Research and Monitoring Program
Quality Assurance Project Plan

Version 2.2 (Public)
April 15, 2020

Prepared by:
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In collaboration with:
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NOTE

This Version 2.2 is an amended public copy of Sierra Pacific Industries' *Research and Monitoring Quality Assurance Project Plan* Version 2.0 (April 15, 2020). A full revision history is detailed in the table below.

Version	Description
2.0	Original internal version of the April 15, 2020 document
2.1	Original public version of the April 15, 2020 document (proprietary and/or confidential information has been truncated)
2.2	Amendment to 2.1 that includes Table 24 (i.e., *Quality Control: Conventional Analytes in Water*) and Table 25 (i.e., *Recommended Corrective Action: Conventional Analytes in Water*) updates to reflect Caltest silica analyses

Group A: Project Management

A1: TITLE AND APPROVAL SHEET

DOCUMENT SUMMARY

Table 1: Document Summary

Lead Organization	Sierra Pacific Industries PO Box 496028 Redding, CA 96409 http://www.spi-ind.com/
Primary Contact	Cajun James, Ph.D. Program Director; Quality Assurance Manager Research and Monitoring Program Sierra Pacific Industries PO Box 496028 Redding, CA 96049 (530) 378-8151 cjames@spi-ind.com
Effective Date	April 15, 2020

APPROVALS

Cajun James, Ph.D.; Program Director, Quality Assurance Manager
Research and Monitoring Program, Sierra Pacific Industries

Cajun James ______________________ 4/15/2020 ______________
Signature Date

William Hagan; Quality Assurance Oversight Manager
Quality Assurance Services, Marine Pollution Studies Laboratory, Moss Landing Marine Laboratories

______________________ 04/15/20 ______________
Signature Date

ACKNOWLEDGEMENTS

This document represents the contributions of numerous individuals and organizations, including:

- Sonya Allahyari (Caltest Analytical Laboratory)
- Lee Benda, Ph.D. (TerrainWorks)
- Autumn Bonnema (Marine Pollution Studies Laboratory - Department of Fish and Wildlife)
- Alan Fox (Fox Weather, LLC)
- William Hagan, Marco Sigala, Stacey Swenson, and Beverly H. van Buuren (Marine Pollution Studies Laboratory at the Moss Landing Marine Laboratories)
- Morgan Hannaford, Ph.D. (Shasta College)
- James Harrington and Daniel Pickard (California Department of Fish and Wildlife Aquatic Bioassessment Laboratory)
- Bruce Krumland, Ph.D. (Private Consultant)
- Roxanne Moore and Jeff Schindler (North Coast Laboratories, Ltd.)
- Research Foresters (Sierra Pacific Industries Research and Monitoring Program)
- Rosalina Stancheva, Ph.D. (California State University at San Marcos)

RECOMMENDED CITATION

James, C. *Research and Monitoring Program Quality Assurance Project Plan*; Sierra Pacific Industries: Redding, CA, 2020.

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A3: DISTRIBUTION LIST

OFFICIAL DISTRIBUTION

This quality assurance (QA) project plan (QAPP) will be officially distributed to representatives from Sierra Pacific Industries (SPI), and to SPI contractors specializing in quality management, field sampling and analysis, laboratory analysis, and consulting. Details are presented in Table 2.

Table 2: Quality Assurance Project Plan Distribution List

Recipient	Mailing Address
Brian Adair Research Forester Lead (530) 378-8192 badair@spi-ind.com	Sierra Pacific Industries Research and Monitoring PO Box 496028 Redding, CA 96409
Sonya Allahyari Chemistry (707) 258-4000 sonya_allahyari@caltestlabs.com	Caltest Analytical Laboratory 1885 N Kelly RD Napa, California 94558
Lee Benda, Ph.D. Scientific Advisor (530) 926-1066 leebenda@gmail.com	TerrainWorks 310 N Mt. Shasta BLVD, STE 6 Mt Shasta, CA 96067
Autumn Bonnema Chemistry (831) 771-4175 bonnema@mlml.calstate.edu	Moss Landing Marine Laboratories Marine Pollution Studies Laboratory 7544 Sandholdt RD Moss Landing, CA 95039
Alan Fox Scientific Advisor (707) 725-8013 alan@foxweather.com	Fox Weather, LLC 726 13th ST, STE A Fortuna, CA 95540
William Hagan Quality Assurance Oversight Manager (206) 527-3313 whagan@mlml.calstate.edu	Moss Landing Marine Laboratories Marine Pollution Studies Laboratory 7544 Sandholdt RD Moss Landing, CA 95039
Morgan Hannaford, Ph.D. Scientific Advisor (530) 242-2324 mhannaford@shastacollege.edu	Shasta College 11555 Old Oregon Trail PO Box 496006 Redding, CA 96049-6006

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Dan Pickard Project Lead - Benthic Macroinvertebrates (530) 898-4792 dpickard@csuchico.edu	California State University at Chico Aquatic Bioassessment Laboratory 400 W First ST Chico, CA 95929-0555
Marco Sigala Bioassessment Studies Manager (831) 771-4173 msigala@mlml.calstate.edu	Moss Landing Marine Laboratories Marine Pollution Studies Laboratory 7544 Sandholdt RD Moss Landing, CA 95039
Rosalina Stancheva, Ph.D. Project Lead - Algae Analysis (858) 231-0506 rhristov@csusm.edu	California State University at San Marcos Department of Biological Sciences 333 S Twin Oaks Valley RD San Marcos, CA 92096

ADDITIONAL DISTRIBUTION

While the individuals specified in Table 2 formally received a copy of this approved QAPP, the document was also informally distributed to various individuals and organizations that may benefit from partnering with SPI:

- California Board of Forestry (BOF)
- California Department of Fish and Wildlife (CDFW) Timberland Conservation Program
- California Department of Forestry and Fire Protection (CAL FIRE) – Fresno, Redding, and Santa Rosa offices
- California Geological Survey
- Central Valley Regional Water Quality Control Board (RWQCB) – Rancho Cordova and Redding offices
- Bruce Krumland (Scientific Advisor)
- Lahontan RWQCB
- National Fish and Wildlife Foundation

- State Water Resources Control Board (SWRCB) – Surface Water Ambient Monitoring Program (SWAMP); California Environmental Data Exchange Network (CEDEN)

This informal distribution was intended to:

- Increase the transparency of SPI's forest management activities
- Promote collaboration among SPI and its stakeholders
- Demonstrate SPI's commitment to sustainability and QA

A4: PROJECT/TASK ORGANIZATION

In January 2017, SPI began partnering with the QA Services Group at the Marine Pollution Studies Laboratory (MPSL) at the Moss Landing Marine Laboratories (MLML) to develop a comprehensive QA system for SPI's Research and Monitoring Department. In this system, SPI and MPSL serve in oversight roles, with project managers and scientific advisors representing a variety of other organizations.

OVERSIGHT

Cajun James, Ph.D. – Sierra Pacific Industries

Program Direction, Quality Assurance Management

Since 2000, Dr. Cajun James has worked at SPI to establish the Research and Monitoring Department. She develops and directs several large monitoring networks, integrating water quality studies with the largest private weather station and repeater network in the United States. Dr. James' specialties include water quality, benthic macroinvertebrates (BMIs), land-use related erosion, instream wood recruitment, canopy cover estimation, near stream microclimate studies, watershed analysis, pre- and post-wildfire sedimentation, riparian responses to forest management and wildfire, rare plant surveys, road erosion inventories and modelling, and creating daily Project Activity Levels (PALs) using the National Fire Danger Rating System (NFDRS).

As Program Director, Dr. James:

- Ensures that SPI's research and monitoring is implemented in a manner consistent with project QA documentation (including this QAPP)
- Ensures that SPI's research and monitoring is implemented in a manner consistent with the *Sustainable Forestry Initiative*
- Reviews and approves project QA documentation (including this QAPP)
- Is responsible for the accuracy, completeness, and scientific defensibility of all data and publications produced
- Is responsible for obtaining all services and deliverables for the project

- Approves data for use

As Quality Assurance Manager, Dr. James:

- Creates and maintains this QAPP and any relevant standard operating procedures (SOPs)
- Reviews and approves project QA documentation (including this QAPP)
- Implements project QA documentation (including this QAPP)
- Is responsible for the accuracy, completeness, and scientific defensibility of all data produced under this project
- Coordinates with MPSL's QA Oversight Manager as necessary
- Approves data for use

<u>William Hagan – Marine Pollution Studies Laboratory</u>

Quality Assurance Oversight

William Hagan of the MPSL QA Services Group provides objective, third-party QA oversight of SPI's Research and Monitoring Department. Since joining MPSL in 2005, Will has partnered with the SWRCB (Surface Water Ambient Monitoring Program, California Integrated Water Quality System), CDFW (Office of Water, Office of Spill Prevention and Response), several RWQCBs, the CALFED Bay-Delta Program, and numerous other public, private, and non-profit organizations. The scope of this work has included ambient monitoring, spill response, instream flow, habitat studies, and bioassessment. As QA Oversight Manager, Mr. Hagan:

- Reviews and approves project QA documentation (including this QAPP)
- Creates and maintains this QAPP and any relevant SOPs
- Audits SPI on an annual basis
- Provides presentations to SPI and externally to other groups as needed
- Provides QA training as needed
- Assists the program director in developing measurement quality objectives (MQOs) and QA systems that meet SPI objectives
- Ensures comparability with SWRCB's SWAMP

BIOASSESSMENT STUDIES MANAGER AND PROJECT LEADS

Brian Adair – Sierra Pacific Industries

Water Quality Stations, Weather Stations

Brian Adair became an SPI researcher in 2008 before being designated the Research and Monitoring Department's Research Forester Lead in 2016. As Research Forester Lead, Mr. Adair:

- Downloads and formats data from long-term monitoring of microclimate and water quality sites
- Analyzes data onsite to ensure that equipment is functioning properly
- Calibrates water quality equipment
- Builds, deploys, and maintains an expanding network of fire weather stations and repeaters
- Performs ground cover and riparian surveys of forest-fire-burned areas on SPI property
- Performs sediment/erosion surveys relating to sediment production
- Schedules time-sensitive tasks
- Oversees the work of Research Foresters
- Ensures crew compliance with SOPs
- Follows a "no surprises" policy using real-time QC communication
- Prepares and reviews elements for this QAPP as needed
- Acknowledges necessary lead and turnaround times
- Acknowledges corrective actions
- Provides routine contact with Program Director
- Communicates with the Program Director and the QA Oversight Manager when QA requirements are not met and when systemic QA issues are identified
- Initiates the corrective action process when isolated QA issues are identified

Roxanne Moore - North Coast Laboratories, Ltd.

Chemistry Analyses

Roxanne Moore received a BS in Chemistry from Humboldt State University and has been employed at North Coast Laboratories (NCL) since 1987. Roxanne has worked as a bench chemist, gas chromatograph and high-performance liquid chromatography analyst, organic laboratory supervisor, laboratory manager and director of operations. She currently is a project manager
As the chemistry analyses Project Lead, Ms. Moore:

- Ensures that the overall project is completed according to the proposed plan in consultation with the Program Director and Bioassessment Studies Manager
- Ensures that laboratory work is conducted and that data are reported accordingly
- Oversees data reporting, including field data entry and laboratory reporting as well as overall data completeness and quality control checks
- Verifies laboratory compliance with SOPs and methods
- Follows a "no surprises" policy using real-time QC communication
- Prepares and reviews elements for this QAPP as needed
- Acknowledges necessary lead and turnaround times
- Acknowledges corrective actions
- Provides routine contact with the Program Director, QA Oversight Manager, and Bioassessment Studies Manager
- Follows a "no surprises" policy using real-time QC communication
- Acknowledges necessary lead and turnaround times
- Communicates with the Program Director, QA Oversight Manager and Bioassessment Studies Manager when QA requirements are not met and when systemic QA issues are identified
- Initiates the corrective action process when isolated QA issues are identified

<u>Daniel Pickard - California Department of Fish and Wildlife Aquatic Bioassessment Laboratory</u>

Benthic Macroinvertebrate Analyses

Daniel Pickard has over 25 years of experience identifying aquatic invertebrates from all areas of the United States using standard taxonomic principles, dichotomous keys, extensive literature review, and colleague interaction. Mr. Pickard's background also includes research, teaching, BMI-related software applications, and curation of BMI museum specimens. As the BMI Project Lead , Mr. Pickard:

- Ensures that the overall project is completed according to the proposed plan in consultation with the Program Director and Bioassessment Studies Manager
- Provides routine contact with the Program Director, QA Oversight Manager, and Bioassessment Studies Manager
- Ensures that laboratory work is conducted and that data are reported accordingly
- Oversees data reporting, including field data entry and laboratory reporting as well as overall

data completeness and quality control checks

- Verifies laboratory compliance with SOPs and methods
- Follows a “no surprises” policy using real-time QC communication
- Prepares and reviews elements for this QAPP as needed
- Acknowledges necessary lead and turnaround times
- Acknowledges corrective actions
- Provides routine contact with the Program Director, QA Oversight Manager, and Bioassessment Studies Manager
- Communicates with the Program Director, QA Oversight Manager and Bioassessment Studies Manager when QA requirements are not met and when systemic QA issues are identified
- Initiates the corrective action process when isolated QA issues are identified

Marco Sigala - Marine Pollution Studies Laboratory

Bioassessment Studies

Since 2000, Mr. Sigala has participated in many state, regional, and federal (e.g., Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA)) projects performing and managing all duties such as sample collection, logistical support, coordination of field teams and laboratories, data management, and reporting. As the Bioassessment Studies Manager, Mr. Sigala:

- Ensures that the overall project is completed according to the proposed plan in consultation with the Program Director
- Oversees field sampling
- Ensures that laboratory work is conducted and that data are reported accordingly
- Oversees data reporting, including field data entry and laboratory reporting as well as overall data completeness and quality control checks
- Ensures laboratory adherence to all QC standards outlined in this QAPP
- Verifies laboratory compliance with SOPs and methods
- Follows a “no surprises” policy using real-time QC communication
- Prepares and reviews elements for this QAPP as needed
- Acknowledges necessary lead and turnaround times
- Acknowledges corrective actions

- Provides routine contact with the Program Director, QA Oversight Manager, BMI Project Lead, chemistry analyses Project Lead, and algae Project Lead
- Communicates with the Program Director and the QA Oversight Manager when QA requirements are not met and when systemic QA issues are identified
- Initiates the corrective action process when isolated QA issues are identified

Rosalina Stancheva, Ph.D. – California State University at San Marcos

Algae Analyses

In 2007, Dr. Stancheva began algae-based stream bioassessment for SWAMP. She has developed with co-authors two SWAMP laboratory SOPs for soft-bodied algae and diatoms, based on a novel quantification method for stream algae, and an online identification tool with original images of 802 algae from California. She has published over 40 peer-reviewed articles and a book chapter on taxonomy, systematics, ecology, and biogeography of freshwater diatoms and non-diatom algae, with a concentration on molecular phylogeny of green algae and nitrogen-fixing and toxigenic cyanobacteria from streams in California - including eight new-to-science species from SWAMP's dataset. As Project Lead for algae analyses, Dr. Stancheva:

- Ensures that the overall project is completed according to the proposed plan in consultation with the Program Director and Bioassessment Studies Manager.
- Provides routine contact with the Program Director, QA Oversight Manager, and Bioassessment Studies Manager
- Ensures that laboratory work is conducted and that data are reported accordingly
- Oversees data reporting, including field data entry and laboratory reporting as well as overall data completeness and QC checks
- Ensures adherence to all QC standards as outlined in this QAPP
- Verifies laboratory compliance with SOPs and methods
- Follows a "no surprises" policy using real-time QC communication
- Prepares and reviews elements for this QAPP as needed
- Acknowledges necessary lead and turnaround times
- Acknowledges corrective actions
- Communicates with the QA Manager when QA requirements are not met
- Communicates with the QA Manager when systemic QA issues are identified

- Initiates the corrective action process when isolated QA issues are identified

SCIENTIFIC ADVISORS

Lee Benda, Ph.D. - Terrain Works

In 2014, Dr. Benda co-founded TerrainWorks, a company designed to administer the NetMap tool system. He has published over thirty journal articles and book chapters on topics ranging from the theoretical to the applied in interdisciplinary ecosystem research. Dr. Benda's specialty includes hillslope and fluvial processes. His professional work covers slope stability (e.g., landslides, debris flows, flash floods), land use related erosion processes, pre- and post-wildfire evaluations, instream wood recruitment, floodplain delineation and analysis, stochastic simulation modeling, computerized watershed analysis, and interdisciplinary research.

As a scientific advisor to SPI, Dr. Benda:

- Performs erosion modeling
- Investigates instream wood recruitment
- Provides post-fire analysis, including forest road erosion and sediment delivery
- Develops the Road Erosion and Sediment Delivery Index (READI) model

Alan Fox - Fox Weather, LLC

Alan Fox is the Director of Fox Weather, LLC, a private meteorological firm providing weather forecasting for agriculture and water management. They specialize in satellite remote sensing of rainfall, agricultural weather forecasting for California and selected other areas, and the development of new forecast technologies. Current clients include water management and flood control agencies, engineering companies who do water quality monitoring, the U.S. Army Corps of Engineers, and numerous agribusiness and construction firms. As a scientific advisor to SPI, Mr. Fox:

- Provides daily and extended weather forecasts to support forestry operations, including forest management and general fire weather support
- Provides daily spot weather forecasts for all of SPI's weather station locations, available all year
- Provides forecast weather input for NFDRS parameters to be used by SPI to calculate PALs

- Provides Haines Index forecast maps, and site-specific Haines Index forecasts out five days to assist in planning forestry operations
- Provides programming services to repackage National Weather Service (NWS) Red Flag Warning information
- Provides high resolution of weather parameters at the time of particular historical events, and prepares analyses and reports (if requested)

Morgan Hannaford, Ph.D. - Shasta College

Dr. Hannaford is a recognized expert in the use of biological indicators for evaluating water and habitat quality in streams. He is a Department Chair at Shasta College and a specialist in BMI biology, identification, sampling techniques, study design, and data analysis. Dr. Hannaford also conducts research on microhabitat stream-flow, hyporheic exchange, and their combined influence on stream water temperature patterns. He is knowledgeable with current techniques for evaluating macroinvertebrate data, including rapid bioassessment metric analysis and multivariate statistical models of benthic community structure. With over 25 years of experience in academic research, industry and agency consulting, and college teaching, he is skilled at communicating results in written reports and presentations to a wide range of interested citizens, agency groups, and scientists.

Bruce Krumland, Ph.D. – Independent Consultant

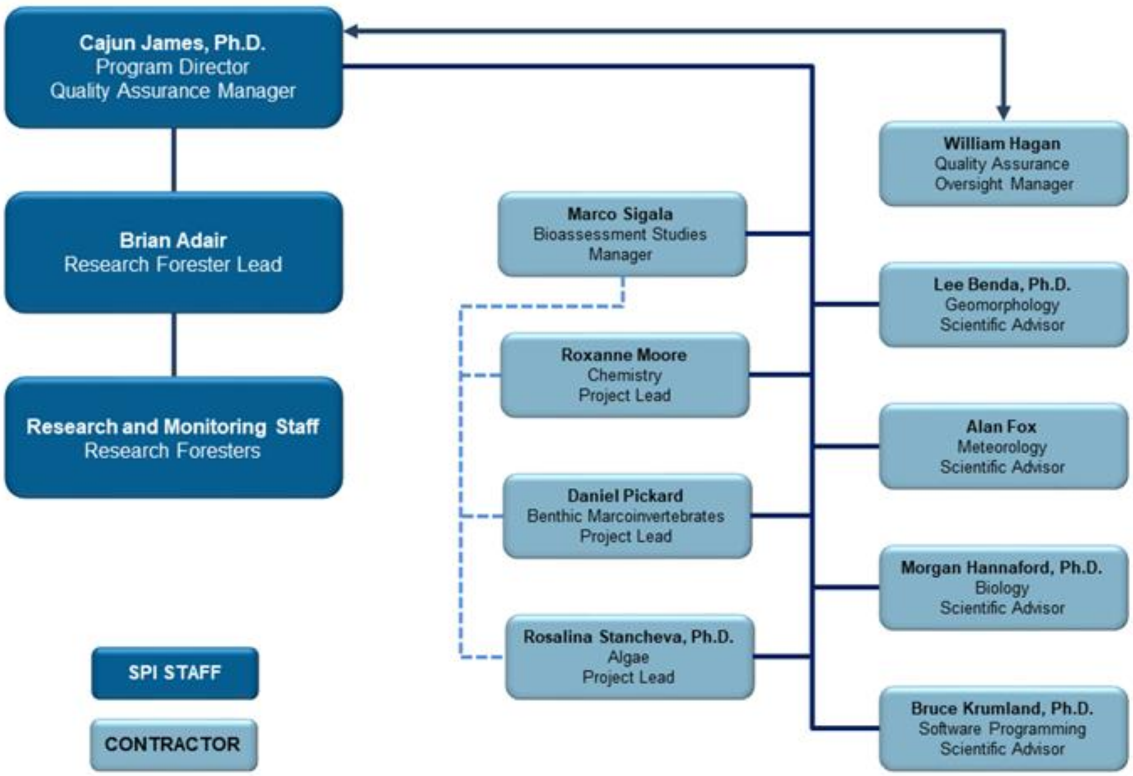
In 2000, Dr. Krumland began working as a forestry consultant doing projects with CAL FIRE, Forest Inventory and Analysis, the California Growth and Yield Modeling Cooperative, and numerous private clients. Since 2001, he has been employed continuously as a consultant by SPI's Research and Monitoring Department. Utilizing his experience with large timber inventory datasets, Dr. Krumland has partnered with the Program Director to develop a world class data storage, processing, and analysis system for SPI. As a scientific advisor to SPI, Dr. Krumland:

- Designs and manages databases
- Performs statistical analyses
- Performs customized software design and coding to support QA and data management

ORGANIZATIONAL STRUCTURE

The project QA staff specified above operates in an oversight role and are completely independent of data production. This relationship is shown in Figure 1: *Organizational Chart.*

Figure 1: Organizational Chart



A5: PROBLEM DEFINITION/BACKGROUND

BACKGROUND

SPI is committed to using scientifically defensible data of known and documented quality to inform the management of its forestlands. In 2000, SPI established its Research and Monitoring Program to study and reduce potential impacts of timber harvest operations on:

- Water quality
- Near-stream microclimate
- Stream temperature
- Sediment production
- Surface erosion
- Aquatic insects
- Fire weather
- Riparian vegetation
- Herbicide applications
- Road erosion and delivery to stream networks

While the California Forest Practice Rules (CFPRs) provide for the protection of environmental resources in forested areas, their scientific basis is unknown. SPI's Research and Monitoring Program seeks to create a transparent, accountable, and defensible dataset that fosters both scientific understanding (e.g., monitoring, publications) and practical usage (e.g., weather forecasting, hillslope erosion control methods, best management practices to reduce sediment discharge to watercourses, and road management). The broad timeframe and scope now represented by programmatic data allows SPI to optimize its actions with regard to water quality, and to justify those actions to regulators and stakeholders.

The growing dataset will also aid SPI in its creation of meaningful timber harvest plans.
Currently, timber harvest plans are submitted by registered professional foresters and are reviewed by an interdisciplinary review team consisting of:

- CAL FIRE
- CDFW
- SWRCB
- RWQCBs
- California Geological Survey

CAL FIRE is the lead agency that approves timber harvest plans in California. Members of the public are allowed to participate in timber harvest plan review process, which is functionally equivalent to the California Environmental Quality Act.

Project activities are described in the following sections below:

- Water quality stations
- Weather stations
- Bioassessment studies

Each of these activities is then further discussed with regard to its products and tools, and in the context of the National Water Quality Monitoring Council's (NWQMC's) monitoring framework.

WATER QUALITY STATIONS

Problem Statement

Prior to 2000, there were few historical data available to investigate the potential effects of forestry operations and wildfire on surrounding streams and watersheds. Of particular significance was the inability of state and federal agencies, scientists, and forest managers to evaluate water quality over time and space.

Decisions and Outcomes

Since 2001, SPI has installed 19 continuous water quality stations throughout its forestlands (see Figure 2).

Figure 2: Water Quality Station

These stations collect 15-minute data for a suite of parameters. Each water quality station collects 15-minute data for:

- Conductivity (uS/cm)
- Dissolved oxygen (%, mg/L, charge)
- Stage (ft)
- pH
- Specific conductance (uS/cm)
- Temperature (°C)
- Turbidity (Nephelometric turbidity units (NTU))

Flow and turbidity measurements are collected manually along established transects at all monitoring locations, and ISCO pump samplers are programmed to collect suspended sediment concentration samples during storm events. Four locations within a single watershed in northern California have Parshall flumes installed to measure flow (see Figure 3).

Figure 3: Flume Installation

Water quality station data are used to achieve multiple project objectives:

1. Provide long-term continuous datasets to characterize water quality parameters over time throughout SPI forestlands
2. Measure the effects of wildfires on water quality
3. Measure post-fire recovery in water quality
4. Compare measured turbidity and water temperature values to typical thresholds for adverse effects on salmonids
5. Provide long-term time series data to characterize water quality parameters over time
6. Create annual suspended sediment concentration (SSC) budgets
7. Measure the particular organic components of SSC budgets
8. Use water quality data results in context of prior timber harvest activities upstream of each station to help guide future monitoring and forest management activities
9. Submit water quality data to CEDEN and other state and federal agencies

Related Projects

Southern Exposure Research Project

Anadromous fish habitat is impacted by water temperature, which is itself impacted by the width and canopy characteristics of forested riparian buffers that surround streams. Around 2000, the significance of these buffers was a source of public debate and potential revision to the CFPRs.

Unfortunately, in the state of California, few quantitative or objective guidelines were available to manage timber operations in riparian zones. Additionally, a lack of relevant data has led to unsubstantiated proposals put forth in public forums that would result in significant regulatory takes of private forest land.

SPI, in collaboration with the University of California College of Natural Resources, petitioned the BOF to conduct riparian research to test the CFPR's ability to adequately protect aquatic resources. The Southern Exposure Research Project (SERP) was granted experimental designation status by BOF in October 2001. This ongoing, nineteen-year study examines the cumulative impacts on stream temperature, near-stream microclimate, canopy cover, water quality, and the response of aquatic organisms following clearcut harvesting of multiple units adjacent to a Class I (i.e., headwater) stream. Headwater streams make up 81% of SPI's 1.8 million acres in California.

In 2000, this project established seven, ~30-acre adjacent parcels along a stream reach (Judd Creek) that was as physically uniform as possible in stream and riparian vegetation characteristics. The stream channel was oriented east-to-west, thus having a continuous southern exposure. The odd numbered units were designated as controls and the even numbered units were treated according to Table 3.

Table 3: Southern Exposure Research Project Treatments

Year	Treatment
2000	No treatment
2001	Clear cut to 175 ft from the bank; thinned the WLPZ zone to 50% overhead canopy cover
2002	Clear-cut to 100 ft from the bank
2003	No Treatment
2004	Clear–cut to 50 ft from the bank.
2005	Economic clear-cut of all remaining conifer trees greater than 12" diameter at breast height that would not fall in the stream when harvested

Year	Treatment
2006-2008	No treatment
2009 – 2010	Patch clear cut of ~ 20-acre parcels of 13% of the drainage area
2011 – 2012	No treatment

After the initial SERP in 2005, another study was implemented by SPI. This study examined, at the watershed scale, the effectiveness of forest management practices to adequately protect water quality. A six-year, phased-in watershed-wide timber harvest plan, which was written specifically for this study, was peer-reviewed and implemented as part of a cooperative research monitoring project with the BOF Monitoring Study Group. All studies within the Judd Creek Watershed continue to contribute to a better understanding of the CFPR's ability to protect water quality and aquatic resources at multiple scales over time and space. Table 3 specifies the treatments employed at Judd Creek during the SERP.

To examine the effect of buffer width on water temperature, temperature data are collected by 332 sensors within the stream between July 1 and August 15 of each year, and utilized for analysis starting in 2000 and continuing to date. SPI's analysis of these temperature datasets concurred with other published research that this is the date range during which the maximum daily water temperature peaked each year. It also ensured a constant annual solar heat flux.

In these studies, SPI approached the problem of quantifying the effects of buffer characteristics on water temperature as a matter of physics. Thus, all factors affecting temperature were either continuously measured by sensors and dataloggers or surveyed on an annual basis. Empirical measurements produced heat fluxes through each experimental unit at each hour of every day. A simplistic temperature model produced estimates that were largely within one degree of actual empirical heat fluxes. We found that buffer sun-shading values were a primary factor in affecting stream temperature flux and that this metric would provide a much better scientific basis for regulating buffer characteristics than buffer width and overhead canopy density. We also found that at low flow levels, stream discharge, velocity, and width affected temperature flux to the same extent as shading.

Road Erosion and Sediment Delivery Index

Unpaved roads are considered to be the dominant source of land use–related sediment pollution in forested landscapes in the United States, with the potential to impact water quality and aquatic biota.

The contribution of roads to sediment pollution has led the States of Washington (Washington Department of Natural Resources, 2001) and California (California State Board of Forestry, 2013) to impose Best Management Practices (BMPs) to hydrologically disconnect forest roads from streams and reduce sediment delivery. BMPs may include:

- Paving
- Converting native surfaces to gravel surfaces
- Adding drainage structures
- Increasing outsloping
- Increasing the number of outside road segments
- Moving roads away from watercourses
- Other erosion-control practices (e.g., vegetation seeding, sediment catch basins)

To address forest road sediment production and delivery to streams, the Program Director collaborated with Terrain Works, Inc. to design and build a new forest road model called READI (Road Erosion and Sediment Delivery Index). The READI model was designed to link the condition of SPI's constructed road network with site-specific road segments and crossings that produce sediment, and to identify locations that potentially deliver erosion to the stream network. READI is designed to provide capabilities and flexibilities not currently available, as a set, in other road erosion and sediment delivery models.

The foundation for accurate, site-specific READI model results is a detailed field inventory collected on SPI's road network to enumerate, map, and assess all constructed drainage features. This process is detailed in the programmatic SOP *Road Survey and Inventory*. Crew members are systematically assigned field reconnaissance over a specified portion of SPI's road network. A pre-loaded GPS system guides trucks and/or all-terrain vehicles to individual road segments and constructed drainage features (e.g., culverts, waterbars, rolling dips). At these sites, GPS and observational data (e.g., road surface, condition) are collected on a tablet and transferred daily to cloud storage and a hardcopy map. Also assessed are the effectiveness and functioning of each road segment, constructed drainage feature, and crossing with respect to delivery of erosion sediment to the stream network

Figure 4: READI Field Reconnaissance

Within the READI model, it is possible to specify an individual design storm or a precipitation time series event, where:

- Runoff volumes are calculated as functions of time;
- Sediment production is estimated using road gradient, road surface area, surface type, and soil type as a function of time; and
- Delivery to streams is estimated by following the downslope progression of the overland-flow plume emanating from each road drain point, or discharging flow with sediment directly to streams at road crossings.

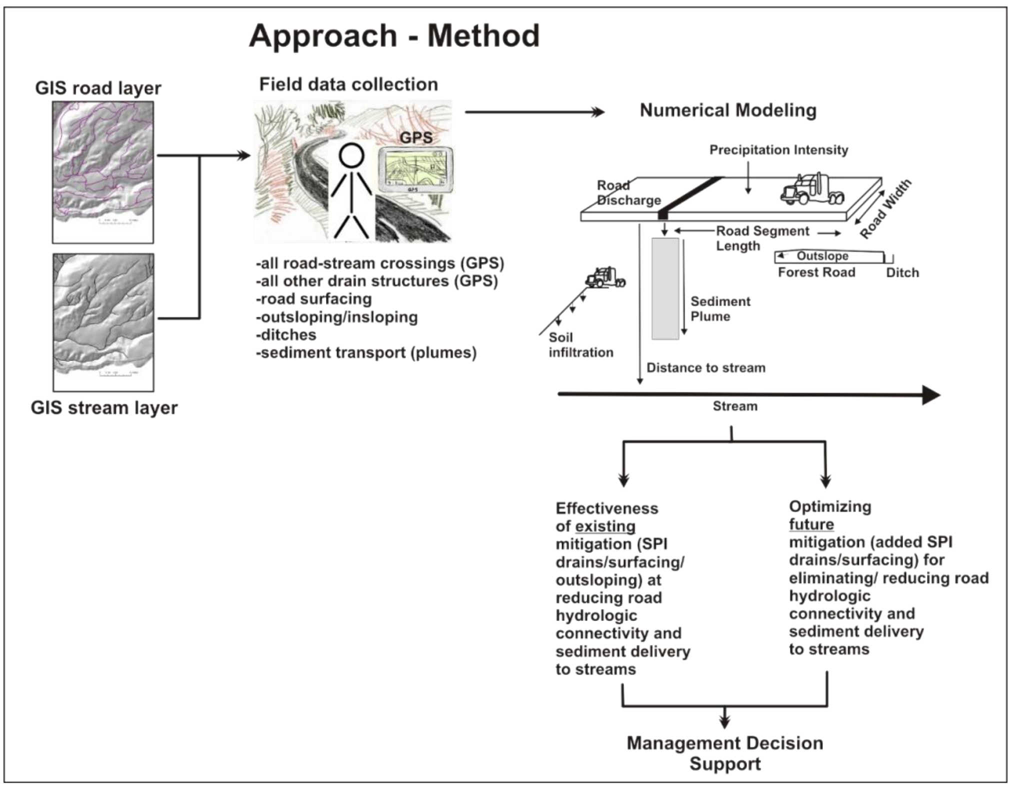
These capabilities allow SPI to:

- Predict spatial patterns of sediment production over entire road networks for a specified storm or sequence of storms;
- Predict water and sediment delivery to streams and assess hydrologic connectivity of the road and channel networks;
- See how connectivity varies with storm and soil characteristics;

- Evaluate the degree to which existing road surfacing, constructed drains, and outsloping act to reduce sediment delivery;
- Predict locations where future drains, surface upgrades and increased outsloping will maximize reductions in runoff and sediment delivery to streams;
- Predict locations where road sediment and water delivery would increase from reduced soil infiltration capacity and surface roughness associated with fire; and
- Predict locations where new drains, surface upgrades, and increased outsloping would maximize reduction in post-fire runoff and sediment delivery.

The READI process is summarized in Figure 5.

Figure 5: READI Process Summary



WEATHER STATIONS

Problem Statement

California's publicly available weather data are often insufficient to evaluate localized fire danger in areas of SPI's forest management operations. It was determined that SPI needed its own weather station network to better inform timber managers of current fire risk.

Decisions and Outcomes

Beginning in 2001, a network of weather stations and data repeaters were installed across SPI's ownership in northern California. These stations provided hourly data of critical fire-related parameters, including:

- Air temperature (°C)
- Fuel moisture (%)
- Fuel temperature (°C, °F)
- Precipitation (inches/day)
- Relative humidity (%)
- Soil moisture (%)
- Soil temperature (°C, °F)
- Solar radiation (W/m^2)
- Wind direction (azimuth/degrees)
- Wind direction deviation (azimuth/degrees)
- Wind speed (mph)

SPI's Research and Monitoring Program determines proper placement of weather stations by considering a potential site's:

- Location
- Operations
- Elevation
- Slope
- Aspect
- Topography
- Fuel conditions

Thirty-two permanent weather stations were deployed in locations that district managers and the principal research scientist deemed most representative of district lands. Up to 68 additional portable stations are deployed annually in areas where forest management operations are taking place and coverage by the permanent weather stations is determined to be unrepresentative of local operational conditions.

Figure 6: Permanent (Left) and Portable (Right) Weather Stations

Currently, SPI's weather station network produces over 64,000 data points per day. SPI's weather station data are combined with the following information to populate the NFDRS model, which provides a standardized measure of fire risk:

- Latitude/longitude
- Elevation
- Slope
- Aspect
- Forest stand type
- Grass/shrub type
- NOAA climate class
- NOAA fire weather zone
- Annual understory green-up date

The NFDRS is scientifically based and is utilized by all federal and most state agencies to assess fire danger conditions. SPI's use of the NFDRS allows for consistency in fire potential assessments with weather stations located in other areas that are used by state and federal agencies. The NFDRS is considered to be the best rating model available to predict the relationships between fuels, weather topography, and risk conditions.

SPI's Research and Monitoring Department uses two NFDRS outputs – ignition component and energy release component – to produce an evidence-based PAL rating (see Figure 7).

Figure 7: Project Activity Level Ratings

Ignition Component

Energy Release Component

	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
0-10	A	A	A	B	C	C	C	C	C	C
10-20	A	A	B	B	C	C	C	C	C	C
20-30	A	B	B	B	C	C	C	C	C	C
30-40	A	B	C	C	C	D	D	D	D	D
40-50	B	B	C	C	D	D	D	D	D	D
50-60	B	B	C	C	D	Ev	Ev	Ev	E	E
60-70	B	B	C	C	D	Ev	Ev	Ev	E	E
70-80	B	B	C	C	D	Ev	Ev	Ev	E	E
80-90	C	C	C	D	D	Ev	Ev	Ev	E	E
90-100	C	C	C	D	D	E	E	E	E	E
>100	C	C	C	D	D	E	E	E	E	E

An ongoing comparison between forecasts and actual data enhance model accuracy over time.
Each PAL rating (A-E) specifies which timber harvest activities are restricted, and which must be immediately followed by onsite inspection.

Table 4: Project Activity Level Actions

PAL	Daily Procedures and Restrictions
A	Immediately following the cessation of operations using Hot Saws, a walking foot patrol is required over all of the Hot Saw area operated that day.
B	Immediately following the cessation of operations using Hot Saws, chainsaws, ground-based tracked equipment, cable yarding, ripping, clearing, mastication, welding, blasting, or cutting torches, a walking foot patrol is required over all of the areas operated that day.
C	Immediately following the cessation of operations using Hot Saws, chainsaws, ground-based tracked equipment, cable yarding, ripping, clearing, mastication, welding, blasting, or cutting torches, a walking foot patrol is required over all of the areas operated that day. Blasting is prohibited from 1:00 p.m. until 8:00 p.m.
D	Operations using Hot Saws, cable yarding (with tail hold blocks or motorized carriages) and those additional non-cable operations listed in Level C must be suspended at 1:00 p.m. and a walking foot patrol for two continuous hours is required over all of the areas operated that day. These operational activities may continue if a walking foot patrol is conducted once every hour on all areas operated that day, with patrols commencing at 1:00 p.m. and continuing for two continuous hours after cessation of operations.
Ev	Welding, blasting, and cutting torches are prohibited. All non-landing chainsaw operations, Hot Saws, ground-based tracked equipment, cable yarding with tail hold blocks or motorized carriages, ripping, clearing, and mastication may operate until 1:00 p.m. as long as a walking foot patrol is conducted once every hour on all areas operated that day, with patrols commencing at 9:00 a.m. and continuing for two continuous hours after cessation of operations.
E & Red Flag (Non-Lightning)	All non-landing chainsaw operations, Hot Saws, ground-based tracked equipment, cable yarding with tail hold blocks or motorized carriages, ripping, clearing, mastication, welding, blasting, and cutting torches are prohibited.

SPI weather station data, SPI NFDRS PAL forecasts, spot forecasts, NOAA Red Flag Warning Information, the SPI Fire Policy, and other important weather-related information is broadcast to nearly 1,000 SPI employees and contractors via text, email, automated phone line, and daily updates to the company's Research and Monitoring Program fire weather web page.

This program has led to an increase in fire weather awareness and is the scientific foundation of the annual SPI Fire Policy. This policy provides guidance to SPI employees, Licensed Timber Operators, and contractors to minimize the incidence of ignitions and to reduce the size of potential wildfires. The SPI Fire Policy has greatly increased the awareness of fire weather conditions related to SPI forest management operations.

BIOASSESSMENT STUDIES

Problem Statement

Very little quantitative information is available on the impacts of California's forest management operations on the three most dominant biological groups that typically form stream communities (i.e., fish, aquatic invertebrates, and attached algae). To protect aquatic resources, current CFPRs limit or prohibit operations within watercourses and riparian zones. These regulations are founded on the potential of forest operations to change the condition and water quality of these habitats. Additionally, a lack of relevant data has led to unsubstantiated proposals put forth in public forums that would result in significant regulatory increases and possible takes of private forest land.

Decisions and Outcomes

Resident biota indicate both the current and recent condition of a stream's habitat, water-quality, and hydrology. In general:

- Algae reflect the conditions of the previous days to weeks
- Invertebrates reflect conditions during their lifespans of several months to a year
- Fish reflect previous conditions for as much as several years

Beginning in 2000, SPI began supporting research on the response of BMI to near-stream harvest operations. BMI were selected because fish are not sufficiently abundant within SPI's streams, and electrofishing regulatory requirements were becoming too cumbersome.

Initially, Dr. Morgan Hannaford performed rapid biological assessments for various riparian buffer widths, comparing the presence of BMI before and after harvesting. He listed taxa and numbers of invertebrates collected at the study sites. In 2014, SPI expanded BMI sampling by contracting with the Chico Foundation to have SWAMP sampling performed in 5-20 locations each year. SWAMP sampling is performed on SPI forestlands by field crews approved in the SWAMP bioassessment protocols, and the data are available in CEDEN. SWAMP data collection includes BMIs, physical habitat (PHAB), chemistry, and algae sampling to characterize water quality. SWAMP sampling has been performed near all of SPI's continuous water quality stations to compare the long-term continuous water quality results from the stations with SWAMP sampling.

Results from this research are critical to gain a better understanding of what the stream biota indicates about both the current and recent conditions of the habitat, water-quality, and hydrologic factors within SPI's forestlands. Additionally, SWAMP sampling has been performed in six fire areas to understand how perennial running streams recover from wildfires. Sample points in the

Ponderosa Fire (2012), Rim Fire (2013), King Fire (2014), Carr Fire (2018), Delta/Hirz Fire (2018), and Camp Fire (2018) have been collected for at least three years post-fire to better understand how biological stream communities recover over time.

NATIONAL WATER QUALITY MONITORING COUNCIL

The SPI Research and Monitoring Program has developed its water quality monitoring projects to be consistent with the tennants put forth by the NWQMC "Montoring Framework" (see Figure 5). The center of the NWQMC's framework states that the goal of water quality monitoring is to "understand, protect, and restore our waters". SPI strives to meet these goals through various components of its work by using best management practices and scientific research to inform timber harvest plans and land management. The elements within the middle circle of the NWQMC's framework are detailed throughout this QAPP and are summarized pictorially in Figure 5. The NWQMC's framework is meant to be used in an iterative process and therefore new results and findings may inform evolving monitoring objectives from year to year. SPI uses the NWQMC's guidance to ensure that "all components are included, balanced, connected, and collectively focused on producing quality information". Table 5 itemizes SPI's efforts in utilizing the framework as the overarching guidance to successful design, implementation, and outreach of its water quality monitoring program.

Table 5: Adherence to the National Water Quality Monitoring Framework

NWQMC Guideline	SPI Research and Monitoring Project
Develop monitoring objectives	• *Water Quality Stations:* evaluate water quality over time and space to investigate the potential effects of forestry operations and wildfire on surrounding streams and watersheds • *Weather Stations:* Evaluate localized fire danger in areas of SPI's forest management operations • *Bioassessment Studies:* Evaluate the impacts of forestry operations and fires on aquatic invertebrates and attached algae
Design monitoring program	• *Water Quality Stations:* 19 permanent stations • *Weather Stations:* 32 permanent stations with up to 68 additional seasonal stations • *Bioassessment Studies:* Determined annually or as needed (e.g., fires); generally located in the vicinity of water quality stations • EPA 24-element QA project plan
Collect field and laboratory data	• Continuous water quality data • Weather data • Flow data • BMIs • Algae • Physical habitat • Chemistry

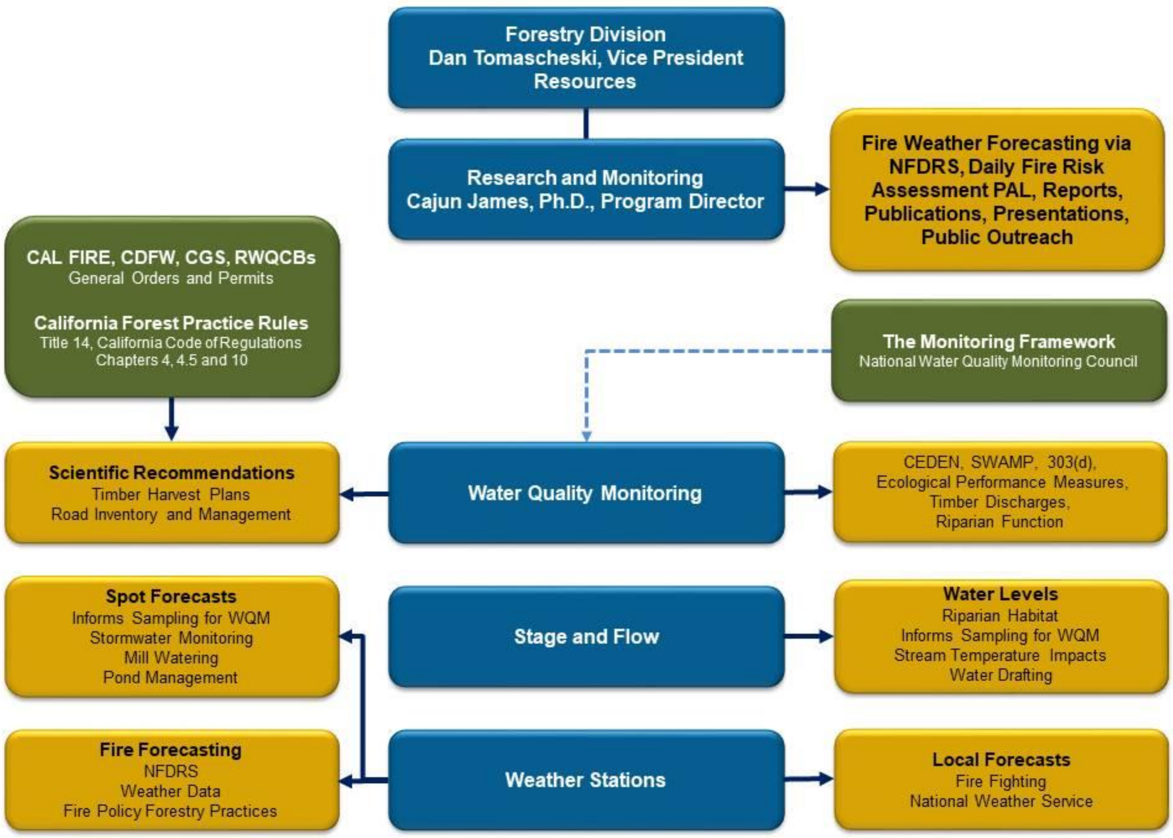
NWQMC Guideline	SPI Research and Monitoring Project
Compile and manage data	• Research data resides on ANFOSERVER • Capture of essential metadata • Use of SWAMP and CEDEN conventions
Assess and interpret data	• In-house, Ph.D. research scientist interprets data • Consultants in geology, meterology, statistical anlysis, custom sofware design, and statistical modelling • Third-party QA consulting/oversight
Convey results and findings	• CEDEN • SWRCB Integrated Report 303(d) solicitation • Peer-reviewed publications and journal articles • SPI Research and Monitoring website postings • Conference presentations • National Weather Service • Sustainable Forestry Initiative
Collaborate	• SWAMP • CDFW • MPSL/MLML • CSU CHICO • CalPoly Swanton Pacific Ranch • National Weather Service • USFS Region 5 Northern California Operations (GACC) • U.S. National Fire Danger Rating Model (2016)
Coordinate	• SWRCB • CVRWQCB Redding • National Weather Service • USFS Region 5 Northern California Operations (GACC) • U.S. National Fire Danger Rating Model (2016)
Communicate	• CEDEN • SWRCB Integrated Report 303(d) solicitation • Peer-reviewed publications • SPI website • Conference presentations • Presentations at California universities and colleges • QAPP distribution

Figure 8: National Water Quality Monitoring Council Framework

PRODUCTS AND TOOLS

Product and tool development is a core component and necessary outcome from SPI's water quality monitoring program. The Program Director reviews the program's product and tool inventory on an annual basis. Through discussions with program staff and other SPI managers, the Program Director determines the focus of product and tool development for the coming year. In addition, the annual QA audits performed by the MPSL QA Services Group address products and tools that pertain to QA such as SOPs, reports, and data documentation. The program's products and tools are used internally by SPI, and externally by government agencies, the scientific community, the timber industry, and the public. Figure 9 depicts a portion of the relationships between the program and highlighted products and tools.

Figure 9: Highlighted Products and Tools



A6: PROJECT/TASK DESCRIPTION

This element details the logistics (i.e., measurements, sample counts, scheduling, locations, and constraints) associated with SPI's:

- Water quality stations
- Weather stations
- Bioassessment studies

Element B1: *Sampling Process Design* details the experimental design behind these logistics.

WORK SUMMARY

The Research and Monitoring Program at SPI maintains weather and water quality stations, and performs ongoing bioassessment studies. This results in the collection of biotic and abiotic samples from watercourses to determine the effects of timber harvesting operations and wildfire on watercourse zones and riparian buffers.

CONSTITUENTS TO BE MONITORED

Analytes and parameters associated with SPI's water quality stations, weather stations, and bioassessment studies are detailed in the following sections.

Water Quality Stations

SPI's water quality stations are the setting for eight sonde-based analyses, as well as two manual analyses (i.e., flow, turbidity) that are performed in conjunction with sonde rotations. These constituents and their associated details are provided in Table 6.

Table 6: Water Quality Station Constituents

Analyte[1]	Organization
Conductivity (mS/cm)	Sierra Pacific Industries
Dissolved oxygen (%, mg/L, charge)	Sierra Pacific Industries

Analyte[1]	Organization
Flow[2] (ft^3/s)	Sierra Pacific Industries
pH	Sierra Pacific Industries
Specific conductance (mS/cm)	Sierra Pacific Industries
Stage (ft)	Sierra Pacific Industries
Temperature (°C)	Sierra Pacific Industries
Turbidity[3] (NTU)	Sierra Pacific Industries

[1]Unless otherwise specified, all parameters are measured via sonde
[2]Measured via flume or manually during sonde rotation
[3]Measured via sonde, and manually during sonde rotation

Weather Stations

SPI's weather stations use a variety of technologies to passively monitor weather and fire conditions. Monitored parameters and their associated details are provided in Table 7.

Table 7: Weather Station Constituents

Parameter	Organization
Air Temperature (°C)	Sierra Pacific Industries
Fuel Moisture (%)	Sierra Pacific Industries
Fuel Temperature (°C, °F)	Sierra Pacific Industries
Precipitation (inches/day)	Sierra Pacific Industries
Relative Humidity (%)	Sierra Pacific Industries
Soil Moisture (%)	Sierra Pacific Industries
Soil Temperature (°C, °F)	Sierra Pacific Industries
Solar Radiation Flux (W/m^2)	Sierra Pacific Industries
Wind Direction (azimuth/degrees)	Sierra Pacific Industries
Wind Direction Deviation (azimuth/degrees)	Sierra Pacific Industries
Wind Speed (mph)	Sierra Pacific Industries

Bioassessment Studies

SPI's ongoing bioassessment studies are performed by MPSL-MLML, NCL, the CDFW's Aquatic Bioassessment Laboratory (ABL), California State University at San Marcos (CSUSM), the Marine Pollution Studies Laboratory – Department of Fish and Wildlife (MPSL-DFW), and Caltest Analytical Laboratory. Their scope includes the analysis of algae, BMIs, conventional analytes, nutrients, and solid parameters. Details are presented in Tables 8-12, respectively.

Table 8: Bioassessment Studies - Algae

Analyte	Sample Count	Sampling Frequency	Collection Organization	Analysis Organization
Algae	5	Once annually	MPSL-MLML	CSUSM

Table 9: Bioassessment Studies - Benthic Macroinvertebrates

Analyte	Sample Count	Sampling Frequency	Collection Organization	Analysis Organization
Benthic macroinvertebrates	20	Once annually	MPSL-MLML	ABL

Table 10: Bioassessment Studies - Conventional Analytes

Analyte	Sample Count	Sampling Frequency	Collection Organization	Analysis Organization
Chloride	19	Once annually	MPSL-MLML	NCL
Chlorophyll a	5	Once annually	MPSL-MLML	MPSL-DFW
Organic carbon (dissolved)	20	Once annually	MPSL-MLML	NCL
Hardness (as CaCO3)	19	Once annually	MPSL-MLML	NCL
Silica (dissolved, as SiO2)	20	Once annually	MPSL-MLML	Caltest
Sulfate	19	Once annually	MPSL-MLML	NCL

Table 11: Bioassessment Studies - Nutrients

Analyte	Sample Count	Sampling Frequency	Collection Organization	Analysis Organization
Ammonia (as N)	19	Once annually	MPSL-MLML	NCL
Kjeldahl nitrogen (total)	19	Once annually	MPSL-MLML	NCL
Nitrate (as N)	19	Once annually	MPSL-MLML	NCL
Nitrite (as N)	19	Once annually	MPSL-MLML	NCL
Nitrogen (total)	19	Once annually	MPSL-MLML	NCL
Orthophosphate (dissolved, as P)	20	Once annually	MPSL-MLML	NCL
Phosphorus (total, as P)	19	Once annually	MPSL-MLML	NCL

Table 12: Bioassessment Studies - Solid Parameters

Analyte	Sample Count	Sampling Frequency	Collection Organization	Analysis Organization
Ash-free dry mass	5	Once annually	MPSL-MLML	MPSL-DFW
Suspended sediment concentration	19	Once annually	MPSL-MLML	NCL
Suspended solids (total)	19	Once annually	MPSL-MLML	NCL

SCHEDULE

Table 13 identifies key events related to data production and supporting activities.

Table 13: Schedule of Key Project Events

Task	Projected Start Date	Projected Completion Date	Product	Responsible Party
Internal QC Audit (field/laboratory)	Quarterly starting January 2020	Ongoing	Audit checklist	QA Manager; Research Forester Lead
Onsite program audit	Annually April - June	Annually June - Aug	Audit letter	QA Oversight Manager
QAPP review	Biennially December - March	Biennial March - May	Revised QAPP	Program Director
SOP review	Annually September - February	Annually September - February	Revised SOPs	Program Director
PHAB assessment	Annually August - October	Annually October - December	PHAB metrics; Sample results in CEDEN	Bioassessment Studies Manager
BMI sampling	Annually August - October	Annually March - May	California Stream Condition Index scores and BMI metrics; Sample results in CEDEN	Bioassessment Studies Manager and BMI Project Lead
Chemistry grab sampling	Annually August - October	Annually October - December	Sample results in CEDEN	Bioassessment Studies Manager, Chemistry Project Lead, and MPSL Data Management Team
Algae sampling	Annually August - October	Annually March - May	Algae IBI scores and metrics; Sample results in CEDEN	Bioassessment Studies Manager and Algae Project Lead

GEOGRAPHICAL SETTING

While samples for SPI's bioassessment studies are located based on sampling design, SPI's water quality and weather monitoring occur at established facilities throughout SPI's land holdings. Figure 10 provides context for the general locations of SPI's water quality and weather stations. The red insets on the map appear enlarged as Figures 11 and 12.

Figure 10: Water Quality and Weather Station Location Overview

[redacted]

Figures 11 and 12 show the specific locations associated with the northern and southern stations, respectively.

Figure 11: Northern Water Quality and Weather Stations

[redacted]

Figure 12: Southern Water Quality and Weather Stations

[redacted]

Water Quality Stations

In addition to the BMI sampling sites identified above, SPI maintains 19 designated water quality sites across multiple forestry districts. The locations of water quality sites are identified in Table 14 and detailed in the narratives that follow.

Table 14: Water Quality Station Locations

ID	Name	Label	Latitude	Longitude
498	Judd Creek 1	SEUM	[redacted]	
499	Judd Creek 2	SELM		
501	Judd Creek 3	SEU		
505	Upper USA	USAU		
509	Lower USA	USAL		
514	Judd Creek 4	SEL		
531	Hazel Creek	HAZ		
533	Papoose	PAP		
550	Judd Creek 5	SEB		
560	South Fork Digger Creek	SDC		
561	North Fork Digger Creek	DC		
562	Rock Creek	RC		
571	Upper Jawbone	UJC		
572	Lower Jawbone	LJC		
581	Upper Pilot Creek	UPC		
582	Lower Pilot Creek	LPC		
596	Upper Bailey Creek	BC1		
597	Middle Bailey Creek	BC2		
599	Lower Bailey Creek	BC3		

Southern Exposure: Station IDs 498, 499, 501, 514, 550

Southern Exposure is on the Lassen District near the town of Paynes Creek. It is home to five sondes, four flumes, and numerous dataloggers (i.e., 59 Campbell, 75 Outdoor, 75 ProAir, 69 Tidbit). The bulk of the project is over 150 chains long from top to bottom. There are three, even-age units situated on the south side of Judd Creek. The even-age units are bordered by unharvested control units on each side. The units are named as follows; Control 1 (C1), Unit A, Control 2 (C2), Unit B, Control 3 (C3), Unit C, Control 4 (C4). There is an additional unit not adjacent to the others called the Reference

Clearcut (RCC). There are three dataloggers (i.e., one Campbell, one Outdoor, one ProAir) in the RCC. 42 Tidbit dataloggers deployed throughout Judd Creek record water temperature, while the other 27 Tidbit dataloggers are deployed several miles downstream near the confluence of Judd and Antelope Creeks.

Upper San Antonio Creek: Station IDs 505, 509

Upper San Antonio Creek is on the Sonora District near the town of Arnold. There are two sonde water quality sites and nine Tidbit dataloggers.

Hazel Creek: Station ID 531

Hazel Creek is located on the Redding District eight miles South of Dunsmuir on Sims Road. There is one sonde continuously monitoring the water quality at this site all year.

Papoose Creek: Station ID 533

Papoose Creek is located within the Carr Fire (2018) east of Trinity Lake on the Redding District. There is one sonde continuously monitoring water quality at this site all year.

Greater Battle Creek: Station IDs 560, 561, 562

Greater Battle Creek is located on the Lassen District near the town of Manton. It consists of several creeks. There is one sonde at Rock Creek, one at Digger Creek, and one at South Digger Creek. The South Digger Creek sonde records stage value through a pressure transducer built into the sonde, whereas the other sonde sites record stage with a gas bubbler.

Jawbone Creek: Station IDs 571, 572

Jawbone Creek is located on the Sonora District near Cherry Lake. There are two sondes monitoring two water quality sites here. This project was installed within the boundary of the Rim Fire (2013).

Pilot Creek: Station IDs 581, 582

Pilot Creek is located on the Camino District east of Georgetown. This project was installed within the boundary of the King Fire (2014). Here, there are two sondes at two sites that monitor stream conditions continuously.

Bailey Creek: Station IDs 596, 597, 599

Bailey Creek is on the Lassen District near Viola. The bulk of the project is 106 chains long. The project consists of harvest units and control units. There are lines of Campbell dataloggers on the south side of the creek in Control C1, Unit A, Unit B and Control C3. There are seven, streambank-based Campbell dataloggers that measure water temperature located on the boundary between each unit. There are also 33 Tidbit dataloggers throughout the creek. There are three sondes in Bailey Creek. Two of the sondes monitor water quality all year. The third sonde is located several miles downstream from the other two sondes. It is removed from the field when that portion of the creek is dry, and re-deployed when flow resumes.

Millseat Creek

Millseat Creek is located on the Redding District off of Hwy 44 just east of Shingletown. There are 32 Tidbit dataloggers between chains 0 and 34.

Ponderosa Fire

There are 10 large sediment fences constructed within the boundary of the Ponderosa Fire (2012). Each fence has a Campbell datalogger, and an ultrasonic depth sensor. There are two time-lapse digital cameras mounted to each sediment fence.

Flumes

Four of the above water quality sites include flumes designed for flow measurements. Table 15 identifies the location of each flume.

Table 15: Flume Locations

ID	Site	Latitude	Longitude	District
497	SE Upper Meadow Flume	[redacted]	[redacted]	Lassen
500	SE Lower Meadow Flume	[redacted]	[redacted]	Lassen
504	SE Upper Flume	[redacted]	[redacted]	Lassen
526	SE Lower Flume	[redacted]	[redacted]	Lassen

Weather Stations

In addition to water quality stations, SPI maintains a network of permanent and portable weather stations. Permanent weather stations are deployed in locations that district managers and the Program Director deem most representative of district lands. The duration of portable weather station deployment varies, and may be year-round in special circumstances (e.g., wildfire, research project). At the end of water year 2019, 38 full time weather stations were in operation (i.e., 32 permanent stations, six portable stations deployed all year). Specific locations appear in Table 16.

Table 16: Weather Station Locations

ID	Type	Latitude	Longitude	Elevation (ft)
801	Permanent	[redacted]	[redacted]	[redacted]
802	Permanent	[redacted]	[redacted]	[redacted]
803	Permanent	[redacted]	[redacted]	[redacted]
804	Permanent	[redacted]	[redacted]	[redacted]
805	Permanent	[redacted]	[redacted]	[redacted]
806	Permanent	[redacted]	[redacted]	[redacted]
807	Permanent	[redacted]	[redacted]	[redacted]
808	Permanent	[redacted]	[redacted]	[redacted]
809	Permanent	[redacted]	[redacted]	[redacted]
810	Permanent	[redacted]	[redacted]	[redacted]
811	Permanent	[redacted]	[redacted]	[redacted]
812	Permanent	[redacted]	[redacted]	[redacted]
813	Permanent	[redacted]	[redacted]	[redacted]
814	Permanent	[redacted]	[redacted]	[redacted]
815	Permanent	[redacted]	[redacted]	[redacted]
816	Permanent	[redacted]	[redacted]	[redacted]
817	Permanent	[redacted]	[redacted]	[redacted]
818	Permanent	[redacted]	[redacted]	[redacted]
819	Permanent	[redacted]	[redacted]	[redacted]
820	Permanent	[redacted]	[redacted]	[redacted]
821	Permanent	[redacted]	[redacted]	[redacted]
822	Permanent	[redacted]	[redacted]	[redacted]
823	Permanent	[redacted]	[redacted]	[redacted]
824	Permanent	[redacted]	[redacted]	[redacted]

ID	Type	Latitude	Longitude	Elevation (ft)
825	Permanent	[redacted]		
826	Permanent			
827	Permanent			
828	Permanent			
829	Permanent			
830	Permanent			
831	Permanent			
832	Permanent			
851	Portable			
855	Portable			
868	Portable			
871	Portable			
875	Portable			
883	Portable			

These weather station locations are mapped in Figures 10-12 above.

Bioassessment Studies

While not associated with the above facilities, SPI's bioassessment studies are carried out at the well-defined sampling locations identified in Table 17.

Table 17: Bioassessment Studies – Sampling Locations

Site	SWAMP Site Code	Target Latitude	Target Longitude
Papoose Creek above North Fork Papoose Creek	106SPIPP1	[redacted]	
Digger Creek above South Fork	507DCABSF		
Digger Creek below Love Branch	507DCBLLB		
Rock Creek below Onion Creek	507RCABRS		
Rock Creek above Bailey Creek	507RCBLPF		
Onion Creek above Rock Creek	507SPION1		
Digger Creek above Mainstem	507SPISFD		
Pilot Creek below Plum Creek	514PCAPC2		
Pilot Creek above Ruby Canyon	514PCASMR		
Empire Creek at 130V	518EMPR01		

Site	SWAMP Site Code	Target Latitude	Target Longitude
Fall Creek on W-Line	518FALL01	[redacted]	[redacted]
Mosquito Creek near I-5	524MSQT01	[redacted]	[redacted]
North Fork Cottonwood Creek above Rainbow Lake	524NFCTN1	[redacted]	[redacted]
Boulder Creek above Sacramento River	525BLDR01	[redacted]	[redacted]
Clear Creek M35N06W31	525CLRC01	[redacted]	[redacted]
North Salt Creek above Sacramento River	525NSLT01	[redacted]	[redacted]
Jawbone Creek below Crane Creek	536SPILJW	[redacted]	[redacted]
Jawbone Creek above Crane Creek	536SPIUJW	[redacted]	[redacted]

CONSTRAINTS

EPA defines "completeness" as *the amount of valid data obtained compared to the planned amount - usually expressed as a percentage*. While heavy snowfall, wildlife (see Figure 13), and vandalism may impact the number of valid sample results, they are very unlikely to affect SPI's completeness goal of 90%.

Figure 13: Weather Station with Bear Damage

A7: QUALITY OBJECTIVES AND CRITERIA

A project's strategic planning process must consider each of the data quality indicators (DQIs). EPA defines DQIs as *the quantitative statistics and qualitative descriptors used to interpret the degree of acceptability or utility of data to the user*. The principal DQIs are:

- Precision
- Accuracy
- Bias
- Comparability
- Completeness
- Representativeness
- Sensitivity

Definitions associated with each DQI are provided in Table 18.

Table 18: Data Quality Indicator Definitions

Indicator	Definition
Precision	The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated as either the range or as the standard deviation.
Accuracy	A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.
Bias	The systematic or persistent distortion of a measurement process that causes errors in one direction.
Representativeness	A qualitative term that expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.
Comparability	A qualitative term that expresses the measure of confidence that one dataset can be compared to another and can be combined for the decision(s) to be made.
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.
Sensitivity	The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest.

This element describes the objectives and criteria used to assess performance in SPI's:

- Water quality stations
- Weather stations
- Bioassessment studies

Further discussion of these objectives and criteria is found in QAPP Element B5: *Quality Control*.

WATER QUALITY STATIONS

SPI's Research and Monitoring Program maintains 19 water quality stations throughout its 1.8 million acres of California forestlands. Each station uses sondes to collect continuous data for the following parameters:

- Conductivity (uS/cm)
- Dissolved oxygen (%, mg/L, charge)
- pH
- Specific conductance (uS/cm)
- Turbidity (NTU)
- Temperature (°C)

For SPI's water quality stations, DQIs are evaluated and optimized according to Table 19.

Table 19: Water Quality Stations: Data Quality Indicators

Indicator	Quality Control
Precision	• Use of the same equipment at all water quality monitoring stations • Use of the same procedures for all manual measurements • Systematic checking and calibrating of equipment per manufacturer specifications • Replacement rather than repair of defective equipment
Bias	• Fouling prevention
Accuracy	• Fouling prevention
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of the same equipment at all water quality monitoring stations • Use of paired measurements to ensure continuity between old and new technologies • Use of paired measurements to ensure comparability between manual and flume-based flow measurements • Use of paired particulate organic matter measurements to ensure continuity during method modification
Completeness	• Fouling prevention
Sensitivity	• Fouling prevention • Adherence to QAPP Element B6: *Instrument/Equipment Testing, Inspection, and Maintenance* • Adherence to QAPP Element B7: *Instrument/Equipment Calibration and Frequency*

WEATHER STATIONS

SPI's Research and Monitoring Program maintains 32 permanent and numerous temporary weather stations throughout its 1.8 million acres of forestlands in California. Each station measures the following parameters:

- Air temperature (°C)
- Fuel moisture (%)
- Fuel temperature (°C, °F)
- Precipitation (inches/day)
- Relative humidity (%)
- Soil moisture (%)
- Soil temperature (°C, °F)
- Solar radiation (W/m^2)
- Wind direction (azimuth/degrees)
- Wind direction deviation (azimuth/degrees)
- Wind speed (mph)

While there are no performance criteria associated with these measurements, results are screened against minimum and maximum values before being uploaded to the McQAQC database (see Table 20).

Table 20: McQAQC Minimum and Maximum Values

Description	Minimum Value	Maximum Value
Air temperature (°C)	-20	65
Fuel moisture (%)	-20	120
Fuel temperature (°C)	-20	80
Fuel temperature (°F)	-20	180
Precipitation (inches/day)	0	1000
Relative humidity (%)	-5	107
Soil moisture (%)	-2	100
Soil temperature (°C)	-15	80
Soil temperature (°F)	-10	180
Solar radiation (W/m^2)	-10	1500
Wind direction (azimuth/degrees)	0	360
Wind direction deviation (azimuth/degrees)	0	720
Wind speed (mph)	0	200

If a measurement is out of range, a database field is populated with a code indicating that the measurement is unusable (see Element B10: *Data Management*).

BIOASSESSMENT STUDIES

SPI's Research and Monitoring Program conducts ongoing bioassessment studies that include the following analytical categories:

- Algae
- BMI
- Chemistry
- Physical habitat

Category-specific quality objectives and criteria are specified below.

Algae Analysis

SPI's algae analyses are performed by CSUSM, and as feasible, are subject to the SWAMP-comparability guidelines of SWAMP's *Bioassessment Program Quality Assurance Project Plan*. To promote data comparability with SWAMP, SPI requires the use of the following algae collection and analysis methods:

- *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016)
- *Standard Operating Procedures for Laboratory Processing, Identification, and Enumeration of Stream Algae* (November 2015)
- *Standard Operating Procedures for Internal and External Quality Control of Laboratory Processing, Identification and Enumeration of Stream Algae in California* (November 2019)

Benthic Macroinvertebrate Analysis

SPI's BMI analyses are performed by ABL, and as feasible, are subject to the SWAMP-comparability guidelines of SWAMP's *Bioassessment Program Quality Assurance Project Plan*. An external QC SOP (see below) ensures taxonomic comparability with other SWAMP data. To promote data comparability, SPI requires the use of the following BMI collection and analysis methods:

- *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016)
- *Standard Operating Procedures for Laboratory Processing and Identification of Benthic*

Macroinvertebrates in California (October 2012)

- *Standard Operating Procedures for External Quality Control of Benthic Macroinvertebrate Taxonomy Data Collected for Stream Bioassessment in California* (July 2015)

Chemistry

The chemistry portion of SPI's bioassessment study includes the conventional analytes, nutrients, and solid parameters identified in Tables 21-23, respectively. For each analyte/parameter, locations of MQOs and recommended corrective actions are provided

Table 21: Conventional Analyte s– Criteria Table References

Analyte	MQOs	Corrective Action
Chloride	See Table 24	See Table 25
Chlorophyll a	See Table 24	See Table 25
Organic carbon (dissolved)	See Table 24	See Table 25
Hardness (as $CaCO_3$)	See Table 24	See Table 25
Silica (dissolved, as SiO_2)	See Table 24	See Table 25
Sulfate	See Table 24	See Table 25

Table 22: Nutrients – Criteria Table References

Analyte	MQOs	Corrective Action
Ammonia (as N)	See Table 26	See Table 27
Kjeldahl nitrogen (total)	See Table 26	See Table 27
Nitrate (as N)	See Table 26	See Table 27
Nitrite (as N)	See Table 26	See Table 27
Nitrogen (total)	See Table 26	See Table 27
Orthophosphate (dissolved, as P)	See Table 26	See Table 27
Phosphorus (total, as P)	See Table 26	See Table 27

Table 23: Solid Parameters – Criteria Table References

Analyte	MQOs	Corrective Action
Ash-free dry mass	See Table 28	See Table 29
Suspended sediment concentration	See Table 28	See Table 29
Suspended solids (total)	See Table 28	See Table 29

Table 24: Quality Control[1]: Conventional Analytes in Water

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Calibration Verification	Per 10 analytical runs	80-120% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Reference Material[2]	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent (n/a for chlorophyll a)	80-120% recovery (silica: 70-130%)
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (n/a for chlorophyll a)	80-120% recovery (silica: 70-130%); RPD<25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (chlorophyll a/pheophytin a: per method)	RPD<25% (n/a if native concentration of either sample<RL)
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate[3]	5% of total project sample count	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Travel Blank, Equipment Blank	Per method	<RL for target analyte

[1] Unless method specifies more stringent requirements
[2] Laboratory control sample for silica
[3] Field duplicate relative percent differences are not calculated for chlorophyll a analyses for bioassessment

Table 25: Recommended Corrective Action: Conventional Analytes in Water

Laboratory Quality Control	Recommended Corrective Action
Calibration Standard	Recalibrate the instrument. Affected samples and associated quality control must be reanalyzed following successful instrument recalibration.
Calibration Verification	Reanalyze the calibration verification to confirm the result. If the problem continues, halt analysis and investigate the source of the instrument drift. The analyst should determine if the instrument must be recalibrated before the analysis can continue. All of the samples not bracketed by acceptable calibration verification must be reanalyzed.
Laboratory Blank	Reanalyze the blank to confirm the result. Investigate the source of contamination. If the source of the contamination is isolated to the sample preparation, the entire batch of samples, along with the new laboratory blanks and associated QC samples, should be prepared and/or re-extracted and analyzed. If the source of contamination is isolated to the analysis procedures, reanalyze the entire batch of samples. If reanalysis is not possible, the associated sample results must be flagged to indicate the potential presence of contamination.
Reference Material/Laboratory Control Sample	Reanalyze the reference material to confirm the result. Compare this to the matrix spike/matrix spike duplicate recovery data. If adverse trends are noted, reprocess all of the samples associated with the batch.

Laboratory Quality Control	Recommended Corrective Action
Matrix Spike	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike to confirm the result. Review the recovery obtained for the matrix spike duplicate. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Matrix Spike Duplicate	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike duplicate to confirm the result. Review the recovery obtained for the matrix spike. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Laboratory Duplicate	Reanalyze the duplicate samples to confirm the results. Visually inspect the samples to determine if a high RPD between the results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity.
Field Quality Control	**Recommended Corrective Action**
Field Duplicate	Visually inspect the samples to determine if a high RPD between results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Travel Blank, Equipment Blank	Investigate the source of contamination. Potential sources of contamination include sampling equipment, protocols, and handling. The laboratory should report evidence of field contamination as soon as possible so corrective actions can be implemented. Samples collected in the presence of field contamination should be flagged.

Table 26: Quality Control[1]: Nutrients in Water

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

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Field Blank, Travel Blank, Equipment Blank	Per method	<RL for target analyte

[1] Unless method specifies more stringent requirements

Table 27: Recommended Corrective Action: Nutrients in Water

Laboratory Quality Control	Recommended Corrective Action
Calibration Standard	Recalibrate the instrument. Affected samples and associated quality control must be reanalyzed following successful instrument recalibration.
Calibration Verification	Reanalyze the calibration verification to confirm the result. If the problem continues, halt analysis and investigate the source of the instrument drift. The analyst should determine if the instrument must be recalibrated before the analysis can continue. All of the samples not bracketed by acceptable calibration verification must be reanalyzed.
Laboratory Blank	Reanalyze the blank to confirm the result. Investigate the source of contamination. If the source of the contamination is isolated to the sample preparation, the entire batch of samples, along with the new laboratory blanks and associated QC samples, should be prepared and/or re-extracted and analyzed. If the source of contamination is isolated to the analysis procedures, reanalyze the entire batch of samples. If reanalysis is not possible, the associated sample results must be flagged to indicate the potential presence of the contamination.
Reference Material	Reanalyze the reference material to confirm the result. Compare this to the matrix spike/matrix spike duplicate recovery data. If adverse trends are noted, reprocess all of the samples associated with the batch.
Matrix Spike	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike to confirm the result. Review the recovery obtained for the matrix spike duplicate. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Matrix Spike Duplicate	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike duplicate to confirm the result. Review the recovery obtained for the matrix spike. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Laboratory Duplicate	Reanalyze the duplicate samples to confirm the results. Visually inspect the samples to determine if a high RPD between the results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity.
Field Quality Control	**Recommended Corrective Action**
Field Duplicate	Visually inspect the samples to determine if a high RPD between results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank, Travel Blank, Equipment Blank	Investigate the source of contamination. Potential sources of contamination include sampling equipment, protocols, and handling. The laboratory should report evidence of field contamination as soon as possible so corrective actions can be implemented. Samples collected in the presence of field contamination should be flagged.

Table 28: Quality Control[1]: Solid Parameters in Water

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

[1] Unless method specifies more stringent requirements

[2] Applicable only to total suspended solids

Table 29: Recommended Corrective Action: Solid Parameters in Water

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

The following calculations are used to compare QC sample performance with MQOs:

<u>Reference Materials and Laboratory Control Samples</u>

$$\%\ \text{recovery} = \frac{V_{analyzed}}{V_{certified}} \times 100$$

Where:

$v_{analyzed}$: the analyzed concentration of the reference material or laboratory control sample (LCS)

$v_{certified}$: the certified concentration of the reference material or LCS

Matrix Spikes

$$\%\ \text{recovery} = \frac{(v_{MS} - v_{ambient})}{v_{spike}} \times 100$$

Where:

v_{MS}: the concentration of the spiked sample

$v_{ambient}$: the concentration of the original (unspiked) sample

v_{spike}: the concentration of the spike added

Matrix Spike Duplicates

$$RPD = \left| \frac{(v_{MS} - v_{MSD})}{mean} \right| \times 100$$

There are two different ways to calculate this relative percent difference (RPD), depending on how the samples are spiked.

The samples are spiked with the same concentration of analyte. In this case,

v_{MS}: the concentration for the matrix spike

v_{MSD}: the concentration of the matrix spike duplicate

mean: the mean of the two concentrations (MS + MSD)

The samples are spiked with differing concentrations of analyte. In this case,

v_{MS}: the recovery associated with the matrix spike

v_{MSD}: the recovery associated with matrix spike duplicate

mean: the mean of the two recoveries (recovery_{MS} + recovery_{MSD})

Laboratory Duplicates and Field Duplicates

$$\mathrm{RPD} = \left| \frac{(v_{\mathrm{sample}} - v_{\mathrm{duplicate}})}{\mathrm{mean}} \right| \times 100$$

Where:

v_{sample}: the concentration of the original sample

$v_{\mathrm{duplicate}}$: the concentration of the duplicate sample

mean: the mean concentration of both samples

Physical Habitat Analysis

As feasible, SPI's physical habitat analyses are subject to the SWAMP-comparability guidelines of SWAMP's *Bioassessment Program Quality Assurance Project Plan*, as well as the SWAMP performance requirements specified in the SOP: *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016).

A8: SPECIAL TRAINING NEEDS/CERTIFICATION

Training for field, laboratory, administrative, and maintenance work is conducted for all SPI Research and Monitoring technicians following the processes detailed in the SOP *Staff Training*. The SOP contains steps for training and evaluating staff as well as forms used to populate training files. These files and processes are evaluated annually through an onsite audit performed by the QA Oversight Manager from an outside organization.

This element identifies recommended and required qualifications associated with SPI's:

- Water quality and weather station staff
- Algae laboratory staff
- Bioassessment studies field staff
- BMI laboratory staff
- Chemistry laboratory staff

WATER QUALITY AND WEATHER STATION STAFF

SPI staff collecting data from stations, maintaining instruments, or conducting laboratory work must be familiar with, and trained on, any applicable project SOPs.

SPI personnel assigned to weather stations are required to attend a two-day *Tower Climber and Rescuer* training course that includes:

- Hazard assessment
- Personal protective equipment
- Fall protection
- Suspension work
- Safety planning
- Rescue and response planning

- Tower-climbing practice

Each individual must pass a written test and all field practice activities. SPI personnel that work on the Research and Monitoring weather and repeater network are required to attend this course and to receive a certificate of *Authorized Climber- Rescuer*, meeting Occupational Health and Safety CFR 1910.268 and American National Standards Institute Z359 & Z49 standards.

ALGAE LABORATORY STAFF

Contractors are required to ensure that taxonomists responsible for determining all algal specimen identifications are subject to the following requirements and recommendations:

Requirements

- Have a minimum of two years of experience identifying freshwater algae (i.e., diatoms and/or cyanobacteria, green algae, xanthophytes, chrysophytes, and red algae), preferably from stream benthos
- Hold a bachelor's degree or masters of science in botany, ecology, biology, or related field
- Possess strong academic preparation in algae taxonomy demonstrated by one or more of the following:
    - Coursework related to plant taxonomy, aquatic ecology, or limnology
    - Graduate thesis or undergraduate research projects in algal taxonomy or ecology of benthic freshwater algae
    - University-level phycology class, or soft-bodied algae and/or diatom taxonomy class
- Be able to identify algae to the SOP-recommended taxonomy levels
- Regularly attend taxonomy training and QC reconciliation workshops offered by SWAMP
- Know how to access and use SOP-recommended algae taxonomic literature (contact CSUSM for assistance with identifying relevant taxonomic literature, if necessary)
- Be proficient at using dichotomous keys to identify soft-bodied algae
- Have experience in the use of light microscopy and digital microphotography for taking high-quality algae light photomicrographs
- Have experience with standard specimen preparation techniques, including slide preparation

- Have good record-keeping and computer skills

Recommendations

- Have a knowledge and experience identifying benthic diatoms and/or soft-bodied algae from streams and rivers in California
- Have experience in culturing algae or other microorganisms
- Have experience in molecular sequencing techniques
- Have experience in algal specimen preparation techniques for electron microscopy

BIOASSESSMENT STUDIES FIELD STAFF

Contractors performing sample collection for bioassessment studies and/or related physical habitat assessments must adhere to the requirements below, and are encouraged to consider the recommendations that follow.

Requirements for the Contractor's Project Lead

Please note that the Project Lead is required to be present on all field days. If the Project Lead is unable to attend a field day, an alternate contractor staff member may be designated if they meet the requirements listed below.

- Be present on all field days
- Have a *minimum of three consecutive years of experience* in this work
- Participate in intercomparison exercises provided by CDFW
- Train on and be aware of all SWAMP SOPs, QC, and reporting requirements

Recommendations

- Complete training through the College of Bioassessment provided by CDFW
- Participate in courses hosted by the Water Boards Training Academy
- Participate in regular (e.g., yearly) field audits of sampling crews, with additional training and follow-up auditing as necessary
- Participate in annual intercalibration events involving multiple crews with experience in different regions of California

BENTHIC MACROINVERTEBRATE LABORATORY STAFF

Contractors are required to ensure that taxonomists responsible for determining all specimen identifications are subject to the following recommendations and requirements.

Requirements

- Have a minimum of two consecutive years of experience identifying BMIs
- Hold a bachelor's degree or masters of science in entomology, ecology, evolution, or a related degree
- Complete coursework related to entomology, insect morphology, insect taxonomy, aquatic ecology, limnology, or insect ecology
- Complete a graduate thesis or undergraduate research in taxonomy, phylogenetics, or ecology of benthic aquatic organisms
- Be an active member of the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT)
- Be able to identify BMIs to all levels of SAFIT-recommended taxonomy (i.e., Level 1, Level 2, Level 2a)
- Regularly attend taxonomy training workshops offered by SAFIT
- Participate in at least one BMI taxonomic workshop per year
- Know how to access and use BMI taxonomic literature (contact SAFIT for assistance with identifying relevant taxonomic literature, if necessary)
- Be proficient at using dichotomous keys to identify BMIs
- Have experience in the use of light microscopy and standard specimen preparation techniques, including slide preparation, clearing, and dissection

CHEMISTRY LABORATORIES

Most chemistry analyses are performed by NCL, which holds certificate #1247 with California's Environmental Laboratory Accreditation Program (ELAP). The certificate includes all available analytes and parameters analyzed on behalf of SPI, and requires biennial renewal. As part of its accreditation, NCL participates in routine proficiency tests through multiple vendors, and is subject to ELAP audits.

Silica analysis is performed by Caltest Analytical Laboratory, which holds certificate #1664 with

ELAP. This certificate includes the laboratory's silica method, though the analyte itself is not within ELAP's scope. As part of its biennially renewed accreditation, Caltest Analytical Laboratory participates in routine proficiency tests through multiple vendors, and is subject to ELAP audits.

ELAP does not offer certification for the analyses performed by MPSL-DFW (i.e., chlorophyll a, AFDM).

A9: DOCUMENTATION AND RECORDS

CRITICAL RECORDS

SPI will collect and compile records from contractor and in-house sample collection and laboratory analyses. A portion of data produced by this project will be uploaded to CEDEN, including a reference to this QAPP. The critical records required for this project include the following:

- This QAPP
- Field and laboratory records
- Databases
- Technical reports
- Corrective action files
- Audit reports

PLANNING DOCUMENT DISTRIBUTION

Copies of this QAPP will be sent via electronic mail by the Program Director to all parties identified in Element A3: *Distribution List*. Revised or amended QAPPs will be distributed in the same fashion. Master copies of each QAPP will be held at the SPI Redding offices under direction and supervision of the Program Director.

DOCUMENT CONTROL REQUIREMENTS

The Program Director will ensure that this QAPP is subject to strict document control standards. Revised or amended versions will be noted through the version number system. Specifically, the number preceding the decimal point denotes each revision of the document while the number following the decimal point denotes amendments. All field crews and laboratories must ensure use of the most recent copy of this QAPP and all relevant methods and/or SOPs.

REPORTING REQUIREMENTS

Field crews and laboratories (including SPI staff, contractors, and their subcontractors) producing data for this project will follow all reporting requirements outlined in the procedures specified in Element B2: *Sampling Methods* and Element B4: *Analytical Methods*. Reporting requirements noted in pertinent laboratory QA manuals or other QA documents will also be followed. The data collected for the bioassessment portion of this project will adhere to all SWAMP reporting requirements, including the capture of all required metadata.

Analytical results produced by contractors (and their subcontractors) will be organized in a data report package. In addition to the reported data, the data report package will include sufficient QC information to determine that the method was within control limits at the time that the samples were analyzed. A typical report package includes:

- A copy of the chain of custody (COC)
- Specific sample identifiers, including but not limited to laboratory sample ID, coded field sample ID, matrix, and dilution factors
- Holding time verification
- QA/QC results
- All relevant metadata
- For chemistry analyses: final analyte concentration including reporting limit, laboratory qualifiers, and reanalysis
- For biological analyses: final identification, laboratory qualifiers, and re-identification

RECORD MAINTENANCE

All records generated by SPI staff will be maintained by the Program Director in an electronic or hardcopy format and will be archived for a minimum of five years from the date of record. Records generated by contractors and their subcontractors are to be maintained by the contractor and archived for a minimum of five years from the date of record. It is acceptable to scan documents and keep electronic copies if the contractor has a backup system for its electronic files. In addition, any relevant requirements regarding record maintenance outlined in laboratory QA manuals shall be followed unless those requirements stipulate records retention beyond five years.

Group B: Data Generation and Acquisition

B1: SAMPLING PROCESS DESIGN

This element describes the experimental design behind SPI's:

- Water quality stations
- Weather stations
- Bioassessment studies

Element A6: *Project/Task Description* details the resulting logistics (i.e., measurements, sample counts, scheduling, locations, and constraints).

WATER QUALITY STATIONS

SPI's network of continuous water quality monitoring stations was implemented in 2001 to better assess the impact of forest management operations on water quality. Its primary goal is to track how water quality in headwater streams responds to forest management activities over time. Water quality stations host both sonde- and flume-based measurements.

Sondes

To select representative streams for sampling, a thorough geographical information system (GIS) analysis was performed across all 1.8 million acres of SPI's California forestlands to identify and categorize all perennial flowing Class I streams according to the CFPRs. The streams selected for monitoring were determined to be representative of the headwater watersheds owned by SPI in the mixed-conifer forests of the Southern Cascades and Sierra Nevada Mountains. Considered characteristics included:

- Stream gradients
- Annual rainfall
- Flow
- Soil types
- Aspects
- Slopes
- Land use

Headwater watersheds like those selected account for 81% of the 1.64 million acres that SPI currently owns in California.

After the initial GIS screening was performed, the Program Director visited approximately 30 streams to determine potential monitoring locations that meet guidelines from the United States Geological Survey (USGS) and Yellow Springs Instruments (YSI). Recommended conditions include:

- A perennially running stream that is deep enough during low-flow conditions to properly deploy and maintain equipment
- Banks that are stable and high enough to contain flood waters
- A total flow that is confined to one channel at all stages with no bypass flow
- A general stream course that is straight for roughly 300 feet below the site
- Accessibility for installation and operation throughout the year

Starting in 2012, four more streams had water quality monitoring stations established following four high intensity fires (i.e., Ponderosa Fire (2012), Rim Fire (2013), King Fire (2014), Carr Fire (2018)). Eight more suitable monitoring locations were found on Class I perennial flowing streams within the fire perimeter and stream monitoring station(s) were installed to study post-fire recovery. The continuous water quality data results will be monitoring post-fire recovery where salvage logging has been performed upstream of the sites. The locations of these stations also met the sampling location and equipment guidance standards recommended by USGS and YSI. In addition, the water quality monitoring stations needed to be located where the drainage area above the water quality station is owned by SPI and where timber harvest activities will likely occur over the next several decades.

Flumes

In 2004, a cooperative watershed scale experiment was developed between SPI's Research and Monitoring Program, CAL FIRE, and the Central Valley RWQCB. This study was implemented by SPI and is based on the Judd Creek "Engebretsen" timber harvest plan approved in 2004.

The objective of this cooperative monitoring project is to examine the response of water quality in Judd Creek due to intensive upland forest management activities. Changes in the spatial and temporal variability of stream flow, turbidity, and suspended sediment transport regimes for Judd Creek will be characterized before and after timber harvest operations to determine the effect of timber harvest operations on water quality. In addition, the effect of stream crossing reconstruction, road abandonment, and new road construction on turbidity above and below treatment sites will be evaluated.

In December of 2005, four Parshall flumes were installed in the Judd Creek Project. Each flume was located as close to the closest water quality station as physically possible. Rand Eads, a retired USFS Redwood Sciences technician with extensive experience measuring flow, was contracted to help SPI select, place, and size the installed flumes. These self-cleaning flumes are well suited for open-channel streams where flows contain sediment and debris. Flumes need to be installed in free-flowing stream channel locations that are flat and free of irregularities.

WEATHER STATIONS

Early in 2001, an initial GIS screening was performed on each SPI forestry District to characterize the area by mapping general topographic features (e.g., slope, aspect, elevation, roads, waterbodies, streams, ownership, NWS Fire Weather Zones). These maps were used to identify the different areas that may need weather stations to provide adequate coverage for each SPI District. The results of the GIS screening process were also reviewed with SPI District Managers and staff. The Program Director then visited between three and seven potential locations per SPI District (eight California districts in 2001) to identify which locations were most suitable to represent local weather conditions for SPI forest management operations.

Since 2001, 32 permanent weather stations have been installed on SPI timberlands in California. To further understanding of local fire weather conditions, SPI deploys up to 68 portable weather stations between May and November each year, or during increased fire weather conditions. The portables are deployed annually prior to fire season to generate the locally based weather data necessary to populate the NFDRS model and generate PAL forecasts (see A5: *Problem Definition/Background*). The location of these portable stations is determined under careful review of the yearly harvest plan at SPI by the Program Director. The number and location of portable weather stations deployed in the field changes depending upon the location of planned forest management activities.

BIOASSESSMENT STUDIES

BMI sampling sites are located on stream reaches where water quality stations are within fire boundaries or timber harvest plans. Each year, the Program Director re-evaluates these sites with input from the Bioassessment Studies Manager, BMI Project Lead, and SPI forest managers. Consequently, new sites are added on an as-needed basis (see A6: *Project/Task Description*). Overall, the general location in the stream reach is identified prior to sampling, but the field crew has made the specific sampling location placements.

Original BMI sampling locations were selected in 2016 by James Harrington, then of the California Department of Fish and Wildlife, and a scientific advisor to SWRCB's SWAMP. Based on field visitation and timber harvest plan review, he recommended BMI sampling in locations for which baseline water quality data were available.

B2: SAMPLING METHODS

Sampling methods associated with SPI's water quality stations, weather stations, and bioassessment studies are described below.

Sample processing is further addressed in Element B3: *Sample Handling and Custody.*

WATER QUALITY STATIONS

Sondes

Sondes deployed at water quality stations record eight different parameters:

- Conductivity (uS/cm)
- Dissolved oxygen (%, mg/L, charge)
- pH
- Specific conductance (uS/cm)
- Temperature (°C)
- Turbidity (NTU)

The sondes are connected to a datalogger (see Figure 14), which is connected to a gas bubbler (see Figure 15) that records stage. The datalogger records sonde and stage data every 15 minutes on the quarter hour.

Figure 14: Datalogger

Figure 15: Gas Bubbler

Figure 16: Flow Measurement Equipment

Manual Flow

Manual flow measurements are made at each site during scheduled sonde rotations and during unscheduled maintenance and repairs. There are established flow locations at each sonde site indicated by flagging or rebar. However, there are times when one may need to take flow slightly upstream or downstream due to rocks in the stream that become exposed during lower flows. Flow measurements are to be taken in the same spot every time, or as close as possible to the established spot. The goal is to get as many unobstructed flow readings as possible (see Figure 16).

ISCO Samplers

ISCOs are automatic grab samplers that collect stream water samples from the water quality stations. These samples are retrieved and brought back to the SPI laboratory where they are processed and analyzed for suspended sediment concentration. These studies generally occur during the rainy season.

Flumes

At each flume (see Figure 17), there is an air line running from a gas bubbler to the water inside of a stilling well on the side of the flume. The bubbler forces air through the line, providing a value for creek depth (i.e., stage). The bubbler is connected to a datalogger, which records the stage readings every 15 minutes. All flumes are typically scheduled to be downloaded and overhauled on a monthly basis. A main download consists of collecting all the data files from the datalogger, a manual purge, and a system reset.

Figure 17: Flume Installation

WEATHER STATIONS

Weather station measurement frequency is every 30 seconds and the data values are stored every 60 minutes. Each hour, 120 measurements are captured and are stored in the short-term memory of the datalogger. The average value for each parameter is then computed from the 120 hourly measurements and only this value is stored in the datalogger. The minimum value and the maximum value of the 120 hourly measurements are also stored in the datalogger. For relative humidity, a measurement is taken at the hour and stored in the datalogger, and the maximum and minimum are then computed from the 120 hourly measurements and stored in the datalogger.

BIOASSESSMENT STUDIES

SPI's bioassessment studies will follow the SWAMP document *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016), recognized by EPA as California's standard in the assessment of wadeable streams and rivers. Sampling will be conducted by staff from either MPSL-MLML or ABL.

SPI's ongoing bioassessment studies include multiple analytical categories in need of sampling:

- Algae analysis
- BMI analysis
- Chemistry
- Probe measurements
- Physical habitat

The sampling methods associated with each of these categories are given section-specific coverage below.

Algae Sampling

Benthic algal samples are collected along the same main transect locations where BMI samples are collected (see below), but offset upstream by 0.5 meters to avoid disturbed substrate. One of three types of collection devices (i.e., rubber delimiter, PVC delimiter, or syringe scrubber) will be used at each transect to collect benthic algae and then composite it in one jar. The composite jar will be processed to produce one diatom and one soft algae quantitative sample for taxonomic identification. A qualitative soft algae sample will also be collected from throughout the sampling reach to aid in identification.

The composite jar collected for benthic algal taxonomy will also be used to create chlorophyll a and ash-free dry mass filters for analysis. These data will provide an indicator of the amount of benthic biomass available in the stream reach.

Benthic Macroinvertebrate Sampling

BMI samples are collected along the sampling reach at each of the 11 main transects and then composited into one sample. A D-frame kick net is used to capture BMI that flow into the net with the water current as the sampler disturbs 1 ft^2 upstream of the net. The sample is fixed in ethanol and then sent to the taxonomy laboratory for identification.

Chemistry Sampling

Water samples will be collected prior to (preferred) or after physical habitat and taxonomy collections depending on the time of day and applicable holding time restrictions. The sampler will stand in an undisturbed portion of the stream facing upstream. The sampler will dunk the capped bottle ~0.1 m under the water surface, uncap the bottle, fill it with a small amount of water, cap it, and then bring it out of the water. The first two times this process occurs for a bottle, it will be shaken and then the contents discarded. This serves to rinse the inside of the sample bottle. The bottle will be filled the third time it is dunked. If a sample bottle has preservative in it, it will not be rinsed in this manner but rather filled directly from a bottle that has been rinsed. After all sample bottles are filled and returned to the vehicle, they will be placed into a cooler with ice.

Multiparameter Probe Sampling

Ambient water flowing down the stream will be measured in the field with a probe instrument to characterize:

- Temperature (°C)
- pH
- Dissolved oxygen (mg/L)
- Specific conductance (uS/cm)
- Salinity (ppt)
- Alkalinity (mg/L)

Optional measurements of turbidity (NTU), oxygen saturation (%), silica (mg/L), and air temperature (°C) may also be recorded at the discretion of the field team. The probe instrument will be calibrated daily, prior to the field season, or from the manufacturer depending on the analyte. The device will be placed into flowing water and allowed to equilibrate before measurements are recorded.

The amount of flow at each site will be measured using either the velocity area method (preferred) or the buoyant object method. The velocity area method measures velocity (ft/sec) at 10-20 equidistant points along a transect. The distance, water depth, and velocity can be combined to calculate flow or discharge in cubic feet per second. The buoyant object method is commonly referred to as the ‘orange peel’ method in which the amount of time it takes for a buoyant object to float down an area of known depth and width can be used to estimate discharge.

Physical Habitat Sampling

PHAB measurements will be recorded at the reach scale (typically 150 meters) and along 21 transects and inter-transects evenly spaced within the reach to characterize instream channel and bank substrates and morphology, riparian vegetation cover, flow habitats, and human influence. Standard measurements and observations are performed along the reach in a consistent manner producing more than 1,700 data points for a given sampling event.

B3: SAMPLE HANDLING AND CUSTODY

While SPI's weather stations and water quality stations generate a great deal of data, they produce no physical samples in need of handling or custody systems. However, SPI's bioassessment studies require the collection and analysis of BMI, algae, and grab samples for nutrients, conventional analytes, and solid parameters. Custody, transport, and holding times associated with these samples are detailed below.

CUSTODY

The COC form must be filled out and delivered with the samples to the designated laboratory. An electronic version of the COC will also be emailed to the laboratory prior to or on the day of sample arrival. Laboratory-specific custody processes follow.

California Department of Fish and Wildlife Aquatic Bioassessment Laboratory

BMI samples will have their sample labels checked against COC forms to confirm the presence of all samples and required ancillary information. Unique *LabSampleIDs* will be assigned to each sample upon log in to the database. The laboratory's COC form appears in Appendix D of this QAPP.

California State University at San Marcos

The soft algae (qualitative and quantitative) and diatom (quantitative) samples will have their labels checked against COC forms to confirm the presence of all samples and required ancillary information. Unique LabSampleIDs may be assigned to each sample upon log in to the database. The laboratory's COC form appears in Appendix D of this QAPP.

North Coast Laboratories, Ltd.

At the time of delivery, the time, date, and temperature of the cooler blank bottle or one sample bottle will be recorded by NCL. The laboratory's COC form appears in Appendix D of this QAPP.

Marine Pollution Studies Laboratory – Department of Fish and Wildlife

Laboratory personnel logging in sample(s) will carefully inspect each sample for COC documentation, sample labeling, packing lists, and the condition of the sample packing materials and containers. Any discrepancies or problems associated with sample shipment will be documented on the COC and in the sample receiving logbook. The original COC and a copy of the logbook will be retained together in a binder in the laboratory office. The laboratory's COC form appears in Appendix D of this QAPP.

Caltest Analytical Laboratory

At the time of delivery, the time, date, and temperature of the cooler blank bottle or one sample bottle will be recorded by Caltest Analytical Laboratory (Caltest). The laboratory's COC form appears in Appendix D of this QAPP.

SHIPMENT

California Department of Fish and Wildlife Aquatic Bioassessment Laboratory

BMI samples are preserved and either hand-delivered to ABL, or shipped in a cooler using ground delivery.

California State University at San Marcos

Soft algae and diatom samples are preserved and sent to CSUSM. They may be shipped via ground delivery except for the qualitative soft algae sample, which is not preserved and must remain on wet ice for overnight delivery.

North Coast Laboratories, Ltd.

Coolers will be shipped via overnight FedEx to NCL. Prior to any sampling effort, the laboratory will be contacted to order the appropriate containers, coolers, and ice containers. The container, coolers, and ice containers ordered will be reviewed with laboratory staff to confirm appropriate supplies are ordered and shipped correctly. Prepaid FedEx shipping forms will be sent by NCL for each cooler when ordered.

Marine Pollution Studies Laboratory – Department of Fish and Wildlife

MPSL delivers frozen samples directly to MPSL-DFW's freezer and the associated COC is given to the appropriate staff.

Caltest Analytical Laboratory

Samples are collected and stored on wet ice during the week. The samples are brought back to MPSL and put into a refrigerator until shipped as one batch via overnight FedEx to Caltest. Prior to any sampling effort, the laboratory will be contacted to order the appropriate containers, coolers, and ice containers. The container, coolers, and ice containers ordered will be reviewed with laboratory staff to confirm appropriate supplies are ordered and shipped correctly. Prepaid FedEx shipping forms will be sent by Caltest for each cooler when ordered.

RECEIPT AND STORAGE

Holding times refer to the period of time allowed between one part of the sample handling process (e.g., sample collection) and a subsequent part of that process (e.g., filtration). These intervals are defined as follows:

- *Collection to Filtration Holding Times*: Required holding times for filtration of samples begin at the time of sample collection and conclude when the sample is filtered. Filtration holding times vary by parameter and range from within 15 minutes to 48 hours from the time of collection.
- *Collection to Preservation Holding Times:* Required holding times for sample preservation begin at the time of sample collection and conclude when the sample is preserved.
- *Collection to Analysis Holding Times*: Required holding times for sample analysis begin at the time of sample collection and conclude when sample analysis is completed. Analytical holding times are dependent on the parameter and the analytical methodology employed.

Laboratory-specific holding times and other sample handling guidelines are specified in the following sections. To promote comparability with other federal and state monitoring activities, they are based on information published in the *Code of Federal Regulations, Title 40 Protection of the Environment, Part 136 Guidelines Establishing Test Procedures for the Analysis of Pollutants* (40 CFR Section 136).

California Department of Fish and Wildlife Aquatic Bioassessment Laboratory

BMI samples will be received and processed according to Section 2 of the SWAMP document *Standard Operating Procedures for Laboratory Processing and Identification of Benthic Macroinvertebrates in California* (October 2012), including a sample integrity check and a hydrometer check to ensure that each sample contains a minimum of 70% ethanol.

California State University at San Marcos

Soft algae and diatom samples will be received and processed according to the SWAMP documents

Standard Operating Procedures for Laboratory Processing, Identification, and Enumeration of Stream Algae (November 2015) and *Standard Operating Procedures for Internal and External Quality Control of Laboratory Processing, Identification and Enumeration of Stream Algae in California* (November 2019). Qualitative soft algae samples will be checked to confirm that the sample is cool (i.e., 4 °C) but not frozen, leak-free, and received within two weeks of collection. Quantitative soft algae and diatom samples will be preserved in the field (5 mL of 2% glutaraldehyde). If the total volume in a sample tube is less than 50 mL, it may indicate that a sample leaked during transport or was not preserved. Follow-up with the field crew may be required.

Table 30 specifies the sample handling guidelines associated with algae analyses.

Table 30: Sample Handling - Algae Analyses

Parameter	Sample Handling
Diatoms	Add 5% formalin for a 1% final concentration immediately after collection; keep dark and away from heat; fixed samples can be stored for at least two years
Soft Algae (Qualitative Sample)	No fixative; keep fresh sample on wet ice (or refrigerated) and in the dark; tally species present within two weeks of collection (preferably much sooner)
Soft Algae (Quantitative Sample)	Keep unfixed samples in the dark on wet (not dry) ice; add glutaraldehyde (to a 2% final concentration) in a well-ventilated area as soon as possible, but no later than 96 hours after sampling; after fixing, refrigerate and keep in dark; fixed samples can be stored for at least two years

North Coast Laboratories, Ltd.

The laboratory will receive the samples and store them in a walk-in refrigerator or freezer as appropriate. Each sample will be properly identified and stored. The date, time, and temperature of any acidified or preserved samples will be recorded by the laboratory. Samples will be stored at NCL until results are confirmed and outstanding questions are resolved.

Tables 31-33 specify the sample handling guidelines associated with NCL's nutrients, conventional analytes, and solid parameters, respectively.

Table 31: Sample Handling - Nutrients in Water

Analyte	Required Holding Time
Ammonia (as N)	48 hours; 28 days if acidified
Kjeldahl nitrogen (total)	7 days; 28 days if acidified
Nitrate (as N)	48 hours (unless calculated from nitrate + nitrite (as N) and nitrite (as N))

Analyte	Required Holding Time
Nitrite (as N)	48 hours
Nitrogen (total)	28 days
Orthophosphate (dissolved, as P)	Filter within 15 minutes; 48 hours
Phosphorus (total, as P)	28 days

Table 32: Sample Handling - Conventional Analytes in Water

Analyte	Required Holding Time
Chloride	28 days
Hardness (as $CaCO_3$)	6 months
Organic carbon (dissolved)	Filter within 48 hours; 28 days
Silica (dissolved, as SiO_2)	28 days; 6 months if acidified
Sulfate	28 days

Table 33: Sample Handling - Solid Parameters

Parameter	Required Holding Time
Suspended sediment concentration	7 days
Suspended solids (total)	7 days

Marine Pollution Studies Laboratory – Department of Fish and Wildlife

Samples will be stored for the required holding time. Thereafter, the laboratory supervisor or project leader will determine if the sample will be archived. When the holding time interval has passed and the samples are approved for disposal, samples and sample containers will be disposed of according to applicable regulations.

Tables 34-35 specify the sample handling guidelines associated with MPSL-DFW's conventional analytes and solid parameters, respectively.

Table 34: Sample Handling - Conventional Analytes in Water

Analyte	Required Holding Time
Chlorophyll a	Filter, wrap in foil, store on wet ice in the field, but freeze (preferably to -80 ºC) within four hours of collection; analyze within 28 days

Table 35: Sample Handling - Solid Parameters

Parameter	Required Holding Time
Ash-free dry mass	28 days

Caltest Analytical Laboratory

Table 36 specifies the sample handling guidelines associated with Caltest Analytical Laboratory's conventional analytes.

Table 36: Sample Handling - Conventional Analytes in Water

Analyte	Required Holding Time
Silica (dissolved, as SiO_2)	28 days; 6 months if acidified

B4: ANALYTICAL METHODS

There are no analytical methods associated with SPI's weather station network. Analytical methods associated with its water quality stations and bioassessment studies are described below.

WATER QUALITY STATIONS

While sonde analyses are performed passively, two water quality parameters (i.e., flow, turbidity) are analyzed manually in conjunction with sonde rotations. Per Table 37, both are analyzed according to the *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016): Pages 10-11.

Table 37: Analytical Methods – Water Quality Stations

Parameter	Analytical Method	Detector Type	Range	Resolution	Accuracy
Flow	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016): Pages 10-11	Flow staff	0.25 fps (.075mps) - 3 fps (.914mps)	0.001 fps/mps	Not applicable
Turbidity	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016): Page 10	Portable turbidimeter	0 - 4000 NTU	1 NTU	± 2% of reading

BIOASSESSMENT STUDIES

SPI also performs ongoing bioassessment studies that include multiple analytical categories:

- Algae analysis
- BMI taxonomy
- Nutrients in water
- Conventional analytes in water
- Solid parameters

Each of these categories is given section-specific coverage below.

Algae Analysis

CSUSM performs laboratory taxonomy of all soft algae (qualitative and quantitative) and diatom samples collected for this SPI study. In the interest of SWAMP comparability, identifications are performed according to the SWAMP documents *Standard Operating Procedures for the Laboratory Processing, Identification, and Enumeration of Stream Algae* (November 2015) and *Standard Operating Procedures for Internal and External Quality Control of Laboratory Processing, Identification, and Enumeration of Stream Algae in California* (November 2019). This document details:

- Laboratory infrastructure
- Staff qualifications
- Sample receipt
- Sample preparation and processing
- Algae identification and enumeration
- QA/QC
- Results reporting

Benthic Macroinvertebrate Taxonomy

ABL performs taxonomy of all BMIs collected for SPI. In the interest of comparability with SWAMP, identifications are performed according to the SWAMP document *Standard Operating Procedures for the Laboratory Processing and Identification of Benthic Macroinvertebrates in California* (October 2012). This document details:

- Laboratory infrastructure
- Staff qualifications
- Sample receipt
- Sample preparation and processing
- BMI identification and enumeration
- Internal QC checks

Identification of 10% of BMI specimens is confirmed according to the SWAMP document *Standard Operating Procedures for the External Quality Control of Benthic Macroinvertebrate Taxonomy Data Collected for Stream Bioassessment in California* (July 2015).

Nutrients in Water

SPI's analysis of nutrients in water samples is performed by NCL. Utilized analytical methods and their associated details are presented in Table 38.

Table 38: Analytical Methods - Nutrients in Water

Analyte/Parameter	Analytical Method	Detector Type	Method Detection Limit (mg/L)	Reporting Limit (mg/L)
Ammonia (as N)	SM 4500 - NH_3 B, D	Ion Selective Electrode	0.064	0.1
Kjeldahl nitrogen (total)	SM 4500 - NH_3 B, D	Ion Selective Electrode	0.74	1
Nitrate (as N)	EPA 300.0	Conductivity	0.072	0.1
Nitrite (as N)	EPA 300.0	Conductivity	0.024	0.1
Nitrogen (total)	Calculation	N/A	0.74	1
Orthophosphate (dissolved, as P)	SM 4500 - P E	Colorimetric	0.00056	0.01
Phosphorous (total, as P)	SM 4500 - P E	Colorimetric	0.0074	0.02

These methods are provided by EPA and *Standard Methods for the Examination of Water and Wastewater* (*Standard Methods*). Section-specific method summaries are provided below.

Standard Methods 4500 - NH_3 B, D

Ammonia as N (NH3)

The pH of a 50-mL sample is adjusted to greater than 11 pH units and an ammonia-selective electrode is used to potentiometrically determine the concentration. Environmental samples are distilled prior to analysis unless parallel studies on file indicate that distillation is not necessary. The practical range of the determination is 0.1 to 100 mg/L.

Environmental Protection Agency Method 300.0

Nitrite as N

Nitrate as N

Approximately 5 mL of sample is filtered into an autosampler vial through a 0.2-µm syringe filter and injected into the ion chromatograph (IC). The anions of interest are separated using the appropriate guard column, analytical column and suppressor device. The concentration of the analytes is then measured in mg/L using a conductivity detector. The practical range of the determination is 0.1 to 20 mg/L.

Standard Methods 4500 – P E

Orthophosphate as P

Phosphorous as P

A sample is pH-adjusted and a color reagent is added. The resulting intensity of color is determined by spectrophotometer and compared to a standard calibration curve to determine orthophosphate. Total phosphates are determined by converting all forms of phosphate to orthophosphate by a persulfate digestion (SM 4500 - P B) before analyzing colorimetrically. The practical range of the determination is 0.01 to 6 mg/L.

Standard Methods 4500 – NH_3 B, D

Total Kjeldahl Nitrogen (TKN)

A sample is digested in a high temperature, high acid environment. This converts the organic nitrogen, free ammonia, and ammonium-nitrogen to ammonium sulfate. The sample is distilled and cooled and the ammonia-nitrogen is measured by an ammonia-selective electrode. TKN is determined by summing the ammonia-nitrogen and the organic nitrogen. The practical range of the determination is 1 to 100 mg/L.

Conventional Analytes in Water

SPI's analysis of conventional analytes in water samples is performed primarily by NCL. Chlorophyll a analysis is performed by MPSL-DFW. Utilized analytical methods and their associated details are presented in Table 39.

Table 39: Analytical Methods - Conventional Analytes in Water

Analyte/Parameter	Analytical Method	Detector Type	Method Detection Limit	Reporting Limit
Chloride	EPA 300.0	Conductivity	0.097 mg/L	0.1 mg/L
Chlorophyll a	MPSL-115	Fluorescence	30 µg/L	30 µg/L
Hardness (as $CaCO_3$)	EPA 200.7	ICP-OES[1]	n/a	1 mg/L
Organic carbon (dissolved)	SM 5310 C	Infrared	0.21 mg/L	0.3 mg/L

Analyte/Parameter	Analytical Method	Detector Type	Method Detection Limit	Reporting Limit
Silica (dissolved, as SiO2)	EPA 200.8	ICP-MS[2]	60 µg/L	100 µg/L
Sulfate	EPA 300.0	Conductivity	0.22 mg/L	0.5 mg/L

[1] Inductively coupled plasma - optical emission spectrometry
[2] Inductively coupled plasma - mass spectrometry

These methods are provided by EPA, *Standard Methods,* and MPSL-DFW. Section-specific method summaries are provided below.

Environmental Protection Agency 300.0

Chloride

Sulfate

Approximately 5 mL of sample is filtered into an autosampler vial through a 0.2-µm syringe filter and injected into the IC. The anions of interest are separated using the appropriate guard column, analytical column, and suppressor device. The concentration of the analytes is then measured in mg/L using a conductivity detector. The practical range of the determination is 0.1 to 20 mg/L for chloride and 0.5 to 200 mg/L for sulfate.

MPSL-115 (*Benthic Chlorophyll a in Marine and Freshwater Algae by Fluorescence*)

Chlorophyll a

A measured volume of sample is filtered at low vacuum through a glass fiber filter. Periphyton collected on the filter contains the pigments chlorophyll a and pheophytin a. Pigments are extracted from the filter in 90% acetone solution. The filters are vortexed, sonicated, shaken, and allowed to steep. The sample is then centrifuged and an aliquot of the supernatant is filtered and transferred to a culture tube for analysis. Fluorescence is measured before and after acidification. Sensitivity calibration factors, which have been previously determined on solutions of pure chlorophyll a of known concentrations, are used to calculate the concentration of chlorophyll a and pheophytin a in the sample extract.

<u>Standard Methods 5310 C</u>

Dissolved Organic Carbon

This analysis is performed using *Standard Methods 5310 C* where samples are filtered through 0.45-µm syringe filters directly into pre-persevered 0.5-mL phosphoric acid volatile organic analysis vials. Samples run through a series of purging and sparging steps via autosampler and are then subjected to oxidation by persulfate and ultraviolet radiation. Organic carbon is converted to CO_2 and carried to the infrared detector. The concentration is determined from a calibration curve generated from the analysis of total organic carbon standards. The practical quantitation limit is 0.30 mg/L.

<u>Environmental Protection Agency 200.7</u>

Hardness as $CaCO_3$

The amount of calcium and magnesium is determined with inductively coupled plasma optical emission spectrometry (ICP-OES). Hardness is calculated from their results using *Standard Methods 2340 B*.

<u>Environmental Protection Agency 200.8</u>

Silica

Sample material in solution is introduced by pneumatic nebulization into a radiofrequency plasma where energy transfer processes cause desolvation, atomization, and ionization. The ions are extracted from the plasma through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a quadrupole mass spectrometer having a minimum resolution capability of 1 amu peak width at 5% peak height. The ions transmitted through the quadrupole are detected by an electron multiplier or Faraday detector and the ion information processed by the data handling system.

Solid Parameters

SPI's analysis of solid parameters is performed by NCL and MPSL-DFW. Utilized analytical methods and their associated details are presented in Table 40.

Table 40: Analytical Methods - Solid Parameters

Parameter	Analytical Method	Detector Type	Method Detection Limit (mg/L)	Reporting Limit (mg/L)
Ash-free dry mass	MPSL-114	Balance	n/a	1
Suspended sediment concentration	ASTM D 3977-97	Balance	Not Determined	1
Suspended solids (total)	SM 2540 D	Balance	0.6	1

MPSL-114 (*Determination of Ash-Free Dry Mass in Periphyton*)

Ash-Free Dry Mass

Sample moisture is evaporated by controlled heating in a drying oven. The dry filter is weighed and the measurement recorded. The sample filters are then ashed using a muffle furnace to decompose the organic matter. The filters are moistened with water to rehydrate the clays, and returned to the drying oven. Dried filters are weighed and that measurement is recorded. Ash-free dry mass is then calculated using the weight measurements and field data (i.e., area scraped, number of transects, volume of sample collected, and volume of sample filtered).

American Society for Testing and Materials D 3977-97

Suspended Sediment Concentration

This is a whole sample analysis for samples containing <10,000 parts per million (ppm) sand and <200 ppm clay. The sample is filtered through a pre-weighed glass fiber filter and the residue retained on the filter is dried to a constant weight at 103-105 °C.

Standard Methods 2540 D

Total Suspended Solids

A well-mixed sample is filtered through a weighed glass-fiber filter. The residue on the filter is dried to a constant weight at 103 – 105 °C. The increase in filter weight per sample volume filtered represents the total suspended solids. The practical range of the determination is 1 to 20,000 mg/L.

B5: QUALITY CONTROL

OVERVIEW

This element describes SPI's QC systems as they relate to each of the DQIs identified in Element A7: *Quality Objectives and Criteria*. Separate coverage is given to SPI's three primary monitoring components:

- Water quality stations
- Weather stations
- Bioassessment studies

WATER QUALITY STATIONS

SPI's Research and Monitoring Program maintains 19 water quality stations throughout its 1.8 million acres of forestlands in California. Each station uses sondes to collect continuous data.

While continuous monitoring lacks the discrete QC samples associated with laboratory analyses, DQIs are evaluated and optimized according to Table 41.

Table 41: Water Quality Stations: Data Quality Indicators

Indicator	Quality Control
Precision	• Use of the same equipment at all water quality monitoring stations • Use of the same procedures for all manual measurements • Systematic checking and calibrating of equipment per manufacturer specifications • Replacement rather than repair of defective equipment
Bias	• Fouling prevention
Accuracy	• Fouling prevention
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of the same equipment at all water quality monitoring stations • Use of paired measurements to ensure continuity between old and new technologies • Use of paired measurements to ensure comparability between manual and flume-based flow measurements • Use of paired particulate organic matter measurements to ensure continuity during method modification • As feasible, comparability with SWAMP quality control

Indicator	Quality Control
Completeness	• Fouling prevention
Sensitivity	• Fouling prevention • Adherence to QAPP Element B6: *Instrument/Equipment Testing, Inspection, and Maintenance* • Adherence to QAPP Element B7: *Instrument/Equipment Calibration and Frequency*

WEATHER STATIONS

SPI's Research and Monitoring Program maintains 32 permanent and up to 68 temporary weather stations throughout its 1.8 million acres of California forestlands.

While there are no performance criteria associated with weather station measurements, results are screened against minimum and maximum values before being uploaded to the McQAQC database.

If a measurement is out of range, a database field is populated with a code indicating that the measurement is unusable (see QAPP Element B10: *Data Management*).

BIOASSESSMENT STUDIES

SPI's Research and Monitoring Program conducts ongoing bioassessment studies that include the following analytical categories:

- Algae analysis
- BMI analysis
- Chemistry
- Physical habitat

Category-specific DQIs and their associated QC are identified in Tables 38-42.

Algae Analysis

For diatom and soft algae analyses (qualitative and quantitative), applicable DQIs are evaluated and optimized according to Table 42.

Table 42: Algae Analysis: Data Quality Indicators

Indicator	Quality Control
Accuracy	• Adherence to QAPP Element A8: *Special Training and Certification*

Indicator	Quality Control
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of consistent methods/SOPs • Intercomparison study participation • As feasible, comparability with SWAMP quality control • External laboratory confirmations
Completeness	• Adherence to a 90% completeness requirement

Benthic Macroinvertebrates

For BMIs, applicable DQIs are evaluated and optimized according to Table 43.

Table 43: Benthic Macroinvertebrate Analysis: Data Quality Indicators

Indicator	Quality Control
Accuracy	• Adherence to QAPP Element A8: *Special Training and Certification*
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of consistent methods/SOPs • External laboratory confirmations • Intercomparison study participation • As feasible, comparability with SWAMP quality control
Completeness	• Adherence to a 90% completeness requirement

Chemistry

Much of the QC associated with chemistry analyses comes in the form of field or laboratory QC samples. Table 44 identifies these samples, as well as other ways of assessing and optimizing each of the DQIs.

Table 44: Chemistry: Data Quality Indicators

Indicator	Quality Control
Precision	• Use of laboratory, field, and matrix spike duplicates
Bias	• Contamination-based bias: use of laboratory, field, travel, and equipment blanks • Matrix-based bias: use of matrix spikes and surrogates
Accuracy	• Use of calibration verification samples • Use of laboratory control samples • Use of reference materials
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of consistent methods/SOPs • Adoption of SWAMP MQOs and holding times
Completeness	• Adherence to a 90% completeness requirement

Indicator	Quality Control
Sensitivity	• MDLs/RLs/etc.

The following section describes laboratory and field QC samples performed by the testing laboratory during sample preparation and analysis.

Instrument Calibration

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

Calibration curves shall be established for each analyte covering the range of expected sample concentrations. Only data that result from quantification within the demonstrated working calibration range may be reported unflagged by the testing laboratory. Quantification based on extrapolation is not acceptable. Data reported outside of the calibration range shall be flagged as “Detected not Quantified”. Alternatively, if the instrumentation is linear over the concentration ranges to be measured in the samples, the use of a calibration blank and one single standard that is higher in concentration than the samples may be appropriate. Samples outside the calibration range shall be diluted or concentrated, as appropriate, and reanalyzed.

Initial Calibration Verification

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

Continuing Calibration Verification

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

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

Laboratory Blanks

Laboratory blanks (also called extraction blanks, procedural blanks, or method blanks) are used to assess the background level of target analyte resulting from sample preparation and analysis. Laboratory blanks are carried through precisely the same procedures as the field samples. Blanks that are too high require corrective action to bring the concentrations down to acceptable levels. This may involve changing reagents, cleaning equipment, or even modifying the utilized methods or standard operating procedures.

Although acceptable laboratory blanks are important for obtaining results for low-level samples, improvements in analytical sensitivity have reduced detection limits such that some amount of analyte will be detected in even the cleanest laboratory blanks. The magnitude of the blanks shall be evaluated against the concentrations of the samples analyzed, the RL, and project objectives.

Reference Materials

Evaluation of the accuracy of testing laboratory procedures is achieved through the preparation and analysis of reference materials with each analytical batch. Ideally, the reference materials selected are similar in matrix and concentration range to the samples being prepared and analyzed.

The accuracy of an analytical method can be assessed using reference materials only when certified values are provided for the target analytes. When possible, reference materials that have certified values for the target analytes should be used. This is not always possible, and often certified reference values are not available for all target analytes. Many reference materials have both certified and non-certified (or reference) values listed on the certificate of analysis.

The distinction between a reference material and a certified reference material isn't how the two are prepared, but how the reference values were established. Certified values are determined through replicate analyses using two independent measurement techniques for verification. The certifying agency may also provide "non-certified" or "reference" values for other target analytes. Such values are determined using a single measurement technique that may introduce bias.

When available, it is preferable to use reference materials that have certified values for all target analytes.

Matrix Spikes

A matrix spike (MS) is prepared by adding a known concentration of the target analyte to a field sample, which is then subjected to the entire analytical procedure. Matrix spikes are analyzed in order to assess the magnitude of matrix interference and bias present. Because matrix spikes are analyzed in pairs, the second spike is called the matrix spike duplicate (MSD). The MSD provides information regarding the precision of the matrix effects.

In order to properly assess the degree of matrix interference and potential bias, the spiking level should be approximately 2-5x the ambient concentration of the spiked sample. To establish spiking levels prior to sample analysis, laboratories should review any relevant historical data. In many instances, the laboratory will be spiking samples blind and will not meet a spiking level of 2-5x the ambient concentration. If this technique is not practical, then laboratories should spike near the mid-point of the calibration curve.

In addition to the recoveries, the relative percent difference between the MS and MSD is calculated to evaluate how matrix affects precision.

Recovery data for matrix spikes provides a basis for determining the prevalence of matrix effects in the samples. If the percent recovery for any analyte in the MS or MSD fails programmatic MQOs, instrument outputs such as peak areas, surrogate recoveries, and raw data quantitation reports should be reviewed by the testing laboratory. Data should be scrutinized for evidence of sensitivity shifts (indicated by the results of the CCVs) or other potential problems with the analytical process. If associated QC samples (reference materials or LCSs) are in control, matrix effects may be the source of the problem. If the standard used to spike the samples is different from the standard used to calibrate the instrument, it shall be checked for accuracy prior to attributing poor recoveries to matrix effects.

Laboratory Duplicates

In order to evaluate the precision of an analytical process, a field sample is selected and prepared in duplicate. Specific requirements pertaining to the analysis of laboratory duplicates vary depending on the type of analysis.

Equipment Blanks

Equipment blanks are generated by the personnel responsible for cleaning sampling equipment. Equipment blanks shall be analyzed before the equipment is shipped to the sampling site. In order to accommodate any necessary corrective action, equipment blank results should be available well in advance of the sampling event.

To ensure that sampling equipment is contaminant-free, water known to be low in the target analyte(s) (i.e., pre-tested for contamination levels) shall be processed through the equipment as during sample collection. The specific type of water used for blanks is selected based on the information contained in the relevant sampling or analysis methods. The water shall be collected in an appropriate sample container, preserved, and analyzed for the target analytes (i.e., treated as an actual sample).

Typically, equipment blanks are collected when the following are used:

- New equipment
- Equipment that has been cleaned after use at a contaminated site
- Equipment that is not dedicated for surface water sampling

Field Blanks

A field blank is collected to assess potential sample contamination levels that occur during field sampling activities. Field blanks are taken to the field, transferred to the appropriate container, preserved (if required by the method), and treated the same as the corresponding sample type during the course of a sampling event.

Field blanks for other media and analytes should be conducted upon initiation of sampling. If field blank performance is acceptable, further collection and analysis of field blanks should be performed on an as-needed basis.

The water used for field blanks shall be free of target analyte(s) and appropriate for the analysis being conducted.

Field Duplicates

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

Physical Habitat Analysis

SPI's PHAB analyses are subject to SWAMP performance requirements. DQIs are evaluated and optimized according to Table 45.

Table 45: Physical Habitat Assessment: Data Quality Indicators

Indicator	Quality Control
Accuracy	• Adherence to QAPP Element A8: *Special Training and Certification*
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of consistent methods/SOPs (see below) • Intercomparison study participation • As feasible, comparability with SWAMP quality control
Completeness	• Adherence to 90% completeness requirement

To promote data comparability with SWAMP, SPI requires the use of the SWAMP document: *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016).

B6: INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

SPI's water quality stations, weather stations, and bioassessment studies depend on a variety of instrumentation and equipment for data production. The testing, inspection, maintenance, and corrective action of these devices are summarized in the following sections. Additional information may be found in standard operating procedures and the *SPI Research and Monitoring Water Quality Manual* (November 2016).

Instruments and equipment in need of calibration are further addressed in Element B7: *Instrument/Equipment Calibration and Frequency.*

WATER QUALITY STATIONS

SPI's water quality stations utilize sondes for continuous monitoring, and other instruments and equipment for sampling and manual measurements (see Figures 18-22). Testing, inspection, maintenance, and corrective action procedures for water quality station devices are detailed in the planning and procedural documents identified in Table 46.

Table 46: Device Management - Water Quality Stations

Item	Document Reference(s)	Responsible Organization
Flow staff	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
Flumes	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
Teledyne 6712 ISCO sampler	*Field Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*	Sierra Pacific Industries
YSI 6136 Turbidity sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
Item	**Document Reference(s)**	**Responsible Organization**
YSI 6560 Temperature/conductivity sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6561 pH sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6562 Dissolved oxygen sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6820 Multi-parameter sonde	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries

Figure 18: YSI 6820 Multi-parameter Sonde from Side (Left) and Front (Right)

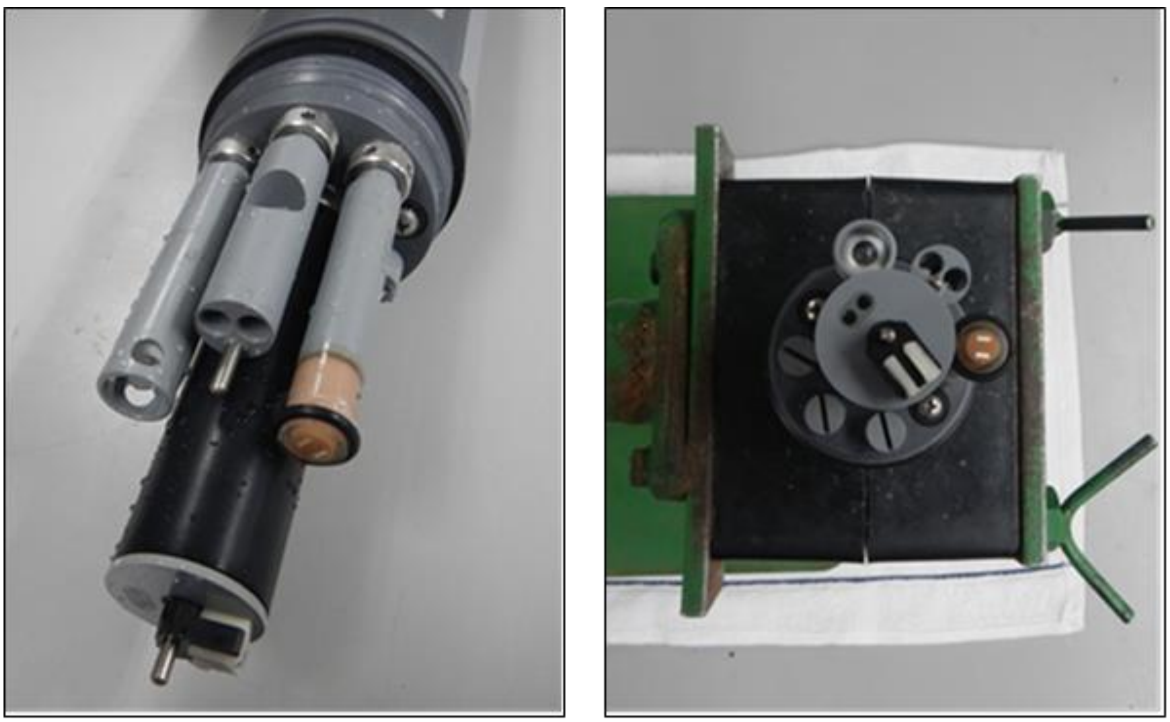


Figure 19: YSI 6561 pH Sensor

Figure 20: YSI 6560 Temperature/Conductivity Sensor

Figure 21: YSI 6136 Turbidity Sensor

Figure 22: YSI 6562 Dissolved Oxygen Sensor

WEATHER STATIONS

Because all SPI weather stations have identical components produced by one manufacturer, device-incompatibility is not encountered. Prior to installation, the manufacturer's sensor calibrations are validated in the laboratory. Three to six times a year, each station is physically visited and inspected to ensure that all sensors are operating correctly, that no animal or physical damage is evident, and that batteries, solar panels and wiring/radio connections are in proper order. Fuel temperature and fuel moisture dowelling is replaced at the start of each fire season.

A proprietary software application (i.e., *Weathermon*) is programmed to connect to each station, download all data since the last connection, examine all data for possible problems, store in a common database, and produce reports that are either emailed or posted on SPI's website. Diagnostic reports are examined daily and problem stations are physically visited for remediation as soon as physically possible, usually within two days. Malfunctioning radios, dataloggers, and sensors are replaced with factory-new components rather than repaired or recalibrated. Occasionally, data cannot be downloaded due to radio interference or bad batteries. In these instances, stations are physically visited and data are manually downloaded.

BIOASSESSMENT STUDIES

SPI's bioassessment studies utilize instruments and equipment associated with the analysis of BMIs, algae, nutrients, conventional analytes, and solid parameters. Testing, inspection, maintenance, and corrective action procedures for these devices are detailed in the planning and procedural documents identified in Table 47.

Table 47: Device Management - Bioassessment Studies

Item	Document Reference(s)	Responsible Organization
BMI-related devices[1]	*Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016) *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)	ABL
Algae-related devices[1]	*Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat*	CSUSM

Item	Document Reference(s)	Responsible Organization
	(May 2016) *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)	
Chemistry-related devices	*North Coast Laboratories, Ltd. Quality Assurance Manual* (March 2018)	NCL
Field sampling-related devices	*Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)	MPSL-MLML
Chlorophyll a- and AFDM-related devices	*Marine Pollution Studies Laboratory Quality Assurance Program Plan* (November 2016)	MPSL-DFW
Silica-related devices	*Caltest Analytical Laboratory Quality Assurance Manual 23* (August 2019) *Determination of Trace Elements in Waters and Wastes by Inductively-Coupled Plasma-Mass Spectrometry (3 Mode)* (April 2011)	Caltest Analytical Laboratory

[1] Items appear in the documents *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016) and *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)

B7: INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

SPI's water quality stations, weather stations, and bioassessment studies depend on a variety of instrumentation and equipment for data production. The calibration of applicable devices is summarized in the following sections. Detailed information may be found in standard operating procedures and in the *SPI Research and Monitoring Water Quality Manual* (November 2016).

Instrument and equipment management is further addressed in Element B6: *Instrument/Equipment Testing, Inspection, and Maintenance.*

WATER QUALITY STATIONS

SPI's water quality stations utilize sondes for continuous monitoring, and other instruments and equipment for sampling and manual measurements. Calibration procedures for water quality station devices are detailed in the planning and procedural documents identified in Table 48.

Table 48: Device Calibration – Water Quality Stations

Item	Document Reference(s)	Responsible Organization
Teledyne 6712C ISCO sampler	*Field Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*	Sierra Pacific Industries
YSI 6136 Turbidity sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6560 Temperature/conductivity sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6561 pH sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6562 Dissolved oxygen sensor	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries
YSI 6820 Multi-parameter Sonde	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016)	Sierra Pacific Industries

Per the documents referenced above, sensor calibration requires a variety of parameter-specific solutions (see Figures 23-25).

Figure 23: Turbidity Sensor Calibration Standard

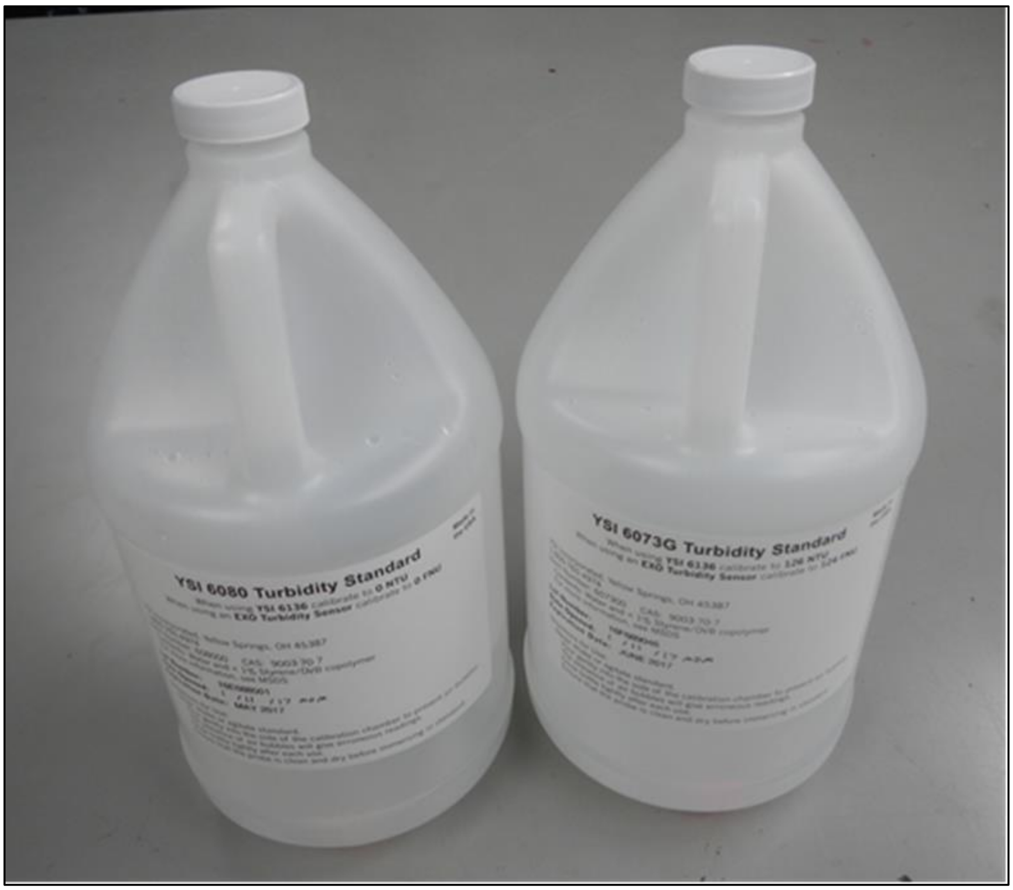


Figure 24: Conductivity Sensor Calibration Solution

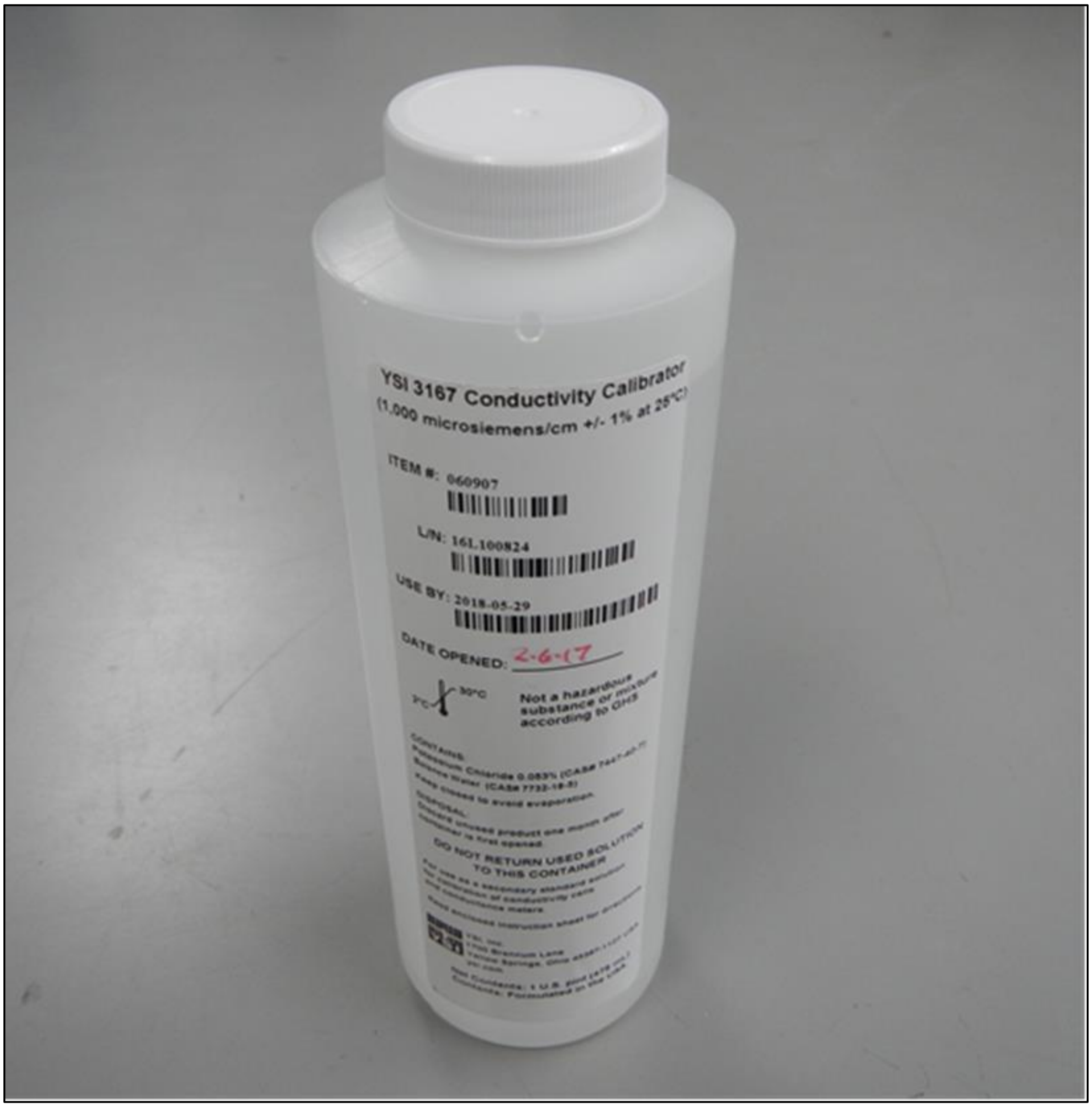


Figure 25: pH Sensor Calibration Solutions

WEATHER STATIONS

SPI's weather station sensors are calibrated and certified by the manufacturer. Prior to installation, all sensors are validated in the laboratory. Sensors are returned to Campbell Scientific if readings fail to meet specifications or match those of identical devices.

BIOASSESSMENT STUDIES

SPI's bioassessment studies utilize instruments and equipment associated with the analysis of BMIs, algae, nutrients, conventional analytes, and solid parameters. Calibration of these devices is detailed in the planning and procedural documents identified in Table 49.

Table 49: Device Calibration – Bioassessment Studies

Item	Document Reference(s)	Responsible Organization
BMI-related field and laboratory devices[1]	*Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016) *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)	ABL MPSL-MLML
Algae-related field and laboratory devices[1]	*Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016) *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)	CSUSM ABL MPSL-MLML
Chemistry-related devices	*North Coast Laboratories, Ltd. Quality Assurance Manual* (March 2018)	NCL
Chlorophyll a- and AFDM-related devices	*Marine Pollution Studies Laboratory Quality Assurance Program Plan* (November 2016)	MPSL-DFW
Silica-related devices	*Caltest Analytical Laboratory Quality Assurance Manual 23* (August 2019) *Determination of Trace Elements in Waters and Wastes by Inductively-Coupled Plasma-Mass Spectrometry (3 Mode)* (April 2011)	Caltest Analytical Laboratory

[1] Items appear in the documents *Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat* (May 2016) and *Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California* (March 2014)

B8: INSPECTION/ACCEPTANCE FOR SUPPLIES AND CONSUMABLES

Supplies and consumables will be inspected by the Program-Director-assigned laboratory personnel to make sure that they are intact, meet specifications, are available in adequate supply, and are stored properly. Specifications are detailed in standard operating procedures. If specifications are not met, the project manager or laboratory personnel will notify the QA Manager and a corrective action will be implemented and documented. Adherence to this policy will be assessed during the annual onsite audits performed by the QA Oversight Manager.

B9: NON-DIRECT MEASUREMENTS

The SPI Program Director utilizes measurements obtained from outside sources to supplement project data and, occasionally, to verify potential outliers. These non-direct measurements are itemized in Table 50.

Table 50: Non-Direct Measurements

Source	Use
California Environmental Data Exchange Network (State Water Resources Control Board) http://ceden.waterboards.ca.gov/AdvancedQueryTool	Fill information gaps and confirm results (chemistry, BMIs, temperature, turbidity)
Fire Weather - National Weather Service (National Oceanic and Atmospheric Administration) https://www.wrh.noaa.gov/fire2/cafw/index.php	Fill information gaps and comply with warnings (Red Flag Zones)
Sacramento Forecast - National Weather Service (National Oceanic and Atmospheric Administration) https://www.weather.gov/sto/	Fill information gaps and comply with warnings (Red Flag Zones)
Northern California Geographic Area Coordination Center: Operations Northern California (Multi-Agency) https://gacc.nifc.gov/oncc/predictive/fuels_fire-danger/	Confirm results (fuel and fire data)
MesoWest (University of Utah, Department of Atmospheric Sciences) http://mesowest.utah.edu/cgi-bin/droman/mesomap.cgi?state=CA&rawsflag=3	Fill information gaps and confirm results (weather station data)

Since data are mined from state and federal agencies that have internal QA systems, no further verification or validation is performed by SPI. Further, mined data are not subject to the requirements or stipulations contained in this QAPP or any relevant procedural documents.

B10: DATA MANAGEMENT

SPI's Research and Monitoring Program uses field and laboratory forms, proprietary data processing software, and multiple databases to optimize data management for its:

- Water quality stations
- Weather stations
- Bioassessment studies

Data management systems associated with each of these sources are addressed in the following sections. An additonal section is devoted to two master databases that utilize data from multiple sources.

WATER QUALITY STATIONS

All monitoring projects managed by SPI have an associated Installation Definition database. This database contains descriptive tables identifying:

- Station identification name
- Type and datalogger IDs
- Sensor IDs
- Measured parameters
- Physical location data

All sonde and flume measurements are 15-minute time-series samples.

Databases/Tables

Data are manually downloaded in the field for each water quality station, typically every 1-2 weeks. Downloading is performed by trained SPI research technicians. Field sheets for each site visit are cataloged and stored in annual, station-specifc binders for hardcopy reference. The field sheets are also entered into a field form database. Downloaded data are copied first to an external thumb drive or a data card, and then transferred to a portable computer as text files in the field (see Figure 26).

Figure 26: Field Data Transfer Equipment

These text files are then transferred to a central file server in the research office. This is a permanent repository. All data files from a download are stored in a folder reflecting the date of the download under the project name. All text files from a download are then uploaded into a single Microsoft Access database. Stored queries and procedures are then used to create a single table with standardized formatting, coding, and date/time stamping conventions. These are called processed raw sonde (PRS) databases/tables.

Data Cleanup

PRS tables are then processed by a proprietary primary QA/QC application called McQAQC. McQAQC uploads PRS tables and parses all data for each specific parameter into tables in a separate database.

Data coding and formats must agree 100% with specifications in the Installation Definition database or McQAQC will not upload it. One McQAQC database for each upload is created. Each McQAQC database is stored in a separate folder along with the PRS database. During a McQAQC upload, each measurement is programmatically examined to ensure that it is within the minimum and maximum values specified in Table 51.

Table 51: McQAQC Minimum and Maximum Values

Parameter	Description	Auto_Min	Auto_Max
AT	Air temperature (°C)	-20	65
ATF	Air temperature (°F)	-20	180
ATSD	AT standard deviation	0	1500
BV	Battery volts	-100	100
CFS	Discharge (ft/sec)	0	100
CT	Conductivity (mS/cm)	0	300
DO	Dissolved oxygen (mg/L)	0	30
DOC	Dissolved oxygen (charge)	-200	1000
DOP	Dissolved oxygen (%)	0	200
Flume	Flume	-1	30
FM	Fuel moisture (%)	-20	120
FT	Fuel temperature (°C)	-20	80
FTF	Fuel temperature (°F)	-20	180
FWS	Fire weather stage 0,1,2	0	2
GT	Ground temperature (°C)	-20	80
GTSD	Ground temperature standard deviation	0	1500
IT	Internal temperature (°C)	-20	200
ITF	Internal temperature(°F)	-100	200
PAR	Photosynthetically available radiation	0	3000
PARSD	PAR standard deviation	0	1500
PCOUNT72	Precipitation counter	0	72
pH	pH	0	10
PR	Pressure (centibar)	0	1000
PRECIP	Precipitation (inches/day)	0	1000
PRECIP72	Precipitation (72-hour total)	0	1000
RH	Relative humidity (%)	-5	107
RHSD	Relative humidity standard deviation	0	1500

Parameter	Description	Auto_Min	Auto_Max
SDAve	Swale depth (avg)	-200	200
SDMax	Swale depth (max)	-200	200
SDMin	Swale depth (min)	-200	200
SM	Soil moisture (%)	-2	100
SPC	Specific conductance (mS/cm)	0	300
SR	Solar radiation (W/m^2)	-10	1500
ST	Soil temperature (°C)	-15	80
STAGE	Water stage (ft)	0	100
STF	Soil temperature (°F)	-10	180
STSD	Soil temperature standard deviation	0	1500
SWD	Swale depth sample	-200	200
TB	Turbidity (NTU)	-10	5000
TB2	6136 NTU DUAL Bulkhead	-10	5000
TR	Tree	-1000	3000
WD	Wind direction (azimuth/degrees)	0	360
WDD	Wind direction deviation (azimuth/degrees)	0	720
WS	Wind speed (mph)	0	200
WT	Water temperature (°C)	-20	40

If a measurement is out of range, a database field is populated with a code indicating that the measurement is unusable. Additional data may be deemed unusable and can be marked and coded as such. McQAQC databases are the primary source of data used in subsequent analysis.

McADS

A second level of data processing is provided by another proprietary application called McADS. The primary purpose of McADS is to combine several McQAQC tables for specific date ranges and parameter selections into one database using only valid QA/QC data. All 15-minute data are combined in the process to produce hourly averages, minima, and maxima. McADS also produces reports indicating missing data sequences. If missing text files can be found, additional McQAQC databases are created and the McADS database is recreated. McADS databases are produced two to four times per water year for selected water quality and weather station parameters. These databases are stored on an SPI file server.

Manual Flow Measurements

Manual flow measurements adjacent to water quality monitoring stations are taken at select times by SPI research technicians. A field form is filled out for each measurement. Each observer has their own database with data entry capabilities. These databases are stored on an SPI file server. The data from the field form are entered into the individual database. The field form is then stored in a binder for reference. All of the individual flow databases are programmaticaly scanned and newer measurements are extracted into a master manual flow (MMF) database. The MMF database is stored on an SPI file server. Internal diagnostic routines examine the imported data for errors and inconsistencies. If problems arise, the involved databases and/or field forms are examined, the data are either corrected or marked as unusable, and the extraction procedure is repeated.

Water Chemistry Samples

Water chemistry samples are collected by SPI Research Foresters and contractors and sent to NCL for analysis. Standardized field forms are filled out for each sample and entered in the field forms database. The field forms are cataloged in binders for hardcopy reference. COC forms are maintained for each sample from the time of collection to delivery to NCL. Copies of the field forms are also sent with the sample. Batches of bottle samples are delivered to NCL within 48 hours of collection. NCL returns the results for all samples in a batch in a database with a table of agreed upon field names, coding conventions, and analytical results. This table is appended to a master chemistry sample database table. Standard diagnostic queries and procedures are processed for each new batch to see if there are any irregularities in the data. If there are, mitigation with NCL ensues, and a revised batch database is re-uploaded. Queries and stored procedures in the database provide summarization and reporting capabilities.

Sediment Samples

Automated sediment samples are collected in batches where approximately 0.33-L bottles are filled every 1-2 hours over a 24- or 48-hour period. Standardized field batch forms are filled out to reflect the sampling location and batch characteristics before being stored in binders for hardcopy reference. These data are also entered in the field forms database. The batch forms and samples are then processed in the SPI laboratory to determine the sediment weights in each bottle. The processed filters are cataloged and stored in the original filter boxes. Measurement results are manually entered in a standard batch analysis form and cataloged into binders. These data are then manually entered into a master sediment sample (MSS) database through built in forms. The MSS database is stored on an SPI file server with appropriate backups. The MSS database contains diagnostic and reporting routines to check and verify all of the manual data entry.

Particulate Organic Matter Samples

A subsample of the processed sediment filters is sent to NCL for particulate organic matter (POM) weight analysis. The MSS program produces a database table with relevant information about the subsample filters that accompany the physical filters. NCL returns the POM results in a Microsoft Excel database, which is then uploaded into a master POM database stored on an SPI file server. The new data are examined manually and by internal POM database diagnostics to find possible inconsistencies or errors. If errors or inconsistencies are found, NCL is contacted for mitigation and the data are either corrected or marked as unusable.

WEATHER STATIONS

With the exception of precipitation and relative humidity, weather station data are measured every 30 seconds and stored on dataloggers, taking 120 measurements per hour and storing an hourly average, minimum, and maximum. Precipitation is measured every thirty seconds and the incoming precipitation is totaled for the hour and stored in the datalogger. Relative humidity is measured every thirty seconds, and a sample and an hourly minimum and maximum are stored in the datalogger.

WeatherMon

Weather stations are linked to a dedicated computer at SPI headquarters through low-band radio communications. A proprietary software program called WeatherMon (WM) is programmed to download the hourly data each day and consolidate data from all weather stations into a single database. The WM database is automatically backed up daily and stored on a central SPI file server and on portable storage devices. Weather stations are visited multiple times annually by SPI research technicians to provide maintenance, repairs, and routine checkups. Field sheets of the station visits are maintained and stored in binders for hardcopy reference and entered into the field forms database. During the field visits, the station data are downloaded onto a portable computer as a backup to radio telemetry data. These data are handled the same as water quality station sonde text files (see above). WM provides daily reports of data acquisition progress as well as diagnostics. A 30-day diagnostic query is checked daily to determine sensor performance on all deployed weather stations.

WS_Maker

Once a year or as needed, a software program called WS_Maker produces databases and tables analogous to PRS databases and tables. The subsequent data handling procedures described above for water quality stations are followed. Currently, one annual water year weather station McQAQC database is created at the end of each water year with all stations and parameter values. These databases are stored on an SPI file server. Currently, one McADS database is created each year with only precipitation data.

MASTER DATABASES

Master Water Quality Database

A master water quality (MWQ) database is maintained with stage, turbidity, water temperature, precipitation, and flow (flumes where installed) and their associated QC codes for all water quality and associated precipitation stations from the time of their installation to the present water year. This database is updated annually at the end of each water year. It is the primary source of water quality time-series data for subsequent analysis. The source of the data for the update is McADS databases for the water year. The MWQ database has records for every hour from installation to the end of the water year for every station and parameter (values and QC codes). The MWQ database has stored procedures that will find every gap sequence (one hour or more of null values) for every parameter in the date range. For complete annual sediment budgets, values for every hour must be available. The database utilizes a robust interpolation routine to estimate values for small (usually five hours or less) gaps and set appropriate codes indicating the estimation method.

A proprietary charting program (i.e., MDBGrapher) has recently been extended to include a suite of missing data estimation procedures for time series data. Each gap is examined individually, the appropriate estimation method is selected and implemented, and each record in the gap has an estimate and estimation code assigned to it.

Master Watershed Analysis Database

Once a year, a master watershed analysis database is created using a standard database template. This database is the source of subsequent annual analysis and reports. The database consists of the following elements:

- The current MWQ database
- The current cubic feet per second (CFS)/stage models derived from data in the manual flows database
- The current SSC-prediction models derived from the suspended sediment database
- The current POM prediction models derived from the POM database
- The watershed logging activity table (provided by SPI area foresters)
- The sonde catchment area

The master watershed analysis database has built-in stored procedures and/or queries that are used to:

- Estimate SSC, POM, and CFS (for stations without flumes) for every hour and station
- Classify each hour and station by turbidity class

Additional stored queries calculate annual SSC and POM budgets for each station.

BIOASSESSMENT STUDIES

Bioassessment Sampling

Data collected will be managed in a Microsoft SQL Server database maintained at the MPSL-MLML Data Center, which allows the user data access through secure online forms.

The field crew uses the most current SWAMP bioassessment wadeable stream field data sheets during collection. Hard copy forms will be used in the field to record data. Within a month of collection, the data will be transferred by the field crew or MPSL staff from hard copy into soft copy using Microsoft Access SWAMP bioassessment data entry forms provided by MPSL. At least 10% of the electronic data will be compared against hard copy reports for accuracy. Any errors will be fixed and an additional 10% of electronic data will be checked. This process will continue until no errors are found within a 10% batch or 100% of the field forms are checked. Hard copy data sheets will be retained by the field crew and provided to the Program Director and/or QA Oversight Manager in either hard or soft copy if requested.

When PHAB data entry is complete, MPSL staff will export the data from Microsoft Access into

Microsoft Excel in the SWAMP template format. This template will be run through the MPSL SWAMP online checker to look for basic errors in the data. All errors will be fixed or addressed prior to submittal through the checker. MPSL staff will then load the data into the MPSL SQL server database. The MPSL SQL server database is backed up daily.

After PHAB data are entered into the MPSL SQL Server database, a Microsoft Excel reporting template will be created by MPSL staff for the algae and water chemistry laboratories. Each template will provide the necessary sample collection information upon which the laboratory will add their results. When the template is complete, laboratory staff will use the appropriate MPSL online checker to check for errors and submit their file.

BMI data are entered by ABL staff into the SWAMP database. Once finalized in the SWAMP database, SPI data are queried and loaded into the MPSL SQL Server database before being sent to CEDEN. Samples will be logged in by laboratory staff to assign LabSampleIDs prior to entering taxonomic data. When the BMI data have undergone internal and external QC review, the laboratory manager will notify MPSL staff that the data are final.

Algae results will be entered into the Microsoft Excel template provided by MPSL and checked for errors and submitted using the online MPSL SWAMP checker.

NCL, MPSL-DFW, and Caltest Analytical Laboratory will analyze water chemistry samples following the guidelines and requirements delineated in this QAPP. Results will be reported in the Microsoft Excel template provided by MPSL and checked for errors and submitted using the online MPSL CEDEN checker.

When all data components exist in the database, MPSL staff will conduct completeness checks across all data types checking for typographical errors, suspect values, and conformity to SWAMP business rules. MPSL staff will also verify field and chemistry data following MPSL protocols. BMI taxonomy external QC results will be compared against the MQOs specified in the SWAMP SOP *External Quality Control of Benthic Macroinvertebrate Taxonomy Data Collected for Stream Bioassessment in California* (July 2015). Algae-related external QC results will be compared against the SWAMP document *Standard Operating Procedures for Internal and External Quality Control of Laboratory Processing, Identification and Enumeration of Stream Algae in California* (November 2019). MPSL staff will report the findings to the QA Oversight Manager, Program Director, and Bioassessment Studies Manager.

Group C:
Assessment and Oversight

C1: ASSESSMENTS AND RESPONSE ACTIONS

SPI's Research and Monitoring Program implements various internal and external assessments to ensure that:

- Elements of this QAPP have been correctly implemented as prescribed;
- The quality of generated data meets project objectives;
- Data is produced in a manner consistent with "known and documented" quality; and
- Corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

THIRD-PARTY AUDITS

In December 2016, April 2018, and April 2019, SPI's Research and Monitoring Program hosted external, third-party audits by the QA Services Group from MPSL. Similar MPSL audits will recur on an annual basis between April and June each year.

INTERNAL AUDITS

To supplement MPSL's external audits, SPI staff performs internal audits on a quarterly basis. SPI staff also holds weekly internal QA meetings to address issues not associated with audit events.

DATA VERIFICATION

SPI data are reviewed according to Element D1: *Data Review, Verification, and Validation* and Element D2: *Verification and Validation Methods*. Review criteria are specified in Element A7: *Quality Control*.

CORRECTIVE ACTION

Corrective actions associated with the above assessments are specified in Element A7: *Quality Control*. Generally, SPI employs a "real time" corrective action policy in which the Program Director is notified of quality control issues within 24 hours.

C2: REPORTS TO MANAGEMENT

The Sierra Pacific Industries Research and Monitoring Program Director is responsible for all project reports to management. A variety of reports, including presentations, are provided internally to SPI managers to inform management decisions including, but not limited to, best management practices, fire prevention, road maintenance, watering, water monitoring, and timber harvest plans (see Table 52).

Table 52: Reports to Management

Type of Report	Date/ Frequency	Responsible Party	Report Recipients
Fire forecasting	Daily	Program Director	Forestry staff; Contractors covered under the SPI Fire Policy
Log plan review as part of fire forecasting	Daily and monthly	Program Director	Forestry staff
Timber harvest plan review	As requested,	Program Director	Contractors; Foresters; Management
Monitoring report (per Regional Water Quality Control Board general orders)	Annually	Program Director	Regional Water Quality Control Boards
Presentation	Monthly or bimonthly	Program Director	Foresters; District Managers
Content for sustainable yield plans	Annually	Program Director	Forestry Managers
Presentation for Sustainable Forestry Initiative	Annually	Program Director	Third-party auditors

Group D: Data Validation and Usability

D1: DATA REVIEW, VERIFICATION, AND VALIDATION

According to EPA, data verification is the process for evaluating the completeness, correctness, and conformance/compliance of a specific dataset against the method, procedural, or contractual specifications. Data validation extends the evaluation of data beyond verification to determine the quality of a specific dataset relative to the end use.

Data associated with SPI's bioassessment studies, water quality stations, and weather stations are evaluated against the requirements specified in the following elements of this QAPP:

- A7: *Quality Objectives and Criteria*
- B2: *Sample Handling and Custody*
- B7: *Instrument/Equipment Calibration and Frequency*

Data review, verification, and validation are performed using the procedures specified in Element D2: *Verification and Validation Methods.*

D2: VERIFICATION AND VALIDATION METHODS

SPI's data are reviewed against the criteria specified in Element D1: *Data Review, Verification, and Validation*. This element describes the review procedures associated with SPI's:

- Water quality stations
- Weather stations
- Bioassessment studies

Following the verification and validation procedures described below, the SPI project manager assesses data completeness by examining the:

- Number of samples collected compared to the sampling plan
- Number of samples shipped and received at the laboratory in good condition
- Laboratory's ability to produce usable results for each sample

WATER QUALITY STATIONS

SPI's water quality stations host a variety of sonde-based and manual field measurements. Resulting data are verified and validated according to the *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016).

WEATHER STATIONS

SPI's weather stations collect a variety of atmospheric and fire-related measurements. Resulting data are verified and validated according to the *Sierra Pacific Industries Research and Monitoring Water Quality Manual* (November 2016).

BIOASSESSMENT STUDIES

SPI's bioassessment studies generate data produced by NCL, ABL, CSUSM, MPSL-DFW, and Caltest

Analytical Laboratory. These data are ultimately subject to the verification and validation processes of this QAPP. Laboratory-specific data review processes are identified in the following sections.

North Coast Laboratories, Ltd.

NCL's data verification and validation are performed according to the *North Coast Laboratories, Ltd. Quality Assurance Manual* (March 2018).

California Department of Fish and Wildlife Aquatic Bioassessment Laboratory

ABL's data verification and validation are performed according to the SWAMP documents *Standard Operating Procedures for the Laboratory Processing and Identification of Benthic Macroinvertebrates in California* (October 2012) and *Standard Operating Procedures for the External Quality Control of Benthic Macroinvertebrate Taxonomy Data Collected for Stream Bioassessment in California* (July 2015). Because ABL is a SWAMP master-contract laboratory, data produced for SPI will ultimately be uploaded to CEDEN.

California State University at San Marcos

CSUSM's data verification and validation are performed according to the SWAMP documents *Standard Operating Procedures for the Laboratory Processing, Identification, and Enumeration of Stream Algae* (November 2015) and *Standard Operating Procedures for Internal and External Quality Control of Laboratory Processing, Identification and Enumeration of Stream Algae in California* (November 2019). Because CSUSM is a SWAMP master-contract laboratory, data produced for SPI will ultimately be uploaded to CEDEN.

Marine Pollution Studies Laboratory – Department of Fish and Wildlife

MPSL-DFW chlorophyll a data are verified and validated according to Section 12 of the *Marine Pollution Studies Laboratory Quality Assurance Program Plan*. Because MPSL-DFW is a SWAMP master-contract laboratory, data produced for SPI will ultimately be uploaded to CEDEN.

Caltest Analytical Laboratory

Caltest's Analytical Laboratory's data verification and validation are performed according to the *Caltest Analytical Laboratory Quality Assurance Manual 23* (August 2019).

D3: RECONCILIATION WITH USER REQUIREMENTS

The Program Director and supporting consultant Dr. Bruce Krumland are responsible for sampling site selection, method selection, the design of data collection and processing systems, and subsequent analysis. Reconciliation of all phases of the data processing stream are managed by these two researchers together by verbal, email, or written communication.

Continuous hourly data are screened for anomalies by:

- Automated methods that detect improbable values
- Field personnel at the time of collection
- Graphical time series examination by the Program Director and supporting consultant Dr. Krumland

Samples (i.e., flow, turbidity) are screened for anomalies by:

- Field personnel at the time of collection
- Lab personnel during the measurement process (e.g., insufficient sample volume, excessive gravel)
- Graphical time series examination by the Program Director and supporting consultant Dr. Krumland

All data deemed anomalous are flagged with appropriate codes.

Anomalous and missing hourly data are estimated by a suite of regression, interpolation and diurnal traverse procedures. Every time series gap in each station is examined individually and, depending on the nature of the gap, an appropriate estimation procedure is implemented. All time series data estimated are flagged with the type of estimation procedure employed.

Suspended sediment concentrations, flow, and particulate organic matter (Y values), are modeled from samples by one of the following:

- Linear regression
- Step-wise linear regression
- Non-linear regression methods

The X values are typically turbidity and/or stage and various transformations thereof. When logarithmic transformations of the Y variable are employed, predictions are corrected for bias using Baskerville's method. Outlier detection is accomplished by visual examination of residuals versus predicted values, and by frequency distributions of residuals. Data for suspected outliers (both Ys and Xs) are examined to ensure validity. When deemed an outlier, the sample is marked as being anomalous and removed from analysis. Predictions throughout the range of available X values are examined to ensure that there are no spurious predictions due to extrapolations beyond the limits of the samples. If there are, alternate model forms are utilized.

Data that are estimated (<10% of data are estimated) are treated as actual observations in analysis. Data that are anomalous have been flagged and will be used in analysis. Analytical results are presented as:

- Standard regression summaries
- Residual plots against predicted/X values
- Numbers of observations (i.e., total, estimated, not used)

Comparisons between stations and water years will be analyzed by univariate analysis of variance with results tabled.

Turbidity data are classified into ranges (e.g., 0-10, 10-25, 25+) and presented as frequency histograms by station and water year. Suspended sediment and particulate organic matter results (T/km^2 per catchment) are presented as annual budgets in tables and line graphs of cumulative yields by day of the year for stations and water years. Weather station hourly data are used to run the NFDRS.

Appendices

APPENDIX A: ABBREVIATIONS AND ACRONYMS

ABL	Aquatic Bioassessment Laboratory
AFDM	Ash-Free Dry Mass
ASTM	American Society for Testing and Materials
BMI	Benthic Macroinvertebrate
BMP	Best Management Practice
BOF	California Board of Forestry
CAL FIRE	California Department of Forestry and Fire Protection
CCV	Continuing Calibration Verification
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
CFPR	California Forest Practice Rules
CFS	Cubic Feet per Second
CGS	California Geological Survey
COC	Chain of Custody
CRM	Certified Reference Material
CSUSM	California State University at San Marcos
DFW	California Department of Fish and Wildlife
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQI	Data Quality Indicator
ELAP	Environmental Laboratory Approval Program
EPA	United States Environmental Protection Agency
GIS	Geographic Information System
IC	Ion Chromatograph
ICP-MS	Inductively-Coupled Plasma – Mass Spectrometry
ICP-OES	Inductively-Coupled Plasma - Optical Emission Spectrometry
ICV	Initial Calibration Verification

LCS	Laboratory Control Sample
MDL	Method Detection Limit
MLML	Moss Landing Marine Laboratories
MPSL	Marine Pollution Studies Laboratory
MQO	Measurement Quality Objective
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSS	Master Sediment Sample Database
MWQ	Master Water Quality Database
NCL	North Coast Laboratories, Ltd.
NFDRS	National Fire Danger Rating System
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Unit
NWQMC	National Water Quality Monitoring Council
NWS	National Weather Service
PAL	Project Activity Level
PHAB	Physical Habitat
POM	Particulate Organic Matter
ppm	Parts per Million
PRS	Processed Raw Sonde Data
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCC	Reference Clearcut
READI	Road Erosion and Sediment Delivery Index
RL	Reporting Limit
RPD	Relative Percent Difference
RWQCB	Regional Water Quality Control Board
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SERP	Southern Exposure Research Project
SOP	Standard Operating Procedure
SPI	Sierra Pacific Industries, Inc.
SSC	Suspended Sediment Concentration

SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
USGS	United States Geological Survey
YSI	Yellow Springs Instruments

APPENDIX B: GLOSSARY

Accuracy	The closeness or agreement of the observed value or test response to the true or acceptable reference value or the test response from a reference method. It is influenced by both random error (precision) and systematic error (bias). The terms "bias" and "precision" are often used in lieu of "accuracy".
Analytical Batch	A group of 20 or fewer samples and associated quality control that is processed by the same instrument within a 24-hour period (unless otherwise specified by method). An analytical batch may comprise multiple sample batches.
Assessment	A general evaluation process used to evaluate the performance, effectiveness and processes of a management and/or technical system.
Batch	The collection of samples of the same group which is to be analyzed in one test run or inspected together within a specific time limit and traceable as a unit.
Bias	The constant or systematic distortion of a measurement process that manifests itself as a persistent positive or negative deviation from the known or true value. This can result from improper data collection, poorly calibrated analytical or sampling equipment, or limitations or errors in analytical methods and techniques.
Blank	A specimen that is intended to contain none of the analytes of interest and which is subjected to the usual analytical or measurement process to establish a zero baseline or background value.
Calibration	A comparison of a measurement standard, instrument, or item with one having higher accuracy to detect, quantify, and record any inaccuracy or variation; the process by which an instrument setting is adjusted based on response to a standard to eliminate the inaccuracy.
Calibration Standard	Reference solution of known value used to correct an instrument reading.
Certified Reference Material	A substance whose property values are certified by a procedure which establishes its traceability and uncertainty at a stated level of confidence.
Comparability	A measure of the confidence with which one dataset, element, or method can be considered as similar to another.
Completeness	A measure of the amount of valid data obtained from a measurement system.

Continuing Calibration Verification	A periodic standard used to assess instrument drift between calibrations.
Control Limit	The variation in a process dataset expressed as plus/minus standard deviations from the mean, generally placed on a chart to indicate the upper and lower acceptable ranges of process data and to judge whether the process is in or out of statistical limitations.
Corrective Action	Any measures taken to rectify conditions adverse to quality and/or to eliminate the causes of an existing nonconformity, defect, or other undesirable situation in order to prevent reoccurrence.
Data Validation	An analyte- and sample-specific process that evaluates the information after the verification process (i.e., determination of method, procedural, or contractual compliance) to determine analytical quality and any limitations.
Data Verification	The process of evaluating the completeness, correctness, and conformance/compliance of a specific information set against the method, procedural, or contractual specifications for that activity.
Equipment Blank	An aliquot of reagent water that is subjected in the laboratory to all aspects of sample collection and analysis, including contact with all sampling devices and apparatus. The purpose of the equipment blank is to determine if the sampling devices and apparatus for sample collection have been adequately cleaned before they are shipped to the field site. An acceptable equipment blank must be achieved before the sampling devices and apparatus are used for sample collection.
Field Blank	A clean analyte-free sample which is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. This blank is used to provide information about contaminants that may be introduced during sample collection, storage, and transport.
Field Duplicate	An independent specimen collected from the same point in time and space as the previous specimen.
Field Measurements	Those activities associated with performing analyses or measurements in the habitat being examined.
Holding Time	The period of time a sample may be stored following collection, preservation, extraction, or analysis. While exceeding the holding time does not necessarily negate the veracity of analytical results, it causes the qualification of any data not meeting all of the specified acceptance criteria.
Initial Calibration Verification	A standard used to assess instrument drift at the beginning of an analytical batch.
Intercomparison	An exercise in which samples are prepared and split by a reference laboratory, then analyzed by one or more testing laboratories and the reference laboratory. The intercomparison,

	with a reputable laboratory as the reference laboratory, serves as the best test of the precision and accuracy of the analyses at natural environmental levels.
Interference	An element, compound, or other matrix effect present in a sample which disturbs the detection of a target analyte leading to inaccurate concentration results for the target analyte.
Laboratory Blank	An aliquot of reagent water that is treated exactly as a sample including exposure to all glassware, equipment, solvents, and reagents that are used with samples. The laboratory blank is used to determine if method analytes or interferences are present in the laboratory environment, the reagents, or the apparatus.
Laboratory Duplicate	Two or more representative portions taken from one homogeneous sample by the analyst and analyzed in the same testing facility.
Laboratory Control Sample	A specimen of known composition prepared using contaminant-free reagent water, or an inert solid, that is spiked with the analyte of interest at the midpoint of the calibration curve or at the level of concern; and then analyzed using the same preparation, reagents, and analytical methods employed for regular specimens and at the intervals set in the Quality Assurance Project Plan.
Matrix	The material of which the sample is composed or the substrate containing the analyte of interest, such as drinking water, waste water, air, soil/sediment, biological material, etc. Also called medium or media.
Matrix Spike	A test specimen prepared by adding a known concentration of the target analyte to a specified amount of a specific homogenized specimen where an estimate of the target concentration is available and subjected to the entire analytical protocol.
Matrix Spike Duplicate	A sample prepared simultaneously as a split with the matrix spike sample with each specimen being spiked with identical, known concentrations of targeted analyte.
Measurement Quality Objectives	The individual performance or acceptance goals for the individual Data Quality Indicators such as precision or bias.
Method	A procedure, technique, or tool for performing a scientific activity.
Method Blank	A blank prepared to represent the sample matrix as closely as possible and analyzed exactly like the calibration standards, samples, and quality control (QC) samples. Results of method blanks provide an estimate of the within-batch variability of the blank response and an indication of bias introduced by the analytical procedure.
Method Detection Limit	The minimum concentration of an analyte that undergoes the entire measurement process and can be reported with a stated level of confidence that the analyte concentration is greater than

	zero.
Non-Direct Measurements	Data obtained from existing sources rather than measured or generated directly.
Parameter	A statistical quantity, usually unknown, such as a mean or a standard deviation, which characterizes a population or defines a system.
Precision	A measure of mutual agreement between two or more individual measurements of the same property, obtained under similar conditions.
Quality Assurance	An integrated system of management activities (planning, implementation, assessment, reporting, and quality improvement) that focuses on providing confidence in the data or product by ensuring that it is of the type and worth needed and expected by the client.
Quality Assurance Project Plan	A document that describes the intended technical activities and project procedures that will be implemented to ensure that the results of the work to be performed will satisfy the stated performance or acceptance criteria. The amount of information presented and the planned activities to ensure the value of the work will vary according the type of study and the intended use of the data.
Quality Assurance Program Plan	A document describing in comprehensive detail the necessary decisions and decision criteria to be used by an overall regulatory program.
Reference Material	A substance whose properties are sufficiently homogeneous and established to be used for calibration and measurement.
Reporting Limit	The minimum value below which data are documented as non-detected.
Sensitivity	The capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest.
Spike	A known quantity of an analyte added to a sample for the purpose of determining recovery or efficiency (analyst spikes), or for quality control (blind spikes).
Standard Deviation	The measure of the dispersion or imprecision of a series of accepted results around the average, equal to the square root of the variance.
Standard Operating Procedure	A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps and that is officially approved as the method for performing certain routine or repetitive tasks.
Working Standard	A dilution of a stock standard.

APPENDIX C: REFERENCES

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APPENDIX D:
CHAIN-OF-CUSTODY FORMS

Figure 27: Chain-of-Custody - Aquatic Bioassessment Laboratory

MPSL-MLML REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY (COC) RECORD

ProjectCode:
AgencyCode:
Funding:
Date:
Field Crew:

Contact Person:
Phone:
email:
Mailing Address:

StationCode	Sample Type Code	Location Code	Field Replicate	Sample Date	Collection Time	Collection Depth wat (m) sed (cm) integrated (-88)	Salinity (ppt) EC (µS/cm)	Field Preparation Preservation	Bioassessment TRC[1] SAFIT STE Level II Taxonomy	Bioassessment RWB[2] SAFIT STE Level II Taxonomy	Bioassessment MCM[3] SAFIT STE Level II Taxonomy
								TOTAL			

Comments:

Samples Relinquished by: Name (Print and Sign)	**Date & Time**	**Samples Received by:** Name (Print and Sign)	**Date & Time**

Figure 28: Chain-of-Custody - Caltest Analytical Laboratory

MPSL-MLML REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY (COC) RECORD

ProjectCode:
AgencyCode:
Funding:
Date:
Field Crew:

Contact Person:
Phone:
email:
Mailing Address:

StationCode	Sample Type Code	Location Code	Field Rep	Sample Date	Collection Time	CollectionDepth wat (m) sed (cm) integrated (-88)	Salinity (ppt) EC (µS/cm)	Field Preparation Preservation	Water Silica dissolved 500 ml HDPE				
								TOTAL					

Comments:

Samples Relinquished by: Name (Print and Sign)	**Date & Time**		**Samples Received by:** Name (Print and Sign)	**Date & Time**

Figure 29: Chain-of-Custody - California State University at San Marcos

MPSL-MLML REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY (COC) RECORD

ProjectCode:
AgencyCode:
Funding:
Date:
Field Crew:

Contact Person:
Phone:
email:
Mailing Address:

StationCode	Sample Type Code	Location Code	Field Replicate	Sample Date	Collection Time	CollectionDepth wat (m) sed (cm) integrated (-88)	Salinity (ppt) EC (ppt)	Field Preparation Preservation	Composite Volume (ml)	Sample Volume (ml)	GrabSize or Area Sampled (cm2)	Taxonomy Soft Algae[1]	Taxonomy Diatoms[1]	Taxonomy Soft Algae
												Quantitative	Quantitative	Qualitatitve
								TOTAL						

Comments:

Samples Relinquished by: Name (Print and Sign)	Date & Time	**Samples Received by:** Name (Print and Sign)	Date & Time

Figure 10: Chain-of-Custody - Marine Pollution Studies Laboratory - Department of Fish and Wildlife

MPSL-MLML REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY (COC) RECORD

ProjectCode:
AgencyCode:
Funding:
Date:
Field Crew:

Contact Person:
Phone:
email:
Mailing Address:

StationCode	Sample Type Code	Location Code	Field Rep	Sample Date	Collection Time	CollectionDepth wat (m) sed (cm) integrated (-88)	Salinity (ppt) EC (µS/cm)	Field Preparation Preservation	Composite Volume (ml)	Sample Volume (ml)	GrabSize or Area Sampled (cm2)	Benthic Chl[1] filter	Benthic AFDM_Algae[2] filter		
								TOTAL							

Comments:

Samples Relinquished by: Name (Print and Sign)	Date & Time		**Samples Received by:** Name (Print and Sign)	Date & Time

Figure 11: Chain-of-Custody - North Coast Laboratories, Ltd.

MPSL-MLML REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY (COC) RECORD

ProjectCode:
AgencyCode:
Funding:
Date:
Field Crew:

Contact Person:
Phone:
email:
Mailing Address:

StationCode	Sample Type Code	Location Code	Field Rep	Sample Date	Collection Time	CollectionDepth wat (m) sed (cm) integrated (-88)	Salinity (ppt) EC (ppt)	Field Preparation Preservation	Water Inorganics[1] 500 ml HDPE	Water Inorganics[2] 500 ml amber	Water Inorganics[2] 250 ml HDPE	Water Hardness[4] 250 ml HDPE	Water TSS[5] 1 qt HDPE	Water SSC[5] 500 ml HDPE	Water DOC[6] 40 ml amber
								TOTAL							

Comments:

Samples Relinquished by: Name (Print and Sign)	Date & Time	Samples Received by: Name (Print and Sign)	Date & Time