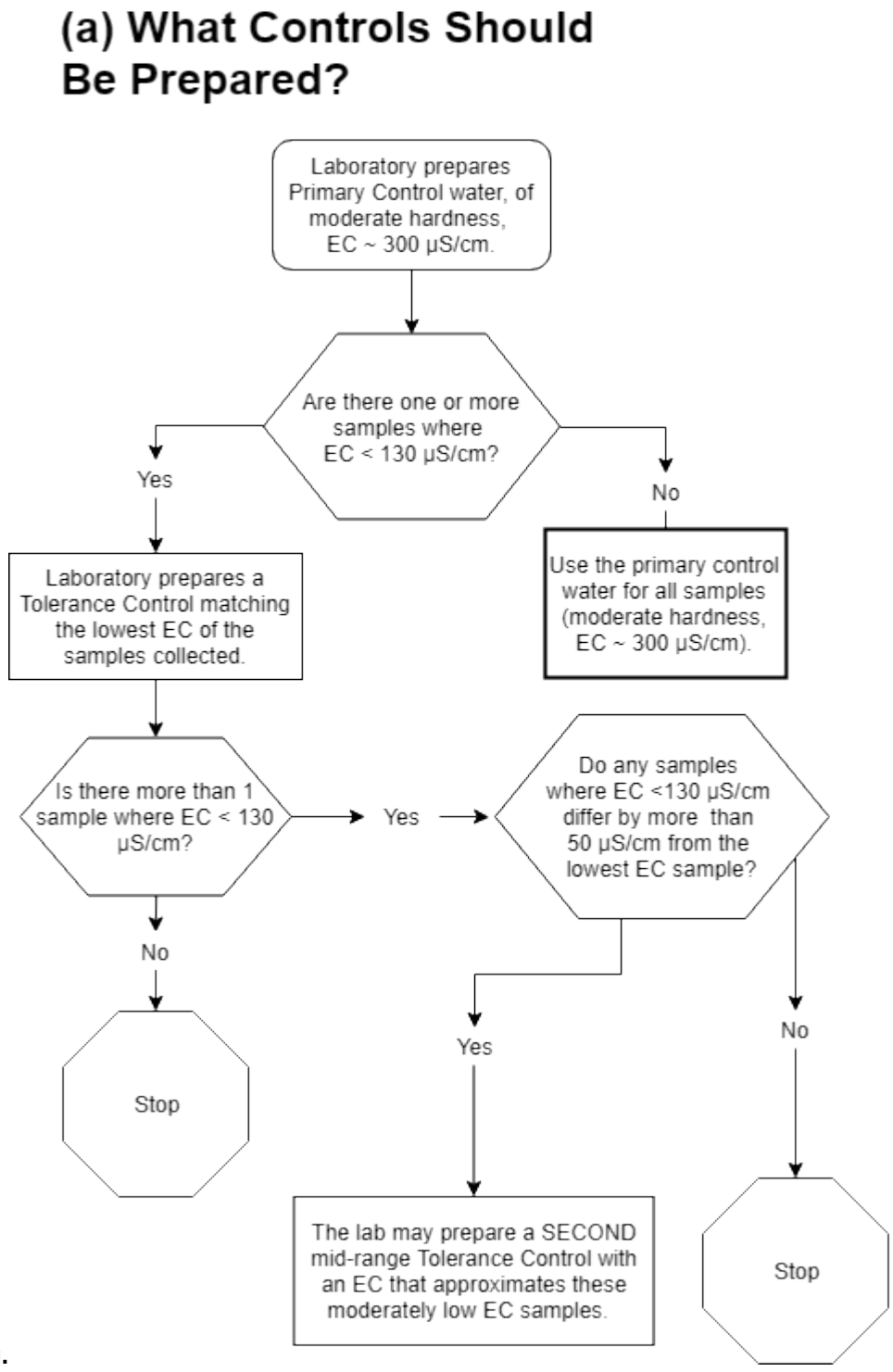
Depending on the range of conductivities observed in ambient sample waters, additional negative controls may be tested to control for water quality near the organisms' tolerance threshold. Figure 13.1 on the following page is a flowchart showing how low-conductivity controls for *C. dubia* toxicity testing should be handled. Part (a) of the figure is a flowchart

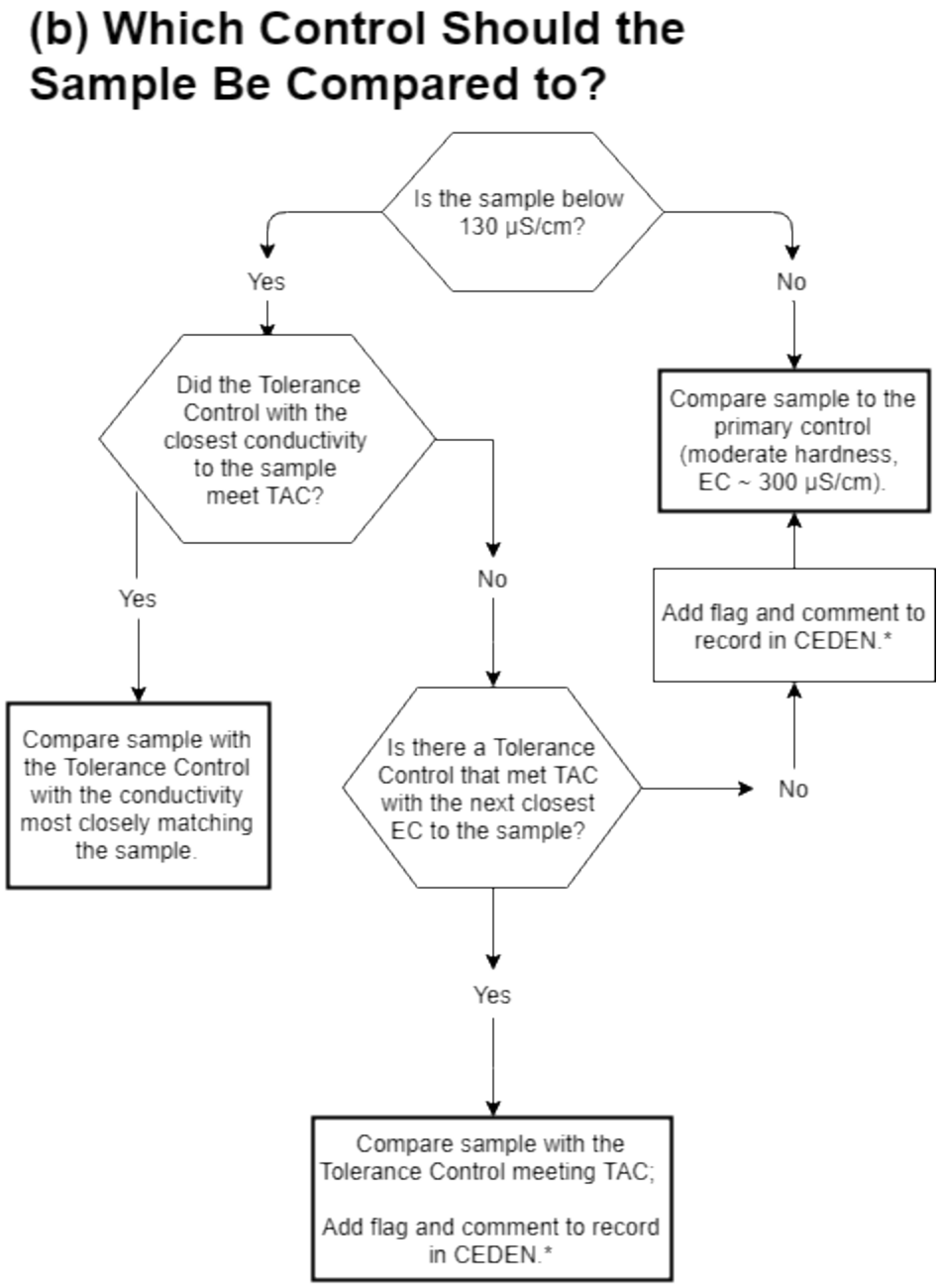
[9] Conductivity refers to specific conductance (i.e., conductivity normalized to 25°C).

depicting what controls the lab should prepare based on the range of conductivity in ambient samples. Part (b) is a flowchart showing which control each ambient sample should be compared to for performing a t-test, which will result in a binary determination of whether the ambient sample toxic (i.e. yes/no).

SWAMP guidance states that for *C. dubia* toxicity testing, the sample conductivity should be above 100 µS/cm; although, previous Delta RMP testing found that *C. dubia* reproduction in AHPL cultures may be affected by conductivity as high as 127 µS/cm. Therefore, the lab shall run a tolerance control matching the lowest sample conductivity when there are sample(s) with conductivity ≤ 130 µS/cm. The laboratory will also have discretion to run a second tolerance control when there are multiple samples with conductivity ≤ 130 µS/cm (i.e., if samples with conductivity ≤ 130 µS/cm have a difference of at least 50 µS/cm).

Figure 13.1 Flowchart illustrating procedure for handling low-conductivity controls for *C. dubia* toxicity testing.





*In cases like these for C. dubia toxicity testing, where sample conductivity is low, but the low-conductivity tolerance control does not meet test acceptability criteria, the sample is compared to the regular, medium-hardness control. In cases like these, the result of the statistical comparison may indicate that the sample is toxic, but it may not be (entirely) due to toxic contaminants, but rather due to a deficiency of ions that C. dubia need in order to thrive. Therefore, a comment may be added to the CEDEN database field ToxTestComments (limit 255 characters) as follows: “Tolerance control based on sample conductivity did not meet test acceptability criteria; percent effect based on comparison with standard control. Effects may include response to low EC in sample.” In addition, it is also appropriate to add a “TW” flag to the field

ToxResultQACode. This code means, “Water quality parameters outside recommended test method ranges.”

If the conductivity is less than 130 µS/cm, field crews should ensure sufficient volume is collected for all testing, and possible TIEs. (The AHPL lab manager has indicated that the planned volume is sufficient, but staff should continue to track this and adjust if necessary, for example, if larger volumes of water are required for TIEs.)

Ceriodaphnia dubia will **not** be tested in samples with specific conductance > 2,500 µS/cm, which is outside of the maximum tolerance of this test species. SWAMP MQOs state that *Hyalella azteca* can be used as a surrogate for *C. dubia* in this case. The Delta RMP is already testing with *H. azteca*.

Nutrient addition in low-conductivity samples

This paragraph describes additional testing for research purposes, with the intent of understanding if nutrient additions to low conductivity samples will increase *C. dubia* reproduction as AHPL has shown it does in the tolerance controls. If there is at least one sample with conductivity ≤ 130 µS/cm in a batch, the lab shall use water from one low-conductivity environmental sample to run an additional test. In this sample, the lab will treat the environmental sample by adding the standard blend of nutrients (i.e., biotin, sodium selenate, and vitamin B_{12}). The amount of nutrients added should match the amount added to the lowest conductivity tolerance control. The results of the research treatments will be compared to the secondary controls with the most closely matching conductivity, and also with the untreated sample. The purpose of this small experiment is to inform the Delta RMP if background water quality and/or nutrients affect the test organism response.

Hyalella azteca

Feeding during toxicity tests will follow the SCCWRP method where food is given two hours prior to water changes (Schiff and Greenstein 2016). This approach is consistent with SWAMP MQOs and reduces the potential for contaminants to sorb to food where they may be less bioavailable to the organism and bias the results.

Chironomus dilutus

Chronic toxicity testing is recommended by the CUP TAC to assess the potential for effects from imidacloprid and fipronil, to which the midge is sensitive. SWAMP MQOs for this 10-day chronic survival and growth test were published in August 2018, and Delta RMP sample testing with this midge will commence in the fall of 2018, as long as the laboratory has demonstrated proficiency in testing with this method, at the discretion of the SWAMP QA Officer.

***Selenastrum capricornutum*[10]**

Micronutrient stock solution should NOT contain ethylenediaminetetraacetic acid (EDTA), as EDTA is known to chelate metals and therefore the presence of EDTA in the algal growth test can mask metal toxicity.

13.2.3. Sample Retesting

When a test fails to meet test acceptability criteria, the RMP project team may request a re-test. Therefore, retesting samples may require using samples that have exceeded the 48-hour hold time. Decisions to retest samples need to be made as quickly as possible by the testing lab in consultation with the TIE Committee (see Appendix I). The laboratory will notify the TIE Committee by email of the possible need to retest immediately upon identifying an invalid test or, if possible, when the control is exhibiting a poor or irregular survival or reproduction pattern that causes the laboratory staff to anticipate that Test Acceptability Criteria may not be met. In this notification, the laboratory will describe the concern and could provide a recommendation for retesting or continued monitoring of the results.

Within 24 hours of test result notification from the toxicity laboratory, the TIE Committee will review the laboratory notification, discuss (i.e., over email or a conference call), and make a consensus decision regarding whether to retest a sample. The CVRWQCB SWAMP project manager or designee, who will be a part of the TIE Committee communications, will inform the laboratory of the decision on retesting. The laboratory will initiate the retest of the previously collected sample within 24 hours of notification from the subcommittee (i.e., within ~48 hours of the lab notification).

If the TIE Committee does not respond within 24 hours, then the laboratory will implement its recommendation. In the event that retesting is delayed beyond this timeline (e.g., organisms need to be ordered from a supplier or samples need to be recollected), such delays will be communicated to the TIE Committee and documented. Any issues contributing to an invalid test and its resolution will also be documented and submitted to the SWAMP QA Officer and to the Delta RMP program manager to inform adaptive management of the Delta RMP.

The potential need for resampling or retesting may also arise if, for example, samples are accidentally lost or destroyed in whole or in part. The bioassay laboratory will immediately notify the TIE Committee, SFEI/ASC TAC project manager, and the USGS analytical lab with a description of the problem so that a decision to resample can be made by the project team.

[10] Currently accepted scientific name for this algae species is *Raphidocelis subcapitata*. Also formerly known as *Pseudokirchneriella subcapitata*. Nevertheless, it is still widely referred to as *Selenastrum* by the aquatic toxicity testing community.

13.2.4. Statistical Analyses

Statistical analysis of laboratory toxicity test data will be consistent with standard single concentration statistical protocols (EPA 2002; Appendix H, page 306-308). This approach compares each sample with the appropriate control and calculates the test result according to standardized statistical methods used in aquatic toxicology. Statistics for toxicity data will be made with the SWAMP Toxicity Transformer Excel sheets, as provided by the SWAMP.

Samples will be compared with the appropriate negative control. This will be the negative control (i.e., primary or tolerance control) with water quality (i.e., specific conductance) most closely matching the sample when multiple negative controls are included as part of a toxicity test. See the SWAMP 2018 Memo: "Use of Additional Controls in SWAMP Toxicity Tests."[11] Statistical analyses shall follow the method and SWAMP memo for additional controls. Specifically:

- Samples with conductivity > 130 µS/cm will be compared with the primary control.
    - If the primary control does not meet Test Acceptability Criteria then results are rejected. Retesting the sample and control can be considered.
- Samples with conductivity ≤ 130 µS/cm will be compared with the tolerance control. If there is more than one tolerance control then samples with ≤ 130 µS/cm will be compared with the tolerance control with water quality (i.e., conductivity) most closely matching the sample.
    - If the tolerance control with water quality (i.e., conductivity) most closely matching the sample does not meet Test Acceptability Criteria then either:
        - 1) Compare the sample with the other tolerance control if the other tolerance control meets Test Acceptability Criteria. Add a flag and a comment to the record in CEDEN.*.
        - 2) Compare the sample with the primary control if there was no other tolerance control that met Test Acceptability Criteria. Add a flag and a comment to the record in CEDEN.* .

*A comment may be added to the CEDEN database field **ToxTestComments** (limit 255 characters) as follows: "Tolerance control based on sample conductivity did not meet test acceptability criteria; percent effect based on comparison with standard control. Effects may include response to low EC in sample." In addition, it is also appropriate to add a "TW" flag to the field **ToxResultQACode**. This code means, "Water quality parameters outside recommended test method ranges."

A flowchart illustrating the steps above is shown in Figure 13.1.

[11] https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/swamp_toxicity_test_control_water_memorandum.pdf

Sample comparisons with the primary control will generally determine toxicity due to contaminants in the sample when the sample is not outside or near the organisms' limit of tolerance. Likewise, comparing samples outside or near an organism's tolerance limit with the appropriate tolerance control accounts for possible background water quality effects to indicate effects due to contaminants. These comparisons will help answer the Delta RMP Assessment Question 1 (Status and Trends) "To what extend to current use pesticides contribute to observed toxicity in the Delta?" by identifying toxicity effects due to contaminants (e.g., pesticides).

When a tolerance control fails to meet Test Acceptability Criteria, it is an indication that the background water quality does not support the test organism and that the toxicity endpoint is not a reliable indicator of the effects due to contaminants in samples with similar water quality. Background water quality effects may be included in the observed effects when comparisons are made between a sample at or near an organism's tolerance limit and the primary control when the tolerance control fails to meet test acceptability criteria. This may describe the 'absolute toxicity' of a sample (i.e., difference between the sample performance and the maximum potential performance in its normal culture water conditions), but the result may reflect effects of the background water quality.

Lab analysts shall use the software application *Comprehensive Environmental Toxicity Information System*™ (CETIS; Tidepool Scientific, McKinleyville, CA, USA) to calculate Effect Concentration and Lethal Concentration values (EC_{25} for sublethal endpoints and LC_{50} for survival endpoints) for reference toxicant tests.

Delta RMP samples will be compared with the control (either primary or secondary/tolerance control) with the most similar water quality conditions, measured by specific conductivity. This group or 'batch' will be analyzed independently of other batches. If the negative control for a batch does not meet Test Acceptability Criteria, then the test organism health is compromised in those water quality conditions. There is not a valid benchmark for comparing the toxicity endpoint in samples associated with a negative control that does not meet Test Acceptability Criteria. Samples may be retested once. Sample results will remain invalid if a batch control fails to meet Test Acceptability Criteria in a retest. The potential cause(s) of repeated control failures will then be investigated and corrective actions identified.

13.2.5. Toxicity Identification Evaluation (TIEs)

This section provides guidance for when, and under what conditions, the toxicity testing laboratory should conduct a Toxicity Identification Evaluation (TIE). A TIE is an investigative process that uses laboratory modifications of test sample chemistry and resulting changes in toxicity to identify the constituent groups (e.g., organophosphates) that are the likely cause(s) of toxicity.

The trigger for a TIE shall be a ≥ 50% reduction in the organism response compared to the appropriate lab control. This trigger shall apply to all test organisms and all endpoints (acute and chronic). The decision on whether or not to perform a TIE will be made by the toxicity testing laboratory in consultation with a Delta RMP TIE subcommittee. Decisions to perform a TIE are event-specific and dependent on the degree of effects observed in baseline testing, what is known about the sample (e.g., location, previous effects and toxicants, relevant pesticide applications), test species, and the available funding to conduct the TIE. The TIE Subcommittee and testing lab shall quickly decide whether to conduct TIEs (the subcommittee should be notified within 48 hours of the TIE trigger, and the TIE should begin less than 96 hours after the TIE trigger), and whether to conduct any follow-up study (e.g., additional TIE treatments, supporting analytical chemistry).

This description is intended to be a starting point to inform the discussion and interpretation of any TIEs that are conducted on Delta RMP samples. TIEs may provide additional information that lead to other approaches to identify the cause of effects that are not identified here.

Phase 1 TIEs attempt to characterize the physical and chemical properties of the possible toxicant(s) in the sample. Information is gained regarding the physical/chemical properties of the toxicant(s) when the toxicity endpoint effect is reduced in the treated sample, adding to the weight of evidence regarding the class of contaminants that may have caused the toxicity. Phase 2 TIEs attempt to identify specific constituents causing or contributing to toxicity through chemical analyses or additional TIE treatments. Multiple TIE methods are presented in EPA guidance documents (USEPA 1991, 1992, 1993a, 1993b). Other approaches may be adopted from the peer-reviewed literature (e.g., Wheelock et al., 2004) or developed to address study-specific questions.

TIEs should be initiated as soon as possible (e.g., within 96 hours) after exceeding the TIE trigger and following approval of the TIE Subcommittee. The laboratory must also conduct a preliminary validation of the initial toxicity test results by confirming that basic water quality parameters (e.g. conductivity, dissolved oxygen) were within acceptable ranges for the affected test species and that test acceptability criteria were met, unless sufficient acute effects provide clear direction on the need for retesting. Follow-up investigations (e.g., Phase 2 or 3 TIEs) may also be considered.

Delta RMP TIE testing has the primary goal of identifying whether pesticides are causing or contributing to observed toxic effects. A secondary goal may be to identify (or exclude) other factors (i.e., water quality conditions or other toxicants) contributing to reduced survival, growth, or reproduction. A phased TIE approach will be used, to the extent possible, to achieve these goals by initially focusing on treatments that identify major classes of contaminants that could include pesticides:

- EDTA (evidence of metals toxicity; minimum of 2 EDTA concentrations will be tested)
- Solid-phase extraction column (e.g., C-8 or C-18; evidence of toxicity due to non-polar organics, organic-metal chelates, and some surfactants)
- Centrifugation (evidence of toxicity due to particulate-bound contaminants such as chlorpyrifos and pyrethroids; use with turbid samples or at the discretion of the TIE subcommittee)
- PBO (evidence of toxicity due to a substance that is metabolized by the CYP450 enzyme system; evidence of OP insecticides if toxicity is reduced and of pyrethroid insecticides if toxicity is potentiated)
- Carboxylesterase addition (evidence of toxicity due to a contaminant with an ester bond, such as pyrethroid insecticides)
- Baseline (confirms if the toxicity is persistent)

If the cause of an observed effect is not clear after initial TIE testing, or if further detail describing the type or specific toxicant is desired, then the TIE Subcommittee may choose to have the laboratory conduct additional TIE treatments. Considerations for additional TIEs could include the level of available funding, magnitude of toxicity (TIE treatment effectiveness is easier to determine when there is a strong toxicity signal), species tested, and other data (e.g., potential sources, initial TIE results, and the likelihood that pesticides will be identified). As examples, the following TIE treatments could be selected to assess factors contributing to the observed effect:

- Low temperature – evidence of toxicity due to a contaminant that is metabolized, so lower temperatures slow the organisms' metabolism; increases the toxicity of pyrethroid insecticides
- Aeration – evidence of toxicity due to volatile, sublatable, or oxidizable compounds including surfactants
- Non-polar organic solid-phase extraction (SPE) column – evidence of toxicity due to a relatively polar organic contaminant
- pH 3/11 – evidence of toxicity due to hydrolysable/pH-dependent compounds (and filtration to assess/remove/control for settleable/coagulated toxicants and particulates).
- $Na_2S_2O_3$ – evidence of toxicity due to oxidants
- Cation Exchange – removes metals and other divalent cations
- Chemical analysis of cyanotoxins (to be compared with species-specific toxicity values). This would require freezing a subsample of the freshly collected sample for potential analysis if toxicity is observed from a location with known or potential cyanobacteria bloom.

The specific TIE treatments will depend on the test species. Salinity/conductivity is an important factor affecting toxicity test results for some species in the Delta, and TIEs in some samples with species sensitive to conductivity may require appropriate low-specific conductance or high-specific conductance secondary controls in addition to laboratory culture water controls treatments as indicated in SWAMP MQOs.

13.2.6. Sample Archive and Disposal

Project samples shall not be disposed of until all analyses are complete and analytical and QC results have been reviewed and approved by the SFEI-ASC Program Manager and the SFEI-ASC QAO.

14. Quality Control

14.1. Field Measurements

Prior to use in the field (typically within 24 hours prior to sampling), handheld water quality instruments are calibrated against appropriate standards and, if possible, checked against a standard from a different source. For some measurements such as dissolved oxygen, probes are often calibrated to ambient conditions rather than to known standards. In such cases, the field staff should verify appropriate qualitative instrument response (e.g., in water deoxygenated by sparging, sodium sulfite addition, or other means). All calibrations are documented on a calibration checklist on the individual instrument or its case with date, time, and operator name. If an instrument cannot be calibrated or is not reading correctly, a backup instrument will be used to measure water quality parameters.

For single or multi-parameter water quality meters, the following standards will be used to calibrate:

1. **pH** – commercially available standards pH 4, 7, 10. Perform a 2-point calibration covering the range of expected measurements. Use the 3rd pH standard (or standard supplied by another manufacturer) as a check standard to verify calibration accuracy.
2. **Specific Conductance** – perform a single-point calibration in the middle of the expected environmental range and use two check standards (KCl solution) bracketing the expected measurement range.
3. **Dissolved oxygen** – use calibration procedure recommended by manufacturer, typically in 100% air saturation.
4. **Temperature** – check against thermometer of known accuracy before each deployment. An ice water bath of approximately 0°C can be used to semi-quantitatively verify temperature probe response but may vary due to uncontrolled factors such as container size and

geometry, ice/water disequilibrium, or the presence of melting point-lowering contaminants.

Flow-through instrumentation will be calibrated by applying temperature corrections to all fDOM, chlorophyll *a*, and phycocyanin measurements. Organic free DI water offsets will be collected and applied to optical nitrate measurements and fluorescence measurements (fDOM, chlorophyll *a*, and phycocyanin). All fDOM measurements will be corrected for turbidity interference and converted to quinine sulfate equivalents.

Data collected by the flow through system are inspected in real time and instruments are troubleshot in the field. If needed, calibration checks or standard curves are re-run in the field. Data are validated by comparing in situ field data with laboratory results. Correction factors can be applied when needed.

All instruments used with the flow-through system undergo blank and calibration checks as described in Table 14.1. The flow-through system makes redundant measurements (e.g. two chlorophyll fluorimeters, two fDOM fluorimeters, two thermistors), which allows technical staff to check constituent measurement accuracy throughout the day. Fouling and drift of instruments may occur due to electrical, optical, and/or communication issues, but redundant measurements can distinguish such issues, and/or environmental conditions. Additionally, grab samples are collected for laboratory analysis to ground-truth environmental measurements.

The Timberline ammonium analyzer requires a calibration curve at the start and end of each field day. The instrument is intermittently flushed with blank water and additional standards are run over the course of the field day. Repeat measurement will allow for confirmation of precision at calibration and in situ. Instrument measurements will be repeated a minimum of three (3) times, after the reading has stabilized, during every calibration or accuracy check event in the laboratory. Field measurements will be repeated a minimum of three (3) times only when conditions are not dynamically variable, after the reading has stabilized, while not in motion, at a minimum of two (2) sites per trip. Table 14.1 provides information on the performed QC checks and acceptable limits.

Measurement quality objectives for field measurements performed with the YSI 6600 V2 sonde for the SRiNCS project are described in Table 14.1. Parameters include temperature, pH, specific conductance, dissolved oxygen, and turbidity.

If failure of an instrument should occur, a backup instrument should be checked and calibrated. All sampling and measurement modifications or failures that occur in the field due to instrument malfunction will be recorded in the Field Form and the Field Reference Sheet. The Field Collection Coordinators, SFEI-ASC Program Manager, and the SFEI-ASC QAO will be responsible for ensuring that staff document all deviations from planned operations and schedule repairs and/or additional training as needed.

14.2. Laboratory Analysis

For all participating labs, the Laboratory Project Manager must demonstrate and document that the methods performance meets the data quality requirements of the project. Two separate factors are involved in demonstrating method applicability: first, demonstrating that the laboratory can perform the method properly in a clean matrix with the analytical system under control, and second, demonstrating that the method selected generates "effective data" in the matrix of concern. The former addresses lab or operator training and proficiency, while the latter demonstrates that the selected method performs with the appropriate selectivity, sensitivity, accuracy, bias and precision, in the actual analytical matrix, to achieve project goals.

14.2.1. Measurement Quality Objectives

Laboratory Performance Measurements for Laboratory Analyses

Laboratory performance measurements are included in the QA data review to check if measurement quality objectives are met. Results of analyses of QC samples are to be reported with results of field samples. Minimum frequencies and target performance requirements for QC measures of reported analytes are specified in Table 14.2.

QC measures typically used for evaluation of laboratory and field sampling performance include the following:

7. **Method (or extraction/preparation) blanks**: samples of a clean or null (e.g., empty container) matrix taken through the entire analytical procedure, including preservatives, reagents, and equipment used in preparation and quantitation of analytes in samples.
8. **Field (or equipment/collection) blanks**: samples of a clean or null matrix taken through the sampling procedure, then analyzed much like an ordinary field sample.
9. **Surrogate standards**: analytes introduced to samples prior to sample extraction to monitor sample extraction method recoveries.
10. **Internal standards**: analytes introduced after the last sample-processing step prior to analysis, to measure and correct for losses and errors introduced during analysis, with recoveries and corrections to reported values generally reported for each sample individually.
11. **Matrix spike samples/duplicates**: field samples to which known amounts of target analytes are added, indicating potential analytical interferences present in field samples and errors or losses in analyses not accounted for by surrogate correction.
12. **Lab reference materials/laboratory control samples**: materials collected, bought, or created by a laboratory as internal reference samples, to track performance across batches.

13. **Instrument replicates**: replicate analyses of extracted material or standards that measure the instrumental precision.
14. **Laboratory replicates**: replicate sub-samples of field samples (preferred), standard reference materials, lab reference materials, matrix spike samples, or laboratory control samples, taken through the full analytical procedure including all lab processes combined.

MQOs for Aquatic Toxicity Testing

As shown in Table 14.2, the study design calls for a rate of field duplicates of 1 per 20 field samples for aquatic toxicity testing. The field duplicate sample should be handled the same as for all other samples, and the full suite of toxicity tests should be run using all 5 species.

The water quality measurements specifically coupled to toxicity tests are intended to help interpret toxicity test data. Quality control practices and MQOs for toxicity testing and water quality measurements parallel those used for field meter instrumentation. Meters are calibrated at the beginning of each day and calibration checks are performed when measurements for the day exceed 20 readings for each meter. Meters are recalibrated when drift exceeds the MQO for accuracy in Table 14.3. Quality control samples are expected to fall within the precision MQOs below and data are qualified in instances when these are exceeded.

14.2.2. Corrective Actions Procedures

If chemical analytical laboratory results fail to meet the MQOs, the corrective actions in Table 14.5 will be taken. Corrective actions will be documented, resolved, and followed-up on following the process for corrective actions that is outlined by the SWAMP. The process is based on the SWAMP Corrective Action Form and is applied to sample results that fail to meet the technical and non-technical requirements of SWAMP and its associated projects.

A description of corrective actions taken will be provided to the Delta RMP Technical Advisory Committee and other interested parties as a part of the QA Report accompanying the datasets produced in each focus area (mercury, pesticides, and nutrients (including the SRiNCS project).

14.2.2.1. Laboratory Analysis Corrective Actions for SRiNCS Project

Any issues that arise in relation to laboratory analyses during the SRiNCS project will be communicated to the overall project manager, Lisa Thompson, by the project managers for AMS, BSA, SFSU, and USGS. Thompson will communicate said issues with SFEI Principal Investigator Mett Heberger, in conjunction with the relevant sub-project managers as appropriate. In order to minimize the chance of such issues arising in the first place, Heberger, Thompson and the SRiNCS project team sub-project managers will conduct a monthly standing 30-minute conference call. The aims of these calls will be to keep SFEI/ASC and the DRMP

apprised of progress on laboratory analysis tasks. Should issues nevertheless arise, the project would be subject to the DRMP's corrective actions procedures, as described in Section 14.2.2 (note that there is planned a forthcoming DRMP formal procedure to document deviations from what is described in the Workplan, Sampling and Analysis Plan, and QAPP, and to document corrective actions).

15. Instrument/Equipment Testing, Inspection, and Maintenance

15.1. Field Equipment

Field equipment such as boats, nets, and traps are inspected prior to each sampling event and are maintained throughout the field season and prior to storage during the off-season. Minimum equipment for the respective project elements includes:

Mercury - Fish

Boats (electro-fishing and/or for setting nets)

Bone saw, gill nets (various sizes), filet knives, fish picks, shackles, pliers, sharpening stone

Rod and reels, tackle box, landing net, live bait container

Plastic ice chests, inflatable buoy, floats, anchor chains, anchors, patch kit

Otter trawls

Blocks

Measuring boards, tape measure, id keys, Teflon cutting boards

Coolers

Mercury - Sediment

van Veen, Ekman, or Ponar grab sampler

Polycarbonate core tubes

Sampling scoops

Coolers

Mercury - Water

Collection devices appropriate for site

Field meters

Coolers

Nutrients - SCRiNCS Project

(Instrument/Equipment Testing, Inspection, and Maintenance information is in Table 14.1)

Flow-Through System

YSI EXO2 sonde

YSI 6600 V2

Pesticides and Aquatic Toxicity

Boat

collection devices

field meter

bottles

coolers and ice

Technical staff from the USGS Biogeochemistry group independently tests all mechanical and electrical components attached to instrumentation of the flow-through system for functionality prior to use in the field. Routine maintenance of boat motors and batteries is required to meet standards for safety. Instruments routinely require attention by the manufacturer (typically every 1-3 years).

With the exception of the Timberline ammonium analyzer, the Biogeochemistry group keeps back-up instruments in house and has a network of researchers from whom they can borrow equipment when needed. Discrete samples for ammonium can provide redundancy and possibly a stand-in for environmental measurements made by the Timberline, should the instrument fail during field sampling.

Additional detail on the testing, inspection, and maintenance (including calibration) of the flow-through system and its components can be obtained from TM-9 (USGS Field Manual) and from Downing et al. (2016) and Fichot et al. (2015).

15.2. Laboratory Equipment and Supplies

Contract laboratories maintain equipment in accordance with their respective SOPs, which include those specified by the manufacturer and those specified by the method.

Laboratories maintain internal SOPs for inspection and quality checking of supplies. Under a performance-based measurement system approach, these procedures are presumed to be effective unless field and QC data from analyses indicate otherwise. SFEI-ASC will then work with the laboratory to identify the causes and address deficiencies in the SOPs that resulted in those problems. If the problem is serious and cannot be corrected by the laboratory, the SFEI-ASC Program Manager and QAO will discuss and identify alternatives, including changing the sampling materials and methods, the extraction and analytical methods, the laboratory, or any combination of these.

16. Instrument/Equipment Calibration and Frequency

16.1. Field Instruments/Equipment

Whenever an environmental water sample is collected, field crews shall collect basic water quality measurements using handheld measurement devices. Instruments for field data collection are described in Section 14.1, Field Measurements.

16.2. Laboratory Equipment

All laboratory instruments involved in analyses of Delta RMP samples shall be inspected, maintained, calibrated (as applicable) and tested prior to use. Laboratory instruments are calibrated, standardized, and maintained following procedures detailed in laboratory Quality Assurance Plans (QAPs) and Standard Operating Procedures (SOPs), adopted herein by reference, and listed in Appendix E.)

At a minimum, calibration procedures shall meet the requirements specified in the approved method, e.g. from USEPA or Standard Methods. Calibration procedures are described briefly below.

Upon initiation of an analytical run, after each major equipment disruption, and whenever on-going calibration checks do not meet recommended MQOs, the system will be calibrated with a full range of analytical standards. Immediately after this procedure, the initial calibration must be verified through the analysis of a standard obtained from a different source than the standards used to calibrate the instrumentation, prepared in an independent manner, and ideally having certified concentrations of target analytes (e.g., a certified solution). The calibration curve is acceptable if it has an R^2 of 0.995 or greater for all analytes present in the calibration mixtures. If not, the calibration standards, as well as all the samples in the batch, must be re-analyzed. All calibration standards will be traceable to an organization that is recognized for the preparation and certification of QA/QC materials (e.g., NIST, NRCC, U.S. EPA).

Calibration curves will be established for each analyte and batch analysis from a calibration blank and a multi-point calibration (as described or required in the method), covering the range of expected sample concentrations. Only data within the working calibration range (above the MDL) should be reported (i.e., extrapolation is not acceptable). Samples outside the calibration range will be diluted as appropriate and reanalyzed.

Table 14.1 lists the project requirements for the frequency of calibration and type of calibration for field instruments. The required rate of calibration verification samples for laboratory instruments is listed in Table 14.2. A variety of sample types is used to check the accuracy and precision of lab instruments, including calibration verification samples, laboratory blanks, and lab duplicates.

If analytical instrumentation fails to meet performance requirements, the instrument(s) will be checked according to their respective SOP(s) and recalibrated. If the instrument(s) does again does not meet specifications, it will be serviced and retested until performance criteria are achieved. The maintenance will be entered in the instrument log. If sample analytical information is in question due to instrument performance, the PM will be contacted regarding the proper course of action including reanalyzing the sample(s).

17. Inspection/Acceptance for Supplies and Consumables

All supplies shall 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. Laboratory staff shall log in all chemicals to the appropriate logbook and dated upon receipt. All supplies shall be stored appropriately following manufacturer recommendations. Chemicals and reference standards shall discarded upon expiration date or if there is evidence that the material is degraded or damaged. Table 17.1 indicates items that should considered for accuracy, precision, and contamination. If these items are not found to be in compliance with the acceptance criteria, they will be discarded or returned to the manufacturer.

17.1. Field Supplies

All containers should meet or exceed the required trace limits established by the U.S. EPA in the document EPA/540/R-93/051, Section 10, *Specifications and Guidance for Contaminant-Free Sample Containers*. Chemical-resistant powder-free nitrile and polyethylene gloves shall be worn.

At a minimum, the following supplies are required for the respective project elements:

Mercury - Fish

- Waterproof labels
- Bait
- Heavy-duty aluminum foil (prepared), zipper-closure polyethylene bags
- Field sheet (see Appendix F)
- Ice
- Chain-of-custody form (see Appendix G)

Mercury - Sediment

- Sampling containers and labels

- Polycarbonate core tubes
- Nitrile gloves
- Wash bottles
- Field sheet (see Appendix F)
- Ice
- Chain-of-custody form (see Appendix G)

Mercury -Water

- Sampling containers and labels
- Powder-free nitrile gloves
- Deionized water squirt bottle
- Field sheet (see Appendix F)
- Ice
- Chain-of-custody form (see Appendix G)

Nutrients - SRiNCS Project

- Flow-through system - Back-up tubing, hose clamps, filter cases, pumps, and the like are brought to the field on each outing.
- Safety gear, personal flotation devices, wet-weather gear if necessary, sun protection, paddles, and a bilge pump
- Field meters (Water quality, Turbidity, depth, PAR)
- Sampling containers, pens, pencils, and labels
- Powder-free nitrile gloves, work gloves
- Deionized water in squirt bottles
- Secchi disk and rope
- Field sheets, Rite-in-the-Rain notebook, clipboard
- Coolers, ice, dry ice
- Clam trawl, with ropes, float, sorting basin, cable ties, clam bags, and bag tags
- Portable batteries, vacuum pumps, water pumps, tubing, Lugol's solution, pipettes, zooplankton nets, flow gauge, back filter, net storage bucket, funnel, and rope

- $NaH^{13}CO_3$ (stable isotope), filter rigs, 25 mm Whatman glass fiber filters (GF/F), 2 mL Eppendorf microcentrifuge tubes, tweezers, and aluminum foil
- Incubation chamber with 2 layers of darkened neutral density netting (top and sides), acid-cleaned 250 mL polycarbonate square bottles, and bucket

Pesticides and Toxicity Sampling

- Safety gear; personal flotation devices; wet-weather gear if necessary
- GPS unit; mobile phone and/or radio
- Sampling containers and labels
- Collection devices appropriate for site
- Powder-free nitrile gloves
- Field meters
- Deionized water squirt bottle
- Field sheet (see Appendix F)
- Coolers and ice
- Chain-of-custody forms (see Appendix G)

18. Non-direct Measurements

Non-Delta RMP data (e.g., from Irrigated Lands Regulatory Program) may be used in determining ranges of expected concentrations in field samples, characterizing average conditions (e.g., temperature, barometric pressure) for calculations, and other purposes. These data will be reviewed against the measurement quality objectives and used only if they meet all of the specified criteria (See Section 14.2.1, Measurement Quality Objectives). Data not meeting Delta RMP quality objectives should be used only in a qualitative manner for developing conceptual models and prioritizing future data needs.

Hydrologic data (stage, flow, etc.) will be obtained from existing gauges and recorders located at or near designated monitoring locations. Only fully QA-reviewed hydrologic data will be used in analysis and reporting. Acceptable sources include the USGS National Water Information System (NWIS, https://waterdata.usgs.gov/nwis) and the DWR Water Data Library (WDL, http://wdl.water.ca.gov/waterdatalibrary/). Provisional data and modeled/forecasted data may be used for planning sampling events, for example determining whether there is sufficient rainfall and runoff forecasted to meet one of the event triggers described in Table 6.7.

19. Data Management

This section provides a brief overview of how project staff manage data generated by the project's sampling and analysis. For more detailed information, refer to SFEI-ASC's *Data Management and Quality Assurance Standard Operating Procedure*s document, included as Appendix H.

All raw and statistical analysis data are subject to a 100% check for accuracy by the PM and Laboratory QAOs. Data are analyzed and proofread for accuracy, and then QA checked against the QAPP and project criteria before being entered into the CEDEN database. Original hard copies of the data are stored securely until requested by the PM and/or inclusion into the Final Report. Electronic copies are stored and backed up by each analyst and respective laboratory internal project manager.

SFEI and cooperators shall update computer hardware and software as recommended by the manufacturer or as needed. Regular testing of individual components is not required, other than verifying day to day functionality. Each entity is responsible for the necessary updates or upgrades, whether provided regularly through an Information Technology department or otherwise.

19.1. Entering and formatting of sampling and QA data results

19.1.1. Laboratory reporting of results

Chemical-analytical data shall be reported by labs in CEDEN's Water Quality (WQ) template. Tabulated data will include the following information for each sample (when applicable):

1. **Sample identification**: Unique sample ID, site code, site name, collection date, collection time, analysis date, sample type (field or QC types), and matrix.
2. **Analytical method**s: Preparation, extraction, and quantitation methods (codes should reference SOPs submitted with the data submission package). Also include preparation, extraction, and analysis dates.
3. **Analytical results**: Analyte name, fraction, result, unit, method detection limit (MDL), and reporting limit (RL) for all target parameters. The appropriate data qualifiers should be submitted with the results.
4. **Batch and result comments**: Lab comments must be applied to any batch when any QA code was applied to a result in the batch that may affect data use. A brief explanation of the issue shall be included.

Required additional data include:

- Lab replicate results (and field replicates, when sent for analysis)

- Quality assurance information for each analytical chemistry batch:
- CRM or LRM results: absolute concentrations measured, certified value, and percent recovery relative to certified or expected value.
- Matrix (or blank) spike results: include expected value (native + spike) for each analyte, actual recovered concentrations, calculated per recovery, and RPD.
- Method blank sample results in units equivalent to field sample results (e.g., if the field samples are reported as ng/g, method blanks are given in the same units). Lab replicate results and calculated RPD or RSD.

Documentation containing definitions, field length, field requirement, and associated lookup lists (if applicable) for each field is available on the CEDEN website at http://www.ceden.org/ceden_datatemplates.shtml.

Fields requiring controlled vocabulary can be identified by hovering over the field name in the template and referring to the lookup list that is referenced. Lookup lists are available on the CEDEN website at http://www.ceden.org/CEDEN_Checker/Checker/LookUpLists.php.

Batches must be reviewed for QC completeness and any deviation in QC results should be documented in the accompanying case narrative. The required fields will be identified in the template in green font. Each laboratory shall establish a system for detecting and reducing transcription and calculation errors prior to reporting data.

Only data that have met MQOs or that have deviations explained appropriately will be accepted from the laboratory. When QA requirements have not been met, the samples will be reanalyzed when possible. Only the results of the reanalysis should be submitted, provided they are acceptable.

Reporting turnaround times for submission of results from sample analyses are specified in contracts with the analytical laboratories. However, samples should be extracted and analyzed within the holding times specified for the analytical methods used (Table 12.1). Turnaround time requirements specified in subcontracts are generally 90 days or less.

19.1.2. Discrete water quality sampling data

The collection agencies and laboratories provide discrete data to SFEI-ASC in appropriate CEDEN templates (as provided by SFEI-ASC) within the timeframe stipulated in the contract, usually 90 days or less. The laboratories should use the current online data checker to review data for vocabulary and business rule violations prior to submitting to SFEI-ASC (contact DS@sfei.org for the current web address). SFEI-ASC will work with the labs to address vocabulary and business rule issues identified from using the data checker. SFEI-ASC will work with CEDEN to populate the lookup lists with new values as identified by the labs from using the online data checker.

The laboratories should report data as outlined in Section 19.1.1, Laboratory reporting of results. Data are maintained at SFEI-ASC. SFEI-ASC tracks each data set, from submittal to final upload to the RDC database. Once all expected data have been received, expert staff on SFEI-ASC's Data Services team process the data using a series of queries designed to identify any issues remaining with the format of the data. The QA Officer or designee then reviews data for quality assurance and quality control and appropriate CEDEN QA codes are applied to the dataset.

Data approved for public release are made available through SFEI-ASC's Contaminant Data Display and Download tool (CD3), usually within one year of sample collection. Data will also be made available through CEDEN's Advanced Query tool. The contact individual for steps and tasks of data management is the SFEI-ASC data manager, Amy Franz.

SFEI-ASC maintains regular backups of their enterprise databases both to disk and tape, nightly and weekly, respectively. The RDC database, specifically, is also backed up hourly. As a further protective measure, copies of the tape sets are stored both onsite and offsite. The lifetime of the backup files on tape is about 2-3 weeks. Additionally, a backup of the RDC database from the first of every month is stored on disk indefinitely, allowing for quick restore and review of archived data as the need warrants.

19.1.3. Pesticides Chemistry Data

Pesticides chemistry is analyzed by the USGS Organic Chemistry Lab (OCRL) in Sacramento. The handling of these data is different from other Delta RMP datasets due to the nature of our cooperation with the USGS, which is not simply a contract lab, but a federal science agency with its own long-standing policies and procedures. According to USGS policy, results from their labs shall be included in the National Water Information System (NWIS). This is an online database where results are freely available to the public.

OCRL staff perform a quality assurance review of the results generated in their lab, and then upload provisional data to the NWIS database. Afterwards, OCRL transmits the data to ASC in the CEDEN data template format. ASC staff format these data and perform a thorough and independent QA review. As with other datasets, if serious issues arise, ASC will communicate with OCRL to resolve these issues. This would include, for example, missing or duplicate data, data that appear to have been reported incorrectly, results outside of the expected range, incorrect units, serious deviations from the measurement quality objectives, or any other issue identified that could indicate problems with the lab analysis.

As a part of ASC's QA review, the ASC QA Officer may flag records which did not meet MQOs, or reject results that are considered unacceptable by the QA officer. The QA officer writes a short memo summarizing the findings of the QA review, and summarizing the quality of the data. This memo describes whether the results received from the lab are complete and accurate and whether there is any evidence of contamination or other problems. The audience for the QA

memo is both internal (the ASC project manager and staff) and external (stakeholders with an interest in reviewing the data and findings of the QA review).

The ASC project manager will distribute the provisional pesticides chemistry data and QA summary to the Delta RMP Technical Advisory Committee for review. ASC data analysts upload these data to CEDEN, and they are made viewable by the public once approved by the Delta RMP Steering Committee. Note that some stakeholders have suggested that this practice of withholding data pending SC approval is inappropriate and possibly illegal under California's open data laws. Staff and stakeholders will be reviewing this policy in 2019 and may suggest changes.

19.1.4. Underway flow-through measurements

Continuous field data collected by the USGS is immediately copied to multiple memory devices in the field upon completion of the measurements. The field data are uploaded to a secure USGS redundant network location upon return to the office that day or the following day. Quality assurance is performed by automated algorithms developed at USGS and checked by project technical staff. Temperature corrections and blank water offsets are applied to WET-Star (FDOM, Chl-a), YSI EXO total chlorophyll and fDOM probes, and nitrate instruments. WET-Star and EXO FDOM measurements are converted to quinine sulfate equivalents; turbidity and inner filter effect corrections are applied when necessary. A twenty-second median is applied to all data. All values that fall outside of 3 standard deviations of the mean are removed. A thirty-second mean is calculated to reduce the size of the data files.

The USGS documentation for the data processing can be found in Technical report in the USGS Techniques and Methods Report 1-D5 by Pellerin et al. (2013), and general guidance for field measurements and in the USGS *National Field Manual for the Collection of Water-Quality Data* (2015).

At present, the CEDEN database is not capable of storing high-frequency data such as collected by this project. Provisional field data will be made available to interested parties the week following collection. Final corrected data will be warehoused by the USGS and made available to interested parties upon request or via FTP. A final report will be prepared following data collection with a draft planned for spring 2019.

19.2. Laboratory data report package information

Analytical results, including associated quality control samples (see Section 14.2.1 Measurement Quality Objectives), will be provided to SFEI-ASC by the analytical laboratories. The laboratories analyze samples according to the hold times listed in the Delta RMP QAPP. The final report may be finalized for review up to 90 days after samples are received from the laboratory. Exceedances of the standard turnaround time should be discussed with and approved by the Delta RMP Program Manager and QAO.

Laboratory personnel will verify, screen, validate, and prepare all data, including QA/QC results, and will provide (upon request) detailed QA/QC documentation that can be referred to for an explanation of any factors affecting data quality or interpretation. Any detailed QA/QC data not submitted as part of the reporting package should be maintained in the laboratory's database or files for future reference.

Laboratories will provide electronic copies of the tabulated analytical data in a format agreed upon with the SFEI-ASC Program Manager, Data Manager, or a designee.

Results should be flagged by the laboratory for exceedances of Delta RMP MQOs for completeness, sensitivity, precision, and accuracy, using data quality codes as defined by CEDEN's list of QA codes, which have been adopted by the Delta RMP for reporting data. The data quality codes should be provided in the LabResult table in the ResQualCode and QACode fields. A list of commonly used result qualifier codes is shown in Table 23.1. The most commonly used QA codes are shown in Table 23.2. A complete list of codes is available online at CEDEN's Controlled Vocabulary web page.

For a detailed description of the measurements and procedures that are used by the lab QA Officer and ASC's QA Officer to demonstrate the quality of reported, see Section 7, Quality Objectives and Criteria.

19.3. Data storage/database

Data are managed by SFEI-ASC Data Services staff under the supervision of the Data Services Manager and the SFEI-ASC Quality Assurance Officer. Upon completion of QA/QC review and data validation, data are compiled into the SFEI-ASC RDC database and distributed to the project managers.

Data that are approved for public release are made available through SFEI-ASC's Contaminant Data Display and Download website (CD3), usually within one year of sample collection. Data will also be made available through CEDEN's Advanced Query Tool webpage.

19.4. Data management plan for the SRiNCS nutrients project

19.4.1. Point of contact

Lisa C. Thompson, Chief Scientist, Regional San, thompsonlis@sacsewer.com, (916) 876-6364. Alternate contact: Timothy Mussen, Scientist, Regional San, mussent@sacsewer.com, (916) 875-4344.

19.4.2. Data description

Data produced for this project include: physical river parameters (depth, temperature, photosynthetically active radiation); mobile high frequency boat sampling of river water quality

parameters (nutrients, turbidity, pH salinity, dissolved oxygen, Chlorophyll-a, phytoplankton concentration by group, fluorescent dissolved organic matter); "grab" sampling of river water for laboratory analysis of water quality parameters (nutrients, turbidity, pH salinity, dissolved oxygen, Chlorophyll-a), picoplankton biomass, and phytoplankton species identification and biomass; net tows for zooplankton species identification and biomass; trawls for clam biomass; phytoplankton nutrient uptake rate including carbon uptake to determine growth rates (obtained from shipboard incubations); zooplankton growth rate (obtained from laboratory incubations); model datasets, computer input files, computer output files.

19.4.3. Related data

Nutrient data previously collected by the Delta Regional Monitoring Program are relevant to this study, particularly data collected in the 2018 high frequency boat mapping surveys conducted by the USGS. These data have been used in designing this study, and may be used for comparison with our project data sets. Data from USGS high frequency fixed water quality stations at Freeport and Walnut Grove will be used for comparison with our project data sets. We will also reference data from the California Department of Water Resources Environmental Monitoring Program (EMP), including dissolved oxygen, turbidity, salinity, nutrients, Chlorophyll, zooplankton.

19.4.4. Metadata

Metadata will conform to minimum metadata standards, and will include summary, description, date, point of contact, field definitions, abbreviation definitions, access constraints, use constraints, data distribution, progress, update frequency, keywords, projection, and geographic coordinate system. Users will be able to access the metadata file, SacNutrientChangeStudy.docx, from the Regional San Public Website: https://www.regionalsan.com/research-studies-collaborations

19.4.5. Storage and backup

Regional San Environmental Laboratory, part of the Sacramento Regional Wastewater Treatment Plant, maintains all the sample collection chain of custody forms, field data sheets, laboratory worksheets and laboratory reports. All analytical results for water data will be reported in the Laboratory's approved format as electronic data deliverables (EDDs) accompanied with an electronic report. All data stored electronically will include a back-up version stored on an in-house (Regional San) computer system routinely backed up to a network. Collaborators (i.e., sub-contractors) will provide Regional San with copies of their datasets in order that they can be stored electronically on an in-house (Regional San) computer system routinely backed up to a network.

19.4.6. Archiving and preservation

Regional San Environmental Laboratory maintains all sample collection chain of custody forms, field data sheets, laboratory worksheets and laboratory reports for a minimum of 10 years. All data stored electronically will include a back-up version stored on an in-house computer system routinely backed up to a network.

19.4.7. Quality assurance

The Regional San Environmental Laboratory is certified by the California Environmental Laboratory Accreditation Program (ELA). Data quality objectives for this project will measure both completeness and correctness. An acceptable completeness goal for this project will be 90% completeness and will include both collection and transport of sample and the laboratory analysis completeness. Completeness is assessed based on the number of samples successfully obtained and validated for use in this study and the proportion of quality control samples that are within acceptance criteria.

Correctness will include using the appropriate analytical method, sampling technique, preservation and all the required Quality Control (QC) for the type of analysis performed.

Data quality objectives for accuracy, precision, recovery, and contamination are determined through a combination of instrument calibration and the analysis of duplicates, blanks, and spikes. Accuracy, precision, and recovery are assessed through the use of QC samples by the laboratories. Laboratory spikes and matrix spikes are used to assess accuracy and recovery, and duplicates are used to assess precision. All of the sampling and analysis performed for this project will comply with the appropriate laboratory or method required QC. When analysis is not in compliance with these established method criteria the lab will notify the program manager and will include a narrative/qualifier in the report.

19.4.7. Access and use rights

(1) At the completion of the project the integrated data in the Access relational database will be made available upon request. (2) Data protected under federal or state regulations or due to proprietary considerations will typically be classified as private/confidential data until those statutes or considerations no longer exist. (3) Prior to the completion of the project, all eligible data will be submitted to the California Environmental Data Exchange Network (CEDEN, http://ceden.org/), and the Access relational database will be made available on the Regional San Public Website noted above. (4) Data sharing will commence no later than the completion date of the project, with key manuscripts submitted prior to this completion date. (5) Rights and requirements for data users: Regarding confidential data, following peer-reviewed publication, data may be freely distributed to investigators wanting the information for non-commercial research. Requests for data from for-profit corporations to use the information commercially will be negotiated by each collaborating institution's technology transfer office. All licensing

shall be subject to distribution pursuant to the home institution's policies and procedures on royalty income.

20. Assessment and Response Actions

Before a new monitoring project is initiated, an initial desktop or on-site performance audit will be performed by the QAO and designated staff to determine if each laboratory can meet the requirements of the QAPP and to assist the laboratory where needed. Additional audits may be conducted at any time during the scope of the study. The QAO will review every data file submitted as part of these audits and ensure that QC issues will be addressed as soon as they are detected. Results will be reviewed with participating laboratory staff and corrective action recommended and implemented, where necessary. Furthermore, laboratory performance will be assessed on a continual basis through laboratory intercomparison studies (or "round robins") where available, such as those conducted by the National Institute of Standards and Technology (NIST).

If data quality issues are identified, a preliminary meeting will be held between SFEI-ASC's QAO, the SFEI-ASC Program Manager, and the lab QAO to discuss possible solutions. If necessary, a corrective action plan will be developed in consultation with the appropriate lab(s), the corrective actions taken, and the issue and its resolution summarized in a brief report or memorandum. A summary of these issues will be maintained in the project files and will be noted in any reporting that includes affected data.

21. Reports to Management

The Implementing Entity of the Delta RMP (currently SFEI-ASC) will produce Annual Monitoring Reports for each of the focus areas, which documents the activities of the program each year; an interpretive main report (The *Pulse of The Delta*) that summarizes monitoring results and synthesizes the information they provide; and technical reports that document specific studies and synthesize information from diverse sources in relation to specific topics and prioritized assessment questions. Reporting products and schedule are described in more detail in Section 6.6.

The Annual Monitoring Reports and/or QA Reports for each of the focus areas will present the results of the previous July-June fiscal year of sampling. The main purpose of these reports is to summarize the final data and results of the QA review. The QAO is responsible for summarizing potential QA issues with reported data and communicating those issues to the Program Manager. The QAO also reviews any SFEI-ASC analyses and reports generated from the data, to ensure that QA issues are appropriately acknowledged in the presentation and interpretation of data. The QAO will prepare a QA memo for each monitoring element (mercury, nutrients, etc.) annually, after completion of the QA review.

22. Data Review, Verification, and Validation

All Delta RMP data undergo review and evaluation to ensure that the data conform to quality criteria identified in this document and other project-specific criteria. In addition, data are assessed to determine usability and whether the data support their intended use. Review of the data consists of three discrete processes: verification, validation, and assessment.

22.1. Data Validation

Data are evaluated as meeting or failing MQOs, first by the laboratory, and again by the project QA Staff. In addition to contamination and other artifacts introduced by sampling and analytical methods, errors may arise at many points in the processing and transmittal of data generated for the Delta RMP. Characteristics of reported data are examined to identify possible problems in the generation and transmission of data.

Before submitting data, the contract laboratory's QA Officer (QAO) performs checks of all of its records and the laboratory's Director or Project Manager will recheck 10%. All checks by the laboratory may be reviewed by SFEI-ASC. Issues are noted in a narrative list and communicated to the field or laboratory teams as needed to correct any problems found (e.g. unanalyzed samples left in storage, transcription errors).

Data are submitted to SFEI-ASC in electronic form. After data are submitted and included in the Delta RMP database, SFEI-ASC staff examines the data set for completeness (e.g., correct numbers of samples and analyses, appropriate QC sample data included) and accuracy (e.g., in sample IDs), and spot-check for consistency with hardcopy results reported by the laboratory. The SFEI-ASC QAO or designee will examine submitted QA data for conformance with MQOs, specified previously (Section 14.2.1).

Data that are incomplete, inaccurate, or failing MQOs without appropriate explanation will be referred back to the laboratory for correction or clarification. The Project Manager and QAO will discuss data failing MQOs with laboratory staff to determine corrective actions and whether the samples need to be re-collected. If problems cannot be readily corrected (insufficient sample, irremovable interferences, or blank contamination), results outside the MQOs will be flagged using CEDEN codes appropriate for the specific deviations to alert data users to uncertainties in quantitation. Results greatly outside the target MQO range (z-scores >2, e.g., for acceptance criteria of ±25%, >±50%) may be censored and not reported. The z-score is calculated as follows:

$$z\text{–}score = \left|\frac{result - expected\ value}{acceptable\ deviation}\right|$$

23. Verification and Validation Methods

The QA/QC requirements presented in the preceding sections are intended to provide a common foundation for each laboratory's protocols; the resultant QC data will enable assessment of the comparability and uncertainty of results generated by different laboratories and analytical procedures. It should be noted that the QC requirements specified in this plan represent the minimum requirements for any given analytical method; labs are free to perform additional QC in accordance with their standard practices.

SFEI staff, working under the supervision of the SFEI QA Officer, perform data verification and validation following methods described in the Data Management and Quality Assurance Standard Operating Procedures. The latest version of this document is in Appendix H.

In addition to performance on required QC measures and samples (i.e., MDLs, blanks, matrix spikes, CRM, and replicates), data are also examined for internal and external consistency to ensure that reported values are realistic and representative for the locations and matrices of collected samples. This review may include but is not limited to:

1. Comparison of reported values to those from previous monitoring to evaluate if they are within the expected range of values for a given study. Simple statistics (e.g., minimum, maximum, mean, median) may be generated to quickly identify data sets or individual data points greatly outside of their expected range. Anomalous individual points will be examined for transcription errors. Unit conversions and sample quantitation calculations may be reviewed to identify larger and systematic errors. However, large differences from previously reported values may not necessarily indicate analytical issues and may simply reflect natural spatial and temporal variability of the ecosystem.
2. Comparison of reported values to those in the published literature, where available – differences from other regions and/or species may merely indicate differences in resident species and ecosystem structure, but very large (e.g. 2-3 orders of magnitude) differences may sometimes help identify errors in analysis or reporting (e.g. unit conversions).
3. Internal checks of relative analyte abundance. Variations in concentrations of one compound or isomer are often tightly linked to those of related compounds, such as its degradation products, manufacturing byproducts, or other compounds from the same group of chemicals (e.g., congeners of the same class of chemicals within a commercial mixture). Deviations in these relative abundances can sometimes indicate matrix interferences or other analytical problems, although care should be taken to not disregard results that might reveal atypical sources and/or ecosystem processes.

Table 23.1 shows the CEDEN controlled vocabulary for result qualifiers.

Table 23.2 shows the most frequently used CEDEN QA codes. A full list of QA codes that may be applied can be found online at CEDEN's Controlled Vocabulary web page.

When measurement quality objectives (MQOs) are not met, verification codes from the Batch Verification Look -up and/or QA Code Lookup tables may be applied by ASC staff or QA Officer and entered into the database. These codes are preceded by a "V" in the "Batch Verification Code" or "QA Code" fields. Individual records for field data and taxonomy, and laboratory batches for chemistry, tissue and toxicity will be coded "VAC" once verification is complete. This code is contained in the Batch Verification Code field. If deviations from the MQOs are detected by ASC staff that were not detected by the laboratory, the data is coded " VAC, VMD. "

If some QC information is missing, the data will be coded with "VAC, VQI." If all QA data were expected to be reported and none are available, then the data are coded as "VQN ". When batches are determined to be missing some or all QC required information, ASC staff will initiate communication with the lab to obtain this information, and will recommend corrective action so this information is included in future data deliverables. When MQOs do not exist for certain data types, the data are coded as "NA" ("Not Applicable").

At the completion of the QA review by the QAO, results are assigned a compliance code on an individual record level. See Table 23.3 for compliance codes.

Data are further assigned a batch verification code on a batch level. See Table 23.4 for batch verification codes. Results from the data review will be summarized in the annual QA Report.

24. Reconciliation with User Requirements

Measurement quality objectives listed previously (Section 14.2.1) establish targets to be routinely achieved by the analytical laboratory. However, it is uncertain whether obtained data, even when meeting all stated MQOs, will be sufficient to answer the Delta RMP management questions with sufficient certainty, as the relative contributions of environmental variability and analytical uncertainty to cumulative uncertainty (e.g. for use in modeling, comparisons to guidelines, or other functions) cannot be known *a priori* before sufficient data have been collected. However, as Delta RMP studies proceed, the ability of collected data to answer these management questions should be periodically re-evaluated for study design and budget planning in subsequent years.

Limitations on data use shall be reported to data users in the form of flags or qualifiers in the CEDEN electronic database. Further, program staff and contractors will describe important limitations on the use and interpretation of program data in reports. Program staff, working under the supervision of SFEI's Quality Assurance Officer (QAO), write quality assurance summaries is for each dataset produced by the Delta RMP. These are reviewed and approved by the QAO and program manager, and are typically attached to year-end data reports as an appendix. These reports are reviewed by the Delta RMP Technical Advisory Committee and approved by the Steering Committee prior to being published.

One of the goals of the initial phase of Delta RMP fish mercury monitoring is to obtain robust information on interannual variation to support future power analysis. The power to detect interannual trends in mercury in largemouth bass on a per site basis will be reevaluated when 3-5 years of monitoring data are available. It will be discussed then, whether the DQO needs to be refined and/or whether the monitoring design should be modified (e.g. increase or decrease the number of fish to be collected at each site).

The Sacramento River Nutrient Change Study is similar to a proof-of-concept in terms of meeting DQOs. Assessing the statistical significance of spatial variation will depend on meeting the required performance criteria. There are currently no plans for additional underway flow-through measurement studies within the Delta RMP. Results from this study and their utility for answering management questions may inform future decisions about any future studies and any modifications that may be required.

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Table 3.1. Distribution list

Name	Affiliation	Title	Email Address
Steering Committee members			delta-rmp-sc@sfei.org (distribution list)
Technical Advisory Committee members			delta-rmp-tac@sfei.org (distribution list)
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Table 4.3 Analytical laboratories

Analytical laboratory	Lab abbreviation	Matrix to be analyzed	Analytical Services	Lab QA Manual Link
Marine Pollution Studies Lab, Moss Landing Marine Labs	MPSL	Sediment, Tissue, Water	Fish attributes, mercury, suspended solids, sediment Nutrients, chl-a, phaeopigments	MPSL Laboratory QAP, Revision 7. November 2016
U.S. Geological Survey, National Water Quality Laboratory	USGS-NWQL	Water	Copper, DOC, PIC, POC, TPC, and TPN	Quality Assurance and Quality Control
U.S. Geological Survey, Organic Matter Research Laboratory	USGS-OMRL	Water	Dissolved organic carbon (DOC), optical measurements, particulate absorbance (Ap)	n/a
U.S. Geological Survey, Organic Chemistry Research Laboratory	USGS-OCRL	Water	Current Use Pesticides Chemistry	n/a
University of California Davis, Aquatic Health Program Laboratory	UCD-AHPL	Water	Aquatic Toxicity, Toxicity Identification Evaluations	UCD AHPL QAM
Regional San Environmental Laboratory	RSEL	Water	Nutrients, chl-a	Regional San Environmental Laboratory Quality Manual, July 2019. Sacramento Regional Wastewater Treatment Plant, 8521 Laguna Station Road, Elk Grove, CA 95758. Document available upon request.
BSA Environmental Services, Inc.	BSA	Water	Phytoplankton, Zooplankton	n/a

Table 5.1. Delta RMP mercury management and assessment questions addressed by each mercury monitoring element. Questions in bold were identified by the Steering Committee as the highest priority for initial studies.

Type	Core Management Questions	Assessment Questions	Sub-Questions	Subregional Trends in Bass	Subregional Trends in Water	Restoration Monitoring
Status and Trends	**Is there a problem or are there signs of a problem?** a.Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta?	**1.What are the status and trends in ambient concentrations of total mercury and methylmercury (MeHg) in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large-scale restoration**	**A. Are trends over time in MeHg in sport fish similar or different among Delta subareas?**	●		-
			B. Are trends over time in MeHg in water similar or different among Delta subareas?	-	●	-
Sources, Pathways, Loadings, and Processes	Which sources and processes are most important to understand and quantify? a.Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b.What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c.What are the magnitudes of internal sources (e.g., benthic flux) and sinks in the Delta?	1. Which sources, pathways, and processes contribute most to observed levels of MeHg in fish?	A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)?	-	●	-
			B. How do internal sources and processes influence MeHg levels in fish in the Delta?	●	●	●
			C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence MeHg levels in fish in the Delta?	-	-	-
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios? b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?		●	●	●
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?	[none]		●	●	●

Table 5.2. Beneficial uses associated with Delta RMP monitoring elements.

Beneficial Use	Pesticides	Mercury	Nutrients
Cold Freshwater Habitat (COLD)	•	•	•
Commercial and Sport Fishing (COMM)	-	•	•
Estuarine Habitat (EST)	•	•	•
Fish Migration (MIGR)	•	-	•
Municipal and Domestic Water Supply (MUN)	-	-	•
Water Contact Recreation (REC1)	-	-	•
Non-contact Water Recreation (REC2)	-	-	•
Fish Spawning (SPWN)	•		•
Warm Freshwater Habitat (WARM)	•	•	•
Wildlife Habitat (WILD)	•	•	•

Table 5.3. Water quality thresholds for pesticide analytes. All concentrations are in µg/L. See also Table 7.3(b) for reporting limits and lab methods for pesticide analytes.

CASRN	Compound	Type	Removed from analyte list in 2018[1]	New, i.e. added in WY 2019	WQO R5-Delta Acute	WQO R5-Delta Chronic	WQO CA Toxics Rule Acute	WQO CA Toxics Rule Chronic	OW Aquatic Life Criteria Acute	OW Aquatic Life Criteria Chronic	OPP ALB Fish Acute	OPP ALB Fish Chronic	OPP ALB Invertebrates Acute	OPP ALB Invertebrates Chronic	OPP ALB Nonvascular plants Acute	OPP ALB Vascular plants Acute	Are values at left "OPP Benchmark Equivalents"[2] from DPR?	Lowest treshold	Lowest Threshold is:
135410-20-7	Acetamiprid	Insecticide									>50,000	19,200	10.5	2.1	>1,000	>1,000		2.1	OPP ALB Invertebrates Chronic
34256-82-1	Acetochlor	Herbicide		TRUE							190	130	4,100	22.1	1.43	3.4		1.43	OPP ALB Nonvascular plants Acute
135158-54-2	Acibenzolar-S-methyl	Herbicide									400	-	2,400	-	500	-	TRUE	500	DPR OPP ALB Equivalent - Nonvascular plants Acute
15972-60-8	Alachlor	Herbicide	TRUE								900	187	1,250	110	1.64	2.3		1.64	OPP ALB Nonvascular plants Acute
584-79-2	Allethrin	Insecticide									-	-	1.05	-	-	-		1.05	OPP ALB Invertebrates Acute
1912-24-9	Atrazine	Herbicide									2,650	-	360	60	<1	0.001		0.001	OPP ALB Vascular plants Acute
86-50-0	Azinphos methyl	Insecticide	TRUE								0.18	0.44	0.08	0.25	-	-		0.08	OPP ALB Invertebrates Acute
NONE	Azinphos methyl oxon	Degradate	TRUE								-	-	-	-	-	-		n/a[4]	
131860-33-8	Azoxystrobin	Fungicide									235	147	130	44	49	3,400		44	OPP ALB Invertebrates Chronic
1861-40-1	Benfluralin	Herbicide									34.85	1.9	1090	15.5	> 100	-		1.9	OPP ALB Fish Chronic
1072957-71-1	Benzovindiflupyr	Fungicide		TRUE							1.75	0.95	42.5	5.6	240	880		0.95	OPP ALB Fish Chronic
82657-04-3	Bifenthrin	Insecticide									0.075	0.04	0.8	0.013	-	-		0.013	OPP ALB Invertebrates Chronic
188425-85-6	Boscalid	Fungicide									1,350	116	>2,665	790	1,340	>3,900		116	OPP ALB Fish Chronic
116255-48-2	Bromuconazole	Fungicide	TRUE								-	-	-	-	-	-		n/a[4]	
33629-47-9	Butralin	Herbicide									-	-	-	-	-	-		n/a[4]	
2008-41-5	Butylate	Herbicide	TRUE								105	-	5,950	-	-	-		105	OPP ALB Fish Acute
133-06-2	Captan	Fungicide									13.1	16.5	4,200	560	320	>12,700		13.1	OPP ALB Fish Acute
63-25-2	Carbaryl	Insecticide					2.1	2.1	2.1	2.1	110	6	0.85	0.5	660	1,500		0.5	OPP ALB Invertebrates Chronic
10605-21-7	Carbendazim	Fungicide									190	n/a[2]	150	n/a[2]	7,700	n/a[2]	TRUE	150	DPR OPP ALB Equivalent - Invertebrates Acute
1563-66-2	Carbofuran	Insecticide									44	5.7	1.115	0.75	-	-		0.75	OPP ALB Invertebrates Chronic
5234-68-4	Carboxin	Fungicide		TRUE							600	0	42,200	0	370	670		0	OPP ALB Fish Chronic
500008-45-7	Chlorantraniliprole	Insecticide									>600	110	4.9	4.5	1,800	2,000		4.5	OPP ALB Invertebrates Chronic
122453-73-0	Chlorfenapyr	Insecticide		TRUE							3.72	3.68	2.915	3.57	0	0		0	OPP ALB Nonvascular plants Acute
1897-45-6	Chlorothalonil	Fungicide									5.25	3	1.8	0.6	6.8	630		0.6	OPP ALB Invertebrates Chronic
2921-88-2	Chlorpyrifos	Insecticide			0.025	0.015			0.083	0.041	0.9	0.57	0.05	0.04	140	-		0.015	WQO R5- Delta Chronic
5598-15-2	Chlorpyrifos OA	Degradate									-	-	-	-	-	-		n/a[4]	
81777-89-1	Clomazone	Herbicide									1,450	350	2,700	2,200	167	30,200		167	OPP ALB Nonvascular plants Acute
210880-92-5	Clothianidin	Insecticide									>50,750	9,700	11	11	64,000	121,000		11	OPP ALB Invertebrates Acute
56-72-4	Coumaphos	Insecticide									140	11.7	0.037	0.0337	-	-		0.0337	OPP ALB Invertebrates Chronic
736994-63-1	Cyantraniliprole	Insecticide									>5,000	10,700	10.2	6.56	>10,000	12,100		6.56	OPP ALB Invertebrates Chronic
120116-88-3	Cyazofamid	Fungicide									>53.5	90.1	>650	<87	-	>1,220		53.5	OPP ALB Fish Acute
1134-23-2	Cycloate	Herbicide									2,250	-	1,300	-	-	-		1300	OPP ALB Invertebrates Acute
68359-37-5	Cyfluthrin, Total	Insecticide									0.034	0.01	0.0125	0.0074	>181	-		0.0074	OPP ALB Invertebrates Chronic
122008-85-9	Cyhalofop-butyl	Herbicide									790	n/a[2]	2,700	n/a[2]	960	n/a[2]	TRUE	790	DPR OPP ALB Equivalent - Fish Acute
91465-08-6 and 76703-62-3	Cyhalothrin, Total[3]	Insecticide									0.0145	-	0.00024	> 2,850	-	-		0.00024	OPP ALB Invertebrates Acute
57966-95-7	Cymoxanil	Fungicide									29,000	n/a[2]	27,000	n/a[2]	254	n/a[2]	TRUE	254	DPR OPP ALB Equivalent - Nonvascular plants Acute
52315-07-8	Cypermethrin, Total	Insecticide									0.195	0.14	0.21	0.069	-	-		0.069	OPP ALB Invertebrates Chronic
94361-06-5	Cyproconazole	Fungicide									-	-	-	-	-	-		n/a[4]	
121552-61-2	Cyprodinil	Fungicide									1,205	230	16	8	2,250	-		8	OPP ALB Invertebrates Chronic
1861-32-1	Dacthal	Herbicide									15,000	-	13,500	-	>11,000	>11,000		11000	OPP ALB Nonvascular plants Acute
72-54-8	DDD(p,p')	Degradate									-	-	-	-	-	-		n/a[4]	
72-55-9	DDE(p,p')	Degradate									-	-	-	-	-	-		n/a[4]	
50-29-3	DDT(p,p')	Insecticide					1.1	0.001	1.1	0.001	-	-	-	-	-	-		0.001	WQO CA Toxics Rule Chronic
52918-63-5	Deltamethrin	Insecticide									0.29	0.017	0.055	0.0041	-	-		0.0041	OPP ALB Invertebrates Chronic
120983-64-4	Desthio-Prothioconazole	Fungicide									-	-	-	-	-	-		n/a[4]	
333-41-5	Diazinon	Insecticide			0.16	0.1			0.17	0.17	45	<0.55	0.105	0.17	3,700	-		0.1	WQO R5- Delta Chronic
962-58-3	Diazoxon	Degradate									-	-	-	-	-	-		n/a[4]	
95-76-1	Dichloroaniline, 3,4-	Degradate									-	-	-	-	-	-		n/a[4]	
626-43-7	Dichloroaniline, 3,5-	Degradate									-	-	-	-	-	-		n/a[4]	
2327-02-8	Dichlorophenyl Urea, 3,4-	Degradate									-	-	-	-	-	-		n/a[4]	
3567-62-2	Dichlorophenyl-3-methyl Urea, 3,4-	Degradate									-	-	-	-	-	-		n/a[4]	
62-73-7	Dichlorvos	Insecticide		TRUE							91.5	5.2	0.035	0.0058	14,000	0		0	OPP ALB Vascular plants Acute
119446-68-3	Difenoconazole	Fungicide									405	8.7	385	5.6	98	1,900		5.6	OPP ALB Invertebrates Chronic
110488-70-5	Dimethomorph	Fungicide									3,100	<341	>5,300	110	-	-		110	OPP ALB Invertebrates Chronic
165252-70-0	Dinotefuran	Insecticide									>49,550	>6,360	>484,150	>95,300	>97,600	>110,000		6360	OPP ALB Fish Chronic
97886-45-8	Dithiopyr	Herbicide									235	56	> 850	81	20	-		20	OPP ALB Nonvascular plants Acute
330-54-1	Diuron	Herbicide									200	26.4	80	200	2.4	15		2.4	OPP ALB Nonvascular plants Acute
759-94-4	EPTC	Herbicide									7,000	-	3,250	800	1,400	5,600		800	OPP ALB Invertebrates Chronic
66230-04-4	Esfenvalerate	Insecticide									0.035	0.035	0.025	0.017	-	-		0.017	OPP ALB Invertebrates Chronic
162650-77-3	Ethaboxam	Fungicide									1090	880	185	50	> 3600	-		50	OPP ALB Invertebrates Chronic
55283-68-6	Ethalfluralin	Herbicide									16	0.4	30	24	25	-		0.4	OPP ALB Fish Chronic
80844-07-1	Ethofenprox	Insecticide									1.35	23	0.4	0.17	>18.8	>26		0.17	OPP ALB Invertebrates Chronic
153233-91-1	Etoxazole	Insecticide		TRUE							185	15	3.65	0.13	51.9	56		0.13	OPP ALB Invertebrates Chronic
131807-57-3	Famoxadone	Fungicide									11	n/a[2]	12	n/a[2]	22	n/a[2]	TRUE	11	DPR OPP ALB Equivalent - Fish Acute
161326-34-7	Fenamidone	Fungicide									370	4.7	24.5	12.5	70	>880		4.7	OPP ALB Fish Chronic
60168-88-9	Fenarimol	Fungicide	TRUE								450	180	3,400	113	100	-		100	OPP ALB Nonvascular plants Acute
114369-43-6	Fenbuconazole	Fungicide									1,500	n/a[2]	2,300	n/a[2]	330	n/a[2]	TRUE	330	DPR OPP ALB Equivalent - Nonvascular plants Acute
126833-17-8	Fenhexamid	Fungicide									670	101	>9,400	1,000	4,820	>2,300		101	OPP ALB Fish Chronic
39515-41-8	Fenpropathrin	Insecticide									1.1	0.091	0.265	0.064	-	-		0.064	OPP ALB Invertebrates Chronic
134098-61-6	Fenpyroximate	Insecticide									0.22	0.11	0.8	0.56	1.9	>190		0.11	OPP ALB Fish Chronic
55-38-9	Fenthion	Insecticide	TRUE								415	7.5	2.6	0.013	400	>2,800		0.013	OPP ALB Invertebrates Chronic
120068-37-3	Fipronil	Insecticide									41.5	6.6	0.11	0.011	140	>100		0.011	OPP ALB Invertebrates Chronic
205650-65-3	Fipronil Desulfinyl	Degradate									10	0.59	100	10.3	140	>100		0.59	OPP ALB Fish Chronic
205650-69-7	Fipronil Desulfinyl Amide	Degradate									17,000	-	20,000	-	-	-	TRUE	17000	DPR OPP ALB Equivalent - Fish Acute
120067-83-6	Fipronil Sulfide	Degradate									41.5	6.6	1.065	0.11	140	>100		0.11	OPP ALB Invertebrates Chronic
120068-36-2	Fipronil Sulfone	Degradate									12.5	0.67	0.36	0.037	140	>100		0.037	OPP ALB Invertebrates Chronic
158062-67-0	Flonicamid	Insecticide									100,000	n/a[2]	100,000	n/a[2]	3,300	n/a[2]	TRUE	3,300	DPR OPP ALB Equivalent - Nonvascular plants Acute
79622-59-6	Fluazinam	Fungicide									18	0.69	90	68	1.1	-		0.69	OPP ALB Fish Chronic
272451-65-7	Flubendiamide	Insecticide		TRUE							32.55	60.5	0.14	41.1	69.3	54.6		0.14	OPP ALB Invertebrates Acute
131341-86-1	Fludioxonil	Fungicide									235	19	450	<19	70	>1,000		19	OPP ALB Fish Chronic
142459-58-3	Flufenacet	Herbicide									130	75	1400	6300	2.9	2.45		2.45	OPP ALB Vascular plants Acute
62924-70-3	Flumetralin	Plant Growth Regulator									-	-	-	-	-	-		n/a[4]	
239110-15-7	Fluopicolide	Fungicide									174.5	151	>850	190	<1.4	>3,200		1.4	OPP ALB Nonvascular plants Acute
658066-35-4	Fluopyram	Fungicide		TRUE							-	-	-	-	-	-		n/a[4]	
361377-29-9	Fluoxastrobin	Fungicide									433	n/a[2]	480	n/a[2]	350	n/a[2]	TRUE	350	DPR OPP ALB Equivalent - Nonvascular plants Acute
951659-40-8	Flupyradifurone	Insecticide		TRUE							-	-	-	-	-	-		n/a[4]	
59756-60-4	Fluridone	Herbicide									2,800	480	680	-	-	-		480	OPP ALB Fish Chronic
85509-19-9	Flusilazole	Fungicide	TRUE								-	-	-	-	-	-		n/a[4]	
66332-96-5	Flutolanil	Fungicide									1,250	233	>3,400	530	8,010	8,010		233	OPP ALB Fish Chronic
76674-21-0	Flutriafol	Fungicide									16,500	4,800	33,550	310	460	780		310	OPP ALB Invertebrates Chronic
907204-31-3	Fluxapyroxad	Fungicide									-	-	-	-	-	-		n/a[4]	
51235-04-2	Hexazinone	Herbicide									137,000	17,000	75,800	20,000	7	37.4		7	OPP ALB Nonvascular plants Acute
35554-44-0	Imazalil	Fungicide									1,480	n/a[2]	3,500	n/a[2]	870	n/a[2]	TRUE	870	DPR OPP ALB Equivalent - Nonvascular plants Acute
138261-41-3	Imidacloprid	Insecticide									>114,500	9,000	0.385	0.01	>10,000	-		0.01	OPP ALB Invertebrates Chronic
120868-66-8	Imidacloprid urea	Insecticide		TRUE							0	0	47,400	0	0	0		0	OPP ALB Fish Acute
950782-86-2	Indaziflam	Herbicide		TRUE							1,000	n/a[2]	10,000	n/a[2]	750	n/a[2]	TRUE	750	DPR OPP ALB Equivalent - Nonvascular plants Acute
173584-44-6	Indoxacarb	Insecticide									145	150	300	75	>110	>84		75	OPP ALB Invertebrates Chronic
125225-28-7	Ipconazole	Fungicide									765	0.18	850	-	-	-		0.18	OPP ALB Fish Chronic
36734-19-7	Iprodione	Fungicide									-	260	120	-	>130	>12,640		120	OPP ALB Invertebrates Acute
875915-78-9	Isofetamid	Fungicide		TRUE							1,135	86	2,350	390	4,100	4,900		86	OPP ALB Fish Chronic
143390-89-0	Kresoxim-methyl	Fungicide									95	87	166	55	29.2	>301		29.2	OPP ALB Nonvascular plants Acute
1634-78-2	Malaoxon	Degradate							0.065	0.013	-	-	-	-	-	-		0.013	OW Aquatic Life Criteria Chronic
121-75-5	Malathion	Insecticide								0.1	16.5	8.6	0.295	0.035	2,400	>9,630		0.035	OPP ALB Invertebrates Chronic

374726-62-2	Mandipropamid	Fungicide						-	220	3,550	-	>2,500	>7,400			220	OPP ALB Fish Chronic
57837-19-1	Metalaxyl	Fungicide						65,000	9,100	14,000	100	140,000	92,000			100	OPP ALB Invertebrates Chronic
125116-23-6	Metconazole	Fungicide						2,100	n/a[2]	4,200	n/a[2]	1,700	n/a[2]	TRUE		1,700	DPR OPP ALB Equivalent - Nonvascular plants Acute
950-37-8	Methidathion	Insecticide	TRUE			0.065	0.013	1.1	6.3	1.5	0.66	-	-			0.013	OW Aquatic Life Criteria Chronic
40596-69-8	Methoprene	Insecticide						380	48	165	51	-	-			48	OPP ALB Fish Chronic
161050-58-4	Methoxyfenozide	Insecticide						>2,100	530	25	6.3	>3400	-			6.3	OPP ALB Invertebrates Chronic
51218-45-2	Metolachlor	Herbicide						1,600	30	550	1	8	21			1	OPP ALB Invertebrates Chronic
2212-67-1	Molinate	Herbicide	TRUE					105	390	170	340	220	3,300			105	OPP ALB Fish Acute
88671-89-0	Myclobutanil	Fungicide						1,200	980	5,500	-	830	-			830	OPP ALB Nonvascular plants Acute
15299-99-7	Napropamide	Herbicide						3,200	1,100	7,150	1,100	3,400	-			1100	OPP ALB Fish Chronic
116714-46-6	Novaluron	Herbicide						>490	6.16	0.075	0.03	3,549	>75.4			0.03	OPP ALB Invertebrates Chronic
19044-88-3	Oryzalin	Herbicide						1,440	220	750	358	42	>15.4			15.4	OPP ALB Vascular plants Acute
19666-30-9	Oxadiazon	Herbicide						600	33	1,090	33	5.2	41			5.2	OPP ALB Nonvascular plants Acute
1003318-67-9	Oxathiapiprolin	Fungicide		TRUE				345	460	280	750	140	790			140	OPP ALB Nonvascular plants Acute
42874-03-3	Oxyfluorfen	Herbicide						100	1.3	750	13	1.1	0.33			0.33	OPP ALB Vascular plants Acute
76738-62-0	Paclobutrazol	Fungicide						7,950	49	120	9	40,800	8			8	OPP ALB Vascular plants Acute
298-00-0	Parathion, Methyl	Insecticide						925	<10	0.485	0.25	15,000	18,000			0.25	OPP ALB Invertebrates Chronic
82-68-8	PCNB	Fungicide						50	13	385	18	-	-			13	OPP ALB Fish Chronic
1114-71-2	Pebulate	Herbicide	TRUE					3,150	-	3,315	-	230	1,800			230	OPP ALB Nonvascular plants Acute
40487-42-1	Pendimethalin	Herbicide						69	6.3	140	14.5	5.2	12.5			5.2	OPP ALB Nonvascular plants Acute
219714-96-2	Penoxsulam	Herbicide						>51,000	10,200	>49,250	2,950	92	3			3	OPP ALB Vascular plants Acute
1825-21-4	Pentachloroanisole	Insecticide						28	-	150	-	-	-			28	OPP ALB Fish Acute
183675-82-3	Penthiopyrad	Fungicide		TRUE				145	100	1,266	471	1,200	1,205			100	OPP ALB Fish Chronic
52645-53-1	Permethrin, Total	Insecticide						0.395	0.0515	0.0106	0.0014	68	-			0.0014	OPP ALB Invertebrates Chronic
26002-80-2	Phenothrin	Insecticide						7.9	1.1	2.2	0.47	-	-			1.1	OPP ALB Fish Chronic
732-11-6	Phosmet	Insecticide						35	3.2	1	0.8	-	-			0.8	OPP ALB Invertebrates Chronic
117428-22-5	Picoxystrobin	Fungicide						32.5	36	12	1	4	210			1	OPP ALB Invertebrates Chronic
51-03-6	Piperonyl Butoxide	Synergist						950	40	255	30	-	-			30	OPP ALB Invertebrates Chronic
29091-21-2	Prodiamine	Herbicide						>6.5	-	>6.5	1.5	-	-			1.5	OPP ALB Invertebrates Chronic
1610-18-0	Prometon	Herbicide						6,000	19,700	12,850	3,450	98	-			98	OPP ALB Nonvascular plants Acute
7287-19-6	Prometryn	Herbicide						1,455	620	4,850	1,000	1.04	11.9			1.04	OPP ALB Nonvascular plants Acute
23950-58-5	Pronamide	Herbicide						36,000	7,700	>2,800	600	>4,000	1,180			600	OPP ALB Invertebrates Chronic
709-98-8	Propanil	Herbicide						1,150	9.1	600	86	16	110			9.1	OPP ALB Fish Chronic
2312-35-8	Propargite	Insecticide						59	16	37	9	66.2	75,000			9	OPP ALB Invertebrates Chronic
60207-90-1	Propiconazole	Fungicide						425	95	650	260	21	4,828			21	OPP ALB Nonvascular plants Acute
175013-18-0	Pyraclostrobin	Fungicide						3.1	2.35	7.85	4	1.5	1,720			1.5	OPP ALB Nonvascular plants Acute
96489-71-3	Pyridaben	Insecticide						-	-	-	-	-	-			n/a[4]	
53112-28-0	Pyrimethanil	Fungicide						5,050	20	1,500	1,000	1,800	7,800			20	OPP ALB Fish Chronic
95737-68-1	Pyriproxyfen	Insect growth regulator		TRUE				165	4.3	200	0.015	56	0.18			0.015	OPP ALB Invertebrates Chronic
124495-18-7	Quinoxyfen	Fungicide						0.36	0.087	0.265	0.044	> 665	> 16.2			0.044	OPP ALB Invertebrates Chronic
10453-86-8	Resmethrin	Insecticide						0.14	0.35	1.55	-	-	-			0.14	OPP ALB Fish Acute
874967-67-6	Sedaxane	Fungicide						-	-	-	-	-	-			n/a[4]	
122-34-9	Simazine	Herbicide						3,200	-	500	-	2.24	140			2.24	OPP ALB Nonvascular plants Acute
946578-00-3	Sulfoxaflor	Insecticide		TRUE				181,500	660	24.5	37	81,200	99,000			24.5	OPP ALB Invertebrates Acute
107534-96-3	Tebuconazole	Fungicide						1,135	12	1,440	120	1,450	151.5			12	OPP ALB Fish Chronic
112410-23-8	Tebufenozide	Insecticide		TRUE				1,500	51.1	1,900	29	740	940			29	OPP ALB Invertebrates Chronic
96182-53-5	Tebupirimfos	Insecticide						44.5	130	0.039	0.011	630	8,800			0.011	OPP ALB Invertebrates Chronic
NONE	Tebupirimfos oxon	Degradate						-	-	-	-	-	-			n/a[4]	
79538-32-2	Tefluthrin	Insecticide						0.03	0.004	0.035	0.008	-	-			0.004	OPP ALB Fish Chronic
112281-77-3	Tetraconazole	Fungicide						1,925	300	1,315	190	-	310			190	OPP ALB Invertebrates Chronic
116-29-0	Tetradifon	Insecticide	TRUE					-	-	-	-	-	-			n/a[4]	
7696-12-0	Tetramethrin	Insecticide						1.85	-	22.5	-	-	-			1.85	OPP ALB Fish Acute
102851-06-9	T-Fluvalinate	Insecticide						0.175	0.064	0.47	0.1	-	-			0.1	OPP ALB Invertebrates Chronic
148-79-8	Thiabendazole	Fungicide						280	110	155	42	3,060	2,320			42	OPP ALB Invertebrates Chronic
111988-49-9	Thiacloprid	Insecticide						12,600	918	18.9	0.97	45,000	>95,400			0.97	OPP ALB Invertebrates Chronic
153719-23-4	Thiamethoxam	Insecticide						>50,000	20,000	17.5	-	>97,000	>90,000			17.5	OPP ALB Invertebrates Acute
902493-06-5	Thiamethoxam Degradate (CGA-35!	Insecticide		TRUE				-	-	-	-	-	-			n/a[4]	
NONE	Thiamethoxam Degradate (NOA-40	Insecticide		TRUE				-	-	-	-	-	-			n/a[4]	
117718-60-2	Thiazopyr	Herbicide	TRUE					3,400	-	6,100	-	40	-			40	OPP ALB Nonvascular plants Acute
28249-77-6	Thiobencarb	Herbicide						220	21	50.6	1	17	770			1	OPP ALB Invertebrates Chronic
129558-76-5	Tolfenpyrad	Insecticide						0.0815	0.188	0.5	0.244	1 > 30				0.5	OPP ALB Invertebrates Acute
43121-43-3	Triadimefon	Fungicide						2,050	41	800	52	17,000	-			41	OPP ALB Fish Chronic
55219-65-3	Triadimenol	Fungicide						21,300	-	51,000	-	9,600	-			9600	OPP ALB Nonvascular plants Acute
2303-17-5	Triallate	Herbicide						600	38	45.5	14	21	2,400			14	OPP ALB Invertebrates Chronic
78-48-8	Tributhyl Phosphorotrithioate, S,S,S	Herbicide						122.5	3.5	3.4	1.56	148	1,100			1.56	OPP ALB Invertebrates Chronic
41814-78-2	Tricyclazole	Fungicide		TRUE				-	-	-	-	-	-			n/a[4]	
141517-21-7	Trifloxystrobin	Fungicide						7.15	4.3	12.65	2.76	37.1	>1,930			2.76	OPP ALB Invertebrates Chronic
68694-11-1	Triflumizole	Fungicide						290	33	700	67	140	720			33	OPP ALB Fish Chronic
1582-09-8	Trifluralin	Herbicide						20.5	1.14	280	2.4	7.52	43.5			1.14	OPP ALB Fish Chronic
131983-72-7	Triticonazole	Fungicide						3,600	-	9,000	-	1,000	-			1000	OPP ALB Nonvascular plants Acute
156052-68-5	Zoxamide	Fungicide						78	3.48	>390	39	10	19			3.48	OPP ALB Fish Chronic

[1]This table includes analytes that were dropped by the lab in 2018, as it may be a useful reference for our "historic" Delta RMP data.

[2] The California California Department of Pesticide Regulation (DPR)'s "OPP Benchmark Equivalents" are only listed for acute exposure. According to Luo et al. (2013), Appendix 3, these values represent LC50s.

[3] The USGS Organic Chemistry Research Laboratory (OCRL) reports "Total Cyhalothrins" which includes all isomers of this compound. OPP Aquatic Live Benchmarks are listed here for Gamma-cyhalothrin, CAS # 76703-62-3. There are also benchmarks for Lambda-cyhalothrin, CAS # 91465-08-6.

[4] We found no thresholds of any kind for 25 of the analytes in this table.

Table 5.4 Water quality objectives for mercury, biostimulatory substances, and dissolved oxygen (Central Valley Regi

Constituent	Water Quality Objectives					
Mercury, Methyl	Central Valley Basin Plan /Sacramento-San Joaquin Delta and Yolo Bypass waterways					
	Muscle tissue of trophic level 4 fish			Muscle tissue of trophic level 3 fish		
	0.24			0.08		
Biostimulatory substances	Water shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.					
Dissolved Oxygen	Central Valley Basin Plan					
	Within the legal boundaries of the Delta			Outside the legal boundaries of the Delta		
	Minimum levels(mg/L)			Monthly median of the daily mean (% of saturation)	95 percentile concentration (% of saturation)	Minimum levels (mg/L)
	Sacramento River (below the I Street Bridge) and all Delta waters west of the Antioch Bridge	San Joaquin River (between Turner Cut and Stockton, 1 September through 30 November)	All other Delta waters			
	7	6	5	85%	75%	Waters designated WARM 5.0 mg/L COLD or SPWN 7.0 mg/l

Table 6.1. Delta RMP target constituents and reporting units

Constituent/ Measurement	Reporting Group	Matrix	Sample Type	Target Detection Limit	Unit
Field parameters – measured by field crews anytime a sample is collected					
Oxygen, Dissolved	Field Measurements	Water	In situ		mg/L
Oxygen, Dissolved	Field Measurements	Water	In situ		% saturation
pH	Field Measurements	Water	In situ		pH
Specific Conductivity	Field Measurements	Water	In situ		µS/cm
Temperature	Field Measurements	Water	In situ		°C
Turbidity	Field Measurements	Water	In situ		FNU
Aquatic Toxicity Testing – Aquatic Health Program Laboratory at UC Davis					
Ceriodaphnia dubia (Reproduction)	Water Column Toxicity	Water	grab	n/a	young/original organisms exposed
Ceriodaphnia dubia (Survival)	Water Column Toxicity	Water	grab	n/a	%
Hyalella azteca (Survival)	Water Column Toxicity	Water	grab	n/a	%
Pimephales promelas (Larval biomass)	Water Column Toxicity	Water	grab	n/a	mg/original organisms exposed
Pimephales promelas (Larval survival)	Water Column Toxicity	Water	grab	n/a	%
Selenastrum capricornutum (Growth)	Water Column Toxicity	Water	grab	n/a	cells/mL
Chironomus dilutus (Growth)	Water Column Toxicity	Water	grab	n/a	mg/original organisms exposed
Chironomus dilutus (Survival)	Water Column Toxicity	Water	grab	n/a	%
Pesticides Monitoring – USGS National Water Quality Laboratory (NWQL)					
Dissolved Organic Carbon (DOC)	Conventional	Water, filtered	Grab	0.23	mg/L
Carbon, Total	Conventional	Suspended Sediment	Grab	0.05	mg/L
Nitrogen, Total	Conventional	Suspended Sediment	Grab	0.03	mg/L
Particulate Organic Carbon (POC)	Conventional	Suspended Sediment	Grab	0.05	mg/L
Total Inorganic Carbon	Conventional	Suspended Sediment	Grab	0.03	mg/L
Total Suspended Solids (TSS)	Conventional	Water	Grab	0.1	mg/L
Copper (dissolved)	Trace Metals	Water, filtered	Grab	0.8	µg/L
Pesticides Monitoring - USGS Organic Chemistry Research Laboratory (OCRL)					
Suite of 161 Current Use Pesticides – see full list in Table 7.3.	Pesticides	Water	Grab	varies	ng/L
Suite of 161 Current Use Pesticides – see full list in Table 7.3.	Pesticides	Suspended Sediment	Grab	varies	ng/L
Mercury – Fish Sampling					
Total Length	Fish Attributes	Tissue	Individual	n/a	mm
Fork Length	Fish Attributes	Tissue	Individual	n/a	mm
Weight	Fish Attributes	Tissue	Individual	n/a	g
Sex	Fish Attributes	Tissue	Individual	n/a	male/female/ unknown
Moisture	Fish Attributes	Tissue	Individual	n/a	%
Total Mercury	Trace Metals	Tissue (fillet muscle)	Individual	0.004	µg/g ww

Mercury - Water Sampling					
Chlorophyll a	Conventional	Water	Grab	24	µg/L
Dissolved Organic Carbon (DOC)	Conventional	Water	Grab	0.23	mg/L
Total Suspended Solids (TSS)	Conventional	Water	Grab	n/a	mg/L
TSS (volatile)	Conventional	Water	Grab	n/a	mg/L
Mercury, Methyl, total (unfiltered)	Trace Metals	Water	Grab	0.009	ng/L
Mercury, Methyl, (filtered)	Trace Metals	Water	Grab	0.009	ng/L
Mercury (unfiltered)	Trace Metals	Water	Grab	0.07	ng/L
Mercury (filtered)	Trace Metals	Water	Grab	0.07	ng/L
Mercury - Sediment Sampling					
Total Organic Carbon (TOC)	Conventional	Sediment	Grab	n/a	mg/L
Clay, <0.0039 mm	Sediment Grain Size	Sediment	Grab	n/a	% dw
Silt, 0.0039 mm to <0.0625 mm	Sediment Grain Size	Sediment	Grab	n/a	% dw
Sand, >0.0625	Sediment Grain Size	Sediment	Grab	n/a	% dw
Mercury	Trace Metals	Sediment	Grab	0.004	mg/kg dw
Mercury, Methyl	Trace Metals	Sediment	Grab	0.004	mg/kg dw
Nutrients - Water Sampling					
Chlorophyll a, total	Laboratory Analysis	Water	Mobile flow-through	0.1	µg/L
Chlorophyll a (filtered, > 5 µm)	Laboratory Analysis	Water	Mobile flow-through	0.1	µg/L
Chlorophyll a	Field Measurements	Water	Mobile flow-through	0-100	µg/L
Fluorescence of dissolved organic matter (fDOM)	Field Measurements	Water	Mobile flow-through	0.07 - 300	QSE
Nitrate as N	Field Measurements	Water	Mobile flow-through	0.07 - 28	mg/L
Oxygen, Dissolved	Field Measurements	Water	Mobile flow-through	0-20 ±1	mg/L
Oxygen, Dissolved	Field Measurements	Water	Mobile flow-through	0-200	% saturation
pH	Field Measurements	Water	Mobile flow-through	43565	pH
Phycocyanin	Field Measurements	Water	Mobile flow-through	0-100	µg/L
Specific Conductivity	Field Measurements	Water	Mobile flow-through	10-10,000	µS/cm
Temperature	Field Measurements	Water	Mobile flow-through	n/a	°C
Turbidity	Field Measurements	Water	Mobile flow-through	0-999 ±3	FNU
Ammonium as N	Laboratory Analysis	Water	Mobile flow-through	0.01	mg/L
Nitrate and Nitrite as N	Laboratory Analysis	Water	Mobile flow-through	0.02	mg/L
Orthophosphate, dissolved, as P (Soluble reactive phosphorus)	Laboratory Analysis	Water	Mobile flow-through	0.004	mg/L

Table 6.2(a) Monitoring locations for mercury in water and sportfish.

#	CEDEN Site Code	Site Name	Latitude	Longitude	Annual Sportfish Sampling	Water Sampling, July - Oct 2019	Water Sampling, March - June 2020
1	510ADVLIM	Cache Slough at Liberty Island Mouth	38.24213	-121.68539	●	●	●
2	544LILPSL	Little Potato Slough	38.09627	-121.49602	●	●	●
3	544MDRBH4	Middle R @ Borden Hwy (Hwy 4)	37.89083	-121.48833	●	●	●
4	544ADVLM6	Lower Mokelumne R 6	38.25542	-121.44006	●	●	●
5	510ST1317	Sacramento R @ Freeport	38.45556	-121.50189	●	●	●
6	541SJC501	San Joaquin R @ Vernalis/Airport Way	37.67556	-121.26417	●	●	●
7	207SRD10A	Sacramento River at Mallard Island	38.04288	-121.92011	●	●	–
8	544DMC020	Delta-Mendota Mendota Canal at Byron-Bethany Road	37.81239	-121.57887	–	●	–

Note: For a list of valid CEDEN site codes, see:
http://ceden.org/CEDEN_Checker/Checker/DisplayCEDENLookUp.php?List=StationLookUp

Table 6.2(b) Sampling schedule for mercury

Year →	2016						2017						2018												2019												2020					
Fiscal Yr →	FY 16/17												FY17/18												FY18/19												FY19/20					
Month →	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Monitoring element (# of sites sampled)																																														
Bass - Core		6												6												7														7							
Water		5			5			5		5						6				8	8	8	8	8	8	8	8	8	8			8	8	8	8	8	8	8	8	8	8				6	6	6	6
Sediment																6				6			6		6																						

gray shading = March-October period used for the linkage analysis in the TMDL
bold = proposed wetland restoration monitoring component

Table 6.2(c). Number of mercury samples by type and by fiscal year.

	Sportfish (bass)			Water			Sediment		
	Events	Sites	# Samples	Events	Sites	# Samples*	Events	Sites	# Samples*
FY16-17	1	6	6	4	5	20	-	-	-
FY17-18	1	6	6	7	6 - 8	54	4	6	24
FY18-19	1	7	7	10	8	80	-	-	-
FY19-20	1	7	7	8	6 - 8	56	-	-	-

* Indicates the number of environmental samples. Additional field duplicates and field blanks are collected as specified in Table 14.2

Table 6.3. Sampling plan for pesticides and toxicity water samples

Number of random sample locations per year in each subregion	24 in first subregion 12 in second subregion
Subregions evaluated per year	2
Number of repeated sample locations per subregion	0
Number of fixed -site sampling locations	2
Sampling events per year	6
Number of samples per year	36 samples at random locations; 12 samples at 2 fixed sites; **48 samples** total each year
Time (years) to collect 24 samples in all subregions covering the Delta	One subregion fully evaluated (n = 24) in any given year. Second subregion will be sampled at half the intensity (n=12) with sampling to be continued over two subsequent years to reach the desired number of samples. It will take 4 years in order to obtain the desired 24 samples in each of the 6 subregions and cover the whole Delta with the desired margin of error.

Table 6.4. Sampling locations for pesticides and toxicity monitoring
(a) Subregion 1 Sites - Yolo Bypass - Cache Slough

siteID	Planned Sampling Event	Subregion	Latitude	Longitude
Yolo-001	WY2019 Event #1	Yolo Bypass - Cache Slough	38.27952	-121.661
Yolo-002	WY2019 Event #1	Yolo Bypass - Cache Slough	38.26919	-121.69239
Yolo-003	WY2019 Event #1	Yolo Bypass - Cache Slough	38.26105	-121.74786
Yolo-004	WY2019 Event #1	Yolo Bypass - Cache Slough	38.31957	-121.69276
Yolo-005	WY2019 Event #2	Yolo Bypass - Cache Slough	38.25905	-121.66765
Yolo-006	WY2019 Event #2	Yolo Bypass - Cache Slough	38.25214	-121.67558
Yolo-007	WY2019 Event #2	Yolo Bypass - Cache Slough	38.27122	-121.70283
Yolo-008	WY2019 Event #2	Yolo Bypass - Cache Slough	38.2743	-121.67392
Yolo-009	WY2019 Event #3	Yolo Bypass - Cache Slough	38.24957	-121.67482
Yolo-010	WY2019 Event #3	Yolo Bypass - Cache Slough	38.46178	-121.58863
Yolo-011	WY2019 Event #3	Yolo Bypass - Cache Slough	38.30568	-121.65721
Yolo-012	WY2019 Event #3	Yolo Bypass - Cache Slough	38.28241	-121.681
Yolo-013	WY2019 Event #4	Yolo Bypass - Cache Slough	38.2082	-121.66306
Yolo-014	WY2019 Event #4	Yolo Bypass - Cache Slough	38.38195	-121.62601
Yolo-015	WY2019 Event #4	Yolo Bypass - Cache Slough	38.26789	-121.66321
Yolo-016	WY2019 Event #4	Yolo Bypass - Cache Slough	38.25806	-121.7258
Yolo-017	WY2019 Event #5	Yolo Bypass - Cache Slough	38.2833	-121.68577
Yolo-018	WY2019 Event #5	Yolo Bypass - Cache Slough	38.26025	-121.67886
Yolo-019	WY2019 Event #5	Yolo Bypass - Cache Slough	38.43301	-121.60288
Yolo-020	WY2019 Event #5	Yolo Bypass - Cache Slough	38.27881	-121.6778
Yolo-021	WY2019 Event #6	Yolo Bypass - Cache Slough	38.30108	-121.72977
Yolo-022	WY2019 Event #6	Yolo Bypass - Cache Slough	38.31798	-121.65177
Yolo-023	WY2019 Event #6	Yolo Bypass - Cache Slough	38.27899	-121.68779
Yolo-024	WY2019 Event #6	Yolo Bypass - Cache Slough	38.18487	-121.66101
Yolo-025	Yolo Bypass Oversample Point #1	Yolo Bypass - Cache Slough	38.53725	-121.58398
Yolo-026	Yolo Bypass Oversample Point #2	Yolo Bypass - Cache Slough	38.26114	-121.67271
Yolo-027	Yolo Bypass Oversample Point #3	Yolo Bypass - Cache Slough	38.28616	-121.72181
Yolo-028	Yolo Bypass Oversample Point #4	Yolo Bypass - Cache Slough	38.26864	-121.67708
Yolo-029	Yolo Bypass Oversample Point #5	Yolo Bypass - Cache Slough	38.26053	-121.68851
Yolo-030	Yolo Bypass Oversample Point #6	Yolo Bypass - Cache Slough	38.411	-121.6164
Yolo-031	Yolo Bypass Oversample Point #7	Yolo Bypass - Cache Slough	38.288	-121.68209
Yolo-032	Yolo Bypass Oversample Point #8	Yolo Bypass - Cache Slough	38.2411	-121.68302
Yolo-033	Yolo Bypass Oversample Point #9	Yolo Bypass - Cache Slough	38.37009	-121.63221
Yolo-034	Yolo Bypass Oversample Point #10	Yolo Bypass - Cache Slough	38.23202	-121.67517

(b) Subregion 2 Sites - Sacramento River

siteID	Planned Sampling Event	Subregion	Latitude	Longitude
Sacr-001	WY2019 Event #1	Sacramento River	38.16498	-121.62099
Sacr-002	WY2019 Event #1	Sacramento River	38.26207	-121.65129
Sacr-003	WY2019 Event #2	Sacramento River	38.23917	-121.52149
Sacr-004	WY2019 Event #2	Sacramento River	38.37058	-121.55289
Sacr-005	WY2019 Event #3	Sacramento River	38.18899	-121.64127
Sacr-006	WY2019 Event #3	Sacramento River	38.24024	-121.60198
Sacr-007	WY2019 Event #4	Sacramento River	38.47372	-121.52027
Sacr-008	WY2019 Event #4	Sacramento River	38.19473	-121.61907
Sacr-009	WY2019 Event #5	Sacramento River	38.31436	-121.57723
Sacr-010	WY2019 Event #5	Sacramento River	38.45881	-121.5024
Sacr-011	WY2019 Event #6	Sacramento River	38.51454	-121.54563
Sacr-012	WY2019 Event #6	Sacramento River	38.19272	-121.56752
Sacr-013	WY2020 Event #1	Sacramento River	38.33821	-121.5653
Sacr-014	WY2020 Event #1	Sacramento River	38.3777	-121.54217
Sacr-015	WY2020 Event #2	Sacramento River	38.53481	-121.51925
Sacr-016	WY2020 Event #2	Sacramento River	38.17289	-121.64852

Sacr-017	WY2020 Event #3	Sacramento River	38.27415	-121.58859
Sacr-018	WY2020 Event #3	Sacramento River	38.23966	-121.53999
Sacr-019	WY2020 Event #4	Sacramento River	38.57538	-121.51169
Sacr-020	WY2020 Event #4	Sacramento River	38.1846	-121.64806
Sacr-021	WY2020 Event #5	Sacramento River	38.31035	-121.59847
Sacr-022	WY2020 Event #5	Sacramento River	38.41424	-121.52147
Sacr-023	WY2020 Event #6	Sacramento River	38.49416	-121.55587
Sacr-024	WY2020 Event #6	Sacramento River	38.2297	-121.60339
Sac-025	Sac. R. Oversample Point #1	Sacramento River	38.294	-121.58244
Sac-026	Sac. R. Oversample Point #2	Sacramento River	38.34605	-121.54344
Sac-027	Sac. R. Oversample Point #3	Sacramento River	38.47041	-121.50671
Sac-028	Sac. R. Oversample Point #4	Sacramento River	38.22488	-121.55672
Sac-029	Sac. R. Oversample Point #5	Sacramento River	38.33216	-121.58293
Sac-030	Sac. R. Oversample Point #6	Sacramento River	38.39327	-121.51421
Sac-031	Sac. R. Oversample Point #7	Sacramento River	38.56492	-121.52079
Sac-032	Sac. R. Oversample Point #8	Sacramento River	38.16693	-121.62877
Sac-033	Sac. R. Oversample Point #9	Sacramento River	38.24861	-121.60203
Sac-034	Sac. R. Oversample Point #10	Sacramento River	38.43376	-121.53173

(c) Subregion 3 Sites - Northeast Delta

siteID	Planned Sampling Event	Subregion	Latitude	Longitude
Nort-001	Water Year 2020, Event #1	Northeast Delta	38.14477	-121.4394
Nort-002	Water Year 2020, Event #1	Northeast Delta	38.16557	-121.49133
Nort-003	Water Year 2020, Event #1	Northeast Delta	38.2702	-121.46575
Nort-004	Water Year 2020, Event #1	Northeast Delta	38.11585	-121.55172
Nort-005	Water Year 2020, Event #2	Northeast Delta	38.1425	-121.49683
Nort-006	Water Year 2020, Event #2	Northeast Delta	38.25355	-121.47979
Nort-007	Water Year 2020, Event #2	Northeast Delta	38.22487	-121.53438
Nort-008	Water Year 2020, Event #2	Northeast Delta	38.12016	-121.58254
Nort-009	Water Year 2020, Event #3	Northeast Delta	38.12235	-121.49829
Nort-010	Water Year 2020, Event #3	Northeast Delta	38.26999	-121.47745
Nort-011	Water Year 2020, Event #3	Northeast Delta	38.14596	-121.60069
Nort-012	Water Year 2020, Event #3	Northeast Delta	38.1228	-121.52521
Nort-013	Water Year 2020, Event #4	Northeast Delta	38.20981	-121.50713
Nort-014	Water Year 2020, Event #4	Northeast Delta	38.24697	-121.49829
Nort-015	Water Year 2020, Event #4	Northeast Delta	38.12969	-121.56176
Nort-016	Water Year 2020, Event #4	Northeast Delta	38.20163	-121.54138
Nort-017	Water Year 2020, Event #5	Northeast Delta	38.14276	-121.47036
Nort-018	Water Year 2020, Event #5	Northeast Delta	38.16881	-121.47039
Nort-019	Water Year 2020, Event #5	Northeast Delta	38.28613	-121.50318
Nort-020	Water Year 2020, Event #5	Northeast Delta	38.13087	-121.57406
Nort-021	Water Year 2020, Event #6	Northeast Delta	38.15614	-121.50311
Nort-022	Water Year 2020, Event #6	Northeast Delta	38.26963	-121.49641
Nort-023	Water Year 2020, Event #6	Northeast Delta	38.10115	-121.56298
Nort-024	Water Year 2020, Event #6	Northeast Delta	38.13515	-121.5631
Nort-025	Northeast Delta Oversample Point #1	Northeast Delta	38.12899	-121.49945
Nort-026	Northeast Delta Oversample Point #2	Northeast Delta	38.22743	-121.49593
Nort-027	Northeast Delta Oversample Point #3	Northeast Delta	38.15123	-121.54201
Nort-028	Northeast Delta Oversample Point #4	Northeast Delta	38.1161	-121.54768
Nort-029	Northeast Delta Oversample Point #5	Northeast Delta	38.20663	-121.48201
Nort-030	Northeast Delta Oversample Point #6	Northeast Delta	38.23858	-121.49731
Nort-031	Northeast Delta Oversample Point #7	Northeast Delta	38.11541	-121.58356
Nort-032	Northeast Delta Oversample Point #8	Northeast Delta	38.21212	-121.53676
Nort-033	Northeast Delta Oversample Point #9	Northeast Delta	38.14361	-121.50598
Nort-034	Northeast Delta Oversample Point #1	Northeast Delta	38.20431	-121.45748

(d) Subregion 4, South Delta

siteID	Planned Sampling Event	Subregion	Latitude	Longitude

Sout-001	Water Year 2021, Event #1	South Delta	38.05283	-121.49864
Sout-002	Water Year 2021, Event #1	South Delta	37.95823	-121.37949
Sout-003	Water Year 2021, Event #1	South Delta	38.04623	-121.47557
Sout-004	Water Year 2021, Event #1	South Delta	37.80751	-121.41535
Sout-005	Water Year 2021, Event #2	South Delta	38.03876	-121.48338
Sout-006	Water Year 2021, Event #2	South Delta	38.03283	-121.37984
Sout-007	Water Year 2021, Event #2	South Delta	37.99765	-121.41004
Sout-008	Water Year 2021, Event #2	South Delta	38.08578	-121.55262
Sout-009	Water Year 2021, Event #3	South Delta	37.82028	-121.49248
Sout-010	Water Year 2021, Event #3	South Delta	38.00564	-121.4443
Sout-011	Water Year 2021, Event #3	South Delta	37.79368	-121.30747
Sout-012	Water Year 2021, Event #3	South Delta	38.10007	-121.48869
Sout-013	Water Year 2021, Event #4	South Delta	37.95268	-121.3415
Sout-014	Water Year 2021, Event #4	South Delta	38.04105	-121.42992
Sout-015	Water Year 2021, Event #4	South Delta	37.79666	-121.46729
Sout-016	Water Year 2021, Event #4	South Delta	38.08991	-121.4808
Sout-017	Water Year 2021, Event #5	South Delta	38.04166	-121.49771
Sout-018	Water Year 2021, Event #5	South Delta	37.88673	-121.4445
Sout-019	Water Year 2021, Event #5	South Delta	38.05089	-121.46503
Sout-020	Water Year 2021, Event #5	South Delta	38.10563	-121.48937
Sout-021	Water Year 2021, Event #6	South Delta	37.81977	-121.52646
Sout-022	Water Year 2021, Event #6	South Delta	38.05065	-121.41834
Sout-023	Water Year 2021, Event #6	South Delta	37.9959	-121.36884
Sout-024	Water Year 2021, Event #6	South Delta	38.06388	-121.49817
Sout-025	South Delta Oversample Point #1	South Delta	37.91663	-121.32144
Sout-026	South Delta Oversample Point #2	South Delta	38.00774	-121.45576
Sout-027	South Delta Oversample Point #3	South Delta	37.80179	-121.31318
Sout-028	South Delta Oversample Point #4	South Delta	38.08441	-121.5025
Sout-029	South Delta Oversample Point #5	South Delta	37.95635	-121.29327
Sout-030	South Delta Oversample Point #6	South Delta	38.01117	-121.45969
Sout-031	South Delta Oversample Point #7	South Delta	37.81982	-121.47719
Sout-032	South Delta Oversample Point #8	South Delta	38.08585	-121.4327
Sout-033	South Delta Oversample Point #9	South Delta	38.03779	-121.48623
Sout-034	South Delta Oversample Point #10	South Delta	38.01175	-121.37018

(e) Subregion 5, Central Delta

Station Code	Planned Sampling Event	Subregion	Latitude	Longitude
Cent-001	Water Year 2021, Event #1	Central Delta	37.83573	-121.55504
Cent-002	Water Year 2021, Event #1	Central Delta	37.92102	-121.51735
Cent-003	Water Year 2021, Event #2	Central Delta	38.07762	-121.57553
Cent-004	Water Year 2021, Event #2	Central Delta	38.03804	-121.59668
Cent-005	Water Year 2021, Event #3	Central Delta	37.90153	-121.614
Cent-006	Water Year 2021, Event #3	Central Delta	37.99242	-121.52336
Cent-007	Water Year 2021, Event #4	Central Delta	38.10001	-121.60055
Cent-008	Water Year 2021, Event #4	Central Delta	38.04206	-121.59015
Cent-009	Water Year 2021, Event #5	Central Delta	37.99109	-121.57778
Cent-010	Water Year 2021, Event #5	Central Delta	37.97646	-121.51462
Cent-011	Water Year 2021, Event #6	Central Delta	38.03492	-121.60047
Cent-012	Water Year 2021, Event #6	Central Delta	38.0232	-121.51372
Cent-013	Water Year 2022, Event #1	Central Delta	37.94248	-121.55928
Cent-014	Water Year 2022, Event #1	Central Delta	38.06307	-121.56103
Cent-015	Water Year 2022, Event #2	Central Delta	38.05692	-121.60865
Cent-016	Water Year 2022, Event #2	Central Delta	38.1042	-121.593
Cent-017	Water Year 2022, Event #3	Central Delta	37.92026	-121.55569
Cent-018	Water Year 2022, Event #3	Central Delta	37.99156	-121.51535
Cent-019	Water Year 2022, Event #4	Central Delta	38.06157	-121.61927
Cent-020	Water Year 2022, Event #4	Central Delta	38.02919	-121.58338
Cent-021	Water Year 2022, Event #5	Central Delta	37.8893	-121.57467

Cent-022	Water Year 2022, Event #5	Central Delta	38.00364	-121.52884
Cent-023	Water Year 2022, Event #6	Central Delta	38.05159	-121.63419
Cent-024	Water Year 2022, Event #6	Central Delta	38.03892	-121.56968
Cent-025	Central Delta Oversample Point #1	Central Delta	38.00963	-121.54678
Cent-026	Central Delta Oversample Point #2	Central Delta	37.97532	-121.52924
Cent-027	Central Delta Oversample Point #3	Central Delta	38.02158	-121.60701
Cent-028	Central Delta Oversample Point #4	Central Delta	38.05344	-121.52894
Cent-029	Central Delta Oversample Point #5	Central Delta	37.97748	-121.57555
Cent-030	Central Delta Oversample Point #6	Central Delta	38.0854	-121.5748
Cent-031	Central Delta Oversample Point #7	Central Delta	38.05183	-121.61223
Cent-032	Central Delta Oversample Point #8	Central Delta	38.09282	-121.66764
Cent-033	Central Delta Oversample Point #9	Central Delta	37.91614	-121.57317
Cent-034	Central Delta Oversample Point #10	Central Delta	37.98716	-121.51273

(f) Subregion 6, Confluence

Station Code	Planned Sampling Event	Subregion	Latitude	Longitude
Conf-001	Water Year 2022, Event #1	Confluence	38.04107	-121.82461
Conf-002	Water Year 2022, Event #1	Confluence	38.05926	-121.82224
Conf-003	Water Year 2022, Event #1	Confluence	38.02936	-121.75401
Conf-004	Water Year 2022, Event #1	Confluence	38.0217	-121.73516
Conf-005	Water Year 2022, Event #2	Confluence	38.02386	-121.81611
Conf-006	Water Year 2022, Event #2	Confluence	38.06217	-121.84303
Conf-007	Water Year 2022, Event #2	Confluence	38.07803	-121.68256
Conf-008	Water Year 2022, Event #2	Confluence	38.04345	-121.70929
Conf-009	Water Year 2022, Event #3	Confluence	38.03502	-121.83132
Conf-010	Water Year 2022, Event #3	Confluence	38.0252	-121.74828
Conf-011	Water Year 2022, Event #3	Confluence	38.10005	-121.71903
Conf-012	Water Year 2022, Event #3	Confluence	38.10961	-121.71
Conf-013	Water Year 2022, Event #4	Confluence	38.07439	-121.77288
Conf-014	Water Year 2022, Event #4	Confluence	38.04787	-121.79496
Conf-015	Water Year 2022, Event #4	Confluence	38.02104	-121.70428
Conf-016	Water Year 2022, Event #4	Confluence	38.13653	-121.68669
Conf-017	Water Year 2022, Event #5	Confluence	38.04499	-121.80214
Conf-018	Water Year 2022, Event #5	Confluence	38.05608	-121.80726
Conf-019	Water Year 2022, Event #5	Confluence	38.05904	-121.67786
Conf-020	Water Year 2022, Event #5	Confluence	38.0094	-121.71992
Conf-021	Water Year 2022, Event #6	Confluence	38.02724	-121.81124
Conf-022	Water Year 2022, Event #6	Confluence	38.07076	-121.83746
Conf-023	Water Year 2022, Event #6	Confluence	38.08438	-121.71004
Conf-024	Water Year 2022, Event #6	Confluence	38.03909	-121.72454
Conf-025	Confluence Oversample Point #1	Confluence	38.06592	-121.79342
Conf-026	Confluence Oversample Point #2	Confluence	38.03582	-121.77693
Conf-027	Confluence Oversample Point #3	Confluence	38.05161	-121.69158
Conf-028	Confluence Oversample Point #4	Confluence	38.1158	-121.68543
Conf-029	Confluence Oversample Point #5	Confluence	38.08838	-121.73959
Conf-030	Confluence Oversample Point #6	Confluence	38.02255	-121.79957
Conf-031	Confluence Oversample Point #7	Confluence	38.01509	-121.69463
Conf-032	Confluence Oversample Point #8	Confluence	38.14447	-121.69162
Conf-033	Confluence Oversample Point #9	Confluence	38.0364	-121.80651
Conf-034	Confluence Oversample Point #10	Confluence	38.07157	-121.85175

Table 6.5 Sampling schedule for random samples in the six Delta subregions

Subregion Number	Subregion Name	Number of Random Samples Planned in Water Year				
		2019	**2020**	**2021**	**2022**	**Total**
1	Yolo Bypass - Cache Slough	24				24
2	Sacramento River	12	12			24
3	Northeast Delta		24			24
4	South Delta			24		24
5	Central Delta			12	12	24
6	Confluence				24	24
	Total	**36**	**36**	**36**	**36**	**144**

Table 6.6 Schedule for ambient water samples to be collected in Water Year 2019 for pesticides ar

Sampling Event	GRTS Sites in Subregion 1	GRTS Sites in Subregion 2	Fixed Site 1: San Joaquin River at Buckley Cove	Fixed Site 2: Ulatis Creek at Brown's Road	**Total**
Event #1	4	2	1	1	8
Event #2	4	2	1	1	8
Event #3	4	2	1	1	8
Event #4	4	2	1	1	8
Event #5	4	2	1	1	8
Event #6	4	2	1	1	8
Total	**24**	**12**	**6**	**6**	**48**

Table 6.7. Planned sampling events for pesticides and toxicity monitoring, storm triggers, and criteria

#	Event	Event Type	Criteria	Water Year 2019 Sampling Triggers	Water Year 2020 Triggers	Notes
1	First Flush	Storm Sampling	First runoff event in response to Central Valley rainfall after Oct 1st that meets the trigger.	Guidance plots* at appropriate discharge sites or recorded discharge at upstream flow stations show an approximately 2-3X increase in flows. Timing of actual sampling must take streamflow peak travel time into consideration.	The first event shall be an "urban first flush" event. The trigger shall be 0.5" of rainfall forecast in 24 hours for the basin. There should be at least 10 consecutive dry days between sampling events. This allows pesticide applicators time to go out and spray.	Recommended change in 2020, as it was felt the trigger in 2020 was too high, and there were several large precipitation events that occurred but did not technically meet this trigger.
2	Second Winter Storm	Storm Sampling	Minimum of 2 weeks since last event (time for lab to complete previous tests)	Guidance plots at appropriate discharge sites or recorded discharge at upstream flow stations show an approximately 2-3X increase in flows. Timing of actual sampling must take streamflow peak travel time into consideration.	Same as 2019	Reservoir releases for flood control may mask storm runoff signal, need to watch Valley rainfall rates and totals.
3	Third Winter Storm or Spring Snowmelt runoff prior to irrigation	Storm Sampling/winter runoff	Minimum of 2 weeks since last event (time for lab to complete previous tests)	Guidance plots at appropriate discharge sites or recorded discharge at upstream flow stations show an approximately 2-3X increase in flows. Timing of actual sampling must take streamflow peak travel time into consideration.	Same as 2019	If a 3rd significant storm does not materialize. Sample by the end of April during snowmelt period and prior to irrigation season.
4	Spring	Irrigation/Baseflow	Approximately May-June but at least 30 days following last major rainfall/runoff event in Valley, to give time for drying of soils and initiation of irrigation season.	None	None	Timing of this sampling event is variable based on winter/spring rainfall timing and initiation of irrigation.
5	Summer	Irrigation/Baseflow	Approximately mid July	None	None	
6	Fall	Irrigation/Baseflow	Approximately September - October	None	None	

Table 6.8 Delta RMP reporting cycle.

Deliverable	Frequency	Planned release date to the public
Data uploads		
CD3	Annually[1]	March 1
CEDEN	Annually	March 1
California Estuaries web portal	Annually	March 1
Reports		
Annual Monitoring Reports (including QA report)	Annually	March 1
Technical Reports	Variable	Variable
Mercury monitoring report	Every 2-3 years	February 2020 (Final Report for Years 1-3)
Nutrient special study (SRiNCS project) report. Data from this project will also be uploaded to CEDEN.	Once	Draft Final Report 11/5/2020 Final Report 12/31/2020
Pulse of the Delta	Every 2-3 years	Next edition planned for Fall 2020

[1]Time period of data for annual reporting: September 1 – October 31.

Table 7.1 Data Quality Objectives for Pesticides and Aquatic Toxicity Monitoring: Analytic approach, decision rule, and data quality objectives

(a) Spatial extent of pesticide, toxicity occurrence

Questions to Answer with Delta RMP Pesticide Data	**Analytic Approach**	**Decision Rule**	**Data Quality Objectives**	**Power Analysis**
Spatial extent of pesticide, toxicity occurrence: For what percent of the subregion was aquatic toxicity and co-occurrence of pesticides greater than risk-based thresholds observed? Over what percentage of the subregion does a pesticide concentration exceed a threshold? **Secondary objective that can be evaluated qualitatively:** Identify spatial patterns in aquatic toxicity and pesticide concentrations within the subregion to inform decisions about sensitive habitats, sources, and strata for future designs.	Me**trics for toxicity:** 1. Binary variable (0/1, or True/False) indicating whether significant toxicity was observed (stratified by species, and possibly by endpoint) 2. Continuous variable - Percent effect observed for individual toxicity tests: reduction in organism survival, reproduction, or growth compared to control. **Metric for pesticides:** 1. Continuous variable: Observed concentration of individual pesticides, in ng/L 2. Binary variable (0/1 or True/False) Individual pesticide observations exceeding a risk threshold. 3. Frequency with which individual pesticides exceed a threshold. 4. Cumulative frequency of exceedance (for one or all pesticides) 5. Cumulative frequency of exceedance for classes of pesticides grouped by type or mode of action (organophosphate and pyrethroids) Pesticide Toxicity Index*Metric for determining cause of toxicity: outcome of Toxicity Identification Evaluations (TIEs)	Population estimates will be made using open source R software ('spsurvey'). Population estimates are not a statistical test. There is no null hypothesis. The result will be a percent of subregion water area meeting a certain condition such as: -Percent of subregion with statically significant aquatic toxicity -Percent of subregion with pesticide concentrations above risk based thresholds -Percent of subregion with significant toxicity AND pesticide concentrations above risk based thresholds	The sample size for each subregion should be large enough to be able to estimate the percent of subregion's water area with a certain condition with error bars of ±10%. Assume a Type 1 error of <0.05 and a Type 2 error of <0.2 (80% statistical power).	Under a random sampling design, a standard probability distribution known as the binomial distribution can be used to estimate of the upper and lower bounds of confidence intervals. A sample size of n = 24 gives a 90% confidence interval of around ±13%. (This is acceptably close to our objective of ±10%.) More details on the power analysis are available in the study proposal; copies available upon request.

(b) Co-Occurrence of Pesticides and Toxicity

Questions to Answer with Delta RMP Pesticide Data	**Analytic Approach**	**Decision Rule**	**Data Quality Objectives**	**Power Analysis**

Causes of toxicity *Evaluate the co-occurrence of aquatic toxicity and pesticides.*	**Metrics for toxicity:** 1. Binary variable (0/1, or True/False) indicating whether significant toxicity was observed (stratified by species, and possibly by endpoint) 2. Continuous variable - Percent effect observed for individual toxicity tests: reduction in organism survival, reproduction, or growth compared to control. **Metrics for pesticides:** 1. Continuous variable: Observed concentration of individual pesticides, in ng/L 2. Binary variable (0/1 or True/False) Individual pesticide observations exceeding a risk threshold. 3. Frequency with which individual pesticides exceed a threshold. 4. Cumulative frequency of exceedance (for one or all pesticides) 5. Cumulative frequency of exceedance for classes of pesticides grouped by type or mode of action (organophosphate and pyrethroids) 6. Pesticide Toxicity Index*	**Statistical Test:** -Logistic Regression -Multivariate linear regression All data from all sites will be pooled for the test if and/or sites to be analyzed individually based on a statistical analysis of their similarity using Generalized Linear Models or Principal Components Analysis. Null hypotheses: Ho: Toxicity is not related to exposure to pesticides. (There is no relationship between pesticide levels and toxicity.) Ha: There exists a relationship between pesticide exposure and the toxicity.	The test should be able to detect a 5% effect** of pesticide exposure with a Type 1 error of <0.1 and a Type 2 error of <0.2 (80% power).	For the site on the San Joaquin River at Buckley Cove, to detect an effect size = 0.03 would require around 60 samples. In this context, an effect size of 0.03 is equivalent to a 3% increase in toxicity to macroinvertebrates for each unit increase in the Pesticide Toxicity Index (PTI). Requires 36 new samples at each site, or 6 years (i.e., collecting 6 samples per year at this fixed location). More details on the power analysis are available in the study proposal; copies available upon request

* The Pesticide Toxicity Index (PTI) is a screening tool to assess potential aquatic toxicity of complex pesticide mixtures by combining measures of pesticide exposure and acute toxicity in an additive toxic-unit model. For mor

** An effect size of 5% means that a unit increase of the PTI would result in a 5% reduction in a toxicity endpoint such as reproduction, survival, or growth. In general, large effect sizes (e.g. 50% reduction in survival) are easi

Table 7.2. Purposes of field and laboratory QC sample types and data quality indicators applic

QC Sample Type	Data Quality Indicator/Purpose
Calibration	Accuracy of measurement (field parameters, laboratory chemical analysis).
Calibration Check	Accuracy of calibration (field parameters, laboratory chemical analysis).
Laboratory Blanks -Method Blanks	Contamination/confirm the absence of analytes introduced in the lab (laboratory chemical analysis).
Laboratory Blanks - Instrument Blanks	Contamination/Assess the presence or absence of instrument contamination (laboratory chemical analysis).
CRM (Certified Reference Material)	Accuracy of measurement (primarily); precision/most robust indicator of measurement accuracy; may also be used to evaluate replicate precision and recovery where average values for field samples are expected (based on historical or literature results) to fall in a non-quantitative range (laboratory chemical analysis).
Laboratory Duplicates - Matrix Spikes (MS)/Matrix Spike Duplicates (MSD)	Accuracy and precision/evaluate the effect of the sample matrix on the recovery of the compound(s) of interest and providing an estimate of analytical precision when measured in duplicate (laboratory chemical analysis).
Laboratory Duplicates - Matrix Duplicates	Precision of intra-laboratory analytical process (laboratory chemical analysis)
Surrogate Spikes	Accuracy of analytical method/assess the efficiency of the extraction method for organic analytes (laboratory chemical analysis).
Internal Standards	Accuracy of analytical method/enable optimal quantitation, particularly of complex extracts subject to retention time shifts or instrument interferences relative to the analysis of standards. Internal standards can also be used to detect and correct for problems in the injection port or other parts of the instrument (laboratory chemical analysis).
Field Blanks	Contamination/To check cross- contamination during sample collection, field sample processing, and shipment. Also to check sample containers (laboratory chemical analysis). Field crews will need to include filtration in processing blanks for applicable sample types.
Field Duplicate/Replicate	Precision/Check reproducibility of field procedures. To indicate non-homogeneity. (Field Duplicate: n = 2; Field Replicate: n > 2). This sample is to be collected in the field in tandem with a regular environmental sample. To be preserved, handled and processed as a unique sample. Lab precision is covered below (laboratory chemical analysis).
Instrument Replicates	Precision of instrument (laboratory chemical analysis).
Travel/bottle blanks	Contamination/To account for contaminants introduced during the transport process between the laboratory and field site, in addition to any contamination from the source solution and container (laboratory chemical analysis).
For Aquatic Toxicity Testing Only	
Negative Control (e.g., Laboratory control)	To evaluate test performance, health, and sensitivity of the specific batch of organisms (laboratory toxicity testing).
Negative Control –Tolerance Control Water for Unmanipulated Samples (e.g., Conductivity control)	Evaluates the effects of water quality parameters near the tolerance threshold of the organism (laboratory toxicity testing).

Positive Control (Reference toxicant testing)	Sensitivity, precision and accuracy of toxicity tests performed in the laboratory/dDetermine the sensitivity of the test organisms over time; assess comparability within and between laboratory test results; identify potential sources of variability, such as test organism health, differences among batches of organisms, changes in laboratory water or food quality, and performance by laboratory analysts (laboratory toxicity testing).

Table 7.3 Summary of reporting limits (RL) and method detection limits (MDL) for Delta RMP constituents.

(a) Conventional analytes, Field Parameters, Trace Metals, and Nutrients

CAS Registry Number	Constituent	Matrix	Reporting group	RL	MDL	Unit	Analyzing laboratory/laboratories	Method used
479-61-8	Chlorophyll a	Water	Conventional	30	24	µg/L	MPSL (mercury monitoring), USGS (nutrient monitoring)	EPA 445.0 or EPA 446.0
7440-44-0	Dissolved Organic Carbon	Water	Conventional	0.23	0.23	mg/L	MPSL	TM O-1122-92
7440-44-0	Total Organic Carbon	Sediment	Conventional	NA	NA	%	MPSL	EPA 440
479-61-8	Chlorophyll-a	Water	Field Parameters	0 - 100	0 - 100	µg/L	USGS	National Field Manual for the Collection for Water-Quality Data, Chapter A6, Field Measurements
n/a	fDOM	Water	Field Parameters	0.07 - 300	0.07 - 300	Quinine sulfate equivalent (QSE)	USGS	
4797-55-8	Nitrate	Water	Field Parameters	0.07 - 28	0.07 - 28	mg N per L	USGS	
11016-15-2	Phycocyanin	Water	Field Parameters	0 - 100	0 - 100	µg/L	USGS	
7782-44-7	Oxygen, Dissolved	Water	Field Parameters	0.5	0.5	mg/L	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	pH	Water	Field Parameters	4-8	4-8	NA	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	Specific Conductivity	Water	Field Parameters	10	10	µS/cm	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	Temperature	Water	Field Parameters	NA	NA	NA	MPSL (mercury monitoring), USGS (nutrient monitoring)	
n/a	Turbidity	Water	Field Parameters	1	1	FNU	USGS	
7440-50-8	Copper, dissolved	Water	Trace Metals	0.8	0.8	µg/L	USGS	TM-5-B1
14798-03-09	Ammonium	Water	Nutrients	0.01	0.01	mg N/L	USGS	I-2525-89, I-2522-90
14797-55-8	Nitrate	Water	Nutrients	0.02	0.02	mg N/L	USGS	I-2547-11
n/a	Orthophosphate	Water	Nutrients	0.008	0.008	mg P/L	USGS	I-2601-90, I-2606-89
7439-97-6	Mercury, total	Tissue	Trace Metals	0.012	0.004	µg/g ww	MPSL	EPA 7473
7439-97-6	Mercury, total (unfiltered)	Water	Trace Metals	0.2	0.07	ng/L	MPSL	EPA 1631E
7439-97-6	Mercury, dissolved (filtered)	Water	Trace Metals	0.2	0.07	ng/L	MPSL	EPA 1631E
7439-97-6	Mercury, total	Sediment	Trace Metals	0.012	0.004	mg/kg dw	MPSL	EPA 7473
22967-92-6	Mercury, Methyl	Sediment	Trace Metals	0.013	0.004	µg/kg dw	MPSL	MPSL-110
22967-92-6	Mercury, Methyl, total (unfiltered)	Water	Trace Metals	0.025	0.009	ng/L	MPSL	EPA 1630
22967-92-6	Mercury, Methyl, dissolved (filtered)	Water	Trace Metals	0.025	0.009	ng/L	MPSL	EPA 1630

n/a	Temperature	Water	Field Parameters	0	NA	degrees Celsius	RSEL	Standard Methods [SM] 2550 B per 40 CFR Part 136, Table I B
n/a	pH	Water	Field Parameters	4	NA	pH units	RSEL	SM 4500-H+ G per 40 CFR Part 136, Table I B
n/a	Specific Conductivity	Water	Field Parameters	10	NA	umhos/cm	RSEL	EPA 120.1
n/a	Dissolved Oxygen	Water	Field Parameters	0.1	NA	mg/L	RSEL	ASTM D888-09 C
n/a	Turbidity	Water	Field Parameters	1	NA	NTU	RSEL	SESDPROC-103-R4
14798-03-09	Ammonium	Water	Conventional	0.5	0.19	mg/L	RSEL	EPA 350.1
14797-55-8	Nitrate - Nitrite	Water	Conventional	0.1	0.02	mg/L	RSEL	EPA 353.2
n/a	Total Kjeldahl nitrogen (dissolved)	Water	Chemistry	0.2	0.07	mg/L	RSEL	EPA 351.2
7723-14-0	Dissolved phosphorus	Water	Conventional	0.1	0.07	mg/L	RSEL	EPA 365.4
7440-44-0	Dissolved organic carbon	Water	Conventional	1	0.35	mg/L	RSEL	SM 5310B per 40 CFR Part 136, Table I B
479-61-8	Chlorophyll-a	Water	Conventional	0.04	NA	mg/L	RSEL	SM 10200 H per 40 CFR Part 136, Table I B
7631-86-9	Silica	Water	Conventional	50	21	ug/L	RSEL	EPA 200.8

Table 7.3 Summary of reporting limits (RL) and method detection limits (MDL) for Delta RMP constituents.
(b) For current use pesticides analyzed by USGS Organic Chemistry Research Laboratory (OCRL).
All pesticides are reported in nanograms per liter (ng/L).
See also Table 5.3 for water quality thresholds for pesticides analytes

CAS Registry Number	Analyte	MDL in Suspended Sediment (ng/L)	MDL in Filtered Water (ng/L)	Method, Suspended Sediment	Method, Filtered Water
135410-20-7	Acetamiprid	–	3.3	–	SIR 2012-5206
34256-82-1	Acetochlor	1.5	1.5	TM5–C3	Hladik et al. 2008
135158-54-2	Acibenzolar-S-methyl	3	3	TM5–C3	Hladik et al. 2008
584-79-2	Allethrin	1	1	TM5-C2	TM5-C2
1912-24-9	Atrazine	2.3	2.3	TM5–C3	Hladik et al. 2008
131860-33-8	Azoxystrobin	3.1	3.1	TM5–C3	Hladik et al. 2008
1861-40-1	Benefin (Benfluralin)	2	2	TM5–C3	Hladik et al. 2008
1072957-71-1	Benzovindiflupyr	3.4	3.4	TM5–C3	Hladik et al. 2008
82657-04-3	Bifenthrin	0.7	0.7	TM5-C2	TM5-C2
188425-85-6	Boscalid	2.8	2.8	TM5–C3	Hladik et al. 2008
33629-47-9	Butralin	2.6	2.6	TM5–C3	Hladik et al. 2008
133-06-2	Captan	10.2	10.2	TM5–C3	Hladik et al. 2008
63-25-2	Carbaryl	6.5	6.5	TM5–C3	Hladik et al. 2008
10605-21-7	Carbendazim	–	4.2	–	SIR 2012-5206
1563-66-2	Carbofuran	3.1	3.1	TM5–C3	Hladik et al. 2008
5234-68-4	Carboxin	–	4.5	–	SIR 2012-5206
500008-45-7	Chlorantraniliprole	–	4	–	SIR 2012-5206
122453-73-0	Chlorfenapyr	3.3	3.3	TM5–C3	Hladik et al. 2008
1897-45-6	Chlorothalonil	4.1	4.1	TM5–C3	Hladik et al. 2008
2921-88-2	Chlorpyrifos	2.1	2.1	TM5–C3	Hladik et al. 2008
5598-15-2	Chlorpyrifos oxon	5	5	TM5–C3	Hladik et al. 2008
81777-89-1	Clomazone	2.5	2.5	TM5–C3	Hladik et al. 2008
210880-92-5	Clothianidin	–	3.9	–	SIR 2012-5206
56-72-4	Coumaphos	3.1	3.1	TM5–C3	Hladik et al. 2008
736994-63-1	Cyantraniliprole	–	4.2	–	SIR 2012-5206
120116-88-3	Cyazofamid	–	4.1	–	SIR 2012-5206
1134-23-2	Cycloate	1.1	1.1	TM5–C3	Hladik et al. 2008
68359-37-5	Cyfluthrin	1	1	TM5-C2	TM5-C2
122008-85-9	Cyhalofop-butyl	1.9	1.9	TM5–C3	Hladik et al. 2008
91465-08-6	Cyhalothrin (all isomers)	0.5	0.5	TM5-C2	TM5-C2
57966-95-7	Cymoxanil	–	3.9	–	SIR 2012-5206
52315-07-8	Cypermethrin	1	1	TM5-C2	TM5-C2
94361-06-5	Cyproconazole	4.7	4.7	TM5–C3	Hladik et al. 2008
121552-61-2	Cyprodinil	7.4	7.4	TM5–C3	Hladik et al. 2008
1861-32-1	DCPA	2	2	TM5–C3	Hladik et al. 2008
3567-62-2	DCPMU	–	3.5	–	SIR 2012-5206
2327-02-8	DCPU	–	3.4	–	SIR 2012-5206
52918-63-5	Deltamethrin	0.6	0.6	TM5-C2	TM5-C2
120983-64-4	Desthio-prothioconazole	–	3	–	SIR 2012-5206
205650-65-3	Desulfinylfipronil	1.6	1.6	TM5–C3	Hladik et al. 2008
205650-69-7	Desulfinylfipronil amide	3.2	3.2	TM5–C3	Hladik et al. 2008
333-41-5	Diazinon	0.9	0.9	TM5–C3	Hladik et al. 2008
962-58-3	Diazoxon	5	5	TM5–C3	Hladik et al. 2008
95-76-1	Dichloroaniline, 3,4-	8.3	3.2	TM5–C3	SIR 2012-5206
626-43-7	Dichloroaniline, 3,5-	7.6	7.6	TM5–C3	Hladik et al. 2008
62-73-7	Dichlorvos	5.1	5.1	TM5–C3	Hladik et al. 2008
119446-68-3	Difenoconazole	10.5	10.5	TM5–C3	Hladik et al. 2008
110488-70-5	Dimethomorph	6	6	TM5–C3	Hladik et al. 2008
165252-70-0	Dinotefuran	–	4.5	–	SIR 2012-5206
97886-45-8	Dithiopyr	1.6	1.6	TM5–C3	Hladik et al. 2008
330-54-1	Diuron	–	3.2	–	SIR 2012-5206
759-94-4	EPTC	1.5	1.5	TM5–C3	Hladik et al. 2008
66230-04-4	Esfenvalerate	0.5	0.5	TM5-C2	TM5-C2
162650-77-3	Ethaboxam	–	3.8	–	SIR 2012-5206
55283-68-6	Ethalfluralin	3	3	TM5–C3	Hladik et al. 2008

80844-07-1	Etofenprox	2.2	2.2	TM5–C3	Hladik et al. 2008
153233-91-1	Etoxazole	4.2	4.2	TM5–C3	Hladik et al. 2008
131807-57-3	Famoxadone	2.5	2.5	TM5–C3	Hladik et al. 2008
161326-34-7	Fenamidone	5.1	5.1	TM5–C3	Hladik et al. 2008
114369-43-6	Fenbuconazole	5.2	5.2	TM5–C3	Hladik et al. 2008
126833-17-8	Fenhexamid	7.6	7.6	TM5–C3	Hladik et al. 2008
39515-41-8	Fenpropathrin	0.6	0.6	TM5-C2	TM5-C2
134098-61-6	Fenpyroximate	5.2	5.2	TM5–C3	Hladik et al. 2008
120068-37-3	Fipronil	2.9	2.9	TM5–C3	Hladik et al. 2008
120067-83-6	Fipronil sulfide	1.8	1.8	TM5–C3	Hladik et al. 2008
120068-36-2	Fipronil sulfone	3.5	3.5	TM5–C3	Hladik et al. 2008
158062-67-0	Flonicamid	–	3.4	–	SIR 2012-5206
79622-59-6	Fluazinam	4.4	4.4	TM5–C3	Hladik et al. 2008
272451-65-7	Flubendiamide	6.2	6.2	TM5–C3	Hladik et al. 2008
131341-86-1	Fludioxonil	7.3	7.3	TM5–C3	Hladik et al. 2008
142459-58-3	Flufenacet	4.7	4.7	TM5–C3	Hladik et al. 2008
62924-70-3	Flumetralin	5.8	5.8	TM5–C3	Hladik et al. 2008
239110-15-7	Fluopicolide	3.9	3.9	TM5–C3	Hladik et al. 2008
658066-35-4	Fluopyram	3.8	3.8	TM5–C3	Hladik et al. 2008
361377-29-9	Fluoxastrobin	9.5	9.5	TM5–C3	Hladik et al. 2008
951659-40-8	Flupyradifurone	–	3	–	SIR 2012-5206
59756-60-4	Fluridone	–	3.7	–	SIR 2012-5206
66332-96-5	Flutolanil	4.4	4.4	TM5–C3	Hladik et al. 2008
76674-21-0	Flutriafol	4.2	4.2	TM5–C3	Hladik et al. 2008
907204-31-3	Fluxapyroxad	4.8	4.8	TM5–C3	Hladik et al. 2008
51235-04-2	Hexazinone	8.4	8.4	TM5–C3	Hladik et al. 2008
35554-44-0	Imazalil	10.5	10.5	TM5–C3	Hladik et al. 2008
138261-41-3 or 105	Imidacloprid	–	3.8	–	SIR 2012-5206
120868-66-8	Imidacloprid urea	–	4	–	SIR 2012-5206
950782-86-2	Indaziflam	2.1	2.1	TM5–C3	Hladik et al. 2008
173584-44-6	Indoxacarb	4.9	4.9	TM5–C3	Hladik et al. 2008
125225-28-7	Ipconazole	7.8	7.8	TM5–C3	Hladik et al. 2008
36734-19-7	Iprodione	4.4	4.4	TM5–C3	Hladik et al. 2008
875915-78-9	Isofetamid	2	2	TM5–C3	Hladik et al. 2008
143390-89-0	Kresoxim-methyl	4	4	TM5–C3	Hladik et al. 2008
1634-78-2	Malaoxon	5	5	TM5–C3	Hladik et al. 2008
121-75-5	Malathion	3.7	3.7	TM5–C3	Hladik et al. 2008
374726-62-2	Mandipropamid	–	3.3	–	SIR 2012-5206
57837-19-1	Metalaxyl	5.1	5.1	TM5–C3	Hladik et al. 2008
125116-23-6	Metconazole	5.2	5.2	TM5–C3	Hladik et al. 2008
40596-69-8	Methoprene	6.4	6.4	TM5–C3	Hladik et al. 2008
161050-58-4	Methoxyfenozide	–	2.7	–	SIR 2012-5206
298-00-0	Methyl parathion	3.4	3.4	TM5–C3	Hladik et al. 2008
51218-45-2	Metolachlor	1.5	1.5	TM5–C3	Hladik et al. 2008
88671-89-0	Myclobutanil	6	6	TM5–C3	Hladik et al. 2008
15299-99-7	Napropamide	8.2	8.2	TM5–C3	Hladik et al. 2008
116714-46-6	Novaluron	2.9	2.9	TM5–C3	Hladik et al. 2008
19044-88-3	Oryzalin	–	5	–	SIR 2012-5206
19666-30-9	Oxadiazon	2.1	2.1	TM5–C3	Hladik et al. 2008
1003318-67-9	Oxathiapiprolin	–	3.2	–	SIR 2012-5206
42874-03-3	Oxyfluorfen	3.1	3.1	TM5–C3	Hladik et al. 2008
72-54-8	p,p'-DDD	4.1	4.1	TM5–C3	Hladik et al. 2008
72-55-9	p,p'-DDE	3.6	3.6	TM5–C3	Hladik et al. 2008
50-29-3	p,p'-DDT	4	4	TM5–C3	Hladik et al. 2008
76738-62-0	Paclobutrazol	6.2	6.2	TM5–C3	Hladik et al. 2008
40487-42-1	Pendimethalin	2.3	2.3	TM5–C3	Hladik et al. 2008
219714-96-2	Penoxsulam	–	3.5	–	SIR 2012-5206
1825-21-4	Pentachloroanisole	4.7	4.7	TM5–C3	Hladik et al. 2008
82-68-8	Pentachloronitrobenzene	3.1	3.1	TM5–C3	Hladik et al. 2008
183675-82-3	Penthiopyrad	–	3.2	–	SIR 2012-5206
52645-53-1	Permethrin	0.6	0.6	TM5-C2	TM5-C2
26002-80-2	Phenothrin	1	1	TM5-C2	TM5-C2
732-11-6	Phosmet	4.4	4.4	TM5–C3	Hladik et al. 2008

117428-22-5	Picoxystrobin	4.2	4.2	TM5–C3	Hladik et al. 2008
51-03-6	Piperonyl butoxide	2.3	2.3	TM5–C3	Hladik et al. 2008
29091-21-2	Prodiamine	5.2	5.2	TM5–C3	Hladik et al. 2008
1610-18-0	Prometon	2.5	2.5	TM5–C3	Hladik et al. 2008
7287-19-6	Prometryn	1.8	1.8	TM5–C3	Hladik et al. 2008
709-98-8	Propanil	10.1	10.1	TM5–C3	Hladik et al. 2008
2312-35-8	Propargite	6.1	6.1	TM5–C3	Hladik et al. 2008
60207-90-1	Propiconazole	5	5	TM5–C3	Hladik et al. 2008
23950-58-5	Propyzamide	5	5	TM5–C3	Hladik et al. 2008
175013-18-0	Pyraclostrobin	2.9	2.9	TM5–C3	Hladik et al. 2008
96489-71-3	Pyridaben	5.4	5.4	TM5–C3	Hladik et al. 2008
53112-28-0	Pyrimethanil	4.1	4.1	TM5–C3	Hladik et al. 2008
95737-68-1	Pyriproxyfen	5.2	5.2	TM5–C3	Hladik et al. 2008
124495-18-7	Quinoxyfen	3.3	3.3	TM5–C3	Hladik et al. 2008
10453-86-8	Resmethrin	1	1	TM5-C2	TM5-C2
874967-67-6	Sedaxane	5.2	5.2	TM5–C3	Hladik et al. 2008
122-34-9	Simazine	5	5	TM5–C3	Hladik et al. 2008
946578-00-3	Sulfoxaflor	–	4.4	–	SIR 2012-5206
102851-06-9	tau-Fluvalinate	0.7	0.7	TM5-C2	TM5-C2
107534-96-3	Tebuconazole	3.7	3.7	TM5–C3	Hladik et al. 2008
112410-23-8	Tebufenozide	–	3	–	SIR 2012-5206
96182-53-5	Tebupirimfos	1.9	1.9	TM5–C3	Hladik et al. 2008
na	Tebupirimfos oxon	2.8	2.8	TM5–C3	Hladik et al. 2008
79538-32-2	Tefluthrin	0.6	0.6	TM5-C2	TM5-C2
112281-77-3	Tetraconazole	5.6	5.6	TM5–C3	Hladik et al. 2008
7696-12-0	Tetramethrin	0.5	0.5	TM5-C2	TM5-C2
148-79-8	Thiabendazole	–	3.6	–	SIR 2012-5206
111988-49-9	Thiacloprid	–	3.2	–	SIR 2012-5206
153719-23-4	Thiamethoxam	–	3.4	–	SIR 2012-5206
na	Thiamethoxam Degradate (CGA-35	–	3.5	–	SIR 2012-5206
na	Thiamethoxam Degradate (NOA-40	–	3.4	–	SIR 2012-5206
28249-77-6	Thiobencarb	1.9	1.9	TM5–C3	Hladik et al. 2008
129558-76-5	Tolfenpyrad	–	2.9	–	SIR 2012-5206
43121-43-3	Triadimefon	8.9	8.9	TM5–C3	Hladik et al. 2008
55219-65-3	Triadimenol	8	8	TM5–C3	Hladik et al. 2008
2303-17-5	Triallate	2.4	2.4	TM5–C3	Hladik et al. 2008
78-48-8	Tribufos	3.1	3.1	TM5–C3	Hladik et al. 2008
41814-78-2	Tricyclazole	–	4.1	–	SIR 2012-5206
141517-21-7	Trifloxystrobin	4.7	4.7	TM5–C3	Hladik et al. 2008
68694-11-1	Triflumizole	6.1	6.1	TM5–C3	Hladik et al. 2008
1582-09-8	Trifluralin	2.1	2.1	TM5–C3	Hladik et al. 2008
131983-72-7	Triticonazole	6.9	6.9	TM5–C3	Hladik et al. 2008
156052-68-5	Zoxamide	3.5	3.5	TM5–C3	Hladik et al. 2008
Count of analytes	**161 distinct analytes**	**127 in susp. sed.**	**161 in water**		

See also Table 5.3 for water quality thresholds for pesticide analytes.
This table (7.3b) does not list "historic" analytes that were dropped by the lab in 2018.

Table 7.4 Recovery surrogate standards used for pesticide analyses and associated meas

Recovery surrogate standard	Matrix	Method	Acceptable limits (% recovery)
$^{13}C_3$-atrazine	Water	TM-5-C2	70%–130%
Di-N-propyl-d1$_{14}$ trifluralin	Water	TM-5-C2	70%–130%
Monuron	Water	USGS – SIR 2012-5026	70%–130%
Imidacloprid-d_4	Water	USGS – SIR 2012-5026	70%–130%

Table 2.1. Acronyms and abbreviations

Abbreviation	Meaning
°C	degrees Celsius
AHPL	Aquatic Health Program Laboratory at UC Davis
ALB	Aquatic Life Benchmark
AMS	Applied Marine Sciences, Inc.
Ap	particulate absorbance
ASC	Aquatic Science Center
ASTM	An international standards organization, formerly American Society for Testing and Materials
BGC	Biogeochemistry
BNR	Biological nutrient removal
BPA	Basin Plan Amendment
BrCl	bromine chloride
BSA	BSA Environmental Services, Inc.
C18	Octadecylsilane
C8	Octylsilane
CA	California
CAAS	Cyanotoxin Automated Assay System
CAS	Chemical Abstracts Service
CD3	Contaminant Data, Display and Download Tool
CEDEN	California Environmental Data Exchange Network
CFR	Code of Federal Regulations
chl-a	chlorophyll a
COC	chain of custody
COLD	Cold Freshwater Habitat Beneficial Use
COMM	Commercial and Sport Fishing Beneficial Use
CRM	certified reference material
CSD	Community Services District
CVCWA	Central Valley Clean Water Agency
CVRWQCB	Central Valley Regional Water Quality Control Board
DA	discriminant analysis
DFW	California Department of Fish and Wildlife
DI	deionized water
DIN	Dissolved inorganic nitrogen
DNRP	Delta Nutrient Research Plan
DOC	dissolved organic carbon
DOI	Digital Object Identifier System
DPR	California Department of Pesticide Regulation
DQI	data quality indicator
DQO	data quality objectives
dw	dry weight
DWR	California Department of Water Resources
DWR	Department of Water Resources
EDD	Electronic Data Deliverable
EDTA	Ethylenediaminetetraacetic acid
ELAP	Environmental Laboratory Accreditation Program
ELISA	Enzyme-Linked Immunosorbent Assay
EMP	Environmental Monitoring Program
EMPC	Estimated maximum possible concentration
EPTC	A pesticide, also referred to as Eradicane, Eptam, and other names. CAS Registry Number: 759-94-4.
EST	Estuarine Habitat Beneficial Use
EVR	Effluent Valve Replacement

fDOM	fluorescent dissolved organic matter
FNU	Formazin Nephelometric Units
FS	Forecasting scenarios
FY	fiscal year
g	gram
GC	gas chromatography
GF/F	Glass Microfiber Filters
GLP	good laboratory practices
GPS	global positioning system
GRTS	Generalized Random Tessellation Stratified
h	hours
H2SO4	sulphuric acid
HAB	Harmful algal bloom
HAC	Hardness adjusted control
HCl	hydrochloric acid
Hg	mercury
Hz	Hertz
ID	identification
ISUS	In situ Ultraviolet Spectrophotometer
KCl	potassium chloride
LC50	Lethal concentrations that kills 50% of test animals during an observation period
LCS	laboratory control sample
LEC	Low electrical conductivity control
LIMS	Laboratory Information Management System
LRM	laboratory reference material
LWA	Larry Walker Associates
m	meter
m/s	meters per second
MDL	Method detection limit
MeHg	methylmercury
MEI	McCord Environmental Inc.
mg/kg	milligram per kilogram
mg/L	milligram per liter
MIGR	Fish Migration Beneficial Use
MLML	Moss Landing Marine Laboratory
mm	millimeter
MPSL	Marine Pollution Studies Laboratory
MQO	measurement quality objective
MS	matrix spike
MS4	Municipal Separate Storm Sewer System
MSD	matrix spike duplicate
MUN	Municipal and Domestic Water Supply Beneficial Use
MWD	Metropolitan Water District
N	nitrogen or normal (e.g. 12N HCl)
n/a, NA	not applicable
NBC	Not blank corrected
NDT	Nondestructive Testing
NF	North Fork
NFM	National Field Manual for the Collection of Water-Quality Data
ng	nanogram
NIST	National Institute of Standards and Technology
nm	nanometer
NMFS	National Marine Fisheries Service
NO3-N	nitrate nitrogen

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCC	National Registry of Certified Chemists
NWIS	National Water Information System
NWQL	USGS National Water Quality Laboratory
OA	Oxygen Analog
OCRL	USGS Organic Chemistry Research Laboratory
OEHHA	California Office of Environmental Health Hazard Assessment
OFR	USGS Open-File Report
OFW	organic free water
OMRL	USGS Organic Matter Research Laboratory
OPP	Office of Pesticide Programs
OSHA	Occupational Safety and Health Administration
P	phosphorus
p	probability
PAR	photosynthetically active radiation
PARAFAC	parallel factor analysis
PBO	Piperonyl Butoxide
PC	Project Coordinator
PCA	principal component analysis
PCNB	Pentachloronitrobenzene
PE	Petroleum ether
PETG	polyethylene terephthalate, with a glycol modification
PFRG	USGS Pesticide Fate Research Group
pH	potential of hydrogen
PI	Principal Investigator
PIC	Particulate Inorganic Carbon
POC	particulate organic carbon
POD	Pelagic Organism Decline
POTW	Publicly owned treatment works
PPE	personal protection equipment
ppm/yr	parts per million per year
PSC	Percent community similarity
PTFE	Polytetrafluoroethene (Teflon)
PTI	Pesticide Toxicity Index
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QAPrP	Quality Assurance Program Plan
QB	quality assurance blank sample
QC	quality control
QREC	quality assurance recovery
QSE	quinine sulfate equivalent
R/V	Research Vessel
R^2	coefficient of determination
RB5	Central Valley Regional Water Quality Control Board (Region 5)
RDC	Regional Data Center
REC1	Water Contact Recreation Beneficial Use
REC2	Non-contact Water Recreation Beneficial Use
Regional San	Sacramento Regional County Sanitation District
RL	reporting limit
RMA	Resource Management Associates, Inc.
RMA11	Resource Management Associates 11 Numerical Model

RMA2	Resource Management Associates 2 Numerical Model
RMATRK	Resource Management Associates Particle Tracking Numerical Model
RMP	Regional Monitoring Program
RPD	relative percent difference
RSD	relative standard deviation
RSEL	Regional San Environmental Laboratory
RTC	Romberg-Tiburon Center
S/N	signal-to-noise
S&T	Status and Trends
SC	Steering Committee
SD	Sanitary District
SF	South Fork
SFCWA	State and Federal Contractors Water Agency
SFEI	San Francisco Estuary Institute
SFSU	San Francisco State University
SJR	San Joaquin River
SO	Synthetic Organic
SOP	standard operating procedure
SPLP	sources, pathways, loadings, and processes
SPWN	Fish Spawning Beneficial Use
SRiNCS	Sacramento River Nutrient Change Study
SRM	standard reference material
SRWTP	Sacramento Regional Wastewater Treatment Plant
ST	Status and Trends
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee or Test Acceptability Criteria
TIE	Toxicity Identification Evaluation
TM	Technical method(s)
TM	Trace metals
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TPC	total particulate carbon
TPN	total particulate nitrogen
TSS	total suspended solids
TWRI	Techniques of Water-Resources Investigations, a series of USGS publications
U.S. EPA	United States (U.S.) Environmental Protection Agency
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
v:v	volume-to-volume
VSS	volatile suspended solids
WARM	Warm Freshwater Habitat Beneficial Use
WDL	Water Data Library
WDR	Waste Discharge Requirement
WILD	Wildlife Habitat Beneficial Use
WQ	water quality
WQO	Water Quality Objective
WT	water tracing
ww	wet weight
YSI	A water quality instrument manufacturer, formerly Yellow Springs Instrument Company
µg	microgram
µm	micrometer
µM	micro-Molar

µS/cm	micro-Siemens per centimeter

Table 10.1. Sampling sites and schedule.
(a)(2) FY19-20 Mercury monitoring

CEDEN Station Code	Station Name	Fish Aug 2019	Water July - Oct 2019	Water Mar - Jun 2020
510ST1301	Sacramento River at Freeport	●	●	●
544ADVLM6	Lower Mokelumne River 6	●	●	●
510ADVLIM	Cache Slough at Liberty Island Mouth	●	●	●
544LILPSL	Little Potato Slough	●	●	●
544MDRBH4	Middle River at Borden Highway (Hwy 4)	●	●	●
541SJC501	San Joaquin R. at Airport Way near Vernalis	●	●	●
207SRD10A	Sacramento River at Mallard Island	●	●	–
544DMC020	Delta-Mendota Canal at Byron-Bethany Road	–	●	–
	Total sampling locations visited	**7**	**8**	**6**
	Sampling Events	1	4	4
	Number of samples	7	32	24
			Total water samples = 56	

Table 10.1. Sampling sites and schedule.
(a)(1) Mercury monitoring in FY18-19 (keeping table as reference to historical Delta RMP data)

Site Name	CEDEN Site Code	Target Latitude	Target Longitude	Water	Sportfish	Sampling frequency	Schedule
1. Cache Slough at Liberty Island Mouth	510ADVLIM	38.24213	-121.68539	•	•	**Sportfish:** Once Annually at 6 sites	**Sportfish:** August 2018:
2. Little Potato Slough	544LILPSL	38.09627	-121.49602	•	•		
3. Middle River @ Borden Hwy (Hwy 4)	544MDRBH4	37.89083	-121.48833	•	•		**Water:**
4. Lower Mokelumne River 6	544ADVLM6	38.25542	-121.44006	•	•	**Water:** 10 times/year at 8 sites	1. July 2018
5. Sacramento River at Freeport	510ST1301	38.45735	-121.50459	•	•		2. August 2018
6. San Joaquin River at Airport Way near Vernalis	541SJC501	37.67556	-121.26417	•	•		3. September 2018
7. Sacramento River at Mallard Island (Water only; no sportfish sampling at this site.)	207SRD10A	38.04288	-121.92011	•	-		4. October 2018
8. Delta-Mendota Mendota Canal at Byron-Bethany Road (Water only; no sportfish sampling at this site.)	544DMC020	37.81239	-121.57887	•	-		5. Nov or Dec 2018
							6. Jan or Feb 2019
							7. March 2019
							8. April 2019
							9. May 2019
							10. June 2019

Table 10.1. Sampling sites and schedule.					
(b) Pesticides and aquatic toxicity monitoring					
Site Name	**CEDEN Site Code**	**Target Longitude**	**Target Longitude**	**Sampling frequency**	**Schedule**
San Joaquin River at Buckley Cove	544LSAC13	37.9718	-121.3736	6 x per year	3 wet-weather events, and 3 dry-weather events per Water Year. See Table 6.7 for the timing of events.
Ulatis Creek at Brown Road	511ULCABR	38.307	-121.7942	6 x per year	
Probabilistic or Random sites chosen with GRTS	Varies, see Table 6.4 for monitoring locations.			Each site sampled one time only; 6 sampling events per year	

Table 10.1. Sampling sites and schedule.
(c) Nutrients monitoring special project - high-frequency mapping

Cruise Track	Overview	Frequency	Schedule
Cruise Track A	Launch at Miller Park or Garcia Bend and head downstream to Old River and Middle River via Georgianna Slough and Mokelumne River. End at Rio Vista.	3 times/year	Day 1 of 3 successive days in October, May, August
Cruise Track B	From Rio Vista, upstream on the Sacramento River to Delta Cross Channel and explore more of the Mokelumne (North and South branches) and adjacent sloughs to extend feasible, then upstream as far as possible on the San Joaquin River. Return to Rio Vista.	3 times/year	Day 2 of 3 successive days in October, May, August
Cruise Track C	From Rio Vista, circumnavigate the Cache Slough Complex, head downstream on the Sacramento River to the Confluence with the San Joaquin River and onward to Honker Bay and Grizzly Bay. Head upstream on the San Joaquin River and return to Rio Vista via Three Mile Slough.	3 times/year	Day 3 of 3 successive days in October, May, August

Table 10.1. Sampling sites and schedule.
(d) Nutrients monitoring special project - Sacramento River Nutrient Change Study

Site number	Location Description	Directions from Nearest Town or Landmark	Lat	Long
Freeport HF	Freeport Fixed High Frequency Sampling Location	North of Freeport Bridge	38.28287	-121.30381
Walnut Grove HF	Walnut Grove Fixed High Frequency Sampling Location	North of Walnut Grove	38.15479	-121.31069
Decker HF	Decker Island Fixed High Frequency Sampling Location	At Decker Island	38.5671	-121.42974
1	Sampling Station 1	North of Freeport Bridge	38.28467	-121.31037
2	Sampling Station 2	At Hood	38.22066	-121.31274
3	Sampling Station 3	At Vorden	38.17513	-121.33693
4	Sampling Station 4	Northern section of Georgiana Slough	38.1365	-121.31823
5	Sampling Station 5	Central section of Georgiana Slough	38.11466	-121.33273
6	Sampling Station 6	Southern section of Georgiana Slough	38.9712	-121.35083
7	Sampling Station 7	Northern section of North Fork Mokelumne River, south of Walnut Grove	38.1278	-121.30301
8	Sampling Station 8	Central section of North Fork Mokelumne River, south of Walnut Grove	38.10261	-121.31569
9	Sampling Station 9	Southern section of North Fork Mokelumne River, south of Walnut Grove	38.8795	-121.32957
10	Sampling Station 10	Northern section of South Fork Mokelumne River, south of Walnut Grove	38.12757	-121.29688
11	Sampling Station 11	Central section of South Fork Mokelumne River, south of Walnut Grove	38.10649	-121.29847
12	Sampling Station 12	Southern section of South Fork Mokelumne River, south of Walnut Grove	38.8513	-121.30265

Table 11.1 Habitat parameters recorded by field crews at each samplin

Parameter	Possible responses
Site odor	None, Sulfides, Sewage, Petroleum, Smoke, Other
Sky code	Clear, Partly cloudy, Overcast, Fog, Smoky, Hazy
Other presence	Vascular, Nonvascular, Oily Sheen, Foam, Trash, Other
Dominant substrate	Bedrock, Concrete, Cobble, Boulder, Gravel, Mud, Unknown, Other
Water clarity	Clear (see bottom), Cloudy (>4" visibility), Murky (<4" visibility)
Water odor	None, Sulfides, Sewage, Petroleum, Mixed, Other
Water color	Colorless, Green, Yellow, Brown
Overland runoff (last 24 hours	None, light, moderate/heavy, unknown
Observed flow	NA, Dry Waterbody bed, No Observed Flow, Isolated Pool, Trickle (<0.1 cfs), 0.1 - 1 cfs, 1-5cfs, 5-20 cfs, 20-50cfs, 50-200cfs, >200cfs
Wadeability	Yes, No, Unknown
Wind speed (Beaufort scale)	0–12
Wind direction	
Precipitation (at time of sampl	, Fog, Drizzle, Rain, Snow
Precipitation (last 24 hours)	Unknown, <1", >1"
Occupation Method	Walk-in, Bridge, Other
Starting bank (facing downstre	Left bank, Right bank, Not applicable
Distance from bank (m)	
Stream width (m)	
Water depth (m)	
Location	Bank Thalweg, Mid-channel, Open Water
Hydromodification	None, Bridge, Pipes, Concrete channel, Grade control, Culvert, Aerial zipline, Other

Table 11.2. Sample container type and volume used for each parameter group for collection of water

Matrix	Program Eleme	Parameter Group	Bottle type*	Number of bottles/event	Sample Volume/Site
Water					
	Mercury	Trace metals Conventional	Clear glass	7	4L
	Nutrients	Nutrients Conventional	Amber glass or Polypropylene	50	125 mL
	Nutrients	Chl-a, chl-a > 5 µm	Amber glass	90	Requirement varies; typically 200-500 mL for both
	Pesticides	Pesticide suite	Amber glass	16 – 20, depending on number of QC samples planned for the event	1L
	Pesticides	Copper, DOC, PIC, POC, TPC, and TPN	Teflon	8	3L
	Aquatic Toxicity	Toxicity	Amber glass	80	4L
Sediment					
	Mercury	Conventional	Polypropylene jar or WhirlPac bag	13	60 mL
	Mercury	Trace metals	Glass jar	13	60 mL
Fish					
	Mercury	Mercury	Target species = Largemouth Bass	16 fish at each site @ 8 sites = 96 fish per event	16 fish at each site, target lengths: 3 x (200-249 mm), 3 x (250-304 mm), 7 x (305-407 mm), 3 x (>407 mm)

Table 11.3. Corrective actions procedures for field QC samples.

Issue / Field QC Sample Type	Corrective action
Evidence of contamination based on analytes detected in Field Blank, Equipment Blank, Travel/Bottle Blank (Water only)	Table 11.3. Corrective action procedures for field QC samples.
Evidence of Poor repeatability due to significant differences detected between/among Field Replicates (for Water, Sediment, Tissue)	If criteria are exceeded, field sampling and handling procedures will be evaluated and problems corrected through greater attention to detail, additional training, revised sampling techniques, or other procedures deemed appropriate to correct the problems.

Table 12.1. Storage and hold time requirements for each parameter group.

Parameter group	Storage (Collection to Extraction, where applicable)	Hold time (Collection to Extraction, where applicable)	Hold time (Extraction to analysis, where applicable)	Storage (Extraction to analysis, where applicable)
Ammonium (Water)	4 ±2°C in dark	Cool to 4 ±2°C and preserve with 2 mL of H2SO4 per L within 48 hours of collection	28 day, if acidified	4 ±2°C
Chlorophyll-a (Water)	0 to 6°C in dark	Filtration within 24 hours of collection	28 days	≤ –20°C in dark
Dissolved Organic Carbon, DOC (Water)	0 to 6°C in dark	Filtration within 24 hours of collection	DOC: 30 days/ POC: 100 days	0 - 6°C in dark
Mercury, total (Sediment)	≤ 6°C	Cool to < 6°C within 24 hrs of collection	1 year	≤ –20°C
Mercury, total (Tissue)	0 to 6°C in dark	Cool to < 6°C within 24 hrs of collection	1 year	≤ –20°C
Mercury, total (Water)	0 to 6°C in dark	Preserve with 0.5% v:v pretested BrCl or 12N HCl within 48 hours of collection	90 days	Room temperature
Mercury, dissolved (Water)	0 to 6°C in dark	Filter and preserve with 0.5% v:v pretested BrCl or 12N HCl within 48 hours of collection	90 days	Room temperature
Methylmercury, total (Sediment)	≤ –20°C	Freeze to ≤ –20 °C immediately	1 year	≤ –20°C
Methylmercury, total (Water)	0 to 6°C in dark	Preserve with 0.5% v:v pretested 12N HCl within 48 hours	6 months	0 to 6°C in dark
Methylmercury, dissolved (Water)	0 to 6°C in dark	Filter as soon as possible after collection; preserve with 0.5% v:v pretested 12N HCl within 48 hours of collection	6 months	0 to 6°C in dark
Nitrate + Nitrite (Water)	4 ±2°C in dark	Cool to 4 ±2°C and reduce pH to <2 with H2SO4 within 48 hours of collection	28 day, if acidified	4 ±2°C in dark
Orthophosphate (Water)	4 ±2°C in dark	Filter within 15 minutes of collection; cool to 4 + 2°C	48 hours	4 ±2°C in dark
Total Organic Carbon, TOC (Sediment)	0 to 6°C in dark	Freeze at the end of day	1 year	≤ –20°C
Total Suspended Solids, TSS (Water)	4 ±2°C in dark	Cool to 4 ±2°C	7 days	4 ±2°C
Volatile Suspended Solids, VSS (Water)	4 ±2°C in dark	Cool to 4 ±2°C	7 days	4 ±2°C
Copper, dissolved	0 to 6°C in dark	Filter in the field as soon as possible after collection	180 days	0 - 6°C in dark

Pesticides—dissolved fraction*	0 to 6°C in dark	Extract within 48 hours of collection	Not to exceed 90 days	≤ –20°C in dark
Pesticides—particulate fraction*	0 to 6°C in dark	Extract within 48 hours of collection	Not to exceed 180 days	≤ –20°C in dark
Aquatic Toxicity Tests	0 to 6°C in dark	Initiate Test within 36 hours of sample collection	NA	NA
Sacramento River Nutrient Change Study				
Ammonium	0-6 °C	Filter within 15 min	28 days	0-6 °C
Nitrate-Nitrite	0-6 °C	Filter within 15 min	28 days	0-6 °C
Total Kjeldahl nitrogen (dissolved)	0-6 °C	Filter within 15 min	28 days	0-6 °C
Dissolved total phosphorus	0-6 °C	Filter within 15 min	28 days	0-6 °C
Dissolved organic carbon	0-6 °C	Filter within 15 min	28 days	0-6 °C
Chlorophyll-a	frozen	Filter within 12 hours	6 months	frozen
Silica, dissolved	0-6 °C	Filter within 15 min	28 days	0-6 °C
Phytoplankton enumeration	Ambient temperature in a dark bottle	Preserve with 2% Lugol's solution	1 year	Room temperature
Zooplankton enumeration	Ambient temperature in a dark bottle	Preserve with 5% Lugol's solution	1 year	Room temperature
Clams	keep chilled, below 20°C	Fix in buffered 10% formalin and transfer into 70% ethanol within 2 weeks	1 year	Room temperature

*Former versions of this document listed hold times of 30 days for pesticides. OCRL scientists have done studies to

Table 13.1. Summary of analytical methods and instruments.

Parameter group	Instrument	Methods
Nitrogen, ammonia	Segmented flow analyzer	By colorimetry after reaction with salicylate-hypochlorite by measurement on an automated-segmented flow analyzer (Fishman 1993)
Nitrogen, nitrate, and nitrite(Water)	Segmented flow analyzer	Colorimetric determination following enzymatic reduction, and reaction with sulfanilamide and naphthyl ethylenediamine followed by measurement on an automated segmented flow analyzer (Patton and Kryskalla, 2011)
Orthophosphate(Water)	Segmented flow analyzer	By colorimetry after reaction with ammonium molybdate and reduction with ascorbic acid, then measurement on an automated-segmented flow analyzer (Fishman 1993)
Chlorophyll a (method #1)	Turner TD700	In Vitro determination by fluorescence (EPA 445.0)
Chlorophyll a (method #2)	Genesis 10S	In Vitro determination by visible spectrophotometry (EPA 446.0)
Mercury (Sediment, Tissue)	Milestone DMA80	Thermal decomposition amalgamation and atomic absorption spectrophotometry (EPA 7473)
Mercury (Water)	Tekran 2600	Oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (EPA 1631, Revision E)
Methylmercury (Sediment)	Tekran 2700	Potassium hydroxide/copper sulfate/methylene chloride extraction followed by aqueous ethylation, purge and trap, and cold vapor atomic fluorescence spectrometry (MPSL-110, EPA 1630)
Methylmercury (Water)	Tekran 2700	Distillation, aqueous ethylation, purge and trap, and cold vapor atomic fluorescence spectrometry (EPA 1630)
Pesticides by GC/MS	Agilent 7890 GC with a 5975 c mass spectrometer with a DB-5ms column (30 m × 0.25 mm ×	Gas Chromatography/ Mass Spectrometry (USGS TM-5-B1)
Pesticides by LC/MS/MS	Agilent 1260 HPLC coupled to a 6430 tandem MS system with a Zorbax Eclipse XDB-C18 column (2.1 mm × 150 mm× 3.5 mm; Agilent).	Liquid chromatography with tandem mass spectrometry (LC/MS/MS).
SRiNCS Analytical Methods and Instruments		
Temperature	YSI 6600 V2 sonde	Direct measurement, electronic sensor
pH	YSI 6600 V2 sonde	Direct measurement, glass electrode, reference electrode, and automatic temperature compensation
Specific Conductivity	YSI 6600 V2 sonde	Direct measurement, platinum electrode with automatic temperature compensation
Dissolved Oxygen	YSI 6600 V2 sonde	Direct measurement, luminescence based sensor, automatic temerature compensation
Ammonium	Lachat Quick Chem 8500	Phenol hypochlorite / colorimetric
Nitrate - Nitrite	Lachat Quick Chem 8500	Sulfanilamide / colorimetric
Total Kjeldahl nitrogen (dissolved)	Lachat Quick Chem 8000	Semi-automated colirimetry and flow injection
Dissolved phosphorus	Lachat Quick Chem 8000	Molybdate-antimony / colorimetric
Dissolved organic carbon	OI Analytical TOC analyzer, model 1020A	Acidification and infrared detection, high temperature combustion, total dissolved cabon minus dissolved inorganic carbon
Chlorophyll-a	Turner Designs Trilogy model 7200-000 fluorometer with fluorescene module #046	Acetone (90%) extraction, fluorometry
Silica	Agilent 7900 ICP/MS, model G8403A	Pneumatic nebulization into radiofrequency plasma, vacuum extraction into quadrupole mass spectrometer
Photosynthetically active radiation (PAR)	LI-COR underwater quantum sensor (model LI-192SA)	The LI-192 uses a silicon photodiode and glass optical filters to create uniform sensitivity to light between 400 nm to 700 nm, which closely corresponds to light used by most aquatic plants and algae. A precision optical filter blocks light with wavelengths beyond 700 nm, which is critical for measurements in a water column, where the ratio of infrared to visible light may be high.

Table 14.1 Measurement quality objectives for field measurements.

Method	Parameters	QC check	Matrix	Frequency	Acceptable limits (MQOs)
Satlantic model ISUS V3, Nitrate analyzer	Nitrate	Calibration; range 0-70 µM	Water	Monthly calibration check (blank and standard curve). Blank check within 24 h before sampling. Comparison to discrete grab samples (~1 sample collected every hour) analyzed by standard laboratory methods.	Precision: Calibration to within 10% of nominal 2.5 µM S/N Accuracy/bias: Allowable drift +10%
Seabird model 45 Thermo-salinograph WET Labs beam transmissometer (676 nm) YSI EXO 2	pH, SC, turbidity	Calibration	Water	Blank check within 24 h before sampling and at the end of the sampling event. Calibration check within 24 h before sampling. Temperature check with NIST certified thermometer every 6 months.	Precision: Allowable performance (accuracy) ±10% for Specific Conductivity, ±0.2 for pH, ±5 turbidity units or ±5% of the measured value (whichever is greater) +0.2 deg C for temperature Accuracy/bias: Drift from prior calibration ±10%
Timberline TL-2800 Analyzer	Ammonium	Calibration; range 0-70 µM	Water	Standard curve at start and end of sampling day. Blank water and standard checks intermittently (~ 1 per hour) throughout day	Precision: Calibration to within 10% of nominal 2.5 µM S/N Accuracy/bias: Allowable drift ±10%
WET Labs model WETStar cDOM fluorimeter	fDOM	Calibration in quinine sulfate	Water	Blank water check within 24 h before sampling. Intermittent functionality checks with fluorescent plastic test stick. Calibration check within 24 h before sampling.	Precision ±10% Accuracy/bias:Drift from prior calibration ±10%
YSI EXO 2 Total Algae probeWET Labs model WETStar chlorophyll-a fluorimeter	Chlorophyll-a, phycocyanin	Calibration in with Rhodamine WT	Water	Calibration check within 24 h before sampling. Blank water check within 24 h before sampling. Intermittent functionality checks with fluorescent plastic test stick	Precision ±10% Accuracy/bias: Drift from prior calibration ±10%
YSI 6600 V2	Temperature	Calibration at 6, 20, and 40 Celsius	Water	Annually	Correction factor is assigned and units with correction factor >1 are removed from service.
YSI 6600 V2	pH	Calibration at 4,7, 10, check at 6 Duplicate analysis post-sampling pH 7 check	water water water	Daily prior to use At least 10% of samples Daily after sampling	+/- 0.1 pH unit RPD <0.6 +/- 0.1 pH unit
YSI 6600 V2	Specific Conductiviry	1413 umhos/cm standard MB LCS bracketing working range Duplicate analysis	water water water water	Once daily or per batch of 20 samples Daily prior to use Daily prior to use At least 10% of samples	94-106% recovery <reporting limit 94-106% recovery RPD <1
YSI 6600 V2	Dissolved Oxygen	Calibration in oxygen saturated water Duplicate analysis	water water	Daily prior to use At least 10% of samples	+/- 1% RPD <1.9
YSI 6600 V2	Turbidity	Calibration at 0, 20, 200, 800 reporting limit check Method blank LCS bracketing working range LCS Duplicate analysis	water water water water water water	quarterly Daily prior to use Daily prior to use Daily prior to use Every 10th analysis At least 10% of samples	+/- 10% 80-133% recovery <reporting limit 90-111% recovery 90-111% recovery RPD <9.5%

Table 14.2. Measurement quality objectives for laboratory measurements

Method	Sample type	Matrix	Frequency	Acceptable limits (MQO)
Conventional – Chlorophyll a				
EPA 445.0 or EPA 446.0	Calibration Verification	Water	Per 10 analytical runs	Recovery limit is ±20%; Expect 80% – 120% recovery
EPA 445.0 or EPA 446.0	Laboratory Blank	Water	1 per 20 or batch	< MDL
EPA 445.0 or EPA 446.0	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample < MDL
EPA 445.0 or EPA 446.0	Filter Blank	Water	Per method	< MDL
EPA 445.0 or EPA 446.0	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
Conventional – DOC				
METH011.00 or TM-O-1122-92	Laboratory Blank	Water	1 per 20 or batch	< MDL
METH011.00 or TM-O-1122-92	Matrix Spikes/Duplicates	Water	1 per 20 or batch	Expected value 20%; RPD < 25%
METH011.00 or TM-O-1122-92	Lab Duplicate	Water	1 per 20 or batch	RPD < 25%; n/a if concentration of either sample < MDL
METH011.00 or TM-O-1122-92	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
Conventional – TOC				
EPA 440	Laboratory Blank	Sediment	1 per 20 or batch	< MDL
EPA 440	Matrix Spikes/Duplicates	Sediment	1 per 20 or batch	Expected value ±10%; RPD < 10%
EPA 440	Lab Duplicate	Sediment	1 per 20 or batch	RPD < 10%
EPA 440	Instrument Blank	Sediment	12 hours	< MDL
EPA 440	Field Duplicates	Sediment	Not less than 5% of all samples	RPD < 25%
EPA 440	Filter Blank	Sediment	1 per lot of filters or higher frequency	< MDL
Conventional – Moisture				
SM 2540B	Laboratory Blank	Sediment	not applicable	
SM 2540B	Lab duplicate	Sediment	≥5% of all samples	<10% nominal difference
SM 2540B	Field Duplicates	Sediment	≥5% of all samples	<10% nominal difference
SM 2540B	Field samples	Sediment	All samples	Usually 90%>x>10%, results outside that range often (but not always) transcription errors.
Conventional – TSS, VSS				
SM 2540D or TWRI-5-A1	Laboratory Blank	Water	1 per 20 or batch	< MDL
SM 2540D or TWRI-5-A1	Field Blank	Water	Not less than 5% of all samples	< MDL
SM 2540D or TWRI-5-A1	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
Nutrients – Ammonium				
I-2525-89 or I-2522-90	Calibration Verification	Water	Per 10 analytical runs	Recovery limit is ±10%; Expect 90% – 110% recovery
I-2525-89 or I-2522-90	Laboratory Blank	Water	1 per 20 or batch, whichever is more frequent	< MDL
I-2525-89 or I-2522-90	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample < MDL
I-2525-89 or I-2522-90	Matrix Spikes/Duplicates	Water	1 per 20 or batch, whichever is more frequent	Expected value ±20%; RPD < 25% for duplicates
I-2525-89 or I-2522-90	Field Blank	Water	Per method	< MDL
I-2525-89 or I-2522-90	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
Nutrients – Nitrate and Nitrite				
I-2545-90 or I-2546-91	Calibration Verification	Water	1 per 10 analytical runs	Recovery limit is ±10%; Expect 90% – 110% recovery

I-2545-90 or I-2546-91	Laboratory Blank	Water	1 per 20 or batch, whichever is more frequent	< MDL
I-2545-90 or I-2546-91	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample < MDL
I-2545-90 or I-2546-91	Matrix Spikes/Duplicates	Water	1 per 20 or batch, whichever is more frequent	Expected value ±20%; RPD < 25% for duplicates
I-2545-90 or I-2546-91	Field Blank	Water	Per method	< MDL
I-2545-90 or I-2546-91	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
Nutrients – Orthophosphate				
I-2601-90 or I-2606-89	Calibration Verification	Water	1 per 10 analytical runs	Expected value ±10%; i.e. expect 90% – 110% recovery
I-2601-90 or I-2606-89	Laboratory Blank	Water	1 per 20 or batch, whichever is more frequent	< MDL
I-2601-90 or I-2606-89	Lab Duplicate	Water	1 per batch	RPD < 25%; n/a if concentration of either sample < MDL
I-2601-90 or I-2606-89	Matrix Spikes/Duplicates	Water	1 per 20 or batch, whichever is more frequent	Expected value ±20%; RPD < 25% for duplicates
I-2601-90 or I-2606-89	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
Trace Metals – Mercury				
EPA 7473	Laboratory Blank	SedimentTissue	1 per 20 or batch	< MDL
EPA 7473	Matrix Spikes/Duplicates	SedimentTissue	1 per 20 or batch	Expected value ±25%; RPD < 25%; n/a if concentration of either sample < MDL
EPA 7473	Lab Duplicate	SedimentTissue	1 per 20	RPD < 25%; n/a if concentration of either sample < MDL
EPA 7473	Field Duplicate	Sediment	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
EPA 1631, Revision E	Laboratory Blank	Water	1 per 20 or batch.	< MDL
EPA 1631, Revision E	Matrix Spikes/Duplicates	Water	1 per 20 or batch	Expected value ±25%; RPD < 25%; n/a if concentration of either sample < MDL
EPA 1631, Revision E	Lab Duplicate	Water	1 per 20	RPD < 25%; n/a if concentration of either sample < MDL
EPA 1631, Revision E	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL
EPA 1631, Revision E	Field Blank	Water	Not less than 5% of all samples	< MDL
Trace Metals – Mercury, Methyl				
MPSL-110	Laboratory Blank	Sediment	1 per 20 samples or 1 per batch, whichever is more frequent	< MDL
MPSL-110	Laboratory Control Sample	Sediment	1 per 20 samples or 1 per batch, whichever is more frequent	Expected value ±30%; RPD < 25%
MPSL-110	Matrix Spikes/Duplicates	Sediment	1 per 20 samples or 1 per batch, whichever is more frequent	Expected value ±30%; RPD < 25% for duplicates; n/a if concentration of either sample < MDL
MPSL-110	Lab Duplicate	Sediment	Not less than 5% of all samples	RPD < 25%; n/a if concentration of either sample < MDL

MPSL-110	Field Duplicates	Sediment	Not less than 5% of all samples	RPD < 25%: n/a if concentration of either sample < MDL
Trace Metals – Mercury, Methyl				
EPA 1630	Laboratory Blank	Water	For batches with fewer than 20 samples: 1 duplicate per batch; For batches with over 20 samples: minimum of 1 per 20	< MDL
EPA 1630	Laboratory Control Sample	Water	For batches with fewer than 20 samples: 1 duplicate per batch; For batches with over 20 samples: minimum of 1 per 20	Expected value ±30%; RPD < 25%
EPA 1630	Matrix Spikes/Duplicates	Water	For batches with fewer than 20 samples: 1 per batch; For batches with over 20 samples: minimum of 1 per 20	Expected value ±30% RPD < 25% for duplicates; n/a if concentration of either sample < MDL
EPA 1630	Lab Duplicate	Water	For batches with fewer than 20 samples: 1 duplicate per batch; For batches with over 20 samples: minimum of 1 duplicate per 20	RPD < 25%; n/a if concentration of either sample < MDL
EPA 1630	Field Duplicates	Water	Not less than 5% of all samples	RPD < 25%: n/a if concentration of either sample < MDL
EPA 1630	Field Blank	Water	Not less than 5% of all samples	< MDL
Pesticides				
USGS TM-5-C2	Calibration	Water	At each instrument set up, major disruption, and when routine calibration check exceeds specific control limits.	Linear regression, $R^2 > 0.995$ using a 7 point calibration curve ranging from 0.01 to 1 ng/uL
USGS TM-5-C2	Calibration Check	Water	Every 6 samples.	Recovery limit is ±25%; Recovery = 75 -125%
USGS TM-5-C2	Laboratory Blanks	Water	1 per 20 samples	< MDL
USGS TM-5-C2	Matrix Spikes/Duplicates	Water	1 per 20 samples	Recovery 70-130%, RPD < 25%
USGS TM-5-C2	Surrogate Spikes	Water	Every sample	Recovery limit is ±30%; Recovery = 70 -130%
USGS TM-5-C2	Internal Standards	Water	Every sample	Recovery limit is ±30%; Recovery = 70 -130%
USGS TM-5-C2	Field Blanks	Water	1 per 20 samples	< MDL
USGS TM-5-C2	Field Duplicate/ Replicate	Water	1 per 20 samples	RPD < 25%
USGS – SIR 2012-5026	Calibration	Water	At each instrument set up, major disruption, and when routine calibration check exceeds specific control limits.	Linear regression, $R^2 > 0.995$ using a 7 point calibration curve ranging from 0.01 to 1 ng/uL
USGS – SIR 2012-5026	Calibration Check	Water	Every 6 samples.	Recovery limit is ±25%; Recovery = 75 -125%
USGS – SIR 2012-5026	Laboratory Blanks	Water	1 per 20 samples.	< MDL
USGS – SIR 2012-5026	Matrix Spikes/Duplicates	Water	1 per 20 samples	Recovery 70-130%, RPD < 25%
USGS – SIR 2012-5026	Surrogate Spikes	Water	Every sample	Recovery limit is ±30%; Recovery = 70 -130%
USGS – SIR 2012-5026	Internal Standards	Water	Every sample	Recovery limit is ±30%; Recovery = 70 -130%
USGS – SIR 2012-5026	Field Blanks	Water	1 per 20 samples	< MDL
USGS – SIR 2012-5026	Field Duplicate/ Replicate	Water	1 per 20 samples	RPD < 25%
Trace Metals – Copper (dissolved)				
USGS TM-5-B1	Laboratory Blank	Water	1 per 20 samples	< MDL
USGS TM-5-B1	CRM	Water	1 per 20 samples	Expected value +/- 25%; RPD < 25%

USGS TM-5-B1	Matrix Spikes/Duplicates	Water	1 per 20 samples	Expected value +/- 25%; RPD < 25%
USGS TM-5-B1	Lab Duplicate	Water	1 per 20 samples	RPD < 25%
USGS TM-5-B1	Instrument Blank	Water	Every 6 samples	<MDL
USGS TM-5-B1	Field Duplicates	Water	1 per 20 samples	RPD < 25%
Aquatic Toxicity Testing by AHPL				
Ceriodaphnia (water flea) 7-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Hyalella (amphipod)10-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Selenastrum (algae) 96-hr test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Chironomus (midge larvae) 10-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Pimephales (fathead minnow) 7-day test	Field Duplicates	Water	1 per 20 samples, (3 per fiscal year)	RPD <25%
Sacramento River Nutrient Change Study				
Ammonium				
EPA 350.1	Method Blank	Water	1 per analytical batch	<MDL
	Laboratory Control Sample	Water	1 per analytical batch	90-110% recovery
	Matrix Spike	Water	1 per analytical batch	90-110% recovery
	Matrix Spike Duplicate	Water	1 per analytical batch	90-110% recovery, RPD <10%
Nitrate - Nitrite				
EPA 353.2	Method Blank	Water	1 per analytical batch	<MDL
	Matrix Spike	Water	1 per analytical batch	90-110% recovery
	Matrix Spike Duplicate	Water	1 per analytical batch	90-110% recovery; RPD <10%
	Laboratory Control Sample	Water	1 per analytical batch	90-110% recovery
Total Kjeldahl nitrogen (dissolved)				
EPA 351.2	Method Blank	Water	1 per analytical batch	<MDL
	Matrix Spike	Water	1 per analytical batch	90-110% recovery
	Matrix Spike Duplicate	Water	1 per analytical batch	90-110% recovery, RPD <10%
	Laboratory Control Sample	Water	1 per analytical batch	90-110% recovery
Dissolved total phosphorus				
EPA 365.4	Method Blank	Water	1 per analytical batch	<MDL
	Matrix Spike	Water	1 per analytical batch	90-110% recovery
	Matrix Spike Duplicate	Water	1 per analytical batch	90-110% recovery, RPD <10%
	Laboratory Control Sample	Water	1 per analytical batch	90-110% recovery
Dissolved organic carbon				
Standard Methods [SM] 5310B	Method Blank	Water	Beginning and end of analytical run, every tenth analysis	<reporting limit
	Laboratory Control Sample	Water	Beginning and end of analytical run, every tenth analysis	90-110% recovery
	Matrix spike	Water	10% of samples	66-127% recovery
	Matrix spike duplicate	Water	10% of samples	66-127% recovery, RPD <13.4%
	Reporting limit check	Water	1 per analytical batch	80-120% recovery
Chlorophyll-a				
SM 10200 H	Method Blank	Water	1 per analytical batch	<reporting limit
	Duplicate	Water	10% of samples	RPD <29%
		Water		
Silica				
EPA 200.8	Method Blank	Water	1 per analytical batch	< MDL
	Laboratory Control Sample	Water	1 per analytical batch	85-115% recovery
	Laboratory Control Sample Dup	Water	1 per analytical batch	85-115% recovery, RPD <20.7%
	Matrix Spike	Water	1 per analytical batch	70-130% recovery
	Matrix Spike Duplicate	Water	1 per analytical batch	70-130% recovery, RPD <20.7%

Table 14.4. Summary of toxicity methods and measurement quality c

Parameter	Accuracy	Precision	Completeness
pH	± 0.2	± 0.5 pH units	90%
Specific Conductance	± 2%	± 10%	90%
Temperature	± 0.1	± 10%	90%
Dissolved Oxygen	± 0.2	± 10%	90%
Ammonia	± 0.5%	± 10%	90%
Hardness	Standard Reference Material (SRM) within 80 to 120% recovery	RPD < 25%	90%
Alkalinity	SRM within 80 to 120% recovery	RPD < 25%	90%
Toxicity Testing Field Duplicates	N/A	Statistical agreement between duplicates (RPD <25%)	90%

Table 14.4. Summary of toxicity methods and measurement quality objectives for aquatic toxicity testing.

Species	Test type	Duration	Endpoint(s)	CEDEN Code for Method	Method Name, Source	AHPL SOP	SWAMP MQOs
Fish, *Pimphales promelas*	Chronic	7 days	Survival, Biomass	EPA 821/R-02-013	Test Method 1000.0: Fathead minnow, Pimephales promelas, larval survival and growth test (EPA 2002)	AHPL SOP1-3	Table 9. 7-Day Chronic Freshwater Pimephales promelas Survival and Growth Toxicity Test
Invertebrate, *Ceriodaphnia dubia*	Chronic	6-8 days	Survival, Reproduction	EPA 821/R-02-013	Test Method 1002.0: Daphnid, Ceriodaphnia dubia, survival and reproduction test (EPA 2002)	AHPL SOP1-2	Table 6. 6-8-Day Chronic Freshwater Ceriodaphnia dubia Survival and Reproduction Toxicity Test
Algae, *Selenastrum capricornutum* , also called *Raphidocelis subcapitata*	Chronic	4 days (96-hour)	Growth	EPA 821/R-02-013	Test Method 1003.0: Green alga, Selenastrum capricornutum, growth test (EPA 2002)	AHPL SOP 1-1	Table 10. 96-Hour Chronic Freshwater Selenastrum capricornutum Growth Toxicity Test
Invertebrate, *Hyalella azteca*	Chronic	10 days	Survival	EPA/600/R-99/064	Modified Test Method 100.1: Hyalella azteca 10-d Survival and Growth Test for Sediments (EPA 2000)	AHPL SOP1-6	Table 8. 10-Day Chronic Freshwater Hyalella azteca Survival and Growth Toxicity Test
Invertebrate, *Chironomus dilutus*	Chronic	10 days	Survival, Growth	EPA/600/R-99/064	Modified Test Method 100.2: Chironomus tentans 10-d Survival and Growth Test for Sediments EPA (2000)	AHPL SOP 1-11	Table 7. 10-Day Chronic Freshwater Chironomus dilutus Survival and Growth Toxicity Tesat

Notes:

EPA Methods are described in the following publications:

EPA. 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Fourth https://www.epa.gov/sites/production/files/2015-08/documents/short-term-chronic-freshwater-wet-manual_2002.pdf

EPA. 2000. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30003SBA.TXT

Measurement Quality Objectives (MQOs) for toxicity testing are published by SWAMP and can be found in the following document

SWAMP. 2018. MQOs - Measurement Quality Objectives for Chronic Freshwater Toxicity Test Methods. https://www.waterboards.ca.gov/water_issues/programs/swamp/swamp_iq/docs/chronic_freshwater_tox_mqo_082218.pdf

Standard operating procedures describe the lab methods in detail and can be found in the documents here:

Aquatic Health Program Laboratory at UC Davis, Standard Operating Procedures (SOPs): https://drive.google.com/drive/folders/1nLZfVlOQ19NUPoOwq5fCeIIJ7KtUnvg6?usp=sharing

Table 14.5. Corrective actions procedures for analytical laboratories

If a problem is found with this laboratory QC sample type	The following corrective action(s) shall be taken
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 re-calibrated before the analysis can continue. All of the samples not bracketed by acceptable calibration verification must be reanalyzed.
Matrix Spikes/Matrix Spike Duplicates	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.
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 re-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.
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.
Instrument Blank	Reanalyze the blank to confirm the result. Investigate, identify, and eliminate the source of contamination (e.g., instrument maintenance/cleaning and/or replacement of contaminated components). Analysis of samples shall be halted until contamination is eliminated.
LCS	If an LCS does not meet the acceptance criteria, there are usually problems with the laboratory method (e.g., imprecise aliquoting). Investigate, identify, and resolve the source of the bias. Samples need to be re-prepared and re-analyzed as samples with an acceptable LCS. If impossible, qualify reported data.
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, Filter Blank	Table 14.5. Corrective action procedures for analytical laboratories

Table 17.1. Inspection/acceptance testing requirements for consumables and supplies

Project-Related Supplies (source)	Inspection / Testing Specifications	Acceptance Criteria	Frequency	Responsible Individual
Certified pre-cleaned glass or plastic (IChem/Fisher Scientific or similar)	Carton custody seal is inspected	Carton custody seal intact	At receipt date of shipment	Field crew or lab personnel
Nitrile Gloves (Fisher Scientific or similar)	Carton seal is visually inspected for damage or tampering	Carton is intact and gloves within are clean and intact	At receipt date of shipment	Field crew or lab personnel
Analytical Standards (Perkin-Elmer, VWR, Fisher Scientific or similar)	Solution bottles are inspected to verify factory seal	Manufacturer's seal intact	At receipt date of shipment	Field crew or lab personnel
Blue ice for coolers (various suppilers)	Check for leaking	no leaks	Upon receipt and at each use	Field crews
Coolers (various suppilers)	Check lid, hinges, and interior	Seals completely, no leaks, interior clean and undamaaged	Upon receipt and at each use	Field crews
Zipper-closure polyethylene bags (various suppilers)	Visually inspected for damage	Carton is intact and bags within are clean and intact	At receipt date of shipment	Field crew or lab personnel

Table 23.1 CEDEN controlled vocabulary for result qualif

Result Qualifier Code	Result Qualifier Name
A	Absent
COL	Colonial
CG	Confluent Growth
w/C	Cw/C - Confluent Growth with Coliforms
/oC	Cw/oC - Confluent Growth without Coliforms
DNQ	Detected Not Quantifiable
=	Equal To
JF	Field Estimated
>	Greater Than
>=	Greater than or equal to
<	Less Than
<=	Less than or equal to
NRS	No Reportable Sum
NRT	No Reportable Total
NSI	No Surviving Individuals
NA	Not Analyzed
ND	Not Detected
NR	Not Recorded
PR	Percent Recovery
P	Present

Table 23.2 Common CEDEN QA codes.

QA Code	Description
Frequently used by the ASC QA Officer:	
BRK	No concentration sample container broken
BRKA	Sample container broken but analyzed
BS	Insufficient sample available to follow standard QC procedures
DO	Coelution
DS	Batch Quality Assurance data from another project
H	A holding time violation has occurred
IL	RPD exceeds laboratory control limit
IP	Analyte detected in field or lab generated blank
IU	Percent Recovery exceeds laboratory control limit
J	Estimated value - EPA Flag
M	A matrix effect is present
NBC	Value not blank corrected
None	None - No QA Qualifier
R	Data rejected - EPA Flag
SC	Surrogate Corrected Value
Other QA Codes available in CEDEN, less frequently used by ASC:	
BB	Sample > 4x spike concentration
BE	Low surrogate recovery; analyzed twice
BLM	Compound unidentified or below the RL due to overdilution
BT	Insufficient sample to perform the analysis
BY	Sample received at improper temperature
BZ	Sample preserved improperly
CS	QC criteria not met due to analyte concentration near RL
CT	QC criteria not met due to high level of analyte concentration
D	EPA Flag - Analytes analyzed at a secondary dilution
DRM	Spike amount less than 5X the MDL
EU	LCS is outside of acceptance limits. MS/MSD are accept., no corr.
EUM	LCS is outside of control limits
FO	Estimated maximum possible concentration (EMPC)
GN	Surrogate recovery is outside of control limits
GR	Internal standard recovery is outside method recovery limit
H24	Holding time was > 24 hours for Bacteria tests only
H6	Holding time was > 6 hrs but < 24 hours for Bacteria tests only
HH	Result exceeds linear range; concentration may be understated
HR	Post-digestion spike
HT	Analytical value calculated using results from associated tests
IF	Sample result is greater than reported value
JA	Analyte positively identified but quantitation is an estimate
LC	Laboratory Contamination
N	Tentatively Identified Compound
NC	Analyte concentration not certifiable in Certified Reference Material
NMDL	No Method Detection Limit reported from laboratory
NRL	No Reporting Limit reported by the laboratory
PG	Calibration verification outside control limits
PJ	Result from re-extract/re-anal to confirm original MS/MSD result
PJM	Result from re-extract/re-anal to confirm original result
QAX	When the native sample for the MS/MSD or DUP is not included in the ba
RE	Elevated reporting limits due to limited sample volume
SCR	Screening level analysis

Table 23.3. Compliance codes

DataCompliance Name	DataCompliance Code
Compliant	Com
Do Not Use	DNU
Estimated	Est
Historical	Hist
Not Applicable	NA
Not Recorded	NR
Pending QA review	Pend
Qualified	Qual
Qualified Historic	QualH
Rejected	Rej
Screening	Scr

Table 23.4 Batch verification codes.

BatchVerification Name	BatchVerification Code
Alternate Level Validation	VAP
Alternate Level Validation, Incomplete QC	VAP,VI
Alternate Level Validation, Incomplete QC, Flagged by QAO	VAP,VQI
Cursory Verification, Data Rejected - EPA Flag, Flagged by QAO	VAC,VR
Cursory Verification, Minor Deviations, Flagged by QAO	VAC,VMD
Cursory Verification, Minor Deviations, Incomplete QC, Flagged by QAO	VAC,VMD,VQI
Cursory Verification	VAC
Cursory Verification, Incomplete QC, Flagged by QAO	VAC,VQI
Cursory Verification/Validation	VLC
Cursory Verification/Validation, Incomplete QC, Flagged by QAO	VLC,VQI
Cursory Verification/Validation, Minor Deviations, Flagged by QAO	VLC,VMD
Cursory Verification/Validation, Minor Deviations, Incomplete QC, Flagged by QAO	VLC,VMD,VQI
Data Rejected - EPA Flag, Flagged by QAO	VR
Full Verification	VAF
Full Verification, Incomplete QC, Flagged by QAO	VAF,VQI
Full Verification, Minor Deviations, Flagged by QAO	VAF,VMD
Full Verification/Validation	VLF
Incomplete QC, Flagged by QAO	VQI
Incomplete QC, Temporary Verificaton, Flagged by QAO	VQI,VTC
Minor Deviations, Flagged by QAO	VMD
No QC, Flagged by QAO	VQN
Not Applicable	NA
Not Recorded	NR
Temporary Verification	VTC

Table 26.1 Summary of species-specific Phase 1 TIE treatments

TIE Treatment	*H. azteca (n = 18)*	*C. dilutus (n=9)*	*C. dubia (n=20)*	Algae (n=7)	Fish (n=11)
Baseline	Laboratory Control	Laboratory Control	Laboratory Control	Laboratory Control	Laboratory Control
	Ambient Sample	Ambient Sample	Ambient Sample	Ambient Sample[1]	Ambient Sample
	Secondary Control (If needed)		Secondary Control (If needed)		Secondary Control (If needed)
	HAC		HAC		HAC
Cation Exchange – removes metals and other divalent cations	Ambient Sample + Chelex	Ambient Sample + 3 mg/L EDTA2	Ambient Sample + 3 mg/L EDTA2	Ambient Water - Chelex 100 Sodium Form (for divalent cations)[2]	Ambient Sample + 3 mg/L EDTA2
	Chelex blank	Ambient Sample + 8 mg/L EDTA2	Ambient Sample + 8 mg/L EDTA2	Control Water Blank for Chelex 100 Sodium Form	Ambient Sample + 8 mg/L EDTA2
			HAC + 8 mg/L EDTA2	-	HAC + 8 mg/L EDTA2
Piperonyl Butoxide (PBO) - increases pyrethroid toxicity and decreases organophosphate pesticide toxicity	Ambient Sample + 100 ppb PBO (chronic and acute tests)	N/A	Ambient Sample + 100 ppb PBO (chronic and acute tests)	N/A	N/A
	Ambient Sample + 25 ppb PBO (chronic test)		Ambient Sample + 25 ppb PBO (chronic test)		
			HAC + 100 ppb PBO (chronic and acute tests)		
Temperature adjustment	HAC 15ºC (if needed)				
	Ambient Sample 15ºC				
BSA	Ambient Sample + BSA	N/A	Ambient Sample + BSA	N/A	N/A
	HAC + BSA blank		HAC + BSA		
Carboxylesterase (CO) – reduces toxicity from	Ambient Sample + CO	N/A	Ambient Sample + CO	N/A	N/A
	HAC + CO blank		HAC + CO		
Solid-Phase Extraction (SPE) - removes non-polar organics	Ambient Sample + C8 SPE	Ambient Sample + C8 SPE	Ambient Sample + C8 SPE	Ambient Sample + SM2 SPE	Ambient Sample + C8 SPE
	HAC + C8 blank	C8 blank	C8 blank	C8 blank	C8 blank
	HAC + MeOH @ 0.5% (blank)	MeOH @ 0.5%	HAC + C8 Blank	Control Water + SM2 SPE	HAC + C8 Blank
	HAC + Eluate addback @ 3x	Eluate addback @ 3x	HAC + MeOH @ 0.5%	-	HAC + MeOH @ 0.5%
	-		HAC + Eluate addback @ 3x	-	HAC + Eluate addback @ 3x
Centrifuge – removes particulate associated toxicity	Ambient Sample Centrifuged	Ambient Sample Centrifuged	Ambient Sample Centrifuged	N/A	N/A
	HAC Centrifuged		HAC Centrifuged		

Table Notes:
Treatment Details are provided in Appendix A
HAC - Hardness adjusted controls
LEC – low EC control (if sample specific conductance is at/near the species tolerance)
N/A – not applicable
[1]Salinity can affect test; monitor and consider ion imbalance at >2ppt
[2]Cation exchange resin may change after AHPL can validate options (e.g., chelex or Suppelco column) for these tests.

Table 26.2 Delta RMP pesticide TIE issue resolutions and lessons learned example table

#	**Sample Affected**	**Issue**	**Resolution**
	Provide the sample location, date, test species and endpoint affected	Describe the question/issue discussed or lesson learned	Describe the resolution, corrective action, lesson learned, or what additional information might be needed
1			
2			
3			
4			

Appendix A. Delta Regional Monitoring Program Participants

Participants	Participant Groups
Regulatory Agencies	Central Valley Regional Water Quality Control Board State Water Resources Control Board U.S. EPA Region 9 Water Division
Resource Agencies	NOAA Fisheries California Department of Fish and Wildlife
Coordinated Monitoring Programs	Interagency Ecological Program California Department of Fish and Wildlife California Department of Water Resources (DWR)
Wastewater Treatment Agencies	City of Brentwood City of Davis City of Rio Vista City of Sacramento City of Stockton City of Tracy City of Vacaville City of Woodland Ironhouse Wastewater Treatment Facility Lodi Water Pollution Control Facility Manteca Wastewater Quality Control Facility Mountain House Community Services District Regional San Town of Discovery Bay
Stormwater Agencies	California Department of Transportation City of Ceres City of Davis City of Hughson City of Lathrop City of Lodi City of Manteca City of Modesto City of Oakdale City of Patterson City of Rio Vista City of Ripon City of Riverbank City of Rocklin City of Stockton City of Tracy City of Turlock

	City of Vacaville City of West Sacramento City of Woodland Colusa County El Dorado County Sacramento County San Joaquin County Stanislaus County Sutter County Yolo County Yuba County
Irrigated Agriculture Coalitions	East San Joaquin Water Quality Coalition Sacramento Valley Water Quality Coalition San Joaquin County and Delta Water Quality Coalition Westside San Joaquin River Watershed Coalition
Dredgers	Army Corps of Engineers Port of Stockton Port of West Sacramento Sacramento Yacht Club
Flood Control and Habitat Restoration	California Department of Water Resources

Appendix B. Management Questions

Category	Management Questions
Status and Trends	Is there a problem or are there signs of a problem? a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?
Sources, Pathways, Loadings, and Processes	Which sources and processes are most important to understand and quantify? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?
Forecasting Water Quality Under Different Management Scenarios	a. How do ambient water quality conditions respond to different management scenarios? b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?

Appendix C. Assessment Questions

Delta RMP assessment questions for pesticides, mercury and nutrients. Questions in bold were identified by the Steering Committee as the highest priority in FY16/17.

Type	Core Management Questions	Mercury	Pesticides and Toxicity	Nutrients
Status & Trends	Is there a problem or are there signs of a problem? a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?	**1. What are the status and trends in ambient concentrations of total mercury and methylmercury (MeHg) in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large-scale restoration projects)?** A. Are trends over time in MeHg in sport fish similar or different among Delta subareas? B. Are trends over time in MeHg in water similar or different among Delta subareas?	**1. To what extent do pesticides contribute to observed toxicity in the Delta?** **1.1. Which pesticides or degradates have the highest potential to be causing toxicity in the Delta and therefore should be the priority for monitoring and management?** A. If samples are toxic, do detected pesticides explain the toxicity? B. If samples are not toxic, do detected pesticide concentrations exceed other thresholds of concern (e.g., water quality objectives or Office of Pesticide Programs aquatic toxicity benchmarks)? **1.2. What are the spatial and temporal extents of lethal and sublethal aquatic and sediment toxicity observed in the Delta?** A. Do aquatic or sediment toxicity tests at targeted sites indicate a toxic response? B. If answer to A is yes, which other toxicity indicator(s) should guide monitoring and management of pesticides in Years 2+? **2. What are the spatial/temporal distributions of concentrations of currently used pesticides identified as likely causes of observed toxicity?** 2.1. Which pesticides have the highest risk potential (based on DPR's risk prioritization	1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally? A. Are trends similar or different across subregions of the Delta? B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? C. **Are there important data gaps associated with particular water bodies within the Delta subregions?** 2. **What is the current status of the Delta ecosystem as influenced by nutrients?** A. **What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?**

			model[1]) and should be included in chemical analyses? A. Is the list of pesticides included in USGS pesticide scan sufficient for Delta RMP monitoring design? B. Are methods available to monitor pesticides with high-risk potential not included in USGS pesticide scan? 2.2.. How do concentrations of the pesticides with the highest risk potential vary seasonally and spatially?	
Sources, Pathways, Loadings & Processes	**Which sources and processes are most important to understand and quantify?** a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?	1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish? A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)? B. How do internal sources and processes influence methylmercury levels in fish in the Delta? C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels in fish in the Delta?	1. What are the principal sources and pathways responsible for aquatic and sediment toxicity observed in the Delta? 2. What are the fates of prioritized pesticides and degradates in the environment? 2.1. Do physical/chemical properties of priority pesticides, application rates and processes, and ambient conditions influence the degree of toxicity observed? **3. What are the spatial/temporal use patterns of priority pesticides?**	**4. Which sources, pathways, and processes contribute most to observed levels of nutrients?** A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters? B. What are the loads from tributaries to the Delta? C. **What are the sources and loads of nutrients within the Delta?** D. What role do internal sources play in influencing observed nutrient levels? E. Which factors in the Delta influence the effects of nutrients? F. **What are the types and sources of nutrient sinks within the Delta?** G. What are the types and magnitudes of nutrient exports from the Delta to Suisun

[1] http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/analysis_memos/prioritization_report_2.pdf

				Bay and water intakes for the State and Federal Water Projects?
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?	1. How do pesticide concentrations respond to different management scenarios? 2. What pesticide loads can the Delta assimilate without exceeding water quality criteria established to protect beneficial uses? 3. How will climate change affect concentrations and/or loadings of pesticides and impacts to aquatic species?	1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?	[none]	1. Are pesticide-related toxicity impacts decreasing over time?	[none]

Appendix D. Short Summaries of Delta RMP Monitoring Elements

Pesticides and Aquatic Toxicity

There will be six sampling events during the Water Year, with 24 samples per year at spatially distributed sites and 6 samples per year at each of 2 fixed sites, for a total of 36 environmental samples, plus.

The timing of 3 sampling events is planned during Wet Weather to capture certain runoff and storm events: (1) first seasonal flush of the water year), (2) significant winter storm; (3) third winter storm. The remaining sampling events shall be during dry weather to capture the irrigation/baseflow season: (4) spring, (5) summer, and (6) fall.

Chemical analyses and toxicity testing will be performed on all samples.

The Aquatic Health Program Laboratory at UC Davis will analyze the toxicity of water samples for a suite of test organisms based on EPA (2002, 2000) and SWAMP (2008) methods. Included Aquatic toxicity test species are, with endpoints in parentheses: (1) *Selenastrum capricornutum*, a single-celled algae (growth), (2) *Ceriodaphnia dubia*, a daphnid or water flea (survival, reproduction), (3) *Hyalella azteca*¸ an aquatic invertebrate (survival), (4) *Chironomus dilutus*, midge larvae (growth, survival), (5) *Pimephales promelas* (growth, survival). Pesticide-focused Toxicity Identification Evaluations (TIEs) for a subset of samples with $\geq$ 50% of the measured endpoint; to be decided real-time by a TIE subcommittee.

The following chemical analyses will be performed by the the USGS: current use pesticides (161 analytes), total suspended solids, dissolved organic carbon (DOC) and particulate organic carbon (POC), hardness, and dissolved copper.

Mercury

Sport Fish

Annual sampling at 7 fixed sites since 2016. Indicator of primary interest is methylmercury in muscle fillet of 350-mm largemouth bass (or similar predator species). Sites are located to represent different subareas of the Delta and to link with water monitoring.

Water

Sampling 8 sites that align with sport fish monitoring sites 10 times per year. Indicator of primary interest is total methylmercury in water.

Important ancillary parameters include total and dissolved total Hg and MeHg, chlorophyll *a*, DOC, suspended sediment concentrations, and volatile suspended solids.

Nutrients

A one-year study to document the variability of nutrients and related water quality parameters at high spatial resolution in the North Delta, Central Delta, and the Western Delta out to Suisun Bay. Measurements will include nitrate, ammonium, phosphate, temperature, conductivity, dissolved oxygen, chlorophyll, blue-green algal pigments, particle size and others. Data-collection cruises will be conducted under three different environmental/flow conditions (October 2017, May 2018, and August 2018).

Sacramento River Nutrient Change Study

This study will track the effects of changes in nutrient loading resulting from a short-term wastewater hold at the Sacramento River Wastewater Treatment Plant (SRWTP). In the summer of 2019, scheduled wastewater effluent holds will occur during the Effluent Valve Replacement (EVR) project, part of the EchoWater upgrade at the SRWTP. During an EVR hold, no treated effluent will enter the Sacramento River for a period of up to 48 hours. Based on prior research (Kraus et al. 2017) this should create a parcel of effluent-free river water over six miles long in the Sacramento River. The impacts of short-term changes in nutrient loading will be tracked in parcels of water with and without effluent during movement downstream in the Sacramento River and nearby channels.

The study will occur in the lower Sacramento River and downstream connecting channels, including Georgiana Slough and the Mokelumne River. The channels in the study area are close enough to the SRWTP that water parcels with or without treated effluent can still be detected and tracked in the river water (i.e., prior to complete mixing). In the shallower lower Mokelumne River and Georgiana Slough, light penetrates a greater proportion of the water column than in the deeper lower Sacramento River. Elevated light levels increase the potential for rapid phytoplankton growth when other regulating factors are favorable, namely low turbidity, shallow water depth or stratification, sufficient nutrient concentrations, and low grazing pressure.

The project consists of one week-long river sampling campaign, field measurements laboratory analyses, numeric modeling, and reporting. The project will use multiple methods, including boat-mounted, high frequency monitoring of nutrients and fluorescence; discrete sampling for analyses of water quality, phytoplankton and zooplankton abundances, clam biomass, and phytoplankton carbon uptake (to determine growth rates). Data and hydrodynamic modeling will be used to evaluate the response of phytoplankton to a range of nutrient loads and forms, as well as factors of light, turbidity, water residence time, and grazing by zooplankton and clams.

The project team is targeting an EVR hold in September 2019 for the field work. Regional San staff will sample at a total of 12 “grab sample” stations, three along the Sacramento River, three

along Georgiana Slough, three along the North Fork Mokelumne River and three along the South Fork Mokelumne River. The USGS high frequency sampling boat will sample these river segments daily during the week of field work. At each "grab sample" station, vertical profiles of temperature, pH, electrical conductivity, dissolved oxygen and photosynthetically active radiation (PAR) will be taken. Discrete samples will be collected for turbidity, chlorophyll a, picoplankton and phytoplankton enumeration, zooplankton enumeration and growth rates, and dissolved inorganic nutrient concentrations. If visual survey of a station indicates that potentially harmful algal species such as Microcystis sp. are present, the team will collect separate water samples for BSA Environmental Services to measure microcystins. Clams will be collected using benthic trawls.

Phytoplankton enumeration will allow examination of any changes in the proportions of beneficial and potentially harmful phytoplankton. During the 1-week study, changes in phytoplankton growth rates and zooplankton growth rates are expected to be detectable and potentially also changes in phytoplankton biomass. Because changes in zooplankton abundance would be minimal during this short time period and difficult to detect, the study will examine growth of zooplankton.

River discharge, velocity, and other water-quality characteristics from three of USGS' fixed monitoring stations Freeport (0.2 km upstream of SRWTP) and Walnut Grove and Decker Island (29.2 km and 39 km downstream of SRWTP, respectively) will be used to plan sampling events and document continuous river conditions. Treated effluent flow rate data (hourly averages) will be provided by SRWTP personnel, along with effluent water quality data, including daily ammonia (NH4+) and weekly nitrate (NO3-) concentrations.

Background - Best Available Science and Conceptual Models

Water and nutrients from the Sacramento River enter Georgiana Slough, and, via the Delta Cross Channel, the North Fork Mokelumne River and South Fork Mokelumne River, providing an opportunity to test the effects of changes in water transit time, depth, light, and nutrient loading on phytoplankton and zooplankton productivity and biomass. High frequency boat mapping, performed by the USGS in support of the Delta Regional Monitoring Program, is able to detect patterns in numerous aquatic variables in these side channels, including nutrient concentrations, turbidity, and chlorophyll a. Biogeochemical model predictions (Zhang et al. 2018) suggest that EchoWater Project upgrades to the SRWTP will result in substantial changes in nutrient concentrations in these side channels. During the EVR holds the load of ammonia and nitrate from SRWTP will be zero, providing an opportunity to investigate the potential impacts of nutrient load reductions that are lower than those mandated in SRWTP's current NPDES permit.

Under our conceptual model, the factors of transit time, light, and nutrient loading will result in different outcomes for phytoplankton productivity and biomass occurring in the side channels compared to those living in the mainstem Sacramento River. In the mainstem Sacramento River, where water depth is sufficient to make light limiting to phytoplankton growth (AMS 2017), we predict that decreased nutrient loading will have little effect on phytoplankton biomass or the higher levels of the aquatic food web. However, in the side channels, where a combination of decreased depth, increased transit time, and decreased turbidity may increase light availability (i.e., euphotic zone depth), we predict that phytoplankton productivity and biomass will be

regulated by nutrient availability. Under scenarios with lower nutrient loading, we would expect to see less phytoplankton growth and biomass than under the current loading scenario. The conceptual model assume that nutrient loading from other sources upstream of Freeport are constant across situations, and that during the summer SRWTP effluent is a high proportion of the total nutrient load to the Sacramento River. We assume a time frame of days, during which increases in phytoplankton and zooplankton growth rates would be detectable, and potentially also changes in phytoplankton biomass. However, changes in zooplankton abundance and clam biomass would be minimal during this short time period and difficult to detect. We do not make an assumption about whether increased phytoplankton biomass would be in the form of beneficial or harmful algal species, but we would be able to observe any changes through the high frequency boat mapping surveys, and through phytoplankton enumerations (species counts and biomass). Changes in nutrient loading from SRWTP will be apparent in the mainstem Sacramento River, but are unlikely to manifest in changes in phytoplankton response until the water reaches the river side channels, where other key factors, namely depth, transit time, and euphotic zone depth are more favorable for phytoplankton growth.

Appendix E. Links to SOPs

The following SOPs, manuals, and method reference documents will be made available on CD by request or can be downloaded from the SFEI-ASC Google Drive.

Field Sample Collection

USGS

- National Field Manual for the Collection of Water-Quality Data (USGS Techniques and Methods, Book 9)
- Collection of Pyrethroids in Water and Sediment Matrices: Development and Validation of a Standard Operating Procedure, (USGS Scientific Investigations Report 2009–5012)
- Optical Techniques for the Determination of Nitrate in Environmental Waters: Guidelines for Instrument Selection, Operation, Deployment, Maintenance, Quality Assurance, and Data Reporting (USGS Techniques and Methods 1-D5)

MPSL

- Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California.Version 1.1 updated March 2014, MPSL Field SOP v1.1
- MPSL-101, Sample Container Preparation for Organics and Trace Metals, including Mercury and Methylmercury
- MPSL-102a, Sampling Marine and Freshwater Bivalves, Fish and Crabs for Trace Metal and Synthetic Organic Analysis
- MPSL-102b, Field Collection Procedures for Bed Sediment Samples
- Low level mercury analysis, USGS National Field Manual A5.6.4.B
- SWAMP SOP 2.1.1.4, Instructions for Constructing a Perforated Bucket Sampler to be Used as an Extended Holder for the Direct Filling of Sample Bottles (SWAMP SOP 2.1.1.4)
- MPSL-111, Field Collection Procedures for Depth Integrated Water via Bucket Sampler

Toxicity Testing

UCD-AHPL

- Initiation of *Selenastrum capricornutum* 96-Hour Chronic Toxicity Test (4th Edition) (SOP 1-1)

- Initiation of *Ceriodaphnia dubia* Chronic Toxicity Test, revised November 7, 2018 (SOP 1-2)
- Initiation of *Pimephales promelas* (Fathead Minnow) Chronic Toxicity Test (4th Edition) (SOP 1-3)
- Initiation of *Hyalella azteca* Acute 96-hour Water Column Toxicity Test (SOP 1-6)
- Initiation of *Chironomus dilutus* Chronic 10-day Water Column Toxicity Test (SOP 1-11)
- Protocol for Sample Receiving and Storage – Delta RMP Testing (SOP 12-7)

Toxicity Identification Evaluations (TIEs)

UCD-AHPL

- Protocol for Making a 5 ppm Solution of PBO and Spiking it into Sample Waters (SOP 7-1)
- C8 Solid Phase Extraction, SOP 7-2
- C8 Column Elution for Phase I TIEs, SOP 7-3
- C8 Column Elution for Phase II TIEs, SOP 7-4
- Amendment of Water Samples with EDTA and Na_2S2O_3, SOP 7-9
- pH Adjustments to pH 3 and pH 11, SOP 7-10
- Aeration (Volatile/Surfactant Stripping), SOP 7-11

Toxicity Testing - Water Quality Measurements

UCD-AHPL

- Analysis for Total Water Hardness, SOP 6-1
- Analysis for Ammonia Nitrogen (mg/L), SOP 6-3
- Analysis for Alkalinity, SOP 6-5
- Use of YSI Model 33 Electrical Conductivity Meter, SOP 8-7
- Operation of Beckman 12 pH/ISE Meter, SOP 8-8
- Protocol for the YSI Model 58 Dissolved Oxygen Meter, SOP 8-9

SWAMP Documentation

- SWAMP Toxicity Template Documentation [link]
- SWAMP Toxicity Template [link]
- SWAMP Sample Handling, Measurement Quality Objectives, and Corrective Action Tables [link]

For the Sacramento River Nutrient Change Study

Clam Measurement SOP, August 2019. By Tim Mussen, Regional San.

Applied Marine Sciences. 2017. Final Report: Spatial and Seasonal Patterns in Irradiance, Phytoplankton, and Grazers Along the Sacramento River, California. Submitted to: Tim Mussen & Lisa Thompson, Sacramento Regional County Sanitation District, 10060 Goethe Road, Sacramento, CA 95827. August 14, 2017. 65 p.

Kimmerer, Wim, Toni R. Ignoffo, Brooke Bemowski, Julien Modéran, Ann Holmes, and Brian Bergamaschi. "Zooplankton Dynamics in the Cache Slough Complex of the Upper San Francisco Estuary." *San Francisco Estuary and Watershed Science* 16, no. 3 (2018). https://escholarship.org/uc/item/63k1z819. (free download)

Kimmerer Lab Zooplankton Growth Rate Experiment Protocol. San Francisco State University, Sept. 2015. Download link.

RMA. 2017. "Regional San Project 3 Documentation: Hydraulic Modeling to Estimate Proportional Water Sources to the Lower Sacramento River." Davis, California: Resource Management Associates.

McNabb, Clarence D. "Enumeration of Freshwater Phytoplankton Concentrated on the Membrane Filter." *Limnology and Oceanography* 5, no. 1 (1960): 57–61. https://doi.org/10.4319/lo.1960.5.1.0057. (free download)

Beaver, John R., David E. Jensen, Dale A. Casamatta, Claudia E. Tausz, Kyle C. Scotese, Kristen M. Buccier, Catherine E. Teacher, Teodoro C. Rosati, Alison D. Minerovic, and Thomas R. Renicker. "Response of Phytoplankton and Zooplankton Communities in Six Reservoirs of the Middle Missouri River (USA) to Drought Conditions and a Major Flood Event." *Hydrobiologia* 705, no. 1 (March 1, 2013): 173–89. doi:10.1007/s10750-012-1397-1. [Download link]

Fichot, Cédric G., Bryan D. Downing, Brian A. Bergamaschi, Lisamarie Windham-Myers, Mark Marvin-DiPasquale, David R. Thompson, and Michelle M. Gierach. "High-Resolution Remote Sensing of Water Quality in the San Francisco Bay–Delta Estuary." *Environmental Science & Technology* 50, no. 2 (January 19, 2016): 573–83. https://doi.org/10.1021/acs.est.5b03518.

Zaffiro, Alan, Laura Rosenblum, and Steven C. Wendelken. "Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay." US Environmental Protection Agency, 2016. https://www.epa.gov/sites/production/files/2016-09/documents/method-546-determination-total-microcystins-nodularins-drinking-water-ambient-water-adda-enzyme-linked-immunosorbent-assay.pdf.

Appendix F. Example Field Data Sheets

Annual ASR and WaterLog

U. S. GEOLOGICAL SURVEY SURFACE-WATER QUALITY FIELD NOTES Station No. _____

USGS science for a changing world

NWIS Record No. _____

Station No. Station Name Field ID

Sample Date _____ Mean Sample Time _____ Time Datum _____ (eg. EST, EDT, UTC) End Date _____ End Time _____

*Sample Medium: WS WSQ OAQ *Sample Type: 9 (regular) 7 (replicate) 2 (blank) 1 (spike) _____ * see last page for additional codes

*Sample Purpose (71999): 10 (routine) 15 (NAWQA) 20 (NASQAN) 25 (NMN) 30 (Benchmark) _____

*Purpose of Site Visit (50280): 1001 (fixed-frequency SW) 1003 (extreme high flow SW) 1004 (extreme low flow SW) 1098 (NAWQA QC) _____

QC Samples Collected? Y N Blank Replicate Spike Other _____

Project No. _____ Project Name _____

Sampling Team _____ Team Lead Signature _____ Date _____

START TIME CODE DST TIME CHT TIME CHT TIME CHT END TIME CHT

FIELD MEASUREMENTS

Property	Parm Code	Method Code (http://water.usgs.gov/usgs/owq/Forms/Fieldmeasurement_parameterusmethcode.doc)	Result	Units	Remark Code	Value Qualifier	Null Value Qualifier	NWIS Result-Level Comments
Gage Height	00065			ft				
Discharge, instantaneous	00061			cfs				
Temperature, Air	00020	TH-M04 (Thermistor) TH-M05 (Thermometer)		°C				
Temperature, Water	00010	TI M01 (Thermistor)		°C				
Specific Conductance	00095	SC001 (Contacting Sensor)		µS/cm				
Dissolved Oxygen	00300	LUMIN (Luminescent) MEMBR (Amperometric) SPC10 (Spectrophotometric)		mg/L				
Barometric Pressure	00025	BAROM (Barometer)		mm Hg				
pH	00400	PROBE (Electrode)		units				
Alkalinity, filtrd, incr. Alkalinity, filtrd, Gran	39086 29802	TT001 (Digital Titrator) TT002 (Buret) TT056 (Digital Titrator) TT057 (Buret)		mg/L				
Carbonate, filtrd, incr. Carbonate, filtrd, Gran	00452 63788	ASM01(Digital Titrator) ASM02(Buret) ASM03(Digital Titrator) ASM04(Buret)		mg/L				
Bicarbonate, filtrd, incr. Bicarbonate, filtrd, Gran	00453 63786	ASM01(Digital Titrator) ASM02(Buret) ASM03(Digital Titrator) ASM04(Buret)		mg/L				
Hydroxide, filtrd, incr. Hydroxide, filtrd, Gran	71834 29800	ASM01(Digital Titrator) ASM02(Buret) ASM03(Digital Titrator) ASM04(Buret)		mg/L				
Turbidity (see attachment for codes and units)								

SAMPLING INFORMATION

Parameter	Pcode	Value	Information
Sampler Type	84164	*see last page for proper codes— consider type of sampler and material*	Sampler ID:
Sampling Method	82398	10 EWI; 20 EDI; 30 single vertical; 40 multiple vertical; other _____	**BAG SAMPLER EFFICIENCY TEST**
Sampler bottle/bag materia	84152	Plastic Bag (11) Teflon Bag (12) Glass Bottle(20) Plastic Bottle (21) Teflon Bottle (22) other (30)	Test / Duration Sampler Collected Water (seconds) / Sample Volume Collected (milli liters)
Sampler Nozzle material	72219	plastic (2) Teflon (3) Brass (1)	1
Sampler Nozzle Diameter	72220	3/16" (3) 1/4" (4) 5/16" (5)	2
Sampler Transit Rate	50015	feet/second	3
Velocity to Calculate Isokinetic transit rate	72196	feet/second	Mean (72217) (72218)
Depth to Calculate Isokinetic transit rate	72195	feet	Bag Sampler Efficiency % (See last page.)
Splitter Type	84171	*See last page for codes* _____	Splitter ID:
Hydrologic Condition	N/A	A Not Determined; 4 Stable, low stage; 5 Falling stage; 6 Stable, high stage; 7 Peak stage; 8 Rising stage; 9 Stable, normal stage	
Observations [Codes: 0=none; 1=mild; 2=moderate; 3=serious; 7=extreme]	Oil-grease (01300) Floating debris (01345) Gas Bubbles (01310) ___	Detergent suds (01305) Turbidity (01350) Sewage Solids (01335) ___	Floating garbage (01320) Floating algae mats (01325) Atm. Odor (01330) Fish kill (01340) Floating Vegetation (84178) ___ Ice Cover(01355) ___

COMPILED BY: _____ **CHECKED BY:** _____ **LOGGED INTO NWIS BY:** _____

SWAMP Tissue Sampling - Non-Trawl (Event Type = TI) **SWB_FishLk_LC_2014**

Entered in d-base (initial/date)		Pg of Pgs	
*StationCode: ___ ___ ___ ___ ___ ___ ___ ___	*StationName:	*Purpose Failure Code:	**Agency**
*FundingCode: 1 3 S W B G 0 1	*Date (mm/dd/yyyy): / /		

Tissue Collection

Location	*Depth (m):	Distance from Bank (m):		Accuracy (ft / m)	Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1				
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2				
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3				
HYDROMODLOC(to sample):	US / DS / NA / WI Other ________ Geoshape: Line Poly Point		Coord. 4				
Location	*Depth (m):	Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1				
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2				
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3				
HYDROMODLOC(to sample):	US / DS / NA / WI Other ________ Geoshape: Line Poly Point		Coord. 4				
Location	*Depth (m):	Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1				
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2				
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3				
HYDROMODLOC(to sample):	US / DS / NA / WI Other ________ Geoshape: Line Poly Point		Coord. 4				
Location	*Depth (m):	Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1				
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2				
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3				
HYDROMODLOC(to sample):	US / DS / NA / WI Other ________ Geoshape: Line Poly Point		Coord. 4				
Location	*Depth (m):	Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1				
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2				
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3				
HYDROMODLOC(to sample):	US / DS / NA / WI Other ________ Geoshape: Line Poly Point		Coord. 4				
Location	*Depth (m):	Distance from Bank (m):			Latitude (dd.ddddd)	Longitude (-ddd.ddddd)	Depth (m)
COLLECTION METHOD:	E-boat, Backpack shocker, Fyke net, gill net, seine, hook & line	Start Time	Coord. 1				
SAMPLE LOCATION:	Bank, Thalweg, Midchannel, Open Water, NA		Coord. 2				
HYDROMODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert,	End Time	Coord. 3				
HYDROMODLOC(to sample):	US / DS / NA / WI Other ________ Geoshape: Line Poly Point		Coord. 4				

Failure Codes: Dry (no water), Instrument Failure, No Access, Non-sampleable, Pre-abandoned, Other

Comments:

SWAMP Tissue Sampling - Non-Trawl (Event Type = TI) **SWB_FishLk_LC_2014** | Entered in d-base (initial/date) | Pg: of Pgs

*StationCode: ___ ___ ___ ___ ___ ___ ___ ___ ___ | StationName: | Date (mm/dd/yyyy): / /

Location #	Organism ID	Tag #	Species Name/Code	FL (mm)	TL (mm)	StdL (mm)	Weight (g)	Count	Count Est.	Sex	Anomaly	Condition
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
										M F U L		
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										M F U L		
										M F U L		
										M F U L		

Location #: Match fish with Location # from Tissue Collection sheet | **Organism ID**: Combine composite # and fish # (e.g., fish 1 of composite WC01 is WC01-01) to be uni | **Tag #**: Use if applicable

Species Code: Largemouth Bass (**LMB**), Smallmouth Bass (**SMB**), Spotted Bass (**SPB**),Sacramento Pike Minnow (**SPM**), Rainbow Trout (**RT**), Brown Trout (**BT**), Brook Trout (**BKT**), White Catfish (**WC**), Carp (**CAR**), Channel Catfish (**CC**), Brown Bullhead (**BRB**), Sacramento Sucker (**SS**), Redear (**RES**), Black Crappie (**CRP**), Bluegill (**BG**), Tilapia (**TIL**), Green Sunfish (**GRS**), Kokanee (**KOK**)

Stage: Adult (A), Juvenile (J), Subadult (SA), Not Recorded (NR) | **Count Est**: If appropriate, add < or > if count is ¢

Anomalies: Ambicoloration (A), Albinism (B), Cloudiness (CL), Deformity-skeletal (D), Discoloration (DC), Depression (DS), Fin Erosion (F), Gill Erosion (T), Hemorrhage (H), Lesion (L), Parasite (P), Popeye (PE), Tumor (T), Ulceration (U), White Spots (W), and any combination | **Sex**:unk(**U**),taken at Lab(**L**) | **BodyLocation**: Branchial Chamber(BRC), Buccal Cavity(BC), Eyes(E), Musculoskeleton(M), Skin/Fins(SF)

Comments: Mark fish requiring further ID; **SEPARATE FISH BY LOCATION AND INDICATE LOCATION # ON LABEL**

Modified 06/19/07

Appendix G. Example for Chain of Custody Form

Chain of Custody Record

Page of

Results to:	Invoice to:	Ship to:
San Francisco Estuary Institute 4911 Central Ave Richmond, CA 94804 Phone: 510-746-7334 Fax: 510-746-7300	San Francisco Estuary Institute 4911 Central Ave Richmond, CA 94804	

Sampled by [Print Name(s)] / Affiliation	Analyses Requested	Project Name:
Sampler(s) Signature(s)		Billing Code:

Sample ID	Sampled Date	Sampled Time	Matrix	Container Type/#	Analyses Requested	Notes
					← Total number of containers	

Relinquished by (Signature) / Affiliation	Date	Time	Received by (Signature) / Affiliation	Date	Time

Shipping Information	Additional Comments
Shipping Date: Courier: Number of Coolers: Cooler Temperature (C):	

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Data Management and Quality Assurance Standard Operating Procedures

Water Quality and Tissue Data Review Procedures for the Delta Regional Monitoring Program

Aquatic Science Center, 2018

By: Amy Franz, Don Yee, John Ross, and Matthew Heberger

Last modified: June 28, 2018

Table of Contents

Introduction

The purpose of this document is to outline the Aquatic Science Center's (ASC) standard operating procedures (SOP) for data management and quality assurance (QA) for all environmental data collected by the Delta Regional Monitoring Program (RMP). ASC's Data Services team (DS) is responsible for handling and reviewing data generated for various water quality monitoring programs and projects.

As a part of the review process, ASC's DS team checks that results are received for all samples collected and that the lab reported results for the analytes requested in the contracts. This "completeness check" includes ensure sufficient laboratory control samples are analyzed to meet the requirements laid out in the project Quality Assurance Project Plan (QAPP) or in the program's qapp . We standardize the data using California Environmental Data Exchange Network (CEDEN) templates, controlled vocabulary, and business rules. ASC's QA officer or designee (under the supervision of the QA Officer) reviews the data to and evaluate whether samples are meeting Measurement Quality Objectives (MQO) as stipulated in the QAPP. Five evaluations make up the core of the QA-review process:

1. **Data completeness:** Has the lab submitted all expected data, including the correct number of QA samples? Were contract expectations met?
2. **Sensitivity**: Were the analytical methods sensitive enough to get detectable results?
3. **Contamination**: Was there contamination present in any of the sample batches?
4. **Accuracy**: Did the lab reliably measure known concentrations?
5. **Precision**: Was the lab able to repeatedly measure the same concentrations?

These processes are necessary to ensure data are usable by project staff, regulatory agencies and members of the public. Corrective actions and communication will take place if there are problems in any of the above 5 areas. These are the responsibility of the QA Officer and the Program Manager.

Vocabulary

This section defines a few "terms of art" from the database world that we use in this document and in our day-to-day work.

Field: equivalent to a column in a data table.

Controlled vocabulary: Some database fields only allow the user to enter predefined entries. Think of this as as a form of "data validation" where the user is only allowed to choose from a menu of options. This helps to ensure standardization and makes the data more usable. Consider for example, the pesticide **DDD(p,p')**. This the *only* allowable entry in the CEDEN database field AnalyteName, and the following synonyms are *never* allowed:

- DDD(p,p') - with a "curly apostrophe" or "right single quotation mark"
- DDD (p,p') - with a space before the opening parenthesis

- p,p'-DDD
- 1,1-Dichloro-2,2-bis(P-chlorophenyl)ethane
- Rhothane
- Dilene

Business rules: a policy applied to the data stored in a database. It constrains some aspect of the database, such as which entries are allowed in a given field or the relationships among data. These constraints help maintain data integrity, or the quality of data in the database in terms of its accuracy, consistency, and validity. As one example, for a water sample that is sent to a lab for analysis, the date entered in the field AnalysisDate should always be *after* the SampleDate.

Data Management & Quality Assurance Overview

The steps in the data management and QA process are briefly outlined here, and more detailed information on each step follows:

1. **Document Field Collection:** The field collection agency provides collection information about the sampling event to ASC's DS staff.
2. **Provide Labs the Reporting Template:** ASC staff provide CEDEN Electronic Data Deliverable (EDD) templates to the laboratories.
    a. For water and sediment samples, ASC staff sends the EDD template directly to the analytical labs after receiving the collection information.
    b. For tissue samples, ASC staff provides the collection information in an EDD template to the compositing lab. The compositing lab adds the compositing information to the EDD template and sends it back to ASC staff.
    c. ASC staff sends the EDD template with the composting information to the analytical labs.
3. **Report Results:** The analytical labs populate the EDD template with the results from field and QA/QC sample analysis.
4. **Check Data:** The analytical labs check their EDD templates using the on-line CEDEN Data Checker and resolve any issues flagged by the checker.
5. **Submit EDD:** The analytical labs submit their final EDD to ASC staff.
6. **Receive Data:** ASC staff intake the data and log it into ASC's Data Management Tracking System
7. **Format Data:** ASC staff compile the data and standardize the dataset to adhere to CEDEN's required business rules and controlled vocabulary.
8. **Perform QA/QC Review:** ASC staff perform QA/QC review to determine whether samples meet measurement quality objectives (MQOs) stipulated in the project Quality Assurance Program Plan (QAPP).
9. **Upload Data:** ASC staff upload approved data to ASC's Regional Data Center (RDC) database. All data in the RDC are replicated weekly to the California Environmental Data Exchange Network (CEDEN) web portal.

10. **Make Data Public:** ASC staff make data available through ASC's Contaminant Data Display and Download Tool (CD3) and CEDEN makes data available to the public through CEDEN's Advanced Query Tool.
11. **Long-term data stewardship:** Records added to the RDC database are securely stored for long-term stewardship of the data. Data may be modified, removed or replaced at the project manager's request to maintain the integrity of the dataset.

1. Document Field Collection

We provide data templates to field crews and laboratories to ensure that they gather and report all the information required by a project, in a format that is standardized and uniform.

Water Quality Template

The CEDEN Chemistry Template for Water Quality Data (WQ template) is used for reporting results in water and sediment matrices, as well as pathogens, and is available as an Excel spreadsheet from the CEDEN website http://www.ceden.org/ceden_datatemplates.shtml. There are four tabs in the WQ template. The turquoise 'Notes' tab contains valuable guidance on populating the other tabs. The 'Locations' tab is used to record actual unique latitudes and longitudes that were recorded while in the field collecting samples. If actual latitudes and longitudes were not recorded at the time of sampling, this tab does not need to be populated. The 'ChemResults' tab is required and is used for reporting the sample information and lab results. The 'LabBatch' tab is required and consists of a unique list of lab batches. The LabBatch is a text string that is assigned by the analytical lab during sample analysis. The LabBatch is a text string, and the only requirements are that it be unique and contain 35 characters or less. Each batch represents samples that were analyzed together under the same laboratory conditions. (Note that different water quality analyses require differing amounts of time, and that some methods require days for analysis of a batch.)

Tissue Data Template

The CEDEN Template for Tissue Data (TI template) is used for reporting results in tissue matrices and is available as an Excel spreadsheet from the CEDEN website http://www.ceden.org/ceden_datatemplates.shtml. There are seven tabs in the tissue template. The turquoise 'Notes_Information' tab contains valuable guidance on populating the other tabs. The 'Locations' tab is used to record actual unique latitudes and longitudes that were recorded while in the field collecting samples. If actual latitudes and longitudes were not recorded at the time of sampling, this tab does not need to be populated. The 'Composite' tab is required and the user will choose between two composite tabs for either fish or bivalves. The composite tab is used to record information about individual organisms as well as tracking what samples are included in the composite and other aggregate information such as average weight or average length. The 'TI Super Composite' tab is to be used when composites are made from multiple composites. The 'TIResults' tab is required and is used for reporting the lab results. The 'LabBatch' tab is required and contains a unique list of lab batches assigned by the analytical lab

during sample analysis. Each batch represents samples that were analyzed together under the same laboratory conditions.

2. Provide Labs the Reporting Template

ASC staff provide a copy of the WQ template to the field collection team. The field collection team transcribes the handwritten field sheets and provides the collection information in an electronic format to ASC. In the 'ChemResults' tab of the WQ template, populate columns A through R with collection details, column W with the analyte code from the sample container, columns AI to AJ with Prep Preservation type, date and time, and column AM with the SampleID. Populate the 'Locations' tab for columns A through S if actual latitudes and longitudes are recorded in the field. The field collection agency provides the populated template to ASC.

ASC staff upload the collection information to a preliminary database on SQL Server and generate an Electronic Data Deliverable (EDD) template in the format of the CEDEN WQ template. ASC staff provide the EDD template to each lab in an Excel workbook that contains the collection information and an expanded analyte list for the samples that the lab will be analyzing. The Principal Investigator (PI) also receives a copy of the EDD template to review and confirm that all samples they are expecting are included.

Tissue Data

For tissue data, the procedure is similar, but some details vary. ASC uploads the compositing information into a preliminary database on SQL Server and generates an Electronic Data Deliverable (EDD) template in the format of the CEDEN TI template. The EDD template is provided to the analytical laboratory in an Excel workbook and the 'TIResults' template is populated with the 'Composite ID', 'CompositeType', and 'Composite Replicate' for the composite samples that will be analyzed.

The analytical lab populates the 'TIResults' tab and the 'LabBatch' tab with the results from the samples and LABQA analysis. The Green fields within the template are required and the data will not be accepted if the lab does not provide acceptable values for these fields.

The CEDEN documentation *Tissue Data Submission Guidance Document*, available on the CEDEN website at http://www.ceden.org/ceden_datatemplates.shtml, contains definitions, data types and lookup list references for each field in the template as well as rules for populating them. CEDEN has developed a list of standard names and codes that are used for describing data in order to make the data understandable to others and increase comparability among data providers. These codes can be found here on the CEDEN website http://www.ceden.org/CEDEN_Checker/Checker/LookUpLists.php. Fields that require a standard code have a red arrow in the top right corner of the cell listing the lookup list to reference for acceptable vocabulary for the field.

3. Report Results

The lab populates the 'ChemResults' tab and the 'LabBatch' tab with the results from the samples and the lab's own QA analysis. The green fields within the template are required and the data will not be accepted if the lab does not provide appropriate values for these fields.

The CEDEN documentation Chemistry Data Submission Guidance Document, available on the CEDEN website http://www.ceden.org/ceden_datatemplates.shtml, contains definitions, data types and lookup list references for each field in the template as well as rules for populating them. CEDEN has developed a list of standard names and codes referred to as 'Lookup lists' that are used for describing data in order to make the data understandable to others and increase comparability among data providers. These codes can be found here on the CEDEN website http://www.ceden.org/CEDEN_Checker/Checker/LookUpLists.php. Fields that require a standard code have a red arrow in the top right corner of the cell listing the lookup list to reference for acceptable vocabulary to use in that field.

4. Check Data

When submitting data to ASC, laboratories are required to use the 'CEDEN Data Checker', available on the CEDEN website at http://ceden.org/CEDEN_checker/Checker/, to resolve any issues with vocabulary or business rules. We expect the submitting lab to fix most issues or errors raised by the CEDEN data checker prior to submittal to ASC. DS staff are available to help labs troubleshoot and resolve issues, and we encourage them to call or email as we have a lot of experience working with CEDEN and odds are good that we can help them fix it quickly. Note that there are some known issues with the CEDEN data checker and some errors messages simply cannot be resolved. We are also available to work with lab staff to determine which error messages can safely be ignored and which are more "critical."

CEDEN provides examples of data in the WQ Template on their website at http://www.ceden.org/ceden_datatemplates.shtml.

5. Submit EDD

Data should be submitted to ASC using the **ASC Data Submittal Portal.** Contact ASC at DS@sfei.org to receive the username and password.

6. Receive Data

ASC will log each dataset submitted through the Data Submittal Portal into the data tracking database.

7. Format Data

CEDEN business rules, vocabulary and format are used by ASC to manage environmental data uploaded to ASC's 'Regional Data Center' database and made available on CEDEN's 'Advanced Query Tool' (AQT) and ASC's 'Contaminant Data Display and Download Tool' (CD3). A series of database queries, listed in Appendix 1, are run to review the data for

formatting and business rule violations. In our experience working with water quality data, this step essential to verifying the integrity of the data and making sure that we can perform the next steps without running into problems.

Business rules allow for integration of data from disparate sources by establishing a uniform language and format. These rules are laid out in guidance documents and templates on the CEDEN website. Many of the fields within the templates only allow vocabulary that has been included in a list of approved words and definitions. These lists are commonly referred to as "Lookup Lists" and are available on CEDEN's website. When a value is not included in a lookup list and there is no acceptable alternative listed, the data provider (in this case ASC) can request CEDEN to add a new value to the lookup list. Templates should be checked by the data provider prior to submitting to ASC by using the CEDEN Data Checker. Issues flagged by the data checker should be addressed prior to submitting data to ASC.

8. Quality Assurance

Data are reviewed upon receipt to ensure that the expected number of samples have been reported, and that the analytical requirements in the contract and the QAPP have been met. This is typically done by DS staff and the project manager. Each contract includes a table stipulating how the lab should report the data with regards to CEDEN approved analyte names, fractions, units, and methods. In addition, data are preliminarily reviewed upon receipt to ensure the appropriate number of QA/QC samples have been provided based on requirements from the contract and the QAPP.

Once the data have been confirmed to report the correct and complete set of analytes for the right numbers and types of field and QA samples, results are reviewed for sensitivity, precision, accuracy and lack of contamination. Results are evaluated against measurement quality objectives (MQOs) listed in the project QAPP. When data do not meet MQOs, QA flags or compliance codes are added to the database to alert data users to limitations or issues with using the data. If problems are particularly severe, data may be rejected and will not be published. QA Codes and compliance codes provided by the reporting lab are verified, or are added or modified by ASC based on the outcome of the review. A summary report is written for each dataset describing the data's adherence to the MQO's and usability. The steps of the Quality Assurance review are highlighted in Step 2 of the Water Quality and Tissue Data Review Steps section.

8.1 Check the Completeness of Submitted Samples and Constituents

Once data are submitted to ASC by the analytical lab the data are uploaded to a preliminary SQL Server database and a "Completeness Check" is performed. The completeness check is performed by running a procedure in SQL Server the compares the expected sample information with what was provided by the lab and confirms that the constituents in the data submittal match those expected based on project code, station code, sample date, sample time, matrix name, fraction name, analyte name, unit name, method name and lab agency name. If

the procedure indicates that records are missing or provided incorrectly, the ASC data reviewer will work with the lab to ensure all expected data is submitted correctly. The lab may be required to make corrections to the data and re-submit until it is approved by the ASC data reviewer.

8.2 Check the Completeness of LABQA Data

A "completeness check" of LABQA data is done to ensure that the LABQA data submitted conforms to the requirements stipulated in the contract and QAPP. A series of three Access queries are used to review number and types of QA samples submitted. The output of these queries is provided to the QA Officer for review to ensure that sufficient QA data was submitted to support quality assurance review. If there is not sufficient LABQA data, the ASC data reviewer must work with the lab to ensure all required LABQA data are provided. The lab may be required to resubmit the dataset until it is approved by the ASC data reviewer. If sufficient LABQA data have not been submitted, we will contact the lab to check whether these results were accidentally omitted from the template. If the required number of LABQA samples were not analyzed to begin with, we may request that samples be reanalyzed if it is practical (sample is still available, hold time requirements, etc.).

8.3 Check the Formatting of the Data

Each dataset provided by a laboratory is reviewed using a series of database queries that have been designed to check the formatting of the dataset. These queries check fields for use of controlled vocabulary and business rules. They also check that the data makes sense by checking that collection dates are before analysis dates, making sure co-elutions are properly formatted, ensuring that percent recoveries are properly calculated, confirming that ResQualCode and QACode have been properly assigned and checking the hold times for time sensitive analytes. A complete list of the formatting queries and a short description of each one is provided in Appendix 1. Labs, collection agencies and project managers are contacted as needed to resolve questions about the validity of the information recorded for the dataset. If the lab has submitted a lab hardcopy or PDF report, we will spot check around 5% of the electronic data against the print report, to make sure there are no discrepancies between the report and the spreadsheet.

8.4 Check Data for Adherence to Measurement Quality Objectives (MQOs)

ASC staff format all datasets submitted by sub-contracting environmental laboratories according to ASC's standard data formats. All data are reviewed internally under supervision of the QA-Officer prior to being reported to the public either on the web as raw data or in publications.

A less formalized, but equally important component of data review is to make sure that the reported data "make sense." Reported data for field samples are evaluated against expectations using best professional judgement, with anomalous results communicated to lab and field staff

to ensure that samples have not been mislabeled, incorrect units reported, or other such errors. For example, individual samples or groups of samples reported at concentrations much higher or lower than previous results for the same project and/or stations might suggest an accidental switch of sample order in a lab autosampler, or conversion errors in calculations. Similarly, a dissolved concentration of an analyte much higher than the reported total concentration for the same site and event might suggest a mislabeling of samples in the field.

When the reported results appear highly unlikely, findings are immediately communicated with the laboratory during the review, in case simple causes and corrections can be quickly identified (e.g., incorrectly reported units, or a missed dilution factor in concentration calculations). In some cases the seeming anomalies may represent real environmental phenomena (e.g., highly heterogeneous field conditions, leading to large variations in dissolved and/or total concentrations for a given location and time), so communication and confirmation with the field and lab staff provide the best opportunity to establish through multiple lines of evidence whether or not any errors occurred. For example, a mislabeling of dissolved and total fraction samples is unlikely if the remaining total sample appears to have settled solids while the dissolved does not. In other cases, there may be enough sample remaining to allow reanalysis.

The QA Officer and Data Management staff write a QA Summary Report during the QA review process to summarize the outcomes of the QA review process. This report contains our conclusions about dataset completeness, sensitivity, blank contamination, whether each dataset meets the MQOs for accuracy and precision. Finally, the report concludes with an assessment of the overall dataset acceptability.

8.5 Sensitivity Review

The sensitivity review evaluates the percentage of field samples that were non-detects (ResultQualCode = ND). This allows us to evaluate whether the analytical methods employed were sensitive enough to detect environmental concentrations of the targeted parameters. In general, if more than 50 % of the samples were ND then the method may not be sensitive enough to detect ambient concentrations. However, review of historical data from the same project/matrix/region (or a similar one) helps to put this evaluation into perspective. Sometimes higher analytical sensitivity is not possible. In other instances, analytes can be positively identified at concentrations near the MDL with lower confidence in the numerical value. In this case, the concentration is reported as an estimate. Frequently, knowing that a sample result is below the detection limit is sufficient to indicate minimal environmental or human health risk, so improved sensitivity is not needed despite a preponderance of ND results.

8.6 Blank Contamination Review

The blank contamination review evaluates laboratory contamination during all stages of sample preparation and analysis. For laboratory analyses, at least one laboratory method blank shall be

run in every sample batch. The method blank is processed through the entire analytical procedure in a manner identical to the samples (i.e., using the same reagents and equipment).

Laboratory blanks are the preferred sample type for evaluating blank contamination, but other procedural or field blanks may be used if there are no laboratory blanks. In order to verify that contamination of samples has not occurred in sampling or lab analysis, we compare the results for blank samples to method detection limits. In cases where an analyte *is* detected in a blank, we compare the measured concentration in the blank sample to concentrations measured in field samples to determine the proportion of the signal that originates from lab contamination. In cases where there are both lab and field blanks, lab blanks are primarily used to assign qualifiers in the database, but field blank contamination is also noted in any narrative reports.

If there is evidence of contamination for a given analyte based on the analysis of blank samples, then qualifiers will be added on a lab-batch basis. An 'IP' qualifier should be added by the reporting lab to the QA Code field when the analyte is detected in the method (usually lab-generated) blank. The IP flag means "analyte detected in field or lab generated blank."

When the QA Officer rather than the reporting lab assigns or modifies any QA Code, it is preceded by 'V'. The QA Code is also prefixed with 'R' when the result is rejected for QA reasons, e.g. in blank contamination cases due to a large portion of the measured signal likely originating from blank contamination. Examples of application of these prefixes to QA Codes are shown for specific examples of flagging blank contamination below. In addition to flagging, if there is problematic (e.g., frequent, and/or high concentration) contamination, ASC staff will communicate this finding to the laboratory (or to field agency if contamination is found only/primarily in field blanks), and work with their staff and management to identify the cause of the problem and take corrective action.

Some analytes are reported as "blank corrected." This is also sometimes called "blank subtracted." Blank correction (akin to taring of a scale) is used for reporting of analytes with irremovable background concentrations in the lab environment that would otherwise elevate reported concentrations. The decision on whether to perform blank correction is made by the analyzing laboratory, with agreement by the PM and QAO, and should be included in the proposed method/SOP provided for the contract. Labs that blank correct results should report the data already corrected, with the BlankCorrected field indicating "yes".

For results that are not blank corrected: if the average measured concentration of an analyte in laboratory blanks is above the detection limit in a batch then a "VIP" qualifier is added to all field samples (FS) that are not already flagged by the lab (with an "IP" qualifier), except those already qualified as Not Recorded (NR). Additionally, if a field sample result (even if reported as ND) is less than 3 times the average blank result, those results are "censored" using a "VRIP" qualifier. Although the reported value remains in the database, the "VRIP" flag indicates the result is not quantitative, as there is likely a large contribution from blank contamination. Only field sample results are qualified. This includes all samples of type: Grab, Integrated, or Composite, including replicates.

For results that are blank corrected: if the standard deviation of all blanks in a batch is greater than the MDL, special handling is required. Typically, one subtracts the average blank concentration from the results in a batch in order to correct for blank contamination in a batch. However, when the standard deviation of the blanks is greater than the MDL, it suggests that even results above MDL after blank subtraction may be uncertain. The "VIP" qualifier is added to all field samples that are not qualified as NR, if not already flagged with an "IP" qualifier by the reporting lab. If a blank corrected field sample result is < 3 times the standard deviation of blanks in the batch, (even if reported as ND) that result is "censored" using a "VRIP" qualifier. Only field sample results are qualified (SampleTypes = Grab, Integrated, or Composite [including replicates]).

8.7 Accuracy Review

Labs typically assess the accuracy of measurements by analyzing samples with a known concentration. Analysis of these samples allows us to evaluate measurement accuracy, or how close our measurement comes to a consensus/expected value. Matrix spikes, where a sample is spiked with a known amount of an analyte, provide an alternative determination of method accuracy that can account for matrix interferences or other analytical problems. The expected value of a matrix spike sample is the environmental result plus the spiked concentration.

The accuracy review is performed on a project or dataset level (not on a batch basis) so that the review takes into account variation across batches. Only samples with expected values greater than 3 times the MDL are used for determining data flagging, as results near the MDL are highly uncertain. Evaluations are done using Certified Reference Materials (CRMs), Matrix Spikes (MS), or Laboratory Control Spikes (LCS), as available for each analyte, with sample type preference in this order, as the former sample types are generally more similar in matrix characteristics to field samples as compared to the latter. Lab Control Material (LCM) is sometimes used, with LCM results getting higher or lower priority for use in flagging depending on the actual material being reported. In some cases an LCM is a processed CRM or similar natural matrix, which would give it high relevance to field samples. In other cases, an LCM may be a synthetic sample in a clean matrix, which would make it simpler to analyze and thus more akin to an LCS sample, and thus easier to achieve high recovery than in natural matrix samples. Such LCMs are thus more an indicator of maximum possible/idealized accuracy and not fully reflective of regularly-achieved recovery in natural samples.

For MS samples, in addition to the requirement that the expected value be at least 3x the MDL, the expected value of the spiked MS sample must be at least 2x that of the unspiked parent sample. This requirement is imposed to ensure that the reported recovery for any MS sample includes a large enough spike to be reliably measured over the background concentration in the parent sample. Conversely, if MS samples are spiked at too high a concentration, their relevance to native analyte concentrations in field samples is diminished, as extremely high concentration samples are often easier to measure reliably. If the MS expected value is >10x the unspiked

sample, the spiked amount was likely too large; the results are reviewable, but the lab should be requested to spike at a lower concentration if possible.

QA Codes are assigned according to the measurement quality objectives (MQOs) detailed in the Delta RMP QAPP. For example, the QAPP Table 4.3 gives an MQO for dissolved organic carbon, stating that the acceptable limit for a CRM is "Expected value +/- 20%." If the average recovery on a submitted group of data is outside of this tolerance limit, the QA Officer will assign a QA code to all DOC results that were reported in the data set to warn data users that the data may be inaccurate. If it is far enough outside this limit, the QA officer may decide that these results are unreportable, and the data will be rejected.

The QA Code 'IU' is typically used by the lab to flag data for accuracy indicating that the percent recovery (PR) is outside the laboratory control limit. As mentioned before, when any QA code is added by ASC rather than by the lab, it is preceded by a 'V'. The QA Code is also preceded by an 'R" when poor QA (in this case accuracy) causes data to be rejected. In the case of recovery, since the performance is evaluated on the average performance for the submitted dataset, the analyte receives the same QA Code for the whole dataset. The threshold for rejection of each analyte or analyte group should be specified in the project QAPP.

Where no rejection threshold is separately indicated in a project QAPP (i.e. only an acceptance threshold) it is set by ASC at twice the acceptance limit, e.g., if dissolved organic carbon has an acceptance limit of expected value +/-20%, recovery averaging outside of the expected value +/-40% (i.e., <60%, or >140%) would lead to rejection of all reported DOC in that dataset.

8.8 Precision Review

The precision of analysis methods (ability to consistently obtain the same result) is determined by analyzing replicate or duplicate samples. We assess precision by calculating the relative percent difference (RPD) between two duplicate samples, or relative standard deviation (RSD) among three or more replicate samples. The precision review is performed on a project or dataset level (not on a batch basis) so that the review takes into account typical variation across batches. Only results that are greater than 3 times the MDL are evaluated. The overarching goal is to review precision using sample results that are most similar to field samples in matrix and concentration ranges. Therefore, preferred sample types for the precision review are selected with this goal in mind: lab-replicates of field samples are best, as they best separate analytical variability from other possible causes. Separately collected field replicates can also be compared (as opposed to lab splits of a field replicate, which are considered lab replicates (of the field replicate)), but may include field variability that is beyond the control of the reporting analytical laboratory. Barring usable results from lab or field replicates (in some cases, analytes may be ND in all lab and field replicates), replicates from CRMs or spiked samples (e.g. Matrix Spike or Blank Spike) should be considered next, with care taken to select the sample types most similar to the targeted ambient samples.

QA codes are assigned according to the MQOs listed in the Delta RMP QAPP. For example, for total organic carbon (TOC), the QAPP states that lab duplicates should have an RPD < 10%, and that field duplicates should have an RPD < 25%. If the sample results average outside of this tolerance limit, ASC will assign a QA code to all TOC results reported in the data set [1]to warn data users that the results may be imprecise, that is to say that there is higher than expected variability.

The QA Codes 'IL' is applied when the relative percent difference (RPD) or relative standard deviation (RSD) exceeds the laboratory control limit. When the QA Officer assigns the code, it is preceded by a 'V'. The QA Code includes an "R" when the precision causes the analyte to be rejected. Similar to the case for recovery qualifiers, data are rejected when the average performance is outside of double the acceptance limit (again using DOC as an example, RPDs averaging >20% would result in the DOC getting assigned a "VRIL" flag).

8.9 Assigning Compliance Codes

Compliance codes of "Rej" (Rejected), "Est" (Estimated), "Qual" (Qualified), and "Com" (Compliant) are assigned to individual results to indicate the degree of compliance to the Delta RMP QAPP. Data with compliance codes 'Est', 'Qual', or 'Com' are considered usable and are made available through ASC's and CEDEN's data query tools. Data with a compliance code 'Rej' are not available through ASC's or CEDEN's data query tools.

Compliance codes[2] are assigned based on QA qualifier as follows:

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[1] We have elected to evaluate and flag recovery and precision across a reported dataset, using the average performance to flag the set. A given QC sample in isolation is just one point in a distribution of likely performance; which often varies within a batch. Thus for a poor QC sample result (e.g. if only one of that type is reported with a lab batch), it is impossible to tell if the given poor performance is isolated or common (the tail or center of a distribution). Evaluated across batches however, you get a better sense of the underlying distribution.

Blanks may have the same issues of a distribution of response, but we report and flag deviations for blanks on a batch basis because 1. Blanks are required with every single batch (vs 1 per 20 samples for some other types), so it is a reasonable expectation (and labs don't typically charge extra) to have a blank in every batch, whereas other QC sample types (e.g. CRMs & MSs), which are often extra charged samples, especially in small batches. 2. Things causing blank contamination may also be more sporadic and easily correctable, e.g. bad batch of solvent, failure of an air handling unit on a given day. Whereas recovery and precision issues likely require larger changes of staff, instruments or SOPs to make an appreciable influence. Labs may want to evaluate precision and accuracy performance at the batch level as well, e.g. is it always the same staffer with the low or high recovery, etc, but DRMP is only a small portion of the labs total output, and does not regularly receive the information to judge whether deviations are isolated or common.

[2] For a full list of CEDEN QA codes, see:
http://ceden.org/CEDEN_Checker/Checker/DisplayCEDENLookUp.php?List=QALookUp

For a full list of Compliance Codes, see:
http://ceden.org/CEDEN_Checker/Checker/DisplayCEDENLookUp.php?List=ComplianceLookUp

- The R*, LR*, and VR* series of QA qualifiers are assigned a compliance code of 'Rej'
- The J, JA, VJ, and VJA QA qualifiers are assigned a compliance code of 'Est'
- The I* series of QA qualifiers (IP, IL, and IU, and their variants with V (but not VR) prefixes) are assigned a compliance code of 'Qual'
- The BS and VBS QA qualifiers are assigned a compliance code of 'Qual'
- There are other QA qualifiers, like "VVQ" that are sometimes added to indicate professional judgment was used, these are assigned a compliance code 'Qual'
- The QA qualifiers None, NBC, and SC receive a compliance code of 'Com'

As a general rule of thumb, if ASC adds a QA Code flag not in the specific 'Rej' or 'Est' categories noted above, then it is assigned a compliance code of 'Qual.'

8.10 Addressing Errors

Errors are addressed as they are identified and are further logged and reviewed. Depending on the seriousness of the error, this may require immediate coordination and communication with field crews or laboratories. Where appropriate, ASC data management staff and the project manager will work with labs to resolve issues and take corrective action to prevent them from occurring again. For minor problems, it may be appropriate to wait until the end of the reporting period (to determine lessons learned and corrective actions that can be taken in the future. ASC maintains detailed error tracking within the project management system utilized by ASC.

9. Upload Data

After all samples have passed QA review for a project or project phase, we upload the data to ASC's Regional Data Center (RDC) database. Data that are reported in the same CEDEN template but from different labs are typically uploaded together. Before uploading the data, we run a series of queries in MS Access to check for common errors that will halt an upload. These queries include the following:

- Q1. Groups records that have multiple Collection Comments for the same key fields. For every key grouping there should only be one standardized collection comment. (This query check for variations in the same collection comments. Frequently, there will be comments that mean the same thing but may be written differently, often because they were entered by different people. This query helps us to standardize the comments and make the data more consistent, professional, and user-friendly.)
- Q2. Groups records that have multiple sample ids for the same key fields. For every key grouping there should only be one sample id.
- Q3. Groups records that have multiple lab sample ids for the same key fields. Lists individual records that have the same key fields but different lab sample ids. For every key grouping there is only one lab sample id. If all of the key fields are the same but the sample ids are different, then one of the key fields needs to be modified, usually time.

- Q4. Groups records that have multiple Position Water Column Codes for the same key fields. For every key grouping there is only one position water column code.
- Q5. Checks that the join between Locations and Results is good. Should return no results.
- Q6. Constituent codes are reviewed and approved for addition to lookup lists. (The constituent code lookup list combines information from several fields. Check that all entries adhere to a standard vocabulary is another way of checking that the data are correct. When a new combination comes up, it is added to the approved list of entries. Checking against this list highlights when something has been formatted incorrectly. For example, TOC should always have a fraction of None; if an analyst entered the fraction as Total, this would violate the constituent code and the fraction would need to be updated to None.)

Once the data has been reviewed using MS Access queries a series of scripts are used in SQL Server to upload the data to a SQL Server development table in the RDC database. Once uploaded, a second person is asked to verify that all expected records have been successfully uploaded. Once the data has been verified it is imported to the main table and the uploader sets the display codes and data export codes based on the QA Codes, Compliance Codes, and project requirements.

10. Make Data Public

Once the data has been included in the Regional Data Center Database the upload is complete and the project manager and principal investigator are notified. If data were approved for public release during the upload process, data will be available to the public within a week through ASC's Contaminant Data Download and Display tool and approximately two weeks through CEDEN's Advanced Query Tool. If data were not approved for public release the data will remain hidden from the public indefinitely and until the data are approved for release by the project manager and/or principal investigator.

Project Completeness

The data management and QA review aspect of a project is complete once all data has been provided by the laboratory, reviewed by ASC's data and QA management staff, and has an associated QA memo written by the ASC's QA Officer discussing the quality of the data. In addition, the project manager may have requirements to provide the data and/or a data quality memo to the Technical Advisory Committee (TAC) and/or Steering Committee (SC), or other stakeholders for review prior to use or release of the data. Once the Project Manager indicates that the project is complete, then the data are released to the public as requested and stored in the RDC database for long-term management and safe-keeping.

Database Synchronization

ASC's database is replicated weekly to CEDEN's database. All existing records in CEDEN's database are dropped and replaced with the current records in ASC's database as a regularly scheduled weekly event.

Query Tools

ASC provides data to the public and other interested stakeholders through the Contaminant Data Display and Download Tool (CD3). Data for the CD3 tool is updated weekly. ASC replicates data to CEDEN on a weekly basis and CEDEN makes data available to the public through the Advanced Query Tool (AQT) and select data is provided by CEDEN to the EPA's Water Quality Exchange Tool (WQX).

11. Long-Term Data Stewardship

The final stage of the data life-cycle is long-term stewardship of the data. Data may be modified, removed or replaced at the project manager's request to maintain the integrity of the dataset. This is a relatively rare, but it does occur from time to time. For example, in 2014 one of the Bay RMP labs began using a new, more accurate method for drying and extracting sediments samples to analyze for PAH and pesticides. A handful of archived samples were re-analyzed using the new method, and we discovered that the new method reported concentrations that were 2 to 5 times *lower* than the previous method. Based on this, the RMP Technical Review Committee decided it was appropriate to censor (remove) the original results and replace them with results from archived samples that were re-analyzed using the new method.

For the Delta RMP, there have been a few instances where we needed to update data that had previously been considered "final." For example, in 2017, we updated toxicity results as requested by the lab to change significant effects codes. This change was made after an error was discovered in the statistical calculations for determining which code to apply to results of a toxicity test (these codes indicate whether there there was a statistically significant difference between a sample and a control, and indicates whether a sample is considered toxic). As another example, in 2018, we amended pesticides data to address errors reported by the lab for MDLs, results, and QA Codes.

Anytime published results are changed, it is important to notify data users and other interested parties. To this end, we have an email distribution list to communicate changes to Delta RMP data that has been published to CEDEN. Contact the program manager Matt Heberger (matth@asc.org) to request membership to the data update listserv (delta-rmp-database-updates@sfei.org).

Appendix Tables

The Water Quality, Tissue and QA Review queries presented in the Appendix Tables of this SOP are internal reference materials and are designed and maintained by ASC staff. These are used to guide and assist staff as they work through datasets. They can be modified by staff as a dataset or project requires. Appendix 1 lists queries used when reviewing the formatting and business rules for data submitted in the CEDEN Water Quality template. Appendix 2 lists queries used for reviewing formatting and business rules when reviewing data submitted in the Tissue Template. Appendix 3 lists the QA review queries used when reviewing the data for adherence to MQO's. These queries and procedures have been modified and adopted over time to accommodate changing templates and criteria so query numbering may not be consecutive.

Appendix 1: Water Quality Data Formatting Queries

F001_CheckSampleID
Checks that reported SampleIDs match SampleIDs in field collection info in dbo_OPCI_WQ table

F002a_Lookups_1
Checks that the values in the StationCode, ProjectCode, EventCode, ProtocolCode, AgencyCode and LocationCode fields in ChemResults are present in the corresponding CEDEN controlled vocabulary lookup lists

F002b_Lookups_2
Checks that the values in the SampleTypeCode, CollectionMethodCode, CollectionDeviceName and UnitCollectioNDeviceName fields in ChemResults are present in the corresponding CEDEN controlled vocabulary lookup lists

F002c_Lookups_3
Checks that the values in the MatrixName, MethodName, AnalyteName, FractionName and UnitName fields in ChemResults are present in the corresponding CEDEN controlled vocabulary lookup lists

F01_Check_StationCode
Chekcs the ChemResult.StationCode against the StationCode value in in the field collection info in dbo_OPCI_WQ

F04B_Check_SampleDate_forFieldSamples
For non-LABQA records, checks if ChemResults.SampleTime is equal to the SampleTime in the field collection info in dbo_OPCI_WQ (joined on SampleID)

F05_Check_SampleDate_forLABQA
Checks if the ChemResults.SampleDate for LABQA Records is equal to the ChemResults.AnalysisDate, and if it is not, checks if the ChemResults.SampleDate is equal to the ChemResults.DigestExtractDate

F05B_Check_SampleDateTime_forFieldBlDup
For FieldBlDup records, checks if ChemResults.SampleTime is equal to the SampleTime in the field collection info in dbo_OPCI_WQ (joined on SampleID)

F06_Check_SampleTime
For non LABQA records, checks if ChemResults.SampleTime is equal to the SampleTime in the field collection info in dbo_OPCI_WQ (joined on SampleID)

F08B2_Check_ProjectCode_inCollection
Checks if ChemResults.ProjectCode values used are in the field collection info in dbo_OPCI_WQ

F08C_Check_ProtocolCodeAgainstProjectCode
Checks if the ProtocolCode and ProjectCode were used together previously

F10_LAB_FS_GeneralFields
Displays the unique combinations of SampleTypeCode, EventCode, ProtocolCode, CollectionDepth, UnitCollectionDepth, ProjectCode, AgencyCode in ChemResults

F10B_CheckSampleDepthAndUnits
Check that SampleDepth and Unit match what was provided in the field collection info in the dbo_OPCI_WQ Table (links on Station Code, Sample ID, and Analyte Group)

F11_0B_CheckSameStationDateTime_MultipleSampleID
Checks if there are multiple SampleID for what would seem to be one sample

F11_1_CheckCRMs
For CRM records, checks if the CRM is in dbo_SRMLookup (checks against Ref_Material and SWAMP_AnalyteName fields in dbo_SRMLookup)

F12_0_CheckFieldPrepPreservationCodeAndDate
Checks if ChemResults.PreparationPreservation values are in the dbo_PrepPreservationLookUp list

F12_2_CheckPreparationPreservationDate
For non-LABQA records, checks if the PreparationPreservationDate is after or equal to the SampleDate.
For LABQA records, checks if the PreparationPreservationDate is before or equal to the SampleDate.

F12_3_CheckPreparationPreservationDate
Use to check that Results with PreparationPreservation value of "None" have the default "01/Jan/1950" date

F13_1_CheckDigestExtractCode
Checks if LabResults.DigestExtractMethod values are in the dbo_DigestExtractLookUp list

F13_2_CheckDigestExtractDate_FS
For non- LABQA records, checks that the DigestExtractDate is after the SampleDate

F13_3_CheckDigestExtractDate_LABQA

For LABQA records, checks that the DigestExtractDate is before or equal to the AnalysisDate

F14_CheckBatch
Checks that all ChemResults.LabBatch values are in LabBatch table, and that all LabBatch.LabBatch values are in the LabResults table

F15_1_CheckAnalysisDate_FS
Checks if the AnalysisDate is after the SampleDate (for field samples)

F15_2_CheckAnalysisDate_LABQA
Checks if the AnalysisDate is equal to the SampleDate, or if it is after or equal to the DigestExtractDate

F18_1_CheckCoelutions
Checks Coelutions are in the LU_Coelution list, for records with Coelutions (i.e. where LabResults.Coelution field not null)

F18_2_CheckCoelutions
Checks if ChemResults.QACode, for records with Coelutions, matches the QACode listed for that Coelution in the LU_Coelution table

F22_CheckBlankCorrected
Shows all values used in the BlankCorrected field
Use to see if sample data was blank corrected
Note: Adding NBC to QACode handled in F29 query

F23_CheckCompCode
Shows all values used in the Compliance_Code field

F24_CheckDilutionFactor
Checks that QACode includes a "D" for results with a DilFactor value greater than one (this excludes non-dominant coeluting records, whose QACode is simply the dominant analyte).

F25_1_Res_MDL_Check
Shows records where the Result is null and the ResultQualCode is "=" or "DNQ", or where the Result is not null and the ResultQualCode is "ND" (excluding non-dominant coeluters)
For "ND" QACode records with Result values, shows the relationship of the Result value to the MDL and RL values.

F25_2_CheckDNQ
Checks if Records with "DNQ" ResQualCode are valid DNQ and if records that qualify as DNQ have "DNQ" as ResQualCode

F25_3_ResultLessThanMDLNotND
Checks for results that qualify as Non-Detects based on Result and MDL values, that are without "ND" for ResQualCode

F26_CheckResQualCode
Checks if ResultQualCode value is in the dbo_ResQualLookUp list

F28_CheckMDL_RLfor-88
Checks for any records with the value -88 for MDL or RL

F29_1_checkQACodesInString
Splits the QACode string on the comma delimiters and checks if the individual QA codes are in the dbo_QALookUp

F29_CheckQACode
Checks if records need to have "NBC", "NMDL", or "NRL" codes added to QACode value
Produces a new QACode value with any necessary additions included, to be used to update QACode field
Note: Copy newQA column to QACode to update

F30_CheckSurrogateExpectedValue
For Surrogate records shows the ExpectedValue and QACode
Use to make sure ExpectedValue field is populated with 100 for Surrogates

F31_1_Check_PR_LCS_CRM
Shows the PR value in the LabResultComments field and the expected PR value (based on Results/ExpectedValue*100)
For blank spike, LCS or CRM results

F31_2_CheckRPDAssigned
Shows Records where the SampleReplicate or LabReplicate field value equals 2, and the LabResultComments for that record
Use to check the LabResultComments for an RPD Value
Excludes Lipid, Moisture, Surrogate and non-dominant coeluters

F31_3_RPD_LabRepCheck
Shows the expected RPD value and the RPD value included in LabResultCommnents field, for comparison

F31_4_RSD_LabRepCheck

F31_5_RPD_FieldRep_FieldBlDup_Check

Shows the expected Field RPD value and the RPD value included in LabResultCommnents field, for comparison

F32_CountAnalytes
Shows a count of records for each AnalyteName

F33_CountSamples
Shows a count of records for each SampleName

F34_CheckQACodeOrig
Shows the original QA Code (QACode_ORIG field) and the current QACode value

F35_CheckConstituentCodes
Checks if MAtrixName, AnalyteName, FractionName and Unit are together part of an existing ConstituentCode in qryConstituentLookup

F36_Check_SampleType_vs_Matrix
Checks if SampleTypeCode has been used with that particular matrix before (in existing RDC data)

Appendix 2. Tissue Formatting Queries

F00_CheckSamplesInOPCI
Checks that reported Composites in TissueComposite match Composites in field collection info in dbo_OPCI_TI table

F00a_JoinCheck1
Checks that the Composites in TissueComposite are present in TIResults (joining on CompositeID and CompositeReplicate)

F00a_JoinCheck2
Checks that the Composites in TIResults are present in TissueComposite (joining on CompositeID and CompositeReplicate)

F01_Sample_StationCode
Checks that the TissueComposite StationCode matches the values in the field collection info in dbo_OPCI_TI (joining on SampleID)

F02_Sample_DateandTime
Checks that the TissueComposite SampleDate and CollectionTime match the values in the field collection info in dbo_OPCI_TI (joining on SampleID)

F03_SampleLocation_LookupsAndOPCI
Checks that the ProjectCode, EventCode, ProtocolCode, AgencyCode and LocationCode in TissueComposite match the values in the field collection info in dbo_OPCI_TI and that they are present in the corresponding CEDEN controlled vocabulary lookup lists

F03b_SampleLocation_LABQA
Checks that the ProjectCode, EventCode, ProtocolCode, AgencyCode and LocationCode in TissueComposite for LABQA are present in the corresponding CEDEN controlled vocabulary lookup lists and that ProjectCode and ProtocolCode match the FieldSamples

F04_TissueCollection_Lookups
Checks that the CollectionMethodCode, CollectionDeviceName, and TisSource in TissueComposite are present in the corresponding CEDEN controlled vocabulary lookup lists

F04b_TissueCollection_OPCI
Checks that the CollectionMethodCode, CollectionDeviceName, and TisSource in TissueComposite match the values in the field collection info in dbo_OPCI_TI

F05_ProcessedOrganisms_Lookups

Checks that the OrganismCode and LifeStageCode in TissueComposite are present in the corresponding CEDEN controlled vocabulary lookup lists

F06_Parts_Lookups
Checks that the TissueName and PrepPreservationName in TissueComposite are present in the corresponding CEDEN controlled vocabulary lookup lists

F07_Composite_LookupsAndDates
Checks that the CompositeType and CompAgencyCode in TissueComposite are present in the corresponding CEDEN controlled vocabulary lookup lists, and that the HomogDate is 1/1/1950, or equal/after the sample date

F08_CheckBatch
Checks that all TIResults.LabBatch values are in LabBatch table, and that all LabBatch.LabBatch values are in the TIResults table

F09_TissueResults_DateChecks_FieldSamples
Checks if the AnalysisDate is 1/1/1950 or greater than or equal to the SampleDate, and if the PrepPreservationDate and DigestExtractDate are 1/1/1950 or greater than/equal to the AnalysisDate

F09b_TissueResults_DateChecks_LABQA
Checks if the AnalysisDate is equal to the SampleDate, and if the PrepPreservationDate and DigestExtractDate are 1/1/1950 or less than/equal to the AnalysisDate

F10_TissueResults_Lookups
Checks that the values in the MatrixName, MethodName, AnalyteName, FractionName,UnitName,PrepPreservationName,DigestExtractMethod, ComplianceCode, and ResQualCode fields in TIResults are present in the corresponding CEDEN controlled vocabulary lookup lists

F10b_TissueResults_AnalyteName
Checks if AnalyteName values not in the CEDEN analyte lookup list are in the dbo_Master_Parameter_Names Table

F11_TissueResults_CheckConstituentCodes
Checks if MatrixName, AnalyteName, FractionName and Unit are together part of an existing ConstituentCode in qryConstituentLookup

F12_CheckCRMs
For CRM records, checks if the CRM is in dbo_SRMLookup (checks against Ref_Material and SWAMP_AnalyteName fields in dbo_SRMLookup)

F13_CheckBlankCorrected
Shows all values used in the BlankCorrected field
Use to see if sample data was blank corrected

F14_DilutionFactorChecks
Checks that QACode includes a "D" for results with a DilFactor value greater than one (this excludes non-dominant coeluting records, whose QACode is simply the dominant analyte). Also Checks that Dilution Factor is <0.

F15_RQCCheck
Checks if Records with "DNQ" ResQualCode are valid DNQ and if records that qualify as DNQ have "DNQ" as ResQualCode, and for results that qualify as Non-Detects based on Result and MDL values that are without "ND" for ResQualCode.

F16_SplitQACodeCheck
Splits the QACode string on the comma delimiters and checks if the individual QA codes are in the dbo_QALookUp

F16b_CheckQACode
Checks if records need to have "NBC", "NMDL", or "NRL" codes added to QACode value
Produces a new QACode value with any necessary additions included, to be used to update QACode field
Note: Copy newQA column to QACode to update

F17a_ExpectedAnalytes
Shows the expected Lab, MethodName, MatrixName, AnalyteName, Fraction, And Unit for the Project and QAReviewGroup

F17b_CATCheck
Checks the MatrixName, AnalyteName, FractionName, And UnitName against the Expected fields in F17a_ExpectedAnalytes

F18b_PR_LCS-CRM
Shows the PR value in the TissueResultComments field and the expected PR value (based on Results/ExpectedValue*100)
For blank spike, LCS or CRM results

Appendix 3. QA Review Queries

Q007_analyte_ProjectMatrixLab

Provides project, matrix, and laboratory summary for sample types Composite, Grab, and Integrated

Q008_analyte_ContractedthisSet

Checks if contracted analytes have been submitted by laboratory
Note: contracted analytes for a project need to be in the table dbo_ContractAnalytes (currently only RMP Status and Trends)

Q009_AllAnalyteList

Lists all analytes and matrix for data submission, includes surrogate analytes (all analytes in ContractAnalytes and LabResults for a given project/lab/matrix)

Q011_Setup_Q_Build_luStationCode

Creates luStationCode table containing list of unique station codes/sample types for use in other queries

Q011Review0_SampleTypesExpectedVsReported

Checks sample types reported agrees with sample types expected for data submission. Provides counts of stations and results for sample types.
EventType needs to be revised as necessary;

Q011Review1_AnalytesReported

Lists analytes reported by laboratory (including surrogates & non-contract analytes)

Q011Review2_AnalytesExpectedVsReported

Checks analytes reported agrees with analytes expected for data submission. Non-target analytes will be missing Project field, missing target analytes will have empty UniqueAnalyteInLabEDD field.

Q011Review4_GenReviewOfResults

Provides summary of results, including LABQA (join of LabBatch and LabResults tables)

Build Table Queries

Q020 FieldSample Batches Protocol Project Codes

For each LabBatch with at least one field SampleType (grab int composite) shows all the possible combinations of ProjectCode and ProtocolCode for those field samples. This select query is linked in the blank and recovery maketable queries below to assign project and prototcolcodes that are missing/in error or "Not Recorded" fillers. Essentially, copies of any QC samples (aside from lab or field replicates) are made for each ProjectCode and ProtocolCode combo applicable to a LabBatch.

Q021_MkQATbl_FIELDSAMPLEStarget

Creates table TblQA_1FieldSamples containing field sample results (*grab*, *int*, or composite. Default no surrogate analytes),
Note: for datasets with FieldBlDup* sampletypes, may need to get query output to convert grab to grab, int to integrated, or else blind dupes will not be included in field replicate calculations.

Q022_MkQATbl_BLANKStarget

Creates table TblQA_2Blanks containing *blank results (default no surrogate analytes)
Note: SampleTypeCode should be LabBlank to exclude field blanks, equipment blanks, etc. if desired
NOTE: This query needs an update to automatically convert "Not recorded" ProjectCode and ProtocolCode to the appropriate project(s) to match field samples in the made tables. For the time being the made table can be updated manually by a search and replace.

Q023_MkQATbl_CRMnSpikestarget

Creates table TblQA_3CRMnSpikes containing recovery sample results (no surrogate analytes)(SampleTypes "CRM","LCM","BlankSp","LCS", or "MS*")
NOTE: This query needs an update to automatically convert "Not recorded" ProjectCode and ProtocolCode to the appropriate project(s) to match field samples in the made tables. For the time being the made table can be updated manually by a search and replace.

Completeness Queries

Q301_Completeness_1SampleTypes

Count of sample types reported; output is copied to Completeness tab of QASummary file

Q301_Completeness_2AnalyteReported

List of analytes reported

Q301_Completeness_3AnalytesBySampleType

Count of results reported by sample type and analyte (crosstab); output is copied to Completeness tab of QASummary file

Sensitivity Queries

Q401_Sensitivity_1GetFirst_FieldSample_n_Replicate

Lists only first field sample and lab replicate results (SampleReplicate and LabReplicate = 1)

Q401_Sensitivity_2Count_Smpls

Count and summary of field sample results (excludes non project samples)

Q401_Sensitivity_3Count_NDs

Count of non-detects per analyte for field samples

Q401_Sensitivity_4percentNDs

Calculates percentage of NDs per analyte and indicates those >50%; output is copied to Sensitivity tab of QASummary file

Blank Contamination Queries - evaluated on a lab batch basis

Q501_BlankContam_1CkIf_FS_BlankCorrected

Lists field sample analytes with information on whether results were blank corrected or not

Q501_BlankContam_2GetQBSummaryByBatch

Summary of lab blank (& field blanks, unless excluded by Q022_MkQATbl_BLANKStarget) analytes per lab batch with information on whether or not there is blank contamination; output is copied to Contamination tab of QASummary file. Group by SampleTypeCode ensures blank types not combined unknowingly.

Q501_BlankContam_3GetQACodesUpdate_AllFS

Summary of blank contamination codes to be added for field sample analytes; if any. The default compares field sample results to 3x the blank (stdev or avg, depending on if blank corrected, or not). Thresholds can be altered depending on project.

Q501_SampleSizes

Lists sample weights, if any, in submission. If sample weights are present, then query Q502_1BlankContam_wtcorrMkTbl_BCSamplesToUpdate is used to create the table TblBlankQualifiers

Q502_1BlankContam_basicMkTbl_BCSamplesToUpdate

Default query to create table TblBlankQualifiers; assumes all samples are the same size as the blank and thus no need for rescaling (typically AXYS water samples)

Q502_1BlankContam_corrMkTbl_BCSamplesToUpdate

Query to create table TblBlankQualifiers; run for samples with semi-constant MDLs (typically BR and CCSF samples) that are adjusted based on sample size.

Q502_1BlankContam_wtcorrMkTbl_BCSamplesToUpdate

Query to create table TblBlankQualifiers; run if sample weights are included in the EDD (typically EBMUD sediment samples, and tissue samples)

Q502a_ADD_BC_QACode_IPtest

Displays records that will be updated with VIP and VRIP codes

Q502a_ADD_BC_QACode_VRIPs

Adds "VRIP" QACodes to LabResults records; skips records with existing VRIPs, ignores the presence or absence of any previous VIPs or IPs. Those need to be stripped semi-manually later by selecting all records with both VRIP and VIP (or ,IP) in the QACode, then doing a search/replace of VIP and ,IP with null substrings.

Q502b_ADD_BC_QACode_VIPs

Adds "VIP" QACodes to LabResults records. Skips records that already contain IP

Q503_blanks_Count_VIPs

Displays count of VIPs by SampleType/Analyte/Fraction

Q503_blanks_Count_VRIPs

Displays count of VRIPs by SampleType/Analyte/Fraction

Q503_Blanks_percentVRIPs

Summarizes count of VIPs, VRIPS and %VRIPS by SampleType/Analyte/Fraction

Accuracy Queries - evaluated on a project or dataset level

Q601_Accuracy_1CRM_Run For Project

Lists CRM and/or LCM analyzed

Q601_Accuracy_2CRM_Results

Calculates CRM and/or LCM results recovery and error % and xMDL (ratio of ExpectedValue over the MDL)

Q601_Accuracy_3CRM_AvgRecovery_GT3xMDL

Averages recovery and error % for CRM analyte results that are >3 times the MDL (only results >3 times MDL are used in accuracy evaluation)

Q602_Accuracy_1MS_Run For Project

Count of MS/MSD samples analyzed

Q602_Accuracy_2MS_Results

Summarizes MS/MSD results with calculation & check of PR values, and ratio of FS/MS ExpectedValue, ExpectedValue/MDL

Q602_Accuracy_3MS_AvgRecovery_getxFS

Summarizes MS/MSD results with check of [FSResult]/[ExpectedValue] values (if [FSResult]/[ExpectedValue]is >0.5 then the analyte can not be evaluated for recovery as the recovery is dominated by analytical noise of the parent field sample (FS))

Q602_Accuracy_4MS_AvgRecovery_GT3xMDL

For precision summary, averages and lists results for MS/MSDs with ExpectedValues that are >3 times the MDL (only results >3 times MDL are used in precision evaluation). Does not use the [FSResult]/[ExpectedValue] check, as size of MS relative to parent sample does not matter as much for precision. RSDs are calculated on raw values if ExpectedValues differ by <1% RSD, on recoveries if >1%.

Q602_Accuracy_4MS_AvgRecovery_GT3xMDL&2xFS

For accuracy summary, averages and lists results for MS/MSDs with ExpectedValues that are >3 times the MDL (only results >3 times MDL are used in accuracy evaluation), AND where the [FSResult]/[ExpectedValue] check is <0.5. The latter matters for accuracy not to be dominated by parent sample quantitation uncertainty. RSDs are calculated on raw values if ExpectedValues differ by <1% RSD, on recoveries if >1%.

Q603_Accuracy_1BlankSpikes_Run For Project

Count of BlankSpike and LCS samples analyzed

Q603_Accuracy_2BlankSpike_Results

Summarizes BlankSpike and LCS results with check of PR values

Q603_Accuracy_3BlankSpike_Avg_GT3xMDL

Averages and lists BlankSpike and LCS recovery and error % for samples with ExpectedValue that are >3 times the MDL (only results >3 times MDL are used in accuracy and precision evaluation)

Q604_Accuracy_RepsSummary

Summary of all recovery SampleType (CRM/LCMS, MS/Ds, BlankSp/LCSs) results for accuracy evaluation; output is copied to Accuracy tab of QASummary file.

Precision Queries - evaluated on a project or dataset level

Q701_Precision_1FieldSample_FindRepsForProject

Lists maximum sample replicate and lab replicate number for field samples along with count of results by analyte for each sample. Groups by station and date as an "event", may need to add SampleTime for loading studies and other projects with multiple non-replicate samples in a day.

Q701_Precision_2FieldSample_NumSamplesRunInReplicate

Lists field samples with maximum lab replicate number >1

Q701_Precision_3CalcRSD

Summary of field sample replicate results with check of RPD values, groups by SampleReplicate and SampleID

Q701_Precision_4AvgRSD_GT3xMDL

Lists and averages field sample replicate RSD results that are >3 times the MDL (only results >3 times MDL are used in precision evaluation)

Q701_Precision_5TEST_Eval_SourceData

? An orphaned query with no apparent reference to /use by another query. Seems to have compiled RSDs like Q701_Precision_4AvgRSD_GT3xMDL but without xMDL condition.

Q702_Precision_1FindFieldSampleReps

Lists maximum sample replicate and count of lab replicates for field samples

Q702_Precision_2CalcRSD

Summary of field sample replicate results with check of RPD values, combining all lab and/or field replicates. For tissue samples with >1 species per site you may need to add group by Species for this to work meaningfully.

Q702_Precision_2CalcRSD_xTab

Summary of field sample replicate results with check of RPD values (Crosstab Display)

Q702_Precision_2CalcRSDold

A condensed summary of field sample replicate results with check of RPD values

Q702_Precision_4AvgRSD_GT3xMDL

Lists and averages field & lab dupe RSD results that are >3 times the MDL (only results >3 times MDL are used in precision evaluation)

Q703_Precision_RepsSummary

Summary of replicate results (Lab, field, CRM, MSD, LCS reps) for precision evaluation; output is copied to Precision tab of QASummary file. For precision this one uses Q602_Accuracy_4MS_AvgRecovery_GT3xMDL as opposed to the *2xFS version because usability of RPD for an MS is less dependent on how big the spike is above the native sample (as compared to the REC).

Queries for Comparing Fraction Results - water samples only

Q801_DisVsTotal_1GetFieldSamples_NDis0

Crosstab per SampleReplicate and LabReplicate with dissolved, particulate, and total fraction results in columns, with NDs treated as zero (SFEIresult in TblQA_1FieldSamples)

Q801_DisVsTotal_2GetRatio_DissToTotal

Calculates and displays dissolved/total and dissolved/particulate result ratios

Q801_DisVsTotal_3CntWhereRatioGT1

Displays count of dissolved/total ratios >1

Q802_DisVsPart_3Summary

Displays average, min, and max of dissolved, particulate and dissolved/particulate ratio results by analyte, for organics sets (where diss & part reported, and total calculated after review)

Q802_DisVsTotal_3Summary

Displays average, min, and max of dissolved, total and dissolved/total ratio results by analyte, for trace elements and other analytes reported as dissolved and total (the latter analyzed rather than calculated from sum of diss & part)

Queries For Comparing To Historic RMP Results

Q901_CompPrevYrs_10Get_HistRMPST_FieldSample_GetData

Selects historic RMP field sample data (from tblCANNED), set appropriate analyte group and test material here. If the tables for CD3 go fully dynamic this will eventually need to be changed to the dynamic output that would be used. For non bay/RMP projects these might not be appropriate to compare to.

Q901_CompPrevYrs_11Get_HistRMPST_FieldSample_GetData

Displays summary of historic RMP field sample data by analyte, cruise, matrix

Q901_CompPrevYrs_2Get_HistRMPST_FieldSample_CntNDs

Displays count of non-detects for historic RMP field sample data by analyte, cruise, matrix

Q901_CompPrevYrs_3Get_HistRMPST_FieldSample_SummaryByCR

Displays summary of analyte/fraction by cruise, including calculation of percent non-detects, for historic RMP field sample data

Q901_CompPrevYrs_4Get_HistRMPST_FieldSample_Final_AnnualAvg

Displays summary of analyte/fraction annual stats, averaged across cruises, for historic RMP field sample data

Q901_CompPrevYrs_5TESTGet_HistRMPST_FieldSample_IndResults

Lists all historic field sample results individually - select by applying conditions/match criteria

Q901_GetCurrentEDD_1FieldSample_Summary

Displays summary of current EDD field sample data grabbing from TblQA_1FieldSamples

Q901_GetCurrYrs__FieldSample_SummaryByCR

same as above query except grabbing summary from Q401 percent NDs query

Q901_GetLabResultEDD_1FieldSample_Summary

same as above query except grabbing straight from LabResults and LabBatch tables

Q902_DisVsTotal_1GetHISTFieldSamples_NDisNull

Crosstab of results with fraction column headers for historic RMP field sample data with NDs treated as zero (uses Q901_CompPrevYrs_5TESTGet_HistRMPST_FieldSample_IndResults)

Q902_DisVsTotal_2GetHISTFieldSamples_DTRatio

Calculates and displays dissolved/total result ratios for historic RMP field sample data (only sites with both diss & total)

Q902_DisVsTotal_3GetHISTFieldSamples_DTRatioSummary

This works to summarize the above if you constrain the dataset to subsets with valid DT ratios. Worked with water PCB*, cruise 20*. The query creates a summary by cruise of the DT ratio per analyte.

Q903_CompPrevYrs_10Get_HistGS

Needs table TblRMPS&T_WQT which is the "canned" semi static table used for WQT. If the tables for CD3 go fully dynamic this will eventually need to be changed to the dynamic output that would be used. For non RMP projects these might not be appropriate to compare to.

Q903_CompPrevYrs_11Get_GranuleResults

Needs query above

Update Queries

The QA0* series queries are used to update QACodes with accuracy and precision qualifiers, same as those in use SL_v2 database.

QA01_update_QualnotNull_test_SWAMP

QA012_update_QualnotNull_run_SWAMP

Both these use tblFinalQualifiers to find analyte matrix combos that get precision or recovery qualifiers. tblFinalRQualifiers and tblFinalPQualifiers are used to store recovery and precision qualifiers that are applied, copied to tblfinalQualifiers to apply updates (or else we would need 2x the number of update queries to look at each table type). Qualifiers first applied to records that already DO NOT have "None" or null as the QACode. Both precision and recovery qualifiers could be put into the same tblfinalQualifiers table if there are no analytes that have both.

QA01_update_QualNull_test_SWAMP

QA012_update_QualNull_run_SWAMP

Then qualifiers applied to records that have "None" or null as the QACode. Repeat, switching tblfinalQualifiers to a copy of the other (P or R) version as needed. This is especially where the queries break down if both precision and recovery QACodes are in the same tblfinalQualifiers; only one of the qualifiers gets applied (once the QACode is added the record no longer meets the condition of a Null or "None" QA Code, so the other qualifier is skipped).

LabBatch Update Summary Queries

These queries are made to try and quickly identify LabBatches that need VMDs (indicating qualified records)

QA999 BatchComplianceCrosstab

Gives a count or records with a given ComplianceCode in each batch

QA999 qualified LabBatch

Gives a listing of unique QACodes for each LabBatch (to give a sense of what to write in LabBatchComment)

QA999 VMD LabBatch create
QA999 VMD LabBatch update

Makes a table of LabBatch that need VMD added to BatchVerificationCode, and updates those records.

Appendix I: TIE Communication Protocol

The TIE Committee shall be notified by the laboratory via email on the day an observation is made that a sample (or samples) exceeds the TIE trigger. If the trigger occurs on a weekend, the lab should call or send a text message to subcommittee members if possible.

The TIE trigger protocol should be followed for all samples where there is > 50 percent effect (for *either* chronic and acute tests, at *any* point during the test, and for *all* test organisms and *all* endpoints). Specific TIE treatments will follow those in Table 26.1 unless the laboratory recommends alternative procedures, or the TIE Committee makes alternative decisions. Direction from the TIE Committee to the laboratory will also be communicated exclusively through the CVRWQCB SWAMP contract manager. In addition, the SWAMP QA Officer will be cc'ed on email communications or otherwise kept informed by the program manager.

Notification from the laboratory will provide preliminary results of the associated control(s) and affected sample(s), identify the species affected, and preliminary confirmation of the test validity (e.g., Test Acceptability Criteria met; water quality parameters were within the acceptable range). The availability of laboratory resources and possible timing for conducting additional testing will also be communicated to the TIE Committee so that any potential scheduling issues can be considered in TIE decisions (e.g., delays for ordering test supplies, organisms, or days when tests can/cannot be started).

Within 24 hours of test result notification from the laboratory, the TIE Committee will review the laboratory results, discuss (i.e., over email or a conference call), and make a consensus decision regarding whether and how to proceed with a TIE. The TIE Committee will approve TIEs based on the degree of effect, available funding, chemical data, and other available information (e.g., pesticide application reports).

The CVRWQCB SWAMP contract manager will then inform the laboratory of the Delta RMP toxicity subcommittee's decision. TIEs will be initiated by the laboratory within 24 hours of notification (i.e., within ~48 hours of the observation of a TIE trigger exceedance) and not more than 96 hours after the TIE trigger.

It is critical to make decisions and start any testing as soon as possible to minimize the potential loss of a toxicity signal (e.g., due to sorption to sample containers, degradation, or transformations) and every attempt will be made to minimize the time between sampling and testing. However, extenuating circumstances may delay TIE initiation beyond these goals (e.g., organisms need to be ordered from a supplier). These delays will be communicated to the TIE Committee and documented so that corrective actions/alternative planning can be considered for the next sampling event.

Decisions and their rationale will be documented to justify the intended objective and benefits of any additional use of resources. Issues and their resolution will also be documented to inform decisions for future TIE testing if the issue arises again (i.e., by providing the information indicated in Table 26.2).

The toxicity testing laboratory will proceed with the default course of action according to the decision flowchart (Figure 26.1) in the absence of clear direction from the TIE Committee (e.g., if none of the subcommittee members are available).

The Delta RMP TIE Committee consists of the following TAC members:

- Cameron Irvine (Robertson-Bryan, Inc.) – TAC alternate for waste water dischargers
- Stephen Clark (Pacific EcoRisk Laboratory) – Representing agriculture
- Melissa Turner (MLJ Environmental) - TAC member for agriculture

Other collaborators who will be involved in discussion of toxicity and TIEs include:

- Marie Stillway (AHPL) – Laboratory Manager; conduct toxicity tests and TIEs
- Alisha Wenzel (Central Valley Regional Water Quality Control Board) – SWAMP/ Regional Project Manager (may identify a designee)
- Matt Heberger (SFEI-ASC) – Delta RMP Program manager, Liaison to the Delta RMP TAC
- Liz Miller (SFEI-ASC) - staff chemist and toxicologist
- Stephen McCord – Delta RMP TAC chair
- Jim Orlando (USGS) – Laboratory Manager; conduct chemical analyses of surface water samples; report preliminary results to the TIE Committee upon request
- Bryn Phillips (UC Davis Granite Canyon Laboratory) – SWAMP Toxicity Work Group
- Stephen Louie (California Department of Fish and Wildlife)

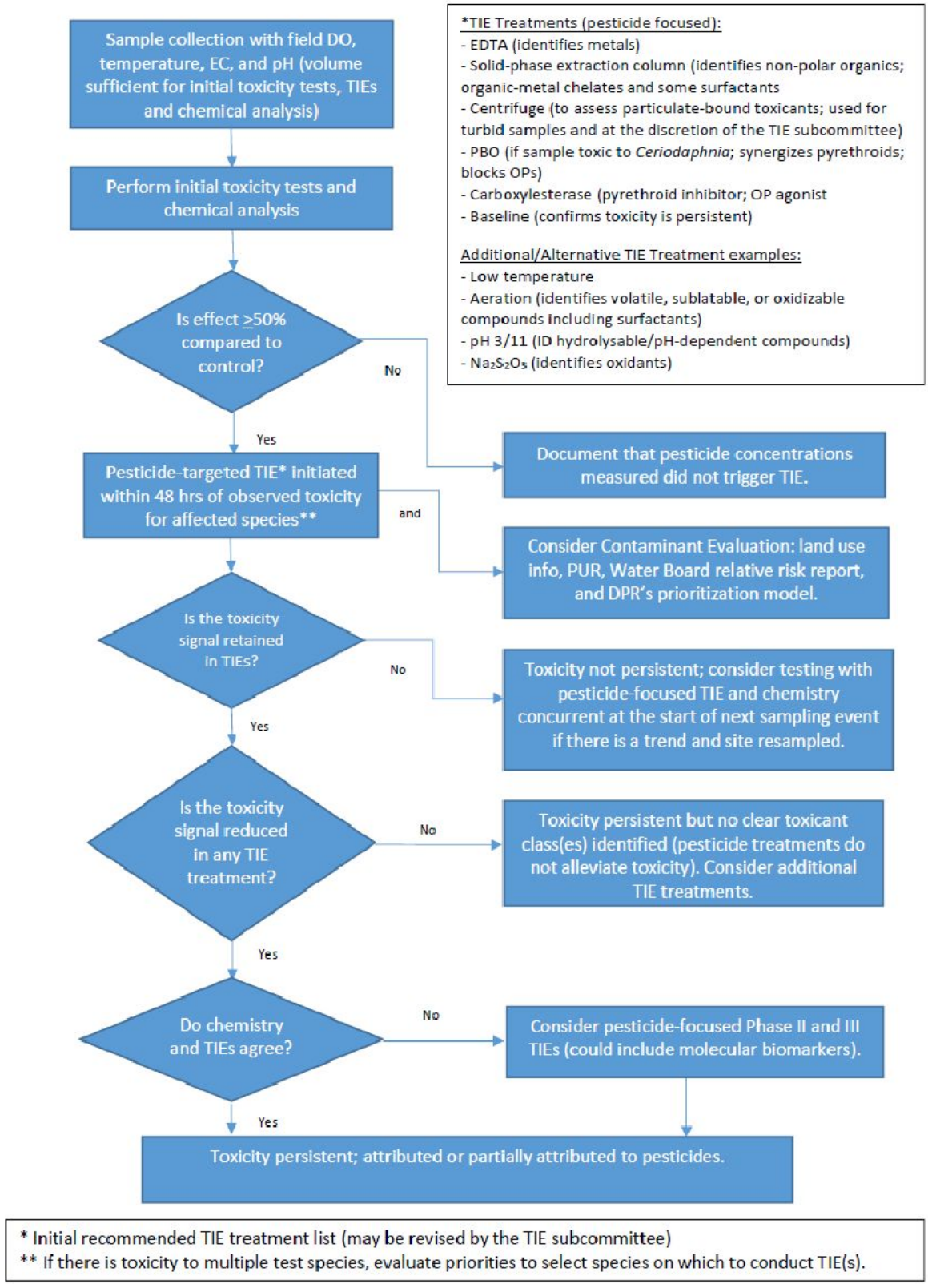

Figure 26.1 Flowchart illustrating decision-making process for initiating TIEs.