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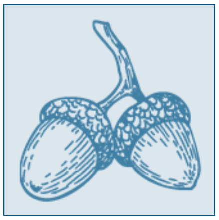

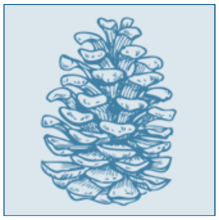


Water Quality Monitoring

Quality Assurance Project Plan

Version 3.1 (Public)
December 23, 2022

Prepared by:
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Research and Monitoring Program
Sierra Pacific Industries
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In Collaboration with:
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NOTE

This Version 3.1 is a public copy of Sierra Pacific Industries' *Water Quality Monitoring Quality Assurance Project Plan* Version 3.0. Proprietary and confidential information, including maps and coordinates, have been removed.

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	December 23, 2022

APPROVALS

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

12/23/22

Signature | Date

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

12/23/22

Signature | Date

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RECOMMENDED CITATION

James, C. *Water Quality Monitoring Quality Assurance Project Plan*; Version 3.1; Sierra Pacific Industries: Redding, CA, 2022.

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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 QA and laboratory analysis (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
Will Hagan Quality Assurance Oversight Manager (206) 527-3313 william.hagan@sjsu.edu	c/o Moss Landing Marine Laboratories Marine Pollution Studies Laboratory 7544 Sandholdt RD Moss Landing, CA 95039
Cajun James, Ph.D. Program Director and Quality Assurance Manager (530) 378-8151 cjames@spi-ind.com	Sierra Pacific Industries Research and Monitoring PO Box 496028 Redding, CA 96409
Roxanne Golich North Coast Laboratories Ltd. Project Manager (707) 822-4649 #101 rgolich@northcoastlabs.com	North Coast Laboratories Ltd. Management Division 5680 W End RD Arcata, CA 95521-9202

ADDITIONAL DISTRIBUTION

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

- California Board of Forestry
- 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 Environmental Data Exchange Network (CEDEN)
- California Geological Survey
- Central Valley Regional Water Quality Control Board (RWQCB) – Rancho Cordova and Redding offices
- Bruce Krumland (Independent Consultant)
- Lahontan RWQCB
- National Fish and Wildlife Foundation
- Marco Sigala and Stacey Swenson (Marine Pollution Studies Laboratory (MPSL) - Moss Landing Marine Laboratories)
- State Water Resources Control Board (SWRCB)

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 SPI's water quality monitoring system, SPI, MPSL, and North Coast Laboratories Ltd. (NCL) staff serve in oversight roles, with scientific advisors representing a variety of other organizations.

OVERSIGHT

Cajun James, Ph.D. – Sierra Pacific Industries

Program Director, Quality Assurance Manager

Since 2000, Dr. Cajun James has worked at SPI to establish the Research and Monitoring Program in California, Oregon, and Washington. 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 using the National Fire Danger Rating System.

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 utilized methods and standard operating procedures (SOPs)
- 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 QA Manager, Dr. James:

- Creates and maintains this QAPP and any relevant 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

Brian Adair – Sierra Pacific Industries

Research Forester Lead

Brian Adair became a Research Forester in 2008 before being designated Lead in 2016. As Research Forester Lead, Mr. Adair performs the following duties in California, Oregon, and Washington:

- 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
- 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.

North Coast Laboratories Ltd. Project Manager

Roxanne Moore has been employed at 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 NCL Project Manager, Ms. Moore:

- Ensures that the overall project is completed according to the proposed plan in consultation with the Program Director
- 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 (QC) 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
- Communicates with the Program Director and 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

Will Hagan – Marine Pollution Studies Laboratory

Quality Assurance Oversight Manager

Will Hagan of MPSL provides objective, third-party QA oversight of SPI's Research and Monitoring Program. Since joining MPSL in 2005, Will has partnered with the SWRCB (Surface Water Ambient Monitoring Program (SWAMP), 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:

- Creates, reviews, and approves project QA documentation (including this QAPP)
- Audits the SPI Research and Monitoring Program as requested by the Program Director
- Provides QA training as needed
- Assists the program director in developing measurement quality objectives (MQOs) and QA systems that meet SPI objectives

SCIENTIFIC ADVISORS

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 Program. 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

Marco Sigala

Marine Pollution Studies Laboratory (Moss Landing Marine Laboratories)

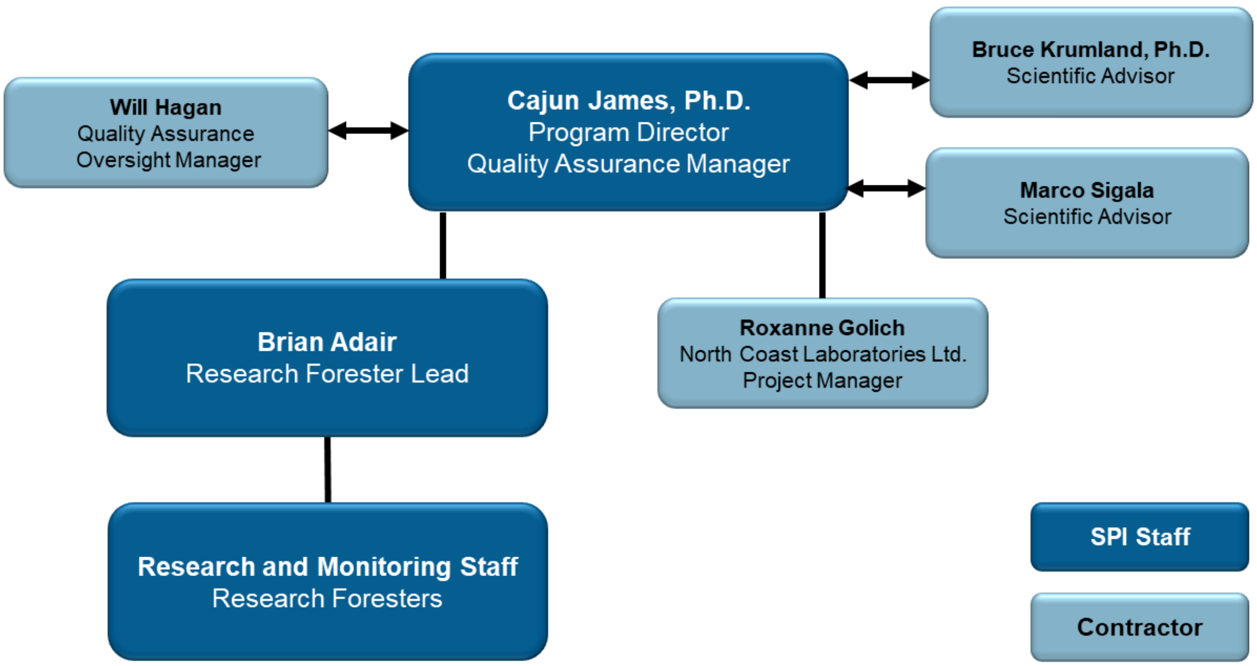
Since 2000, Mr. Sigala has participated in many state, regional, and federal (e.g., Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA)) projects performing and managing all duties such as sample collection, logistical support, coordination of field teams and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

- Assists with project planning and data interpretation as requested by the Program Director
- Prepares and reviews elements for this QAPP as needed
- Provides routine contact with the Program Director, QA Oversight Manager, and Research Forester Lead
- Assists the corrective action process when isolated QA issues are identified

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.

PROBLEM STATEMENT

Prior to 2000, there were few historical data available to investigate the potential effects of forestry operations and wildfire on streams and watersheds within SPI's ownership (i.e., 1.9 million acres in California, 177,000 acres in Oregon, and 310,000 acres in Washington). 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 been developing a water quality program based on in-situ, field, and laboratory analysis (see A6: *Project/Task Description*). Resulting 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. 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
7. Submit water quality data to CEDEN and other state and federal agencies

Figure 2: Water Quality Station

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 National Water Quality Monitoring Council (NWQMC) "Montoring Framework" (Figure 3).

Figure 3: National Water Quality Monitoring Council Monitoring Framework

The center of the NWQMC 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 NWQMC 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 3 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 3: Adherence to the National Water Quality Monitoring Council Framework

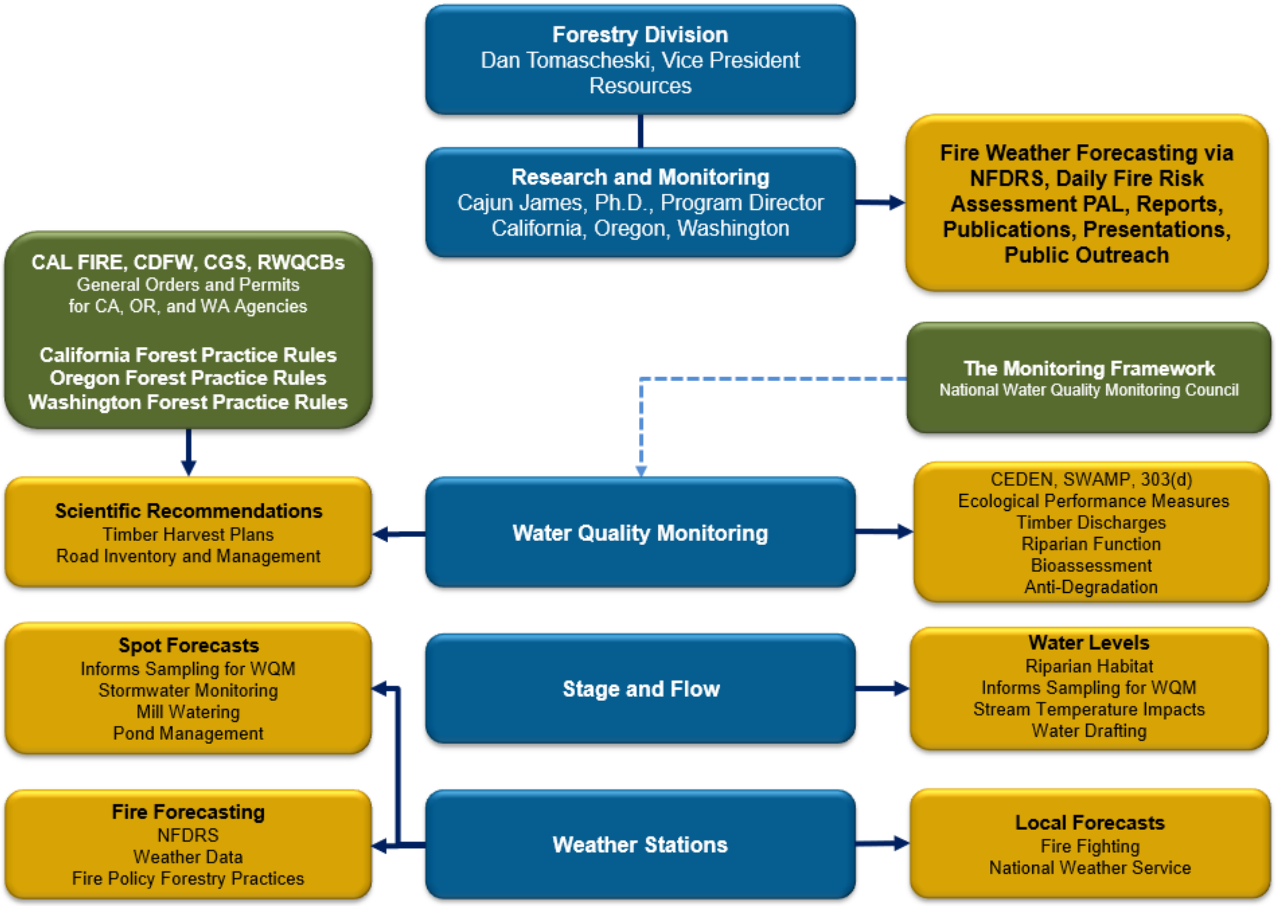
NWQMC Guideline	SPI Research and Monitoring Project
Develop monitoring objectives	• Evaluate water quality over time and space to investigate the potential effects of forestry operations and wildfire on surrounding streams and watersheds
Design monitoring program	• 19 permanent stations • EPA 24-element QA project plan
Collect field and laboratory data	• Continuous water quality data • Flow data

NWQMC Guideline	SPI Research and Monitoring Project
Compile and manage data	• Research data resides on secure SPI cloud-based storage • 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, hydrology, 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 • Sustainable Forestry Initiative
Collaborate	• SWAMP • CDFW • MPSL
Coordinate	• SWRCB • CVRWQCB Redding
Communicate	• CEDEN • SWRCB Integrated Report 303(d) solicitation • Peer-reviewed publications • SPI website • Conference presentations • Presentations at California universities and colleges • QAPP distribution

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 SPI managers, the Program Director determines the focus of product and tool development for the coming year. 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 4 depicts how SPI's water quality monitoring project contributes to the Research and Monitoring Program's products and tools.

Figure 4: Highlighted Products and Tools



A6: PROJECT/TASK DESCRIPTION

This element details the logistics (i.e., constituents, scheduling, geographical setting, and constraints) associated with SPI water quality monitoring. Element B1: *Sampling Process Design* details the experimental design behind these logistics.

CONSTITUENTS TO BE MONITORED

SPI monitors 12 water quality parameters via in-situ, field, and laboratory analysis. These constituents and their associated details are provided in Table 4.

Table 4: Constituents to be Monitored

Constituent	Unit
Conductivity	mS/cm
Dissolved oxygen	%, mg/L, charge
Flow	ft^3/s
Oxidation reduction potential	mV
pH	pH
Specific conductance	mS/cm
Stage	ft
Temperature	°C
Turbidity	NTU

SCHEDULE

Throughout the year, water quality stations host continuous, in-situ, sonde and flume analyses with results collected at 15-minute intervals. During monthly sonde rotations and during unscheduled maintenance and repairs, flow and turbidity are measured manually. As requested by the Research and Monitoring Program Director, additional water quality monitoring may be scheduled at any time. Table 5 identifies key recurring project events.

Table 5: Schedule of Key Project Events

Task	Frequency	Product	Responsible Party
Internal QC Audit (field/laboratory)	Quarterly	Audit checklist	QA Manager; Research Forester Lead
QAPP review	Annually	Current QAPP	QA Oversight Manager; Program Director
Sonde rotation	Monthly	15-minute data	QA Manager; Research Forester Lead
SOP review	Annually	Current SOPs	QA Oversight Manager; Program Director

GEOGRAPHICAL SETTING

Locations

While the Research and Monitoring Program's water quality monitoring may occur anywhere on SPI land in California, Oregon, and Washington, many analyses occur at dedicated water quality monitoring stations in California. There are also established flow measurement locations at each station indicated by flagging or rebar. Currently active California water quality stations are mapped in Figures 5 and 6.

Figure 5: Water Quality Station Map (North)

[redacted]

Figure 6: Water Quality Station Map (South)

[redacted]

Water quality station identifiers and coordinates are specified in Table 6.

Table 6: Water Quality Station Locations

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

Four of the above water quality stations include flumes designed for stage measurements. Table 7 specifies the identifiers and coordinates of each flume.

Table 7: 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

Descriptions

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 (including 69 Tidbit temperature loggers). The bulk of the study 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 in the RCC. 42 Tidbit temperature loggers deployed throughout Judd Creek record water temperature, while the other 27 Tidbit temperature loggers 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 temperature loggers.

North Fork Swift Creek: Station ID 528

Installed in September 2022, North Fork Swift Creek is located on the Weaverville District near Trinity Center. There is one sonde continuously monitoring the water quality at this site all year.

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.

East Fork Browns Creek: Station ID 568

This site is located on the Weaverville District near Douglas City. It will host one continuously monitoring sonde when flow conditions are appropriate.

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 dataloggers on the south side of the creek in Control C1, Unit A, Unit B, and Control C3. There are seven, streambank-based dataloggers that measure water temperature located on the boundary between each unit. There are also 33 Tidbit temperature loggers 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 temperature loggers 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 datalogger and an ultrasonic depth sensor. There are two time-lapse digital cameras mounted to each sediment fence.

Shasta Ranch: Station IDs 534, 535, 536, 537, 538

Started in 2022, this study is located near Lake Shastina and the town of Gazelle in Northern California. Water temperature and DO are recorded via two dataloggers each on Parks and Kettle Springs Creeks, and one datalogger on Shasta River. Time lapse cameras are located at each site to visually monitor stream conditions.

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 damage, and vandalism may impact the number of valid sample results, they are very unlikely to affect SPI's completeness goal of 90%.

A7: QUALITY OBJECTIVES AND CRITERIA

DATA QUALITY INDICATORS

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
- Representativeness
- Comparability
- Completeness
- Sensitivity

EPA definitions associated with each DQI are provided in Table 8.

Table 8: 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.

For SPI's water quality stations, DQIs are evaluated and optimized according to Table 9.

Table 9: Data Quality Indicator Implementation

Indicator	Monitoring Practice
Precision	• Use of consistent devices over time and space • Use of consistent methods and SOPs • Systematic checking and calibrating of equipment per manufacturer specifications • Replacement rather than repair of defective equipment
Bias	• Fouling prevention
Accuracy	• Fouling prevention • Adherence to QAPP Element B6: *Instrument/Equipment Testing, Inspection, and Maintenance* • Adherence to QAPP Element B7: *Instrument/Equipment Calibration and Frequency*
Representativeness	• Adherence to QAPP Element A5: *Problem Definition/Background* • Adherence to QAPP Element A6: *Project/Task Description*
Comparability	• Use of consistent devices over time and space • 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*

MEASUREMENT QUALITY OBJECTIVES

Because SPI's in-situ water quality measurements utilize no QC samples, these analyses have no associated MQOs. Instead, utilized devices must meet the performance requirements specified in B6: *Instrument/Equipment Testing, Inspection, and Maintenance* and B7: *Instrument/ Equipment Calibration and Frequency*.

Turbidity

MQOs are applicable to non-in-situ turbidity measurements, which must adhere to the following MQOs (Table 10) and corrective actions (Table 11).

Table 10: Quality Control[1]: Non-In-Situ Turbidity

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	Monthly, with calibration	80-120% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
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)
Field Blank, Travel Blank, Equipment Blank	Per method	<RL for target analyte

[1] Unless method specifies more stringent requirements

Table 11: Corrective Action: Non-In-Situ Turbidity

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.
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.

A8: SPECIAL TRAINING NEEDS/CERTIFICATION

Training for field, laboratory, administrative, and maintenance work is conducted for all SPI Research Foresters 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.

Non-in-situ turbidity analysis is performed by NCL, which holds certificate #1247 with California's Environmental Laboratory Accreditation Program (ELAP). As part of its accreditation, NCL participates in routine proficiency tests through multiple vendors, and is subject to ELAP audits.

A9: DOCUMENTATION AND RECORDS

CRITICAL RECORDS

SPI will collect and compile records from its water quality monitoring project. 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 Anderson offices under direction and supervision of the Program Director.

VERSION CONTROL

The Program Director will ensure that this QAPP is subject to strict version 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 (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.

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

Sonde and flume placement were carefully considered during project planning.

SONDES

To select representative streams for monitoring, 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 SPI's California acreage.

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.

B2: SAMPLING METHODS

Most SPI water quality monitoring involves in-situ measurements, rather than the collection of samples for subsequent processing. However, samples for non-in-situ turbidity analysis are collected according to the applicable SPI SOP(s):

- *Field Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*
- *Laboratory Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*
- *Grab Sampling*

B3: SAMPLE HANDLING AND CUSTODY

SAMPLE HANDLING

Most SPI water quality monitoring involves in-situ measurements, rather than the collection of samples for subsequent processing. However, samples for non-in-situ turbidity analysis are handled according to the applicable SPI SOP(s):

- *Field Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*
- *Laboratory Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*
- *Grab Sampling*.

Processing of these samples must meet the requirements specified in Table 12.

Table 12: Sample Handling

Constituent	Container	Preservation[1]	Holding Time
Turbidity	Polyethylene or amber glass	Cool to ≤6 °C	48 hours

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

CUSTODY

While most water quality monitoring analyses are performed by SPI Research Foresters, non-in-situ turbidity samples may be collected by SPI (see B2: *Sampling Methods*) and transferred to NCL for analysis (see B4: *Analytical Methods*). In such cases, samples will be transported to NCL by SPI or FedEx. The NCL COC form (Appendix B) will be filled out and delivered with the samples to the laboratory. An electronic version of the chain-of-custody (COC) will also be emailed to the laboratory prior to or on the day of sample arrival. At the time of delivery, the time, date, and temperature of the cooler blank bottle or one sample bottle will be recorded by NCL.

B4: ANALYTICAL METHODS

SPI water quality monitoring utilizes the in-situ, field, and laboratory analyses summarized in Table 13.

Table 13: Analytical Methods

Measurement Device	Constituent	Analytical Method	Analysis Organization
Global Water Instruments FP111 Flow Staff	Flow	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *FP111 Global Water Flow Probe User's Manual* (2009)	SPI
Hach 2100N Laboratory Turbidimeter	Turbidity	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *Hach 2100N IS User Manual* (6th Ed.)	SPI
Hach 2100P Portable Turbidimeter	Turbidity	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *Hach Model 2100P Instrument Manual* (10th Ed.)	SPI
Nephelometer	Turbidity	EPA 180.1: *Determination of Turbidity by Nephelometry*	NCL
Onset HOBO Tidbit MX Temperature Logger	Temperature	*HOBO Tidbit MX Temp 400 Logger Manual* (2021)	SPI
Onset HOBO Tidbit v2 Temperature Logger	Temperature	*Management of Onset® HOBO® Tidbit v2 Temperature Loggers*	SPI
Parshall Flume	Flow	*Field Management of Flumes*	SPI
Xylem 4531 Oxygen Optode	Dissolved Oxygen Temperature	*Xylem 4531 Oxygen Optode Operating Manual* (April 2018)	SPI
YSI 6820 Multi-parameter Sonde	Conductivity Dissolved oxygen pH Specific conductance Temperature Turbidity	*YSI-6820 Multi-parameter Water Quality Sonde Calibration and Maintenance* *Field Management of Multi-parameter Water Quality Sondes*	SPI
YSI EcoSense EC300A	Conductivity Specific conductance Temperature	*EcoSense EC300A Portable Conductivity, Salinity, and Temperature Instrument User Manual* (2017)	SPI
YSI EcoSense ODO200	Dissolved Oxygen Temperature	*EcoSense ODO200 Dissolved Oxygen & Temperature Instrument User Manual* (2017)	SPI
YSI EcoSense ORP15A Pen Tester	Oxidation reduction potential Temperature	*EcoSense ORP15A ORP/Temperature Pen Operations Manual* (2011)	SPI

YSI EcoSense pH100A	pH Temperature	*EcoSense pH100A pH, mV, and Temperature Instrument User Manual (*2017)	SPI
YSI EXO3 Multi-parameter Sonde	Conductivity Dissolved oxygen pH Specific conductance Temperature Turbidity	*EXO User Manual* (2020) *Field Management of Multi-parameter Water Quality Sondes*	SPI

B5: QUALITY CONTROL

SPI's continuous field measurements are performed in-situ and lack discrete quality control samples. However, associated field devices must meet the performance requirements specified in B6: *Instrument/Equipment Testing, Inspection, and Maintenance* and B7: *Instrument/ Equipment Calibration and Frequency.*

Turbidity QC sample analyses must meet the MQOs defined in A7: *Quality Objectives and Criteria*. Analyzed QC samples are defined below based on the *Surface Water Ambient Monitoring Program Quality Assurance Program Plan* (January 2022).

FIELD QUALITY CONTROL SAMPLES

Equipment Blank

An equipment blank is a sample of analyte-free media that has been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling through clean equipment. This blank is useful in documenting adequate decontamination of sampling equipment. This blank is used to provide information about contaminants/bias that may be introduced during sample collection when using filtration equipment or equipment that must be decontaminated between use.

Field Blank

A field blank is a sample of analyte-free media that is carried to the sampling site, exposed to the sampling conditions, returned to the laboratory, and treated as a routine environmental sample. Preservatives, if any, are added to the sample container in the same manner as the environmental sample. The field blank matrix should be comparable to the sample of interest. This blank is used to provide information about contaminants that may be introduced during sample collection, storage, and transport.

Field Duplicate

A field duplicate is an independent sample sharing the same collection methodology, location, and time as the associated field samples.

LABORATORY QUALITY CONTROL SAMPLES

Calibration Standard

A calibration standard is a solution prepared from the dilution of stock standard solutions that includes the internal standards and surrogate analytes, when applicable. The calibration solutions are used to calibrate the instrument response with respect to analyte concentration.

Calibration Verification

Definition: Calibration verification is when calibration check samples are analyzed prior to (i.e., initial), during (i.e., continuing or ongoing), and/or after (i.e., final) analysis of samples. The initial calibration verification, continuing calibration verification, and final calibration verification are used to verify the continued accuracy of an instrument calibration.

Laboratory Blank

A laboratory blank (often reagent water) is free from the target analyte(s) and is used to represent the environmental sample matrix as closely as possible. The method blank is processed simultaneously with and under the same conditions and steps of the analytical procedures (e.g., including exposure to all glassware, equipment, solvents, reagents, labeled compounds, internal standards, and surrogates that are used with samples) as all samples in the analytical batch (including other QC samples). The method blank is used to determine if target analytes or interferences are present in the laboratory environment, reagents, or instruments. Results of method blanks provide a measurement of bias introduced by the analytical procedure.

Laboratory Duplicate

A laboratory duplicate is an analysis or measurement of the target analyte(s) performed identically on two subsamples of the same sample, usually taken from the same container. The results from laboratory duplicate analyses are used to evaluate analytical or measurement precision, and include variability associated with subsampling and the matrix (not the precision of field sampling, preservation, or storage internal to the laboratory).

Reference Material

A reference material or substance has one or more properties that are characterized by a metrologically valid procedure, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability (typically from EPA or the National Institute of Science and Technology). Reference materials are used for calibrating an apparatus, assessing a measurement method, or assigning values to materials. They are used to measure the accuracy of analytical processes, either quantitatively to calibrate or determine concentration accuracy, or qualitatively to identify a substance or species.

B6: INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

SPI's water quality monitoring uses a variety of instruments and equipment. Testing, inspection, and maintenance associated with these devices is summarized in Table 14. Instruments and equipment in need of calibration are further addressed in Element B7: *Instrument/Equipment Calibration and Frequency.*

Table 14: Device Management

<table>
<tr><th>Device</th><th>Procedural Reference(s)</th><th>Responsible Organization</th></tr>
<tr><td colspan="3">YSI 6820 Multi-parameter Sonde and Sensors</td></tr>
<tr><td>6820 Multi-parameter sonde</td><td rowspan="5">Field Management of Multi-parameter Water Quality Sondes

YSI 6820 Multi-parameter Sonde Calibration and Maintenance</td><td rowspan="5">SPI</td></tr>
<tr><td>6136 Turbidity sensor</td></tr>
<tr><td>6560 Temperature/conductivity sensor</td></tr>
<tr><td>6561 pH sensor</td></tr>
<tr><td>6562 Dissolved oxygen sensor</td></tr>
<tr><td colspan="3">YSI EXO3 Multi-parameter Sonde and Sensors</td></tr>
<tr><td>EXO3 Multi-parameter sonde</td><td rowspan="5">EXO User Manual (2020)

Field Management of Multi-parameter Water Quality Sondes</td><td rowspan="5">SPI</td></tr>
<tr><td>EXO Optical Dissolved Oxygen Smart Sensor</td></tr>
<tr><td>EXO pH Unguarded Smart Sensor</td></tr>
<tr><td>EXO Turbidity Smart Sensor</td></tr>
<tr><td>EXO Wiped Conductivity & Temperature Sensor</td></tr>
<tr><td colspan="3">YSI EcoSense Meters</td></tr>
<tr><td>EcoSense EC300A</td><td>EcoSense EC300A Portable Conductivity, Salinity, and Temperature Instrument User Manual (2017)</td><td rowspan="4">SPI</td></tr>
<tr><td>EcoSense ODO200</td><td>EcoSense ODO200 Dissolved Oxygen & Temperature Instrument User Manual (2017)</td></tr>
<tr><td>EcoSense ORP15A Pen Tester</td><td>EcoSense ORP15A ORP/Temperature Pen Operations Manual (2011)</td></tr>
<tr><td>EcoSense pH100A</td><td>EcoSense pH100A pH, mV, and Temperature Instrument User Manual (2017)</td></tr>
<tr><td colspan="3">Data Loggers</td></tr>
<tr><td>HOBO Tidbit MX Temperature Logger</td><td>HOBO Tidbit MX Temp 400 Logger Manual (2021)</td><td>SPI</td></tr>
</table>

Device	Procedural Reference(s)	Responsible Organization
Onset HOBO Tidbit v2 Temperature Logger	*Management of Onset® HOBO® Tidbit v2 Temperature Loggers*	
WaterLOG H350XL	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Field Management of Multi-parameter Water Quality Sondes*	
WaterLOG H500XL		
Xylem Storm 3 Data Logger	*Storm 3 Getting Started Guide* (2020)	
Gas Bubblers		
WaterLOG Amazon 150	*YSI 6820 Multi-parameter Sonde Calibration and Maintenance* *Field Management of Multi-parameter Water Quality Sondes*	SPI
WaterLOG H355XL		
Turbidimeters		
Hach 2100N Laboratory Turbidimeter	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *Hach 2100N IS User Manual* (6th Ed.)	SPI
Hach 2100P Portable Turbidimeter	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *Hach Model 2100P Instrument Manual* (10th Ed.)	
Other Devices		
Global Water Instruments FP111 Flow Staff	*FP111 Global Water Flow Probe User's Manual* (2009) *Sierra Pacific Industries Research and Monitoring Water Quality Manual*	SPI
Parshall Flume	*Field Management of Flumes*	
Teledyne ISCO 6712 Compact Portable Sampler	*Field Procedure for the Teledyne ISCO 6712 Compact Portable Sampler* *Laboratory Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*	
Xylem 4531 Oxygen Optode	*Xylem 4531 Oxygen Optode Operating Manual* (April 2018)	

YSI 6820 MULTI-PARAMETER SONDE AND SENSORS

Figure 7: YSI 6820 Multi-parameter Sonde and Sensors: 6820 (Top); 6136, 6520, 6561, 6562 (Bottom Left to Right)

YSI EXO3 MULTI-PARAMETER SONDE AND SENSORS

Figure 8: YSI EXO3 Multi-parameter Sonde and Sensors: EXO3 Multi-parameter Sonde (Top); EXO Optical Dissolved Oxygen Smart Sensor, EXO pH Unguarded Smart Sensor, EXO Turbidity Smart Sensor, EXO Wiped Conductivity & Temperature Sensor (Bottom Left to Right)

YSI ECOSENSE METERS

Figure 9: YSI EcoSense Meters: EcoSense EC300A, EcoSense ODO200, EcoSense ORP15A Pen Tester, EcoSense pH100A (Clockwise from Top Left)

DATA LOGGERS

Figure 10: Data Loggers: HOBO Tidbit MX Temperature Logger, Onset HOBO Tidbit v2 Temperature Logger (Top Left to Right); WaterLOG H350XL, WaterLOG H500XL, Xylem Storm 3 Data Logger (Bottom Left to Right)

GAS BUBBLERS

Figure 11: Gas Bubblers: WaterLOG Amazon 150 (Left), WaterLOG H355XL (Right)

TURBIDIMETERS

Figure 12: Turbidimeters: Hach 2100P Portable Turbidimeter (Left) and Hach 2100N Laboratory Turbidimeter (Right)

OTHER DEVICES

Figure 13: Other Devices: Global Water Instruments FP111 Flow Staff, Parshall Flume, Teledyne ISCO 6712 Compact Portable Sampler, Xylem 4531 Oxygen Optode (Clockwise from Upper Left)

B7: INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Some of the devices identified in B6: *Instrument/Equipment Testing, Inspection, and Maintenance* also require calibration as summarized in Table 15.

Table 15: Device Calibration Procedures

Device	Procedural Reference(s)	Responsible Organization
YSI 6820 Sensors		
6136 Turbidity sensor	*Field Management of Multi-parameter Water Quality Sondes* *YSI 6820 Multi-parameter Sonde Calibration and Maintenance*	SPI
6560 Temperature/conductivity sensor		
6561 pH sensor		
6562 Dissolved oxygen sensor		
YSI EXO3 Sensors		
EXO Optical Dissolved Oxygen Smart Sensor	*EXO User Manual* (2020) *Field Management of Multi-parameter Water Quality Sondes*	SPI
EXO pH Unguarded Smart Sensor		
EXO Turbidity Smart Sensor		
EXO Wiped Conductivity & Temperature Sensor		
YSI EcoSense Meters		
EcoSense EC300A	*EcoSense EC300A Portable Conductivity, Salinity, and Temperature Instrument User Manual* (2017)	SPI
EcoSense ODO200	*EcoSense ODO200 Dissolved Oxygen & Temperature Instrument User Manual* (2017)	
EcoSense ORP15A Pen Tester	*EcoSense ORP15A ORP/Temperature Pen Operations Manual* (2011)	
EcoSense pH100A	*EcoSense pH100A pH, mV, and Temperature Instrument User Manual* (2017)	
Turbidimeters		
Hach 2100N Laboratory Turbidimeter	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *Hach 2100N IS User Manual* (6th Ed.)	SPI
Hach 2100P Portable Turbidimeter	*Sierra Pacific Industries Research and Monitoring Water Quality Manual* *Hach Model 2100P*	

Device	Procedural Reference(s)	Responsible Organization
	Instrument Manual (10th Ed.)	
Other Devices		
Teledyne ISCO 6712 Compact Portable Sampler	*Field Procedure for the Teledyne ISCO 6712 Compact Portable Sampler* *Laboratory Procedure for the Teledyne ISCO 6712 Compact Portable Sampler*	SPI
Xylem 4531 Oxygen Optode	*Xylem 4531 Oxygen Optode Operating Manual* (April 2018)	

SPI Research Foresters must ensure that sonde sensor and meter calibrations meet the requirements of Table 16.

Table 16: Sonde Sensor and Meter Calibration Requirements

Parameter	Method	Frequency	Acceptance Criteria	Allowable Drift
Conductivity Specific conductance	1-point calibration with a 1000 uS/cm solution	Before each field deployment, or following replacement of the conductivity or temperature sensors	Conductivity: 850-950 uS/cm, depending on water temperature Specific conductance: 1000 uS/cm	± 0.5% of reading; + 0.001 mS/cm
Dissolved oxygen (mg/L) Dissolved oxygen (%) Dissolved oxygen charge	1-point calibration with distilled water	Before each field deployment, or following replacement of the DO membrane cap, DO sensor, or temperature sensor	mg/L: 8-10 %: 95-100 charge: 25-75	0.1%; 0.01 mg/L
pH	3-point calibration with solutions of pH 4, 7, and 10	Before each field deployment, or following replacement of the pH or temperature sensors	pH 4.0: 140 to 220 pHmv; pH 7.0: -40 to 40 pHmv; pH 10.0: -220 to -140 pHmv	± 0.2 unit
Temperature	No calibration; confirmation of temperature sensor functionality	During post-deployment, pre-calibration, and post-calibration readings	± 0.2 °C	0.15 °C
Turbidity	2-point calibration with solutions of 0 and 126 NTU	Before each field deployment, or following replacement of the turbidity sensor	0 NTU; 126 NTU	± 2% of reading or 0.3 NTU, whichever is greater

B8: INSPECTION/ACCEPTANCE FOR SUPPLIES AND CONSUMABLES

Supplies and consumables will be inspected by Program-Director-assigned Research Foresters to make sure that they are intact, meet specifications, are available in adequate supply, and are stored properly. Specifications are detailed in applicable standard operating procedures. If specifications are not met, the Program Director will be notified, and documentation may be initiated according to the SPI SOP *Corrective Action*.

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 17.

Table 17: 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)
SPI internal weather station network	Water-quality-related weather (e.g., precipitation)

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 monitoring. Data management systems are addressed in the following sections.

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 (Figure 14).

Figure 14: Field Data Transfer Equipment

These text files are then transferred to cloud storage and a backed-up solid state drive 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 18.

Table 18: McQAQC Minimum and Maximum Values

Parameter	Description	Auto_Min	Auto_Max
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
pH	pH	0	10
SPC	Specific conductance (mS/cm)	0	300
STAGE	Water stage (ft)	0	100
TB	Turbidity (NTU)	-10	5000
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 in the cloud and on a backed-up solid state drive

Manual Flow Measurements

Manual flow measurements adjacent to water quality monitoring stations are taken at select times by SPI Research Foresters. A field form is filled out for each measurement. Each observer has their own database with data entry capabilities. These databases are saved in cloud storage and on a backed-up solid state drive. 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 database. This database is saved in cloud storage and on a backed-up solid state drive. 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.

Turbidity 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 saved in cloud storage and on a backed-up solid state drive. The MSS database contains diagnostic and reporting routines to check and verify all of the manual data entry.

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

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.

Corrective actions are implemented and documented according to the SPI SOP *Corrective Action*.

THIRD-PARTY AUDITS

In December 2016, April 2018, and April 2019, SPI's Research and Monitoring Program hosted external, third-party audits by MPSL. Similar MPSL audits will recur as requested by the Program Director.

INTERNAL AUDITS

SPI Research Foresters perform internal audits on a quarterly basis and as requested by the Program Director. These audits are performed according to the SPI SOP *Internal Audits*. At a minimum, audit scope includes:

- Water quality/weather station field notes
- Sonde deployment records
- Flow field sheets
- Tidbit field notes
- Terrestrial field notes
- Office notes
- Solution logbooks

- Calibration logbook
- Post calibration/post deployment book
- Sensor change book

The Research and Monitoring Program also holds weekly internal QA meetings to address issues not associated with audit events.

DATA VERIFICATION

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

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 (Table 19).

Table 19: Reports to Management

Type of Report	Date/ Frequency	Responsible Party	Report Recipients
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 water quality monitoring are evaluated against the requirements specified in associated methods and SOPs, and the following elements of this QAPP:

- A7: *Quality Objectives and Criteria*
- B2: *Sample Handling and Custody*
- B7: *Instrument/Equipment Calibration and Frequency*
- D2: *Verification and Validation Methods*

D2: VERIFICATION AND VALIDATION METHODS

SPI's water quality monitoring data are verified and validated according to the *Sierra Pacific Industries Research and Monitoring Water Quality* Manual and the programmatic SOP *Data Verification*.

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 monitoring data intended for CEDEN upload are first reviewed by the MPSL Regional Data Center (RDC) Manager against the SWAMP SOP *Verification of the Surface Water Ambient Monitoring Program Chemistry Template*. Data review issues are resolved by the Program Director, QA Oversight Manager, and MPSL RDC Manager, and when applicable, documented according to the SPI SOP *Corrective Action*.

D3: RECONCILIATION WITH USER REQUIREMENTS

The Program Director and Scientific Advisor 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 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.

Flow (Y value) is modeled from samples by one of the following:

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

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 not 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.

Appendices

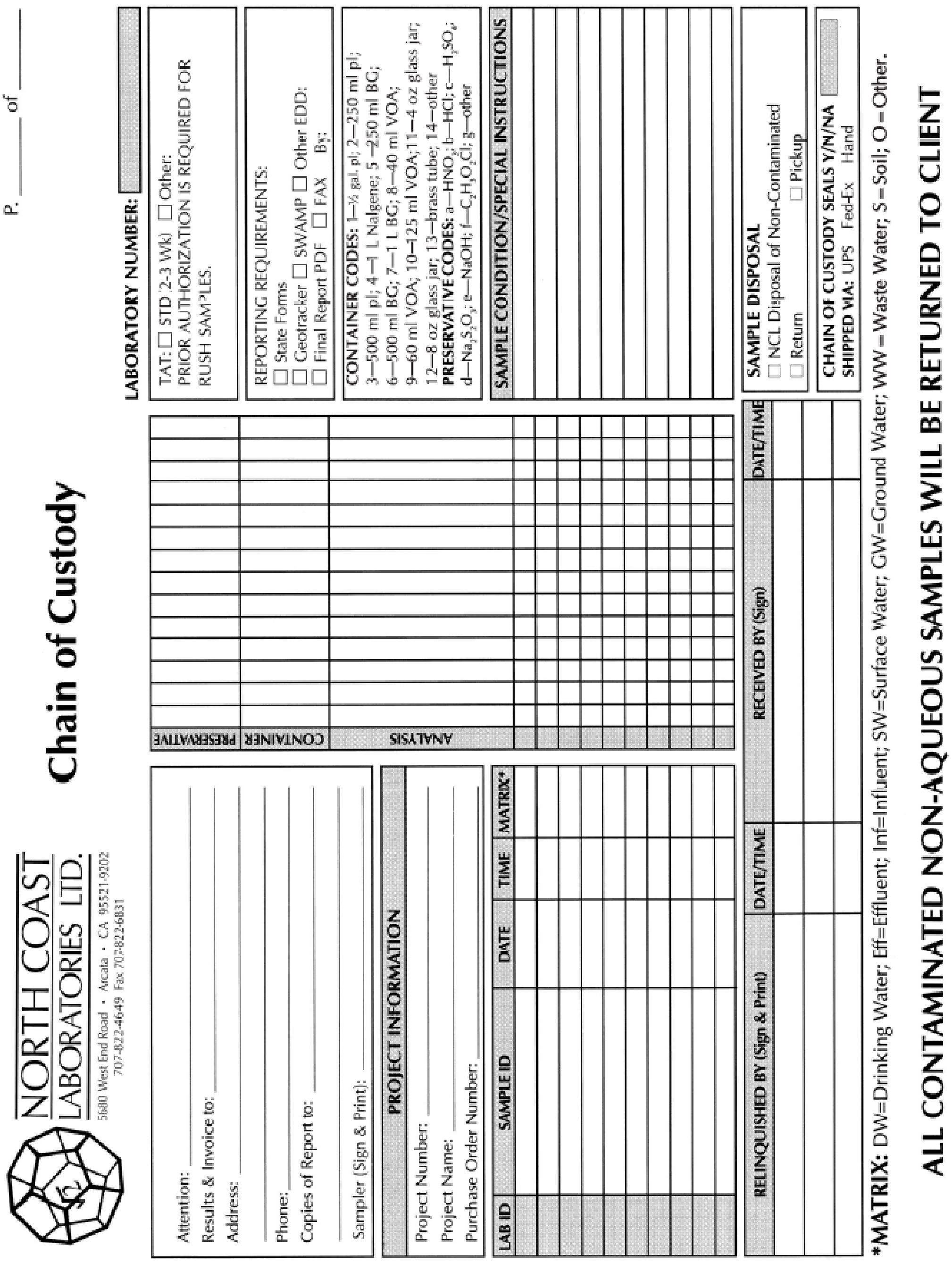
APPENDIX A:
ABBREVIATIONS AND ACRONYMS

BMI	Benthic Macroinvertebrate(s)
CALFIRE	California Board of Forestry and Fire Protection
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
CFPR	California Forest Practice Rules
CFS	Cubic Feet per Second
COC	Chain of Custody
DQI	Data Quality Indicator
ELAP	Environmental Laboratory Accreditation Program
EPA	United States Environmental Protection Agency
GIS	Geographic Information System
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
NTU	Nephelometric Turbidity Unit
NWQMC	National Water Quality Monitoring Council
PRS	Processed Raw Sonde Data
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCC	Reference Clearcut

RDC	Regional Data Center
RWQCB	Regional Water Quality Control Board
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
USGS	United States Geological Survey
YSI	Yellow Springs Instruments

APPENDIX B:
NORTH COAST LABORATORIES
CHAIN-OF-CUSTODY FORM

Figure 15: North Coast Laboratories Ltd. Chain-of-Custody Form


NORTH COAST LABORATORIES LTD.
5680 West End Road • Arcata • CA 95521-9202
707-822-4649 Fax 707-822-6831

Chain of Custody

P. ______ of ______

LABORATORY NUMBER:

Attention: ______
Results & Invoice to: ______
Address: ______
Phone: ______
Copies of Report to: ______
Sampler (Sign & Print): ______

PROJECT INFORMATION
Project Number: ______
Project Name: ______
Purchase Order Number: ______

LAB ID	SAMPLE ID	DATE	TIME	MATRIX*	PRESERVATIVE / CONTAINER / ANALYSIS

TAT: ☐ STD (2-3 Wk) ☐ Other:
PRIOR AUTHORIZATION IS REQUIRED FOR RUSH SAMPLES.

REPORTING REQUIREMENTS:
☐ State Forms
☐ Geotracker ☐ SWAMP ☐ Other EDD:
☐ Final Report PDF ☐ FAX By:

CONTAINER CODES: 1—½ gal. pl; 2—250 ml pl; 3—500 ml pl; 4—1 L Nalgene; 5—250 ml BG; 6—500 ml BG; 7—1 L BG; 8—40 ml VOA; 9—60 ml VOA; 10—125 ml VOA; 11—4 oz glass jar; 12—8 oz glass jar; 13—brass tube; 14—other
PRESERVATIVE CODES: a—HNO_3; b—HCl; c—H_2SO_4; d—$Na_2S_2O_3$; e—NaOH; f—$C_2H_3O_2Cl$; g—other

SAMPLE CONDITION/SPECIAL INSTRUCTIONS

RELINQUISHED BY (Sign & Print)	DATE/TIME	RECEIVED BY (Sign)	DATE/TIME

SAMPLE DISPOSAL
☐ NCL Disposal of Non-Contaminated
☐ Return ☐ Pickup

CHAIN OF CUSTODY SEALS Y/N/NA
SHIPPED VIA: UPS Fed-Ex Hand

*MATRIX: DW=Drinking Water; Eff=Effluent; Inf=Influent; SW=Surface Water; GW=Ground Water; WW=Waste Water; S=Soil; O=Other.

ALL CONTAMINATED NON-AQUEOUS SAMPLES WILL BE RETURNED TO CLIENT

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