From: Israel, Joshua A <JAIsrael@usbr.gov>
Sent: Wednesday, February 15, 2023 2:25 PM
To: Ekdahl, Erik@Waterboards <Erik.Ekdahl@waterboards.ca.gov>
Cc: Mooney, David M <dmmooney@usbr.gov>; Grimaldo, Lenny@DWR <Lenny.Grimaldo@water.ca.gov>; Foresman, Erin@Waterboards <Erin.Foresman@Waterboards.ca.gov>
Subject: TUCO Condition 9

EXTERNAL:

Erik,

Please find attached the Long-Term Monitoring Plan for Harmful Algal Blooms in response to the State Water Resources Control Board April 4, 2022 Temporary Urgency Change Order, Condition 9. We reviewed comments from the EPA (also attached), but were unable to identify specific changes to incorporate at this time. We appreciate our ongoing discussions and engagement on the operation of the CVP and SWP during drought response, development of monitoring programs, as well as on other initiatives. Reclamation will additionally reach out to the leadership of EPA to better understand their agency's interests, potential EPA contributions to future drought actions, and where we can better coordinate federal activities.

Take care,
Josh

Joshua Israel, PhD
Chief, Science Division

Interior Region 10, California-Great Basin
U.S. Bureau of Reclamation, Bay-Delta Office
Sacramento, CA 95814
Telework: 916-296-8792

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION

Long-Term Monitoring Plan for Harmful Algal Blooms

Central Valley Project and State Water Project

California

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The mission of the California Department of Water Resources is to sustainably manage the water resources of California, in cooperation with other agencies, to benefit the state's people and protect, restore, and enhance the natural and human environments.

Long-Term Monitoring Plan for Harmful Algal Blooms

Central Valley Project and State Water Project

California

Authored by

United States Bureau of Reclamation

California Department of Water Resources

Cover Photo: Water sample showing the presence of an algal bloom from a DWR/Reclamation Environmental Monitoring Program station in Disappointment Slough at Bishop's Cut in the Sacramento-San Joaquin Delta. (Photo Credit: Ted Flynn, DWR)

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B DWR Division of Integrated Science and Engineering. 2022. Quality assurance project plan for discrete water quality sampling emergency drought barrier and TUCP Cyanotoxin monitoring. Document number: DES-10-QAP-001, Revision 1.0. 6 pp.

C DWR Division of Regional Assistance North Central Region Office. 2022. Quality assurance project plan Central Delta and emergency drought barrier water quality monitoring program. Document number: DRA-2-QAP-005, Revision 2. 66 pp.

D DWR Division of Integrated Science and Engineering. 2022. Quality Assurance Project Plan for the Continuous Environmental Monitoring Program (CEMP). Document number: DES-3-QAP-001, Version 1.0. 49 pp.

E DWR Division of Integrated Science and Engineering. 2022. Discrete Environmental Monitoring Program field and laboratory manual. Version 6. 83 pp.

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List of Acronyms

CCHAB	California Cyanobacterial and Harmful Algal Bloom Network
CDFW	California Department of Fish and Wildlife
CVP	Central Valley Project
CyanoHABs	cyanobacterial harmful algal blooms
DWR	California Department of Water Resources
DSP	Delta Science ProgramEMP Environmental Monitoring Program
fDOM	fluorescence of dissolved organic matter
FHABs	freshwater harmful algal blooms
HABs	harmful algal blooms
IEP	Interagency Ecological Program
NCRO WQES	DWR North Central Region Office Water Quality Evaluation Section
PWT	Project Work Team
SWAMP	Surface Water Ambient Monitoring Program
SWB	State Water Resources Control Board
SWP	State Water Project
TUCP	Temporary Urgency Change Petition
TUCO	Temporary Urgency Change Order
USGS	United States Geologic Survey
YSI	Yellow Springs Instruments

Purpose

On April 4, 2022, the State of California Environmental Protection Agency State Water Resources Control Board (SWB) issued "Order approving temporary urgency changes to water right licenses and permit terms relating to Delta water quality objectives" to the U.S. Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) for the Central Valley Project and State Water Project. Condition 9 of the order requires Reclamation and DWR to submit a plan for long-term monitoring of Harmful Algal Blooms (HABs) as follows:

> *In coordination with the State Water Board, Central Valley Water Board, IEP, DSP, fisheries agencies, and USEPA, DWR and Reclamation shall prepare a report identifying long-term monitoring needs and implementation options for HABs (including but not limited to cyanobacteria and cyanotoxins) to generate baseline information needed to evaluate potential effects of future drought response actions, including the trends in HABs, potential adverse impacts of HABs on beneficial uses of water in the Delta, and the environmental factors that may influence the variability of HABs in the Delta, including but not limited to flow circulation, residence time, and nutrient concentrations. A draft report shall be submitted to the agencies by November 1, 2022, for a 30-day review and comment period and a final report addressing agency comments shall be submitted to the State Water Board by February 15, 2023, unless the Deputy Director for Water Rights approves a change to this schedule.*

Background

Harmful Algal Blooms (HABs)

The term "Harmful Algal Blooms" (HABs) is used to describe high levels of production of some types of microscopic plankton that can produce strong odors and chemicals toxic to humans, fish, and wildlife, and can deplete oxygen and release noxious gases when the bloom dies. HABs in freshwater are typically caused by cyanobacteria (i.e., blue-green algae), which can produce a number of toxins, including microcystin, anatoxin, and saxitoxin. HABs in brackish and saltwater are usually caused by dinoflagellates or diatoms (i.e., red tide) and can produce domoic acid, another toxin.

Blooms of *Microcystis aeruginosa*, a potentially HAB-forming cyanobacterium, have been observed in the Delta by researchers working at DWR and other agencies since the late 1990s. These blooms were first documented visually and appear as small lettuce-like flakes at the

water's surface (Lehman and Waller 2003). Studies of these blooms demonstrated that *Microcystis* sp. blooms can contain multiple toxins. In sufficiently high concentrations, these cyanotoxins can cause liver damage (Lehman et al. 2005), and the presence of even low concentrations of cyanotoxins in the Delta is cause for concern. Investigations after 2005 have found that the blooms frequently are composed of a mix of cyanobacteria: *Aphanizomenon* sp., *Microcystis* sp., *Dolichospermum* (formerly *Anabaena*) sp., *Planktothrix* sp. and *Pseudoanabaena* sp. (Lehman et al. 2010; Mioni et al. 2012), however research to date has focused primarily on *Microcystis* sp.

Overall, the Central and South Delta have the highest surface concentrations of *Microcystis* sp. and *Aphanizomenon* sp. (Figure 4) (Berg and Sutula 2015; Lehman et al. 2013; Lehman et al. 2008; Lehman et al. 2018; Mioni et al. 2012). Starting in 2012, very high abundances of *Microcystis* sp. colonies were observed in the South-East Delta region in the Turning Basin of the Stockton Shipping Channel, in Discovery Bay, and at Rough and Ready Island (Lehman et al. 2018; Spier et al. 2013). *Microcystis* sp. abundance is typically much lower in Suisun Bay west of Antioch and north of Collinsville on the Sacramento River (Lehman et al. 2013; Lehman et al. 2005; Lehman et al. 2008; Lehman et al. 2018; Mioni et al. 2012).

Factors that influence HABs occurrence and toxicity

The observed increase in HABs during the past 20 years is not confined to the Delta. Indeed, the increased incidence of HABs is a worldwide phenomenon that prompted a great deal of research on the physicochemical factors that may favor their formation (Figure 1; Carmichael 2008; Chorus and Welker 2021; Hudnell 2008; Hudnell 2010; O'Neil et al. 2012; Paerl and Paul 2012). Environmental conditions favoring HAB formation typically include calm and stratified water, warm water temperatures, high light, and an ample supply of nutrients (Berg and Sutula 2015; Huber et al. 2012; Lehman et al. 2013; Lehman et al. 2018; Paerl et al. 2011). The most successful strategies for mitigating HABs have focused on controlling these environmental factors by increasing the flow of water, promoting mixing of the water column, and reducing the supply of nutrients in vulnerable water bodies (Paerl et al. 2011).

Cyanobacterial HABs are controlled by limitations on their photosynthetic rate or by external factors that remove them from the system (Figure 1). Limitations to their photosynthetic rate include nutrient supply, water temperature, and light availability (Lehman et al. 2013; Lehman et al. 2018). Nutrients in the system are controlled by both non-point sources, such as agricultural and urban runoff, and point sources, such as wastewater treatment plants (Figure 2). Nutrient concentrations peak in the winter and spring when high flows increase loading of nutrients from the watershed and decrease during the summer when there is less runoff and when primary productivity and nutrient uptake by phytoplankton are at their peaks. The ratio of nitrogen to phosphorus, and the form of nitrogen present (ammonium versus nitrate) will also favor some taxa over others (Dahm et al. 2016; Wan et al. 2019). Cyanobacteria responsible for HABs thrive at high light intensity and warmer water temperatures, conditions that support high growth rates and greater competitive success over eukaryotic algae (e.g., diatoms, green algae) that are more productive at cooler water temperatures (Berg and Sutula 2015). Light availability changes with solar irradiance and turbidity. *Microcystis* sp. prefers high light, low turbidity conditions and

contain gas vacuoles that provide buoyancy and can be used to vertically migrate in response to light and other factors (Xue et al. 2022).

Other external factors controlling blooms include water flow, water residence time, and grazing rates by planktivorous organisms (Figure 1). Most cyanobacteria are not preferred food for planktivorous grazers, though some zooplankton and clams will consume *Microcystis* sp. and other cyanobacteria (Kimmerer et al. 2018; Liu et al. 2009; Silva et al. 2020). Therefore, top-down control of HABs appears to be rare in the Delta, and blooms are more frequently dissipated through depletion of nutrients and increases in flow. When nutrients, turbidity, temperature and residence time are all at the right level, a phytoplankton bloom will occur (Figure 2; Glibert et al. 2014). However, the type of bloom will depend on the starting community, nutrients available, and time of year. Early in the season, spring blooms are more often dominated by diatoms and other "beneficial" phytoplankton. Later in the year, cyanobacteria are more likely to dominate when temperatures are warmer (Lehman et al. 2013).

Not all cyanobacterial blooms produce toxins, and the size of a bloom is not always correlated with toxicity (Chaffin et al. 2022). Toxicity can be influenced by the genetic structure of the blooms because different genotypes within a species vary in the production of toxins (e.g., microcystin) and in relative abundance within a population over time (Yancey et al. 2022). Other factors, such as pH and the concentrations of different forms of nitrogen (e.g., ammonium and nitrate), have been shown to influence toxin production in some systems and is an area of active research (Barnard et al. 2021; Yancey et al. 2022). In the case of *Microcystis* sp., the production of the cyanotoxin microcystin is thought to be cellular response to protect enzymes from reactive oxygen species (ROS) so environmental conditions that favor ROS formation may also lead to more toxic HABs (Hellweger et al. 2022). Bloom size (i.e., *Microcystis* sp. abundance) and toxicity appear to be correlated in the Delta; however, changes in nutrients and environmental conditions during a bloom could alter the relative proportions of toxic and non-toxic strains (Lehman et al. 2013). Therefore, monitoring both HAB abundance and toxicity is important for understanding HAB development and toxicity potential.

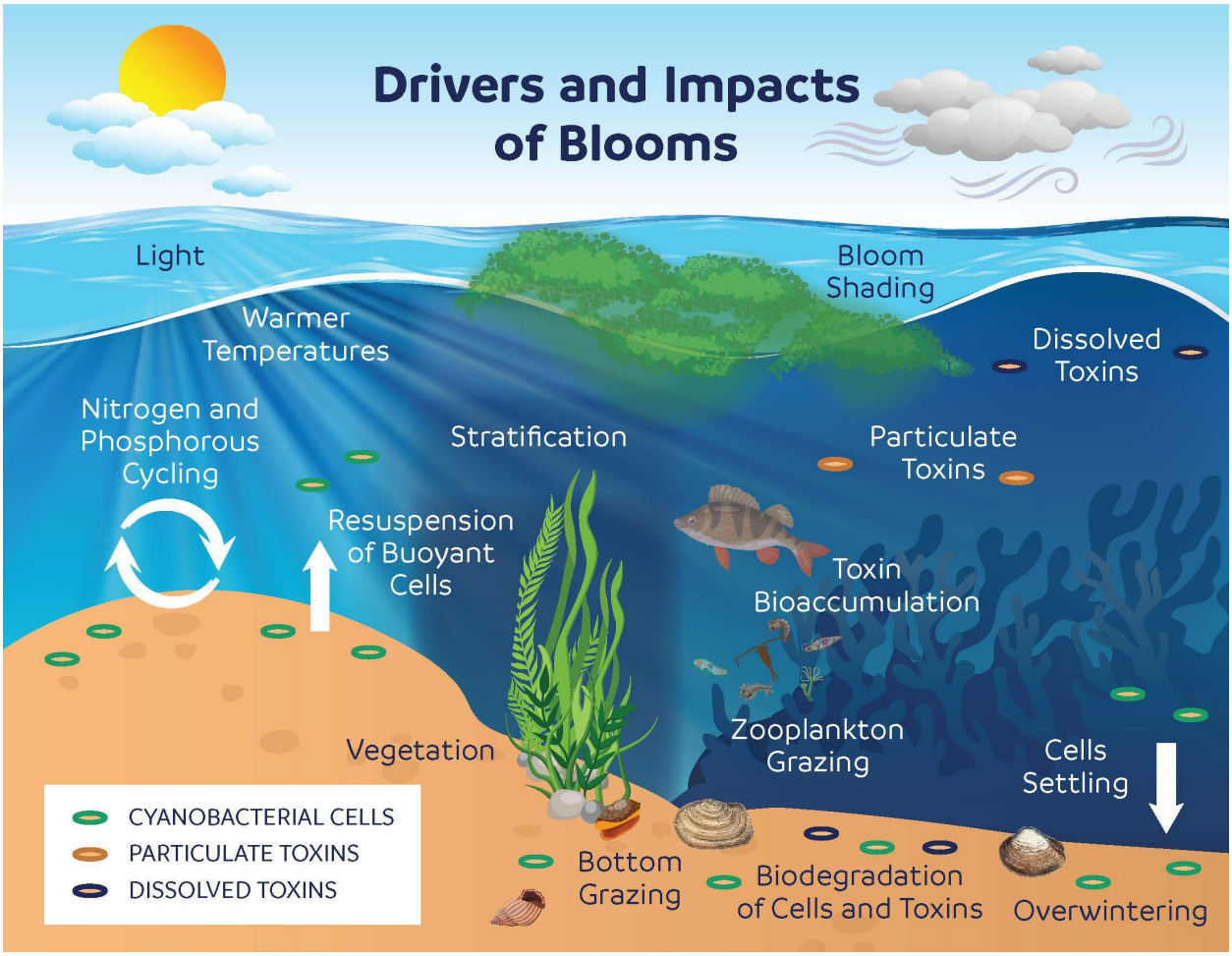

Figure 1. Conceptual model of factors contributing to freshwater Harmful Algal Blooms. Image courtesy of Delta Stewardship Council, Delta Science Program. HAB Development Conceptual Models for Delta HABs Workshop, November 2022.

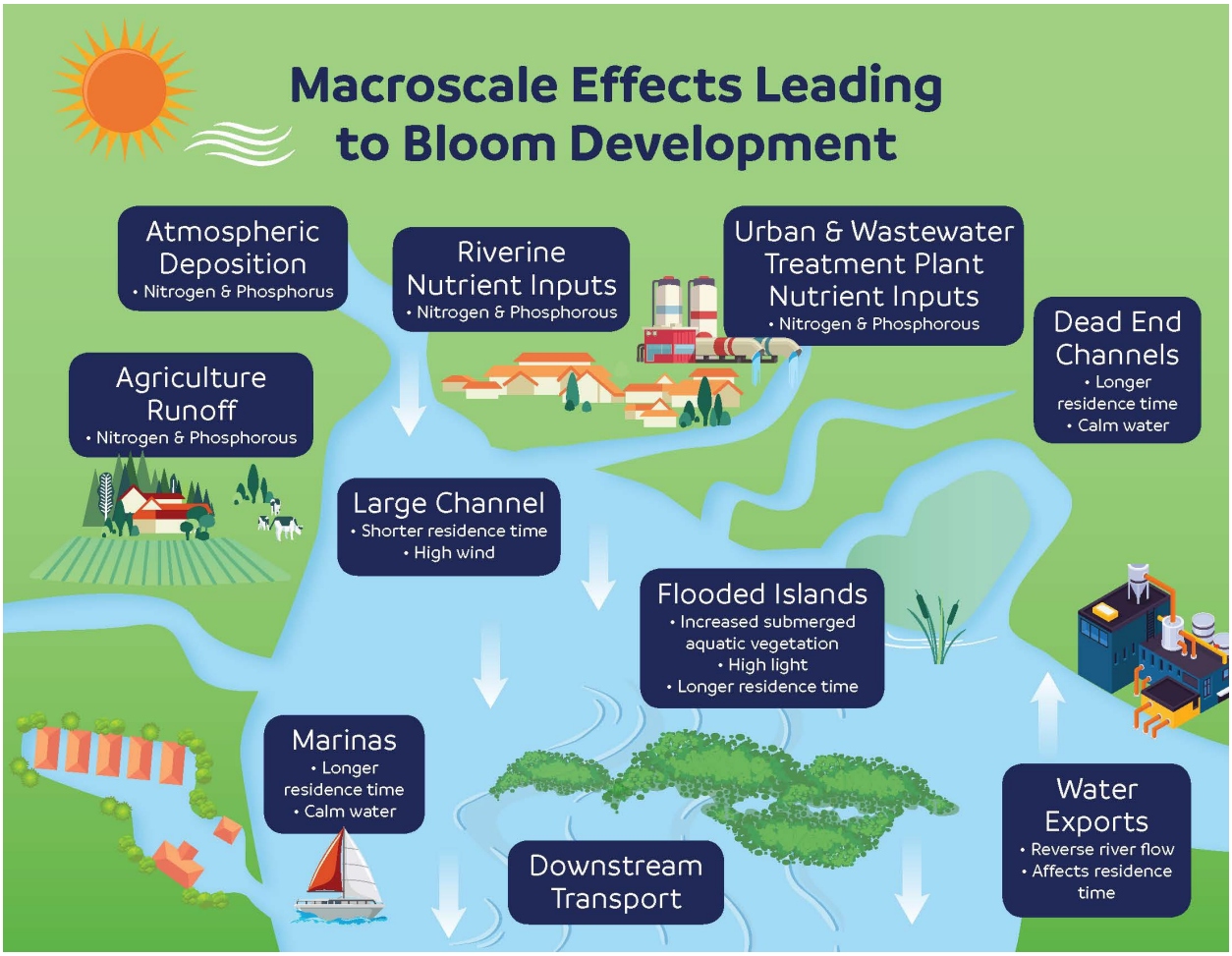

Figure 2. Conceptual model for factors in the Delta that lead to HABs development. Image courtesy of Delta Stewardship Council, Delta Science Program. HAB Development Conceptual Models for Delta HABs Workshop, November 2022.

HAB development in the Delta can be attributed to multiple natural and anthropogenic factors that operate at different spatial and temporal scales (Figure 2). Summertime chlorophyll concentrations are typically relatively low (2.5-3.5 µg/L), and nutrients are generally not considered limiting to phytoplankton growth and biomass accumulation (Jassby 2008). However, sporadically large phytoplankton blooms occur that completely deplete the available nitrogen supply. Water temperatures in the Delta have increased since regular monitoring began in the 1970s (Bashevkin et al. 2022), with substantial increases starting in 1999 (Brooks et al. 2011), consistent with the general warming trend observed throughout California and globally due to climate change (Diffenbaugh et al. 2015). Water temperatures in the Delta are driven mainly by air temperatures (Vroom et al. 2017). Meteorology also plays a role and years with low inflow also tend to have warmer water temperatures (Bashevkin and Mahardja 2022). Temperatures vary spatially within the Delta with warmer temperatures in the South Delta and cooler temperatures along the Sacramento River and in Suisun Bay (Bashevkin et al. 2022).

Summer light availability in the Delta is controlled mainly by turbidity, although cloud cover and smoke may block sunlight temporarily. Turbidity in the Delta is driven by sediment concentration of the incoming water, water velocity and wind. The largest sediment inputs in the Delta occur during winter storms, so summer conditions will have clearer water. Sediment inputs in the Delta have been decreasing over the past 50 years, causing a trend toward increased water clarity (Schoellhamer 2011). As water slows, suspended particles sink and cause the water to clear further. During the summer, water velocity is controlled by tidal action, so water velocity on the local scale is most impacted by physical characteristics of the Delta, particularly the presence of submerged vegetation. Vegetation causes the water to slow (Lacy et al. 2021), and the trend toward increasing water clarity in the Delta has been linked to the increase in aquatic vegetation over the past twenty years (Hestir et al. 2016). Wind increases sediment re-suspension and turbidity in extended areas of shallow open water, such as Suisun Bay, but is less of a factor in narrow channels or areas with dense vegetation (Bever et al. 2018).

Residence time in the Delta is controlled by the combined interaction of tidal action, inflows, diversions, and physical characteristics of the Delta. On the large scale, inflows will dominate the inter-annual and intra-annual differences in residence time, with major floods greatly reducing residence time during the winter and spring months. Decreased flow typically occurs during July–September, which coincides with the occurrence of *Microcystis* sp. blooms (Lehman et al. 2013, 2018, 2020; Spier et al. 2013). At the local scale, particularly at low flow values, tidal action will dominate both residence time and velocity, with greater differences seen on the spring-neap tidal cycle. At low outflow values, changes to the physical characteristics of the Delta, such as installation of barriers, operation of gates, or growth of submerged vegetation will have a greater impact on residence time than changes to outflow since physical changes will alter tidal dynamics.

HABs Monitoring and Coordination in the Delta

HABs monitoring in the Delta includes a wide variety of agencies and organizations that have different missions, objectives, and technical resources, and operate at different spatial and temporal scales. The California Harmful Algal Blooms Portal was developed by the California Cyanobacteria and HAB (CCHAB) Network to provide the public with information and help support coordination among partners across the state (https://mywaterquality.ca.gov/habs/). The CCHAB is a multi-agency workgroup aimed at developing a long-term program to understand and address the factors that contribute to and the effects of cyanobacteria and HABs in California (https://mywaterquality.ca.gov/monitoring_council/cyanohab_network/index.html). The Portal includes a publicly available online form for reporting observed algal blooms to the State Water Resources Control Board (SWB), an incident map displaying the locations of the reported blooms, and a map showing estimates of cyanobacteria in large water bodies, including areas of the Delta, based on satellite imagery. The portal also contains links to different programs and organizations within and outside of the state that conduct HAB-related activities.

California State Water Resources Control Boards' Framework and Strategy of Freshwater Harmful Algal Bloom Monitoring

Following recommendations produced by a statewide workshop on HABs and cyanotoxins in 2012, the SWP's Surface Water Ambient Monitoring Program (SWAMP) developed and published a freshwater HAB assessment and support strategy (SWAMP 2016). The assessment and strategy focused on three main elements for HAB events and monitoring: (1) event response; (2) field assessment and ambient monitoring; and (3) risk assessment (SWAMP 2016). To address element two, ambient monitoring, the Southern California Coastal Water Research Project Authority in partnership with the SWAMP developed a recommended framework and strategy for monitoring freshwater HABs (FHABs) (Smith et al. 2021). The recommended framework provides a strategy for filling information gaps related to (1) FHABs status and trends and (2) the environmental factors that influence the magnitude, frequency, and duration of FHABs such that, if adopted at local scales within the State, the strategy would result in consistent and transparent data collection across the State (Smith et al. 2021). The strategy envisions the development of decision-support products that inform management actions related to five beneficial uses: swimmable, fishable, aquatic life, raw water sources, and tribal tradition and culture. The products would be developed from monitoring that incorporates multiple monitoring approaches, including monitoring data collected and provided to the SWB, as lead agency, by a diverse group of partners. The SWB would support the infrastructure needed for field monitoring activities and data management, access, and visualization (Figure 3; Smith et al. 2021).

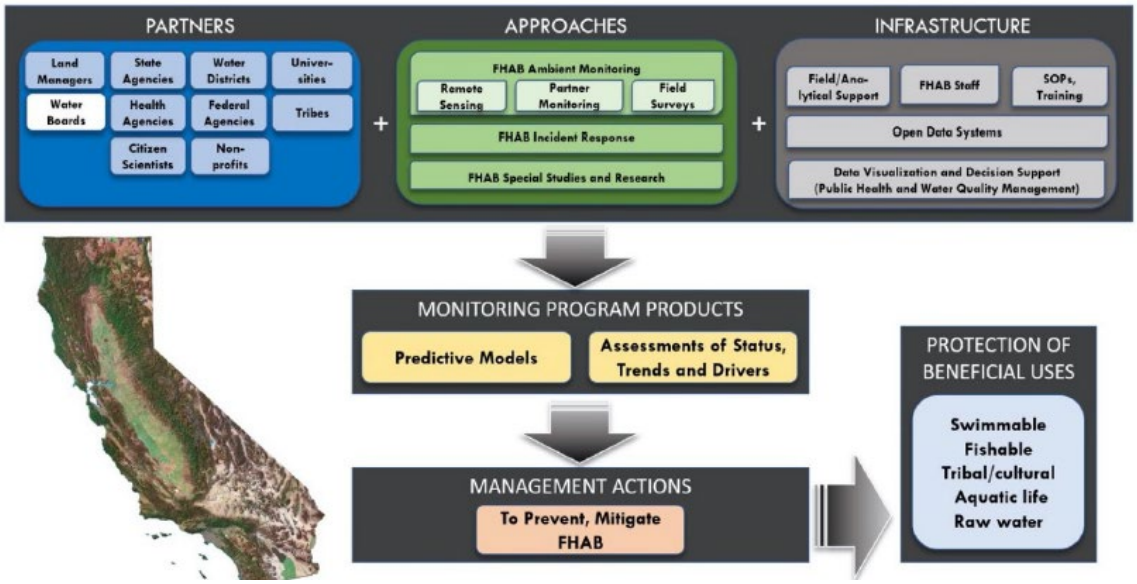

Figure 3. Strategy for FHABs ambient monitoring recommended by Smith et al. (2021). Source: FHAB Strategy Fact Sheet https://ftp.sccwrp.org/pub/download/DOCUMENTS/FactSheets/1141_FHABStrategy_FactSheet.pdf.

The recommended FHAB partner monitoring approach provides a mechanism for the SWB to partner and coordinate with different agencies and organizations who already implement FHABs monitoring programs or collect other relevant data (e.g., human and domestic animal health and safety). The partner monitoring program identifies core indicators and metrics to help address

questions about the overall extent and magnitude of FHABs in a waterbody, the extent to which FHABs are changing over time in a waterbody, and the environmental factors (i.e., drivers) that are frequently associated with FHABs (see Tables 2.3 and 2.4 in Smith et al. 2021). The program is tiered to accommodate different levels of partner resources with respect to indicators measured and the spatial and temporal design (e.g., Figures 3.2 and 3.3 in Smith et al. 2021). The program also recommends monitoring that addresses FHABs status and trends and causal relationships with environmental parameters, recognizing that targeted research is needed to fully identify and understand drivers of FHABs development, frequency and duration of occurrence, magnitude, and toxicity. The partners' role is to work collaboratively with the SWB (i.e., lead agency) on a monitoring design, conduct monitoring following best practices and standard operating procedures, participate in opportunities for training and intercalibration of sensors, and provide quality assurance and quality controlled (QAQC) data and metadata. The SWB would be responsible for creating infrastructure for data management, open access to data, and data visualization of partner data (Smith et al. 2021).

Monitoring Framework

Goal and Objectives

Reclamation and DWR established long-term monitoring programs like the Environmental Monitoring Program (EMP) to meet the permitting requirements for their operation of the Central Valley Project (CVP) and the State Water Project (SWP), particularly Water Right Decision 1641 (D-1641). In addition to fulfilling this requirement, monitoring efforts like EMP greatly inform understanding the status of the Delta ecosystem over time, managing water quality, and providing baseline data for habitat and biological management decisions. Herein we describe how these monitoring efforts will be leveraged to provide meaningful baseline information regarding the status and trends and potential drivers of FHABs in the Delta as they relate to the impacts of future drought response actions for CVP and SWP operations. This plan primarily draws from the efforts of other monitoring programs and activities that are currently being implemented or directly supported by Reclamation and/or DWR, many of which have already integrated FHAB-related metrics into their monitoring programs. The plan has been developed to fit within the Partner Monitoring Program recommended in the SWB's FHABs framework and strategy as described above.

Reclamation and DWR set forth three primary goals for this monitoring plan:

1. Generate baseline information needed to evaluate how SWP and CVP operations, including drought actions, may impact the locations and conditions under which FHABs are likely to form in the Delta;
2. Inform long-term studies on the impact of FHABs on the beneficial uses of water in the Delta, particularly those regarding municipal, domestic, and agricultural supply,

freshwater, estuarine, and wildlife habitat, the migration of aquatic organisms, and rare, threatened, or endangered species; and
3. Provide timely, actionable information on the presence and toxicity of FHABs in areas of the Delta impacted by the SWP and CVP.

Monitoring Approach

The monitoring approach described here was designed to achieve the goals outlined above pertaining to the likely impact of CVP and SWP operations on the Delta ecosystem by leveraging existing relevant water quality, chlorophyll, and phytoplankton monitoring across programs in the Delta. Based on previous studies and modeling, the possible impact of project operation on the formation of FHABs in the Delta is anticipated to primarily relate to changes in the residence time of water in the Delta, the circulation/direction of flow, the salinity of water, and overall water quality. The existing activities described below will need to be supplemented with additional or higher quality algal sensors in some locations and additional data on toxin concentrations and impacts on the beneficial uses identified. The details of how, where, and by whom that will occur will be planned through the inter-agency workshop to be held by the Delta Science Program.

Spatial Scope

The impacts of CVP and SWP operations vary throughout the Delta due to the management of both tributary inflow and Delta water exports and the effects each has on water residence time, salinity, and the direction of water flow. A regional monitoring design allows resources to be focused on areas most impacted by CVP and SWP operations and annual or seasonal water management decisions (e.g., Temporary Urgency Change Petitions [TUCP]) while still monitoring core indicators across the Delta. Ideally, this design will produce data that can be used to differentiate potential impacts of water management, including drought management actions, on drivers of HABs from climatic, land use, and other impacts through regional comparisons. As a practical matter, however, separating the effects of these different stressors can be very difficult. Hydrodynamic modeling of seasonal operations can elucidate potential influences of residence time, circulation/direction, salinity, and nutrients that may be expected to vary due to different management decisions and can inform regional characterization of potential effects.

The Delta will be divided into regions similar to the approach taken by Hartman et al. (2022) in the report on the impacts of the 2021 TUCP on HABs and aquatic vegetation in the Delta (Figure 4).

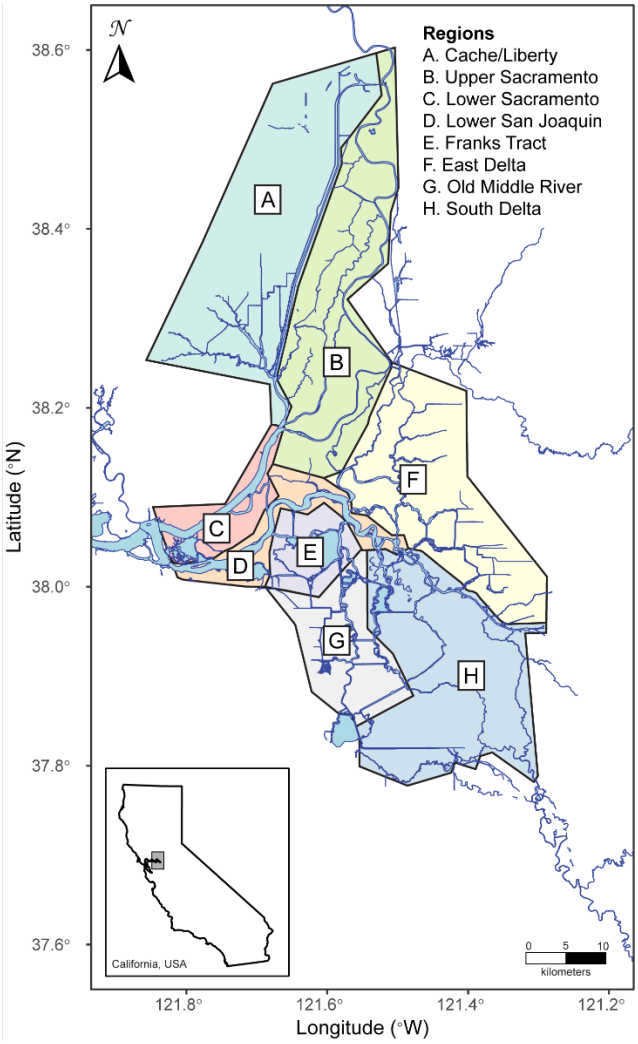

Figure 4. Regions used by Hartman et al. (2022), based on how flow was predicted to change due to the 2021 TUCP and West False River emergency drought barrier.

The operations of the CVP and SWP impact both the timing and magnitude of inflow from the tributaries entering the Delta via reservoir releases and the rate and direction of water movement through the Delta in response to export rates and the operation of controlling gates, such as the Suisun Marsh Salinity Control Gates and the Delta Cross Channel Gates. Both inflow and export rates influence salinity dynamics in the Delta. The North Delta, which includes the Cache Slough Complex and upper Sacramento River, primarily experiences changes in water residence time in response to changes in inflows from the Sacramento River and its tributaries. Seasonal flow reversal in the North Delta can occur as the result of local water diversions for agricultural and other uses. Further downstream in the lower Sacramento River and Suisun Bay and Marsh, inflow rates also influence salinity. Operation of the Suisun Marsh Salinity Control Gates alters both salinity and water flow. In the Central Delta, export rates impact the lower San Joaquin River and Old and Middle River corridor, including Franks Tract, affecting water residence time, salinity, and the direction of water flow. Operation of the Delta Cross Channel Gates allows for

direct movement of Sacramento water into the Central Delta to control salinity levels, which also can alter flows and transport nutrients into the Central Delta. Impacts of CVP and SWP operations in the East and South Delta will primarily be to water residence time in response to reservoir releases and exports.

Temporal Scope

The formation of FHABs is seasonal, occurring summer through mid- to late fall in response to higher water temperatures and solar radiation, longer water residence times, and possibly changes in nutrient concentrations (Berg and Sutula 2015). Similar to spatial considerations, a focused monitoring design that allows resources to be deployed during the period of time from early FHABs development through senescence will be more effective than spreading those resources evenly throughout the year. Sample collection, processing, and analysis specific to documenting and understanding FHABs may need to occur more frequently from April to October and may include collecting data on additional indicators. This may require greater resources and, therefore, will be implemented primarily during the time period when FHABs occur.

Tiered Approach

Reclamation and DWR already implement and support ongoing water quality monitoring activities throughout the Delta that provide both continuous and monthly, discrete data for a variety of physical, chemical, and biological metrics as well as chlorophyll-*a* and phytoplankton enumeration, including cyanobacteria (e.g., the Environmental Monitoring Program, Figure 5). Deployment of more specialized sensors, such as *in situ* fluorometers, has focused on times and locations when higher temporal and/or spatial resolution is desired to better understand finer-scale water quality and phytoplankton responses to water management and areas at greater risk of poor water quality conditions. The same approach has been applied to cyanotoxin sampling, which has focused on areas where FHABs are most likely to be exacerbated by water project operations or where water supply may be impaired by presence of FHABs. FHABs monitoring will continue to occur within these established programs and activities and will follow a similar, tiered approach by coupling continuous and monthly Delta-wide monitoring of core water quality and FHABs indicators. Any additional resources will continue to be focused on locations and periods of time for which HABs are more likely to occur and present a risk to human and wildlife health and safety, such as the Central Delta more generally and Franks Tract in particular.

Monitoring Plan

Programmatic Elements

Programs

Monitoring programs conducted by many agencies collect data on water quality, nutrients, and visual Microcystis observations throughout the Delta. As part of the Delta Science Program's upcoming FHABs workshop, sampling locations have been mapped to visually identify the scope of our monitoring network (Figures 7-9). These maps are included here along with more detailed information on the component sampling programs.

Environmental Monitoring Program

The Environmental Monitoring Program (EMP) is conducted collaboratively by DWR, Reclamation, and the California Department of Fish and Wildlife (CDFW) in compliance with D-1641. This program has been collecting data since 1971, although stations and parameters have shifted somewhat over time. The EMP includes 15 continuous water quality stations, at which Yellow Springs Incorporated (YSI) sondes collect data every 15 minutes on the following water quality parameters: specific conductance, pH, water temperature, dissolved oxygen, turbidity (Figure 5; Table 1) and chlorophyll fluorescence measured using a YSI Total Algae sensor. Discrete water quality and phytoplankton sampling occurs monthly at 24 fixed stations and between 2-4 floating stations, where the bottom specific conductance is 2000 µS/cm and 6000 µS/cm (Figure 5; Table 1). Data collected include the following water quality parameters: water temperature, turbidity, Secchi depth, pH, chlorophyll-a concentration, organic and inorganic species of nitrogen and phosphorus, silica, dissolved organic carbon, specific conductance, and dissolved oxygen. Phytoplankton samples are also collected to enumerate and calculate biovolume for different taxonomic groups and document species composition. Starting in 2015, visual estimates of *Microcystis* sp. have been collected at each discrete water quality station (Figure 8; Flynn et al. 2022).

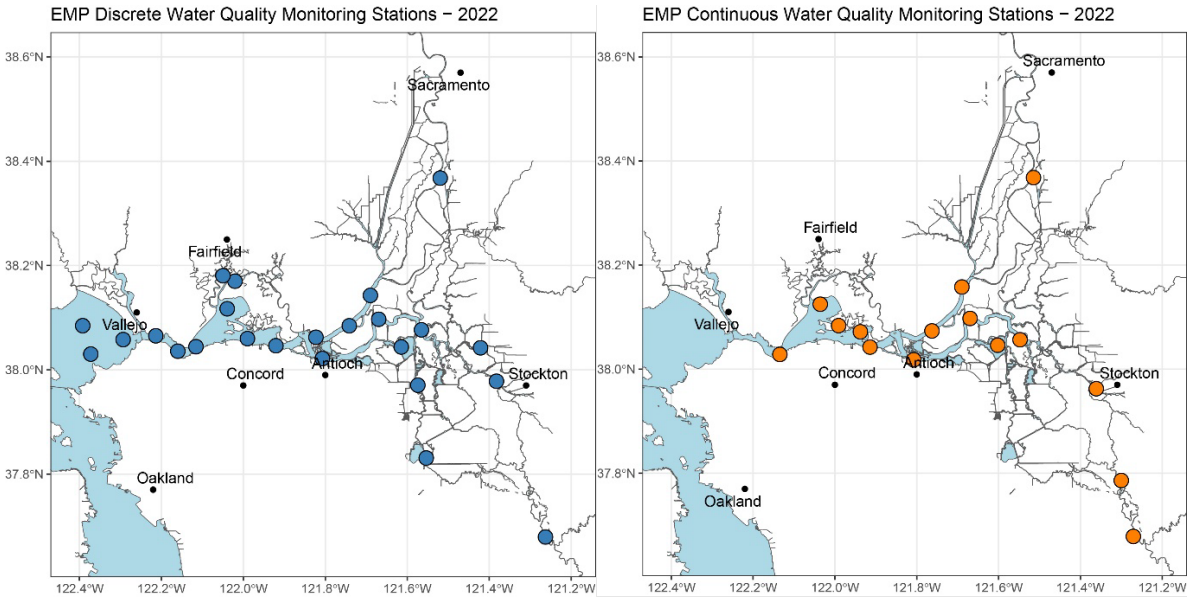

Figure 5. Environmental Monitoring Program discrete and continuous water quality monitoring sites. Discrete monitoring includes phytoplankton sampling for enumeration and community composition.

Table 1. Environmental Monitoring Program stations for discrete water quality (WQ-D), continuous water quality (WQ-C) and phytoplankton.

Station	Location	Latitude	Longitude	CDEC	WQ-D	WQ-C	Phyto
C10A	San Joaquin River nr Vernalis @ SJR Club	37.67934	-121.2647	SJR	×	×	×
C3A	Sacramento River @ Hood	38.36771	-121.5205	SRH	×	×	×
D10	Sacramento River @ Chipps Island	38.04631	-121.9183	n/a	×		×
D12	San Joaquin River @ Antioch Ship Channel	38.02161	-121.8063	n/a	×		×
D16	San Joaquin River @ Twitchell Island	38.0969	-121.6691	n/a	×		×
D19	Frank's Tract near Russo's Landing	38.04376	-121.6148	n/a	×		×
D22	Sacramento River @ Emmaton	38.08453	-121.7391	n/a	×		×
D24	Sacramento River below Rio Vista Bridge	38.15778	-121.6847	n/a			×
D26	San Joaquin River @ Potato Slough	38.07664	-121.5669	n/a	×		×
D28A	Old River @ Rancho Del Rio	37.97048	-121.573	n/a	×		×
D4	Sacramento River above Point Sacramento	38.06248	-121.8205	n/a	×		×
D41	San Pablo Bay near Pinole Point	38.03022	-122.3729	n/a	×		×
D41A	San Pablo Bay nr. Mouth of Petaluma River	38.08472	-122.3907	n/a	×		×
D6	Suisun Bay @ Bulls Head nr. Martinez	38.04436	-122.1177	n/a	×		×
D7	Grizzly Bay @ Dolphin nr. Suisun Slough	38.11714	-122.0397	n/a	×		×
D8	Suisun Bay off Middle Point nr. Nichols	38.05992	-121.99	n/a	×		×
EZ2	Entrapment Zone -2000 µS/cm bottom Sp Cond	Variable	Variable	n/a	×		×
EZ2-SJR	Entrapment Zone in San Joaquin River-2000 µS/cm bottom Sp Cond (when present)	Variable	Variable	n/a	×		×
EZ6	Entrapment Zone -6000 µS/cm bottom Sp Cond	Variable	Variable	n/a	×		×
EZ6-SJR	Entrapment Zone in San Joaquin River-6000 µS/cm bottom Sp Cond (when present)	Variable	Variable	n/a	×		×
MD10A	Disapointment Slough @ Bishop Cut	38.04226	-121.4199	n/a	×		×
NZ002	Carquinez Straite near Glencove Harbor	38.06529	-122.2152	n/a	×		×
NZ004	Carquinez Straite near Ozol Pier	38.03576	-122.1616	n/a	×		×
NZ032	Montezuma Slough, 2nd bend from mouth	38.16991	-122.0211	n/a	×		×
NZ325	San Pablo Bay near Rock Wall and Light 15	38.05798	-122.2919	n/a	×		×
NZS42	Suisun Slough @ Volanti Slough	38.18045	-122.0476	n/a	×		×
P8	San Joaquin River @ Buckley Cove	37.97817	-121.3823	n/a	×		×
NZ068	Sacramento River below Rio Vista Bridge	38.14272	-121.6895	RVB	×	×	×
C9	West Canal @ Clifton Court Intake	37.83095	-121.554	n/a	×		×
MSD	San Joaquin River at Mossdale Bridge	37.786144	-121.306474	MSD		×	
MRZ	Suisun Bay-Martinez	38.02762	-122.14052	MRZ		×	
GZL	Grizzly Bay	38.124281	-122.037962	GZL		×	
RYC	Suisun Bay – Cutoff Near Ryer	38.083961	-121.995641	RYC		×	
HON	Honker Bay	38.072229	-121.93718	HON		×	
MAL	Sacramento River at Mallard Island	38.042799	-121.92013	MAL		×	
SSI	Sacramento R Nr Sherman Island	38.074153	-121.761764	SSI		×	
ANH	San Joaquin River at Antioch	38.017854	-121.802939	ANH		×	
TWI	San Joaquin River at Twitchell Island	38.097455	-121.668718	TWI		×	
FRK	Frank's Tract Mid Tract	38.046499	-121.598063	FRK		×	
PPT	SJR-Prisoner's Point	38.056296	-121.549973	PPT		×	

RRI	SJR-Prisoner-Rough & Ready	37.962726	-121.365603	RRI		×	

Department of Water Resources North Central Region Office

The Department of Water Resources conducts FHAB monitoring in the south and central Delta as required by the South Delta Temporary Barriers Project Section 401 Water Quality Certification (Figure 6, Table 2; see Appendix A for details). In brief, DWR's North Central Region Office (NCRO) Water Quality Evaluation Section (WQES) employs EMP's Visual Index scale (Flynn et al., 2022) to monitoring FHAB formation in the South and Central Delta year-round at all continuous monitoring stations. Tow nets and Van Dorn samplers are used to sample for *Microcystis* sp. and phytoplankton during the months of known peak *Microcystis* sp. presence (July-October) and coincide with Temporary Agricultural Barrier installation which is typically May-October. Sampling can occur outside of that window, however, if the barrier installation timeline is altered and or visual index scores indicate earlier detection of FHABs. Water samples for toxin analysis will be collected only during peak Visual Index periods (Visual Index >4).

Additional FHAB sampling for cyanotoxins also occurs in areas adjacent to the West False River drought barrier in years where the barrier is in place (See Appendix B for details).

Figure 6. DWR NCRO WQES map of south Delta phytoplankton sampling locations. Four primary sampling locations MHO, GLE, ORM, and OH1 noted by orange circles.

Table 2. DWR NCRO WQES station names and locations.

Station Name	Station ID	Latitude (WGS84)	Longitude (WGS84)
Doughty Cut near Grantline Canal	DGL	37.81099	-121.387
Grant Line Canal East	GLE	37.82024	-121.435
Grant Line Canal near Old River	GLC	37.82012	-121.545
Middle River @ Union Point - P10A	MUP	37.89077	-121.488
Middle River at Howard Road	MHO	37.87618	-121.383
Middle River at Undine Road	MRU	37.83394	-121.386
Middle River near Tracy Road	MRX	37.88142	-121.467
Old River above DMC Barrier	OAD	37.81024	-121.542
Old River at Tracy Wildlife Association	TWA	37.80283	-121.457
Old River Below Clifton Court Intake	ORI	37.82800	-121.553
Old River below Headwaters	OH1	37.80759	-121.331
Old River Downstream DMC Barrier	ODM	37.81097	-121.544
Old River near Doughty Cut - ORX	ORX	37.81099	-121.387
Old River Upstream of Mountain House Creek	ORM	37.79384	-121.517
Victoria Canal near Byron	VCU	37.87094	-121.530
West Canal Above Clifton Court Intake	WCI	37.83160	-121.554

State Water Project Cyanotoxin Monitoring

DWR's State Water Project personnel collect samples for cyanobacteria and cyanotoxins twice per month from April-October at Clifton Court Forebay and Banks Pumping plant. Samples are shipped to a contracting lab (currently Greenwater Laboratories) for potentially toxic cyanobacteria screening. If potentially toxigenic cyanobacteria are present, samples are analyzed for cyanotoxins. Data are reported to the State Water Board's CyanoHABs portal and other stakeholders.

United States Geologic Survey monitoring

The United State Geologic Survey's (USGS) California Water Science Center maintains approximately 53 continuous monitoring stations throughout the Delta. Most stations measure water flow or, in some cases, velocity and core water quality parameters including water temperature, specific conductance, and turbidity (Table 3). At some stations, an expanded set of water quality parameters is collected, including dissolved oxygen, pH, chlorophyll, and fluorescence of dissolved organic matter (fDOM) (Table 3; Figure 7). Discrete nutrient samples are collected approximately monthly from 14 stations (Figure 9). Fluoroprobes (bbe Moldaenke) capable of differentiating between groups of phytoplankton with different photosynthetic pigments have been installed at five stations in cooperation with USBR (Table 3). Visual index scores of *Microcystis* sp. colony prevalence are also recorded approximately weekly during spring through fall at a subset of stations (Figure 8; Flynn et al. 2022).

Table 3. USGS continuous and discrete monitoring stations and parameters measured. Partner agencies are identified for each parameter set.

USGS Station Name	Station ID	USGS Station Number	Latitude (NAD83)	Longitude (NAD83)	Flow	Core WQ (Temp, SpC, turb)	Expanded WQ (DO, pH, Chl a, fDOM)	Nutrients (SUNA NO3, nutrient sample)	Fluoroprobe
YOLO BYPASS NR WOODLAND CA	YOLO	11453000	38°40'40"	121°38'35"	SacFO	SacFO			
SAN JOAQUIN R NR VERNALIS CA	VNS	11303500	37°40'34"	121°15'55"	SacFO	SacFO			
SAN JOAQUIN R BL GARWOOD BRIDGE A STOCKTON CA	SJG	11304810	37°56'08"	121°19'45"	USBR	USBR			
TURNER CUT NR HOLT CA	TRN	11311300	37°59'33"	121°27'14"	USBR	DWR	DWR		
VICTORIA CANAL NR BYRON CA	VCU	11312672	37°52'15"	121°31'48"	USBR	DWR	DWR		
MIDDLE R AT MIDDLE RIVER CA	MDM	11312676	37°56'34"	121°31'59"	DWR	USBR	USBR	USBR	USBR
MIDDLE R NR HOLT CA	HLT	11312685	38°00'11"	121°30'39"	USBR	DWR	DWR		
OLD R NR DELTA MENDOTA CANAL CA	ODM	11312968	37°48'38"	121°32'29"	DWR	DWR	DWR		
GRANT LINE CN NR TRACY CA	GLC	11313240	37°49'12"	121°32'41"	DWR	DWR	DWR		
OLD RIVER NEAR BYRON CA	OH4	11313315	37°53'28"	121°34'09"	DWR	USBR			
OLD R A BACON ISLAND CA	OBI	11313405	37°58'12"	121°34'16"	DWR	DWR	DWR	USBR	USBR
HOLLAND CUT NR BETHEL ISLAND CA	HOL	11313431	38°00'59"	121°34'55"	USBR	DWR			
DUTCH SLOUGH BL JERSEY ISLAND RD A JERSEY ISLAND	DSJ	11313433	38°00'49"	121°40'00"	DWR	USBR			
OLD R A QUIMBY ISLAND NR BETHEL ISLAND CA	ORQ	11313434	38°01'38"	121°33'52"	USBR	DWR			
FALSE R NR OAKLEY CA	FAL	11313440	38°03'21"	121°40'01"	USBR	DWR	DWR		
OLD R A FRANKS TRACT NR TERMINOUS CA	OSJ	11313452	38°04'16"	121°34'44"	USBR	DWR	DWR		
SAN JOAQUIN R A PRISONERS PT NR TERMINOUS CA	PRI	11313460	38°03'34"	121°33'26"	USBR		DWR		
DELTA CROSS CHANNEL NR WALNUT GROVE	DLC	11336600	38°14'41"	121°30'19"	USBR	USBR	USBR		
S MOKELUMNE R A NEW HOPE BR NR WALNUT GROVE CA	SMR	11336680	38°13'32"	121°29'28"	USBR	USBR			
N MOKELUMNE NR WALNUT GROVE CA	NMR	11336685	38°13'24"	121°30'26"	USBR	USBR			
LITTLE POTATO SLOUGH A TERMINOUS CA	LPS	11336790	38°05'47"	121°29'46"	USBR	USBR	USBR	USBR	
MOKELUMNE R A ANDRUS ISLAND NR TERMINOUS CA	MOK	11336930	38°06'22"	121°34'16"	USBR	DWR			
SAN JOAQUIN R A CHANNEL MARKER 42 NR ISLETON CA	M42	11336955	38°06'02.35"	121°36'09.67"	DWR	DWR			
THREEMILE SLOUGH NR RIO VISTA CA	TSL	11337080	38°06'12"	121°41'10"	DWR	DWR			
SAN JOAQUIN R A JERSEY POINT CA	SJJ	11337190	38°03'08"	121°41'16"	DWR	USBR	USBR	USBR	USBR
SACRAMENTO R A FREEPORT CA	FPT	11447650	38°27'22"	121°30'01"	DWR/RegSan	RegSan	RegSan	RegSan	
SUTTER SLOUGH A COURTLAND CA	SUT	11447830	38°19'45"	121°34'45"	USBR				
STEAMBOAT SLOUGH NR WALNUT GROVE CA	SSS	11447850	38°17'05"	121°35'12"	USBR				
SACRAMENTO R AB DELTA CROSS CHANNEL CA	SDC	11447890	38°15'28"	121°31'02"	DWR	USBR	USBR	USBR	
GEORGIANA SLOUGH NR SACRAMENTO R	GSS	11447903	38°14'14"	121°31'03"	USBR	USBR			
SACRAMENTO R BL GEORGIANA SLOUGH CA	GES	11447905	38°14'20"	121°31'18"	DWR	USBR			
SACRAMENTO R DEEP WATER SHIP CHANNEL NR FREEPORT	CM 72	11455095	38°28'36.73"	121°35'01.11"	USBR	USBR	USBR	USBR	
SACRAMENTO R DEEP WATER SHIP CHANNEL NR CLARKSBURG	CM 66	11455136	38°24'16.0"	121°36'52.4"	vel	USBR	USBR		
TOE DRAIN A MALLARD RD NR COURTLAND CA	ToeN / ToeS	11455139 / 11455140	38°21'54.50"	121°38'15.87"	USBR	USBR	USBR	USBR	
SACRAMENTO R DEEP WATER SHIP CHANNEL NR COURTLAND	CM 62	11455142	38°20'30"	121°38'38"	vel	USBR	USBR	USBR	
SHAG SLOUGH A LIBERTY ISLAND NR COURTLAND CA	SGG	11455276	38°19'06"	121°41'35"	USBR	USBR	USBR	USBR	
CACHE SLOUGH NR HASTINGS TRACT NR RIO VISTA CA	USC	11455280	38°16'32"	121°42'33"	USBR	USBR			
CACHE SLOUGH A S LIBERTY ISLAND NR RIO VISTA CA	LIB	11455315	38°14'32"	121°41'10"	USBR	USBR	USBR	USBR	
SACRAMENTO R DEEP WATER SHIP CHANNEL CHANNEL MARKER 51 CA (CM51)	CM 51	11455338	38°14'14.61"	121°40'26.24"	USBR	USBR	USBR		
CACHE SLOUGH AB RYER ISLAND FERRY NR RIO VISTA CA	RYF	11455385	38°11'38.24"	121°39'28.81"	USBR	USBR	USBR	USBR	
SACRAMENTO R A RIO VISTA CA	SRV	11455420	38°08'56.56"	121°41'20.20"	DWR	DWR			
SACRAMENTO R BL TOLAND LANDING NR RIO VISTA CA (CM13)	TOL	11455485	38°04'40.11"	121°46'02.23"	vel	USBR	USBR	USBR	USBR
SACRAMENTO R A CHANNEL MARKER 10 NR COLLINSVILLE CA	M10	11455495	38°03'35.39"	121°47'59.60"		State Board			
SACRAMENTO R A CHANNEL MARKER 5 A COLLINSVILLE CA	CM5	11455498	38°03'56.81"	121°50'08.91"		State Board			
SUISUN BAY A VAN SICKLE ISLAND NR PITTSBURG CA	CONFL	11455508	38°02'58.31"	121°53'15.18"	State Board	USBR	USBR	USBR	USBR
SUISUN BAY A CHANNEL MARKER 16 NR BAY POINT CA	M24	380318121571501	38°03'18.34"	121°57'15.46"	State Board	State Board			
SUISUN BAY A CHANNEL A BUOY 19 NR PORT CHICAGO CA	B19	380337122000301	38°03'37.36"	122°00'02.54"		State Board			
SUISUN BAY A CHANNEL MARKER 16 NR PORT CHICAGO CA	M16	380356122023701	38°03'55.90"	122°02'36.67"		State Board			
GRIZZLY BAY A SUISUN SLOUGH NR AVON CA	GRIZ	380631122032201	38°06'30.71"	122°03'21.53		USBR	USBR	USBR	
FIRST MALLARD BRANCH NR FAIRFIELD CA	FMB	381142122015801	38°11'41.62"	122°01'58.13"	USGS*	USGS*	USGS*		
MINER SLOUGH NEAR SACRAMENTO RIVER AND PROSPECT ISLAND	MIR	381410121395801	38°14'08.02"	121°39'57.85"	DWR	DWR			
SACRAMENTO R A CHANNEL MARKER 22 NR RIO VISTA CA	M22	380658121421501	38°06'57.64"	121°42'15.23"		DWR			
SAN JOAQUIN R A CHANNEL MARKER 18 NR OAKLEY CA	M18	380138121441401	38°01'37.76"	121°44'14.15"	DWR	DWR			

CDFW fish survey visual* Microcystis *sp. data

CDFW conducts summer townet and fall midwater trawl fish monitoring surveys in the Delta as part of its cooperative agreements with Reclamation and DWR. Starting in 2007, the crew has conducted visual index scores of *Microcystis* sp. colony prevalence at each sample site following Flynn et al. (2022) (Figure 8). Data like these from summer and fall fish surveys will be combined with the other program visual index data to provide a broad view of HABs formation, distribution, and intensity across the Delta throughout the summer through fall.

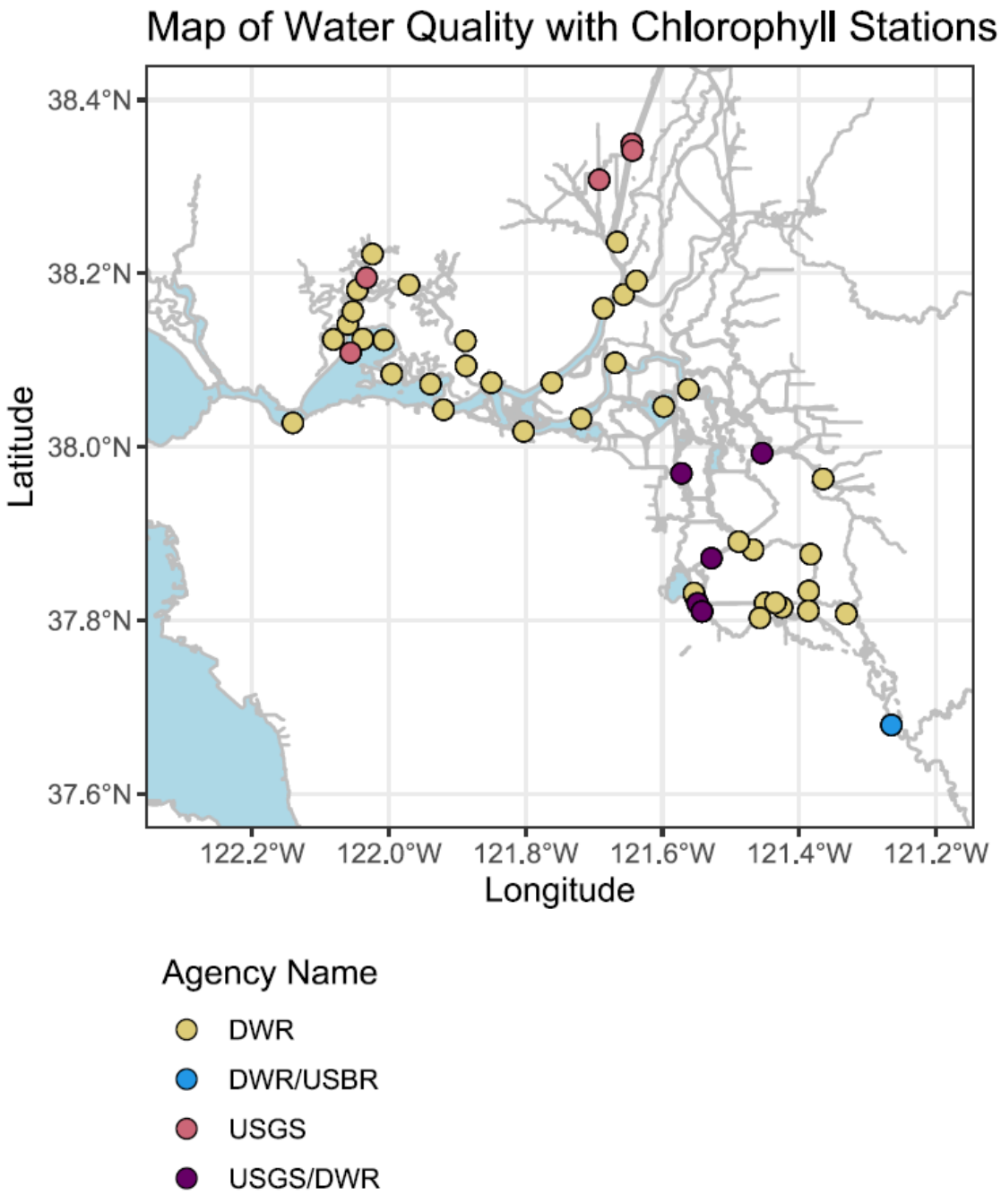

Figure 7. Map of continuous water quality sites that measure chlorophyll a. Stations also measure electrical conductivity, temperature, and some measure pH and Dissolved Oxygen as well. Map courtesy of Jenna Rinde, CDFW, developed for the Delta Science Program HABs Workshop, November 2022.

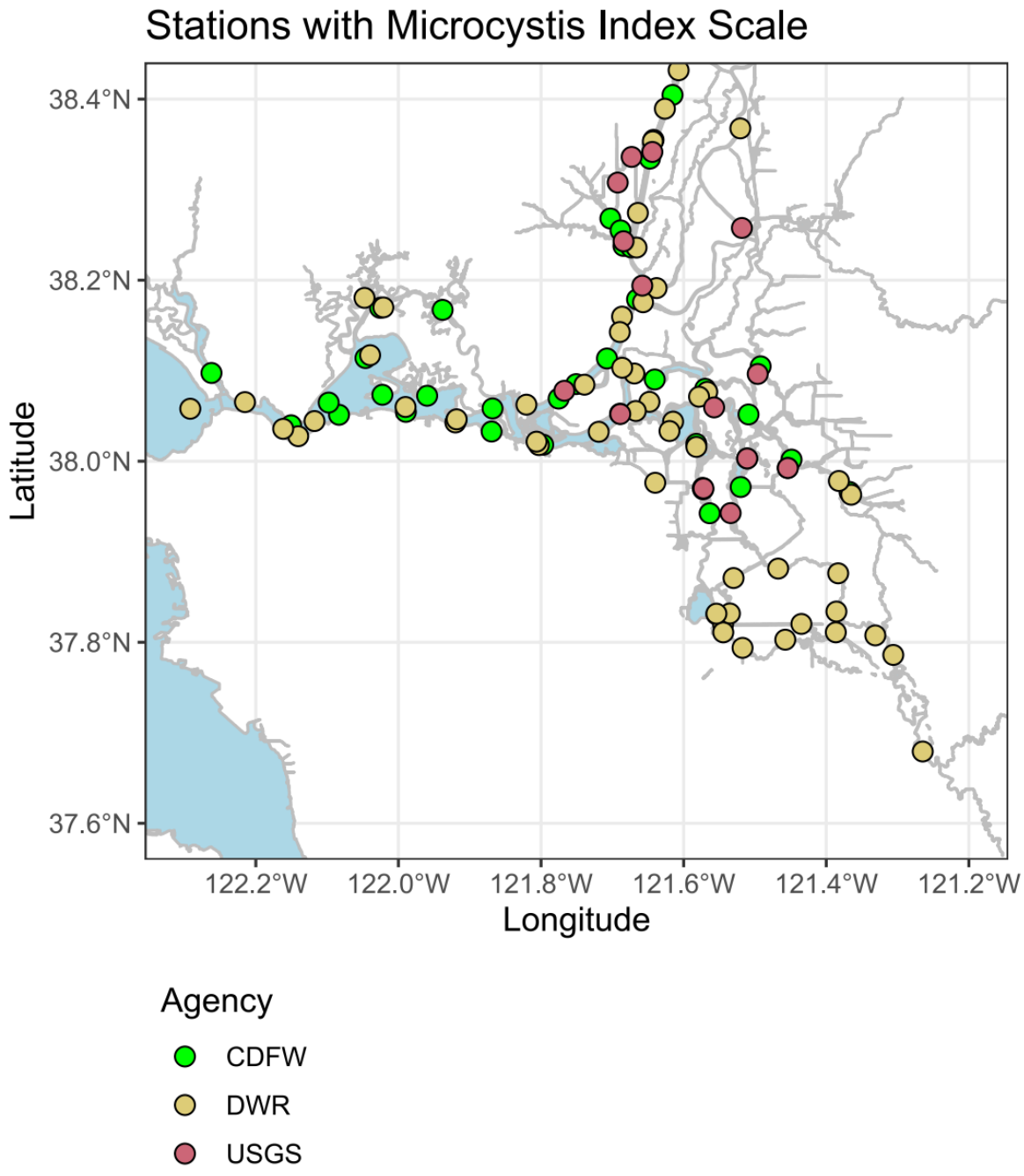

Figure 8. Map of stations that utilize the Microcystis Index scale as a visual assessment (Flynn et al., 2022). CDFW stations include fisheries surveys described above. DWR stations include EMP and NCRO, described above. Map courtesy of Jenna Rinde, CDFW, developed for the Delta Science Program HABs Workshop, November 2022.

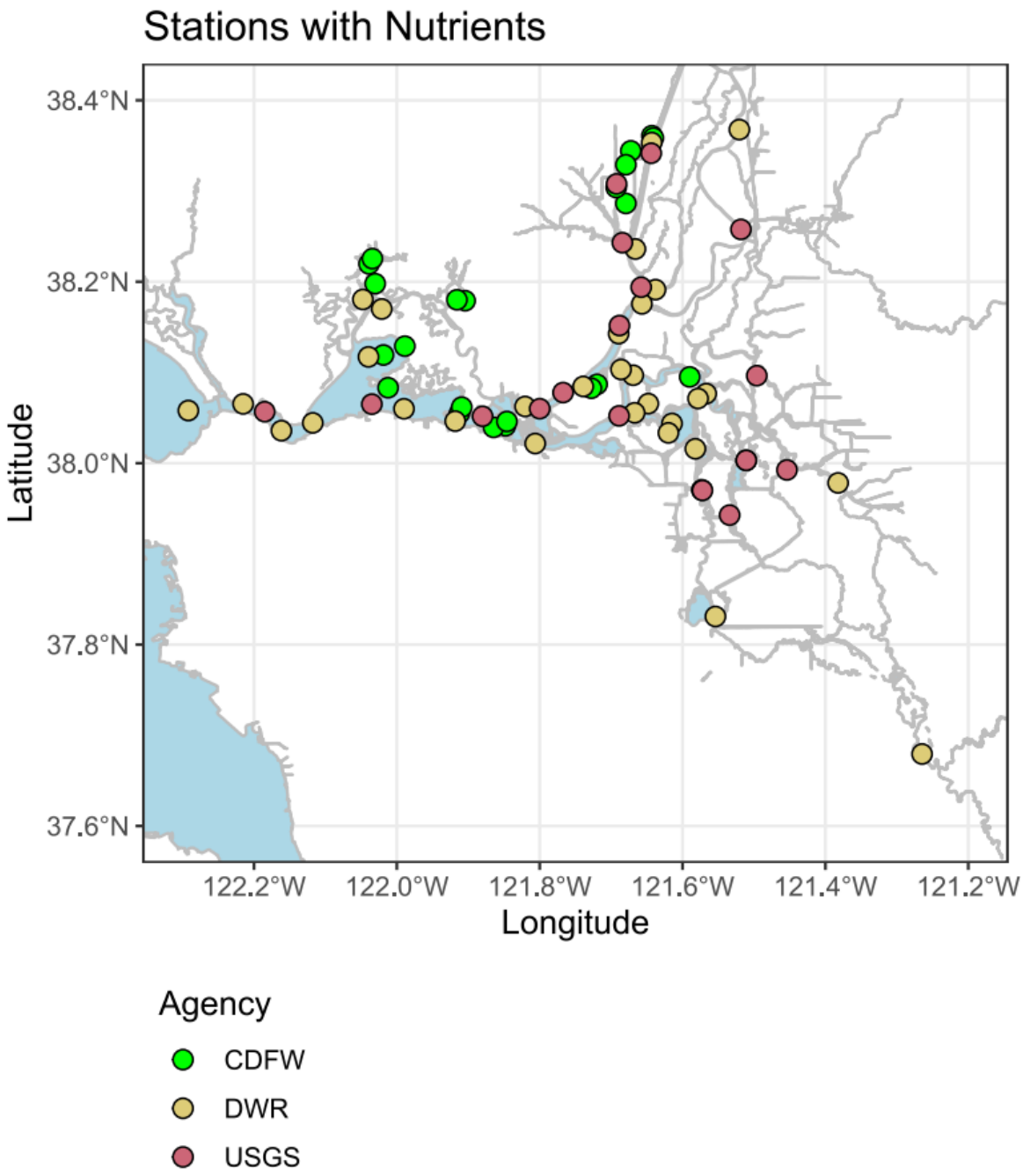

Figure 9. Map of stations that collect nutrients (nitrogen/phosphorous). DWR stations include EMP and NCRO, described above. Map courtesy of Jenna Rinde, CDFW, developed for the Delta Science Program HABs Workshop, November 2022.

Monitoring Elements and Methods

FHAB Framework and Strategy Indicators and Metrics

The FHAB Framework and Strategy identified priority indicators and metrics for response (Table 2.3, pg 20) and environmental drivers (Table 2.4, pg 21). Indicators and metrics measured as part of this monitoring plan are identified in Table 4 and Table 5.

Table 4. Priority FHAB Framework and Strategy response indicators and metrics measured by this monitoring plan.

Indicator Group	Metric	EMP Discrete	EMP Continuous	NCRO Discrete	NCRO Continuous	SWP	USGS Discrete	USGS Continuous	CDFW Fish Surveys
Water Clarity and/or Quality									
	Remotely sensed water clarity								
	Secchi depth or light penetration	X							
	Turbidity or total suspended solids	X	X	X	X		X	X	
	Dissolved oxygen	X	X	X	X			X	
	pH	X	X	X	X			X	
	DOC; fluorescence of dissolved organic matter (fDOM) at continuous stations	X		X	X		X	X	
Sediment Quality									
	Sediment TN, TP and OC								
Photosynthetic Benthic or Planktonic abundance									
	Remotely Sensed Chlorophyll a								
	Water column particulate OC, nitrogen, phosphorus and nutrient ratios	X		X					
	Benthic particulate OC, nitrogen, phosphorus and nutrient ratios								
	Planktonic, benthic, or drift algal Chl-a (discrete samples)	X		X			X		
	In Situ Chl-a Fluorescence	X	X	X	X			X	
	Macrophyte or macroalgal % cover								
Cyanobacterial Abundance									
	Remotely sensed CIcyano								
	Visual scum -- visual *Microcystis* sp. ranking	X		X				X	X
	Discrete planktonic or benthic phycocyanin						X[§]		
	In Situ phycocyanin fluorescence								
	Cyanobacterial cell density				X	X	X	X[¥]	
	Toxigenic species abundance (qPCR)								
Algal/Cyanobacterial Community Composition									
	Species composition via microscopy	X				X	X		
	Species relative abundance via molecular barcoding								
Primary Consumer									
	Invertebrate composition	X							
Toxins/Taste and Odor Compounds									
	Total planktonic/benthic toxin samples			X		X			
	Via passive sampler								
	Toxin gene counts								
	Tissue toxins, MIB, geosimn								
	MIB, Geosimn, Sulfur					X			
	Sediment toxins								

[§] some cyanobacterial cells enumerated as part of general phytoplankton sample enumeration; however, many cells are too small to be counted

[¥] fluoroprobe measurements at some stations

Table 5. Priority FHAB Framework and Strategy environmental drivers indicators and metrics measured by this monitoring plan.

Driver	Indicator Group	Metric	EMP Discrete	EMP Continuous	NCRO Discrete	NCRO Continuous	SWP	USGS Discrete	USGS Continuous	CDFW Fish Surveys
External -Climate										
	Air Temperature									
	Precipitation									
	Wind									
	Insolation									
External-Land use, Geology and Soils										
	Catchment Land Use									
	Catchment Slope									
	Catchment Hydrology									
	Catchment Geology									
	Catchment Soils									
External-Nutrient Loading										
	Catchment Nutrient Loading									
	Atmospheric Deposition									
	Groundwater									
External -Pesticides										
	Human Use									
External-Events										
	Events (e.g., Fires, floods)									
Internal-Physical										
	Waterbody Hydrology/Hydrodynamics			X					X	
	Geomorphology									
	Water Temperature		X	X	X	X		X	X	X
	Ocean derived salinity	Conductance	X	X	X	X		X	X	X
	Physical habitat									

Table 6 (continues). Priority FHAB Framework and Strategy environmental drivers indicators and metrics measured by this monitoring plan.

Internal - Biogeochemical										
	Light Attenuation								*	
	Nutrients	NO3, NO2	X		X			X	X	
		TDN, DON	X		X					
		TKN	X		X					
		NH4	X		X					
		PO4	X		X					
	Water organic matter	fDOM				X			X	
		DOC, TOC	X		X					
	Sediment Organic Matter									
	Carbonate Chemistry									
	Ionic Composition									
	Dissolved Oxygen		X	X		X			X	X
	Stable Isotopes									
Internal - Biological										
	Algal Taxonomy		X	X			X	X	*	
	Algal Toxins				X		X			
	Grazers/Zooplankton		X							X
* near future capability										

Sample Collection and Analysis

Each of the monitoring elements above has its own set of standard operating procedures (SOPs) for equipment maintenance and calibration QAQC, sample collection and analysis, and data management and QAQC. DWR EMP and NCRO SOPs are referenced below and provided as appendices.

DWR Division of Regional Assistance North Central Region Office. 2022. NCRO WQES Proposed HAB monitoring workplan 2022. 6 pp. (Appendix A).

DWR Division of Integrated Science and Engineering. 2022. Quality assurance project plan for discrete water quality sampling emergency drought barrier and TUCP Cyanotoxin monitoring. Document number: DES-10-QAP-001, Revision 1.0. 6 pp. (Appendix B).

DWR Division of Regional Assistance North Central Region Office. 2022. Quality assurance project plan Central Delta and emergency drought barrier water quality monitoring program. Document number: DRA-2-QAP-005, Revision 2. 66 pp. (Appendix C).

DWR Division of Integrated Science and Engineering. 2022. Quality Assurance Project Plan for the Continuous Environmental Monitoring Program (CEMP). Document number: DES-3-QAP-001, Version 1.0. 49 pp. (Appendix D).

DWR Division of Integrated Science and Engineering. 2022. Discrete Environmental Monitoring Program field and laboratory manual. Version 6. 83 pp. (Appendix E).

Wagner, R.J., Boulger, W.R., and Smith, B.A., 2006, Revised Guidelines and standard procedures for continuous water-quality monitors: site selection, field operation, calibration, record computation, and reporting: U.S. Geological Survey Techniques and Methods, Book 9, Chapter B. http://pubs.usgs.gov/tm/2006/tm1D3/

Pellerin, B.A., Bergamaschi, B.A., Downing, B.D., Saraceno, J.F., Garrett, J.A., and Olsen, L.D., 2013, Optical techniques for the determination of nitrate in environmental waters: Guidelines for instrument selection, operation, deployment, maintenance, quality assurance, and data reporting: U.S. Geological Survey Techniques and Methods 1–D5, 37 p. https://pubs.er.usgs.gov/publication/tm1D5

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A10, available online at http://pubs.water.usgs.gov/twri9A.

Data Management

Data collected by each monitoring program will be stored and checked for quality according to each program's SOPs. All HAB-related data collected by these programs will be submitted to the California HABs Portal.

Data Access

EMP data can be accessed from the contacts listed on the EMP website: https://iep.ca.gov/Science-Synthesis-Service/Monitoring-Programs/EMP. QAQCd discrete data are also posted to the Environmental Data Initiative: https://portal.edirepository.org/nis/mapbrowse?scope=edi&identifier=458&revision=7.

NCRO data can be accessed from DWR's Water Data Library or by contacting the Principal Investigator: https://wdl.water.ca.gov/waterdatalibrary/Map.aspx.

NCRO Visual *Microcystis* sp. data are reported through the California Cyanobacteria and Harmful Algal Blooms Network portal: https://mywaterquality.ca.gov/habs/where/freshwater_events.html.

Daily average Delta outflow estimates for a given calendar year can be accessed from DWR's Dayflow website, usually during February of the following year: https://data.cnra.ca.gov/dataset/dayflow/resource/776b90ca-673e-4b56-8cf3-ec26792708c3.

USGS flow data can be accessed from the National Water Dashboard: https://dashboard.waterdata.usgs.gov/app/nwd/lang-en/?aoi=default.

USGS continuous flow and water quality and monthly water quality data can be accessed from the National Water Information System: Mapper: https://maps.waterdata.usgs.gov/mapper/index.html. Data can also be accessed from the USGS California Water Science Center website: https://www.usgs.gov/centers/california-water-science-center/data.

DWR EMP and NCRO and USGS continuous flow and water quality data can also be accessed from the California Data Exchange Center: https://cdec.water.ca.gov/cdecstations.

CDFW visual *Microcystis* sp. data can be obtained by contacting the Principal Investigators for the summer townet and fall midwater trawl fish surveys (https://iep.ca.gov/Data/IEP-Survey-Data).

Data Analysis

The broad-scale, tiered approach that leverages historical datasets where possible allows CVP and SWP operations and physical drivers of HABs to be related to frequency, severity, and toxicity of FHABs throughout the Delta. Data analysis can take a variety of formats depending on the question of interest developed from the conceptual frameworks described above. For example, this monitoring program was used to assess the impact of the 2021 and 2022 TUCOs and Emergency Drought Barrier on FHABs in the Delta (Hartman et al. 2022). Analysis took several forms:

- Inter-annual comparisons allowed conditions in years with Barriers and TUCOs to be compared to years without Barriers and TUCOs;
- Spatial comparisons allowed conditions in areas of the Delta with hydrodynamic changes caused by the TUCO and Barrier to be compared to areas of the Delta unaffected by these actions; and
- Multivariate modeling allowed the relative importance of environmental drivers and management actions to be compared statistically.

Future analyses to evaluate the impacts of drought management actions can be conducted using similar methods to Hartman et al. (2022). These analyses will be made more robust with additional monitoring as recommended in the "Plan Development" section, below.

Plan Development and Interagency Collaboration

CVP and SWP environmental monitoring efforts capture many of the priority indicators and metrics for responses and environmental drivers identified in the California Water Board's FHAB Framework and Strategy (Smith et al 2021). The current monitoring described above (Table 4 and 5) provides a baseline for *Microcystis* occurrence, phytoplankton community composition (including potential FHAB formers), and the environmental parameters necessary for evaluating potential effects of the CVP and SWP that influence FHABs. Utilizing the California Water Board's Framework (Smith et al 2021), Reclamation and DWR have described how its monitoring efforts may fit into the California Water Board's systematic baseline FHAB monitoring. These monitoring efforts are particularly well-suited for providing data on environmental drivers of FHABs. Adding cyanotoxin monitoring to existing monitoring programs during key times and locations may improve our understanding for how the CVP and SWP affect FHAB distribution but will not replace the California Water Board's Framework (Smith et al 2021) for a monitoring program for FHABs.

Reclamation and DWR coordinate with other organizations collecting FHAB data in multiple forums (See *Other Collaboration Platforms* below). DWR and Reclamation participated in the Delta Science Program's HAB workshop and continue to be engaged in the development and publication of the workshop outcomes. The goal of this workshop was to develop a comprehensive, tiered monitoring framework for HABs in the Delta. Once developed, DWR and Reclamation can ensure that their sample collection, analysis, and data management efforts are compatible with other HABs monitoring programs, participate in sensor intercalibration, and, as potential resources allow, add cyanotoxin sampling at locations and times that fit within the overall program needs.

DWR and Reclamation will continue to assess the potential for modifying current monitoring efforts or adding new methods to better monitor FHABs. For example, the observation of potential FHAB conditions in areas monitored by DWR and Reclamation (e.g., by visual index, continuous water quality monitoring, or satellite data) could trigger additional sampling using cyanotoxin- and FHAB-specific assays such as toxin test strips, ELISA, fluorometry, and/or genetic techniques (e.g., qPCR). DWR and Reclamation will first pilot any potential

modification in methods and assess their effectiveness based on the relevance of information to evaluating the CVP and SWP effects of FHABs, data quality, comparability, consistency, and cost-effectiveness.

Other collaboration platforms

On a statewide scale, the California CyanoHAB network (https://mywaterquality.ca.gov/monitoring_council/cyanohab_network/) provides a platform for coordination of HABs sampling across California. When appropriate, DWR and Reclamation will use this platform as a venue to share information and results with the broader HAB research and monitoring community.

Many of the interagency project staff funded by Reclamation and DWR that are collecting FHAB data in this plan participate in Interagency Ecological Program Water Quality and Phytoplankton Project Work Team (PWT; https://iep.ca.gov/Science-Synthesis-Service/Project-Work-Teams/Water-Quality-and-Phytoplankton). The PWT mission is to provide a venue for scientists from diverse agencies and groups to communicate and coordinate findings, which will inform research and monitoring needs on water quality and phytoplankton issues in the Bay-Delta in the future. To that end, DWR and Reclamation will share data and methods with the PWT when appropriate to ensure consistency of data collection and reduce duplication of effort.

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Central Valley Project and State Water Project

Long-Term Monitoring Plan for Harmful Algal Blooms

Appendices

February 15, 2023 Final

Appendix A

DWR Division of Regional Assistance North Central Region Office. 2022. NCRO WQES Proposed HAB monitoring workplan 2022. 6 pp.

CVRWQCB – South Delta Temp. Barriers Project – Section 401 Water Quality Requirements
DWR (NCRO WQES) - Delta Regional Monitoring Program (RMP) Participation Plan
NCRO WQES Proposed HAB Monitoring Workplan 2022

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Introduction:

The collection of additional harmful algal bloom (HAB) data is part of additional requirements by the South Delta Temporary Barriers Project (TBP) Section 401 Water Quality Certification. DWR was required as part of the certification process to provide a revised Delta Regional Monitoring Program (RMP) participation plan that describes a list of proposed monitoring tasks to help the Central Valley Regional Water Quality Control Board (CVRWQCB) better understand the complex water quality questions related to the TBP monitoring program.

The list of additional HAB related Delta RMP monitoring tasks include:

1. Year-Round Visual Harmful Algal Bloom (HAB) Index Reporting – DWR DES Environmental Monitoring Program (EMP) 1-5 *Microcystis* Visual Index
2. Collection of Water Samples for Algal Bloom and/or Toxin Analyses
3. Phytoplankton Identification

Background and Purpose:

HABs are large overgrowths of algae in marine or freshwater ecosystems that have the potential to produce toxins that can harm other living organisms (Zegura et al. 2002). The Sacramento-San Joaquin Delta has observed an increasing number of HABs in the past few years, especially in the central and south Delta. These HABs have been composed primarily of the freshwater algae called cyanobacteria, or blue-green algae (BGA). Specifically, one of the most prevalent cyanobacteria in recent years is *Microcystis aeruginosa* (Lehman et al. 2017); a known producer of toxins called microcyst ins that negatively affect the health of aquatic organisms and can impact human health. In late 2017, as required by South Delta Temporary Barriers Projects CVWRCB Section 401 Water Quality Certification, DWR NCRO began implementing and recording a surface *Microcystis* bloom visual index value during standard water quality station visits.

Monitoring and Evaluation:

Time-period: Visual DWR EMP Visual Index Monitoring of HABs will occur year-round (Jan.-Dec.) in the South and Central Delta at all North Central Region Office (NCRO) Water Quality Evaluation Section continuous monitoring stations. Tow net samples for Microcystis and Van Dorn samples for phytoplankton analyses will occur during the months of known peak *Microcystis* presence (July-October) and coincide with Temporary Agricultural Barrier installation which is typically May-October, but sampling can occur outside of that window if the barrier installation timeline is altered and or visual index scores indicate earlier detection of HABs. Water samples for toxin analysis will be collected only during peak Visual Index periods (Visual Index >4) and will require consultation with CVWRCB before collection.

Location: The NCRO operates monitoring stations and monitors for Microcystis Visual Index from Miner Slough near Sacramento River in the northern Delta south to stations in Old River near Mountain House Creek (Figure 1). The primary study area for the TBP monitoring efforts is in the south Delta channels of Old River and Grant Line Canal near Tracy, CA. The four primary temporary barriers installed are Middle River TBP near MRX station, Grant Line Canal TBP near GLE station, lower Old River TBP near ODM, and Old River near Head TBP near OH1 station (Figure 1).

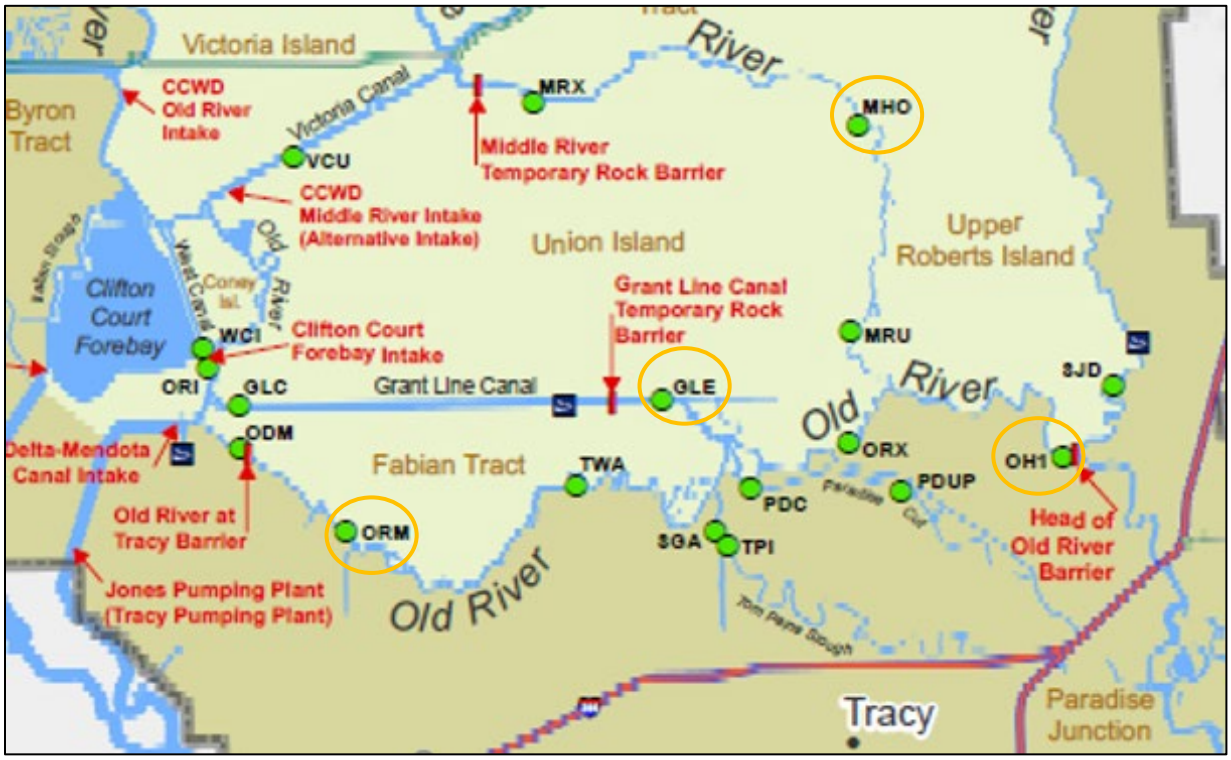


Figure 1. DWR NCRO WQES map of south Delta phytoplankton sampling locations. Four primary sampling locations MHO, GLE, ORM, and OH1 noted by orange circles.

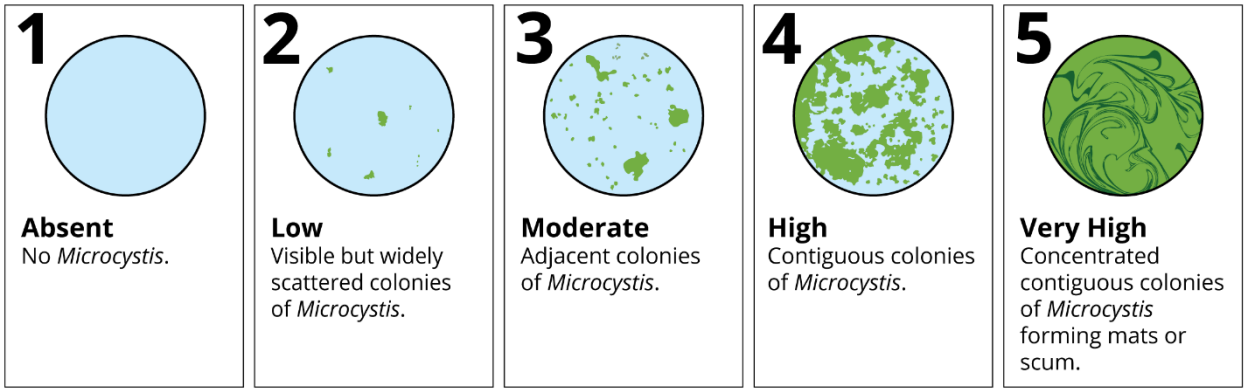
Monitoring Tasks: The following 3 tasks are the procedures which DWR staff accomplish to complete the above listed objectives to monitor HABs in the South Delta**.** Task 3 was drafted in the original workplan upon the creation of this project but has yet to be completed due to a lack

of funding from the CVWRCB. As funding allows, completion of task 3 objectives would be desired during events of high HAB concentrations.

Task 1. Year-Round Visual Harmful Algal Bloom (HAB) Index Reporting

DWR WQES will collect year-round visual analysis of HAB species (*Microcystis* and *Aphanizomenon*) using DWR EMP Visual Qualitative *Microcystis* Scoring Guide (1-5) while performing regular maintenance at continuous water quality stations (typically 1x per month). The primary regions of interest are the south and central Delta regions. These will be reported to the California Water Quality Monitoring Harmful Algal Bloom Portal (https://mywaterquality.ca.gov/habs/index.html). CVRWQCB will provide WQES staff with a modified spreadsheet for importing field data. Data will be reported to the portal monthly after typical continuous water quality station maintenance field runs. Additional photos will be taken and archived to provide visual evidence of index conditions.

Figure 3. DWR EMP Visual *Microcystis* Scoring Guide



Source: Ted Flynn, Environmental Monitoring Program

Task 2. Phytoplankton Sample Collection and Identification

DWR WQES will collect a similar sampling matrix to DWR EMP:

1. *Microcystis* sample will be collected by towing an 80-µm plankton net towed horizontally just below the surface for 1-3 min or using bucket if thick biomass. Sample will then be placed in 50mL Amber glass bottle and preserved w/ Lugol's solution for ID and enumeration of *Microcystis* only using DWR FlowCAM and/or contracted taxonomist (See Appendix for attached protocol).
2. Ambient water sample will be collected at 1m with Van Dorn water sampler and placed in 50 mL amber glass bottle and preserved w/ Lugol's solution for ID and enumeration of all phytoplankton taxa by contracted taxonomist (i.e., BSA Environmental). This sample will correspond with regular chlorophyll-a grab sample completed at each station for corroboration with continuous sonde data.

DWR WQES plans to collect net tow samples at 4 stations (MHO, ORM, GLE, and OH1 – See Figure 1 and 2) during planned water quality station maintenance field runs. These stations are known sites of high (3-4) Visual Qualitative Scoring and cover primary South Delta flow channel corridors potentially effected by temporary barrier installation and/or water project operations. Samples will be collected at these 4 stations 4x each year, 1x per month starting July-Oct (total

net tow samples = 16 for FlowCAM or contracted taxonomist *Microcystis* ID and enumeration and 16 ambient water sample for BSA taxonomist identification).

This task will utilize DWR EMP's standard methods for phytoplankton identification, quantification, biomass estimation, and quality assurance. Samples will be analyzed with the DWR-owned FlowCAM. Samples will typically all be run through FlowCAM within 1-2 months of collection (not exceeding 3-months). Sample biovolume estimates will be completed at the end of the collection period typically by February of the following year.

Task 3. Collection of Water Samples for Algal Bloom and/or Toxin Analyses

DWR WQES will collect a water sample at sites for toxin analysis **only** when Visual Qualitative Scoring is high (4 - 5) and only when CVWRCB provides directive and funding. DWR WQES will contact CVRWQCB to make final decision on whether to collect samples for toxicity (Contacts: Janis Cooke (CVWQCB) 916-464-4672). Samples will be collected in 250 mL amber glass bottles provided by CVWQCB. DWR WQES will contact CVWQCB to coordinate sample drop-off and/or pick-up from laboratory facilities. Samples will typically be held overnight in the WQES laboratory refrigerator or in cooler on ice and picked up the next morning (hold time ~24hours).

Data Management and Analysis:

Data Management and Accessibility

Collected data is stored both physical field datasheets and electronic form. Electronic data is stored on DWR shared drives, cloud-based drives, and external hard drives all of which are housed in DWR facilities on secure servers which experience daily data back-ups. Datasets are maintained by DWR staff and available upon request from Technical Lead and/or Project Manager.

Deliverables

1. Monthly Visual Harmful Algal Bloom (HAB) Index Reporting
2. Phytoplankton Identification and Enumeration Data
3. Annual summary report of years visual scores and HAB biovolume calculations as well as dataset will be delivered in the first quarter of the following year
4. Final Report at end of 401 Certification (every 5 years) summarizing and analyzing the projects visual scoring and biovolume calculations.

Data Analysis

Annual analysis of collected data would consists of 3 main analyses.

1. A monthly average of the HAB visual index over the 12-month periods collected at all the TBP stations.
2. A biovolume estimation of *Microcystis* collected during task 2 at our 4 target stations. Estimation would be completed by one of the following procedures:
    a. FlowCAM processing and classification by DWR staff utilizing EMP's protocols (see Appendix IV for analysis computations)
    b. By outside contracted taxonomic expert in identifying *Microcystis* and other HAB causing phytoplankton
3. A percentage summary of total phytoplankton identified from ambient water samples collected at our 4 target stations over the 4-month sampling period

Further investigation would occur during the final report which could include but is not limited to:

1. Investigation into correlation or causation of HAB abundance in relation to Water Quality and Flow Data collected by NCRO office
2. Statistical analysis of potential trends seen over the project's lifespan
3. Comparing results with other HAB related data collected from throughout the Delta

Funding

All labor and equipment associated with this HAB monitoring project will be funded by Department of Water Resources Operations and Maintenance (O&M) Temporary Barriers Project and Lower San Joaquin South Delta Branch. The primary program manager contacts on the resource agreements for this work are Karen Tolentino (Karen.Tolentino@water.ca.gov 916-902-9897), Bill McLaughlin (William.Mclaughlin@water.ca.gov 916-902-9899), and Jacob McQuirk (Jacob.McQuirk@water.ca.gov (916) 902-9905).

Stakeholder and Agency Coordination

DWR commits to working alongside CVWRCB as well as partners throughout the Interagency Ecological Program to coordinate HAB monitoring efforts and sharing of knowledge to provide the best available results in monitoring the Sacramento San-Joaquin Delta.

References:

Lehman, P. W., Kurobe, T., Lesmeister, S., Baxa, D, Tung, A.., Teh, S. J. 2017. Impacts of the 2014 severe drought on the Microcystis bloom in San Francisco Estuary. Harmful Algae 63:94-108.

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Appendix:

I. 2019 *Microcystis* Field Sampling SOP

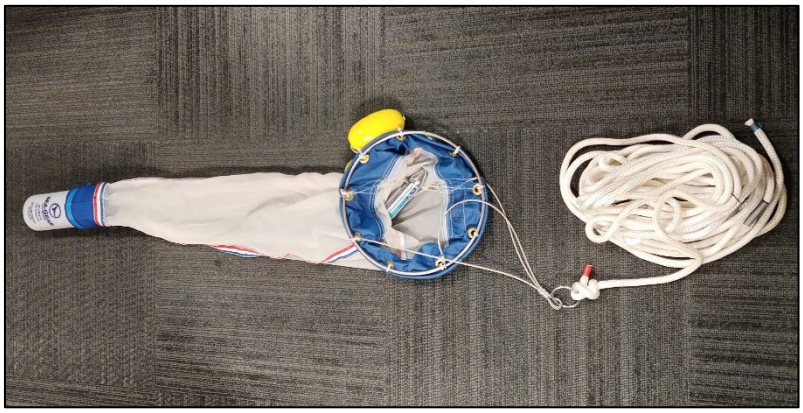
Purpose:

NCRO sampling for Microcystis biovolume and toxins (when appropriate) as part of the 401c permit for temporary barriers in the South Delta.

A. Microcystis net setup

Equipment:

- *Microcystis* net - 0.3 m wide, 80 µm mesh plankton net
- 1 L Plastic Cod End
- 40 ft rope
- General Oceanic 2030R6 Mechanical Flow meter (w/ Low Velocity Rotor)
- Floatation Buoy
- Zip-ties



1. Prepare the flow meter for use by adding water to the body of the meter as directed by manufacture. Attach flow meter to the mouth of the *Microcystis* net using zip-ties. Be sure to attach the flow meter to the net's ring so that it sits in the center of the net and the propeller falls inside of the net.
2. Attach flotation buoys to the top of the *Microcystis* net ring using zip-ties. Attach enough flotations to allow the top of the net's ring to sit at the surface of the water when launched.
3. Attach a plastic wide mouth bottle to the end of the *Microcystis* net. Be sure to tighten any loose bolts that are holding down the hose clamp ring.
4. Tie one end of the 40 ft rope to the steel wires at the mouth of the net. Prepare rope for launch by securely attaching rope to vessel used for towing.

B. *Microcystis* Net Tow samples

Equipment:

- *Microcystis* net - 0.3 m, 80 µm mesh plankton net, flow meter, line, cod end, floats
- 1L amber glass bottle
- 1 Labeled 60ml amber glass bottle with 0.5 mL Lugol's Iodine solution
- 2000 mL graduated cylinder
- 100 mL graduated cylinder
- *Microcystis* tow and toxin data sheet, pencil
- Funnel
- Bucket
- DI water refill and wash bottle

Procedure:

1. Bottle Preparation: Label the bottle before collecting samples with station name, date (mm/dd/yy), sampling method ('net tow'). Add in 0.5 mL of Lugol's Iodine Solution to 60 mL phytoplankton bottle.
2. Read the flow meter value and write down the start value.
3. With the *Microcystis* net, flow meter, line, and cod end attached and ready, drop the net in the water just below the surface of the water without spinning the fin on the flow meter and let the current take it out 50 feet away. If current is slack, slowly spool out line into the water as boat operator drives forward. There should be tape or a visible marker on the line indicating when you are 50 feet away.
4. Once the net reaches 50 feet, gently pull the net in. Try not to break any *Microcystis* colonies
5. Repeat steps 3 and 4
6. Record the ending flow meter reading.
7. Gently rinse the net from the outside using the DI wash bottle to rinse any big colonies into the cod end.
8. Remove the cod end from the net. Pour the cod end water into a 2000 mL graduated cylinder and record the volume.
9. Pour the water from the graduated cylinder into the 1L glass amber bottle if collecting additional sample during high HAB concentration events.
10. At all times, be gentle with the sample. Gently swirl the 1L amber bottle containing net tow water. Using the 100 mL graduated cylinder, measure out 50 mL of the Microcystis Net Tow sample. Be careful not to spill any sample. Use a small funnel for sample transfers if needed.
11. Tightly cap the Net tow 60 mL bottle and invert several times to ensure the mixture of Lugol's Solution. Place in a Ziploc bag. Store the samples in a safe place that will avoid damage to the bottles and keep out of direct sunlight. **Do NOT ice or freeze samples.**
12. Once finished, tightly screw on the lid of the 1L glass amber bottle, and place on wet ice in the cooler.

NOTE: Bucket – If the *Microcystis* is thick, then the flow meter will not function well, and bucket sampling might be necessary. Try to get a representative sample of the surface water and scum – don't scrape the scum to get more *Microcystis*. Place the *Microcystis* sample in a 1L amber glass bottle and place on ice.

C. *Microcystis* Net Tow samples for phytoplankton bottles

Equipment:

- *Microcystis* tow and toxin data sheet, pencil
- Van Dorn water sampler
- 2000 mL graduated cylinder
- 100 mL graduated cylinder
- 1 Labeled 60ml amber glass bottle with 0.5 mL Lugol's Iodine solution
- Small funnel for sample transfers

Procedure:

1. Bottle Preparation: Label the bottle before collecting samples with station name, date (mm/dd/yy), sampling method ('van dorn'). Add in 0.5 mL of Lugol's Iodine Solution to 60 mL phytoplankton bottle.
2. Rinse the van Dorn 3x by dropping it into the water and pulling it back up just above the surface of the water to empty.
3. Using a Van Dorn, collect a water sample 1 meter below the surface of the water.
4. Measure out 50 mL of sample using a 100 mL graduated cylinder and place in 60 mL bottle.
5. Tightly cap the phytoplankton bottle and invert several times to ensure the mixture of Lugol's Solution. Place in a Ziploc bag. Store samples in a safe place that will avoid damage to the bottles and keep out of direct sunlight. **Do NOT ice or freeze phytoplankton samples.**
6. Record data by adding a checkmark to the assigned box on the datasheet. Rinse the graduated cylinder 3x with DI water for the next site.

D. Ambient Water –Toxin samples

Equipment

- 0 - 0.3 m Van Dorn water sampler
- 1 L amber glass bottle

Important: inspect the van Dorn rope for frays or other weak points at the beginning of each sampling day. You do not want to lose the sampler due to rope break.

Procedure:

1. Bottle Preparation: Label the bottle before collecting samples with station name, date (mm/dd/yy), sampling method ('van dorn').
2. Rinse the van Dorn 3x by dropping it into the water and pulling it back up just above the surface of the water to empty.

3. Lower the van Dorn right below the surface of the water column and collect water sample by dropping the messenger to release the rubber end covers. Do not try to collect *Microcystis*, just the water below the surface.
4. Pull up the van Dorn and triple-rinse a 1-L amber glass bottle before filling it all the way up. Place the bottle on wet ice in the cooler.
5. Record data by adding a checkmark to the assigned box on the datasheet and prep the van Dorn for the next site.

E. Sonde readings and additional notes

Note: This step is not required by the Central Valley Regional Water Quality Control Board, but is additional information being collected by WQES staff.

1. Using a calibrated EXO field sonde, take a field reading 1 meter below the surface while collecting the *Ambient water – Toxin Samples*. Record the following parameters: Temperature, Dissolved Oxygen percent and concentration, Specific Conductivity, pH, Turbidity (FNU), Blue Green Algae (ug/L), and Chlorophyll (RFU and ug/L).
2. Record HAB visibility based on WQES' HAB visibility scale (1=not visible, 2= low, 3= medium, 4= high, 5= extreme)

F. Sample Processing

1. The 60 mL **Van Dorn** samples are to be stored in a dimly lit place until it can be processed for phytoplankton analysis. WQES is working with DISE to conduct phytoplankton analysis. Lugol's Iodine solution allows for storage of the sample up to four months after collection.
2. The 1 L Microcystis tow net samples can be discarded after the 60 mL subsample is taken. Please be aware that staff at UC Davis may want to conduct additional analysis on these samples. It is important that you communicate with all stakeholders, assuring the sample is no longer needed before discarding collection. The 60 mL **Net Tow** bottles must be stored in a dimly lit place until it can be processed through the FlowCAM for analysis through LT300 and GT300 lens or analyzed via microscopy by outside taxonomist. Lugol's Iodine solution allows for storage of the sample up to four months after collection. See FlowCAM protocol for procedure or contract language for taxonomist.
3. Enter all data collected from field run into an excel sheet including: Date, Time of collection, Site, Net Tow volume, Flow Meter reading of 100 ft tow, Sonde readings, and any additional notes. This file should be shared with all stakeholders.

II. *Microcystis* Sampling Gear Checklist

Microcystis NCRO Sampling 2019

Boat Check List	Date	Date	Date	Date
Field sheets and pencils				
Clip board				
Van Dorn sampler				
Microcystis net, float, flow meter, line, cod end				
Large funnel (optional)				
2000mL graduated cylinder				
Small transferring funnel				
One Ziploc bag for phyto bottles				
Ice chest with sample bottles (below)				
Two 1L amber glass bottle per station				
Two 60mL phytoplankton bottle per station				

III. 2019 *Microcystis* Field Data Sheet

Microcystis Tow & Toxin Sheet

Site	Date	Time	Net Tow Volume (1-2 L glass amber bottle)	Phytoplankton		Ambient Water (0.3m van dorn; 1-2L glass amber bottle)	HAB visual score (1 – 5)	Microcystis Flow Meter 100 ft tow		Notes
				Net Tow	Van Dorn			Start	Stop	

HAB visual Scoring index: 1=not visible, 2= low, 3= medium, 4= high, 5= extreme

Additional Notes:

_____

_____

DWR: Water Quality Evaluation Section

Updated 08 August 2019

IV. FlowCAM Analysis Computations

***Microcystis* Net Tow**

Microcystis was sampled using an 80 µm mesh plankton net with a General Oceanics' mechanical flow meter attached to the opening of the net (0.3 m in diameter). The following formulae were used to calculate the water volume that passed through the *Microcystis* net (from "General Oceanics Digital Flowmeter Mechanical and Electronic Operators Manual").

Values needed	Description
Start and end of flow meter values	Before casting the net and flow meter into the water, the starting flow meter value is recorded. Once the net is pulled out of the water, the ending flow meter value is recorded.
Net diameter = 0.3 meter	Measurement from opening of the net
Standard Speed Rotor Constant = 26,873	Given value from manufacturer
Formulae:	
$$\text{DISTANCE in meters} = \frac{\text{Difference in COUNTS} * \text{Rotor Constant}}{999999}$$	
$$\text{VOLUME cubic meters} = \frac{3.14 * (\text{Net Diameter})^2 * \text{Distance}}{4}$$	
MA net water VOLUME in Liters = Volume cubic meters * 1000	Convert VOLUME cubic meters to VOLUME Liter for easier computation when calculating Final Chlorophyll Value (below)

Calculating Default Values for Sites with No Difference Values

Updated 08 August 2019

To calculate the water volume that passes through the *Microcystis* net, both START and ENDING flow reading are necessary; however, error in reading can occur due to flowmeter not spinning or getting stuck. When this occur for a site, a default value is calculated for the net volume difference (ENDING – START). Below is the calculation on how to obtain the default value if a site is missing a difference value.

Refer to **Field data Microcystis net comps 02182016.xlsx** for example.

File location: F:_Microcystis 2015\Analysis\Bryte data

Site BI on 10/14/15 did not have a difference value because the flowmeter got stuck. A default value was generated by averaging the difference values for BI from all sampling events.

$$mean\ difference = \frac{(sum\ of\ difference\ value\ for\ BI\ from\ all\ sampling\ events)}{\#\ of\ sampling\ event\ with\ actual\ difference\ value}$$

$$1449 = \frac{(1059 + 1392 + 1363 + 1707 + 2030 + 1145)}{6}$$

Updated 08 August 2019

Final Chlorophyll a Volume

The following calculations were performed to determine the final chlorophyll [µg/L] volume in the *Microcystis* net tow sample. Chlorophyll a from here on is abbreviated as chla.

Values needed	Description
Bryte chla [µg/L]	Value from water quality chlorophyll sampling
Cod volume [mL]	Total Microcystis net tow sample volume that was collected in the brown square sampling bottle
$\text{Cod volume [L]} = \frac{\text{Cod volume [mL]}}{1000}$	total sample volume converted from mL to L for easier calculation
MA net water volume [L]	obtain this MA net water volume from the Microcystis net tow computations (see formulae above for method)

Formulae	Description
$\text{Net chla [µg]} = \text{Bryte chla } \left[\frac{\text{µg}}{\text{L}}\right] * \text{sample vol from cod [L]}$	obtain the net chla by multiplying the Bryte chla and cod volume values together
$\text{Final chla } \left[\frac{\text{µg}}{\text{L}}\right] \text{in net tow } = \frac{\text{Net chla [µg]}}{\text{MA net water volume [L]}}$	Calculate final chla in the net tow sample by dividing the net chla into the MA net tow water volume

Updated 08 August 2019

FlowCAM Total Microcystis Biovolume

Microcystis water samples were collected in phytoplankton bottles and preserved with 0.5 mL of Lugol's solution. The samples were processed with the FlowCAM using two size fractions: greater than 300-micron particles and less than 300-micron particles (See FlowCAM Standard Operating Procedure for more details). Each sample was processed 2 to 3 times. Microcystis spp. were then identified and enumerated for total biovolume. The following calculations were performed to determine the total Microcystis biovolume for each site per sampling event.

Values needed	Description
Cod volume [L]	Total Microcystis net tow sample volume that was collected in the brown square sampling bottle
MA net water volume [L]	MA net water volume from the Microcystis net tow computations (see formulae above for method)
Sample vol from cod (L)	Total Microcystis net tow sample volume that was collected in the brown square sampling bottle
Dilution factor 1 to X	The dilution value from when processing the Microcystis sample with the FlowCAM
Count (Microcystis aeruginosa, Microcystis flos-aquaes, Microcystis wesenbergii)	Obtain the count of Microcystis species after classification and QA/QC processing. Each species is counted separately and added together later for the final count
Particles per ml, summary	Obtain this value after classification and QA/QC processing. The value can be found when exporting the classification summary into an excel file
Average biovolume, ABD (Area Based Diameter) (Biovolume → BV)	Obtain this value by exporting the Microcystis classification summary from FlowCAM

Calculations	Unit
Total mass = count * avg BV	$\mu m^3 = \text{count} * \mu m^3$

Updated 08 August 2019

$Correction\ factor = \frac{particles\ per\ mL}{count}$	$\frac{\text{Particles}}{\text{mL}} = \frac{\text{Particles}}{\text{mL} * \text{count}}$
BV/mL = total mass * correction factor	$\frac{\mu m^3}{\text{mL}} = \mu m^3 * \frac{\text{Particles}}{\text{mL}}$
Dilution correction = BV/ml * dilution factor	$\frac{\mu m^3}{\text{mL}} = \frac{\mu m^3}{\text{mL}} * \text{dilution factor}$
Total BV in brown bottle = dilution correction * sample vol from cod * 1000	$\mu m^3 = \frac{\mu m^3}{\text{mL}} * \text{L} * 1000$
Final BV/L = total BV/L / MA net water volume	$\frac{\mu m^3}{L} = \frac{\mu m^3}{L}$
Repeat all steps to calculate the biovolume/L for all runs and *Microcystis* spp.	

If a replication has more than one *Microcystis* spp. (ex: *Microcystis aeruginosa* and *Microcystis flos aquae*s), add the biovolume together. Obtain the mean value for each sampling event by averaging the biovolume from all the replications. Obtain the total *Microcystis* BV/L by adding the GT300 and LT300 BV/L together. Example below.

1	Date	Site	Station	Rep	size fraction	Microcystis aeruginosa final BV/L	Microcystis flos aquae final BV/L	Microcystis wesenbergii final BV/L		Microcystis LT / GT300 BV/L
2	8/14/15	MI	7	a	gt300	4.38E+08	5.52E+06	0.00E+00		4.43E+08
3	8/14/15	MI	7	b	gt300	7.72E+07	2.40E+06	0.00E+00		7.96E+07
4	8/14/15	MI	7	c	gt300	4.68E+07	1.35E+07	0.00E+00		6.03E+07
5	8/14/2015	MI	7	b	lt300	6.34E+05	0.00E+00	0.00E+00		6.34E+05
6	8/14/2015	MI	7	a	lt300	5.95E+07	7.66E+06	0.00E+00		6.72E+07

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	Collection Date	Station	Site	Rep	MC GT300 bv/L		meanGT300			
2	8/14/2015	7	MI	a	4.43E+08		1.94E+08			
3	8/14/2015	7	MI	b	7.96E+07					
4	8/14/2015	7	MI	c	6.03E+07		+			Total MC BV/L
5								=		2.28E+08
6	Collection Date	Station	Site	Rep	MC LT300 bv/L		meanLT300			
7	8/14/2015	7	MI	b	6.34E+05		3.39E+07			
8	8/14/2015	7	MI	a	6.72E+07					
9										

Appendix B

DWR Division of Integrated Science and Engineering. 2022. Quality assurance project plan for discrete water quality sampling emergency drought barrier and TUCP Cyanotoxin monitoring. Document number: DES-10-QAP-001, Revision 1.0. 6 pp.

1 Title Page

Quality Assurance Project Plan for Discrete Water Quality Sampling

Emergency Drought Barrier and TUCP Cyanotoxin Monitoring

Document number: DES-10-QAP-001
Revision: 1.0
Status: Effective

California Department of Water Resources
Division of Integrated Science and Engineering
3500 Industrial Boulevard
West Sacramento, California 95691

Approval Signatures

Table 1 Approval Signatures

Title	Name	Signature	Date Signed
Project Manager (Program Supervisor)	Rosemary Hartman		6/14/2022
Quality Assurance Officer	John Franco Saraceno		6/14/2022
Lab Manager, if applicable	Sid Fong		6/14/2022
Document Owner	Rosemary Hartman		6/14/2022

Acronyms

Table 2 Definition of acronyms

Acronym	Definition
CDFW	California Department of Fish and Wildlife
CEMP	Continuous Environmental Monitoring Program
COC	Chain of custody
EDB	Emergency Drought Barrier
EMP	Environmental Monitoring Program
DEMP	Discrete Environmental Monitoring Program
DI	De-ionized
DISE	Division of Integrated Science and Engineering
DOC	Dissolved organic carbon
DWR	Department of Water Resources
DQI	Data Quality Indicator(s)
DQO	Data Quality Objective(s)
EDI	Environmental Data Initiative
ELISA	Enzyme-Linked Immunosorbent Assay
EMP	Environmental Monitoring Program
EPA	Environmental Protection Agency
EMAP	Environmental Monitoring and Assessment Program
FLIMS	Field and Laboratory Information Management System
GPS	Global Positioning System
HAB	Harmful Algal Bloom
IEP	Interagency Ecological Program
IT	Information Technology
LCS	Laboratory Control Standard
LQAO	Laboratory Quality Assurance Officer
NCRO	North Central Region Office
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RWQCB	Regional Water Quality Control Board
QAPP	Quality Assurance Project Plan
QC	Quality Control

SWPQC	State Water Project
SWRCB	State Water Resources Control Board
USBR	US Bureau of Reclamation
USGS	United States Geological Survey
RWQCB	Regional Water Quality Control Board
SM	Standard Method
SOP	Standard Operating Procedure
YSI	Yellow Springs Inc.
SWP	State Water Project
SWRCB	State Water Resources Control Board
TUCO	Temporary Urgency Change Order
USBR	US Bureau of Reclamation
USGS	United States Geological Survey
WDL	Water Data Library
WRD	Water Rights Decision
WQES	Water Quality Evaluation Section
YSI	Yellow Springs Inc.

2 Table of Contents

2.1 *List of Figures*

2.2 *List of Tables*

3 QAPP Distribution List

Project staff in the Department of Water Resources (DWR) Environmental Monitoring Program (EMP), project staff in DWR's North Central Region Office (NCRO), the laboratory manager, and DWR Quality Assurance Officer will receive copies of this Quality Assurance Project Plan (QAPP) and any approved revisions of the plan (Figure 1). An approved, current quality assurance project plan will be available online to allow interested parties access to its content.

4 Project Organization

4.1 Key Individuals and Responsibilities

Key individuals involved in this project are depicted in the Program Organizational Chart (Figure 1). The Emergency Drought Barrier Technical lead (Barrier Lead, Currently Rosemary Hartman) provides oversight of all DWR tasks and people related to the project and is responsible for various project audits at their discretion in order to ensure the QAPP directives are met. The Barrier Lead is responsible for all contract management tasks including invoicing and reporting, oversight of project progress, and for collaboration with other agencies and stakeholders active in the area. The Barrier Technical Lead is the author of the QAPP and is referred to as the "Document Owner" in this QAPP. The Document Owner is responsible for the scientific integrity of the data collection effort throughout the duration of the project and for technical dialogs with advisors and experts related to the project.

The Field Lead (currently Elena Huynh) is responsible for coordinating field sampling, shipping samples to GreenWater Laboratories or USGS, and receiving data from GreenWater. The Field Lead works with the Data Lead to make sure all data are collected and integrated in a timely manner.

The Data Lead (currently Ted Flynn) is responsible for integrating data coming in from each of the labs (Lumigen, Bryte, and Greenwater) and field units (DEMP, CEMP, and NCRO) into a single database or flat file (as appropriate) and storing it in a secure location with appropriate QAQC and back-up procedures. The Data Lead is also responsible for the eventual publication of the dataset.

Field crews are made up of a collaborative team from the Discrete Environmental Monitoring Program staff (DEMP), the Continuous Environmental Monitoring Program staff (CEMP), and the North Central Region Office staff (NCRO). These units composed of various field staff and crew leads that are dedicated to discrete water quality monitoring. All Discrete EMP and NCRO staff (Field Data Collectors, Laboratory Personnel, and Data

Managers) provide the workforce for all field collection activities, laboratory analyses, and data management functions of the project.

The USGS leads are responsible for transferring new SPATT samplers to DWR and for receiving SPATT and water samples from DWR for processing at Lumigen. USGS will conduct all of the communication with Lumigen and transfer data to the Data Lead as soon as it is available.

The Quality Assurance (QA) Officer works independently from the Barrier Lead and crew leads and advises the project manager that data collected by the DWR Division of Integrated Science and Engineering (DISE) meets all quality objectives.

The Lab Manager is responsible for the processing of water samples for nutrients at the Bryte Laboratory, quality assurance of the laboratory analysis, and transfer of results to the Barrier Lead.

The Barrier Lead will update the QAPP and be responsible for making changes to it. This individual is also responsible for submitting drafts for review, submitting updates and preparing a final copy, and submitting the final copy for signatures.

4.2 Data Management

While all EMP and NCRO field crew staff are responsible for the collection of the discrete water quality data, it is the crew leads that manage the data collection. The Data Lead is responsible for ensuring all data have been stored on the Barrier Teams site and integrating the data sets. For specific data management roles, see section 19.

4.3 Advisory Roles

The DWR EMP and NCRO monitoring team will collaboratively engage and consult with multiple groups and agencies both within and outside of DWR. These groups include but are not limited to the US Geologic Survey (USGS), and the DWR Quality Assurance Program, among others. While these various groups provide input to the processes of the program, they are not responsible for any components of the program.

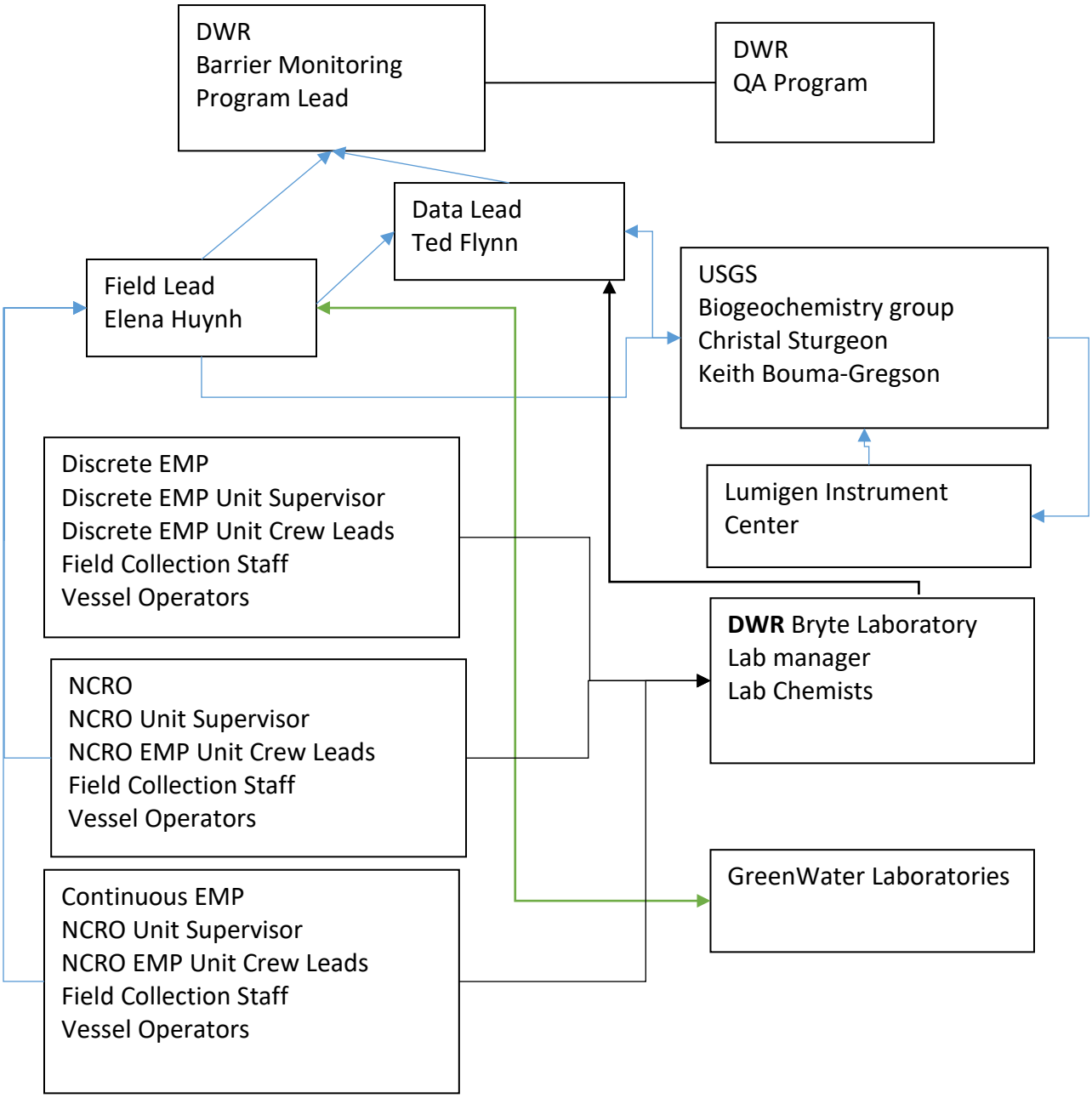


Figure 1 Project Organizational Chart

5 Project Overview

5.1 Project Mandate, Objectives, and Outcomes

5.1.1 Project Mandate

California faces a multitude of environmental impacts due to climate change, one of which is the increased frequency and intensity of droughts. The California drought of 2012-2016 prompted the action by the California Department of Water Resources (DWR) to install the West False River Emergency Drought Salinity Barrier (EDB) in 2015. The 2015 EDB was installed to reduce the intrusion of high salinity water in the central and south Sacramento-San Joaquin Delta, with the goal of preserving beneficial water uses and to meet State Water Board Water Rights Decision (D-1641) water quality objective requirements for the operation of the State Water Project (SWP) and Central Valley Project (CVP). Current drought conditions (2018-2021) brought about DWR's second requested emergency authorization for the installation of the 2021 – 2022 West False River EDB in accordance with Governor Newsom's emergency proclamations issued on April 21 and May 10, 2021. The EDB would serve California water users by reducing the negative impacts of saltwater intrusion from the San Francisco Bay into the central and south Sacramento-San Joaquin Delta. Under drought conditions, reduced freshwater flows in the winter and spring result in the absence of flows to repel high salinity waters from the San Francisco Bay. Installation of the EDB would allow California to conserve water by reducing the need for water releases from reservoirs used to push high salinity water downstream. Lastly, the barrier would also mitigate impacts on wildlife by maintaining important aquatic habitats for sensitive species.

However, the installation of the drought barrier can alter flows and increase residence times and may promote the growth of harmful cyanobacteria blooms (CyanoHABs). CyanoHABs may impose threats to water quality and wildlife in several ways. These includes and is not limited to approximately 25 million Californians being affected by possible cyanotoxin releases by cyanoHABs into the water supply, potentially requiring costly water treatment options. CyanoHABs may also lead to the mortality of wildlife and domestic animals. In addition, the die-off of CyanoHABs can create anoxic conditions that may lead to substantial fish kills. Thus, the monitoring of CyanoHABs, cyanotoxins and the associated water quality is critical to detecting and managing the potential impacts of the EDB.

In 2021, the Delta experienced a harmful CyanoHAB bloom after the installation of the EDB which triggered a request for additional cyanotoxin sampling for 2022 by the State

Water Resources Control Board and the California Department of Fish and Wildlife. DWR's Division of Integrated Science and Engineering (DISE) and the North Central Region Office (NCRO) will share cyanotoxin sampling responsibilities during routine station maintenance and water quality monitoring from April through September 2022. In addition to monitoring cyanotoxins at Franks Tract (FRK), Middle River near Holt—Mildred Island (HLT) will be sampled as a control site because it will not be affected by shifts in flow from the EDB installation. False River Near Oakley (FAL) and Holland Cut near Bethel Island (HOL) will also be sampled for cyanotoxins to conduct a more thorough survey of CyanoHABs around Franks Tract in the event of a bloom. This sampling effort will require sampling and laboratory analysis of water quality samples by Bryte Chemical Laboratory for the suite of constituents listed in Table 4.

5.1.2 Project Objectives

The objective of the project is to address the following questions:

- What are the spatial and temporal trends in the relative abundance and cyanotoxin concentrations of cyanobacterial harmful algal blooms (CyanoHABs) in the central Delta, with specific interest in the areas around Franks Tract and Mildred Island before, during, and after the West False River Emergency Drought Barrier (EDB) is installed?
- Does the installation of the EDB promote an increase in the relative abundance and/or cyanotoxin concentrations from CyanoHABs in the Central Delta?
- How does the relative abundance of cyanobacteria toxin concentrations compare annually and interannually with and without the EDB?

5.1.3 Outcomes

This project will provide information on water quality conditions associated with cyanobacteria blooms in Franks Tract in association with placement of a barrier in False Slough. The information will be used to guide water management during dry conditions. The project will produce a Barrier Effectiveness Report and a HABs/Weeds Report.

5.2 Site Background and Historical Context

5.2.1 Site Background

The San Francisco Estuary is situated in central California and is the largest estuary in California. It consists of a chain of bays to the west of the Coastal Range with a single connection to the Pacific Ocean via central San Francisco Bay through the Golden Gate. The estuary also includes a fresh-water Delta formed by the confluence of the Sacramento and San Joaquin Rivers.

The Delta drains about 37% of the state of California and covers an area of 738,000 acres with more than 700 miles of natural and man-made waterways interspersed by farmed "islands." The Delta receives average yearly inflows of 24 million-acre feet. The Delta is economically important because water in the Delta is exported by approximately 7000 diverters for agricultural, urban, and industrial uses. The largest of these diverters, the California State Water Project (SWP) and the federal Central Valley Project (CVP), draw an average of 5.9 million-acre feet per year. In addition, these water uses compete with water needs of over 400 plant, 225 bird, 52 mammal, 22 reptile and amphibian, and 54 fish species in the Delta. Before the reclamation of the Delta islands in the 19th century, the Delta consisted of vast tidal and season wetlands. Today, 8,000 of the original 345,000 acres of tidal marsh remain in the Delta with the majority of marshland located in Suisun Marsh. Over 52,000 acres of the Delta are under cultivation.

5.3 Historical Context

CyanoHAB blooms were first observed in the Delta region in 1999 (Lehman et al. 2005). In 2003 field sampling indicated these blooms were comprised of a toxic strain of the cyanobacterium *Microcystis aeruginosa*. The bloom persisted in the Delta and was greater during dry years compared with wet years (Lehman et al. 2017). The bloom has also expanded in terms of species complexity and today the bloom is comprised of a suite of toxic cyanobacteria including *Dolichospermum* and *Aphanizomenon,* as well as a suite of *Microcystis* species and strains (Lehman et al. 2021; Otten et al. 2017). In 2020, the CyanoHAB bloom was identified as hazardous based on microcystin concentrations that reached 1000 µg/L (SWRCB unpublished data).

Management to reduce salinity intrusion into Franks Tract in the dry year 2015 included placing a barrier in False River. CyanoHAB sampling in 2015 suggested the barrier did not enhance the CyanoHAB bloom in Franks Tract. However, in a similar dry year, 2021, when the barrier was installed Franks Tract had a large CyanoHAB bloom. To better understand these opposite results and the potential influence of the barrier in False River on CyanoHAB blooms in Franks Tract and nearby regions of the Delta, water quality sampling will be conducted between April and September of 2022 at 4 stations.

5.4 Regulatory Requirements

Low outflows in 2021 and 2022 also necessitated Temporary Urgency Change Petitions to Water Rights Decision D-1641 in June and July of 2021 and April-June of 2022. The 2022

TUCP seeks changes to permit and license conditions imposed pursuant to D-1641 that require the Projects to meet flow-dependent water quality objectives designed to protect fish and wildlife and agricultural beneficial uses in the Delta. These changes were requested because the Projects' storage and inflow may be insufficient to meet D-1641 requirements and additional operational flexibility is needed to support other Project priorities, including: minimum health and safety supplies (defined as minimum demands of water contractors for domestic supply, fire protection, or sanitation during the year); preservation of upstream storage for release later in the summer to control saltwater intrusion into the Delta; preservation of cold water to manage river temperatures for various runs of Chinook salmon and steelhead; maintenance of protections for State and federally endangered and threatened species and other fish and wildlife resources; and other critical water supply needs.

However, the installation of the drought barrier and the changes to outflow and exports associated with the TUCP will alter flows and increase residence times, promoting the growth of harmful algal blooms caused by cyanobacteria (cyanoHABs). CyanoHABs may impose threats to water quality and wildlife in several ways. These includes and is not limited to approximately 25 million Californians being affected by possible cyanotoxin releases by cyanoHABs into the water supply, potentially requiring costly water treatment options. CyanoHABs may also lead to the mortality of wildlife and domestic animals and the die-off of cyanoHABs can create anoxic conditions that may lead to substantial fish kills. Thus, the monitoring of cyanoHABs and cyanotoxins by DWR and USGS is critical to detecting and managing the potential impacts of the EDB.

In 2021, the Delta experienced a harmful algal bloom after the installation of the EDB which triggered a request for additional cyanotoxin sampling for 2022 by the State Water Resources Control Board and the California Department of Fish and Wildlife. As one of the conditions of approval of the 2022 TUCO, DWR is required to continue a special study on the impact of the TUCP on harmful algal blooms in the Delta. Requirements for this report include measurements of cyanotoxin concentrations in areas where this TUCP Order may modify hydrodynamics to Delta waterways. This QAPP describes the cyanotoxin monitoring being conducted in 2022 to fulfill this condition.

6 Project Description

6.1 Summary of Work

Detailed descriptions of monitoring methods, stations, and SOPs are included in Appendix A. Continuous water quality sampling (water temperature, specific conductance,

chlorophyll fluorescence, dissolved oxygen concentration, turbidity and pH) will be conducted using a YSI EX02 sonde at four stations between January and December 2022.

Maintenance of YSI EXO2 sondes will occur typically monthly (or every 3-5 weeks) following protocols from the North Central Regional Office (NCRO) Water Quality Evaluation Section Field Manual at False River near Oakley (FAL), Holland Cut near Bethel Island (HOL), and Middle River near Holt—Mildred Island (HLT) (Table 3; Figure 2). Sondes at Franks Tract (FRK) will be managed and maintained following procedures listed in EMP Continuous Environmental Monitoring Program's QAPP.

Table 3 Discrete water quality monitoring station list

Station Name	**Station Code**	**Latitude**	**Longitude**
Franks Tract	FRK	38.04642	-121.59810
Middle River near Holt--Mildred Island	HLT	38.00310	-121.51080
False River near Oakley	FAL	38.05580	-121.66690
Holland Cut near Bethel Island	HOL	38.01640	121.58190

Discrete water samples will also be collected at the four stations during monthly site visits between April and November 2022 and 2023. Samples will be analyzed by CDWR Bryte Lab for chlorophyll-a, total suspended solids, and nutrients (Table 4). Additional samples will be collected for nutrient analysis at Franks Tract, every 2 weeks. Measurements of Secchi depth will also be taken concurrently with discrete water samples.

Discrete water sampling and data collection procedures will follow those described in the Discrete EMP Field and Lab Manual, which is a collection of SOPs specific to the EMP Discrete Water Quality Monitoring Program (See EMP Discrete QAPP and associated appendices, Appendix B). In general, water samples will be collected at a depth of approximately one meter using a Van Dorn sampler, a submersible pump (van stations), or a flow through pump system on the sampling boat (vessel stations).

Table 4 Water quality variables

Variable name	Reporting Units
chlorophyll a	µg/L
pheophytin a	µg/L
dissolved chloride	mg/L
dissolved bromide	mg/L
dissolved ammonia	mg/L as Nitrogen
dissolved nitrite + nitrate	mg/L as Nitrogen
dissolved organic nitrogen	mg/L as Nitrogen
total Kjeldahl nitrogen	mg/L as Nitrogen
dissolved organic carbon	mg/L as Carbon
total organic carbon	mg/L as Carbon
dissolved orthophosphate	mg/L as Phosphorus
total phosphorus	mg/L as Phosphorus

Concurrent duplicate sampling occurs once per day and is incorporated into NCRO and/or EMP's normal quality assurance procedures. The station chosen as the duplicate is specified by a monthly rotational schedule for quality control purposes, and the HAB sampling stations will be included in the normal rotation for each survey. A full suite of samples for the duplicate station is collected, processed, and stored in the same manner as the parent samples.

Discrete water samples and SPATT (solid phase adsorption toxin tracking) will be collected for cyanotoxin analysis at FRK every 2 weeks between April and September 2022. Discrete water samples for cyanotoxin analysis will be collected at FAL, HOL, and HLT every 4 weeks. In the event of a bloom, cyanotoxin sampling will occur every 2 weeks at FAL, HOL and HLT. USGS will provide sample bottles for NCRO and DISE for cyanotoxin samples collected from FRK. Sample bottles for FRK will be pre-labeled with the field station, date, and time. A DWR subcontractor, GreenWater Laboratories, will analyze cyanotoxin samples from FAL, HOL and HLT. Sample bottles will be labeled directly on the bottles with a waterproof pen (e.g., Sharpie) with the date and time of collection, name of the water body, and station identification.

Cyanotoxin samples will be collected at the surface with with a Van Dorn sampler, bottle, or bucket (depending on the boat and equipment available). Sample bottles will be triple rinsed with water collected from the Van Dorn then dispensed into 250 mL plastic sample bottles. Sample bottles will be filled to the 250 mL line to allow for enough headspace for expansion during freezing. Cyanotoxin samples will then be placed on ice for transport.

Samples collected at FRK will be frozen in the EMP -20°C freezer until retrieved by USGS. All other stations (FAL, HOL, HLT) will be refrigerated (not frozen) for up to 2-3 days prior to shipping to GreenWater. Note: samples will not be frozen as they cause cells to lyse and will not be viable for GreenWater's PTOX screening.

Samples from FAL, HOL, HLT will be shipped to GreenWater Laboratories. A sampling schedule will be sent to GreenWater approximately two weeks prior to the start of cyanotoxin sampling (around mid-March) to allow GreenWater enough time to ship sampling kits prior to field sampling. Sampling kits will include a styrofoam cooler with freeze packs and sample bottles. Bryte and Weck labs will be notified of sampling events and COCs will be provided to them via email.
Sample bottles will be placed in a plastic bag in the cooler. Bubble wrap and extra freeze packs will be used as needed to cushion the sample bottles and prevent samples from shifting during transport.
Coolers will be dropped off and shipped via FedEx standard overnight shipping (not priority or first overnight shipping). Shipping overnight will not occur on Fridays, as GreenWater will not receive samples on the weekends. When dropping off samples, GreenWater's FedEx account number and shipping address as well as the mailing address for the West Sacramento DWR office will be provided.
GreenWater will conduct a Potentially Toxigenic Cyanobacterial (PTOX) screening of cyanotoxin samples to determine which cyanotoxins to test. Taxonomists at GreenWater will use an inverted microscope to inspect the sample for presence of cyanobacteria in the genera *Microcystis*, *Aphanizomenon*, *Cylindricospermum*, *Dolichospermum*, *Planktothrix*, and other potentially toxigenic taxa. Based on the taxa identified, GreenWater will use appropriate analytical chemistry techniques to determine whether any toxins are present (Table 5). Results from GreenWater's analyses will be emailed to DWR.

Table 5 Methods for analyzing samples for cyanotoxins used by GreenWater Laboratories.

Analyte	Lab Method
Microcystins/nodularins	Ada ELISA (Abraxis) EPA Method 546 & Ohio EPA Division of Environmental Services 701.0
Saxotoxin	Saxitoxin specific ELISA (Abraxis Procedure Number 52255B)
Anatoxin-a	Liquid Chromatography Mass Spectrometry

Cylindrospermopsin	Liquid Chromatography Mass Spectrometry

A subset of the 4 stations will be sampled to detect potential cyanoHABS on submerged aquatic vegetation (SAV, See epiphytic algae SOP included in Appendix A). Samples will be analyzed for phytoplankton identification and enumeration. SAV samples will be collected within a 2-meter radius of the water quality station. Leaves of the SAV will be scraped and those scrapings will be collected in deionized water. Samples will be transported back to the West Sacramento DWR office on ice.

Epiphytic HAB samples will be stored and shipped to GreenWater in an identical manner to cyanotoxin water samples collected at FAL, HOL and HLT.

6.2 Sampling Schedule

Discrete water quality samples and Secchi disk depth will be collected monthly between April and September at three stations. Discrete water samples will be collected every two weeks at Franks Tract. In the event of a bloom, all stations will be sampled at 2-week intervals.

6.3 Sampling Locations

Four stations will be sampled for near and far field assessment of water quality. These include Franks Tract (FRK) and Holland Cut near Bethel Island (HOL) for near field effects and Middle River near Holt (HOL) and False River near Oakley (FAL) for far field effects (Figure 2). Table 3 provides the latitude and longitude of each station.

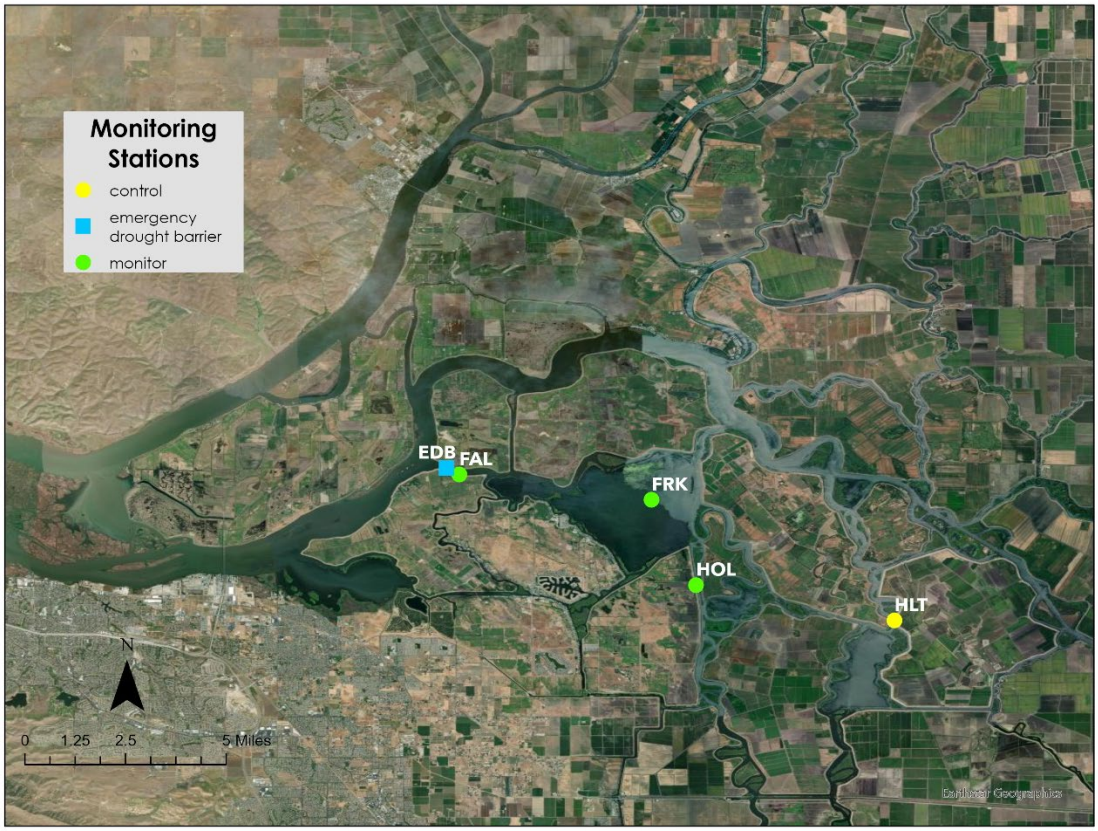


Figure 2 Map of barrier cyanotoxin monitoring sites

6.4 Constraints

While making the best effort to collect data, project constraints include: Inclement weather and hazardous environmental conditions (e.g., unhealthy air quality, worldwide pandemic) or flooding may cause station to be inaccessible or unsafe to sample

In the event one of these project constraints or unforeseen constraints occur, the Discrete EMP Unit Supervisor will be notified immediately, and the problem will be addressed and recorded in the Crew Lead Report.

7 Quality Objectives and Criteria

7.1 Data Quality Objectives

The data quality objectives of this project are to collect discrete water quality samples to provide monitoring data at key sites in and near Franks Tract to evaluate the impact of the barrier at False River on cyanobacteria blooms and water quality.

7.2 Project Action Limits

An Action Limit is a measurement threshold at which a decision is made to take management action. There is not a specific action limit threshold that will trigger management action for any of the parameters being monitored in this plan; however, DWR or other agencies may use the reported data to make management decisions.

7.3 Acceptance Criteria for Previously Collected Information

All data must meet the acceptance criteria based on data quality indicators described in the EMP discrete monitoring program quality assurance plan (Attachment B). Data that fails to meet the minimum requirements or cannot be validated due to lack of documentation is notated in data files upon making publicly available until a flagging system is developed in the existing database.

7.4 Data Quality Indicators

Data Quality Indicators are quantitative and qualitative statements that define quality for this project and include considerations of data accuracy, bias, representativeness, and completeness. All data quality indicators for water quality analysis will follow the EMP Discrete Water Quality Monitoring Quality Assurance Plan (Attachment B).

7.4.1 Accuracy

Accuracy is the degree of agreement of a measurement with a known or true value. To determine accuracy, a laboratory or field value is compared to a known or true concentration. Accuracy is determined by such QC indicators as: matrix spikes, surrogate spikes, laboratory control samples and performance samples.

7.4.2 Precision

Precision is the degree of mutual agreement between or among independent measurements of a similar property (usually reported as a standard deviation or relative percent difference [RPD]). This indicator relates to the analysis of duplicate laboratory or field samples. Field precision is assessed by co-located samples, field duplicates, or field splits and laboratory precision is assessed using laboratory duplicates, matrix spike duplicates, or laboratory control sample duplicates.

7.4.3 Bias

Bias describes the tendency for under or over prediction of samples or measured values relative to the true value. Bias is assessed using matrix spike, standard reference materials, and through negative controls (blanks). Detectable quantities in the blank may indicate positive bias, while low recoveries in matrix spikes, may indicate negative bias. Field data bias is determined by calibrating field instruments with known calibration standards and then conducting post-deployment checks on the instruments after each field run. Bias is controlled by strict adherence to all standard operating procedures that describe appropriate and careful sample collection, preservation, and transportation. Bias is possible however, and is most likely to occur with the current sampling design if samples are not properly:

collected
filtered
preserved
stored
analyzed

7.4.4 Representativeness

Representativeness describes how relevant the data are to the actual environmental conditions. Sampling and station locations were chosen to provide needed coverage for monitoring and comparison to Delta models. Stations in this plan cover many threshold points between waterways as well as monitoring localized and area water quality conditions. An important role of the Technical Leader is to actively participate in sample design development, training, and assessment of representativeness of the resulting data. Only approved/documented sample collection methods, sample transport/holding

methods, and analytical methods will be used to ensure that the measurement data represents the conditions and the sample site to the extent possible. Representativeness is controlled by strict adherence to all standard operating procedures that describe appropriate and careful sample collection, preservation, and transportation.

7.4.5 **Completeness** is expressed as percent of valid usable data obtained compared to the amount that was expected. Sometimes, due to a variety of circumstances, either not all samples scheduled to be collected can be collected or else the data from samples cannot be used (for example, samples lost, bottles broken, instrument failures, laboratory mistakes, etc.). Project data quality objectives for all measurements and samples collected are 75%.

7.5 Measurement Quality Objectives (MQO's)

MQOs for cyanotoxin chemical analyses run by GreenWater are listed in Table 6. MQO's for Lumigen are listed in Table 7. MQOs for nutrients are listed in the DEMP QAPP (Appendix B).

Table 6. Summary of general QAQC requirements for ongoing chemical analyses conducted at GreenWater Laboratories.

Laboratory/ Analytical Method	**Target Analyses**	**Precision Requirements**	**Accuracy (Bias) Requirements**	**Other Related QC Requirements/ Performance Metrics**
Adda ELISA	Total Adda Microcystins	%CV standards: ≤10% %CV LFB: ≤20 %CV samples: ≤20% %RPD LDs: ≤40%	LFB and FLSM: ±30%; Complicated Matrices LFSM: ±50% Low CV: ±50%	Calibration R^2: ≥0.98; Blank: <RL (0.15µg/L)
STX ELISA	Saxitoxin	%CV standards: ≤10% %CV LFB: ≤20 %CV samples: ≤20% %RPD LDs: ≤40%	LFB and FLSM: ±30%; Complicated Matrices LFSM: ±50%	Calibration R^2: ≥0.98; Blank: <RL (0.05µg/L)
Anatoxin-a Suite by LC-MS/MS	ATX, HTX, dhATX, and derivatives	FD. LD, or LFSMD: RPD≤30% (≤50% at 2x MDL)	CCC: ±30% (±50 ≤2x MDL) LFSM: ±50%;	Calibration R^2: ≥0.98; LRB≤1/3 MRL

			Internal Standard: ±50%	
CYN/EPI-CYN by LC-MS/MS	Cylindrospermopsin	FD. LD, or LFSMD: RPD≤30% (≤50% at 2x MDL)	CCC: ±30% (±50 ≤2x MDL) LFSM: ±50%; Internal Standard: ±50%	Calibration R^2: ≥0.98; LRB≤1/3 MRL

MRL: Method Reporting Limit, MDL: Method Detection Limit, LFB: Lab Fortified Blank, LFSM: Lab Fortified Sample Matrix, LFSMD: Lab Fortified Sample Matrix Duplicate, LD: Lab Duplicate, CCC: Continued Calibration Check

Table 7. Measurement Quality Objectives used by Lumigen

Analytical Method	**Target Analysis**	**Precision Requirements**	**Accuracy (Bias) Requirements**	**Other Related QC Requirements**
Microcystins by LC-MS/MS	Microcystins	FD: RPD ≤ 30% (≤ 50% at 2x MDL)	Standard Percent Accuracy: ± 25%, CCC ± 25%, LFSM: ± 50%, Internal Standard ± 50%	Calibration R^2: ≥0.99; Blank ≤1/3 MDL
Anabaenopeptins by LC-MS/MS	Anabaenopeptins	FD: RPD ≤ 30% (≤ 50% at 2x MDL)	Standard Percent Accuracy: ± 25%, CCC ± 25%, LFSM: ± 50%, Internal Standard ± 50%	Calibration R^2: ≥0.99; Blank ≤1/3 MDL
Anatoxins by LC-MS/MS	Anatoxins	FD: RPD ≤ 30% (≤ 50% at 2x MDL)	Standard Percent Accuracy: ± 25%, CCC ± 25%, LFSM: ± 50%, Internal Standard ± 50%	Calibration R^2: ≥0.99; Blank ≤1/3 MDL
Cylindrospermopsin by LC-MS/MS	Cylindrospermopsins	FD: RPD ≤ 30% (≤ 50% at 2x MDL)	Standard Percent Accuracy: ±	Calibration R^2: ≥0.99; Blank ≤1/3 MDL

			25%, CCC ± 25%, LFSM: ± 50%, Internal Standard ± 50%	

FD: Field Duplicate, RPD: Relative Percent Difference, MDL: Method Detection Limit, CCC: Continued Calibration Check, LFSM: Lab Fortified Sample Matrix

8 Training

8.1 Required training, certifications and special training for nutrients and water quality monitoring will follow the guidelines established in the EMP Discrete Water Quality Monitoring Quality Assurance Plan (Attachment B). Additional training for cyanotoxin sampling, which will be minimal, is addressed here.

8.2 Very little additional training is required for collection of cyanotoxin samples. The Field Lead will be responsible for making sure all staff understand the SOP for field collection of cyanotoxin samples before sampling occurs. Field Crews from NCRO and CEMP will coordinate with DEMP and USGS, who have more experience with the methods, to ensure all samples are being collected the same way.

8.3 The Field Lead is responsible for ensuring field staff have required training before sampling begins.

8.4 All training will be recorded in the unit's training log (CEMP, NCRO or DEMP).

9 Documentation and Records

9.1 Report Format

Deliverables will include a Barrier Effectiveness Report and a HABs/Weeds Report.

The HABs/Weeds report, as required by the 2022 April-June TUCO, will "summarize impacts to sub-regions of the Delta consistent with the localized nature of HABs and aquatic weeds and analyze potential for (or presence of) disproportionate impacts to vulnerable communities with respect to drinking water quality, contact and non-contact recreation, impacts to tribal cultural resources, and impacts to aesthetics including odors and the visual character of Delta waterways where HABs and aquatic weeds are prevalent or where this TUCP Order may modify hydrodynamics to Delta waterways. This work shall be

coordinated with IEP and DSP, and any broader watershed evaluation of HABs and aquatic weeds.

An interim draft Report shall be submitted to the State Water Board by December 15, 2022, summarizing the results available at that time. A summary of the interim draft report shall be presented at a public Board meeting in January 2023, or as designated by the Deputy Director of the Division of Water Rights. A completed, draft Report shall be submitted to the State Water Board by April 1, 2023, released for public comment, and presented at a public Board meeting as determined in coordination with the Deputy Director of the Division of Water Rights. In coordination with the State Water Board, Central Valley Water Board, IEP, DSP, CDFW, and USEPA, DWR and Reclamation shall review and consider comments from the State Water Board, other agencies, and the public and modify the final report as appropriate based on these comments. A complete, final report shall be submitted to the State Water Board 30 days after receipt of public and State Water Board staff comments unless the Deputy Director for the Division of Water Rights grants and extension."

Data from this project will be given to the lead of the HABs/Weeds report and visualized to show where and when toxic levels of cyanobacteria were present in the vicinity of Franks Tract. For a full study plan of how all data will be integrated, see:
https://www.waterboards.ca.gov/drought/tucp/docs/2022/20220511-habstudyplandraft-dwr.pdf

The US Bureau of Reclamation is currently leading the data integration and reporting for the HABs/Weeds report. The Barrier Lead will give all water quality, nutrients, phytoplankton, and toxin data from this project to the report leads (Kristi Arend and Erwin Van Neuwenhuyse) after they have been QA/QC'd. The Barrier lead and other staff for this project may assist in writing and analysis for the report.

The Barrier Effectiveness report will summarize the effectiveness of the barrier in achieving project goals, chiefly the ability of the barrier to maintain water quality for State Water Project Operations. The report will also assess any negative impacts on the environment that may have been due to the Barrier. Draft reports will be produced annually in February of 2022, 2023, and 2024, with a final report in summer of 2024, or one year after the end of the monitoring period, whichever is later. The cyanotoxin monitoring data in this study will be combined with other water quality, flow, and biological monitoring data as outlined in the West False River Emergency Drought Barrier Monitoring plan.

9.2 Project Documents, Records, and Electronic Files

9.2.1 Study plans, SOPs, and QAPP

There are several SOPs, QAPPs and Study plans for general project coordination on the Barrier Teams channel. Other important project documents will also be stored in this folder if they arise.

- Study Plan: HABs Monitoring Work Plan 2022-05-09.docx
- Data Management Plan: HAB DMP.docx
- Quality Assurance Project Plan (this document): Barrier HABs QAPP draftv1.docx

Other documents and field sheets associated with individual units (CEMP, DEMP, and NCRO) will be handled as descripted in their QAPPs.

9.2.2 Field Records

All field data gathered by this project will be recorded on electronic field data sheets. Electronic field data sheets are stored on the Discrete EMP unit's shared drive and are printed off and archived in binders at the DISE office. NCRO's field data sheets are pulled from the DWR Quality Assurance Document Control SharePoint and are printed and archived in binders at the NCRO office. Data from field sheets are entered into the FLIMS database, which is then transferred to the Water Data Library (WDL, http://wdl.water.ca.gov) once the lab results have been analyzed. The data that goes into FLIMS includes the vertical sonde data recorded before the zooplankton tow is conducted, collection date and time, Secchi reading, water depth measurement, standardized weather observations, and any field notes for a given station.

9.2.3 Chain of Custody (COC)

Forms are generated for samples that are submitted to Bryte Laboratory (ELAP Certificate #3026). COC forms document which and how many samples were submitted to the lab, when they were submitted, and the temperature of samples upon delivery. PDF copies of chain of custody forms are archived by the lab and sent electronically to the Discrete EMP Crew Lead. The Crew Lead archives the copies of the COC forms on their unit's shared drive. Laboratory records are maintained at the laboratory according to their record retention policy.

9.3 Data Storage

- Hard copy field data sheets are stored in the Discrete EMP unit office on a designated storage cabinet accessible by all Discrete EMP staff. Electronic field data sheets, calibration forms, and lab reports are stored indefinitely on the Discrete EMP unit's servers, which are backed up daily.

- CEMP staff also fill out instrument calibration forms before conducting field work and after returning from the field These calibration sheets are stored on the CEMP SharePoint. Continuous sonde data is downloaded from the sondes when the sondes are exchanged, and the original sonde file is stored on the CEMP data server for an indefinite amount of time. The data recorded from each CEMP station is automatically transmitted to the WQP database. Verified data is maintained by the staff and will be available to the public, upon request, for an indefinite amount of time.

- NCRO hard copy field data sheets with environmental field data will be stored in the NCRO office. Electronic field data sheets and calibration forms are stored indefinitely on the WQES shared drive. Electronic copies of cyanotoxin analysis results from GreenWater Laboratories will be stored in the Drought Barrier shared folder.

- All electronic field and laboratory data are stored indefinitely in the Water Data Library and will soon be stored in the internal KISTERS database, once developments and migrations are fully complete. Electronic records at Bryte laboratory are retained indefinitely and hard copy records are kept for at least three years.

- Sample results reported by the Lab are transmitted to the WDL database by Bryte Lab staff using FLIMS. Electronic analytical lab reports are emailed to Discrete EMP staff and are archived electronically on the Discrete EMP's shared drive.

- The cyanotoxin data from Lumigen lab and nutrient data collected by USGS will be stored in a Microsoft Access database housed on the USGS server. DWR's nutrient data will be stored in the FLIMS database on DWR's server. Cyanotoxin data from GreenWater will be accepted from the lab by Elena Huynh and stored on the DWR Emergency Drought Barrier SharePoint/Teams site (Data). USGS (Keith and/or Crystal) will export a query containing the cyanotoxin and associated nutrient data at regular intervals and transfer the data to DWR (Ted Flynn), where a copy will be stored on the Barrier SharePoint site. Ted will integrate the USGS with the GreenWater and FLIMS data to great one integrated spreadsheet with all the data and store it on the SharePoint site.

9.4 Data Backup

The following records are stored electronically: field and laboratory data, PDF copies of COC forms, lab reports, calibration forms, and **field data sheets. All these records are stored on the DWR server, which is automatically backed up daily. Additionally, the field and laboratory data stored in the WDL is backed up on an annual basis.** After each batch of laboratory data is integrated, the full dataset will be backed up by saving a copy to the DWR server (shared drive).

9.5 QAPP Distribution

The Document Owner (Table 1) is responsible for developing, maintaining, and updating the Quality Assurance Project Plan (QAPP). Electronic and hard copies of all QAPP versions are stored on the Barrier Teams Channel. The latest version of the QAPP and its revisions will be distributed to all parties involved with the project (DEMP, CEPM and NCRO field staff, USGS, and QA). Copies will also be sent to the Bryte Laboratory manager for internal distribution.

10 Data Generation and Acquisition

10.1 Project Design

Routine continuous monitoring of water quality parameters including temperature, specific conductance, chlorophyll/phycocyanin, dissolved oxygen, turbidity, and pH with YSI EXO2 sondes will be conducted at four stations. Field measurements will also be taken upon arrival at each station to document ambient conditions as cyanotoxin samples are collected.
Maintenance of YSI EXO2 sondes will occur typically monthly (or every 3-5 weeks) following protocols from the NCRO Water Quality Evaluation Section Field Manual at False River near Oakley (FAL), Holland Cut near Bethel Island (HOL), and Middle River near Holt—Mildred Island (HLT) (DWR 2020).

Additionally, discrete water samples will be collected at the sampling stations during monthly site visits for analysis by Bryte Lab for chlorophyll-a and standard nutrients (Table 4). Nutrients will be collected at FRK every 2 weeks. Measurements of turbidity with Secchi depth will also be taken alongside discrete samples. Sondes at FRK will be managed and maintained by the Continuous Environmental Monitoring Program. Water samples for cyanobacteria toxin analysis and SPATT samples will also be collected every month for all stations except FRK which will be sampled every 2 weeks.

10.2 Project Justification

The California drought of 2012-2016 prompted the action by the California Department of Water Resources (DWR) to install the West False River Emergency Drought Salinity Barrier (EDB) in 2015. The 2015 EDB was installed to reduce the intrusion of high salinity water in the central and south Sacramento-San Joaquin Delta, with the goal of preserving beneficial water uses and to meet State Water Board Water Rights Decision (D-1641) water quality objective requirements for the operation of the State Water Project (SWP) and Central Valley Project (CVP). Current drought conditions (2018-2021) brought about DWR's second requested emergency authorization for the installation of the 2021 – 2022 West False River

EDB in accordance with Governor Newsom's emergency proclamations issued on April 21 and May 10, 2021. The EDB would serve California water users by reducing the negative impacts of saltwater intrusion from the San Francisco Bay into the central and south Sacramento-San Joaquin Delta. Under drought conditions, reduced freshwater flows in the winter and spring result in the absence of flows to repel high salinity waters from the San Francisco Bay. Installation of the EDB would allow California to conserve water by reducing the need for water releases from reservoirs used to push high salinity water downstream. Lastly, the barrier would also mitigate impacts on wildlife by maintaining important aquatic habitats for sensitive species.

Low outflows in 2021 and 2022 also necessitated Temporary Urgency Change Petitions to Water Rights Decision D-1641 in June and July of 2021 and April-June of 2022. The 2022 TUCP seeks changes to permit and license conditions imposed pursuant to D-1641 that require the Projects to meet flow-dependent water quality objectives designed to protect fish and wildlife and agricultural beneficial uses in the Delta. These changes were requested because the Projects' storage and inflow may be insufficient to meet D-1641 requirements and additional operational flexibility is needed to support other Project priorities, including: minimum health and safety supplies (defined as minimum demands of water contractors for domestic supply, fire protection, or sanitation during the year); preservation of upstream storage for release later in the summer to control saltwater intrusion into the Delta; preservation of cold water to manage river temperatures for various runs of Chinook salmon and steelhead; maintenance of protections for State and federally endangered and threatened species and other fish and wildlife resources; and other critical water supply needs. Evaluation of these impacts will require additional water quality monitoring.

In 2021, a harmful algal bloom also occurred in the Delta after the installation of the EDB. This bloom triggered a request for additional cyanotoxin sampling for 2022 by the State Water Resources Control Board and the California Department of Fish and Wildlife. As one of the conditions of approval of the 2022 TUCO, DWR is required to continue a special study on the impact of the TUCP on harmful algal blooms in the Delta. Requirements for this report include measurements of cyanotoxin concentrations in areas where this TUCP Order may modify hydrodynamics to Delta waterways.

10.3 Sampling Design

DWR's Division of Integrated Science and Engineering (DISE) and the North Central Region Office (NCRO) will share water quality and cyanotoxin sampling responsibilities during routine station maintenance and water quality monitoring from April through September 2022. In addition to monitoring cyanotoxins at

Franks Tract (FRK), Middle River near Holt—Mildred Island (HLT) will be sampled as a control site because it will not be affected by shifts in flow from the EDB installation. False River Near Oakley (FAL) and Holland Cut near Bethel Island (HOL) will also be sampled for cyanotoxins to conduct a more thorough survey of HABs around Franks Tract in the event of an algal bloom.

Sampling will follow the standard operating procedures specified in the Quality Assurance Project Plan for EMP Discrete Water Quality Sampling (Attachment A), with the exception that all cyanotoxin samples will be collected via surface samples instead of at one-meter depth, per the SWAMP SOP (Attachment XXX)

Table 8 Approximate number of samples that will be taken May-November 2022

Cyanotoxin samples	Cyanotoxin duplicates	Epiphytic HAB samples	Nutrient and chlorophyll samples	Nutrient and chlorophyll duplicates	Field Blanks	Total number of samples
56	28	28	126	42	21	301

10.4 Sampling depth and site location marking

Existing stations will be marked as per their programs' QAPPss. (See Appendix B,C,D). All cyanotoxin samples will be taken from the surface of the water per the cyanotoxin sampling SOP (Appendix A).

10.5 Site Access

Station access may be an issue if there is a flood event or if severe weather prevents staff from conducting field work. If a field day is postponed for any reason, samples will be collected when the station becomes accessible again (weather passes and/or flood waters have receded) or when safety conditions improve.

10.6 Project Activity Schedules

Monthly field schedules are scheduled a month in advance and are based on the timing of high slack tide. The field schedule identifies the leave times, crew members, and stations sampled each day of the run. Water quality samples collected and preserved during field runs are submitted to Bryte Laboratory typically the day after they are collected to ensure sufficient time for the lab to analyze the samples before the holding times expire. Samples collected at FRK will be frozen in the EMP -20°C freezer until retrieved by USGS. Upon collection by USGS samples will be frozen at -80°C. All other stations (FAL, HOL, HLT) will be refrigerated (not frozen) for up to 2-3 days prior to shipping to GreenWater.

Samples collected from FAL, HOL, and HLT, will be on a monthly basis, but these may be shifted to as little as three weeks or as much as six weeks apart, if logistical constraints make monthly samples infeasible. Samples at FRK, which are collected every two weeks, may be collected as little as 10 days or as much as 21 days apart, if logistical constraints make sampling every two weeks infeasible.

- Nov 2021—Feb 2022—Planning and drafting of study plan
- April 2022 first week—Emergency Drought Barrier will be closed
- April 2022—Nov 2022—Data collection
- Nov 2022—Removal/opening of EDB
- Dec 2022—Begin data visualization and analysis

Table 9 2022 Timeline

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coordination and planning meetings	General coordination meeting												
	HAB control meetings												
Field Monitoring	Continuous SC, Temp., Turbidity, DO, Chlorophyll/phycocya-nin, pH												
	SPATT samples												
	Discrete cyanotoxin grab samples												
	Epiphytic HAB samples												
	Discrete grab samples (Chlorophyll-a, TSS, nutrients, Secchi Depth)												
Deliverables	Final report special study of barrier effect and TUCP on HABs and aquatic weeds												
	Preliminary draft results of EDB monitoring and												

	analysis												
	Status report covering monitoring period June – Dec 2021												
	Comprehensive report covering monitoring June 2021 – Dec 2022									Fall / Winter 2023			

10.7 Critical and non-critical information

Critical data is that of which successfully satisfies the program mandate and helps guide decision making. This includes cyanotoxins, nutrients, Microcystis visual index, Water temperature, specific conductivity, turbidity, chlorophyll, pH, and dissolved oxygen measurements. All other information is non-critical but may support critical information.

10.8 Sampling locations

Sampling locations and depth are described in DEEMP Quality Assurance Project Plan (Appendix B).

10.9 Reconciliation of natural variation with project information

Natural variation is a component of this project in many ways, especially as the result of tidal fluctuation and a diurnal sampling regime. Such variations can be problematic, as it can result in "noise" in the dataset, which makes it more difficult to pick up the true signals under investigation and establish relationships between stated predictor and response variables of interest. All the potential sources of natural variations that can affect water quality constituents are not be reported as part of this project but are considered when looking at long-term trends in the data.

10.10 Preventative actions

Data may be biased or erroneous if field crew members are not properly trained or the instrumentation being employed is not properly calibrated. Potential sources of bias will be reduced by having field staff strictly adhere to standard operating procedures for water quality monitoring outlined in each unit's water quality sampling manuals and the cyanotoxin-specific SOPs listed in Appendix A, which will help ensure that data is collected in a consistent manner. Calibration and post-deployment calibration check forms are maintained for all

instrumentation to verify each instrument is working within manufacturer specifications, which are listed in their respective manuals.

11 Sampling

11.1 Standard Operating Procedures

Field personnel must adhere to sample collection protocols outlined in the Sample Collection section of the Discrete EMP Field and Laboratory Manual. Cyanotoxin sample collection should follow protocols in Appendix A. Any quality issues that occur during sample collection must be documented on the Crew Lead Report and on the field data sheets, if the issue impacts the data collected at a given station. Severe issues must be reported directly to the Unit Supervisor immediately, while minor and resolvable issues (e.g. software malfunctions) can be communicated after the run is complete. If necessary, the QA Officer is informed, and corrective measures are put in place to mitigate the issue.

11.2 Field sampling

Water quality samples will be collected by either a submersible pump or a horizontal Van Dorn water sampler (depending on the boat) and follow protocols for sample collection outlined in the Sample Collection section of the Discrete EMP Field and Laboratory Manual. Surface samples will be collected with a bottle or bucket.

11.3 Sample filtering

For dissolved analytes, samples are filtered immediately following sample collection (vessel stations) or upon arriving back to the main office laboratory. Specific filters are listed in the Discrete EMP Field and Laboratory Manual (Appendix B).

No filtering is required for cyanotoxin sampling.

11.4 Sample Containers

- The containers required to sample each station during the water quality field runs are specified in Table 7 of the EMP Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B).
- Cyanotoxin samples should be stored in containers as specified in the HABs monitoring work plan (Appendix A).
    - Samples for GreenWater analysis should be held in 250 mL plastic bottles provided by GreenWater Labs
    - Samples for Lumigen water analysis should be held in 250 mL PETG clear bottles supplied by USGS.
    - SPATT samplers should be double-bagged in quart-sized ziplock freezer bags.

11.5 Sample Preservation and Holding Times

The use of containers, preservatives and holding times for nutrient samples will follow guidelines in Table 7 of the EMP Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B).
Hold times and preservation methods for cyanotoxin samples are:

Table 10. Hold times and preservation methods for cyanotoxin samples.

Sample Type	Laboratory	Preservation	Hold Time	Shipping method
Whole water cyanotoxin	GreenWater	Refrigration 4°C	7 days	UPS Overnight in cooler with ice packs
Whole water cyanotoxin	Lumigen	Frozen -80 °C	28 days	Pick up by USGS
SPATTs	Lumigen	Frozen -80 °C	28 days	Pick up by USGS

11.6 Cleaning of Sampling Equipment

Equipment cleaning will follow section 11.6 of EMP Discrete Water Quality Monitoring Quality Assurance Plan.

11.7 Equipment for water quality sampling

Equipment that is used on a regular basis includes:

- EXO2 Multi-parameter sondes
- Van Dorn water samplers
- Millipore vacuum pump
- Nutrient filtering stand with filtering cups
- Chlorophyll filtering stand with filtering cups
- Stainless-steel filtering apparatus for DOC sampling
- Churn splitters
- Sampling containers
- Glassware
- Coolers for sample transport
- DI carboys and squirt bottles

Water quality sampling will be conducted using a DWR research vessel (RV Sentinel or smaller boats, as needed). Field staff utilize state vehicles to access these land-based stations as well as to travel to and from vessel docking locations.

11.8 Individuals Responsible

If there is an issue with the sampling equipment or if the quality of the data collected does not align with expectations based on historical data, the Discrete

EMP or NCRO Crew Lead is responsible for documenting the problem in the field notes section of their field data sheets and in the Crew Lead Report. Actions must be taken by the Crew Lead to replace or repair broken equipment as soon as possible during the field run to ensure accurate and precise data collection. The Discrete EMP Unit and NCRO Supervisor, is responsible for the maintenance of state vehicles. Vessel Operators are responsible for all vessel maintenance and repairs.

12 Sampling Handling and Custody

Sample handling and custody for nutrients will follow the EMP Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B).

12.1 Cyanotoxin Sample Storage

Samples collected at FRK will be frozen in the EMP -20°C freezer until retrieved by USGS. Upon collection by USGS samples will be frozen at -80°C.
All other stations (FAL, HOL, HLT) will be refrigerated (not frozen) for up to 2-3 days prior to shipping to GreenWater. Note: samples will not be frozen as they cause cells to lyse and will not be viable for GreenWater's Potentially Toxicogenic Cyanobacteria (PTOX) screening.

12.2 Cyanotoxin Sample Shipping

Samples from FAL, HOL, HLT will be shipped to GreenWater Laboratories. A sampling schedule will be sent to GreenWater approximately two weeks prior to the start of cyanotoxin sampling (around mid-March) to allow GreenWater enough time to ship sampling kits prior to field sampling. Sampling kits will include a Styrofoam cooler with freeze packs and sample bottles. Bryte and Weck labs will be notified of sampling events and COCs will be provided to them via email.
Sample bottles will be placed in a plastic bag in the cooler. Bubble wrap and extra freeze packs will be used as needed to cushion the sample bottles and prevent samples from shifting during transport.
Coolers will be dropped off and shipped via FedEx standard overnight shipping (not priority or first overnight shipping, since they may arrive too early for GreenWater to receive). Shipping overnight will not occur on Fridays, as GreenWater will not receive samples on the weekends. When dropping off samples, GreenWater's FedEx account number and shipping address as well as the mailing address for the West Sacramento DWR office will be provided.

Samples from FRK will be shipped approximately monthly to Lumigen Instrument Center. Sample bottles will be packed to avoid breakage and shipped with dry ice to keep samples frozen. Samples will be shipped priority overnight.

13 Analytical Methods and Field Measurements

13.1 Standard Operating Procedures – Field Instruments

Field measurements are collected through the use of various sensors that measure different parameters, which are installed on an EXO2 multi-parameter sonde. Standard operating procedures for deploying these field instruments for the use of data collection can be found in the Field Data Collection section of the Continuous EMP Field and Laboratory Manual (CEMP QAPP and associated appendices, APPENDIX C). Instrument specifications and maintenance information can be found in the EXO User Manual (CEMP QAPP and associated appendices, APPENDIX C).

13.2 Field Instrumentation

Continuous sonde *in-situ* water quality and meteorological measurements are logged once every quarter hour by a Campbell data logger. Table 6 lists equipment and sampling method for each CEMP station. The data are transmitted via cellular modem the CEMP telemetry server, where the data are ingested and archived. Data are uploaded to the CEMP WQP database and to CDEC.

Support equipment is installed in a weather-tight aluminum “Traffic Box” containing a data logger, wireless cellular modem, deep cycle battery, and a solar charge controller. Solar panels are installed for battery charging purposes. Station sondes are deployed in a PVC deployment tube that is attached to support structures. PVC deployment tubes have evenly spaced holes for the entire length of the tube at and below the high tide of record to allow water to flow across the sensors. CEMP surface sonde deployments are set up in two types of configuration: floating or fixed. Floating deployments keep the sonde at a constant depth, approximately 1 meter below the surface. Fixed deployments keep the sonde at a constant location in the deployment tube and the depth of the sonde varies with stage.

13.3 - Instrument Deployment and Operation

Prior to deploying any instrumentation, field staff is responsible for ensuring that specified calibration procedures have been performed for each of the selected parameters being measured, and that all sondes have sufficient battery power for deployment. Instruments and their use for field sampling is listed in Table 8 in the EMP Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B) and Table 6 of the EMP Continuous Water Quality Monitoring QAPP (Appendix C).

13.4 - 13.12 Laboratory operating procedures

Standard operating procedures for Bryte's laboratory analyses are listed in the DWR Bryte Laboratory Quality Manual (Appendix E).

Standard operating procedures for GreenWater and Lumigen are available upon request from the laboratories.

14 Quality Control

Quality control for nutrient sampling will follow guidelines established in DWR Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B).

Quality control for continuous (sonde) data will follow guidelines established in the CEMP QAPP (Appendix C)

Quality control for cyanotoxin sampling will be similar to that for nutrient sampling, accomplished by collecting replicates and blanks at several points in the sampling process.

14.1 Quality Control Activities

Field QC frequencies are calculated to ensure that a minimum of 10% all analyses are for QC purposes. All analytical QCs must be analyzed at a frequency of 10% or a minimum of 1 per batch. Acceptance criteria for cyanotoxin samples are listed in Table 6.

If the failure can be corrected, the analyst must document it and its associated corrective actions in the laboratory record and complete the analysis. If the failure is not resolved, it is conveyed to the respective supervisor who should determine if the analytical failure compromised the associated results. The nature and disposition of the problem must be documented in the data report that is sent to the Project Manager.

14.1.1 QC Sample Types

Equipment Blanks – Equipment blanks provide bias information for field handling, transport, and storage operations. They will be collected to evaluate whether contaminants have been introduced into the samples during sample collection due to exposure from ambient conditions or from the sampling containers or filtering equipment used to process the samples. These blanks are obtained by pouring de-ionized water into a churn splitter and processing, transporting, and storing all samples from that churn splitter in the same manner as the regular surface water samples. Blank sampling occurs at the end of each field day and consists of the same laboratory analytes as the regular surface

water samples. The lab results must be less than the RL of the target analytes to be acceptable.

Field Replicates – Field replicate samples provide precision information on all steps after sample collection. These samples are collected as concurrent duplicates in which one station per day is previously chosen at random to collect an additional churn splitter immediately after the normal sample is collected. Discrete EMP staff process, transport, and store the samples obtained from the duplicate churn splitter in the same manner as the "parent" samples from the original churn splitter. The replicate values must have an RPD of less than 25% to be acceptable.

Laboratory Duplicates – Laboratory duplicates provide precision information on the analytical methods with the target analytes. The laboratory will generate the duplicate samples by splitting one sample into two parts, each of which will be analyzed separately. Acceptance criteria can be found in the Bryte Laboratory Quality Manual (Appendix E) and the GreenWater QAPP (Appendix F).

Laboratory Control Samples – Laboratory control samples (LCS) provide bias information about a laboratory's ability to perform acceptable analyses on a clean matric with the chosen methods. The LCS will be prepared by the laboratory using an aliquot of the clean matrix (e.g., water, sediment, or tissue with no detectable levels of the target analytes) that is spiked with the analytes at known concentrations. Acceptance criteria can be found in the Bryte Laboratory Quality Manual (Appendix E) and the GreenWater QAPP (Appendix F).

Matrix Spikes – Matrix Spikes (MS) provide bias information on sample preparation and analysis. MS will be used to verify that the lab can determine if the sample matrix is causing either a positive or negative bias on sample results. MS samples will be prepared by the laboratory using an aliquot of the sample matrix (e.g., water sediment, or tissue) that is spiked with the analytes at known concentrations. Acceptance criteria can be found in the Bryte Laboratory Quality Manual (Appendix E) and the GreenWater QAPP (Appendix F).

Matrix Spike Duplicates – Matrix spike duplicates (MSD) provide precision information on sample preparation and analysis. The laboratory will prepare separate spiked matrix samples (MS) for analysis. Acceptable lab results for bias are the same as described for matrix spikes. Acceptance criteria can be found in the Bryte Laboratory Quality Manual (Appendix E) and the GreenWater QAPP (Appendix F).

15 Instrument and Equipment Testing and Inspection

Instrument and Equipment Testing and Inspection, Maintenance and instrument and Equipment Calibration and Frequency, will follow the guidelines in each Unit's QAPP (CEMP, DEMP, and NCRO) (Appendix B, C, D).

Laboratory equipment at Bryte Lab will be tested and maintained per the Bryte Laboratory QAPP (Appendix E).

Laboratory equipment at Lumigen and Greenwater will be maintained according to each lab's standard operating procedures.

16 Instrument Calibration and Frequency

16.1 Field Instruments

Field instruments will be calibrated by each unit (NCRO, CEMP, and DEMP) per their program's SOPs and QAPPs. This will include documenting and checking that the specified calibration procedures were performed for each of the selected parameters being measured.

16.2 Laboratory Analytical Equipment

Laboratory analytical equipment at Bryte is calibrated according to the procedures and frequencies documented in the Bryte Chemical Laboratory Quality Manual (Appendix E).
Laboratory equipment at Lumigen and GreenWater is calibrated according to each lab's standard operating procedures.

16.3 How Deficiencies Are Resolved and Documented

Instruments and probes that fall outside the specified quality control criteria provided by the manufacturer guidance are either replaced or sent back for repair, when possible. An Access database is used to track when probes are replaced.

17 Inspection and Acceptance Requirements for Supplies and Consumables

Consumables for basic water quality and nutrient sampling will be inspected by each unit (NCRO, CEMP, and DEMP) per their program's SOPs and QAPPs. Procedure for cyanotoxin sampling is described below.

17.1 Procedure

All sample bottles and vials are examined for damage and contamination when they are obtained and are checked again before sample collection. Containers are inspected for breakage and proper sealing of caps. Standards and other

consumables are inspected by the Discrete EMP Staff for conformance with any labeled expiration dates. Reusable supplies are examined for acceptable cleaning and reuse. Any supplies deemed to be in unacceptable condition are replaced.

Table 11 Supplies and Consumable requirements

Item	Vendor	Acceptance Criteria	Documentation	Storage
250 mL PETG Bottles	USGS	Container not damaged	Lab supply spreadsheet	Room Temperature
250 mL plastic bottles	GreenWater	Package not damaged;	Lab supply spreadsheet	Room Temperature
SPATT samplers	USGS	No holes in mesh bag, bag securely fastened to embroidery hoop	Supply spreadsheet tracks SPATTs	Room Temperature
Zip ties	Hardware store	Package not damaged	Supply spreadsheet	Room Temperature
Zip lock bags	Hardware store	No holes in bags, zipper seals effectively	Supply spreadsheet	Room Temperature

17.2 Individuals Responsible

The Barrier Field Lead is responsible for inspection and acceptance of supplies and consumables which are listed in Table 12.

18 Non-Direct measurements

18.1 Data Sources

Data from this project will be combined with a number of other data sources for analysis. These include other cyanotoxin data, community composition data, visual assessments, Satellite data, fluoroprobe data, and water quality data.

Table 12. Other data sources used in this project

Data Source	Use	Acceptance criteria

Fluoroprobe data from EMP and USGS	Increase spatial and/or temporal data on cyanoHABs distribution	Data have been deemed acceptable by DWR or USGS QAQC procedures.
Continuous Salinity, Temperature, Turbidity, and chlorophyll	Compare cyanotoxins to potential environmental drivers	Data have been deemed acceptable by DWR or USGS QAQC procedures.
Discrete water quality and nutrients from other sources (*discretewq* package)	Increase replication of nutrient data	Data have been deemed acceptable by DWR or USGS QAQC procedures.
Other cyanotoxin data from SWRCB	Increase spatial distribution of cyanotoxins and figure out what is going on in other regions	Data that meet Water Board cyanotoxin standards
Satellite data from SFEI	Increase spatial and/or temporal data on cyanoHABs distribution	At least 50% of pixels for region is considered valid.
Visual index data from various sources (*discretewq* package)	Increase spatial data on HABs presence/absence	Data are generated from IEP surveys and QC'd by staff collecting the data.

19 Data Management

19.1 Data Management Scheme

This study will include nutrient data, cyanotoxin data, and water quality data. Cyanotoxin data will come from several sources:

1. Whole-water samples collected by USGS and analyzed by Lumigen Instrument Center.
2. Whole-water samples collected by DWR and transferred to USGS for analysis by Lumigen.
3. Whole-water samples collected by DWR and analyzed by GreenWater lab.
4. SPATT samples collected by DWR or USGS and transferred to USGS for analysis by Lumigen.

Nutrient samples will be collected at the same time and by the same group collecting the cyanotoxin samples. USGS nutrients samples will be analyzed at the USGS lab, and DWR nutrients samples will be analyzed at Bryte laboratory.

The cyanotoxin data from Lumigen lab and nutrient data collected by USGS will be stored in a Microsoft Access database housed on the USGS server. DWR's nutrient data will be stored in the FLIMS database on DWR's server. Cyanotoxin data from GreenWater will be accepted from the lab by Elena Huynh and stored on the DWR Emergency Drought Barrier SharePoint/Teams site (Data). USGS (Keith and/or Crystal) will export a query containing the cyanotoxin and associated nutrient data at regular intervals and transfer the data to DWR (Ted Flynn), where a copy will be stored on the Barrier SharePoint site. Ted will integrate the USGS with the GreenWater and FLIMS data to great one integrated spreadsheet with all the data and store it on the SharePoint site. After each batch of laboratory data is integrated, the full dataset will be backed up by saving a copy to the DWR server (shared drive)

At the end of the study (winter of 2023), all the data will be published and archived on EDI or Science Base. If the study extends past the original end date, data will be published in annual increments.
Handling of the discrete and continuous monitoring data will follow the DWR Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B)

19.2 Continuous Monitoring Files

Continuous monitoring data from station FRK will be downloaded, stored and QC'd as per the Continuous EMP Quality Assurance Plan (Appendix C)
Continuous monitoring data from stations FAL, HLT, and HOL will be downloaded, stored and QC'd as per the NCRO Quality Assurance Plan (Appendix D)

19.3 Files and document control system

This QAPP and all standard operating procedures for this project will follow the Document control system developed by the Departments Quality Assurance Program.

Below the SOP ID is the revision number and date. This informs staff of when each SOP was last updated, which helps ensure that most current methods are being followed. There is also a revision date on the TUCP/Barrier Study Plan to ensure staff are aware of when the document was last updated. Additionally, current SOPs and their supporting appendices are kept in a specific folder, whereas older versions are stored in an archive folder to prevent staff from using

them. The Barrier Monitoring Lead is responsible for final review and acceptance of revised SOP sections.

Chain of custody forms and analytical reports from Bryte Lab, GreenWater, and Lumigen are documented according to month-year and each report/form has a unique submittal identification number. The field sheets for each monthly run are saved as Adobe Acrobat pdf files that are archived based on month and year on the shared drive.

19.4 Data handling equipment

Data handling and management equipment follows the California Department of Technology Services' Responsible Use of Information Technology Policy and referenced documents therein.

19.5 Individuals Responsible

Data management tasks include:

- Recording data in the field – Discrete EMP and NCRO Crew Leads
- Tracking monthly lab data in FLIMS and WDL – Discrete EMP and NCRO Crew Leads
- Accepting data from GreenWater – Elena Hunh, or NCRO lead
- Accepting data from USGS – Ted Flynn
- Management of data files – Ted Flynn or Discrete EMP and NCRO Crew Leads
- Data entry – Discrete EMP and NCRO Crew Leads and Field Collection Staff
- Data QA Checks in WDL – Discrete EMP and NCRO Crew Leads
- Upkeep of document control system – Discrete EMP and NCRO Crew Leads

19.6 Acceptability of Hardware and Software Configurations

All hardware and software configurations must comply with procedures found in the California Department of Technology Services' Responsible Use of Information Technology Policy and referenced documents therein. This policy is designed to ensure that computer hardware and software meet program requirements and are consistent with State standards.

19.7 Checklists, Forms, or Standard Operating Procedures

Checklists, Forms, or Standard Operating Procedures All forms and procedures for data storage and QC will follow the DWR Discrete Water Quality Monitoring Quality Assurance Plan (Appendix B).

20 Assessments and Response Actions

20.1 Type of Assessment Activities

Regular (e.g., monthly) informal assessments are performed as part of the project to ensure that the sampling and quality assurance/quality control methods were followed in accordance with the approved QAPP. All staff should immediately report data or sampling anomalies to their Crew Leads and the Barrier Lead for further investigation.

1. Equipment - It is important that all field equipment be clean and ready to use for each field run. Therefore, prior to using all sampling and/or field measurement equipment, each piece of equipment is checked to make sure that it is in proper working order.
2. Instrument maintenance records - Instrument maintenance records are checked to ensure that all field instruments have been properly maintained and that they are ready for use.
3. Supply checks - Adequate supplies of all preservatives, bottles, labels, gloves, etc. are checked before each field event to make sure that there are supplies to successfully support each sampling event.
4. Documentation - Prior to starting each field event, computers are checked to ensure they have the most updated version of electronic forms that will be filled out during the run.
5. Sample Collection Activities – The Crew Lead is responsible for the oversight of sampling activities and reviews field sheets to verify that the samples were collected in accordance with QAPP requirements.
6. Data Quality Assessment – Bryte Lab is responsible for providing EPA standard Level 2 QA/QC data along with sample analyte concentration data to the Data Lead for performance verification.

21 Reports to Management

21.1 Project Quality Assurance Reports

At the end of the sampling period (October or November), a written report detailing the QA/QC status and QA/QC deficiencies is developed by the Data Lead. To generate the report, the year's data will be summarized for parameters of interest. The Data Lead then uses the QA/QC checklist to identify duplicate and blank data that doesn't meet the data quality objectives and documents any instrument post-deployment checks that did not pass the acceptance criteria. The QA Report also specifies any missing data, outliers, and discusses the data validity and completeness. This report is sent to the Barrier Lead so that any outstanding errors or data quality impacts can be addressed promptly.

21.2 Individuals Responsible

- Data Lead– responsible for drafting and finalizing report
- Barrier Lead – responsible for approving the report and offering guidance

22 - 24 Data Review, Verification, and Validation

Procedures will follow guidelines in the DWR Discrete EMP Water Quality Assurance Plan (Appendix B).

25 References

Lehman, P.W., Boyer, G.L., Hall, C., Waller, S., and Gehrts, K. (2005). Distribution and toxicity of a new colonial Microcystis aeruginosa bloom in the San Francisco Bay Estuary, California. *Hydrobiologia* 541**,** 87-99.

Lehman, P.W., Kurobe, T., Huynh, K., Lesmeister, S., and Teh, S.J. (2021). Covariance of phytoplankton, bacteria and zooplankton communities within Microcystis blooms in San Francisco Estuary. *Frontiers in Aquatic Microbiology* 12**,** 632264. https://doi: 10.3389/fmicb.2021.632264.

Lehman, P.W., Kurobe, T., Lesmeister, S., Baxa, D., Tung, A., and Teh, S.J. (2017). Impacts of the 2014 severe drought on the Microcystis bloom in San Francisco Estuary. *Harmful Algae* 63**,** 94-108.

Otten, T.G., Paerl, H.W., Dreher, T.W., Kimmerer, W.J., and Parker, A.E. (2017). The molecular ecology of Microcystis sp. blooms in the San Francisco Estuary. *Environmental microbiology* 19(9)**,** 3619-3637

26 Appendices

- Appendix A. TUCP and Emergency Drought Barrier Cyanotoxin Monitoring 2022 Work Plan
  - https://cawater.sharepoint.com/:w:/t/DWR-EXT-PROJ-2021-Emer-Drought-Barrier-Report/Ec6tatVkyJVCiaHR0-P3Pw4BxyXpSp5vxFunm660qWGtbQ?e=kjtWbh

- Appendix B Quality Assurance Project Plan for Discrete Water Quality Sampling for the Discrete Environmental Monitoring Program
  - DES-2-QAP-001_v1.0_Quality Assurance Project Plan for Discrete Water Quality Sampling.pdf

- Appendix C Quality Assurance Project Plan for the Continuous Environmental Monitoring Program
  - DES-3-QAP-001v1.0_Quality Assurance Project Plan for Continuous Environmental Monitoring.pdf

- Appendix D. DRA-2-QAP-005 NCRO QAPP

- Appendix E DWR Bryte Laboratory Quality Manual
  - Bryte Quality Manual

- Appendix F GreenWater Laboratories General Quality Assurance/Quality Control Protocols
- Appendix F GreenWater Laboratories General Quality Assurance/Quality Control Protocols
  - GreenWater Labs QAQC Protocols

Appendix C

DWR Division of Regional Assistance North Central Region Office. 2022. Quality assurance project plan Central Delta and emergency drought barrier water quality monitoring program. Document number: DRA-2-QAP-005, Revision 2. 66 pp.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

QUALITY ASSURANCE PROJECT PLAN
CENTRAL DELTA AND EMERGENCY DROUGHT BARRIER WATER QUALITY MONITORING PROGRAM

Document Number: DRA-2-QAP-005
Revision: 2
Status: Effective
Effective Date: 03/17/2022

Prepared by: Tyler Salman and Patrick Scott

Division of Regional Assistance
North Central Region Office
Resources Assessment Branch
Water Quality Evaluation Section
3500 Industrial Blvd.
West Sacramento, CA 95691

DWR Mission: To sustainably manage the water resources of California, in cooperation with other agencies, to benefit the state's people and protect, restore, and enhance the natural and human environments.

Group A: Project Management

1.0 Title and Approval Sheet

1.1 Approvals:

Quality Assurance Project Plan for the Central Delta and Emergency Drought Barrier Water Quality Monitoring Program

APPROVAL SIGNATURES

Table 1 – Approval Signatures

Name	Organization	Title	Signature	Date
Paul Larson	DWR	Project Director		
Jared Frantzich	DWR	Project Manager		
Tyler Salman	DWR	Technical Leader		
Patrick Scott	DWR	Technical Leader		
John Franco Saraceno	DWR	QA Officer		
Sid Fong	DWR	Lab Director		

Acronyms and Abbreviations

Table 2 – Definition of acronyms used throughout this document

Acronym	Definition
BET	Bethel Island at Piper Slough
BLP	San Joaquin River at Blind Point
°C	Celsius Degrees
COC	Chain of Custody
CVP	Central Valley Project
DISE	Division of Integrated Science and Engineering
DQO	Data Quality Objective(s)
DRA	Division of Regional Assistance
DWR	Department of Water Resources
EDB	Emergency Drought Barrier
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency
FAL	False River near Oakley
FCT	Fisherman's Cut
fDOM	Fluorescent Dissolved Organic Matter
FLIMS	Field and Laboratory Information Management System
FNU	Formazin Nephelometric Units
HDPE	High Density Polyethylene
HLT	Middle River near Holt
HOL	Holland Cut near Bethel Island
LCS	Laboratory Control Standard
m	meters
MDL	Method Detection Limit
µg/L	micrograms per Liter
µm	micrometer or micron
µS/cm	microSiemens per centimeter
mg/L	milligrams per Liter
mL	millilieters
MIR	Miner Slough near Sacramento River
MOK	Mokelumne River near Highway 12
MQO	Measurement Quality Objective(s)
NCRO	North Central Region Office
NIST	National Institute of Standards and Technology
OBI	Old River at Bacon Island at USGS Pile
ORQ	Old River at Quimby Island
OSJ	Old River at Frank's Tract near Terminous
QA	Quality Assurance
QAPP	Quality Assurance Project Plan

QC	Quality Control
QSU	Quinine Sulfate Units
RFU	Relative Fluorescence Units
RL	Reporting Limit
RPD	Relative Percent Difference
SM	Standard Methods for the Examination of Water and Wastewater
SOI	Sacramento River downstream of Isleton
SOP	Standard Operating Procedure
SWP	State Water Project
SWRCB	State Water Resources Control Board
SXS	Steamboat Slough near Sacramento River
TRN	Turner Cut near Holt
TSL	Three Mile Slough
USGS	United States Geological Survey
VCU	Victoria Canal near Byron
WDL	Water Data Library
WOMT	Water Operations Management Team
WQES	Water Quality Evaluation Section
YSI	Yellow Springs Inc.

2.0 Contents

2.1 Tables

2.2 Figures

3.0 Distribution List and Contact Information

All project staff (Table 3) at the Department of Water Resources (DWR) North Central Region Office (NCRO) will receive copies of this Quality Assurance Project Plan (QAPP) and any approved revisions of the plan (Figure 1). An approved, current QAPP will also be available online to allow interested parties access to its content. To receive a copy, a request can be made to the DWR NCRO Technical Leader.

4.0 Program Organization

4.1 Involved Parties and Roles

- The **Project Director** will provide supervision of all tasks and people related to the project. The director is responsible for various project audits at their discretion to ensure the Monitoring Plan and QAPP directives are met.
- The **Project Manager** is responsible for all contract management tasks including invoicing and reporting, oversight of project progress, and for collaboration with other agencies and stakeholders active in the watershed.
- The **Technical Leader** of this project reviewed and edited the existing Central Delta and Emergency Drought Barrier Water Quality Monitoring Program QAPP and Monitoring Plan with the assistance of the QA Officer and is responsible for the scientific integrity of the data collection effort throughout the duration of the project. The Technical Leader is responsible for maintaining the official, approved QAPP. The Technical Leader is also responsible for technical dialogs with advisors and experts related to the project.
- The **Quality Assurance Officer** works independently from the sample collectors and data generators.
- The **Lab Director** is responsible for ensuring that all samples analyzed at Bryte Laboratory follow all required procedures as defined in Standard Methods for the Examination of Water and Wastewater (SM 2012) and the Bryte Laboratory QA/QC manual.
- The **Field Crew** are responsible for physical collection of samples and in-situ station maintenance following the appropriate standard operating procedures. **Field Crew** will be trained and overseen by the **Technical Leader**.

Table 3 - Personnel Responsibilities and Distribution List

Name	Organizational Affiliation	Title	Contact Information (phone/email)
Paul Larson	DWR	Project Director	(916) 376-9663 Paul.Larson@water.ca.gov

Jared Frantzich	DWR	Project Manager	(916) 376-9683 Jared.Frantzich@water.ca.gov
Tyler Salman	DWR	Technical Leader	(916) 376-9645 Tyler.Salman@water.ca.gov
Patrick Scott	DWR	Technical Leader	(916) 376-9648 Patrick.Scott@water.ca.gov
John Franco Saraceno	DWR	QA Officer	(916) 376-9714 JohnFranco.Saraceno@water.ca.gov
Sid Fong	DWR	Lab Director	(916) 375-6008 Sid.Fong@water.ca.gov

4.2 Quality Assurance Officer Role

The **QA Officer** is responsible for verification of laboratory suitability, accreditation, and necessary compliance. This position does not report to the Project Director and is independent from those generating all project information.

4.3 Persons Responsible for QAPP Update and Maintenance

The **Technical Leader** is responsible for maintaining and updating the official approved QAPP and is the authorized person to make changes to the QAPP.

4.4 Persons Responsible for Data Management

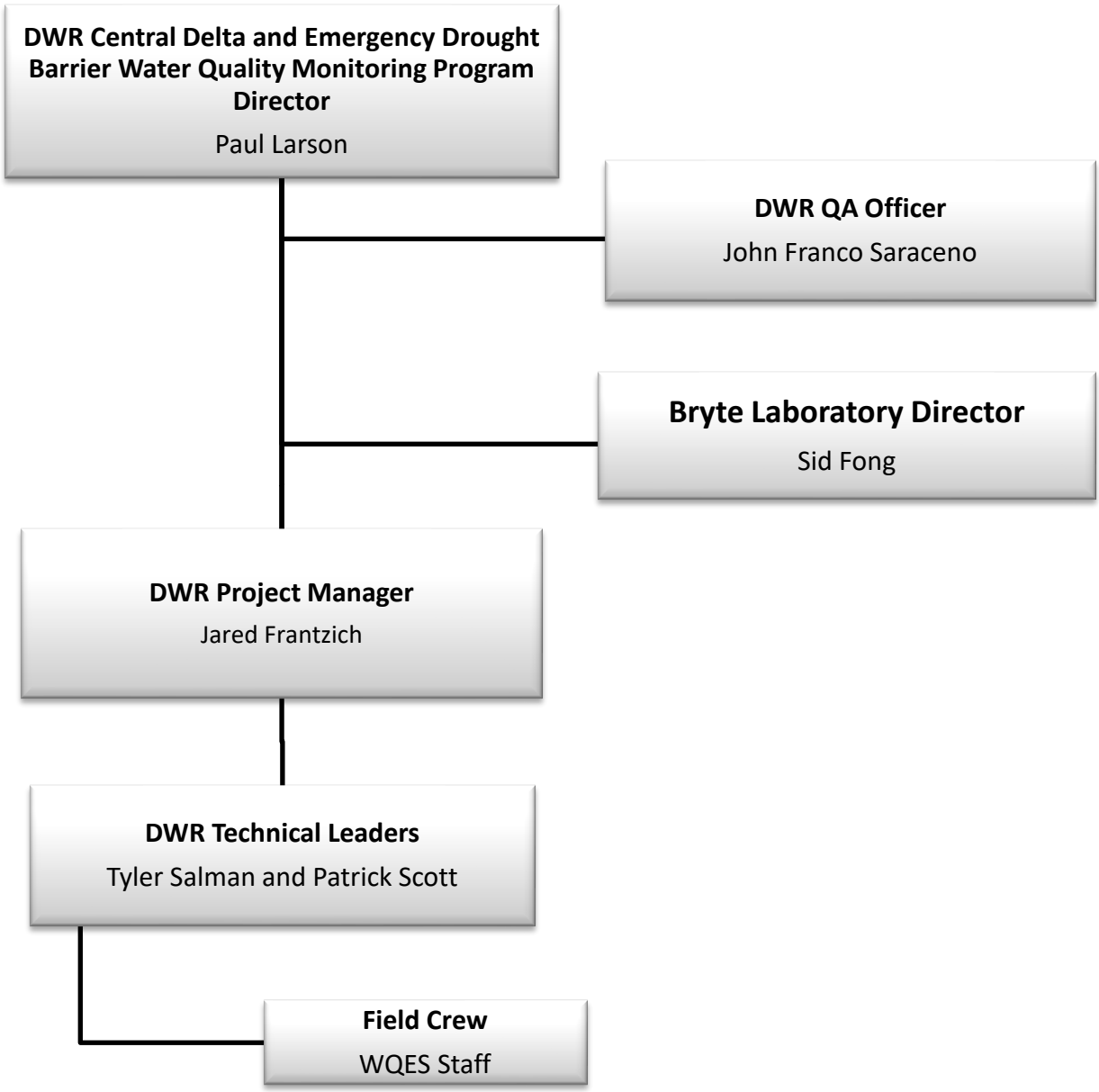
While all staff are responsible for the collection of the discrete water quality data, it is the **Technical Leader** that manage the data monthly. For specific data management roles, see Section 19.0.

4.5 Advisory Roles

This project collaboratively engages and consults with multiple groups and agencies both within and outside of DWR. These groups include, but are not limited to, the United States Geological Survey, the DWR Quality Assurance Program, the DWR Division of Operations and Maintenance, and the DWR NCRO Flow and Surface Water sections, among others. While these various groups provide input to the processes, they are not responsible for any components of the discrete water quality monitoring element of the program.

4.6 Organizational Chart

Figure 1 - Organizational Chart



5.0 Problem Definition/Background

In 2001, USGS (United States Geological Survey) and DWR (Department of Water Resources) received approval from CALFED (the Collaboration Among State and Federal Agencies to Improve California's Water Supply) to install sixteen flow and ten (co-located) water quality stations in the north and central Delta, as part of the Delta Flows Network, to better understand how State and Central Valley (federal) Water Project (SWP and CVP) operations may alter flow and water quality patterns in the Delta. False River near Oakley (FAL), Holland Cut near Bethel Island (HOL), Old River at Quimby Island (ORQ), and Old River at Frank's Tract near Terminous (OSJ) were established in October 2005 to support SWP and CVP operations in interior and western Delta conductivity compliance monitoring as related to California State Water Resources Control Board (SWRCB) Water Rights Decision D-1641 (Table 4). From 2006 to 2009 additional temperature, specific conductance, and turbidity equipped stations were added in the region at Victoria Canal near Byron (VCU), Turner Cut near Holt (TRN), Middle River near Holt (HLT), Old River at Bacon Island at USGS Pile (OBI), Mokelumne River near Highway 12 (MOK), and Three Mile Slough near San Joaquin River (TSL) (Table 4). Turbidity sensors were also added to the four existing stations in response to the 2007 ruling from Judge Oliver Wanger on delta Smelt and Delta water export restrictions that established seasonal turbidity compliance points at HOL and VCU and to better understand sediment transport in the region. The San Joaquin River at Blind Point (BLP) water quality station was a salinity compliance station for SWP and CVP operations under prior Water Rights Decisions (D-1275 and D-1379) (Table 4). BLP was included in the Central Delta monitoring network to maintain a continuous record at the legacy monitoring site. Data from BLP is used in long-term analysis of Delta outflow and water quality.

In 2014, the Governor declared a State of Emergency due to prolonged drought conditions culminating in critically low water storage in reservoirs and snowpack. This emergency declaration, and the CVP and SWP Drought Contingency Plan developed in response, recommended the installation of emergency drought barriers to help limit salinity intrusion into the interior Delta and preserve freshwater flow corridors from the Sacramento and San Joaquin rivers to the Banks (SWP) and Tracy (CVP) Pumping Plant intakes. Ultimately State and federal officials pursued installation of a temporary rock barrier on False River (also referred to as the Emergency Drought Barrier or EDB) and the SWRCB issued a 401 Water Quality Certification requiring the monitoring of any potential changes in flow and water quality associated with the barrier. In the ensuing monitoring plan, DWR identified 21 monitoring stations to support 401 permit requirements and feed into water quality models to improve in-Delta operational efficiency in response to future drought conditions. 10 of the proposed 21 stations were already established and maintained by DWR and USGS and included TSL, OSJ, FAL, HOL, and BLP. In anticipation of the proposed barrier, WQES staff were directed to add dissolved oxygen sensors at HOL, FAL, TSL, and OSJ; establish the new station Fisherman's Cut (FCT); and retrofit and operate the existing station Bethel Island at Piper Slough (BET) to characterize pre-barrier baseline water quality conditions in 2014 (Table 4). In the north Delta, new stations Miner Slough near Sacramento River (MIR), Steamboat Slough near Sacramento River (SXS), and Sacramento River downstream of Isleton (SOI) were installed in 2015 to establish baseline ambient water quality conditions, monitor any potential saltwater intrusion up the Sacramento River and into the Cache Slough Complex, and monitor future north Delta barrier effects when and if Drought conditions persist to necessitate their installation (Table 4). After completion of

the required water quality monitoring for the 2015 EDB, chlorophyll, pH, and fDOM sensors were installed at MIR. The additional monitoring was funded by The Prospect Island Tidal Habitat Restoration project to create a baseline dataset for evaluation of the effects of future wetland habitat restoration on Prospect Island.

At each station, in addition to the continuous monitoring sensors described above, individual grab samples are collected for laboratory analysis. In non-drought years these include chloride bromide, TSS, and chlorophyll a/pheophytin a at most stations. In Drought years requiring installation of the EDB, the suite of collected grab samples is expanded to include standard nutrients and organic carbon at EDB monitoring affiliated central and north Delta stations (TSL, OSJ, FAL, HOL, BLP, BET, FCT, MIR, SXS, and SOI), the details of which can be found in Table 9.

5.1 Problem Statement

1. This monitoring effort will support investigations into water quality conditions contributing to non-compliance with the provisions of the SWRCB Water Right Decision (D-1641) by providing early warning and corroboration for stations out of compliance and by providing real time water quality data that increases the efficiency and flexibility of through-Delta pumping operations by State and federal agencies.

2. The effort will provide critical water quality data needed to determine if daily average turbidity at Old River at Bacon Island (OBI) exceeds 12 NTU per the Turbidity Bridge Avoidance measure described in 5.2.

3. The monitoring program will provide water quality monitoring for compliance with Water Quality Certification 401 permits issued to install, operate, and remove emergency drought barriers in West False River and in the vicinity of the confluences of Steamboat Slough, Miner Slough, Cache Slough, and the Sacramento River.

4. The monitoring plan will investigate sources of water quality degradation and evaluate efficacy of local water quality improvement actions.

5.2 Water Quality or Regulatory Criteria

The primary purposes of these studies are to assess beneficial use protection and water quality trends. Where potential concerns are detected in the assessment, the information will be provided to the appropriate SWRCB program and State Water Projects Analysis Office and Operations and Maintenance for follow-up. Additionally, all data collected in this study will be assessed in accordance with the goals and objectives of SWRCB Water Right Decisions (D-1641) and the SWRCB Water Quality Control Plan 2018 (Appendices F and H).

Turbidity Bridge Avoidance: After the Integrated Early Winter Pulse Protection or February 1 (whichever comes first), until April 1, DWR, in coordination with Reclamation, shall manage exports to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. If the daily average turbidity at OBI is greater than 12 NTU, DWR, in coordination with Reclamation, shall restrict south Delta

exports to achieve an OMR flow that is no more negative than -2,000 cfs until the daily average turbidity at OBI is less than 12 NTU. If, after five consecutive days of OMR flow that is less negative than -2,000 cfs, the daily average turbidity at OBI is not less than 12 NTU the Smelt Monitoring Team may convene to assess the risk of entrainment of delta Smelt. The Smelt Monitoring Team may provide advice to the Water Operations Management Team (WOMT) regarding changes in operations that could be conducted to minimize the risk of entrainment of delta Smelt. The Smelt Monitoring Team may also determine that OMR restrictions to manage turbidity are infeasible and may instead provide advice for a different OMR flow target that is between -2,000 and -5,000 cfs and is protective based on turbidity and adult delta Smelt distribution and salvage to the WOMT for consideration. (CA DFW Incidental Take Permit 2081-2019-066-00)

During installation of the current 2021 West False River Emergency Drought Barrier, and during future emergency barrier installation in the central and northern Delta, EDB affiliated water quality stations TSL, OSJ, FAL, HOL, BLP, BET, FCT, MIR, SXS, and SOI will be used to monitor localized and regional water quality as outlined in the associated 401 permit issued by the SWRCB as well as baseline conditions outside of periods of barrier operation.

6.0 Project Description

This project consists of recurring water quality sampling events at Sixteen stations in the Sacramento-San Joaquin Delta.

6.1 Summary of Work

Water quality sampling is performed at the stations listed in Table 4. The sampling consists of three different techniques:

A. Continuous Instrument Sampling

Sixteen water quality monitoring stations collect time-series data at 15-minute intervals using a YSI (Yellow Springs Instrument) EXO series internal data logging sonde. In-situ, time-series data will be obtained directly from the YSI EXO sonde's internal data storage as a Comma Separated Values (CSV) file.

B. Field Instrument Sampling

Each site will be visited monthly for station maintenance and performance of QA/QC procedures. Current water conditions will be measured with a recently calibrated YSI EXO sonde at the time of station maintenance and discrete sample collection.

C. Discrete Sampling

At the time of station maintenance, physical water samples will be collected and transported for analysis at the designated contract laboratory.

The constituents monitored by this program are organized by sampling technique. Parameters for continuous and field sampling are listed in Table 10, and laboratory analytes (including laboratory analysis methods) are listed in Table 11.

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6.2 Sampling Schedule

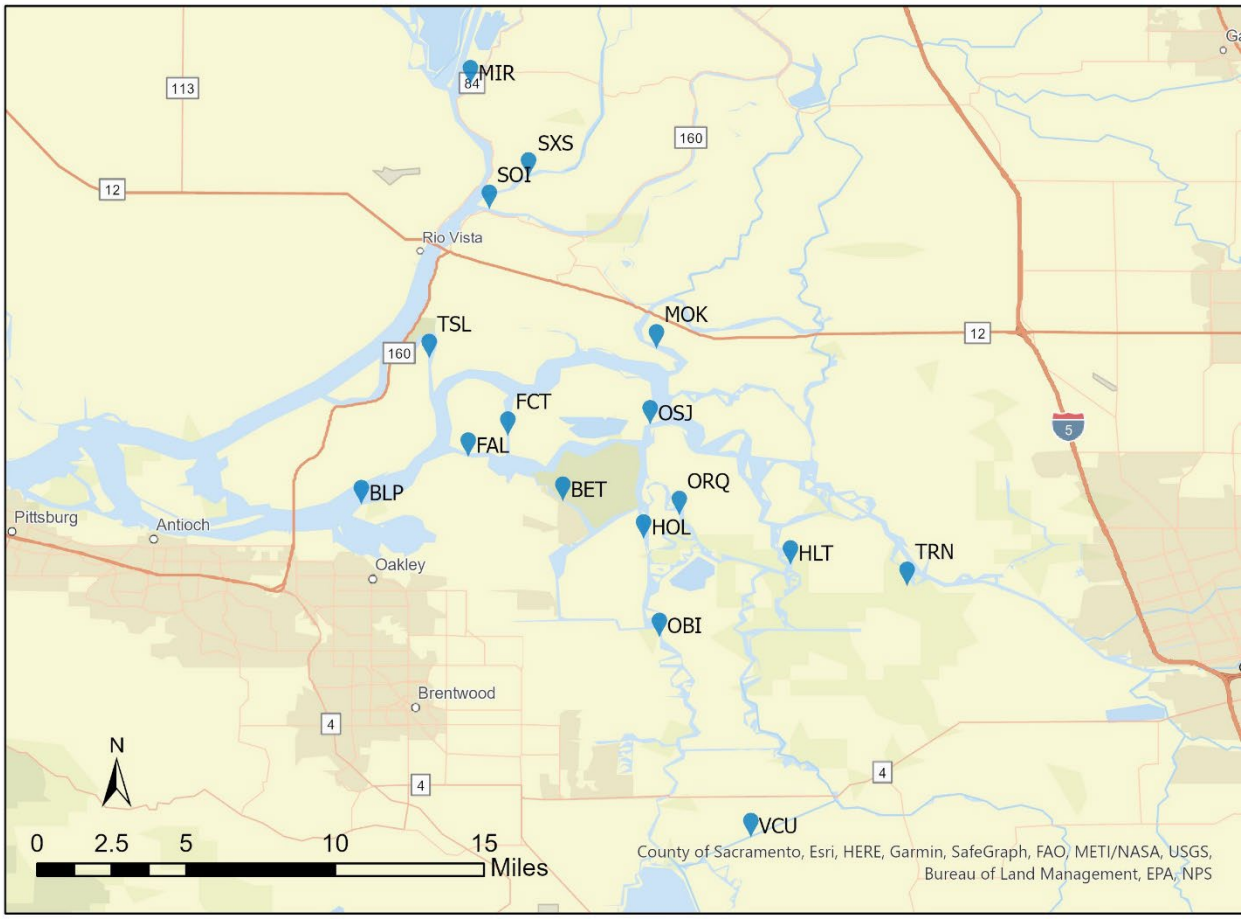
This project does not have a scheduled completion date. All sampling, as defined in Table 10 and Table 11, will occur indefinitely until the project scope is revised under the direction of the Project Director. Sampling and station maintenance will occur monthly.

Table 4 - Monitoring Stations

Map #	Station Name	DWR Station #	Location	Latitude	Longitude
1	False River near Oakley (FAL)	B9504400	Left bank of False River, about 950 yards downstream from confluence with Piper Slough and Little Frank's Tract	38.055444	-121.667166
2	Holland Cut near Bethel Island (HOL)	B9512000	Left bank of Holland Cut, about 800 yards downstream from confluence with Connection Slough	38.015718	-121.582084
3	Old River at Quimby Island (ORQ)	B9520000	Left bank of Old River, about 1,500 yards downstream from confluence with Connection Slough	38.027123	-121.564727
4	Old River at Frank's Tract near Terminous (OSJ)	B9510800	100 yards south from left bank of Old River, about 700 yards upstream from confluence with San Joaquin River	38.071111	-121.578889
5	Middle River near Holt (HLT)	B9545800	Right bank of Middle River, about 500 yards downstream from confluence with Connection Slough	38.003111	-121.510806
6	Victoria Canal near Byron (VCU)	B9528500	Left bank of Victoria Canal, about 2,500 yards upstream from confluence with Old River	37.870945	-121.530010
7	Old River at Bacon Island at USGS Pile (OBI)	B9525000	Left bank of Old River, about 700 yards upstream from confluence with Rock Slough	37.967971	-121.574398
8	Mokelumne River near Highway 12 (MOK)	B9409500	Right bank of Mokelumne River, about 2,500 yards upstream from confluence with San Joaquin River	38.107947	-121.575823
9	Three Mile Slough near San Joaquin River (TSL)	B9506100	Left bank of Three Mile Slough, about 2,000 yards downstream from confluence with San Joaquin River	38.103221	-121.686111
10	Turner Cut near Holt (TRN)	B9561600	Left bank of Turner Cut, about 1,000 yards upstream from confluence with San Joaquin River	37.992777	-121.454207
11	San Joaquin River at Blind Point (BLP)	B9502900	Left bank of San Joaquin River, about 900 yards upstream from confluence with Dutch Slough	38.032418	-121.719022
12	Bethel Island at Piper Slough (BET)	B9504500	Left bank of Piper Slough, mounted to dock at Russo's Marina, about 2,400 yards downstream from confluence with Roosevelt Cut	38.034049	-121.621261
13	Fisherman's Cut (FCT)	B9505000	Left bank of Fisherman's Cut, about 1,000 yards upstream of confluence with False River	38.065612	-121.647933
14	Miner Slough near Sacramento River (MIR)	B9147000	Right bank of Miner Slough, about 800 yards upstream of confluence with Cache Slough	38.236014	-121.666078
15	Steamboat Slough near Sacramento River (SXS)	B9145000	Left bank of Steamboat Slough, about 2,500 yards upstream of confluence with Cache Slough	38.191272	-121.637894

Map #	Station Name	DWR Station #	Location	Latitude	Longitude
16	Sacramento River downstream of Isleton (SOI)	B9125000	Right bank of Sacramento River, about 700 yards upstream of confluence with Cache Slough	38.175587	-121.656919

Figure 2- Map of Central Delta and Emergency Drought Barrier Water Quality Monitoring Network



6.3 Project Deliverable Schedule

The schedule of project deliverables is summarized in Table 5.

Table 5 - Project Milestones Schedule

Project Component	Action	Target Completion
Sampling	Station Maintenance Field Sampling Discrete Sampling	Every 3 to 5 weeks
Quality Check	Verify and Archive Continuous Data	Within 60 days of Station Maintenance
Quality Check	Verify and Archive Discrete Lab Results	Within 30 days of receiving results
Project Management & Administration	Data Summary Reports (By Water Year) and QA/QC Compliance Reports Resource Agreements	Reports are completed by August and Resource Agreements by November on an annual basis

6.4 Geographical Setting

The San Francisco Bay/Sacramento-San Joaquin River Delta Estuary (Bay-Delta Estuary or Estuary) is important to the natural environment and economy of California. The watershed of the Bay-Delta Estuary provides drinking water to two-thirds of the State's population and water for a multitude of other urban uses, and it supplies some of the State's most productive agricultural areas, both inside and outside of the Estuary. The Bay-Delta Estuary itself is one of the largest ecosystems for fish and wildlife habitat and production in the United States. Historical and current human activities (e.g., water development, land use, wastewater discharges, introduced species, and harvesting), exacerbated by variations in natural conditions, have degraded the beneficial uses of the Bay-Delta Estuary, as evidenced by the declines in populations of many biological resources of the Estuary. Most recently, populations of Delta Smelt and other pelagic organisms have exhibited significant declines, leading to investigations as to the possible causes of the degradation of the health of the Delta.

6.5 Project Constraints

While making the best effort to collect data, project constraints include:

- Biological factors can cause erroneous measurements. Algal growth, fish, benthic macroinvertebrates, and aquatic vegetation can interfere with probe sensors reading accurately.
- Biological factors that prevent access and water sampling at stations. Both surface aquatic vegetation, e.g., water hyacinth and water primrose, and submerged aquatic vegetation, e.g., *Egeria densa* can prevent access periodically to boat sites during summer and fall when vegetation coverage is at its highest levels.
- In-situ instrument failure can cause gaps in data until field crews are able to repair or replace.

- Flow data may be unavailable at some locations, and flow data gaps may exist when using data from other agencies.
- Inclement weather, snow, or flooding may cause station to be inaccessible or unsafe to sample.
- Vandalism or theft of in-situ multi-parameter water quality loggers will result in loss of continuous data.
- Damage to station equipment and/or pile may result due to barge, shipping, and other boat traffic as well as heavy objects moving downstream (trees, logs) and can result in loss of equipment and/or continuous data.

  In the event one of these project constraints or unforeseen constraints occur, the Technical Leader will be notified immediately; and the problem will be addressed and recorded in the project notes.

7.0 Quality Objectives and Criteria

7.1 Data Quality Objectives

The Data Quality Objectives (DQOs) for this project provide quality specifications for field instrument measurements and discrete sampling. DQOs for continuous data sampling are not included in this QAPP.

Data acquisition activities will include both field measurements and laboratory analyses, and the MQOs.

7.2 Project Action Limits

Real-time continuous turbidity data collected from OBI is used in the decision process for implementing Turbidity Bridge Avoidance criteria in managing OMR flows (see section 5.2 Water Quality or Regulatory Criteria). NCRO staff may be asked to deploy to Old River, Frank's Tract, and/or surrounding waterways to field truth real-time turbidity values. NCRO staff will utilize supplemental water quality sensors to corroborate real-time monitoring values and may collect TSS samples. Identification and implementation of Turbidity Bridge Avoidance measures and any associated operational actions taken by DWR or outside agencies are the responsibility of the Smelt Monitoring Team and WOMT.

7.3 Acceptance Criteria for Previously Collected Information

All data that will be collected at water quality stations covered in this plan must meet the MQOs outlined in Table 6 and Table 7. All historically collected data must meet the acceptance criteria outlined in Table 6, Table 7, and Table 8 (which covers older equipment that has been retired). Data from entities outside of NCRO are not generally used as part of this project.

7.4 Data Quality Indicators

- **Precision** is the degree of mutual agreement between or among independent measurements of a similar property (usually reported as a standard deviation or relative percent difference [RPD]). This indicator relates to the analysis of duplicate laboratory or field samples. Field precision is assessed by co-located samples, field duplicates, or field splits and laboratory precision is assessed using laboratory duplicates, matrix spike duplicates, or laboratory control sample duplicates. Precision of the field instrument samples is confirmed through the "Auto-Stable" function of the YSI EXO handheld used to communicate with the EXO sensors.

- **Accuracy** is the degree of agreement of a measurement with a known or true value. To determine accuracy, a laboratory or field value is compared to a known or true concentration. Accuracy is determined by such QC indicators as: matrix spikes, surrogate spikes, laboratory control samples and performance samples.

- **Bias** describes the tendency for under or over prediction of samples or measured values relative to the true value. Bias is assessed using matrix spike, standard reference materials, and through negative controls (blanks). Detectable quantities in the blank may indicate positive bias, while low recoveries in matrix spikes, may indicate negative bias. Field data bias is determined by calibrating field instruments with known calibration standards and then conducting post-deployment checks on the instruments after each field run. Bias is controlled by strict adherence to all standard operating procedures that describe appropriate and careful sample collection, preservation, and transportation. Bias is possible however, and is most likely to occur with the current sampling design if samples are not properly:

    - collected
    - filtered
    - preserved
    - stored
    - analyzed

- **Representativeness** describes how relevant the data are to the actual environmental conditions. Sampling and station locations were chosen to provide needed coverage for monitoring and comparison to Delta models. Stations in this plan cover many threshold points between waterways as well as monitoring localized and area water quality conditions. An important role of the Technical Leader is to actively participate in sample design development, training, and assessment of representativeness of the resulting data. Only approved/documented sample collection methods, sample transport/holding methods, and analytical methods will be used to ensure that the measurement data represents the conditions and the sample site to the extent possible. Representativeness is controlled by strict adherence to all standard operating procedures that describe appropriate and careful sample collection, preservation, and transportation.

- **Completeness** is expressed as percent of valid usable data obtained compared to the amount that was expected. Sometimes, due to a variety of circumstances, either not all samples scheduled to be collected can be collected or else the data from samples cannot be used (for example, samples lost, bottles broken, instrument failures, laboratory mistakes, etc.). Project data quality objectives for all measurements and samples collected are 75%. See "Group D: Data Validation and Usability" for processes of data validation, review, and assessment of completeness.

7.5 Measurement Quality Objectives

DQOs for this project are based on Measurement Quality Objectives (MQOs) for the analytes listed in Table 10 and Table 11. The MQOs for field measurements are listed in Table 6, and detail the manufacturer's provided specifications, while MQOs for laboratory analyses are listed in Table 7. Table 8 contains legacy MQOs gathered from the manufacturer specifications of retired and outdated equipment used during historical data collection.

Table 6 - Measurement Quality Objectives for Field Measurements

Parameter	Source	Units	Range	Resolution	Accuracy	Precision	Number of Calibration points	Calibration Check Frequency
Temperature	EXO Conductivity / Temperature Sensor SKU: 599870	Celsius (°C)	-5 to 35	0.001	±0.15	Deviates less than 0.1C for 10 readings at 1 second interval	n/a	Verify (±0.2˚C) agreement with NIST certified thermometer weekly
Specific Conductance	EXO Conductivity / Temperature Sensor SKU: 599870	microSiemens per centimeter (µS/cm)	0 to 200,000	1	±0.5% of reading or 1 µS/cm, whichever is greater	Deviates less than 1 µS/cm for 10 readings at 1 second interval	1	Calibrate and verify calibration weekly
pH	EXO pH Sensor, guarded SKU:599701	pH units	0 to 14	0.01	±0.2 pH units for entire temperature range	Deviates less than 0.01 for 10 readings at 1 second interval	2	Calibrate and verify calibration weekly
Dissolved Oxygen	EXO Optical Dissolved Oxygen Sensor SKU: 599100-01	milligrams per Liter (mg/L)	0 to 50	0.01	±1% or 0.1 mg/L, whichever is greater	Deviates less than 0.1 mg/L for 10 readings at 1 second interval	1	Calibrate and verify calibration weekly
Turbidity	EXO Turbidity Sensor SKU: 599101-01	Formazin Nephelometric Units (FNU)	0 to 4000	0.1	0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater	Deviates less than 0.3 FNU for 10 readings at 1 second interval	2	Calibrate and verify calibration weekly
Chlorophyll-*a*	EXO Total Algae Sensor SKU: 599102-01, 599103-01	Relative Fluorescence Units (RFU), micrograms per Liter (µg/L)	0 to 400 µg/L; 0 to 100 RFU	0.01 µg/L; 0.01 RFU	Linearity: R2 >0.999 for serial dilution of Rhodamine WT solution from 0	Deviates less than 0.3 µg/L for 10 readings at 1 second interval	1	Calibrate and verify calibration weekly

Parameter	Source	Units	Range	Resolution	Accuracy	Precision	Number of Calibration points	Calibration Check Frequency
					to 400 µg/L Chl-a equivalent			
fDOM	EXO Fluorescent Dissolved Organic Matter Sensor SKU: 599104-01	Quinine Sulfate Units (QSU)	0-300 ppb QSU	0.01 ppb QSU	Linearity: R^2>0.999 for serial dilution of 300 ppb Quinine Sulfate Solution	Deviates less than 0.5 QSU for 10 readings at 1 second interval	2	Calibrate and verify calibration with just zero standard weekly. Calibrate and verify calibration with zero and high standard every 6 months.
Depth	EXO Integral, Non-vented Depth Sensor	meters (m)	0 to 100	0.001	±0.04 m	n/a	1	Calibrate and verify calibration weekly

Table 7 - Measurement Quality Objectives for Laboratory Analyses

Quality Control - Conventional Analytes	Frequency of Analysis - Conventional Analytes	Measurement Quality Objective - Conventional Analytes
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs	90-110% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<Reporting Limit (RL) for target analyte
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	80-120% recovery RPD<25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% ((n/a if native concentration of either sample is <RL
Internal Standard	Accompanying ever analytical run as method appropriate	Per method
Field Duplicate	One per field run or per method	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Equipment Blank	One per field run or per method	<RL for target analyte

Quality Control - Conventional Analytes (Solids)	**Frequency of Analysis - Conventional Analytes (Solids)**	**Measurement Quality Objective - Conventional Analytes (Solids)**
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% (n/a if native concentration of either sample<RL)
Field Duplicate	One per field run or per method	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Equipment Blank	One per field run or per method	<RL for target analyte
Quality Control - Inorganic Analytes	**Frequency of Analysis - Inorganic Analytes**	**Measurement Quality Objective - Inorganic Analytes**
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing 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	80-120% recovery

Quality Control - Inorganic Analytes	Frequency of Analysis - Inorganic Analytes	Measurement Quality Objective - Inorganic Analytes
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 is <RL)
Internal Standard	Accompanying every analytical run as method appropriate	Per method
Field Duplicate	One per field run or per method	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Equipment Blank	One per field run or per method	<RL for target analyte

Table 8 – Legacy Measurement Quality Objectives from Retired Equipment Previously Used to Collect Field Measurements

Parameter	Source	Units	Range	Resolution	Accuracy	Precision	Number of Calibration points	Calibration Check Frequency
Turbidity	Hach 2100p	Nephelometric Turbidity Units (NTU)	0 - 1,000	0.01	±2% of reading plus stray light from 0 - 1,000 NTU	±1% of reading or 0.01 NTU, whichever is greater	4	Once Every 3 Months
Temperature	YSI 6560 EC/Temperature Sensor	Degrees Celsius (°C)	-5 - 50	0.01	±0.15 °C	Not Available	1	Once Every 3-4 Weeks
Conductivity	YSI 6560 EC/Temperature Sensor	microSiemens per centimeter (µS/cm)	0 - 100,000 µS/cm	1 - 100	±0.5% of reading + 1 µS/cm	Not Available	1	Once Every 3-4 Weeks
Turbidity	YSI 6136 Turbidity Sensor	Nephelometric Turbidity Units (NTU)	0 - 1,000	0.1	±2% of reading or 0.3 NTU (whichever is greater)	Not Available	2	Once Every 3-4 Weeks
Dissolved Oxygen	YSI 6150 ROX Dissolved Oxygen Sensor	milligrams per Liter (mg/L)	0 - 50	0.01	±1% of reading or 0.1 mg/L from 0 - 20 mg/L, ±15% of reading from 20 - 50 mg/L	Not Available	1	Once Every 3-4 Weeks
pH	YSI 6561 pH Sensor	pH units	0 - 14	0.01	±0.2	Not Available	2	Once Every 3-4 Weeks
Chlorophyll-*a*	YSI 6025 Chlorophyll Sensor	micrograms per Liter (µg/L)	0 - 400	0.1	Not Available	Not Available	1	Once Every 3-4 Weeks
Temperature	YSI-63 Temperature Sensor	Degrees Celsius (°C)	-5 - 75	0.1	±0.1 °C	Not Available	1	Once Every 3-4 Weeks

Parameter	Source	Units	Range	Resolution	Accuracy	Precision	Number of Calibration points	Calibration Check Frequency
Conductivity	YSI-63 Conductivity Sensor	microSiemens per centimeter (µS/cm)	0 - 4999	1	±0.5%	Not Available	1	Once Every 3-4 Weeks
pH	YSI-63 pH Sensor	pH units	0 - 14	0.01	±0.1 pH unit if within ±10 °C of calibration temperature, ±0.2 pH unit if within ±20 °C of calibration temperature	Not Available	2	Once Every 3-4 Weeks
Temperature	YSI ProODO (SKU: 626281)	Degrees Celsius (°C)	-5 - 70 °C	0.1	±0.2 °C	Not Available	1	Once Every 3-4 Weeks
Dissolved Oxygen	YSI ProODO (SKU: 626281)	milligrams per Liter (mg/L)	0 - 50	0.1	±1% of reading or 0.1 mg/L from 0 - 20 mg/L, ±10% of reading from 20 - 50 mg/L	Not Available	1	Once Every 3-4 Weeks

8.0 Special Training Requirements/Safety

8.1 Specialized Training or Certifications

All personnel, whether they participate in field activities or not, are required to complete training courses on the following topics:

- Public Records Act
- Workplace Safety
- Harassment Prevention
- Information Security and Privacy Awareness

All personnel assigned to perform field sampling are required to complete the following courses:

- First Aid/CPR/AED or similar
- Defensive Drivers Training
- California Course for Safe Boating

For general water chemistry field data collection and field measurements, no specialized certification is required. However, field staff are trained in field sampling methods as well as sample collection and boating safety.

Laboratory analyses are performed by a laboratory certified by the State of California Water Resources Control Board, Environmental Laboratory Accreditation Program (ELAP). The selected laboratory shall operate under a written Quality Manual that includes independent onsite audits. All laboratory personnel performing analytical services must be trained to follow the Quality Manual and each Standard Operating Procedure as written for each test method. Additionally, laboratories must maintain a lab safety manual in compliance with Occupational Safety and Health Administration (OSHA) or equivalent state or local regulations.

Most samples are expected to be processed by Bryte Chemical Laboratory. Bryte lab staff will follow the most up-to-date version of the Bryte Chemical Laboratory Quality Manual (Appendix A) and any associated Standard Operating Procedures. All documentation related to the Bryte Chemical Laboratory Quality Manual (Appendix A), Bryte Chemical Laboratory Analysis Fee Schedule (Appendix B), and Bryte Lab ELAP Accreditation (Appendix C) are included in the appendices of this document and can be requested from Bryte's Laboratory Director or the QA Officer.

8.2 Training Schedule and Process

The listed courses below are provided by the Department of Water Resources and all courses, except for First Aid/CPR/AED training, are offered online when needed. The certification renewal schedule for the required courses is listed below:

- Public Records Act – every three years
- Workplace Safety – every three years

- Harassment Prevention – every two years
- Information Security and Privacy Awareness – every two years
- First Aid/CPR/AED – every two years
- Defensive Drivers Training – every three years

The CA Course for Safe Boating is required training for DWR motorized boat operators, crew chiefs, lead persons (on boat operations), and crewmembers. The course is also a pre-requisite to obtain a California Boater Card, required for DWR motorized boat operators of all ages. New staff can enroll in the course by visiting the website for the California State Parks Division of Boating and Waterways. This course meets the California Boater Card boating safety education requirement.

For those certifications required for field activities, there are instances where staff perform field duties prior to receiving certification or with expired certification. However, there is always at least one certified staff member present during all field activities. Training for water quality related activities is provided for new staff members on the first available sampling day.

Each new staff member is trained by an experienced staff member on all protocols in the WQES Field Manual (Appendix D) and practical boat operation and safety. The experienced staff is responsible for determining when new field staff is sufficiently trained on specific field techniques and can correctly follow the protocol without direct supervision.

8.3 Individuals Responsible

The Technical Leader and Project Manager are responsible for determining adequate training of field personnel.

8.4 Training and Certification Documentation

A certification is provided to staff when they complete each required training provided by DWR. DWR administrative staff fills out each employee's training history record, which is accessible online.

CA State Parks will provide Staff with a physical copy of their CA Boater Card upon successful completion of the Course for Safe Boating and associated exam. The CA Boater Card will be on the staff's person when operating DWR motorboats.

Upon completion of training for each protocol, the trainee will initial the "Training Log" located in the WQES Field Manual (Appendix D). When all trainings are complete, the Training Log will be given to the WQES supervisor for approval and storage.

Documentation of laboratory certification and OSHA compliance are required from selected laboratories.

9.0 Documentation and Records

Water quality data collected in this project are included in yearly reports to program managers. These reports are based on Water Year and provide a summary of seasonal and regional trends observed across the project area. Every third year, a multi-Water Year report is prepared examining the previous three Water Years as well as longer term trends in the project area.

During Drought Emergencies necessitating the installation of temporary barriers, a 401 permit may be issued by the State of California Water Resources Control Board (SWRCB) utilizing data from this project and requiring additional associated reporting. An example of 401 monitoring and reporting requirements from 2021 can be found here: https://www.waterboards.ca.gov/docs/2021_emergency_drought_salinity_barrier_wqc.pdf

All field data gathered by this project is recorded on standardized field data entry forms. These forms and processes are described in more detail in Section 19.0 Data Management. Documentation for analytical data will be kept on file at the laboratory and will be available for review during any external audits by the DWR QA Program. The laboratory records will include the analyst's comments on the condition of the sample and progress of the analysis, raw data, instrument printouts, and results of calibration and QC checks.

The Technical Leader is responsible for developing, maintaining, and updating the QAPP. All original QAPPs are held at NCRO. This QAPP and its revisions are distributed to all parties involved with the project. Copies will also be sent to the Bryte Chemical Laboratory manager for internal distribution. Upon revision, the replaced QAPPs are discarded.

NCRO Field crews will collect and maintain all field records, including field data sheets, sampling log sheets, and chain of custody (COC) forms (Appendix I). Bryte Chemical Laboratory generates hard and electronic records for sample receipt, storage, preparation, and analyses.

Following are descriptions of the types of records generated by the proposed project:

- Sample Collection Records – field logs, shipping records, sample tags.
- Field Records – field logs with observations and measurements, sample descriptions, operational records, field instrumentation calibration records, analytical reference material lot numbers and sources.
- Analytical Laboratory Records – sample receipt/log in records, chain of custody forms, instrumentation used, analytical logbooks, raw analytical data, plots,

spectra, lab instrument calibration records, analytical reference material lot numbers and sources, proficiency test results, quality control records.

- Data and Information Records – raw data, sensor and instrument identification, GPS information, statistical summaries, sample descriptions, calibration records, quality control sample results, computer system user guides, programmer software and hardware maintenance.

- Assessment Records – inspection or assessment reports and corrective action reports, annual data summary reports, evaluation summaries, copies of presentations made during and after the project.

- Modeling Records – computer system user guides, programmer software and hardware maintenance documents, model code description documents, model evaluation summaries.

The Technical Leader will oversee the maintenance of all records and will arbitrate any issues related to records retention. The Lab Director is responsible for maintaining and retaining all analytical records, including sample receipt records, chain-of-custody forms, and printed and electronic data from laboratory analyses.

All records generated by this project are stored at the NCRO Office and backup electronic copies of all records are stored on the NCRO network in original formats as well as redundantly in the WQES database and in online repositories including the Water Data Library (WDL). All lab records will also be stored at Bryte Chemical Laboratory using the Field and Laboratory Information Management System (FLIMS) as specified in the Bryte Chemical Laboratory Quality Manual (Appendix A). Copies of the records will be maintained at NCRO and Bryte Chemical Laboratory for five years following project completion. Data files will be maintained without discarding.

The Bryte Chemical Laboratory will archive all analytical records generated for this project. The Lab Director is responsible for archiving all records.

All field operation records are entered into electronic formats and maintained in a dedicated directory. The lab will have a dedicated directory for Bryte Chemical Laboratory in their data repository. They will deliver data in hardcopy and electronic format to the Technical Leader, who is responsible for storage and safekeeping of these records.

Group B: Data Generation and Acquisition

10.0 Sampling Process Design

The Program Design Concept for this project by which stations were selected is based on the following criteria:

1. Select monitoring stations within the Sacramento-San Joaquin Delta.

2. To the extent possible, select sites which have previous monitoring history (including flow gaging).

3. Sites generally coincide with an established watershed management program and or restoration projects within the watershed.

4. Select parameters that are repeatable, not overly burdensome to sample, and are the most information rich regarding evaluation of water quality/beneficial use protection.

5. Focus of the program will be on evaluation of long-term trends, with respect to water quality and the biological community.

10.1 Station Selection Rationale

Sixteen monitoring stations were selected using the Program Design Concept to adequately evaluate water quality in the Sacramento-San Joaquin Delta.

10.2 Station Type

All stations are located on tidally influenced river channels. Field crews perform sampling under the assumption that a station can be experiencing rapidly changing conditions at any time.

10.3 Station Selection Intent

Station selection criteria include the following:

- Channel Representation – Station and sampling locations are chosen with the goal of cross-section representation of the channel. Locations should be free of conditions that cause acutely localized variations in water quality as compared to the general conditions of the channel reach. Potential causes of localized variation include asymmetrical channel morphology, uneven mixing (e.g. eddies or dead-end channels), physical interference from vegetation, or nearby effluent discharges.

  A location's area of upstream and downstream channel representation is unique for every station. If deemed necessary for analysis or reporting purposes, field crews will perform investigations into water quality conditions along the length of the channel reach to identify the area that a station or sample can be assumed to represent.

- Impact assessment – monitoring to determine whether an impact to the ecosystem has occurred through watershed management and or restoration activities.

- Water quality criteria compliance monitoring – monitoring for the purpose of comparison with water quality benchmarks to determine if criteria are meeting state and federal standards.

- Fixed station for long term monitoring – monitoring at the same location each time to create a long-term record of conditions at each selected location.

10.4 Study Timing

The purpose behind the timing of the monitoring at the selected stations includes the following reasons:

- Time Period – Continuous measurements and discrete samples represent water quality conditions at the exact time the measurement or sample is taken. Interpolation of conditions between measurements is left to the discretion of data end-users.

- Routine monitoring – Continuous monitoring on a year-to-year basis to provide long-term data. Continuous monitoring equipment will receive maintenance and calibration monthly.

- Snapshot – One-time monitoring of multiple stations. This provides a periodic "snapshot" in time of the conditions at the selected stations. For example, weekly water quality monitoring updates for the West False River Emergency Drought Barrier.

- Discrete sample collection – Sample collection will coincide with in-situ equipment maintenance monthly.

- 5 field runs covering the 16 stations are expected to occur monthly with a goal of every 3-4 weeks and a maximum of 5 weeks between field runs. A minimum of 10 field runs will be conducted each water year and, subsequently, at least 10 samples will be collected at every station during each water year.

10.5 Station Selection

The station selection design is a knowledge-based and systematic approach where selection is:

- Directed – A deterministic approach in which locations are selected deliberately based on knowledge of their attributes of interest as related to the environmental site being monitored.

- Systematic – A deterministic approach in which station locations are selected deliberately due to the existence of a previously established water quality location.

Station names, GPS coordinates, and physical descriptions are in Table 4. A map of the study area is in Figure 2. All measurements and samples will be collected at a depth of 1 meter or as close to 1 meter as possible without physically disturbing the channel bottom.

10.6 Field Measurements to Support Lab Data

Analysis methods and interpretation of laboratory data often requires knowledge of the ambient conditions at the time samples were collected; so, DWR field crews will conduct field measurements at the same time and the same place when water samples are collected for analysis at the lab.

The DWR field crew will measure Dissolved Oxygen, Temperature, Specific Conductivity, pH, Chlorophyll, and Turbidity at the same spot and the same time where/when they collect grab water samples for lab analyses. The crew will also record site conditions by completing the Field Data Sheets at each station visit.

10.7 Continuous Monitoring

Continuous monitoring data loggers will be employed to collect water temperature, specific conductance, turbidity, dissolved oxygen, chlorophyll, pH, fDOM, and depth (or some combination of those parameters) for the project. The following list gives details about the water temperature, specific conductance, turbidity, dissolved oxygen, chlorophyll, pH, fDOM, and depth monitoring portion of the project:

- Deployment duration will continue for the length of the project.
- 15-minute measurement intervals will be used for the project.
- Each logger will be secured in an inconspicuous location, when possible.

10.8 Sampling Work Statement

DWR field crews will:

- Prepare field equipment and label appropriate bottles for water collection according to the WQES Field Manual (Appendix D).
- Notify the Technical Leader when stations are inaccessible, note the conditions on the Field Record, and make appropriate plans to visit the site when accessible or determine actions required to restore accessibility to the site.

10.9 Sources of Uncertainty

There are major sources of uncertainty in environmental monitoring that are independent of each other. These sources are below as follows:

1.) Measurement error – combines all sources of error related to the entire sampling and analysis process, i.e., to the Measurement System. The actions taken to assure

sample integrity and to reduce measurement error are described in the Standard Operating Procedures located in the WQES Field Manual (Appendix D)

2.) Natural – variability occurs in any environment monitored and is often much wider than the measurement error. Natural variability includes seasonal and tidal changes in flow levels, tidal elevations, and source water runoff. Though natural variability is part of what is monitored in this project some reconciliation is made by floating sondes at 1 meter depth and sampling at generally the same time of day during each monthly field visit.

3.) Sample bias and misrepresentation – happens at the level of an individual sample or field measurement (e.g., collecting a water sample at a backwater pool that does not represent the bulk of the flow) and will be minimized by using field training and adaptive sampling methods. Representativeness and bias are addressed in more detail in Section 7: Quality Objectives and Criteria.

10.10 Relative Importance of Components

Critical information for this project includes all parameters listed in Table 10 and

Table 11.

Critical information includes dates of sampling and accurate sampling station identifications. In addition, critical information consists of all laboratory and field measurements.

All other information collected for the project such as field observations or additional laboratory analyses will be treated as for informational purposes only.

11.0 Sampling Methods Requirements

Field personnel will adhere to sample collection protocols outlined in the WQES Field Manual (Appendix D), last updated June 2020, or approved and documented alternative protocols, to ensure the collection of representative, uncontaminated (contaminants not introduced by the sample handling procedure itself) water, sediment, tissue, and biological samples for laboratory analyses. If protocols are revised or altered, the deviations from the standard protocols will be documented.

Any problems occurring during field collection will be reported by the Technical Leader directly to the Project Manager. Problems will be documented on the field collection sheets. If necessary, the QA Officer will be informed, and corrective measures will be put in place to mitigate the issue.

11.1 Sample Containers and Filtering

Selection of the appropriate sample containers is an important part of the sampling plan. To ensure sample integrity, the Bryte Chemical Laboratory Quality Manual (Appendix A) specifies the types of containers that are acceptable for each kind of sample and the amount of sample that needs to be collected for each analyte. See Table 9 for a list of required sample filtration, sample preservation, sample container types, sample volume, and hold times. The laboratory will supply sample containers to the project. For sample

containers not provided by laboratories the Technical Leader will obtain appropriate sample containers from approved vendors.

11.2 Sample Preservation and Holding Times

Using properly cleaned containers and correct preservatives, as well as adhering to proper holding times, is essential to maintaining sample integrity and correctness. DWR field crews will follow sample collection information in the Bryte Chemical Laboratory Quality Manual (Appendix A) as well as follow guidance approved by the DWR Quality Assurance Committee. The Bryte Chemical Laboratory Quality Manual (Appendix A) strictly follows EPA or Standard Method procedures for all analyzed samples. Requirements for sample containers, preservation techniques, and holding times are found in one of the following references (or later editions):

- Standard Methods for the Examination of Water and Wastewater. American Public Health Association, et al., 19th Edition, or later
- Federal Register Volume 49, No. 209, Friday, October 26, 1984, EPA, 40 Code of Federal Regulations, Part 136
- Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA 600/4-82-029, September 1982.

Sufficient sample volumes must also be collected to ensure that the required detection limits can be met, the QC samples can be analyzed, and any necessary sample re-analyses can be performed. Sample holding times, filtration requirements, and preservation methods are listed in Table 9.

The following information will be included on the sample labels:

- Sample identification number,
- Collection date and time,
- Filtration and preservation requirements,
- Site ID

If monitoring equipment fails, DWR personnel will report the problem in the comment section of their field notes and will not record data values for the variables in question. Actions will be taken to replace or repair broken equipment prior to the next field use. No data will be entered into DWR's FLIMS that were known to be collected with faulty equipment.

11.3 Cleaning of Sampling Equipment

Van Dorns will be cleaned after each field run. Rinse the Van Dorn with DI water and empty through each valve for at least 5 seconds, scrub the inside with a toilet brush or chimney sweep, and rinse again with DI water. If deposits or build-up are not removed by

this process fill the Van Dorn with a mixture of DI water and approved laboratory soap. Allow enough soaking time to loosen the deposits or build up, and then scrub with wire brush and rinse thoroughly with DI water. Use only the approved laboratory soap. Soap itself could cause contamination if not rinsed off completely. Leave Van Dorn in open position until dried. Once dried, the equipment can be transferred to the proper storage area.

All filtering equipment is rinsed with deionized (DI) water and taken apart after each batch of samples are filtered. If growth is observed in any tubing, it is rinsed out with DI water or replaced completely. It should be noted that sample water does not encounter any tubing before it is collected into its respective sample container.

11.4 Equipment and Support Facilities

Equipment that is used on a regular basis includes:

- EXO2 Multi-parameter sondes
- Van Dorn water samplers
- Millipore vacuum pump
- Sample filtering stand with filtering cups
- Chlorophyll filtering stand with filtering cups
- Sampling containers
- Glassware
- Coolers for sample transport
- DI carboys and squirt bottles

Monthly field runs are conducted using the WQES boat, “Quality Time”.

12.0 Sample Handling and Custody Requirements

The field crews will have custody of samples during field sampling and chain-of-custody forms will accompany all samples to the analyzing laboratory. Chain-of-custody procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. The Technical Leader is responsible for ensuring all procedures related to sample handling and custodial duties are followed until custody is transferred to the receiving laboratory. The analytical laboratory will maintain custody logs sufficient to track each sample submitted and to analyze or preserve each sample within specified holding times. The analytical laboratory has a sample custodian who examines the samples for correct documentation, proper preservation and holding times. It will follow sample custody procedures (Table 9) according to the latest approved laboratory Quality Manual.

In the field, all samples are packed in wet ice or ice packs during shipment, so that they are kept $< 6^{o}$ C. Where allowed by the method, samples may be frozen to prevent biological degradation. All samples are handled, prepared, transported, and stored in a manner to minimize bulk loss, analyte loss, contamination, or biological degradation. Sample containers are clearly labeled with waterproof labels generated by DWR’s FLIMS. All caps and lids are checked for tightness prior to shipping. Ice chests are sealed with tape before shipping. Samples are placed in the ice chest

with enough ice, or ice packs, to completely fill the ice chest. Chain of Custody forms are placed in an envelope and taped to the top of the ice chest, or they may be placed in a plastic bag and taped to the inside of the ice chest lid. Shipped samples shall conform to all U.S. Department of Transportation rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) Regulations. Transport of samples to subcontract laboratories is by commercial carriers.

Table 9 – Custody Procedures for Discrete Sample Handling

Constituent	Filter Pore Size and Material	Preservation	Holding Time	Preservation Volume	Container
Total Alkalinity	Unfiltered, no headspace	0-6° C	14 days	N/A	High Density Polyethylene (HDPE); 500 mL
Total Dissolved Solids	0.45 micrometer or micron (µm), nitrocellulose	0-6° C	7 days	N/A	HDPE; 500 mL
Dissolved Hardness	0.45 µm, nitrocellulose	0-6° C, Nitric Acid pH<2	180 days	2 mL	HDPE; 250 mL
Specific Conductance	No headspace, Unfiltered	0-6° C	28 days	N/A	HDPE; 500 mL
Dissolved Bromide	0.45 µm, nitrocellulose	0-6° C	28 days	N/A	HDPE; 250 mL
Dissolved Chloride	0.45 µm, nitrocellulose	0-6° C	28 days	N/A	HDPE; 250 mL
Dissolved Sulfate	0.45 µm, nitrocellulose	0-6° C	28 days	N/A	HDPE; 250 mL
Dissolved Boron	0.45 µm, nitrocellulose	0-6° C, Nitric Acid pH<2	180 days	2 mL	HDPE; 250 mL
Dissolved Calcium	0.45 µm, nitrocellulose	0-6° C, Nitric Acid pH<2	180 days	2 mL	HDPE; 250 mL
Dissolved Magnesium	0.45 µm, nitrocellulose	0-6° C, Nitric Acid pH<2	180 days	2 mL	HDPE; 250 mL
Dissolved Potassium	0.45 µm, nitrocellulose	0-6° C, Nitric Acid pH<2	180 days	2 mL	HDPE; 250 mL
Dissolved Sodium	0.45 µm, nitrocellulose	0-6° C, Nitric Acid pH<2	180 days	2 mL	HDPE; 250 mL
Dissolved Ammonia	0.45 µm, nitrocellulose	0-6° C, Sulfuric Acid pH<2	28 days	1 mL	HDPE; 250 mL
Dissolved Organic Nitrogen	0.45 µm, nitrocellulose	0-6° C, Sulfuric Acid pH<2	28 days	1 mL	HDPE; 250 mL
Dissolved Nitrite + Nitrate	0.45 µm, nitrocellulose	0-6° C, Sulfuric Acid pH<2	28 days	1 mL	HDPE; 250 mL

Dissolved Orthophosphate	0.45 µm, nitrocellulose	0-6° C, Sulfuric Acid pH<2	28 days	1 mL	HDPE; 250 mL
Total Kjeldahl Nitrogen	Unfiltered	0-6° C, Sulfuric Acid pH<2	28 days	1 mL	HDPE; 250 mL
Total Phosphorus	Unfiltered	0-6° C, Sulfuric Acid pH<2	28 days	1 mL	HDPE; 250 mL
Dissolved Organic Carbon	0.45 µm, nitrocellulose	0-6° C, Phosphoric Acid pH<2, amber	28 days	0.2 mL	Glass; 40 mL
Total Organic Carbon	Unfiltered	0-6° C, Phosphoric Acid pH<2, amber	28 days	0.2 mL	Glass; 40 mL
Chlorophyll *a*	1 µm Pall glass fiber	Frozen, dark	28 days	N/A	Manila Envelope
Pheophytin *a*	1 µm, Pall glass fiber	Frozen, dark	28 days	N/A	Manila Envelope
Total Suspended Solids	Unfiltered	0-6° C	7 days	N/A	HDPE; 1000 mL
Volatile Suspended Solids	Unfiltered	0-6° C	7 days	N/A	HDPE; 1000 mL

13.0 Analytical Methods

13.1 Continuous and Field Measurements

Continuous and field measurements are both collected using YSI EXO2 multi-parameter instruments. Specific protocols for calibrating, operating, and deploying these instruments can be found in the WQES Field Manual (Appendix D). Instrument specifications can be found in the YSI EXO User Manual (Appendix E). Instrumentation type, make, and model used to collect field and continuous measurements are listed in Table 10.

Table 10 – Field and Continuous Measurements Instrument Measurement Methods and Specifications

Constituent	Instrument	Measurement Method	Units	Range	Resolution
Temperature	YSI EXO SKU: 599870	Thermistor resistance	°C	-5-50 °C	0.001 °C
Specific Conductance	YSI EXO SKU: 599870	Four internal, pure-nickel electrodes	µS/cm	0-200,000 µS/cm	0.1 µS/cm
pH	YSI EXO SKU:599701	Glass combination electrode	pH Units	0-14	0.01
Dissolved Oxygen	YSI EXO SKU: 599100-01	Optical, luminescence lifetime	mg/L	0-50 mg/L	0.01 mg/L
Turbidity	YSI EXO SKU: 599101-01	Optical, 90° scatter	FNU	0-4000 FNU	0.01 FNU
Chlorophyll	YSI EXO SKU: 599102-01, 599103-01	Optical, fluorescence	RFU, µg/L	0-100 RFU, 0-400 µg/L	0.01 RFU, 0.01 µg/L
fDOM	YSI EXO Fluorescent Dissolved Organic Matter Sensor SKU: 599104-01	Optical, fluorescence	QSU, ppb	0-300 ppb QSU	0.01 ppb QSU
Depth	YSI EXO2 SKU: 59950x-02	Differential strain gauge transducer	m	0-100m	0.001m

13.2 Field Instrument Calibration and Operation

Field instruments are calibrated on Monday of every week or the day prior to a field run. A calibration check of all parameters in a bucket with fully saturated dissolved oxygen is performed the morning of a field run. The morning checks and weekly calibrations serve as post-measurement checks for prior field runs. WQES staff perform multiple field runs every week. The Technical Leader will attempt to correct any issues by following the information specified in the EXO User Manual (Appendix E). Sensor changes for each instrument are documented on the calibration logs.

In accordance with Standard Operation Procedure (SOP) DWR-1-SOP-002, "Temperature Accuracy Verification", each temperature sensor undergoes a two-point Thermometer Accuracy Verification using a water bath twice a year and a five-point check is completed annually. See Appendix I for the Thermometer Accuracy Verification form used during this procedure.

Specific procedures for performing a daily calibration check can be found in the WQES Field Manual (Appendix D).

13.3 In-Situ Continuous Monitoring

All procedures for deployment and operation of in-situ continuous monitoring are in the WQES Field Manual (Appendix D).

13.4 Laboratory Standard Operating Procedures

The approved methods for all discrete samples are referenced in Table 11. All standard operating procedures for the collection, handling, filtration and preservation of samples prior to the transfer of custody to the receiving laboratory are in the WQES Field Manual (Appendix D). The procedures followed by Bryte Laboratory staff are in the Bryte Chemical Laboratory Quality Manual (Appendix A)

13.5 Laboratory Instrumentation

All laboratory instrumentation is listed in the Bryte Chemical Laboratory Quality Manual (Appendix A).

13.6 Method Performance Criteria

All laboratory information regarding method performance criteria is listed in the Bryte Chemical Laboratory Quality Manual (Appendix A).

13.7 Target Analytical Reporting Limits

Information on laboratory instrumentation used to perform these analyses is referenced in the Bryte Chemical Laboratory Quality Manual (Appendix A). Table 11 indicates the test methods to measure each constituent and target reporting limits.

Table 11 – Analytical Methods and Target Reporting Limits

Constituent	Method	Units	Reporting Limit
Total Alkalinity	SM 2320B	mg/L as CaCO3	20
Total Dissolved Solids	SM 2540C	mg/L	2.5
Dissolved Hardness	EPA 200.7	mg/L Total Calc	1
Specific Conductance	SM 2510B	µS/cm @ 25°C	5
Dissolved Bromide	EPA 300.0	mg/L	0.1
Dissolved Chloride	EPA 300.0	mg/L	1
Dissolved Sulfate	EPA 300.0	mg/L	1
Dissolved Boron	EPA 200.7	mg/L	0.1
Dissolved Calcium	EPA 200.7	mg/L	1
Dissolved Magnesium	EPA 200.7	mg/L	1
Dissolved Potassium	EPA 200.7	mg/L	0.5
Dissolved Sodium	EPA 200.7	mg/L	1
Dissolved Ammonia	EPA 350.1	mg/L as N	0.05
Dissolved Organic Nitrogen	EPA 351.2/EPA 350.1	mg/L as N	0.1
Dissolved Nitrite + Nitrate	SM 4500-NO3-F	mg/L as N	0.05
Dissolved Orthophosphate	EPA 365.1	mg/L as P	0.05
Total Kjeldahl Nitrogen	EPA 351.2	mg/L as N	0.1
Total Phosphorus	EPA 365.4	mg/L as P	0.01
Dissolved Organic Carbon	SM 5310 C	mg/L as C	0.5
Total Organic Carbon	SM 5310 C	mg/L as C	0.5
Chlorophyll *a*	SM 10200H	µg/L	0.5
Pheophytin *a*	SM 10200H	µg/L	0.5
Total Suspended Solids	SM 2540D	mg/L	2.5
Volatile Suspended Solids	SM 2540E	mg/L	2.5

13.8 Sample Disposal

After analysis of the project samples the laboratories will dispose of samples in compliance with all federal, state, and local regulations. The laboratory has standard procedures for disposing of its waste, including left over sample materials as detailed in the Bryte Chemical Laboratory Quality Manual (Appendix A).

13.9 Laboratory Method Failure

The Technical Leader is responsible for corrective action and associated documentation to address laboratory method failures. Details of that responsibility are fully explained in section 14.0.

13.10 Turnaround Time

Typically, laboratory results will be emailed to the Technical Leader within 1 month of sample submission. Laboratory results and field data entered in FLIMS are automatically populated to the WDL. Laboratory results enter the WDL as publicly accessible with a status of "Public, Review Status Unknown." Within 30 days of receiving laboratory results from Bryte, the Technical Leader will perform quality control activities on lab results, as described in section 14. If the results meet Data Quality Objectives and acceptance criteria, the Technical Leader will update the results' status to "Public, Reviewed and Validated." If the results do not meet acceptance criteria, the results' status will be updated to "Data Not Validated by Owner", and the Technical Leader will investigate causes and implement corrective actions (Table 12) as appropriate. Data Quality Objectives and acceptance criteria are defined in section 7.0. The procedures to validate lab results are documented in Group D: Data Validation and Usability and the WQES Field Manual (Appendix D). Turnaround times for sample results will be as fast as possible but will depend on the laboratory and Technical Leader's workloads.

13.11 Non-Standard Methods Documentation

Only Standard and EPA methods approved for regulatory purposes are used for sample analysis and data reporting to the State and Regional Water Quality Control Board.

14.0 Quality Control

Quality control activities are integrated into the project through several activities and methods. These methods of quality control are performed to identify possible contamination problems, matrix interference and the ability to duplicate/repeat results. When control limits are exceeded, the Laboratory Director or QA Officer will review with appropriate laboratory staff to ascertain the possible cause of the exceedance. A review of SOPs will be conducted, and any deficiencies will be identified, documented, and corrected. The QAPP, SOPs, and WQES Field Manual (Appendix D) will be updated appropriately by the Technical Leader.

Failures of laboratory measurement systems include, but are not limited to:

1. instrument malfunction
2. calibration failure
3. sample container breakage
4. contamination
5. QC sample failure

If the failure can be corrected, the analyst must document it and its associated corrective actions in the laboratory record and complete the analysis. If the failure is not resolved, it is conveyed to the respective supervisor who should determine how the analytical failure should be addressed. Corrective actions will be documented in the project notes and any necessary updates to procedures will be included in the WQES Field Manual (Appendix D).

Each aspect of laboratory and field sampling quality control is listed in Table 12 and Table 13.

Blanks are prepared by pouring water known to be free of the parameters being monitored into a sample collection container and then subsampling into the appropriate number of replicate sampling containers. Deionized water is used for blanks. Type 1 deionized water with a resistivity greater than 18.0 million ohm-cm (megohm) is provided to the project by Bryte Laboratory.

All field measurements are performed according to the criteria in Table 6. Instrument drift is quantified and corrected on a weekly basis. RPD should be within DQO requirements.

Laboratory quality control activities (Table 12) performed at the laboratory and acceptance criteria for those activities are defined in the Bryte Chemical Laboratory Quality Manual (Appendix A) and applicable Standard Methods listed in the Bryte Chemical Laboratory Analytical Services Fee Schedule (Appendix B). Laboratory quality control acceptance criteria for this project will match Bryte's established criteria, except as noted in section 14.3. Field quality control activities are performed by field crew following the WQES Field Manual (Appendix D). The acceptance criteria for field quality control activities are included in Table 13.

Table 12 - Laboratory Quality Control Activities

Quality Control Activity	Frequency	Corrective Action
Calibration Standards	Run with every sample set	Determine cause of problem, reanalyze calibration standard, perform equipment calibration if necessary.
Check Standards	1 per 10 analytical runs	Determine cause of problem, reanalyze calibration standard, perform equipment calibration if necessary.
Method Blanks	1 per 20 samples, minimum 1 per batch	Determine cause of problem, remove sources of contamination, reanalyze suspect samples or flag all suspect data
Lab Duplicate	1 per 20 samples, minimum 1 per batch	Determine cause, take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data.
Matrix Spike	1 per 20 samples, minimum 1 per batch	Determine cause, take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data. Zero percent recovery requires rejection of all suspect data.
Matrix Spike Duplicate	1 per 20 samples, minimum 1 per batch	Determine cause, take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data.
Laboratory Control Samples	2 per 20 samples, minimum 2 per batch	Determine cause, take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data.

Table 13 - Field Quality Control Activities

Quality Control Activity	Frequency	Acceptable Limits	Corrective Action
Field Duplicate	1 per run	RPD ≤25%	Determine cause, take appropriate corrective action
Field Blank	1 per run	Detectable substance contamination <RL	Determine cause of problem, remove sources of contamination

14.1 Calculations:

- **Percent Recovery** (%R): Percent recovery is a measure of accuracy and is calculated according to the following expression:

  Equation 1 Percent Recovery

$$\%R = \frac{Amount\ Found}{Amount\ Spiked} \times 100\%$$

- **Relative Percent Difference**: Precision for discrete samples is calculated from duplicate analyses, including samples, LCS, or matrix spikes by calculating the RPD using the following expression:

  Equation 2 Relative Percent Difference

$$RPD = \frac{(C_1 - C_2)}{\left(\frac{C_1 + C_2}{2}\right)} \times 100\%$$

- **Relative Standard Deviation** (RSD): Also known as the coefficient of variation.

  Equation 3 Relative Standard Deviation

$$RSD = \frac{Std\ Dev}{Mean} \times 100\%$$

- **Drift** means the difference in readings before sampling and after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

  Equation 4 Percent Drift

$$Drift = \frac{(A - B) \times 100\%}{B}$$

Where:
A = the instrument measurement after sampling
B= the instrument measurement before sampling.

14.2 Control Limit Exceedance

The Technical Leader documents and investigates data that exceeds the acceptable limits for quality control activities.

The Technical Leader investigates suspect data by taking the following actions:

1) Investigates the field instrumentation to determine if there was an instrument malfunction, probe failure, or if there was a calibration issue. If one of these issues is identified as the source of the error, appropriate corrective measures are taken.

2) If the data quality control limits are exceeded for data that was generated by Bryte Laboratory, then the lead contacts the lab immediately to determine the cause of error and ensure the data is flagged in the database.

14.3 Project Modified Control Limits

- Chlorophyll *a* and pheophytin *a* samples that are less than 10.0 µg/L, must be within 2.5 µg/L of their duplicate.

- Total Suspended Solids and Volatile Suspended Solids that are less than 10 mg/L, must be within 2.5 mg/L.

- All other laboratory constituent results that have a RPD of more than 25% will be coded as 3000 (Public, Review Status Unknown) on WDL for public view.

15.0 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

15.1 Field Instruments

The Technical Leader is responsible for ensuring that field measurement equipment (YSI EXO2) is properly inspected, tested, and maintained according to the manufacturer's specifications outlined in the YSI EXO User Manual (Appendix E). This includes battery checks and routine replacement and/or cleaning of parts as specified by the manufacturer. All equipment will be inspected for damage before field runs and again when returned from use. Maintenance logs will be kept for each piece of equipment that document the dates and description of any problems, the action(s) taken to correct problem(s), maintenance procedures, and the person responsible for maintaining the equipment. Individual sensor servicing and replacement will follow the recommendations of the manufacturer The manufacturer’s recommendations for maintenance, servicing, and replacement are provided in the YSI EXO User Manual (Appendix E) and standard operating procedures based on those recommendations are included in the WQES Field Manual (Appendix D).

Spare parts for field equipment are stored at DWR North Central Region Office. Equipment and spare parts are inventoried and purchased twice a year to ensure there are sufficient parts to replace or repair defective or broken equipment.

15.2 Laboratory Analytical Equipment

Laboratory analytical equipment will be maintained in accordance with the Bryte Chemical Laboratory Quality Manual (Appendix A), SOPs, and manufacturer specifications. This includes procedures specified by the manufacturer and by the methods used. Maintenance logs will be kept and each piece of equipment will have its own log that documents the dates and description of any problems, the action(s) taken to correct problem(s), maintenance procedures, system checks, follow-up maintenance dates, and the person responsible for maintaining the equipment.

16.0 Instrument Calibration and Frequency

16.1 Field Instruments

The Technical Leader will be responsible for field measurement equipment calibration. This will include documenting and checking that the specified calibration procedures were performed for each of the selected parameters being measured.

Field instruments are calibrated on Monday of every week or the day prior to a field run. These calibrations will be performed by Field Crew and recorded on the calibration log record. If calibration results are deficient and do not meet specifications, staff will attempt to recalibrate. If the calibration is still not successful staff will try again with new solutions or perform any relevant maintenance. If the equipment continues to malfunction it will be replaced or, when possible, sent to the manufacturer or other qualified entity for repair.

A calibration check of all parameters in a water bucket with fully saturated dissolved oxygen is performed the morning of a field run. The weekly calibrations serve as post-measurement checks for the prior week’s field runs. WQES staff perform multiple field runs every week. Pre- and post-measurement checks of the field instruments for every field run is not conducted due to time constraints and minimal drift of EXO2 sensors over a week's time. The Technical Leader will attempt to correct any issues by following the information specified in the YSI EXO User Manual (Appendix E). Sensor changes for each instrument are documented on the calibration logs.

16.2 Laboratory Analytical Equipment

Laboratory analytical equipment is calibrated according to the procedures and frequencies documented in the Bryte Chemical Laboratory Quality Manual (Appendix A). Prior to sample analysis of conventional constituents in water, external calibrations will be made using 3 – 5 standards that cover the range of sample concentrations. The lowest standard will be at or near the Reporting Limit (RL). Linear regression will be <0.995 or better. Calibration verification will be run after every 20 samples after the initial calibration and will use a standard source that is different from that used for the initial calibration.

Acceptable recovery is documented in the Bryte Chemical Laboratory Quality Manual (Appendix A).

16.3 How Deficiencies Are Resolved and Documented

Instruments and probes that fall outside the specified quality control criteria provided by the manufacturer guidance are either replaced or sent back for repair, when possible. An Access database is used to track when probes are replaced.

17.0 Inspection/Acceptance Requirements for Supplies and Consumables

All supplies are examined for damage as they are received and then again as they are obtained for use with the proposed project. Containers are inspected for breakage and proper sealing of caps. Standards and other consumables are inspected for conformance with any labeled expiration dates. Reusable supplies are examined for acceptable cleaning and reuse. Any supplies deemed to be in unacceptable condition are replaced. The Project Manager is responsible for the inspection and meeting acceptance requirements for supplies and consumables. Bryte laboratory's requirements for supplies and consumables are described in its Bryte Chemical Laboratory Quality Manual (Appendix A).

The lot number and expiration date of all calibration standards, used to calibrate or perform post-measurement checks on field instruments, will be recorded on the instrument's calibration record.

Table 14 – Supplies and Consumables Requirements

Item	Vendor	Acceptance Criteria	Documentation	Storage
2767 Specific Conductance Calibration Standard	Bryte Lab	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard Tracks Remaining Volume, Lot Number, and Expiration Date	Stock of 2 Month Supply Stored in WQES Lab at Room Temperature
6668 Specific Conductance Calibration Standard	Bryte Lab	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard Tracks Remaining Volume, Lot Number, and Expiration Date	Stock of 2 Month Supply Stored in WQES Lab at Room Temperature

Item	Vendor	Acceptance Criteria	Documentation	Storage
11670 Specific Conductance Calibration Standard	Bryte Lab	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard Tracks Remaining Volume, Lot Number, and Expiration Date	Stock of 2 Month Supply Stored in WQES Lab at Room Temperature
100 FNU Turbidity Standard	Bryte Lab - From Provided 4000 NTU Formazin Solution	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard Tracks Remaining Volume, Lot Number, and Expiration Date	Stock of 3 Month Supply Stored in WQES Lab Refrigerator at less than 4 °C
4000 NTU Formazin Stablcal	Hach Company	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard	9 Month Supply Stored in WQES Lab Fridge at less than 4 °C
0-7500 StablCal Calibration Kit	Hach Company	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard	Kit Lasts 1 Year from Manufacture Date, Stored in WQES Lab Fridge at less than 4 °C
pH 7 Standard	Hach Company	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard Tracks Lot Number, and Expiration Date	Stock of 6 Month Supply Stored in WQES Lab at Room Temperature, Shelf Life 12 months
pH 10 Standard	Hach Company	Undamaged and Has Not Expired	Weekly Visual Inventory - Whiteboard Tracks	Stock of 6 Month Supply Stored in WQES Lab at Room

Item	Vendor	Acceptance Criteria	Documentation	Storage
			Lot Number, and Expiration Date	Temperature, Shelf Life 12 months
2 x DI water	Bryte or DES Warehouse	Undamaged, No Visual Contamination	Weekly Visual Inventory - Whiteboard	Stock of 1 Month Supply Stored in WQES Lab at Room Temperature
MF-Millipore Mixed Cellulose Ester Membrane, Triton-free, 0.45 µm, 47mm	MilliporeSigma	Boxes Sealed, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 300 Stored in WQES Lab at Room Temperature
A/E Glass Fiber Filter, 1µm, 47mm	Pall Corporation	Boxes Sealed, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 300 Stored in WQES Lab at Room Temperature
1/2 Pint Plastic Bottles	Bryte Lab	Clean and Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 1 Month Supply Stored in WQES Lab at Room Temperature
1/2 Pint Nitric Acid Plastic Bottles	Bryte Lab	Clean and Undamaged, Lot Number Recorded	Weekly Visual Inventory - Whiteboard	Stock of 3 Month Supply Stored in WQES Lab at Room Temperature

Item	Vendor	Acceptance Criteria	Documentation	Storage
1/2 Pint Sulfuric Acid Plastic Bottles	Bryte Lab	Clean and Undamaged, Lot Number Recorded	Weekly Visual Inventory - Whiteboard	Stock of 3 Month Supply Stored in WQES Lab at Room Temperature
40 mL Glass Amber Vials	Bryte Lab	Clean and Undamaged, Lot Number Recorded	Weekly Visual Inventory - Whiteboard	Stock of 3 Month Supply Stored in WQES Lab at Room Temperature
1 Pint Plastic Bottles	Bryte Lab	Clean and Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 1 Month Supply Stored in WQES Lab at Room Temperature
1 Quart Plastic Bottles	Bryte Lab	Clean and Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 1 Month Supply Stored in WQES Lab at Room Temperature
Coin Envelopes	Purchased Online or From Local Market With Petty Cash	Boxes Sealed, Undamaged	Weekly Visual Inventory - Whiteboard	Box of 200 Stored in WQES Lab at Room Temperature
Kimwipes	Purchased Online or From Local Market With Petty Cash	Boxes sealed, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 6 Month Supply Stored in WQES Lab at Room Temperature

Item	Vendor	Acceptance Criteria	Documentation	Storage
Nitrile Gloves	DWR Supply Warehouse	Boxes Sealed, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 6 Month Supply Stored in WQES Lab at Room Temperature
Cotton Swabs	Purchased Online or From Local Market With Petty Cash	Boxes Sealed, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 6 Month Supply Stored in WQES Lab at Room Temperature
Simple Green	Purchased Online or From Local Market With Petty Cash	Bottles Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 6 Month Supply Stored in WQES Lab at Room Temperature
Compressed Air	DWR Supply Warehouse	Sealed in Plastic Wrap, Unopened, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 3 Month Supply Stored in WQES Lab at Room Temperature
Waterproof Adhesive Labels	Purchased Online or From Local Market With Petty Cash	Boxes Sealed, Undamaged	Self-Tracked by Project Lead	Box of 500 Labels Stored at Desk of Each Project Lead
Wide-mouth Wash Bottle	Purchased Online or From Local Market With Petty Cash	Sealed in Plastic Wrap, Unopened, Undamaged	Weekly Visual Inventory - Whiteboard	Stock of 10 Stored in WQES Lab at Room Temperature
Ice	Acquired from NCRO or DES	Unmelted	Not Tracked	Stored in Warehouse Ice

Item	Vendor	Acceptance Criteria	Documentation	Storage
	Warehouse Ice Machine			Machines at less than 0 °C
Rags	Purchased Online or From Local Market With Petty Cash	Undamaged, Retired as Becomes Threadbare	Weekly Visual Inventory - Whiteboard	Stock of 50 Stored in WQES Lab at Room Temperature

18.0 Data Acquisition Requirements

18.1 External Data

External sources of data have been identified and are planned to be used for the proposed project. These include but are not limited to those identified below.

- External data from the USGS are researched and used.
    - https://waterdata.usgs.gov/nwis
- External data from the California Department of Water Resources are researched and used.
    - Division of Integrated Science and Engineering (DISE), Continuous Environmental Monitoring.
    - https://wdl.water.ca.gov/WaterDataLibrary/

The external data are used in a historical context and as a baseline background comparison of similar analyte concentrations during the period preceding the proposed monitoring project.

Data Quality Indicators are used to determine if external data meets project acceptance criteria. These include, for example, precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. Measurement performance information such as MDLs, method quantitation levels, and the selectivity of a method (or lack of selectivity) for the target analytes are used to judge whether the external data meets acceptance criteria. Acceptance of external data for use will depend on the relevance of the matrix, location of the samples, and the methods that were used for collection and/or analysis (for example, field versus laboratory-based methods, the method of collection and analysis, etc.).

External data that fails to meet acceptance criteria will not be used in the proposed project or be flagged as such. Flagged data may possibly be used under some conditions, but its use will be limited and clearly designated.

There are no known or expected constraints to using the proposed external data. There are no known key resources that are not already available that would be needed to research and use the planned external data.

18.2 Historic Data

Historic data collected by NCRO, USGS, and DISE are used to evaluate the plausibility of new information and long-term trends was collected prior to writing this QAPP. Historic data used for these purposes is not external to the program and in many cases, the laboratory methods and other standard operating procedures have not changed. Historical data and metadata were used to aide in interpretation and application of program data.

19.0 Data Management

The Technical Leader is responsible for field measurements and data management. Field data is entered into FLIMS upon return to the lab. Original field and calibration sheets are retained in a logbook and stored in digital format within NCRO. Copies of the COCs are kept by each receiving laboratory and electronic copies of the COCs are provided to the Technical Leader after sample submission.

All data generated by Bryte Chemical Laboratory are maintained as described in laboratory SOPs and the Bryte Chemical Laboratory Quality Manual (Appendix A). The Lab Director of Bryte Chemical Laboratory is responsible for oversight of the collection of all chemical analysis data and entering QA/QC-checked data into the WDL database. All data collected are entered into the FLIMS module. Each data element is checked and verified by the technician that entered the data. Data are reviewed to ensure they are consistent with the format of the database and other data records. There is no final use of collected data, monitoring projects have no set termination date and funding partners and public entities may use data however they see fit with no guarantees.

Original hardcopies of the data are filed at the laboratory. Electronic copies are stored and backed up by the laboratory.

Physical and electronic copies of all field data sheets, field instrument calibration records, and other documentation will be securely stored at NCRO. The project forms are included in Appendix I – Calibration, Field, and Laboratory forms. Continuous water temperature data will be kept in raw format. Data will be uploaded to the WDL after application of a QA/QC process using Hydstra software. Raw format data will be housed on NCRO's servers indefinitely.

Hardware and software are updated as recommended by the manufacturer or as needed. Each entity is responsible for the necessary updates or upgrades, whether provided regularly through an Information Technology department or otherwise. Data handling and management equipment follows the California Department of Technology Services' Responsible Use of Information Technology Policy. Multiple layers of checks and automated cross-referencing within the Data Import functions of the WQES Database also help prevent human error in data management. These

include, but are not limited to, identification of typing mistakes and entered values outside of normal range, automatic detection of sonde and sensor information from spreadsheet headers cross-referenced against both existing records in the database and what is hand-entered and confirmed by the user while importing new data. Additional simple logic checks are also carried out by the Technical Leader prior to archiving data and include making sure that end points of a previously collected station file line up with the beginning of a new file and that observed beginning and ending data values align. Meticulous and detailed record keeping allows the Technical Leader to back trace any discrepancies to the source of the mistake and correct it.

Group C: Assessment and Oversight

20.0 Assessments and Response Actions

20.1 Readiness Reviews

The Technical Leader will review all field equipment, instruments, containers, and paperwork to ensure that everything is ready prior to each sampling event. Before every sampling event a readiness review is conducted. All sampling personnel are given a brief review of the goals and objectives of the sampling event and the sampling procedures and equipment that will be used to achieve them. It is important that all field equipment be clean and ready to use when it is needed. Therefore, prior to using all sampling and/or field measurement equipment, equipment will be checked to make sure that it is in proper working order.

Adequate supplies of all preservatives, bottles, labels, waterproof pens, etc. will be checked before each field run to make sure that there are sufficient supplies to successfully support each sampling event. It is important to make sure that all field activities and measurements are properly recorded in the field. Prior to each field run, necessary paperwork such as logbooks, chain of custody record forms, etc. will be checked to ensure that enough are available during the field event. If a problem is discovered during a readiness review it will be corrected before the field crew is deployed.

20.2 Field Activity Assessment

The Technical Leader is responsible for continuous assessment of all field activity. The Technical Leader will accompany field crews on sampling events at least during 75% of scheduled sampling events. The Technical Leader will assess the sample collection methodologies, field measurement procedures, and record keeping of the field crew to ensure activities are being conducted as planned (and as documented in this QAPP). Any deviations that are observed will be corrected immediately to ensure all subsequent samples and field measurements collected are valid. (Note: If the deviations are associated with technical changes and/or improvements made to the procedures, the Technical Leader will verify that the changes have been documented in the WQES Field Manual (Appendix D) and addressed in an amendment to this QAPP.) The Technical Leader may stop any sampling activity that could potentially compromise data quality.

Regular, internal audits of field activity are not scheduled because the Technical Leader of this project is expected to lead most of the sampling events. The QA Officer, at their discretion or upon request by NCRO, may conduct field activity audit(s) of the project. The QA Officer will conduct such audits under DWR audit procedures. The QA Officer will submit the resulting audit reports to the Project Manager for concurrence.

If a problem is discovered during a field audit it will be rectified as soon as possible so that all subsequent samples and field measurements collected are valid. The problems and the actions taken to correct them will become a part of the field audit report. The QA Officer has authority to stop any sampling or field measurement activity that could potentially compromise data quality.

20.3 Post Sampling Event Reviews

The Technical Leader is responsible for post sampling event reviews. Any problems identified are documented on the field record. Post sampling event reviews are conducted following each sampling event and will include examination of field records and field instrument documentation to ensure that all information is complete and any deviations from planned methodologies are documented. The notes produced from each post sampling event review are used to identify areas that may be improved prior to the next sampling event. The Technical Leader will resolve single occurrences of identified problems by reviewing methods with the Field Crew. If the issue recurs, the Technical Leader will inform and seek guidance from the Project Manager.

20.4 Laboratory Data Reviews

The Lab Director is responsible for reviewing the laboratory's data for completeness and accuracy. The data will also be checked to make sure that the specified methods were used and that all related QC data was provided with the sample analytical results. Laboratory data reviews are conducted by the Technical Leader following receipt of each data package from a laboratory to ensure that all information is complete and any deviations from planned methodologies are either corrected or the reasons for change are documented. Any laboratory data that is discovered to be incorrect or missing will immediately be reported to the laboratory's QA officer. The lab's Bryte Chemical Laboratory Quality Manual (Appendix A) details the procedures that are followed by laboratory personnel to correct any invalid or missing data. The Technical Leader has the authority to request re-testing if a review of any of the laboratory data is found to be invalid or if it would compromise the quality of the data and resulting conclusions from the proposed project.

20.5 Laboratory Methodology Audits

The QA Officer is responsible for reviewing all laboratory audits. Any problems that are noted are documented along with recommendations for correcting the problem. Laboratory audits are held annually during the project's analytical activities. If a problem is discovered during a laboratory audit, the QA Officer will notify the laboratory QA officer. Problems will be corrected as soon as possible so that all subsequent laboratory analyses are valid. The procedures for implementing such corrections are covered in the Bryte Chemical Laboratory Quality Manual (Appendix A). The problems and the actions taken to correct them will become a part of the laboratory audit report. Blind samples may be submitted as part of a laboratory audit for a proficiency test. The results of the lab's analysis will be compared to the known analytes and their concentrations in those samples. Annual proficiency tests as well as demonstrations of competency ensure that the laboratory's staff can accurately analyze samples from the proposed project using the methods specified for them.

21.0 Reports to Management

Once a year a report summarizing the year’s sample collection will be prepared by the Technical Leader which will show any data trends that have occurred. The report will

discuss how any preventative or corrective actions taken in regard to sample collection during the year may have affected the trends. The report will also highlight any missing or rejected data and provide brief explanation of the cause and any corrective actions taken to address the missing data. This report will be sent to the Project Manager and Project Director for further distribution to interested parties.

Group D: Data Validation and Usability

22.0 Data Review, Validation, and Verification Requirements

Defining data review, verification, and validation procedures helps to ensure that project data is reviewed in an objective and consistent manner. Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. This includes checking that all technical criteria have been met, documenting any problems that are observed and, if possible, ensuring that deficiencies noted in the data are corrected.

Data generated by project activities are reviewed against MQOs that were developed and documented in Section 7.0. This will ensure that the data are of acceptable quality with respect to minimum expected MQOs.

Data are separated into three categories for use with making decisions based upon it. These categories are:

1.) data that meets all acceptance requirements

2.) data that has been determined to be unacceptable for use

3.) data that may be conditionally used and is flagged as estimated

23.0 Validation and Verification Methods

Data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual specifications. The Technical Leader will conduct data verification to ensure that it meets acceptance criteria for completeness, correctness, and conformance. Data validation is an analyte- and sample-specific process that evaluates the information after the verification process (i.e., determination of method, procedural, or contractual compliance) to determine analytical quality and any limitations.

23.1 Methods

Defining the methods for data verification and validation helps to ensure that project data are evaluated objectively and consistently.

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

2. Quality Control and Validation – QA/QC requirements were developed and documented in Sections, 14.0, 15.0, and 16.0 and the data are checked against this information. Checks will include evaluation of field and laboratory duplicate results, field and laboratory blank data, matrix spike recovery data, and laboratory control sample data pertinent to each method and analytical data set.

3. Checking Field Data - Field data consists of all information obtained during sample collection and field measurements, including that documented in field logs and/or recording equipment, photographs, and chain of custody forms. Checks of field data are made to ensure that it is complete, consistent, and meets the data management requirements that were developed and documented in Section 19.0. Field Data is checked on a monthly basis, typically once it is transferred to WDL by Bryte Lab staff.

4. Checking Lab Data - Lab data consists of all information obtained during sample analysis. Data review of laboratory data is performed by the laboratory QA Officer in accordance with the lab's internal data review procedures. The QA Officer may perform independent checks to ensure that it is complete, consistent, and meets the data management requirements that were developed and documented in Section 19.0. This review will include evaluation of field and laboratory QC data and also making sure that the data are reported in compliance with procedures developed and documented in Sections 11.0, 12.0, and 13.0

23.2 Responsible Individuals

The Project Manager is responsible for overseeing and approving data review.

The Technical Leader is responsible for ensuring that chain of custody, lab reports, and field and calibration sheets are completed and archived properly. All data records for the proposed project are checked visually and are recorded as checked by the checker's initials. On an annual basis, the Technical Leader will ensure that all project documentation and associated data files are archived as outlined in Section 19.0. The Project Manager will perform an independent re-check of at least 10% of these records as the validation methodology.

All the laboratory's data is checked as part of the verification methodology process. The Lab Director will conduct reviews of all laboratory data for verification of their accuracy. The Technical Leader will be responsible for verification of data going into the WDL.

23.3 Issue Resolution Process

Any data that is discovered to be incorrect or missing during the verification or validation process will immediately be reported to the Technical Leader. If errors involve laboratory data, then this information will also be reported to the Laboratory Director. The Bryte Chemical Laboratory Quality Manual (Appendix A) details the procedures that will be followed by laboratory personnel to correct any invalid or missing data. The Technical Leader is responsible for reporting and correcting any errors that are found in the data during the verification and validation process.

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

group. The QA Officer has the final authority to resolve any issues that may be identified during the verification and validation process.

23.4 Checklists, Forms, and Calculations

Please see Appendix I for forms used during the calibration, field reading/sample collection, and post calibration process. Most of these forms are updated periodically by the DWR QA Committee. Please visit the QA SharePoint site for the latest effective forms, manuals, and guidance documents (Document Control SharePoint).

24.0 Reconciliation with User Requirements

Problems with potential limitations of the data are handled at three different levels:

1. At the time of routine maintenance (every 3-5 weeks) of the monitoring stations or by the site operators, who have prime responsibility for routine calibrations, maintenance, and analysis of quality control samples;

2. Data validators who review verify and validate station data annually; and

3. By users of the data.

Issues are reconciled at the lowest level and at the earliest time possible. The mechanisms for communication between the producers and the users of the data are telephone, e-mail, and the operator's log.

The QA Officer, Lab Director, Technical Leader, Project Manager, Project Director, and members of field crews are empowered to review and question any part of the measurement process and may initiate data reviews and corrective actions to bring the process back into compliance. To assess the quality of the data produced during the monitoring efforts, the precision, accuracy, and completeness will be assessed in comparison to the quality objectives and measurement quality objectives as discussed in Section 7 on a continuous basis throughout the life of the project. Issues that can lead to non-adherence with the DQOs will be addressed with corrective actions as they are identified.

The proposed project will provide data of known quality for the selected analytes described in Section 13.0 The data generated will be useable for comparative purposes by other water monitoring projects within DWR.

24.1 Reporting Data Limitations

Data limitations are reported to data users through metadata files. Metadata includes information that is pertinent to the data users such as the procedures for data collection, field instrumentation and laboratory analytical methods used throughout the life of the program, and program history. These files are stored with project documentation at NCRO and will be provided publicly through requests directed to NCRO staff.

25.0 REFERENCES

California Department of Fish and Wildlife. 2020. Incidental Take Permit for the Long-Term Operation of the State Water Project in the Sacramento San Joaquin Delta. California Endangered Species Act Incidental Take Permit No. 2081-2019-066-00 https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178057&inline

EPA Region 9 Requirements for Quality Assurance Program Plans; R9QA/03.1; U.S. Environmental Protection Agency Region 9, Quality Assurance Office: San Francisco, CA, 2001. https://19january2017snapshot.epa.gov/sites/production/files/2016-05/documents/mngmt-plan_guidance_2012.pdf

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State Water Resources Control Board. 2018. San Francisco Bay/Sacramento - San Joaquin Delta Estuary Water Quality Control Plan. 12 December 2018. https://www.waterboards.ca.gov/

Bryte Chemical Laboratory Quality, Quality Assurance Technical Document 8, State of California, Department of Water Resources, July 2021.

NCRO WQES Field Manual – Appendix D

26.0 APPENDICES

Appendix A – Bryte Chemical Laboratory Quality Manual

DES-1-MNL-001_v5.
0_Quality Manual.pdf

Appendix B – Bryte Chemical Laboratory Analytical Services Fee Schedule

Bryte Lab -
Analytical Services F

Appendix C – Bryte Laboratory ELAP Accreditation

ELAP-Accreditation-
Certificate-2021_783

ELAP-Fields-of-Accr
editation-2021_1238

Appendix D – WQES Field Manual (Internal SOPs)

WQES Field Manual
6-2020.pdf

Appendix E – YSI EXO Manual

EXO User
Manual.pdf

Appendix F – State Water Resources Control Board Water Rights Decision 1641

D1641_final.pdf

Appendix G – DWR Water Resources Engineering Memorandum 60

WREM60.pdf

Appendix H – SWRCB Water Quality Control Plan for The Bay-Delta 2018

2018 Bay Delta WQ Control Plan.pdf

Appendix I - Calibration, Field, and Laboratory Forms

DWR-1-FRM-003_v2.0_PRE Measurement

DWR-1-FRM-004_v2.0_POST Measuremen

DWR-1-FRM-005_v1.0_Thermometer Acc

Updated Field Sheet_12172019.pdf

Morning Check Attachment_072720

DOCUMENT ADDENDA

Addendum Date	Subject	Summary

Appendix D

DWR Division of Integrated Science and Engineering. 2022. Quality Assurance Project Plan for the Continuous Environmental Monitoring Program (CEMP). Document number: DES-3-QAP-001, Version 1.0. 49 pp.

Quality Assurance Project Plan for the Continuous Environmental Monitoring Program (CEMP)

Environmental Water Quality and Estuarine Studies Branch
Office of Water Quality
Division of Environmental Sciences
California Department of Water Resources
July
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1.0 Approval Signatures

DES Office of Water Quality Chief:

X:	Date:

DES EWQES Branch Chief:

X:	Date:

DES Continuous Environmental Monitoring Program Manager:

X:	Date:

DES Continuous Environmental Monitoring Program Project Leader:

X:	Date:

DES Quality Assurance Officer:

X:	Date:

SWRCB Contract Manager:

X:	Date:
SWRCB Quality Assurance Officer:	
X:	Date:

2.0 Table of Contents

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2.3 List of Abbreviations

BDO	Bay Delta Office
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEMP	Continuous Environmental Monitoring Program
CVP	Central valley Project
DES	Division of Environmental Services
DO	Dissolved Oxygen
DQI	Data Quality Indicator(s)
DQO	Data Quality Objective(s)
DTS	Division of Technology Services
DWR	Department of Water Resources
EPA	Environmental Protection Agency
EWQES	Environmental Water Quality and Estuarine Studies
FLIMS	Field and Laboratory Information Management System
IEP	Interagency Ecological Program
MQO	Minimum Quality Objective(s)
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RWQCB	Regional Water Quality Control Board
SOP	Standard Operating Procedure
SWAMP	Stream Water Ambient Monitoring Program
SWP	State Water Project
SWRCB	State Water Resources Control Board
USBR	US Bureau of Reclamation
USGS	United States Geological Survey
WDL	Water Data Library
WQP	Water Quality Portal
YSI	Yellow Springs Inc.
BDO	Bay Delta Office
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEMP	Continuous Environmental Monitoring Program

3.0 Distribution List

Project staff in the Department of Water Resources Continuous Environmental Monitoring Program and State Water Resources Control Board (SWRCB) staff are provided copies of this Quality Assurance Project Plan (QAPP) and any approved revisions of the plan. This plan will be available online so other interested parties also can benefit from its content.

4.0 Project-Task Organization

- A coordinated monitoring program has operated since the 1970's between the California Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) in cooperation with the U.S. Bureau of Reclamation (USBR). This also includes assistance from the California Department of Fish and Wildlife (CDFW), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS) under the Interagency Ecological Program (IEP) umbrella. Ultimately, they will provide information for water resource management in compliance with flow-rated water quality standards set forth in a series of Water Right Decisions (D-1379, D-1485, and D-1641). Since 1975, the DWR Bryte Laboratory has been responsible for laboratory analyses of both organic/inorganic and conventional analysis. The DWR Bryte Lab has maintained certification by the Environmental Protection Agency and the California Department of Health Services for water analysis since 1978. The laboratory results from Real-Time Monitoring Section are entered into the Field and Laboratory Information Management System (FLIMS) data base. On a regular basis data from the FLIMS database are loaded into DWR's Water Data Library (WDL) database. Real-Time Monitoring laboratory results are retrieved from the WDL and entered into the Discrete Water Quality database. The continuous water quality database Water Quality Portal (WQP) is loaded automatically every 15 minutes. The data is quality control edited approximately every month and the database is updated with edited data.

- The **EWQES Branch Chief** manages all DWR designated tasks and people related to the project. The Branch Chief is responsible for various project audits at their discretion to ensure the QAPP directives are met.
- The **CEMP Section Chief** is responsible for all contract management tasks including: invoicing and reporting, oversight of project progress, and for collaboration with other agencies and stakeholders active in the area.
- The **CEMP Section Leader** of this project is responsible for the scientific integrity of the data collection effort throughout the duration of the project. The Technical Leader responsibilities include maintaining the QAPP. The Section Lead is also responsible for technical dialogs with advisors and experts involved in the project.
- The DWR **Quality Assurance (QA) Officer** works independently from the CEMP Section Chief and the CEMP Section Lead, and is responsible for the implementation and management of DWR's QA program.
- **CEMP Staff Field Data Collectors, Laboratory Personnel, and Data Managers** will provide the workforce for all field collection activities, laboratory analyses, and data management functions of the project.

The Project Organizational Chart (Figure 4) and job descriptions for the key project personnel are provided below. Each position assures collection of quality data and timely delivery of reliable monitoring data.

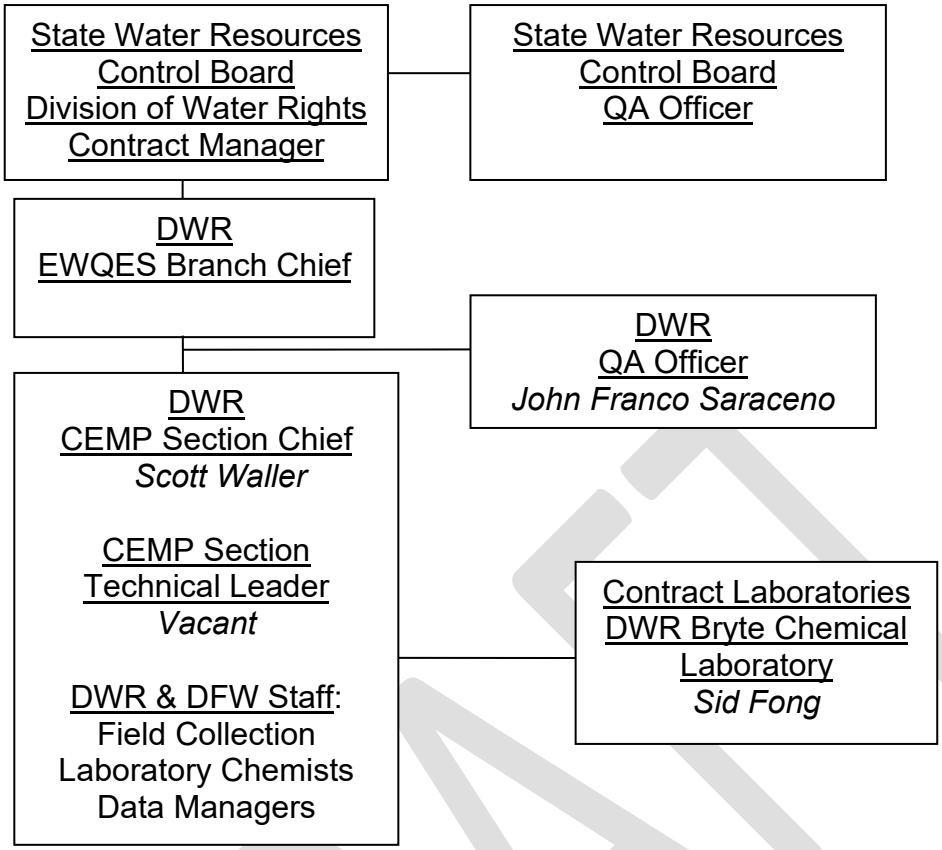

Figure 1 Project Organizational Chart

5.0 Problem Definition and Background

5.1 Project Background

Since 1983, the Department of Water Resources (DWR) has funded and staffed water quality and biological investigations in order to comply with existing and emerging regulatory requirements. Currently IEP funding for staff and contracts for DWR resides in the Division of Environmental Services, specifically in the Office of Water Quality, Environmental Water Quality Estuarine Studies Branch (EWQES). At the core of IEP compliance is Water Rights Decision D-1641. The summation of the mandated work in D-1641 is an ongoing assessment of the Sacramento San Joaquin Delta (Delta) and the impacts of water exports on the ecosystem, specifically the State and federal projects. The CEMP Section is one element of the Environmental Monitoring Program (EMP) which provides near real-time continuous water quality information for D-1641 compliance, State Water Project (SWP) operations, environmental issues and flood forecasting via telemetry to the Departments CDEC web portal and maintains a comprehensive database of water quality data (WQP). As we know, water quality can change frequently over time, necessitating frequent, repeated measurements to adequately characterize variations in quality. When the time interval between repeated measurements is sufficiently small, the resulting water-quality record can be considered continuous (typically every 15 min or every hour). A device that measures water quality in this way is called a continuous water-quality monitor (All our instruments are manufactured by the Yellow Springs Instruments (YSI), we are presently using the EXO2). The YSI EXO sondes have sensors and recording systems to measure physical and chemical water-quality field parameters at discrete time intervals at point locations. Operation of a water-quality monitoring station provides a nearly continuous record of water quality that can be processed and published or distributed directly by telemetry to the Internet (Selected data from all fifteen continuous sites is remotely telemetered through Campbell Scientific Data Loggers (CR-1000) to the California Data Exchange Center (CDEC) in Sacramento). The water-quality record provides a nearly complete record of changes in water quality that can also serve as the basis for computation of constituent loads at a site. Data from the sensors also can be used to estimate other constituents if a significant correlation can be established, often using regression analyses.

Continuous monitoring of water-quality field parameters, such as temperature, specific conductance, pH, dissolved oxygen, and turbidity, takes place in a wide variety of aquatic environments, ranging from clear, pristine, freshwater streams to biologically productive estuaries. Procedures for continuous monitoring in pristine, freshwater streams differ from those needed in coastal environments. Continuous monitoring in coastal environments can be challenging because of rapid biofouling from microscopic and macroscopic organisms, corrosion of electronic components from salt and high humidity, and wide ranges in values of field parameters associated with changing weather and tidal conditions such as our Martinez and Mallard stations.

Temperature and conductivity are physical properties of water bodies, whereas DO and pH are concentrations, and turbidity is an expression of the optical

properties of water (ASTM International, 2003). For the purposes of this report, all of these properties or constituents and the sensor values recorded by the EXO sonde are referred to as field parameters. Sensors also are available to measure other field parameters, such as water level, depth, chloride, and fluorescence. In addition to the measured field parameters, some monitors include algorithms to report calculated parameters, such as specific conductance. Emerging sensor technology broadens the variety of measurable chemical constituents and reduces the limits of detection. Because it has become possible to make near real- time water-quality monitoring data available on the Internet, continual progress is being made to improve applications and refine quality-control procedures.

5.2 Regulatory Information

Water quality data collected by DWR is used by a wide range of stakeholders including private individuals, public and private agencies, and is ultimately the foundation on which these agencies base water planning and management decisions. This monitoring provides data and reports that are used to investigate long-term changes in water quality and determine if water quality parameters are meeting Basin Plan Objectives established by SWRCB.The SWRCB sets water quality objectives to protect beneficial uses of water in the Sacramento-San Joaquin Delta and Suisun Bay. These objectives are met by establishing standards mandated in water right permits issued to the DWR and USBR by the SWRCB. The standards set minimum Delta outflows, limits to Delta water export by the State Water Project (SWP) and the Central Valley Project (CVP), and maximum allowable salinity levels. In 1971, the SWRCB established Water Right Decision 1379 (D-1379). This Decision contained new water quality requirements for the San Francisco Bay-Delta Estuary. D-1379 was also the first water right decision to provide terms and conditions for a comprehensive monitoring program to routinely determine water quality conditions and changes in environmental conditions within the estuary. The monitoring program described in D-1379 was developed by the Stanford Research Institute through a contract with the SWRCB. Implementation of the monitoring program began in 1972, as SWRCB, DWR, and USBR met to define their individual responsibilities for various elements of the monitoring program. In 1978, amendments to water quality standards were implemented and resulted in Water Right Decision 1485 (D-1485). More recently these standards were again amended under the 1995 Water Quality Control Plan and Water Right Decision 1641 (D-1641) established in 1999. The SWP and CVP are currently operated to comply with the monitoring and reporting requirements described in D-1641. D-1641 requires DWR and USBR to conduct a comprehensive environmental monitoring program to determine compliance with the water quality standards and also to submit an annual report to SWRCB discussing data collected. The original set of stations included both continuous recorders for salinity and temperature at shore stations. Discrete sampling sites reached by boat or by road. The original number of discrete stations was expanded in 1978 to accommodate compliance monitoring

for new water quality standards. The Real Time Monitoring Section started in 1983 with a goal to have continuous water quality monitoring to help with the water diversions at the Byron Pumping Plant by Tracy. The stations included Martinez, Mallard Island located on the Pittsburg power plant, Antioch, Rio Vista, and Stockton located on the Rough and Ready Island of the Port of Stockton, Mossdale landing located in Lathrop. These six main water quality stations collect stage, water temperature, specific conductivity, dissolved oxygen, pH, chlorophyll, and turbidity. Sacramento River at Hood station was started in 1998 to get a non-tidal 'rim' station on the Sacramento River. Prisoner's Point located on Mandeville Island was a temporary station that started in 1999 but became a full-time monitoring station in 2004. San Joaquin River at Vernalis was started in July 2005 to get a non-tidal 'rim' station for the San Joaquin to bring our total to nine main compliance stations. As the program expanded, meteorological instruments were added to collect air temperature, solar radiation, wind velocity, and wind direction.

These multi-parameter land-based compliance monitoring stations give a continuous record of hourly data, and now currently 15-minute data, on a real-time basis over a 30-year period. Prior to 2008, data on our database (Water Quality Portal) was only available in hourly intervals. For a short period of time (from 6/2/2005 to 10/06/2008), we were cross- checking our old Schneider instrument measurements with the new YSI Sonde instrument to ensure that their readings were close to each other.

IEP's 2003 Program Review recommended additions of continuous monitoring at four non-mandated EMP stations to improve monitoring efficiency and identifying the effects of State Water Project (SWP) operations and other factors on the Delta ecosystem. As a result, the CEMP Section installed four new pile monitoring stations that began operation on Jan 26, 2006 until Oct. 31, 2007 **(please see Section 6.2 for more detailed information on these 4 historic pile stations)**. In early June 2015, the California Department of Water Resources installed 10 new monitoring stations that were established for the Emergency Drought Barriers due to the four years of drought in California. As of now, all 10 new stations are funded for another year with most being funded longer term by Division of Environmental Services (DES), Bay Delta office (BDO), etc. As a result, the Real-time Section is in charge of the six out of ten pile stations, which are now permanent stations. These new pile stations are also operated under Decision 1641 which is mandated by State Water Resources Control Board (SWRCB) for San Francisco / Sacramento / San Joaquin Delta Estuary (Bay-Delta) Program. DWR now has the ability to analyze a wide range of physical, chemical, and biological parameters with its own in-house lab, Bryte Laboratory, located in West Sacramento.
As the importance and scope of water quality regulations increase over time in the California, we will need to provide the State and its constituents with easily accessible, current, and defensible water quality data in the DWR's Water Data

Library (WDL). The WDL database is managed by DWR which has streamlined the process of organizing and distributing water quality data. **(www.wdl.water.ca.gov)**.

5.3 Project Objectives

The program objectives approved by the SWRCB are included in their Bay-Delta Plan. Specifically, the program objectives are to:

1. Document compliance with Bay-Delta water quality objectives;
2. Provide information necessary to achieve compliance with revised salinity and flow standards as well as with dissolved oxygen standards
3. Document compliance with the State Water Resources Control Board Water Right Decision 1641 (D-1641), which permits DWR and USBR to operate the State Water Project and Central Valley Project.
4. Coordinate IEP and Non-IEP Bay-Delta monitoring programs to minimize duplication and facilitate the exchange of data
5. Develop and improve predictive tools (models) to evaluate project and non-project effects
6. Maintain a long-term baseline record and provide a consistent, long term record of trends;
7. Increase the current understanding of large-scale characteristics and functions of the Delta ecosystem to better predict system-wide responses to management options
8. Develop and improve predictive tools to assess changes within the Bay-Delta System (System) including impacts from operation of the SWP and CVP;
9. Provide accurate and validated water quality information on a timely basis in a format appropriate for a variety of users;
10. Respond to the findings of ongoing monitoring, changing conditions within the System, and the needs of Management with special studies to provide needed information in a timely manner.
11. Produce an annual water quality conditions report as required by the SWRCB and to write annual status and trend articles for the Interagency Ecological Program.

CEMP emphasizes capturing large quantities of data on continuous multi-parameter elements (specific conductance, dissolved oxygen, pH, water temperature, turbidity, and chlorophyll. At eight of the nine land-based stations the additional constituents of air temperature, wind velocity and direction, and solar radiation will also be measured. Data from the continuous monitoring sites are telemetered to DWR's CDEC web portal. All data collected from the stations are ultimately stored in a comprehensive Water Quality Portal database where quality assurance and quality control is performed by CEMP staff. DES staff continues to develop a database that is expected to be a major upgrade over what we have ever had. The WQP database will include a public web portal with

a map driven front end to help users access the data more easily. CEMP staff also responds to operational needs as they arise.

6.0 Project/Task Description

6.1 Summary of Work

The Continuous Environmental Monitoring Program (CEMP) monitors Delta water 24 hours a day, every day. Currently, CEMP sites are sampled continuously every quarter hour with *in-situ* sampling equipment. Data is transmitted to the California Data Exchange Center (CDEC) and Water Quality Portal (WQP) database via telemetry real-time data to provide information on Delta conditions. At the three bay stations: Martinez, Mallard Island, and Antioch, there are bottom sensors (Deployed at the fixed depth of 2 m above the river bottom) to monitor water temperature and specific conductivity that could be different from the surface due to stratification. The Rough and Ready station in the Stockton Deep Water Channel has a middle and bottom sonde to measure all parameters, but it is especially for the dissolved oxygen stratification. All of the water quality data are collected at a one-meter depth regardless of the stage level. At critical locations, redundant instruments are installed to ensure the constant availability of quality data.

6.2 Sampling Schedule

Continuous Sonde Sampling: Time-series data for all constituents will be collected at 15-minute intervals.

Field Sampling: Staff conduct station visits monthly (every 3-5 weeks) to verify and exchange sampling equipment. Equipment exchanges may be more frequent during the summer months, or when needed, due to increased fouling of the instruments.

6.3 Sampling Locations

The area monitored includes the Sacramento River from Hood downstream and San Joaquin River from Vernalis downstream, the Delta and Suisun Bay to Carquinez Straight **(Figure 2)** and click on each station code for the station Meta Data lookup (D6A, in Suisun Bay; D12A, D16A, P8A, C7A, C10A on the San Joaquin River; C3A, D10A, D24A, D11A on the Sacramento River; D29, D19A, D7A, D8A, D9A in the Delta).

These fifteen multi-parameter water quality monitoring stations continuously measure specific conductance, dissolved oxygen, pH, water temperature, turbidity, and chlorophyll samples throughout the Sacramento San Joaquin Delta at 15-minute interval. Eight of the nine land-based stations (With exception of the Prisoners Point site) measure the air temperature, wind velocity and direction, and solar radiation. . Bottom specific conductance and temperature are collected at the 3 (Martinez, Mallard, and Antioch) of the 15 multi parameter stations in support of X2 monitoring. In addition, CEMP is recording the water surface elevation at two (Martinez and Mallard Island) out of the fifteen multi-parameter stations in the Delta.

6.4 Constraints

While making the best effort to collect data, project constraints include:

- Equipment failures caused by the sensors, data loggers or support equipment. This has been reduced by our simplification of the stations and redundant equipment but will never be eliminated.
- Fouling of the sensors, drifting of the sensors, or a mis-calibration caused by a technician. The fouling is reduced by remotely monitoring the stations on a daily basis and exchanging equipment on a monthly basis. The calibration and drifting issues can be reduced by following established Quality Assurance/Quality Control (QA/QC) procedures.
- Vandalism or theft of equipment will result in loss of continuous data.

In the event one of these project constraints or unforeseen constraints occur the CEMP Chief will be notified immediately. The problem will be addressed and recorded in the project notes.

Table 1 Current Continuous Environmental Monitoring Program Stations with GPS Coordinates

Code	Name	CDEC Code	Longitude	Latitude
C10A	San Joaquin River near Vernalis @ SJR Club	SJR	-121.2637	37.67920
C3A	Sacramento River @ Hood	SRH	-121.5194	38.36780
D10A	Sacramento River @ Mallard Island	MAL	-121.91897	38.04310
D12A	San Joaquin River @ Antioch Ship Channel	ANH	-121.8063	38.01770
D24A	Sacramento River @ Rio Vista	RVB	-121.6853	38.16016
D6A	Sacramento River at Martinez	MRZ	-122.13903	38.02750
D29	San Joaquin River at Prisoners Point	PPT	-121.55736	38.05793
P8A	San Joaquin River @ Rough and Ready Island	RRI	-121.36587	37.96277
C7A	San Joaquin River @ Mossdale	MSD	-121.30666	37.78604
D7A	Grizzly Bay	GZL	-122.038120	38.124250
D8A	Suisun Cutoff near Ryer Island	RYC	-121.9958780	38.083971
D9A	Honker Bay	HON	-121.939200	38.072400

D11A	Sacramento River Near Sherman Lake	SSI	-121.761736	38.074097
D16A	San Joaquin River near Twitchell Island	TWI	-121.669100	38.096900
D19A	Franks Tract	FRK	-121.598100	38.046417

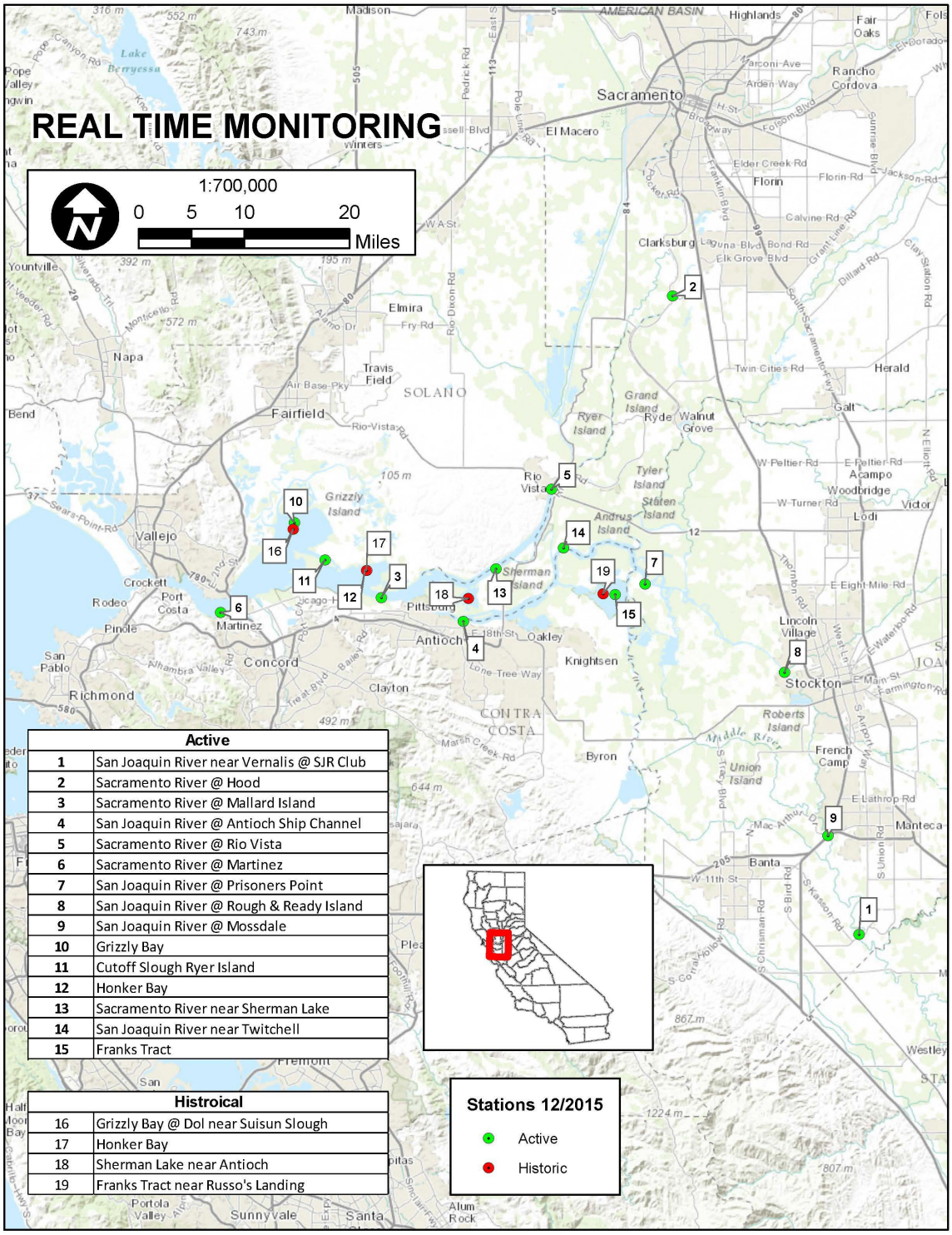

Figure 2 Map of Continuous Environmental Monitoring Program Stations

From 1978 to the later part of 2008 water samples were acquired hourly with meteorological variables sampled every quarter hour. Since 2008 all parameters are sampled every quarter hour.

6.5 Data availability in Water Quality Portal (WQP) Continuous Water Quality database

Although water quality data have been collected for some stations since 1968 under various programs, only data gathered by the EMP continuous water quality since 1983 are available in this database.

7.0 Quality Objectives and Criteria

7.1 Data quality indicators and data quality objectives

There are two types of quality objectives met by the CEMP. Measurement Quality Objectives (MQOs) relate to the quality of the measurement itself (e.g. accuracy or precision). The Data Quality Objectives (DQOs) relate to the entire data set its ability to answer a study question (e.g. completeness or representativeness).

The MQOs for field measurements are listed in Section 14. MQOs for the equipment used as secondary measurements for the water temperature, dissolved oxygen, specific conductivity, pH, and turbidity in this project are detailed in **Table 5**. With proper calibration as indicated in the Field Manual and relevant manufacturer guidance, the range, accuracy, and resolution of each instrument will meet the manufacturer's specifications and meet the MQOs for individual parameters. These parameters are:

- **Accuracy**: A measure of confidence that the data collected in the field and in the laboratory reflect the true value of a given parameter.
- **Range**: Expected values of environment to determine range for instrument calibration used to obtain a range of water quality parameters.
- **Resolution**: Fineness to which on instrument can be read

Adherence to the three data quality objectives of accuracy, range, and precision is essential to the QA/QC objectives of the project. These objectives will be monitored by CEMP staff to maintain the dataset of known and accepted quality.

7.2 Action Limits

An Action Limit is a measurement threshold at which a decision is made to take management action.

The primary objective of CEMP is to maintain a network of real-time telemetered water quality stations for monitoring compliance with water quality objectives established in the State Water Resources Control Board's (SWRCB) Water Rights Decision 1641 (D-1641), and Water Quality Control Plan 95-1 and Biological Opinions. The program provides baseline environmental information

for State Water Project (SWP) operations and special studies. Although no management actions will be directly taken by staff from CEMP, other groups in DWR use this information and check for compliance. In case, potential concerns are detected in the assessment, the information is reported with possible follow-up with the appropriate SWRCB or Regional Board staff.

As an example, adequate dissolved oxygen is required for the respiration of aquatic organisms, including fish. The 1995 Bay-Delta Plan contains a Dissolved Oxygen (DO) objective of 6.0 mg/L from September through November in the lower San Joaquin River between Stockton and Turner Cut to protect fall-run chinook salmon. The Central Valley Regional Water Quality Control Board (RWQCB) Basin Plan contains a DO objective for the entire Delta region of 5.0 mg/L throughout the year. Exceedances will be determined by the criteria in The Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin and the listing criteria for the current Integrated Report cycle. CEMP measures dissolved oxygen to document oxygen levels in order to maintain compliance with the mandated water quality objectives in the Bay-Delta and Basin Plans. If the CEMP Section has observed any DO values that exceed defined objectives (assuming instrumentation errors are ruled out), then the CEMP Chief must report his/her findings to the appropriate Regional Board program in a timely manner.

Additionally, the electrical conductivity and water temperature of water measured by CEMP should comply with D-1641 objectives. The SWP and CVP are currently required to comply with the monitoring and reporting requirements described in D-1641 and is required to submit an annual report to SWRCB to discuss the data collected and to report and discuss any exceedances.

7.3 Acceptance Criteria for Previously Collected Information

All previous data must meet the acceptance criteria outlined in this plan. Data that fails to meet the minimum requirements or cannot be substantiated due to lack of documentation is flagged in the database as unreliable.

7.4 Bias

Bias describes the tendency for under or over prediction of sampled or measured values relative to the true value. Bias is assessed using positive controls such as certified standards of known value and negative controls, such as de-ionized water (DIW) or air, and comparison to a reference sonde”

7.5 Representativeness

Representativeness describes how relevant the data are to the actual environmental conditions. An important role of the DWR Technical Leader is to actively participate in sample design development, training, and assessment of representativeness of the resulting data. Instrument deployments are determined to be representative by comparison to field meters.

Representativeness is controlled by strict adherence to all standard operating procedures that describe instrument calibration, handling, and deployment.

7.6 Completeness

Completeness is expressed as percent of valid usable data actually obtained compared to the amount that was expected. Sometimes, due to a variety of circumstances, either not all samples scheduled to be collected can be collected or else the data from samples cannot be used (for example, equipment failure or malfunction, or a *force majeure* event). The minimum percent of completed analyses defined in this section depends on how much information is needed for decision making. Generally, completeness goals rise the fewer the number of samples taken per event or the more critical the data are for decision making. Goals in the 75-95% range are typical.

8.0 Special Training Requirements/Certifications/Safety

8.1 Required Training and Certifications

Specialized training required is a combination of on-the-job training, following the Standard Operating Procedures for a project, using technical manuals, and periodic specialized classes (i.e. a class given by YSI / Xylem).

Other specialized training includes a QA/QC class, boat handling, CPR/First Aid, along with scientific workshops and conferences. Monthly safety meetings are required by the Department of Water Resources. All State employees who operate motor vehicles are required to attend Defensive Driver Training.

Field staff are required to periodically review the Field Sampling Procedures (Appendix A), Field Safety Manual, and EXOs Calibration Procedure (Appendix D), and etc.

Field staff are also required to read and review the appropriate tailgate field safety plan and Job Hazard Analysis (JHA) prior to conducting field work for any new project.

8.2 Training Schedule

The required course is provided by the Department of Water Resources on an annual or semi-annual basis.

8.3 Individuals Responsible

The CEMP Section Chief and the CEMP Technical Leader will ensure all field collection personnel are appropriately trained in field collection techniques, protocols, and the use of equipment in the field and laboratory as well as their personal safety

8.4 Training Documentation

A certification is provided to staff when they complete required training. Once a staff member receives their certificate, they are required to provide a scanned copy of the document to the Technical Leader for documentation purposes. Additionally, DWR administrative staff uploads the completed course information into the employee's training history record, which is accessible online. The Technical Leader or their designated leadsperson is responsible for keeping scanned copies of class certifications and the completed checklist for each employee.

9.0 Documentation and Records

Documents and records generated by CEMP will be organized and stored in compliance with this QAPP. This will allow for future retrieval, and to specify the location and holding times of all records.

9.1 QAPP Updates and Distribution

The Technical staff will be responsible for developing, maintaining, and updating the Quality Assurance Project Plan (QAPP) and it will be held by CEMP staff. This QAPP and its revisions will be distributed to all parties involved with the project. Copies will also be sent to the Bryte Laboratory manager for internal distribution. Upon revision, the replaced QAPPs will be kept on file for reference.

9.2 Data Records

CEMP collects data that can be generally divided into two groups:
1) Field data measurements,
2) Continuous sonde data.

Discrete field data measurements are collected and written onto field sheets. Hard copies of field sheets will be stored by CEMP and scanned sheets will be stored as PDFs on CEMP servers. All field measurements are entered into the WQP database, which is backed up daily and will be stored indefinitely.

Continuous sonde data is downloaded from the sondes when the sondes are exchanged, and the original file is stored on the CEMP data server for an indefinite amount of time. The data recorded from each CEMP station is automatically transmitted to the WQP database. QA/QC'd data is maintained by the staff and will be available to the public, upon request, for an indefinite amount of time.

The Technical staff will be responsible for making sure that personnel identified in **Figure 1** will receive the most current copy of the approved Quality Assurance Program Plan (QAPP).

9.3 Assessment Records

Inspection or assessment reports, corrective action reports, interim progress reports, final reports, evaluation summaries, and copies of presentations made during and after the project will all be stored digitally in a dedicated directory on CEMP servers. These documents will be organized and kept up-to-date by the CEMP Section Chief or designated DWR staff.

Annually, CEMP will prepare a brief report summarizing the data analyzed to date. This report will be submitted to the State Water Resources Control Board in compliance with D-1641.

9.4 Records Responsibility

The CEMP Section Chief will oversee the maintenance of all records and will arbitrate any issues related to records retention.

9.5 Archive Location and Duration

All records generated by this section will be stored at the CEMP office located on 3500 Industrial Way in West Sacramento. Data files and records made by CEMP will be maintained indefinitely.

9.6 Records Responsibility

The CEMP Section Chief or other assigned DWR staff will be responsible for archiving all other records.

9.7 Electronic Records Responsibility

All field operation records will be entered into electronic formats and maintained in a dedicated directory or databases.

The California Division of Technology Services (DTS) is responsible for back up of the DES servers. Incremental backups are done daily, and full backups are done once a week.

10.0 Sampling Process Design

Continuous monitoring multiparameter sondes measure water quality *in-situ*. A water quality sonde will be deployed at every station, and depending on the project and station objective, each sonde may have 1-6 probes and a depth sensor installed.

Each station sonde will be programmed to take measurements every quarter hour collecting continuous (also known as time-series) data. Stations will be serviced every 2-6 weeks, depending on the project objectives, weather conditions, equipment availability, seasonality, and staff schedules. Each station will be maintained indefinitely.

Generally, station accessibility is limited when water levels are exceptionally high, or inclement weather prevents station maintenance. Stations will be serviced when the station becomes accessible again (weather passes and/or water level decreases) and because sondes will be deployed with battery levels excessive to what they need for the minimum deployment time, so continuous/time series data will not be lost. However, field readings may not be taken, and this will be noted on the field sheet.

Potential sources of bias or misrepresentation include faulty calibrations, faulty probes and sondes. Additionally, due to site-specific constraints, some sites may be shallower or deeper than the desired depth due to varying water levels. These potential sources of bias will be included in field notes. Generally, staff attempt to minimize bias or misrepresentation by installing stations in the main flow of the channel. Section 7 addresses bias as well.

11.0 Sampling Methods

11.1 Continuous Sampling methods

Continuous sonde *in-situ* water quality and meteorological measurements are logged once every quarter hour by a Campbell data logger. Table 2 lists equipment and sampling method for each CEMP station. The data are transmitted via cellular modem the CEMP telemetry server, where the data are ingested and archived. Data are uploaded to the CEMP WQP database and to CDEC.

Support equipment is usually installed in a weather-tight aluminum “Traffic Box” containing a data logger, wireless cellular modem, deep cycle battery, and a solar charge controller. Solar panels are installed for battery charging purposes.

Station sondes are deployed in a PVC deployment tube that is attached to support structures. PVC deployment tubes have evenly spaced holes for the entire length of the tube at and below the high tide of record to allow water to flow across the sensors. CEMP surface sonde deployments are set up in two types of configuration: floating or fixed. Floating deployments keep the sonde at a constant depth, approximately 1 meter below the surface. Fixed deployments keep the sonde at a constant location in the deployment tube and the depth of the sonde varies with stage.

At some stations, a sonde is deployed at the bottom of the water column at a fixed depth, approximately 2 meters from the channel bottom. The sonde is connected to a wire that is held in place by a weight resting on the channel bed. A station may also have a sonde deployed in the middle of the water column, fixed approximately 3 meters above the channel bottom.

Meteorological measurements are taken from equipment (**Table 4**) mounted on masts above the station, typically 5 meters above the deck, and clear from any obstruction that may affect wind measurements.

11.2 Sampling Corrective Action

For all sampling, if equipment fails, a sample is not collected, or a measurement is missed, the incident will be documented on the field sheet along with any relevant information (batteries appear to be dead, equipment malfunctioning, etc.). Corrective measures will be taken by staff in the field doing the sampling if possible, otherwise staff will inform the Section Lead, who will take corrective measures if possible.

If a probe on a sonde is out of acceptance criteria, the sonde will be replaced with a calibrated backup. The malfunctioning probe will be repaired in the laboratory or returned to the manufacturer for repair. All information related to the

probe inspection must be recorded on a field form, which is the basis for data corrections made during the QA/QC data review.

Table 2 Types of Equipment Deployed at CEMP Stations

Station	Location	Surface Equipment	Bottom Equipment	Meteorological Equipment	Stage Equipment
C10A	San Joaquin River near Vernalis @ SJR Club	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
C3A	Sacramento River @ Hood	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D10A	Sacramento River @ Mallard Island	YSI EXO2	YSI EXO1	-RM Young 5106 -Met One air temp -Li-COR 200R	Bubbler
D12A	San Joaquin River @ Antioch Ship Channel	YSI EXO2	YSI EXO1	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D24A	Sacramento River @ Rio Vista	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D6A	Sacramento River at Martinez	YSI EXO2	YSI EXO1	-RM Young 5106 -Met One air temp -Li-COR 200R	Bubbler
D29	San Joaquin River at Prisoners Point	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
P8A	San Joaquin River @ Rough and Ready Island	YSI EXO2	YSI EXO2 YSI EXO2 (middle)*	-RM Young 5106 -Met One air temp -Li-COR 200R	None

C7A	San Joaquin River @ Mossdale	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D7A	Grizzly Bay	YSI EXO2	None	-RM Young 5106	None
D8A	Suisun Cutoff near Ryer Island	YSI EXO2	None	None	None
D9A	Honker Bay	YSI EXO2	None	None	None
D11A	Sacramento River Near Sherman Lake	YSI EXO2	None	None	None
D16A	San Joaquin River near Twitchell Island	YSI EXO2	None	None	None
D19A	Franks Tract	YSI EXO2	None	-RM Young 5106	None

Surface Water Quality Parameters: Water Temperature, Specific Conductivity, Dissolved Oxygen, pH, Turbidity, Fluorescence

Bottom Water Quality Parameters: Water Temperature, Specific Conductivity. Note: The bottom sonde at P8A, San Joaquin River @ Rough and Ready Island, collects the six parameters listed in surface measurements. Station P8A also collects the same six parameters in the middle of the water column.

Meteorological Parameters:
Wind Speed and Wind Direction (RM Young 05106), Air Temperature (Met One Temperature Sensor), Solar Radiation (Li-COR 200R).

12.0 Sample Handling and Custody

Water quality is measured *in-situ* via multi-parameter sonde. See Section 19 for management of CEMP data. Laboratory samples are not generated as part of this project.

13.0 Analytical Methods and Field Measurements

13.1 Water Quality Measurements

Water quality measurement methods used by CEMP are based on the following procedures:

- YSI EXOs Multiparameter Water Quality Sondes User Manual **(Appendix C)**
- Continuous Environmental Monitoring Program Field and Lab Manual **(Appendix D)**

Sondes are deployed in the field for 2-6 weeks, depending on the season, to prevent excess biofouling and to ensure that calibrations of the probes do not drift outside acceptable limits. During summer months, biofouling tends to be more prevalent, so sondes exchanges may be more frequent. EXO2 sondes are equipped with wipers to prevent biofouling on the sensor faces. Sondes are configured to store raw data on internal memory.

Table 3 outlines the types of sensors used for each water quality parameter sampled, as well as their range, accuracy, and resolution.

Table 3 CEMP Water Quality Sensors

Parameter	Sensor Type	Units	Range	Accuracy	Resolution
Temperature	EXO,Thermistor	°C	-5 to 50 °C	±0.2°C	0.001°C
Dissolved Oxygen	EXO, Optical Luminescence lifetime	mg/L	0 to 20 mg/L, 20 to 50 mg/L	± 0.1 mg/L or 1% of reading, ±5% of reading	0.01 mg/L
Specific Conductance	EXO, 4 AC electrode	µS/cm	0 to 100,000 µS/cm	±2 µS/cm or 1%	0.1 to 10 µS/cm, (range dependent)
pH	EXO, Glass Electrode	pH units	0 to 14	±0.2 pH units	0.01
Turbidity	EXO, Optical Nephelometric	NTU	0 to 999 FNU, 1000 to 4,000 FNU	±0.3 FNU or 2% of reading, ±5% of reading	0.01 FNU, 0.1 FNU
Chlorophyll	EXO, Optical Fluorescence	µg/L	0 to 400 µg/L	Linearity: $r^2 \geq 0.999$ for Rhodamine WT across full range	0.1 µg/L

13.2 Meteorological and Stage Measurements

Meteorological and Stage measurements used by CEMP are based on the Continuous Environmental Monitoring Program Field and Lab Manual. Raw data from these sensors are stored on the Campbell datalogger.

Table 4 outlines the types of sensors used for meteorological and stage measurements, as well as its range, accuracy, and resolution.

Table 4 Meteorological and Stage Sensors

Parameter	Instrument	Units	Range	Accuracy	Resolution
Stage	YSI Amazon Bubbler	ft.	0 to 34.6 ft	0.007 ft	0.01 ft
Air Temperature	HygroVue 10	°C	-20 to +60°C	±0.1°C	0.001°C
Wind Direction	R.M. Young 05106	Degrees	0 to 360°	±3° of reading	0.1°
Wind Velocity	R.M. Young 05106	m/s	0 to 100 m/s	± 0.3 m/s or 1% of reading	0.1 m/s
Solar Radiation	Li-COR 200R	Watts/m^2	0 to 3000 Watts/m^2	±2% of reading	0.1 Watts/m^2

14 Quality Control

Quality Control includes activities that measure the attributes and performance of the sampling and analysis process against defined standards to verify that they meet the needs of the project.

14.1 Probe Fouling and Drift

USGS-based drift measurement calculations measure the combined effect of fouling and calibration drift that naturally occurs during an extended *in-situ* sonde deployment.

Total drift is calculated by combining fouling drift and calibration drift. This measurement is used to validate station data over the course of the sonde deployment and assign a data quality rating to the measured parameter (Table 5).

$$T = |F| + |C|$$

Where:
T = total drift
F = fouling drift
C = calibration drift

Fouling drift is assessed by calculating the difference between an initial measurement and a measurement taken after any fouling has been removed. During this procedure, an additional verification sonde is deployed at the same location, with measurements taken at the same times. Verification sonde measurements are used to correct for any changes that may occur during the fouling drift procedure.

$$F = (P_i - P_f) - (V_i - V_f)$$

Where:
P_i = Probe initial (not cleaned)
P_f = Probe final (cleaned)
V_i = Verification initial
V_f – Verification final

Calibration drift is assessed at the conclusion of deployment after the probe has been brought back to the lab. Measurements are taken in calibration standards and the difference between the measurement and standard value is calculated.

$$C = P_v - S_v$$

Where:
P_v = probe value
S_v = standard value

Table 5 Data Quality Ratings Table for Total Drift

Parameter	Excellent	Good	Fair	Poor	Max. Limit	Units
Water temperature	≤±0.2	±0.2-0.5	±0.5-0.8	±0.8-2.0	>±2.0	°C
Specific Conductivity	≤±3%	±3-10%	±10-15%	±15-30%	>±30%	µS/cm
Dissolved Oxygen	≤±0.3 or ≤±5%	±0.3-0.5 or ±5-10%	±0.5-0.8 or ±10-15%	±0.8-2.0 or ±15-20%	>±2.0 or >±20%	mg/L
pH	≤±0.2	±0.2-0.5	±0.5-0.8	±0.8-2.0	>±2.0	pH units
Turbidity	≤±0.5 or ≤±5%	±0.5-1.0 or ±5-10%	±1.0-1.5 or ±10-15%	±1.5-3.0 or ±15-30%	>±3.0 or >±30%	FNU

15.0 Instrument/Equipment Testing, Inspection, and Maintenance

15.1 Field Equipment Testing, Inspection and Maintenance

Field equipment is typically calibrated monthly. During hotter, drier months, bio-fouling can be higher so sondes are exchanged for newly calibrated sondes bi-weekly. Batteries are replaced when voltage drops below 50% battery life as determined by YSI KorEXO software, or as needed. Equipment that is not operating within the manufacturer's specifications will be shipped back to the manufacturer for testing and repair. Instruments are calibrated according to the Calibration and Maintenance for YSI Multi-parameter Water Quality Instruments (Xylem EXO and ProDSS) document created by the Quality Assurance- Real-Time Data Subcommittee. Malfunctions while in the field will be noted on the site visit records. Spare sensors, sondes, and batteries are stored at the CEMP water quality lab. Probes, sondes, and batteries are purchased as needed, at least once a year.

15.2 Sonde Equipment Testing, Inspection and Maintenance

In addition to the routine station visits, the maintenance frequency is also governed by the fouling rate of the sensors. This rate varies by sensor type, hydrologic and environmental conditions, and season. The performance of temperature and specific conductance sensors tends to be less affected by fouling than DO, pH, and turbidity sensors. The use of a wiper on modern turbidity, dissolved oxygen, and chlorophyll instruments has substantially decreased equipment fouling in some aquatic environments. For sites with data-quality objectives that require a high degree of accuracy, maintenance is done bi-weekly or more often. In addition to fouling problems, monitoring disruptions of data collection to the CEMP server and CDEC which can occur from the recording equipment, sedimentation, electrical disruption, debris, or vandalism also may require additional site visits. Specific maintenance requirements depend on the site configuration and equipment.

Sonde and sonde probes will be checked for cleanliness, calibrated, and batteries will be replaced as needed See Appendix D for calibration methods.

Repairs will be tracked by CEMP Section Lead. CEMP staff are responsible for keeping track of equipment and spare probes associated with the sondes. Spare probes, batteries, and parts are stored in the CEMP water quality lab.

Sonde instruments and their specifications are listed in Table 3. Field instrument maintenance will be performed every 2-6 weeks.

Table 6 General maintenance tasks at a water-quality monitoring station

Daily maintenance tasks

- Daily review of station operational status to include station power, sensor performance, and data transfer to telemetry server and WQP - If station operational status or sonde data appears questionable, prepare a freshly calibrated sonde and schedule a station visit for investigation and possible sonde replacement
Maintenance tasks during field visits
- Inspection of the site for signs of physical damage or issues in need of repair - Inspection and cleaning of float and other instrument infrastructure - Battery (or power) check - Check time; verify time on logger and adjust if needed. - Verify water quality instruments with calibrated verification instrument using the Wagner Method for QA

16.0 Instrument/Equipment Calibration and Frequency

CEMP staff are responsible for calibrating sondes for their stations. Sondes will be calibrated prior to each deployment. CEMP's Standard Operating Procedure, Calibration and Maintenance for YSI Multi-Parameter Water Quality Instruments (Appendix D), which describes how calibrations should be performed and documented, and how deficiencies should be resolved and documented.

17.0 Inspection/Acceptance of Supplies and Consumables

All supplies are examined for damage as they are received and then again as they are put into use. Containers are inspected for breakage and proper sealing of caps. Standards and other consumables are inspected for conformance with any labeled expiration dates and lot numbers are tracked on sonde calibration forms and consumable manufacturer certification sheets are tracked in binders in the CEMP lab. Reusable supplies are examined for acceptable cleaning and reuse. Any supplies deemed to be in unacceptable condition are replaced. The CEMP Section Lead is responsible for tracking, storing, and retrieving supplies.

A complete list of supplies used by CEMP can be found in the Calibration and Maintenance for YSI Multi-Parameter Water Quality Instruments Standard Operating Procedure (Appendix D).

18.0 Non-direct Measurements

This QAPP does not include the use of routine data obtained from non-direct measurement sources.

19.0 Data Management

19.1 Data Management Scheme

Continuous water quality data, meteorological data, and stage data are sent via a cellular modem from the stations to the CEMP telemetry server every 15 minutes. Data are stored directly on the server and then imported into the WQP database. Provisional data (non-quality assured) is also uploaded directly to the California Data Exchange Center (CDEC) and made available online.

Site visit, instrument drift, fouling, and calibration information are recorded on field data sheets, instrument calibration sheets, and instrument post-deployment sheets. These sheets are stored on the CEMP network drive.

19.2 Continuous Monitoring Raw Data

When sampling equipment is brought back from the field, data files are downloaded from the sonde in the original raw format and stored on a networked folder. To ensure data are easily accessible, sonde data are also stored as a csv file on the network drive.

19.3 Responsibility for Data Management

CEMP staff are responsible for the data management of the stations they maintain.

19.4 Acceptability of Hardware and Software Configurations

Hardware and software are updated as recommended by the manufacturer or as needed. Each entity is responsible for the necessary updates or upgrades, whether provided regularly through an Information Technology department or otherwise.

20.0 Assessments and Response Actions

Assessment and oversight ensure that the QA Project Plan is being implemented as planned and that the project activities are on track. By implementing proper assessment and oversight, critical problems with any of the stations are minimized.

The Section Lead will report any problems detected and the corrective measures taken to the Section Chief and these are discussed by staff and Section Lead during the weekly Section meeting under the “Station Status Update” in the agenda.

20.1 Readiness Reviews

The staff member conducting a field visit will review all field equipment, instruments, supplies, and paperwork to ensure that everything is ready prior to each field visit. Equipment will be checked to make sure that it has been cleaned and in working order. Equipment maintenance records will be checked to ensure that it has been properly maintained and all calibrations are current. Supplies will be checked to ensure that there are adequate supplies to support the field visit. If a problem is discovered during a readiness review, it will be corrected prior to the field visit and documented along with the actions taken to correct the problem.

20.2 Post Sampling Event Reviews

Post sampling event reviews are conducted following each sampling event to ensure that all data information is complete and any deviations from planned methodologies are documents. The staff member conducting a field visit is responsible for the post sampling event review. Any problems noted during the sampling event are documented along with recommendations for correcting the problem. Reports for each post sampling event will be used to identify areas that may be improved prior to the next sampling event.

20.3 Field assessments

Periodically, the QA Officer or other delegated QA Program staff will review program data, records, and field process, in person or remotely. In addition to a written assessment, any and all findings will be communicated verbally first to CEMP field staff involved in the assessment, the CEMP Section Chief and the QA Officer. Depending on the significance of the finding, additional management may be informed.

21.0 Reports to Management

21.1 Project quality assurance reports

On a semi-annual basis, a short-written report documenting any QA/QC deficiencies (missing data, outliers, replicate data that doesn't meet the data quality objectives, etc.) will be submitted to the CEMP Section Chief. The report will also discuss the data validity and completeness.

21.2 Responsible individuals

- CEMP technical lead – responsible for drafting report
- CEMP Section Chief guidance will finalize report.
- The final report will be sent the EWQES Branch Chief and the QA/QC officer for joint approval.

22.0 Data Review, Verification, and Validation

Data review, verification, and validation procedures helps to ensure that the data will be reviewed in an objective and consistent manner. Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. The Section Lead is responsible for data review. This includes checking that all technical criteria have been met, documenting any problems that are observed and, if possible, ensuring that deficiencies noted in the data are corrected.

22.1 Checking for Typical Errors

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

22.2 Checking Against Method Quality Objectives (MQOs)

Data generated by field activities will be reviewed against MQOs. This will ensure that the data will be of acceptable quality and that it will be comparable with respect to minimum expected MQOs.

22.3 Checking Against QA/QC

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

22.4 Checking Field Data

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

22.5 Data Verification

Data verification is the process of evaluating the completeness, correctness, and conformance / compliance of a specific data set against the method, procedural, or contractual specifications. We will conduct data verification, as described in the Quality Control section, in order to ensure that it is comparable with respect to completeness, correctness, and conformance with minimum requirements. CEMP Staff are responsible for verification of data going into WQP.

22.6 Data Validation

Data validation is an analytic 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. CEMP Staff will conduct data validation in order to ensure that the data are comparable with respect to their end use. CEMP Staff are responsible for validation of data going into WQP.

22.7 Data Separation

Data will be separated into three categories for use with making decisions based upon it. These categories are:

1. data that meets all acceptance requirements,
2. data that has been determined to be unacceptable for use, and
3. data that may be conditionally used and that is flagged as per QA/OC specification.

23.0 Verification and Validation Methods

The station operator documents any problems identified during a station visit in WQP that detail any anomalies and affected data. Data validators may qualify data based on this information.

Each business day, the station operators and the assigned data validator monitor water quality measurements, sample depth measurements, and station communications for anomalies. Data validators may qualify data based on this information.

The WQP database automatically flags data as Unchecked as it comes into the database. WQP will automatically flag data as Missing when it is not retrieved from the data logger because of power outages, equipment malfunction, etc.

After each sonde deployment period, station operators perform a post-deployment check to determine total drift for each probe. If a probe fails the check with a total error beyond the Maximum Allowable Limit (See Section 14), data collected by that probe is flagged as Bad for the deployment period.

On a monthly basis, data validators perform data review using the WQP interface to graphically display the data. Data are reviewed for integrity, continuity, and reasonableness. Any data deemed questionable by the data validator due to inexplicable extreme values, data dropouts, flat-lined data, etc. may be flagged as Bad data.

Data that pass the above checks are flagged as Good data by the data validator. See Table 7 for a list of QA/QC flags and their definitions.

Table 7 QA/QC Flags

Flag	Definition
G	Good Data - These data have been reviewed and it was determined that they reflect measurements made by equipment that was calibrated to a standard and was operating normally.
X	Bad Data - These data have been reviewed and it was determined that they reflect measurements made when equipment that was out of calibration or was not operating normally.
M	Missing Data - These data are known to be missing for one of the following reasons: logging was off (during a visit for instance), logger failure, etc.
U	Unchecked - These data have not yet been reviewed and may include measurements made by equipment that was out of calibration or was not operating normally.

24.0 Reconciliation with User Requirements

The data quality is evaluated according to this document, with respect to sampling method, field and laboratory analysis, and quality control. Data will be evaluated using Sections 7 through 23. By properly following the guidelines in each of these sections, the data quality will be validated—if samples fail to meet these guidelines, the data quality will be questioned and flagged (**Table 5**). Flagged data (**Table 7**) will be carefully scrutinized to determine if the data can be included in the final analysis.

24.1 Reporting of Data Limitations

Data limitations are reported to data users through a combination of flags for suspect data and metadata files available upon request. Metadata files include information such as the methods used, method detection limits, scope of the project, etc. Additionally, fields will be included in the data that indicate information pertinent to data users, such as the method used, method detection limits, units, etc.

21.2 Data use in SWAMP context

Not Applicable.

-END OF DOCUMENT-

Revision History

Revision	Effective Date	Section	Description of Change	Justification of Change

References

A. Methodological Texts

1. Bryte Chemical Laboratory Quality Assurance Manual. 2021. DES-1-MNL-001. Department of Water Resources Publications, Sacramento, California. 48 pp.
2. Methods for Chemical Analyses of Water and Wastes. 1983. EPA-600/4-79-020.

Appendices

Appendix A: CEMP Field and Lab Manual

CEMP Field & Lab Manual_workingdra

Appendix B: Site Visit Record

CEMP Site Visit Sheet.xlsx

Appendix C: YSI EXO User Manual

exo-user-manual.pdf

Appendix D: Calibration and Maintenance for YSI Multi-Parameter Water Quality Instruments (Xylem EXO and ProDSS)

Maintenance and Calibration for Mult

Appendix E: Calibration Sheet

CEMP Sonde Calibration Sheet.xls

Appendix E

DWR Division of Integrated Science and Engineering. 2022. Discrete Environmental Monitoring Program field and laboratory manual. Version 6. 83 pp.

CALIFORNIA DEPARTMENT OF WATER RESOURCES
DIVISION OF INTEGRATED SCIENCE AND ENGINEERING

DISCRETE ENVIRONMENTAL MONITORING PROGRAM

FIELD AND LABORATORY MANUAL

SEPTEMBER 2022

VERSION 6.0

STATUS: APPROVED
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APPROVAL SIGNATURES

Discrete EMP Supervisor: Theodore Flynn

Signature: _____ Date: 9/8/2022

Discrete Water Quality Lead: Morgan Battey

Signature: Morgan Battey Date: 9/8/2022

Discrete Water Quality Lead: Sarah Perry

Signature: Sarah Perry Date: 9/12/2022

Discrete Water Quality Lead: Julianna Manning

Signature: Julianna Manning Date: 9/8/2022

Zooplankton Lead: Arthur Barros

Signature: Arthur Barros Date: 9/8/2022

Benthic Lead: Betsy Wells

Signature: Elizabeth Wells Date: 9/8/2022

Phytoplankton Lead: Tiffany Brown

Signature: Tiffany Brown Date: 9/8/2022

Crew Members

Signature: Laurel Richardson Date: 9/8/2022

Signature: Allegra Rocha Date: 9/12/2022

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FIGURES

TABLES

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ACRONYMS AND ABBREVIATIONS

CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
COC	Chain of Custody
DEMP	Discrete Environmental Monitoring Program
DI	De-ionized
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DWR	California Department of Water Resources
EMP	Environmental Monitoring Program
EPA	Environmental Protection Agency
EZ	Entrapment Zone
FLIMS	Field and Laboratory Information Management System
FNU	Formazin Nephelometric Unit
GPS	Global Positioning System
IEP	Interagency Ecological Program
L	Liters
MCE	Mixed Cellulose Ester
MD	Mid Delta
mL	milliliter
mm	millimeter
µm	micrometer
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
NIST	National Institute of Standards and Technology
ODO	Optical Dissolved Oxygen
PFD	Personal Flotation Device
QAPP	Quality Assurance Project Plan
RFU	Relative Fluorescence Units
RV	Research Vessel
SFE	San Francisco Estuary
SOP	Standard Operating Procedures
SpC	Specific Conductance
SR	Sacramento River
TOC	Total Organic Carbon
VOA	Volatile Organic Analysis
YSI	Yellow Springs Instrument

BACKGROUND

Under the Interagency Ecological Program (IEP), the Environmental Monitoring Program (EMP) monitors the water quality conditions and biological communities in the San Francisco Estuary (SFE). The water quality, zooplankton, and benthic components of the program are mandated by Water Right Decision 1641 and provide necessary information for compliance with flow-related water quality standards associated with the operations of the California water projects. Zooplankton data collection is performed for the California Department of Fish and Wildlife (CDFW).

The objectives of the Environmental Monitoring Program are:

- to obtain consistent and accurate monthly data at established monitoring stations
- to provide and document information necessary to achieve compliance with salinity, flow, and dissolved oxygen standards
- to analyze data that enhances understanding of estuarine ecology
- to report this information to other state/federal/local agencies, as well as the public, enabling the management and conservation of the upper SFE

This field and laboratory manual is a guide and collection of Standard Operating Procedures (SOPs) specific to mandated projects undertaken by the Discrete EMP (DEMP) unit and does not include continuous monitoring or special studies protocols. This manual undergoes a full revision process annually to incorporate any changes made to the procedures outlined and is reviewed and approved by all members of the DEMP unit.

A Quality Assurance Project Plan (QAPP) details the procedures required to carry out a specific sampling project and may reference a protocol included in this manual. Field crews should review specific project plans for additional information specific to their study that may not be included in this manual.

Discrete Water Quality Monitoring

DISCRETE WATER QUALITY MONITORING STATIONS

The Discrete EMP unit collects discrete water quality data monthly at 24 fixed stations, three of which are accessible from shore by vehicle, while the remaining 21 are accessed via vessel (**Table 1**). These monitoring stations range from San Pablo Bay east through the upper estuary to the mouths of the Sacramento, Mokelumne, and San Joaquin rivers (**Figure 1**). DEMP also samples 2-4 stations each month that have varying geographic locations. These locations are determined by specific conductance values that indicate the presence of the entrapment zone (EZ). All stations are sampled within approximately one hour of high slack tide.

Table 1-Discrete Water Quality Monitoring Station Locations and Descriptions

Station Name	Location	Region	Habitat Type	Accessed By
C10A	San Joaquin River near Vernalis	Southern Delta	Tidal River Channel (Freshwater)	Vehicle
C3A	Sacramento River at Hood	Northern Delta	Tidal River Channel (Freshwater)	Vehicle
C9	West Canal at Clifton Court	Southern Delta	Tidal River Channel (Freshwater)	Vehicle
D10	Sacramento River at Chipps Island	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
D12	San Joaquin River at Antioch Ship Channel	Western Delta	Tidal River Channel (Brackish Water)	Vessel
D16	San Joaquin River at Twitchell Island	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
D19	Franks Tract near Russo's Landing	Lower San Joaquin	Flooded Island/Shallow Lake (Freshwater)	Vessel
D22	Sacramento River at Emmaton	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D26	San Joaquin River at Potato Point	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
D28A	Old River opposite Rancho Del Rio	Central Delta	Tidal River Channel (Freshwater)	Vessel
D4	Sacramento River above Point Sacramento	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D41	San Pablo Bay near Pinole Point	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
D41A	San Pablo Bay near Mouth of Petaluma River	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel

D6	Suisun Bay off Bulls Head near Martinez	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
D7	Grizzly Bay at Dolphin near Suisun Slough	Suisun Bay	Estuarine Embayment (Brackish Water)	Vessel
D8	Suisun Bay off Middle Point near Nichols	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
EZ2	Entrapment Zone - Location determined when bottom SpC values occur at approx. 2,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ2-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ2	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6	Entrapment Zone - Location determined when bottom SpC values occur at approx. 6,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ6	n/a	Estuarine Channel (Brackish Water)	Vessel
MD10A	Disappointment Slough near Bishop Cut	Eastern Delta	Tidal River Channel (Freshwater)	Vessel
NZ002	Carquinez Strait near Glen Cove-tow conducted when surface SpC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ004	Ozol near Martinez and Light 25-tow conducted when surface EC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ032	Montezuma Slough, 2nd bend from mouth	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel
NZ068	Sacramento River at US Coast Guard Station	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
NZ325	San Pablo Bay near Light 15- tow conducted when surface SpC values occur below 20,000 µS	San Pablo Bay	Estuarine Channel (Brackish Water)	Vessel
NZS42	Suisun Slough 300' south of Volanti Slough	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel
P8	San Joaquin River at Buckly Cove	Southern Delta	Tidal River Channel (Freshwater)	Vessel

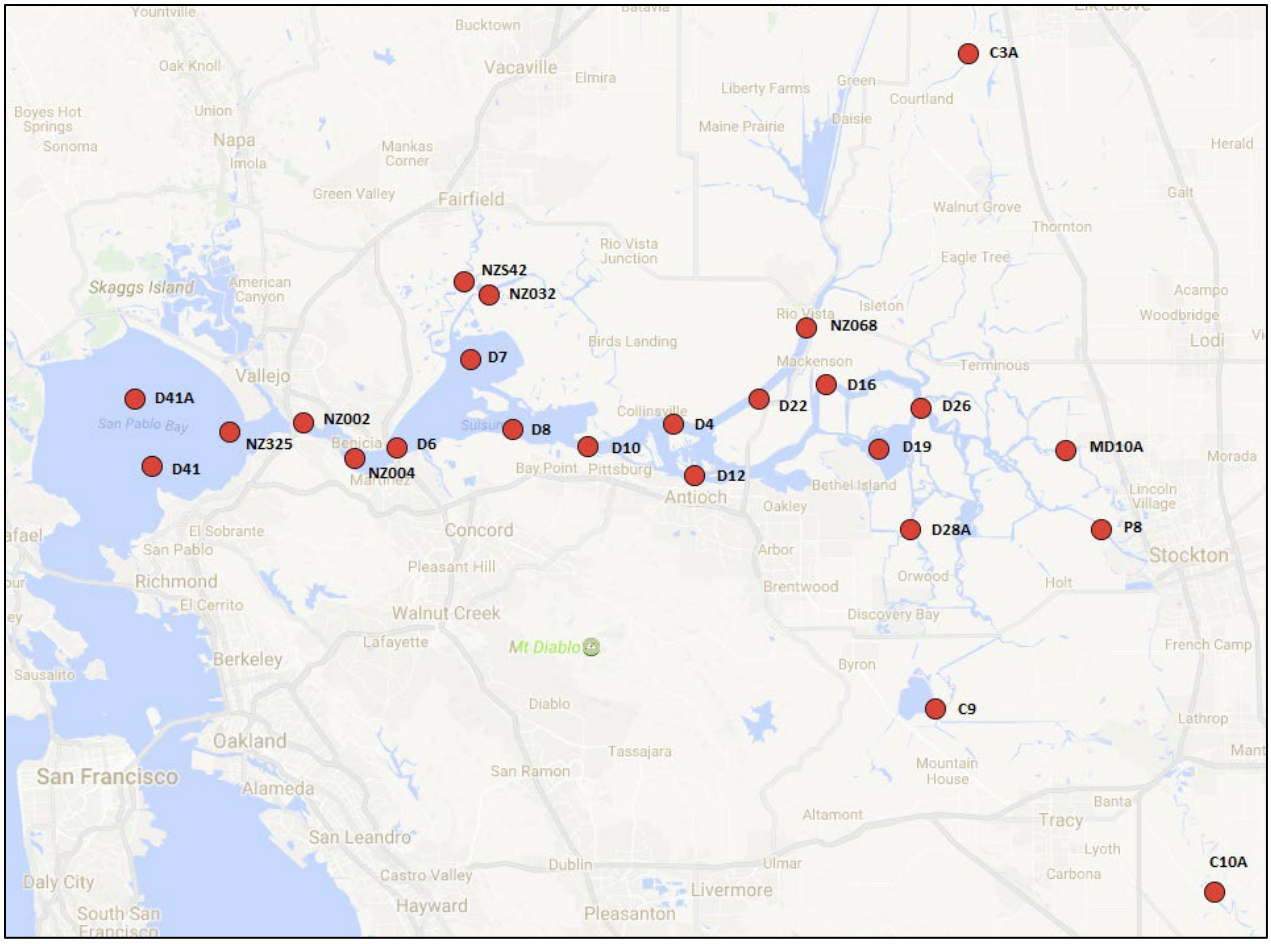


Figure 1-Map of Discrete Water Quality Monitoring Stations

PRE-SAMPLING PREPARATION

Monthly Water Quality Field Runs

Each discrete water quality monitoring station is sampled once a month during the discrete water quality field run (**Figure 1**). The fixed stations are broken up into seven sampling days according to the following order:

Van Run (vehicle): C3A, C9, C10A

Mid Delta Day 1 (vessel): D12, D19, D28A

Mid Delta Day 2 (vessel): D16, D26, MD10A, P8

Sacramento River (vessel): D4, D22, NZ068

Suisun Bay (vessel): D6, D8, D10

Grizzly Bay (vessel): D7, NZS42, NZ032

San Pablo Bay (vessel): D41A, D41, NZ325, NZ002, NZ004

*Note: The EZ stations are sampled on the day they fall into that specific conductance range. Both EZ6 and EZ2 must be sampled on the same day (with the exception of the EZ-SJR stations).

Sampling Containers

All sampling containers (excluding phytoplankton) are obtained from Bryte Laboratory. Before sample collection, containers without preservative are rinsed three times with sample water (either filtered or unfiltered, depending on the analytes in question). All sampling containers are filled to the neck of the container, excluding those analytes that require no headspace or those that have markings requiring an exact volume. Details for each laboratory constituent are shown in **Table 2**.

Containers that are pre-preserved do not require rinsing before filling with sample water. Caution should be taken when processing these samples to not overfill the containers. Nitrile gloves and eye protection should be worn for safety and ensure that bottle caps are secured tightly before storing and transporting. Acid spilled on skin or clothes must be rinsed and diluted immediately with clean water. See Appendix A for additional details on **Laboratory Safety**.

Table 2-Sample containers and storage information for Bryte Laboratory analysis

Analyte Name	Analysis Method	Filter Type	Container	Volume	Storage	Holding Time
Total Alkalinity	SM 2320B	Unfiltered	Polyethylene half pint	250 mL	Unpreserved, 6˚C	14 days
Dissolved Bromide	EPA 300.0	0.45 µm MCE	Polyethylene pint	500 mL	Unpreserved, 6˚C	28 days
Dissolved Ammonia	EPA 350.1	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Dissolved Calcium	EPA 200.7	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL nitric acid, 6˚C	6 months
Dissolved Chloride	EPA 300.0	0.45 µm MCE	Polyethylene pint	500 mL	Unpreserved, 6˚C	28 days
Chlorophyll *a*	SM 10200H	1 µm Glass Fiber	Manila envelope	500 mL	Unpreserved, frozen, dark	28 days
Total Kjeldahl Nitrogen	EPA 351.2	Unfiltered	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Dissolved Nitrate + Nitrite	SM 4500-NO3-F	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Dissolved Organic Carbon	SM 5310C	0.45 µm MCE	Amber glass VOA vial	40 mL	0.2 mL phosphoric acid, 6˚C	28 days
Total Organic Carbon	SM 5310C	Unfiltered	Amber glass VOA vial	40 mL	0.2 mL phosphoric acid, 6˚C	28 days
Dissolved Organic Nitrogen	EPA 351.2/EPA 350.1	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days

Dissolved Ortho-phosphate	EPA 365.1	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Pheophytin *a*	SM 10200H	1 µm Glass Fiber	Manila envelope	500 mL	Unpreserved, frozen, dark	28 days
Total Phosphorus	EPA 365.4	Unfiltered	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Phytoplankton	N/A	Unfiltered	Boston round amber glass	60 mL	2 mL Lugol's Iodine, room temperature	31 days
Dissolved Silica (SiO2)	EPA 200.7	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL nitric acid, 6˚C	6 months
Total Dissolved Solids	SM 2540C	0.45 µm MCE	Polyethylene pint	500 mL	Unpreserved, 6˚C	7 days
Total Suspended Solids	EPA 160.2	Unfiltered	Polyethylene quart	1000 mL	Unpreserved, 6˚C	7 days
Volatile Suspended Solids	EPA 160.4	Unfiltered	Polyethylene quart	1000 mL	Unpreserved, 6˚C	7 days

FLIMS

All seven sampling events for the monthly water quality field run are created in the FLIMS database prior to going out in the field.

1. On the main menu in FLIMS, click "Schedule a Run".

   *Note: Make sure you are using the most updated version of FLIMS. To update, click "Update FLIMS Field" on the desktop of the computer being used.

2. From the Run Name dropdown menu, select the sampling run you would like to create a plan for. The monthly water quality field run includes the following sampling run names:

Van Run	Mid Delta Day 2	Suisun Bay
Mid Delta Day 1	Sacramento River	Grizzly Bay
Entrapment Zone in SJR	Entrapment Zone	San Pablo Bay

   *Note: Entrapment Zone in San Joaquin River should only be created when the SFE is under dry conditions.

3. Under the "Sampler(s)" dropdown menu, choose the appropriate crew lead that is scheduled for that day (this can be found on the monthly DEMP field schedule under each sampling day).

   *Note: If the desired crew lead is not listed in FLIMS, they will need to be created and added to the database by clicking "New Field Crew" and entering their first and last name and phone number.

4. Change the date of the sampling day to reflect the date found on the DEMP field schedule for that month.

5. Once the run window pops up, highlight the station that is titled "(None)" at the bottom of the station list. Click on the "Collection Details" tab and then type in the name of the duplicate station for that day under the "Station Name" box. Assign the corresponding parent station ID to the duplicate from the dropdown menu.

   *Note: The duplicate schedule can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Duplicate and Blank Schedules). The Entrapment Zone runs do not have duplicate or blank samples.

6. Once all sampling runs are created for the month, go back to the main menu and click "Paperwork".
7. Highlight all sampling runs, making sure it says "Yes" next to each run in the "Print Label" column. Then click "Print Labels". Print off the container labels on waterproof label paper (Avery Weatherproof 5520 Labels) and make sure they print in color.
8. After all labels are printed out, amber glass phytoplankton bottles need to be removed from the container list for every station. To do this, highlight a station and click on the "Containers" tab, then right click on the "Phytoplankton" row and click "cut".

   *Note: The phytoplankton samples do not go to Bryte lab, but FLIMS is used to generate labels for the bottles. Blank and duplicate samples do not have phytoplankton bottles.

9. In the "Paperwork" window, highlight the first run listed and click "Chain of Custody". Print off only the first page of the COC form for that run.

   *Note: Printing out the first page of all COCs will allow the crew lead to relinquish the samples upon returning from the field to the person submitting the samples to the lab.

10. Repeat the previous step so that the first page of the COCs for all runs have been printed. Then use a magnet to place the stack of first pages of COCs on the sample refrigerator.

Sampling Checklist

A duplicate sample and a blank sample are processed each day of the water quality field run. A sampling checklist is created each month to identify which station to collect the duplicate sample at. Blank samples should always be listed at the bottom of each day on the sampling checklist and are processed after all stations have been collected.

1. The DEMP Sampling Checklist template can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\WQ Run Sheets.
2. Using the Duplicate and Blank Schedule (found here: S:\M & A BRANCH\Discrete EMP\Water Quality\Duplicate and Blank Schedules) as a reference, update the DEMP Sampling Checklist to highlight which stations have duplicates and what additional samples (if any) need to be collected.

   *Note: Additional samples are typically only collected during special studies.

3. Update the "Sample ID" column with those that were generated for each station when the runs were created in **FLIMS**.

   *Note: For duplicate stations, enter in a "/" at the end of the parent station's sample ID followed by the last two digits of the duplicate sample ID.

4. Once the DEMP Sampling Checklist is updated, print off two copies (one for the crew lead and one for the individual/s processing samples) for the boat run and one copy for the Van Run on Rite in the Rain paper.
5. Place the checklists in the appropriate clipboard to be taken out in the field.

Labeling Containers

Sampling containers are labeled according to station name prior to the monthly water quality field run.

1. Place each label on the appropriate container (specified on the label generated from FLIMS for Bryte sampling) for all samples collected at each station (See **Table 3**).
2. Label the caps of the polyethylene and phytoplankton bottles with the corresponding station name in black Sharpie. Label filtered sample bottles with a red "FF" to indicate field filtration.

   *Note: Write "Dup" next to the station name on the caps for duplicate stations to differentiate from the normal station. Write "B" and the abbreviation for the run name on the caps of blank sample containers (example: "B-MD2").

3. Bottles should be placed in order of station collection for each day into a storage bin to be taken out in the field.

Table 3 – Structure of Sampling Containers for Laboratory Analysis

Sample Type	Container Type	Total Number of Containers
Normal	1 quart 1 pint 1 unpreserved half pint 1 nitric acid half pint 2 sulfuric acid half pints 1 round amber glass bottle 2 amber glass VOA vials 1 manila envelope	10
Duplicate	1 quart 1 pint 1 unpreserved half pint 1 nitric acid half pint 2 sulfuric acid half pints 2 amber glass VOA vials 1 manila envelope	9
Blank	1 quart 1 pint	9

	1 unpreserved half pint 1 nitric acid half pint 2 sulfuric acid half pints 2 amber glass VOA vials 1 manila envelope	

Cleaning Churn Buckets

Prior to the water quality field run each month, churn buckets are washed with Liquinox laboratory detergent to remove any residual material from previous sampling. Every six months, churn buckets are acid washed to ensure complete decontamination. See Appendix B for **Cleaning Protocol for EMP Water Quality Sampling Equipment**.

1. Wet all surfaces of the churn bucket with tap water and use a plastic pipette to add three drops of 1% Liquinox solution to the churn bucket.
2. Scrub the interior and exterior surfaces with a sponge, making sure not to abrade the surface.

   *Note: Pay attention to cleaning the paddle and the area around the spigot.

3. Make sure the churn spigot opening and funnel are free of sediment, including fine particulates (clay), organic matter, and stains.
4. Drain some of the cleaning solution through the spigot before discarding the remaining solution.
5. Fill churn bucket about one-third full of tap water; swirl and shake the churn vigorously to remove detergent residues. Allow tap water to pass through the spigot.
6. Repeat rinse procedure with tap water until no bubbles remain in rinse water after the water is agitated.
7. When there are no bubbles remaining, triple rinse all three parts of the churn bucket with DI water.

Sonde Pre-Measurement Calibration

The DEMP unit collects water quality measurements using EXO2 sondes, which are calibrated prior to each monthly water quality field run using calibration standards. Three sondes are designated for sampling by vessel (vertical, horizontal, and backup) and one sonde is designated for sampling by vehicle. Sondes are calibrated up to 72 hours prior to the run start date and dissolved oxygen sensors are verified for accuracy each morning before data collection. Blank electronic calibration forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Blank Calibration Sheets\Electronic Forms. If a probe is replaced during the calibration process, the information needs to be documented on the DEMP EXO Probe Tracking file located on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde & Probe Tracking. For

information on changing probes or general sonde maintenance, see Appendix C for **EXO User Manual**.

Preparing Calibration Standards

To prevent dilution, standards should be used to calibrate no more than five sondes. A Standards Use Log is posted at each calibration station in the lab to track the lot number and expiration date for each standard and the number of times it has been used to calibrate a sonde.

1. Clean each calibration cup with DI water and triple rinse with its corresponding standard. Calibration cups and lids should be labeled with the standard it holds. Standards will be prepared for the following parameters:

    -Turbidity (124 FNU)

    -Specific Conductance (6668 µS/cm)

    -pH (7 and 10)

2. Record all standard lot numbers and expiration dates on the Pre-Measurement Calibration form and the Standards Use Log.
3. Fill a 5-gallon bucket about 60% full of tap water for the DO calibration. Use an aquarium pump and air stone to aerate the bucket and allow the bucket to aerate for at least one hour to reach full saturation.

Dry Specific Conductance and Water Temperature

A sonde's temperature sensor cannot be calibrated so it must be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST) or a thermometer that has been tested against a NIST thermometer within the last year. This accuracy check should be performed before other sensor calibrations, as temperature can influence other parameters. The serial number for the thermometer and calibration due date is recorded on the Pre-Measurement Calibration form. Each sonde's temperature sensor undergoes a Thermometer Accuracy Verification using a water bath twice a year. See Appendix D for **Thermometer Accuracy Verification SOP**. Temperature checks using the water bath need to be documented on the DEMP Probe Tracking file located on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde & Probe Tracking.

1. Remove the field guard and field wiper from the sonde.
2. Use a paper towel to dry the sonde's sensors completely (you can blow compressed air through the holes of the Conductivity/Temperature sensor).

3. Connect the sonde to a computer with the latest version of KorEXO software using an adapter or via Bluetooth.
4. In Kor, press the "LIVE DATA" tab. Record the value for Specific Conductance Dry under the Pre-Cal column on the Pre-Measurement Calibration form (ideally it should be 0.0).
5. Install the clean calibration wiper and calibration guard onto the sonde. Rinse the sensors, guard, and wiper with DI water and insert the sonde in a clean calibration cup filled with enough DI water to completely cover all the probes.
6. In the "LIVE DATA" tab, press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
7. Insert the thermometer next to the Conductivity/Temperature probe and allow to stabilize.

   *Note: A laboratory stand is useful to hold up the sonde so that the thermometer can fit inside the calibration cup alongside it.

8. Record the temperature values from the thermometer under the Standard column and the sonde under the Pre-Cal column on the Pre-Measurement Calibration form. The values should not have a difference greater than 0.2 ºC.

   *Note: If the values differ greater than 0.2 °C, the temperature sensor may be due for a Thermometer Accuracy Verification. If the sensor does not satisfy the passing criteria during the Thermometer Accuracy Verification process, install a new temperature sensor and repeat the previous procedure.

Chlorophyll

Chlorophyll is measured on the Total Algae sensor. It is normal for the chlorophyll values to fluctuate within a small range during calibration. The chlorophyll sensor needs to be calibrated for both RFU and µg/L. DEMP does not calibrate for Blue Green Algae even though it is listed on the Pre-Measurement Calibration form.

1. Keep the sonde in DI water and remove the thermometer from the calibration cup. Go to the "CALIBRATION" tab, double click the "TAL-PC" box, then press "Calibrate" for Chlorophyll (RFU).
2. Enter "0.00 RFU" (if it is not already set).
3. Press "Apply" when the Data Stability is Stable.
4. Press "Complete Calibration" and record the Pre- and Post-Cal values on the Pre-Measurement Calibration form. Then press "Exit".
5. Keep the sonde in DI water and double click the "TAL-PC" box again in the "CALIBRATION" tab, then press "Calibrate" for Chlorophyll (µg/L).

6. Enter "0.00 µg/L" (if it is not already set).
7. Press "Apply" when the Data Stability is Stable.
8. Press "Complete Calibration" and record the Pre- and Post-Cal values on the Pre-Measurement Calibration form. Then press "Exit".

Turbidity

It is normal for the turbidity values to fluctuate within a small range. A two-point calibration is completed using 0 and 124 FNU standards to bracket the environmental conditions in which the sonde will be deployed.

1. Keep the sonde in DI water.
2. In the "CALIBRATION" tab, double click the "Turbidity" box, then press "Calibrate" for Turbidity (FNU).
3. Enter "0.00" (if it is not already set) for Calibration Point 1.
4. Press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
5. Press "Apply" when the Data Stability is Stable.
6. Press "Add Another Cal Point" and enter 124 FNU as the standard value.
7. Remove the sonde from the water, dry off the sonde's guard and sensors, and shake off any excess water.
8. Rinse the guard and sensors with the 124 FNU rinse bottle and then place the sonde in the 124 FNU standard. Be careful not to agitate the standard.
9. Click "ADVANCED" and then press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
10. Press "Apply" when the Data Stability is Stable.
11. Press "Complete Calibration" and record the Pre- and Post-Cal values for the low and high turbidity on the Pre-Measurement Calibration form. Then press "Exit".

Specific Conductance

1. Remove the sonde from the 124 FNU turbidity standard and rinse the guard and sensors with DI water.
2. Remove the calibration guard and wiper to prevent contamination of the remaining standards.
3. Dry off the sonde's sensors and shake off any excess water.

4. Rinse the sensors with the specific conductance (6668 µS/cm) rinse bottle. Then place the sonde in the specific conductance (6668 µS/cm) standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

5. In the "CALIBRATION" tab, double click the "Conductivity" box, press "Calibrate" for Sp Cond (µS/cm).
6. Enter "6668 µS/cm" (if it is not already set).
7. Press "Apply" when the Data Stability is Stable.
8. Press "Complete Calibration" and record the Pre- and Post-Cal values and the Cell Constant on the Pre-Measurement Calibration form. Then press "Exit".

pH

A two-point calibration is completed using pH 7 and 10 to bracket the environmental conditions in which the sonde will be deployed.

1. Remove the sonde from the specific conductance standard and rinse the sensors with DI water.
2. Dry off the sonde's sensors and shake off any excess water.
3. Rinse the sensors with the pH 7 rinse bottle. Then place the sonde in the pH 7 standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

4. In the "CALIBRATION" tab, double click the "pH" box, then press "Calibrate" for pH.
5. Click on "ADVANCED", press "Auto pH Compensation", then check "USA" (if it is not already checked).
6. Press "Apply" when the Data Stability is Stable.
7. Press "Add Another Cal Point". Then use the drop-down arrow on the 2nd point to change it from 4 pH to 10 pH.

   *Note: EMP does not calibrate to 4 pH.

8. Remove the sonde from the pH 7 standard and rinse the sensors with DI water.
9. Dry off the sonde and shake off any excess water.
10. Rinse the sensors with the pH 10 rinse bottle. Then place the sonde in the pH 10 standard.

    *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

11. Press "Apply" when the Data Stability is Stable.

12. Press "Complete Calibration" and record the Pre- and Post-Cal values for pH 7 and 10, and the pH mV for both. Then press "Exit".
13. The Pre-Measurement Calibration Check form will auto-populate the Delta Slope. Ensure that this value is within the recommended range.

    *Note: If the Delta Slope is outside of the recommended range, the pH module needs replacing.

Dissolved Oxygen

While the DO sensor is calibrated prior to the monthly water quality field run, it also needs to be verified each morning before data is collected. For instructions on how to verify the DO sensor, see **Dissolved Oxygen Verification.**

1. Remove the sonde from the pH 10 standard and rinse the sensors with DI water.
2. Install the field wiper and field guard and place the sonde in the 100% air saturated bucket for at least 5 minutes, then press the "LIVE DATA" tab.
3. Record the DO (mg/L) value under the Pre-Cal column on the Pre-Measurement Calibration form.
4. In the "CALIBRATION" tab, double click the "DO" box, then press "Calibrate" for DO (% Sat).
5. Enter the local Barometer reading from a YSI handheld on the Pre-Measurement Calibration form and in Kor.
6. Press "Apply" when the Data Stability is Stable.
7. Press "Complete Calibration" and record the Pre- and Post-Cal values for DO%, DO Gain, DO mg/L (Post-Cal), Barometer mmHg, and Temperature (°C) from the sonde in the bucket on the Pre-Measurement Calibration form.
8. Calculate the DO (% Sat) and the DO (mg/L) standard values by using the Dissolved Oxygen Solubility Tool (located on the Shared Drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources). Record these values under the Standard column on the Pre-Measurement Calibration Check form.

   *Note: It is not necessary to enter in the specific conductance value when calculating the standard values in the Dissolved Oxygen Solubility Tool. You can also find the DO (% Sat) standard value by dividing the Barometer reading by 7.6.

Depth

1. Remove the sonde from the bucket and place it on the counter.

   *Note: It does not matter if it is positioned upright or laying on its side.

2. In the "CALIBRATION" tab, double click the "Depth" box, then press "Calibrate" for Depth (ft).
3. Enter "0.00" (if it is not already set).
4. Press "Apply" when the Data Stability is Stable.
5. Press "Complete Calibration" and check the "Calibrate depth to 0 feet" box on the Pre-Measurement Calibration form. Then press "Exit".
6. Ensure that there is enough battery voltage on the sonde in the "LIVE DATA" tab and check the "Verify sufficient battery voltage for use" box on the Pre-Measurement Calibration form.

   *Note: Replace batteries if the value is less than 5 volts.

7. Go to the "HOME" tab and disconnect the sonde from Kor. Remove the adaptor or turn off the Bluetooth (whichever was used). Place the sonde back in its original calibration cup with ½ inch of tap water and store upright with a sonde bag to be taken out in the field.

Archiving

Sonde calibration forms get saved to the shared drive and archived in record binders.

1. Save the completed Pre-Measurement Calibration form to the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Saved Calibration Sheets.
2. Print off the completed form and make a black and white copy of it.
3. Place the copy in the plastic sleeve to go out in the field with the sonde.
4. Place the original Pre-Measurement Calibration form inside the EXO Calibration Sheets binder and file it according to sonde ID.

Field Equipment Checklist

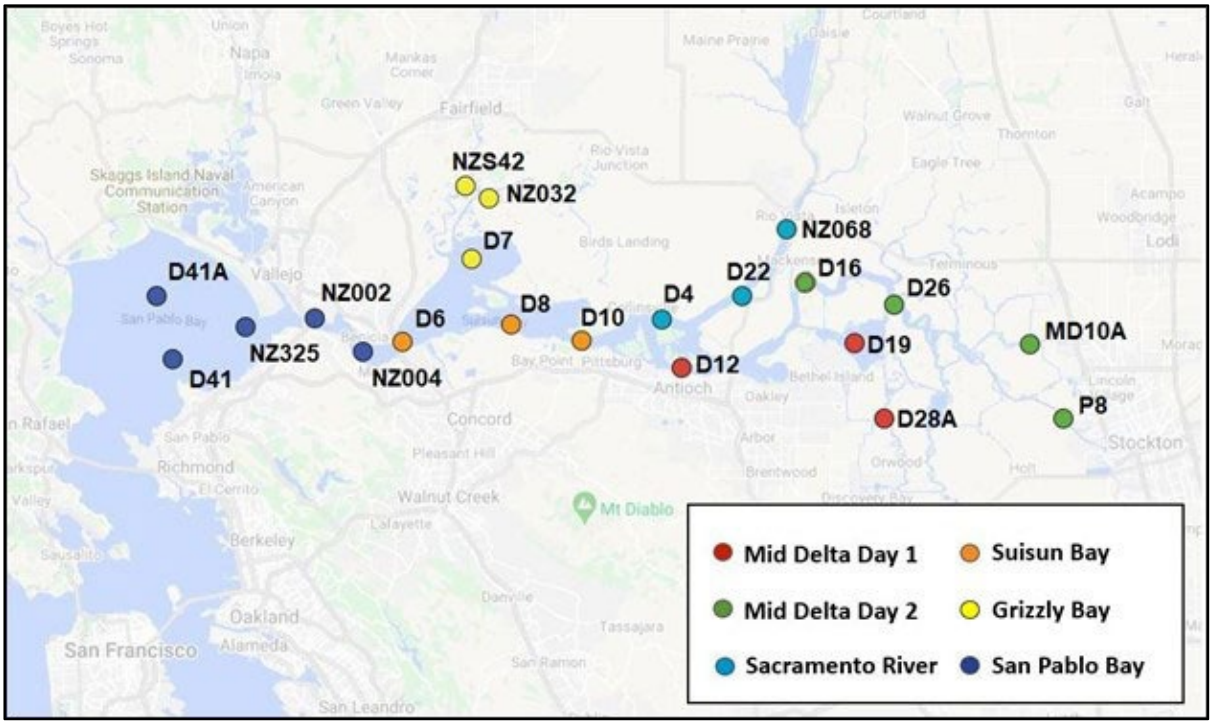
- ☐ Clipboards
- ☐ Sampling Checklist
- ☐ Coolers
- ☐ Sondes
    - Horizontal
    - Vertical
    - Backup
- ☐ Weighted Sonde Guard
- ☐ YSI Handheld
- ☐ 12V Battery (Van Run only)
- ☐ Secchi Disk (Boat Run only)
- ☐ DI Water
- ☐ Churn Buckets
- ☐ Cubitainers (Van Run only)
- ☐ DI Squirt Bottles
- ☐ DI Dispenser
- ☐ Labeled Sampling Containers:
    - Polyethylene Bottles
    - Glass Vials/Bottles
    - Manila Envelopes
- ☐ Filters
    - 0.45 µm Millipore
    - 1.0 µm Glass Fiber
- ☐ Glassware
    - 400 mL Beaker
    - 500/250 mL Volumetric Flask
    - Erlenmeyer Flask
    - Pipette
- ☐ Vacuum Pump Assembly
    - Vacuum Pump
    - Tubing
    - Chlorophyll Filtering Stand with Filtering Cups
    - Nutrient Filtering Stand with Filtering Cups and Bases
- ☐ Stainless Steel Filtering Apparatus
- ☐ Magnesium Carbonate
- ☐ Bucket for DO Checks
- ☐ Bubbler & Air Stone
- ☐ Thermometer
- ☐ Forceps
- ☐ Vacuum Grease
- ☐ Ziploc Bags
- ☐ Paper Towels & Kimwipes
- ☐ Writing Utensil
- ☐ Drinking Water
- ☐ Nitrile Gloves
- ☐ PFDs
- ☐ Safety Glasses
- ☐ First Aid/Emergency Kits
- ☐ Standard Operating Procedures

SAMPLING PROCEDURES

Sampling by Vessel

DEMP samples 21 fixed monitoring stations monthly aboard a research vessel over the course of six sampling days (**Figure 2**). These stations are located offshore and have specific GPS coordinates and landmarks associated with each. There are also 2-4 stations that are sampled each month with varying geographic locations indicating the presence of the Entrapment Zone (see **Entrapment Zone Stations**). The RV Sentinel is equipped with a flow-through system that pulls the surrounding water from three feet below the surface into a collection chamber for the horizontal sonde and into tubing that drains into laboratory sinks for sample collection. See Appendix E for **Field Safety**, Appendix F for **Job Hazard Analysis**, and Appendix G for **Navigation** to the Antioch and Benicia marinas.

Figure 2-EMP Discrete Water Quality Monitoring Stations Accessed by Vessel



Field Data Collection

Field measurements are taken from horizontal and vertical profile sondes that have been calibrated up to 72 hours prior to the monthly water quality field run (**Sonde Pre-Measurement Calibration**). The vertical profile sonde measures water quality parameters at one-second intervals from the surface to the bottom of the water column at each monitoring station. Surface readings are obtained when the sonde is three feet below the surface and bottom readings are obtained three feet above the total depth of the water column. This sonde is operated manually using a crane on the back deck of the research

vessel. The horizontal profile sonde remains stationary inside a flow-through chamber on the vessel that pulls water from a depth of three feet. This sonde measures continuous water quality parameters every five seconds for the entire duration of each sampling day. The protocols below are specific to sampling conducted on the RV Sentinel and may differ on other vessels. See Appendix K for **Sentinel Cheat Sheet**.

Dissolved Oxygen Verification

Because daily changes in local barometric pressure can impact the calibration of the DO sensor, every sonde used needs to be verified each morning before any data is collected (excluding the first day of the run due to aeration time). On the vessel, fill a 5-gallon bucket about 60% full of tap water and place an aquarium pump and air stone in the bucket. Allow the bucket to aerate for at least one hour to reach full saturation. Dissolved Oxygen Calibration Check forms can be found on the Sentinel computer and on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Blank Field Sheets\E-Forms.

1. Fill out the field run and sonde information for the day on the Dissolved Oxygen Calibration Check form.
2. For each sonde, remove the calibration cup and place the sonde (with the guard on) in the 100% air saturated bucket for at least 5 minutes. Connect the sonde to the KorEXO software on the computer via bluetooth. Click the "LIVE DATA" tab.
3. Enter the temperature (°C) reading in the bucket from a NIST traceable thermometer and the local barometric pressure (mmHg) from a YSI handheld. In doing so, the Dissolved Oxygen Calibration Check form will auto-populate the DO standard values for mg/L and % Sat.

   *Note: You can also find the DO standard values by using the Dissolved Oxygen Solubility Tool, located on the desktop of the Sentinel lab computer and on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources.

4. From the data on the "LIVE DATA" screen in Kor, record the DO (% Sat) and DO (mg/L) values under the Reading column on the Dissolved Oxygen Calibration Check form.
5. Calculate the difference between the Standard value and the Reading for both DO (% Sat) and the DO (mg/L). If the deviation falls within the Passing Criteria, disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket and begin **Setup**.
6. If the deviation does not pass, go to the "Calibration" tab, double click the "DO" box, then press "Calibrate" for DO (% Sat).

7. Enter the local Barometer reading from the YSI handheld in Kor.
8. Press "Apply" when the Data Stability is Stable.
9. Press "Complete Calibration" and record the new values for DO%, DO mg/L, and the ODO Gain in the Post-Cal column on the Dissolved Oxygen Calibration Check form. Then disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket and begin **Setup**.

Setup

EXO2 Sonde Setup

1. To assemble the flow-through setup, remove the calibration cup and sonde guard from the horizontal sonde and carefully screw the sonde into the flow-through chamber of the vessel. Connect the cable to the sonde connector.
2. To assemble the vertical sonde, remove the calibration cup and sonde guard from the vertical sonde and carefully screw on the weighted sonde guard. Connect the cable attached to the crane on the back deck of the vessel to the sonde connector and attach the strain relief connector to the handle. Place the sonde in the sleeve on the back deck, making sure there is enough water in it to cover all probes.
3. Set up the crane on the back deck of the vessel by using the crane controls to position the arm in the direction of deployment.
4. Check with the boat captain for permission to turn on the flow-through system. When permission is granted, open the cabinet under the sink to the right of the horizontal sonde setup and turn and hold the switch towards "Open" for approximately 30 seconds until the green light turns on. Then press "Start", which will start the water flow into the sinks.
5. Open the valve on the flow-through manifold to allow water into the horizontal sonde chamber by turning the bottom red nozzle so that it is positioned parallel to the pipe.

*Note: Ensure there are no leaks in the flow-through system. If a leak occurs, close the horizontal sonde valve and make sure the sonde is secured to the flow-through cup.

FluoroProbe Setup

The FluoroProbe is an instrument that determines the concentration of chlorophyll in water and is designed to take continuous measurements. This is set up is within the same flow-through system as the horizontal sonde but does not sync to MOPED. The FluoroProbe reads in data to its own software and runs simultaneously with MOPED for the entire duration of each sampling day. For information on cleaning, calibrations, and general maintenance, see Appendix J for **FluoroProbe User Manual**.

1. Open the valve on the flow-through manifold to allow water into the FluoroProbe chamber by turning the second from the bottom red nozzle so that it is positioned at a 45-degree angle.

    *Note: Ensure there are no leaks in the flow-through system. If a leak occurs, close the FluoroProbe valve and make sure the flow-through rings are secured tightly.

2. Open the "bbe" FluoroProbe software on the desktop and click the "Start" button in the upper left-hand corner.
3. Ensure sequential lines of data are being displayed every few seconds and are also being plotted on the graph in the lower half of the screen.
4. The program can be minimized, but total concentrations of chlorophyll should be compared to the fluorescence readings from the sonde at each station.

MOPED Setup

MOPED is a data acquisition program that communicates with field instrumentation (vertical and horizontal profile sondes, and GPS) and compiles all data into a single format. The protocols listed in this manual are specific to the MOPED version 2.2. For information on how to modify crew members, boat operators, cruise extensions, or for general troubleshooting, see Appendix H for **MOPED User Guide**.

1. Turn the computer on in the lab of the vessel, then turn on the GPS unit just below the computer.
2. Open the MOPED V2 program on the desktop and select the "Cruise Info" tab.
3. Under the "Cruise Information", select the appropriate Operator, Field Crew, Vessel Name, Purpose, and Cruise Extension for the day from the dropdown menus.
4. Under "Cruise Commands", click "Start Cruise". The Cruise ID box will light up green when the cruise has started.

    *Note: There may be a few second delay before the box lights up green.

5. Ensure that the latitude, longitude, depth, and sonde information (serial number and sonde ID) is displayed at the top.

    *Note: If the sonde information is missing, click "Stop/Pause Cruise" and "Load Equipment". Then start the cruise again. If the latitude and longitude are missing, ensure that the GPS unit below the computer is turned on.

6. Select the "Horizontal Profile" tab and check to make sure sequential lines of data are being displayed every five seconds.
7. Verify that the vertical data is coming in by selecting the "Vertical Profile" tab and selecting the "Check" under the station dropdown menu. Click "Start Profile" and make sure sequential lines of data are being displayed every second, then click "Stop Profile".

*Note: There may be a few second delay before data appears.

8. At this point, the back deck monitors can be turned on. To do this, flip the "Port Aft Deck Monitor" and "Starboard Aft Deck Monitor" switches on the breaker panel to "On". Check to ensure that the computer screen in the lab is being mirrored on the port side back deck monitor and that the starboard side back deck monitor shows the navigational information.
9. Once all programs are up and running and all crew members have the necessary equipment on board, let the boat captain know you are ready to go.

Sonde Measurements

Field data is obtained from the vertical and horizontal sondes at each monitoring station before the zooplankton tow is conducted. The field parameters recorded at each station can be found in **Table 5**.

Pre-Check

A Pre-Check is performed at the beginning of each sampling day upon departing the marina (excluding Mid Delta Day 1 due to the close proximity of the first station to the marina). The purpose of the Pre-Check is to verify that the horizontal and vertical sondes are reading within range of each other.

1. Place the vertical sonde over the side of the boat once it has come to a complete stop. Make sure the sonde is positioned approximately three feet below the surface.
2. Under "Vertical Options" in the Vertical Profile tab, select "Pre-Check" and the "No tow Surface" options in the dropdown menus. Then click "Start Profile".

*Note: There may be a few second delay before data appears.

3. When the horizontal and vertical sonde data has stabilized, click "Data Snapshot" in the Vertical Profile tab to copy the data over to the Data Entry tab.
4. In the Data Entry tab, check to make sure the readings from the horizontal and vertical sondes transferred correctly.
5. Enter the time (in PST) to the nearest five-minute increment in the Data Entry tab, then click "Save".

Pre-Tow Measurements

1. Upon arriving to each monitoring station, place the vertical sonde over the side of the boat once it has come to a complete stop. Make sure the sonde is positioned approximately three feet below the surface.

2. Under "Vertical Options" in the Vertical Profile tab, select the appropriate station name and the "Pre-tow Surface" option in the dropdown menus. Then click "Start Profile".

   *Note: There may be a few second delay before data appears. If using a PAR sensor on the vertical sonde, click "Start PAR" instead of "Start Profile" to allow the PAR readings to display in MOPED.

3. When the horizontal and vertical sonde data are stable, click "Data Snapshot" in the Vertical Profile tab to copy the data over to the Data Entry tab.
4. In the Data Entry tab, check to make sure the readings from the horizontal and vertical sondes transferred correctly and enter the time (in PST) to the nearest five-minute increment. Relay the collection time and the surface turbidity value to the person responsible for the sample collection.
5. In the Data Entry tab, enter in the churn bucket number used to collect the sample, the sample ID (found on the sampling checklist), the Secchi reading given by the person responsible for the **Secchi Disk Reading**, the air temperature (°F), wind speed (mph), sky conditions, wave scale, precipitation (if any), and the *Microcystis* score. Then click "Check GPS" to obtain the depth reading and the GPS coordinates.
6. Use the crane controls on the back deck to lower the sonde three feet above the bottom of the water column while watching depth readings on the port side back deck monitor in the Vertical Profile tab.
7. Under "Vertical Options" in the Vertical Profile tab, select the "Pre-tow Bottom" option in the dropdown menu. When the vertical data is stable, click "Data Snapshot" and ensure the readings transferred over to the Data Entry tab correctly. Then click "Save".
8. In the Vertical Profile tab, click "Stop Profile", then raise the sonde back up to three feet below the surface using the crane controls. Manually pull up the sonde the rest of the way and place it back in the sleeve.

   *Note: If using a PAR sensor on the vertical sonde, click "Stop PAR".

<u>Blanks and Duplicates</u>

Blank sampling is a way to test for contamination in sampling equipment and takes place at the end of each day of the water quality run. When blank sampling occurs, enter in the time (in PST, to the nearest five-minute increment) in which the churn bucket was filled, the churn bucket number used, and the sample ID (found on the sampling checklist) in the Equipment Blank box located in the Data Entry tab. Then click "Save".

Duplicate sampling is a method commonly used to assess precision and takes place at one station per day during the water quality run. When sampling a duplicate station,

check the "Duplicate" box in the Data Entry tab, enter in the churn bucket number used to collect the duplicate sample, the sample ID for that duplicate station (found on the sampling checklist), then click "Save".

Secchi Disk Reading

A Secchi disk is used to measure water clarity. Secchi measurements are typically performed upon arriving to each monitoring station by the individual responsible for **Zooplankton Monitoring**.

1. Lower the Secchi disk into the water in a shaded area. Remove sunglasses if you are wearing any.
2. Continue lowering until the white sections of the Secchi disk are no longer visible, then make note of what measurement mark is closest to the surface of the water.

   *Note: Twisting the Secchi can make it easier to see underwater.

3. Determine what the measurement is (in centimeters) for the portion that was below the surface of the water if each tape mark is spaced every 20 cm and the lines in between tape marks are spaced every 4 cm. Then relay this reading to the person responsible for **Sonde Measurements**.

Entrapment Zone Stations

The location of the Entrapment Zone stations is determined by specific conductance values and therefore varies in geographic location each month. If the specific conductance at the bottom is between 5400 and 6600 µS/cm, that location can be designated as EZ6 (or EZ6-SJR, if in the San Joaquin River). If the specific conductance at the bottom is between 1800 and 2200 µS/cm, that location can be designated as EZ2 (or EZ2-SJR, if in the San Joaquin River). EZ2-SJR and EZ6-SJR are only sampled during dry conditions when the entrapment zone is pushed upstream and splits into both the Sacramento and San Joaquin Rivers, creating two disparate zones.

Finding an EZ Station

1. Calculate the difference between the surface and bottom SpC values from the previous station. This will be used to estimate the stratification to help predict the location of the EZ station.
2. Take the desired bottom EZ range (5400-6600 µS/cm for EZ6 or 1800-2200 µS/cm for EZ2) and subtract the value obtained in the previous step to determine the estimated surface SpC range.

   *Note: If the difference calculated in the previous step was 1,000 µS/cm and you are trying to find EZ6, then the estimated surface SpC range to look for would be 4400-5600 µS/cm.

3. Monitor the incoming horizontal sonde readings in MOPED until it reaches the desired surface SpC range. Then notify the captain to stop the boat to perform a check.
4. When the boat has come to a complete stop, place the vertical sonde over the side of the boat.
5. Under "Vertical Options" in the Vertical Profile tab, select "Check" for the station dropdown. Then click "Start Profile".

   *Note: You do not need to have a tow type selected. There may be a few second delay before data appears.

6. Use the crane controls on the back deck to lower the sonde three feet above the depth of the water column while watching depth readings on the port side back deck monitor in the Vertical Profile tab.
7. If the bottom SpC value falls within the range for the desired EZ station, proceed with the collection of field measurements and samples in the same manner as **Pre-Tow Measurements** and **Sample Collection**.

   *Note: It is easiest to collect bottom readings first, before collecting surface readings, since the sonde is already at the bottom of the water column. You will need to click "Stop Profile" and then click start again with the appropriate dropdown options selected. Write in a descriptive name for the location (e.g. "located 100 yards downstream of the Antioch bridge) in the "Field Notes" section of the Data Entry tab and ensure that the GPS coordinates are captured correctly.

8. If the bottom SpC value is outside of the range for the desired EZ station, click "Stop Profile" in the Vertical Profile tab and bring the sonde back on board the vessel.
9. Repeat this procedure again using the surface and bottom SpC values just obtained to calculate the new desired surface SpC range.

<u>Doubling Up</u>

It is possible for the location of the EZ stations to overlap with that of a fixed station, which is referred to as "doubling up", and only one zooplankton tow is conducted. This can happen in one of three ways:

- **Scenario 1** – The EZ station is found at the pre-tow location of the fixed station
- **Scenario 2** – The fixed station's tow ends at an EZ station or passes through an EZ station during the tow
- **Scenario 3** – The EZ station's tow ends at a fixed station or passes through a fixed station during the tow

For Scenario 1:

1. Take the pre-tow surface and bottom sonde readings for the fixed station.
2. Collect an additional churn bucket for the EZ station immediately following the collection of the fixed station churn bucket.
3. At the top of the "Data Entry" tab, select the appropriate EZ station under the "Copy selected to station" dropdown menu.
4. Select "Pre-Tow Surf" under the "Copy selected from tow type" dropdown menu and "Pre-tow Surf" under the "Copy selected to tow type" dropdown menu. Then click "Copy".

    *Note: This will tell MOPED that the pre-tow surface readings are the same for the fixed station and the EZ station.

5. Select "Pre-Tow Bot" under the "Copy selected from tow type" dropdown menu and "Pre-tow Bot" under the "Copy selected to tow type" dropdown menu. Then click "Copy".

    *Note: This will tell MOPED that the pre-tow bottom readings are the same for the fixed station and the EZ station.

6. Select "Horizontal" under the "Copy selected from tow type" dropdown menu and "Horizontal" under the "Copy selected to tow type" dropdown menu. Then click "Copy".

    *Note: This will tell MOPED that the horizontal readings are the same for the fixed station and the EZ station.

7. Select the EZ station from the "Station" dropdown menu in the upper left corner of the "Data Entry" tab and ensure that all readings were copied over correctly.
8. Enter in the churn bucket number used for the EZ station sample and the Lab ID, then click "Check GPS" and ensure that the GPS coordinates are captured correctly.
9. In the "Field Notes" section, write in that the EZ station was located at the fixed station (e.g. "EZ6 was located at station D4").
10. The collection time, secchi reading, weather information, and MC score can be copied over from the fixed station.

For Scenario 2:

1. At the fixed station's post-tow location, collect a horizontal sonde reading, surface and bottom vertical sonde readings, a secchi reading, and fill up a churn bucket for the EZ station. Ensure these are recorded in the "Data Entry" tab with the new collection time.

    *Note: Since an additional zooplankton tow is not conducted, choose "No tow Surf" and "No tow Bot" when collecting the vertical sonde readings.

2. Enter in the remaining data in the "Data Entry" tab, click "Check GPS" and ensure that the GPS coordinates are captured correctly.

3. In the "Field Notes" section, write in where the EZ station was located relative to the fixed station (e.g., "EZ6 was located at the end of the D4 tow" or "Passed through EZ6 during the D4 tow").

For Scenario 3:

4. In the instance of passing through the fixed station, fill up a churn bucket while physically passing through the fixed station. Use the navigation screen to determine when the boat is directly over the station.
5. At the EZ station's post-tow location, collect a horizontal sonde reading, surface and bottom vertical sonde readings, a secchi reading, and fill up a churn bucket (if ending at the fixed station) for the fixed station. Ensure these are recorded in the "Data Entry" tab with the new collection time.

   *Note: Since an additional zooplankton tow is not conducted, choose "No tow Surf" and "No tow Bot" when collecting the vertical sonde readings.

6. Enter in the remaining data in the "Data Entry" tab, click "Check GPS" and ensure that the GPS coordinates are captured correctly.
7. In the "Field Notes" section, write in where the EZ station was located relative to the fixed station (e.g., "D4 was located at the end of the EZ6 tow" or "Passed through D4 during the EZ6 tow").

Carquinez Straight Stations

Since CDFW is only interested in zooplankton data from the Carquinez Straight during high outflow events, a zooplankton tow is not conducted at stations NZ325, NZ002, and NZ004 when the specific conductance is above 20,000 µS/cm on the surface. In this case, only water quality samples and field measurements (including secchi) are collected upon arriving to the station. When obtaining sonde measurements for these stations under dry conditions, select the "No Tow Surface" and "No Tow Bottom" options in the dropdown menu under the Vertical Profile tab in MOPED and document that a zooplankton tow was not conducted in the "Field Notes" section in the Data Entry tab.

Shutdown

<u>Saving Sonde Data and MOPED Shutdown</u>

At the end of each sampling day, the data sheet and data file generated from MOPED is saved before the application is shut down.

1. In the Data Sheet tab, click the "Export" icon and select "PDF" from the list of download options.

   *Note: If the dropdown menu does not appear, switch the date to the previous one listed and then switch back to the current date. The dropdown menu should now appear.

2. Save the data sheet to the appropriate water quality folder on the desktop of the Sentinel computer according to the month and year. Name the file in the following format: "EMP Data Sheet_MD1_May21.pdf", depending on the run name.

    *Note: If it is the first day of the run, a new folder needs to be created with the current month. All files for that month are saved in this new folder.

3. Under "Cruise Commands" in the Cruise Info tab, click "Pause/Stop Cruise".
4. Click "Export Cruise Data as CSV" and save the file to the same folder as the data sheet. Name the file in the following format: "MOPED_Export_#_MMDDYYYY_MD1.csv" depending on the run name.

    *Note: MOPED will automatically generate the first part of the file name.

5. Exit out of the MOPED application.

FluoroProbe Shutdown

1. In the "bbe" FluoroProbe software, click the "Stop" button in the upper left-hand corner of the screen.
2. Click "File", hover over "Export (ASCII)", then click "Export all".
3. In the Export Options pop-up window, ensure that the "Export all data sets" is checked, and then click "OK".
4. Save the file to the same folder as the data sheet and MOPED file. Name the file in the following format: "Fluoroprobe_MD1_May21" depending on the run name and date.

    *Note: The FluoroProbe's flow cell needs to be cleaned every other month. To do this, remove the FluoroProbe from the flow-through setup and clean the flow cell according to the manufacturer guidelines. See Appendix J for **FluoroProbe User Manual**.

EXO2 Sonde Cleanup

The horizontal and vertical sondes are kept on the vessel in the field for the entire duration of the monthly water quality field run. If it is the end of the monthly water quality field run, sondes are transported back to the office where they will undergo a **Sonde Post-Measurement Calibration Check** in the calibration lab.

1. Turn off the flow-through system by opening the cabinet under the sink to the right of the horizontal sonde setup. Press "Stop" and then turn and hold the switch towards "Close" for approximately 30 seconds until the red light turns on. Close the valve of the FluoroProbe and horizontal sonde flow-through chambers by turning the bottom and second to bottom red nozzles so that they are positioned perpendicular to the pipes.

2. Making sure there is no water feeding into the horizontal flow-through, disconnect the cable from the horizontal sonde connector and unscrew the horizontal sonde from the flow-through cup.
3. Gently rinse the probes on the horizontal sonde with DI water over the sink in the lab. Carefully screw on the original sonde guard and calibration cup (with ½ inch of tap water) and put the cable connector plug back on.
4. Drain the remaining water in the flow-through cup by removing the latch that secures the cup in place and discarding the water in the sink (use an empty container).
5. Use the crane controls on the back deck to move the crane back to its original position.
6. Disconnect the field cable from the vertical sonde by unscrewing the cable connector from the sonde and strain relief connector from the handle.
7. Carefully remove the weighted sonde guard and gently rinse the probes on the vertical sonde with DI water over the sink in the lab. Carefully screw on the original sonde guard and calibration cup (with about ½ inch of tap water) and put the cable connector plug back on.
8. Store the vertical and horizontal sondes upright in the appropriately labeled spots of the sonde stand located near the flow-through setup.

*Note: Do not store the sondes on their side because the tap water will leak out of the calibration cup, which can cause the probes to dry out.

SharePoint Upload

At the end of each day of the run, all files that were generated are saved to the EMP SharePoint site.

1. Once all files are saved to the Sentinel computer, open up the EMP SharePoint site and navigate to the following folder: "Water Quality" > "Field Data" > "Water Quality (current year)" and select the folder for the current month.
2. Click "Upload" and then click the "Choose Files" button in the pop-up window.
3. Find the appropriate water quality folder on the computer and highlight the data sheet, MOPED file, and FluoroProbe file from that day. Click "Open" and then click "OK".

*Note: If it is the final day of the water quality run, the Crew Lead Report and all DO Calibration Check Attachment forms need to be saved to the same SharePoint folder.

Sample Collection

Upon arriving to each station, samples are immediately collected, processed, and preserved on the vessel. Sample water is obtained via a flow-through system taken at a depth of

approximately three feet below the surface that drains out of tubing in the laboratory sinks and is collected into a churn bucket. The churn bucket is rinsed three times with the sample water prior to collection. Churning the sample before dispensing is required to homogenize the particulates in the water. When filling up a container with sample water from the churn bucket, pumping approximately ten times is adequate for homogenization. All samples for any given site can be obtained from a single, full churn bucket. Nitrile gloves should be worn at all times for the entire duration of the sample collection and filtration process. Individuals performing this role will be responsible for checking to see which station has a duplicate for any given sampling day, and when the blank samples need to be processed. This information can be found on the **Sampling Checklist**.

Unfiltered Analytes

Unfiltered analytes do not require filtration and are collected directly from the churn bucket. Samples that require pre-preserved containers do not require rinsing prior to collection. Caution should be taken when collecting sample water into these containers so as not to overfill. See **Table 2** for a list of unfiltered analytes.

1. Churn the sample water with three pumps in the churn bucket and collect a small amount of sample water into the polyethylene quart container that will be analyzed for total suspended solids and volatile suspended solids.
2. Cap the quart and shake to ensure that the sample water covers all inside surfaces of the container (and cap) and then dump the water out. Repeat this procedure two more times so that the container gets rinsed a total of three times.
3. Churn the sample water ten times and fill the entire contents of the quart.

   *Note: This unfiltered sample container will be used to transfer sample water from the churn bucket to the sterafil cups (see **Dissolved Nutrients**).
4. Triple rinse the unfiltered half pint container that will be analyzed for alkalinity and specific conductance directly from the churn bucket. Fill the container all the way up to the top with no headspace. Secure the cap tightly and store in the refrigerator.
5. Triple rinse a clean beaker with water from the churn bucket and then fill to the 250 mL line. Carefully pour the contents into the unfiltered sulfuric acid half pint container that will be analyzed for total kjeldahl nitrogen and total phosphorus. Fill exactly to the 250 mL line. Secure the cap tightly and store in the refrigerator.

   *Note: This container is pre-preserved with 1 mL of sulfuric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.
6. Churn the sample water in the churn bucket with ten pumps and carefully fill up the round amber glass phytoplankton sample up to the neck of the container. Cap tightly

and invert the bottle a few times to create a uniform mixture of the sample water and the preservative. Write the collection time on the label of the bottle and store at room temperature.

*Note: This container is pre-preserved with 2 mL of Lugol's iodine and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

7. Churn the sample water again and carefully fill up the TOC sample to the neck of the container. Store in the refrigerator.

*Note: This container is pre-preserved with 0.2 mL of phosphoric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

Filtered Analytes

Dissolved Nutrients

Dissolved nutrient samples are filtered through a 0.45 µm mixed cellulose ester (MCE) membrane filter using a vacuum pump assembly and collected into an array of polyethylene containers. Pre-acidified containers should never be placed inside this vacuum pump assembly to avoid overspilling into the vacuum base. See **Table 2** for a list of dissolved analytes.

1. Prepare the vacuum pump assembly by connecting the vacuum base to the tubing that connects to the vacuum pump.

*Note: On the first day of the monthly water quality field run, vacuum grease can be applied around the edges of the vacuum base to allow for easy removal of the sterafil bases while filtering.

2. Rinse the two sets of sterafil bases and cups three times with DI water. Dry with a Kimwipe and attach the sterafil bases to the vacuum base.
3. Using forceps, place one 0.45 µm MCE membrane filter on each of the sterafil bases and then screw the cups onto the sterafil bases to secure the filter.
4. Remove the cap of the polyethylene pint container that will be analyzed for total dissolved solids, dissolved chloride, and dissolved bromide and place the container into the vacuum base. Then secure the sterafil bases/cups with the filter on top.
5. Remove the cap of an extra polyethylene pint container and place it into the vacuum base. Then secure the sterafil bases/cups with the filter on top.

*Note: Since pre-preserved containers cannot be placed inside the vacuum base for direct filtration, this pint bottle will act as a vessel to collect filtered sample water, which will be poured into the acidified half pint bottles.

6. Turn on the vacuum pump, shake the contents of the quart container collected with the **Unfiltered Analytes**, and pour a small amount of sample water into both sterafil cups to filter into the pint containers. When the water filters through completely, remove one of the rubber stoppers to release the seal.
7. Remove the pint containers from the vacuum base, replace the caps, and then shake them to rinse all surfaces with the filtered sample water. Then discard the water.
8. Uncap and replace the pint containers into their respective vacuum bases, place the sterafil bases and cups on top, and replace the rubber stopper. Repeat the previous two steps two more times so that both containers are rinsed with filtered sample water for a total of three times.

    *Note: Make sure to shake the contents of the quart container each time before pouring sample water into the sterafil cups to ensure homogenization.

9. Once the containers have been triple rinsed, pour the sample water from the quart to the tops of the sterafil cups. The water will filter into the pint containers. Stop filtering when the water reaches the necks of the pint bottles.

    *Note: In turbid conditions (e.g. above 20 FNU), fill the sterafil cups halfway to prevent clogging.

10. Remove the pint container that will be analyzed for total dissolved solids, dissolved chloride, and dissolved bromide from the vacuum base. Secure the cap tightly and store in the refrigerator.
11. Remove the extra pint container from the vacuum base and carefully pour the filtered contents into the sulfuric acid half pint container that will be analyzed for dissolved nitrate+nitrite, dissolved ortho-phosphate, dissolved ammonia, and dissolved organic nitrogen. Fill exactly to the 250 mL mark. Secure the cap tightly and store in the refrigerator.

    *Note: This container is pre-preserved with 1 mL of sulfuric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

12. Carefully pour the remaining filtered contents into the nitric acid half pint container that will be analyzed for dissolved calcium and dissolved silica. Fill to the neck of the container. Secure the cap tightly and store in the refrigerator.

    *Note: This container is pre-preserved with 1 mL of nitric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

13. Refill the quart a final time from the churn bucket to the neck of the container. Secure the cap tightly and store in the refrigerator.

14. Discard the used filters and triple rinse extra pint container and the sterafil cups and bases with DI water. Let dry before using at the next station.

    *Note: If it is the final day of the water quality run, open the red valve under the counter to empty the collection tank and rinse the tubing of the filtering apparatus with DI water.

Chlorophyll *a* and Pheophytin *a*

Chlorophyll *a* and pheophytin *a* samples are submitted in the form of a 1.0 µm glass fiber filter that has had 500 mL (or 250 mL if the surface turbidity is higher than 20 FNU) of sample water pass through it.

1. Prepare the vacuum pump assembly by connecting the tri-manifold vacuum base via the tubing that connects to the vacuum pump.

   *Note: This can also be within the same assemblage as the **Dissolved Nutrients** setup.

2. Place a 47 mm glass fiber filter with the smooth side face down onto the vacuum base. Carefully screw the filtering cup onto the base to secure the filter.
3. Churn the sample in the churn bucket with three pumps and add a small amount of sample water to a 500/250 mL volumetric flask. Swirl the water around to cover all surfaces and then dump the water out. Repeat two more times to rinse the flask for a total of three times.
4. Once the flask has been triple rinsed, churn the sample water with ten pumps and fill up the volumetric flask to just above the 500/250 mL mark. Use the pipette to remove enough water to where the bottom of the meniscus is in line with the 500/250 mL mark.
5. Pour the 500/250 mL of sample water into the filtering cup and turn on the vacuum pump. Add a small amount of the magnesium carbonate solution and open the valve to allow all of the sample water to pass through the filter.

   *Note: The vacuum pump should be set to a pressure no higher than 5 psi (or 10 in Hg), as the cells of the filter can lyse and affect the laboratory analysis.

6. While the sample water is filtering, rinse the volumetric flask three times with DI water and discard into the filtering cup. Once all of the water has passed through the filter, rinse the filtering cup three times with DI water to rinse off any residual sample particles.
7. Turn the pump off and unscrew the (now clean) filtering cup to expose the filter. Use forceps to carefully fold the filter in half and remove it from the pump base. Avoid coming in contact with the top surface of the filter where the particulates are collected.
8. Place the folded filter inside of the labeled manila envelope and write the collection time and volume (500 or 250 mL) of sample water used in the corner of the envelope. Seal the envelope and store in the freezer.
9. Clean the exposed vacuum base by turning on the pump and rinsing it with DI water.

*Note: If it is the final day of the monthly water quality field run, open the red valve under the counter to empty the collection tank and rinse the tubing of the filtering apparatus with DI water.

Dissolved Organic Carbon

Dissolved organic carbon (DOC) samples are filtered with a 0.45 µm MCE membrane filter using a gravity filter and collected into a 40 mL glass vial. These sample containers are pre-preserved and do not require rinsing prior to collection.

1. Triple rinse the stainless-steel filtering reservoir and filtering spout with DI water.
2. Use forceps to place a 0.45 µm MCE membrane filter onto the mesh face of the filtering spout. Attach the reservoir to the top by lining up the conjunction notches and twisting to secure it in place.
3. Place the stainless-steel filtering apparatus onto a clean glass Erlenmeyer flask with tubing hooked up to a vacuum pump.
4. Fill up a clean beaker with approximately 100 mL of DI water and pour it into the stainless-steel reservoir. Turn on the pump and let the DI water filter into the flask.
5. Turn off the pump and remove the filtering apparatus from the flask. Then discard the water in the flask. Place the filtering apparatus back on the flask.
6. Triple rinse the beaker with sample water from the churn bucket and then fill with approximately 30 mL of sample water.
7. Pour the sample water from the beaker into the stainless-steel reservoir and turn on the pump, letting the water filter into the flask. Turn off the pump and remove the filtering apparatus from the flask. Discard the water in the flask.

   *Note: The filter has now been adequately rinsed to remove any potential contaminants.
8. Fill the beaker with another 30 mL of sample water. Pour approximately 10 mL into the stainless-steel reservoir. Turn off the pump and remove the filtering apparatus from the flask. Swirl and discard the water in the flask. Repeat two more times to adequately rinse the flask with the sample water.

   *Note: The flask has now been adequately rinsed to remove any residual DI water.
9. Fill up the beaker a final time with approximately 50 mL of sample water and pour it into the stainless-steel reservoir. Turn on the pump and let the water filter into the flask.
10. Turn off the pump and remove the filtering apparatus from the flask. Carefully pour the filtered sample water from the flask into the DOC sample bottle. Secure the cap tightly and store in the refrigerator.

*Note: This container is pre-preserved with 0.2 mL of phosphoric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

11. Discard the used filter and triple rinse the filtering apparatus and glassware with DI water. Let dry before using for the next station.

Quality Control Samples

Equipment Blanks

Blank sampling is performed to ensure that samples have been processed, transported, and stored properly and to detect any contamination introduced into the sample by the sampling containers and/or equipment, or by exposure to ambient conditions. Equipment blanks are collected each day of the water quality run after all stations have been collected and processed. This type of sampling consists of collecting a churn bucket of DI water, which is processed, stored, and submitted in the same manner as normal surface water samples for all analytes (excluding phytoplankton).

Duplicates

Duplicate sampling is performed to assess the precision of sampling methods and the ability to replicate results. Concurrent duplicate samples are collected at one station per day during the water quality run, which is previously determined by an alternating schedule. Upon arriving to a duplicate station, an additional churn bucket is collected immediately after the normal (or parent) churn bucket is collected. This second set of samples is processed in the same manner as the parent samples for all the same analytes (excluding phytoplankton). The duplicate samples will have their own lab ID that is separate from the parent samples.

Sample Transport, Storage, and COC Relinquishing

At the end of each sampling day, samples collected on the vessel are transported back to the West Sacramento office where they are stored until they are submitted to the lab. Sample temperature must be maintained at < 6º until delivery to the laboratory. See **Table 2** for storage requirements for each analyte.

1. Upon arriving back to the marina, place all samples collected that day into a cooler.

   *Note: Chlorophyll envelopes should be double bagged and DOC/TOC vials should be single bagged prior to putting them into a cooler.

2. Cover the samples with sufficient ice to keep the temperatures from rising during transport.
3. Upon returning to the office from the field, transfer samples from the coolers into either the refrigerator or freezer in the DEMP lab, making sure there are no missing or damaged sample containers.

*Note: It is easiest to see that all samples are accounted for if they are grouped by station in the fridge.

4. The Crew Lead will then formally relinquish the samples to the person submitting them to the laboratory by filling out the "Sampled/Relinquished By" section on the first page of the COC for that run (located on the sample fridge).

   *Note: The first page of all COCs were printed in the **FLIMS** section. If the Crew Lead is submitting the samples to the lab, then the middle "Received By" and "Relinquished By" sections do not need to be filled out.

5. If the samples were filtered immediately following collection, write "Same as Collection" at the bottom of the page below the Container Summary,
6. If the samples were not filtered immediately following collection (e.g., Van Run), write in the filtration time at the bottom of the page below the Container Summary.

Sampling by Vehicle

The DEMP unit samples three monitoring stations by vehicle, referred to as the Van Run (**Figure 3**). Two of these stations (C3A and C10A) are sampled from a pier positioned above the edge of the Sacramento and San Joaquin rivers. The third station (C9) is sampled from a dock near the intake of Clifton Court Forebay. See Appendix L for **Van Run Cheat Sheet** Appendix F for **Job Hazard Analysis** and Appendix G for **Navigation** to the Van Run stations.

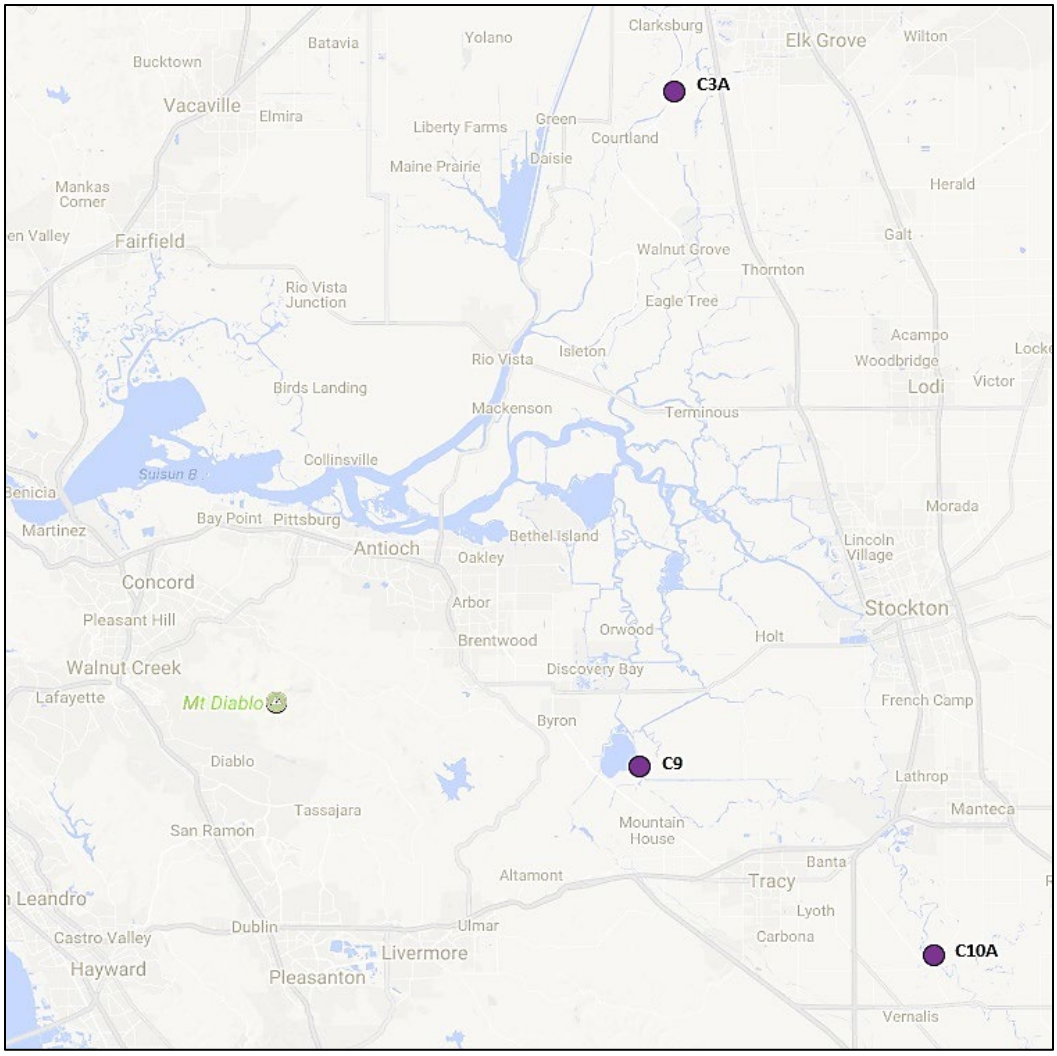


Figure 3-EMP Discrete Water Quality Monitoring Stations Accessed by Vehicle

Field Data Collection

Dissolved Oxygen Verification

Before leaving the office on the morning of the Van Run, a Dissolved Oxygen Verification needs to be performed on the sonde going out in the field. In the calibration lab, fill a 5-gallon bucket about 60% full of tap water and place an aquarium pump and air stone in the bucket. Allow the bucket to aerate for at least one hour to reach full saturation (if it is not already done). Dissolved Oxygen Calibration Check forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Blank Field Sheets\E-Forms.

1. Fill out the field run and sonde information for the day on the Dissolved Oxygen Calibration Check form.

2. Remove the calibration cup and place the sonde (with the guard on) in the 100% air saturated bucket for at least 5 minutes. Connect the sonde to the KorEXO software using an adapter or via Bluetooth. Click the "LIVE DATA" tab.
3. Enter the temperature (°C) reading in the bucket from a NIST traceable thermometer and the local barometric pressure (mmHg) from a YSI handheld. In doing so, the Dissolved Oxygen Calibration Check form will auto-populate the DO standard values for mg/L and % Sat.

   *Note: You can also find the DO standard values by using the Dissolved Oxygen Solubility Tool, located on the desktop of the Sentinel lab computer and on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources.

4. From the data on the "LIVE DATA" screen in Kor, record the DO (% Sat) and DO (mg/L) values under the Reading column on the Dissolved Oxygen Calibration Check form.
5. Calculate the difference between the Standard value and the Reading for both DO (% Sat) and the DO (mg/L). If the deviation falls within the Passing Criteria, disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket. Store it upright with a sonde bag to go out in the field.
6. If the deviation does not pass, go to the "Calibration" tab, double click the "DO" box, then press "Calibrate" for DO (% Sat).
7. Enter the local Barometer reading from the YSI handheld in Kor.
8. Press "Apply" when the Data Stability is Stable.
9. Press "Complete Calibration" and record the new values for DO%, DO mg/L, and the ODO Gain in the Post-Cal column on the Dissolved Oxygen Calibration Check form. Then disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket. Store it upright with a sonde bag to go out in the field.
10. Name the file with "DO Calibration Check Attachment" followed by the month and year (ex. DO Calibration Check Attachment_Jul22) and save it to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

EXO2 Sonde Readings

Field measurements are obtained using an EXO 2 Sonde and are recorded at quarter-hourly time intervals for data verification using CDEC readings (http://cdec.water.ca.gov). The sonde is placed in the river within approximately 10 feet of the deployed continuous sonde (for C3A and C10A).

1. Upon arriving to a station, connect the cable to both the sonde and the handheld.

2. Remove the calibration cup and sonde guard from the sonde and screw on the weighted sonde guard, being careful to avoid coming in contact with the sensors.
3. Five to ten minutes before the quarter-hour, lower the sonde into the river three feet below the surface (near the deployed continuous sonde) to allow for equilibration.
4. At the quarter hour, record the time (in PST) and surface field measurements on the EMP Water Quality electronic data sheet (documented field parameters can be found in **Table 5**).
5. When all surface measurements have been recorded, slowly lower the sonde down to the bottom of the water column. When the sonde reaches the bottom, record the depth reading on the data sheet.
6. After the depth measurement has been recorded, bring the sonde up three feet above that bottom depth measurement. Once equilibrated, record the bottom field measurements on the data sheet at this depth.
7. Once all surface and bottom readings have been recorded, bring the sonde back up to the station. Remove the weighted sonde guard and replace it with the field guard and calibration cup (with ½ inch of tap water). Disconnect the cable from both the sonde and the handheld and put the cable connector plug back on.
8. Upon arriving back to the office, use AirDrop to send the completed data sheet from the iPad to a phone and then email the data sheet to be saved on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

Sample Collection

Start out with properly cleaned sample collection equipment. Samples are collected directly from the water body using a peristaltic pump (or a Van Dorn during low water events) and are obtained at the same time as the field data is being recorded. Duplicate samples are collected immediately after the parent sample. All samples collected are stored on ice and transported back to the office where they are processed for the full suite of laboratory analytes. The procedures outlined in the **Sample Transport, Storage, and COC Relinquishing** section should be followed.

1. Attach the peristaltic pump to a battery and lower the input end of the tubing 3 feet below the surface of the water.
2. Turn on the pump and allow sufficient time (5 to 10 minutes) to flush out the system before collecting any water.

> *Note: During low water events when the pump is not able to carry water up to the station, lower a Van Dorn water sampler three feet below the surface and release the weighted messenger to collect the sample.

3. At the quarter hour, triple rinse a clean sample container (and lid) and then fill up the container to collect the sample.
4. Place the container in a cooler on ice.

Unfiltered Analytes

Unfiltered analytes are to be processed in the same manner as **Sampling by Vessel** and takes place upon arrival back to the office.

Filtered Analytes

Filtered analytes are to be processed in the same manner as **Sampling by Vessel** and takes place upon arrival back to the office.

Quality Control Samples

Equipment blanks and concurrent duplicates are to be processed in the same manner as **Sampling by Vessel** and takes place upon arrival back to the office.

POST-RUN PROCEDURES

Sonde Post-Measurement Calibration Check

After a field run has been completed, a Post-Measurement Calibration Check is performed within 24 hours of returning from the field. This determines the amount of drift the sonde's sensors experienced while being out in the field. The data collected during deployment is not valid without this record, because the accuracy and precision of the data cannot be verified. Blank electronic calibration forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Blank Calibration Sheets\Electronic Forms. For information on changing probes or general sonde maintenance, see Appendix C for **EXO User Manual**.

Dry Specific Conductance and Water Temperature

1. Prepare the calibration standards in the same manner as **Sonde Pre-Measurement Calibration**. Make sure to document the lot numbers and expiration dates for the standards used and the serial numbers and calibration due dates for the instruments used.
2. Remove the field guard and field wiper from the sonde.
3. Use a paper towel to dry the sondes sensors completely (you can blow compressed air through the holes of the Conductivity/Temperature sensor).
4. Connect the sonde to a computer with the latest version of KorEXO software using an adapter or via Bluetooth.
5. In Kor, press the "LIVE DATA" tab. Record the value for Dry Specific Conductance under the Reading column on the Post-Measurement Calibration Check form (ideally it should be 0.0). The difference between the Standard value and the Reading will auto-populate in the Deviation column.
6. Install the clean calibration wiper and calibration guard onto the sonde. Rinse the sensors, guard, and wiper with DI water and insert the sonde in a clean calibration cup filled with enough DI water to completely cover all the probes.
7. In the "LIVE DATA" tab, press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
8. Insert the thermometer next to the Conductivity/Temperature probe and allow to stabilize. A laboratory stand is useful to hold up the sonde so that the thermometer can fit inside the calibration cup alongside it.
9. Record the temperature values from the thermometer under the Standard column and the sonde under the Reading column on the Post-Measurement Calibration

Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

*Note: If the deviation between the standard value and the reading is greater than 0.2 °C, the temperature sensor may be due for a **Thermometer Accuracy Verification** (Appendix D).

Chlorophyll

1. Keep the sonde in DI water and remove the thermometer from the calibration cup.
2. In the "LIVE DATA" tab, record the value for chlorophyll (µg/L) and chlorophyll (RFU) under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard values and the Readings will auto-populate in the Deviation column.

Turbidity

1. Keep the sonde in DI water and press the "Start Wiping" button in the "LIVE DATA" tab to wipe the sensors. Check that the wiper parks correctly in the garage.
2. Record the value for turbidity (FNU) in DI water under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.
3. Remove the sonde from the DI water. Dry off the sonde's guard and sensors and shake off any excess water.
4. Rinse the guard and sensors with the 124 FNU rinse bottle and then place the sonde in the 124 FNU standard. Be careful not to agitate the standard.
5. In the "LIVE DATA" tab, press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
6. Record 124 under the Standard column and the value for turbidity (FNU) in standard under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

Specific Conductance

1. Remove the sonde from the 124 FNU turbidity standard and rinse the guard and sensors with DI water.
2. Remove the calibration guard and wiper to prevent contamination of the remaining standards.
3. Dry off the sonde's sensors and shake off any excess water.

4. Rinse the sensors with the specific conductance (6668 µS/cm) rinse bottle. Then place the sonde in the specific conductance (6668 µS/cm) standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

5. Record 6668 under the Standard column and the value for specific conductance (µS/cm) in standard under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

pH

1. Remove the sonde from the specific conductance standard and rinse the sensors with DI water.
2. Dry off the sonde's sensors and shake off any excess water.
3. Rinse the sensors with the pH 7 rinse bottle. Then place the sonde in the pH 7 standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

4. The pH standard value needs to be adjusted to the temperature of the solution, which is 7.02 for room temperature. Record this value under the Standard column for pH 7.
5. Record the value for pH and pH mV under the Reading and Additional Info columns on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.
6. Remove the sonde from the pH 7 standard and rinse the sensors with DI water.
7. Dry off the sonde and shake off any excess water.
8. Rinse the sensors with the pH 10 rinse bottle. Then place the sonde in the pH 10 standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

9. The pH standard value needs to be adjusted to the temperature of the solution, which is 10.05 for room temperature. Record this value under the Standard column for pH 10.
10. Record the value for pH and pH mV under the Reading and Additional Info columns on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.
11. The Post-Measurement Calibration Check form will auto-populate the Delta Slope. Ensure that this value is within the recommended range.

*Note: If the Delta Slope is outside of the recommended range, the pH module needs replacing.

Dissolved Oxygen

1. Remove the sonde from the pH 10 standard and rinse the sensors with DI water.
2. Install the field wiper and field guard and place the sonde in the 100% air saturated bucket for at least 5 minutes.
3. In the "LIVE DATA" tab, record the DO (% Sat) and DO (mg/L) values under the Reading column and the Temperature (°C) from the sonde in the bucket on the Post-Measurement Calibration Check form.
4. Record the local Barometer reading from a YSI handheld.
5. Calculate the DO (% Sat) and the DO (mg/L) standard values by using the Dissolved Oxygen Solubility Tool (located on the Shared Drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources). Record these values under the Standard column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

   *Note: It is not necessary to enter in the specific conductance value when calculating the standard values in the Dissolved Oxygen Solubility Tool. You can also find the DO (% Sat) standard value by dividing the Barometer reading by 7.6.
6. Go to the "HOME" tab and disconnect the sonde from Kor. Remove the adaptor or turn off the Bluetooth (whichever was used). Place the sonde back in its original calibration cup with ½ inch of tap water and store upright in the calibration lab until the next use.

Archiving

Sonde calibration forms get archived in record binders and saved to the shared drive.

1. Save the completed Post-Measurement Calibration Check form to the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Saved Calibration Sheets.
2. Print off the completed form and make a black and white copy of it. Place the copy in the plastic sleeve to be stored with the sonde.
3. Place the original Post-Measurement Calibration Check form inside the EXO Calibration Sheets binder and file it according to sonde ID.

Sonde Rating

After completion of each post-measurement calibration check, the sonde readings are rated based on criteria developed by the USGS (see **Table 4**). These ratings are used to assess the validity of the data that was collected in the field.

1. Open the current sonde rating file found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Rating Sheets.

   *Note: If this is the first sonde rating for the month, open up the most recent file and save it as a new file with the current month (Ex. 04_April Sonde Ratings).

2. Make a copy of the Template tab and name the new tab based on the run the sonde was used for (and the sonde's position, if more than one sonde was used on the run).
3. Fill out the information at the top of the worksheet, which includes the sonde ID, information about the run the sonde was used on, and information about the post-measurement calibration check.
4. Use the information on the Post-Measurement Calibration Check form to fill in the boxes under "Post-Deployment". The error boxes will automatically calculate, and a rating will be generated based on those calculations.
5. If ratings fall into the Fair or Poor range for any parameter, the data collected by that sonde needs to be flagged in the database and the probe should be investigated for any issues.

Table 4-Acceptance Criteria for Sonde Rating

	Excellent	Good	Fair	Poor	Max Limit
Water Temperature °C	≤±0.2	±0.2-0.5	±0.5-0.8	>±0.8-2.0	>±2.0
Spec. Conductance µS/cm	≤±3%	±3-10%	±10-15%	>±15-30%	>±30%
Dissolved Oxygen mg/L	≤±0.3 or ≤±5%	±0.3-0.5 or ±5-10%	±0.5-0.8 or ±10-15%	>±0.8/2.0 or >±15-20%	>±2.0 or >±20%
pH	≤±0.2	±0.2-0.5	±0.5-0.8	>±0.8-2.0	>±2.0
Turbidity FNU	≤±0.5 or ≤±5%	±0.5-1.0 or ±5-10%	±1.0-1.5 or ±10-15%	>±1.5-3.0 or >±15-30%	>±3.0 or >±30%

Enter Field Data

Following each sampling day, the field data collected needs to be entered into the FLIMS database before the samples are submitted to the lab. See Appendix O for **FLIMS Data Entry Best Practices**.

1. Go to the main menu in FLIMS and click "Runs and Field Data".
2. Select the sampling day for which you would like to enter field data and click "Edit Run".
3. Highlight the first station in the Collection Events box in the top left corner. Enter in the correct collection time under Sample Collection Date and Time and make sure the collection date is accurate.
4. Use the field data sheet to fill in all data entry fields for that station. This includes the surface and bottom sonde measurements for the parameters listed in **Table 5**, secchi reading, weather information, MC score, field notes (if any), and chlorophyll volume (determined from surface turbidity value).

   *Note: Only the collection times and chlorophyll volumes are entered for the blanks and duplicates. GPS coordinates only need to be entered for EZ stations.

5. Repeat the previous two steps for the remaining stations listed in the Collection Events box.

Table 5-Field Parameters and Accuracy Ranges for YSI EXO Sensors

Parameter	Units	Sensor	Model Number	Accuracy
Water Temperature	˚C	Conductivity/Temperature	599870	±0.01 ˚C
Specific Conductance	µS/cm	Conductivity/Temperature	599870	±0.5% of reading or 0.001 mS/cm
pH	pH units	pH and pH module	599701	±0.1 within 10 ˚C of calibration temp
Dissolved Oxygen	mg/L and % Saturation	Optical DO	599100-01	±1% or 0.1 mg/L

Turbidity	FNU	Turbidity	599101-01	±2% or 0.3 FNU
Chlorophyll	µg/L and RFU	Total Algae	599759-01	n/a
Depth	feet	N/A	N/A	± 0.04%

Chain of Custody

COC forms need to be printed out and accompany the samples when taken into Bryte lab for submission.

1. Go to the main menu in FLIMS and click "Paperwork".
2. Select the sampling day for which you would like to print off the COC. Make sure it says "Yes" on the left-hand column next to the run name, then print all pages except the first page.

   *Note: The first page of all COCs should have already been printed and the phytoplankton bottles should have been removed from the COC in the **FLIMS** section.

3. On the first page of the COC, fill out the first "Received By" section (if you did not collect the samples) and the second "Relinquished By" section with your information.
4. Go through the "Checklist for Sample Submittal to Bryte" and initial each line as it is confirmed correct. This will include writing down the lot numbers for all acidified containers and indicating whether samples were processed on site or at a later time.
5. Write in the date and time samples were filtered at the bottom of the "Container Summary" box and initial to confirm the total container count.

   *Note: If samples were filtered immediately after collection, write in "Same as collection date and time".

Sample Submission

Samples from each sampling event are submitted to Bryte lab (with the exception of phytoplankton) typically the day after they are collected. See **Navigation** (Appendix G) for driving directions to Bryte Lab.

1. Using the **Chain of Custody** as a guide, pack up all necessary samples from the refrigerator and freezer in the downstairs lab into a blue cooler.
2. Cover the samples with ice from the ice maker in the warehouse to keep the temperatures from rising.
3. Transport the samples with the corresponding COC to Bryte lab and place all samples on the counter at the receiving desk in order of lab IDs and grouped by station.

   *Note: See Sid Fong or Allan Wong to get a Bryte lab staff member to check in the samples.

4. After the samples have been processed, the receiving department will email a copy of the COC, which is to be saved on the shared drive located here: S:\M & A BRANCH\Discrete EMP\Water Quality\Lab COCs.

    * Bryte Chemical Laboratory
      Department of Water Resources
      1450 Riverbank Road
      West Sacramento, CA 95605
      Phone: (916) 375-6008
      Contact: Sid Fong

Van Run CDEC Verification

The accuracy of the sonde readings collected on the Van Run needs to be verified with the corresponding continuous station readings on CDEC. These CDEC station IDs are SRH for C3A Hood, SJR for C10A Vernalis, and ORI for C9. Blank Van Run CDEC Verification forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Blank Field Data Sheets\E-Forms.

1. Fill in the Sonde ID, Field Crew, and collection date for the Van Run on the CDEC Verification form.
2. Copy the collection time and surface sonde readings from the Van Run field data sheet for each station.
3. Write in the non-PST time for each CDEC station.
4. Go to cdec.water.ca.gov and hover over "Query Tools" at the top of the page. Then click "Real Time Data".
5. Enter in the station ID (either SRH, ORI, or SJR) and click "Get Data".
6. Locate the desired time stamp that corresponds to the Van Run sampling time. Use the "Earlier" button to get past data.
7. Copy the corresponding line of surface sonde readings onto the CDEC Verification form for that station.

    *Note: Be sure to record the water temperature, not the air temperature. Water temperature values taken from CDEC need to be converted from Fahrenheit to Celsius.

8. Compare the Van Run sonde readings with the CDEC readings to ensure they are within range of each other and document any large discrepancies in the "Notes" section.
9. Save the CDEC Verification form to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets and enter the month and year in the file name (e.g., Van Run CDEC Verification_Jul22).

Compile and Print Field Data Sheets

After completion of the monthly water quality field run, the electronic field data sheets need to be compiled and archived. Field data sheets should be checked for errors or missing data prior to printing.

1. In Adobe Acrobat, combine the electronic field data sheets in the following run order:

    -Van Run
    -Mid Delta Day 1
    -Mid Delta Day 2
    -Sacramento River
    -Suisun Bay
    -Grizzly Bay
    -San Pablo Bay

2. Name the file according to month and year followed by "Field Data Sheets" (ex. February 2020 Field Data Sheets) and save it to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

    *Note: You will need to flatten the Van Run data sheet before combining them. To do this, go to "Print" and then click "Adobe PDF" and save it as a new file.

3. In Adobe Acrobat, combine the Dissolved Oxygen Calibration Check forms with the Van Run CDEC Verification form. Name the file according to month and year followed by "QA Data Sheets" (ex. February 2020 QA Data Sheets) and save it to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

    *Note: You will need to flatten the data sheets before combining them.

4. Save the Crew Lead Report as a separate pdf and save the file to the same folder on the shared drive as the rest of the data sheets for that month. Use the month and year to name the file (ex. February 2020 Crew Lead Report).

5. Print off all data sheets for the month (field data sheets, QA data sheets, and Crew Lead Report). Three hole punch the stack of field data sheets and place them in the water quality data binder for the appropriate year and month.

Zooplankton Monitoring

ZOOPLANKTON MONITORING STATIONS

The Discrete EMP unit monitors the zooplankton abundance monthly at 19-24 stations in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay (**Table 6**, **Figure 4**). These stations overlap with the **Discrete Water Quality Monitoring** stations and are sampled over the course of six days. See Appendix E for **Field Safety**, Appendix F for **Job Hazard Analysis**, Appendix G for **Navigation** to the Antioch and Benicia marinas, and Appendix M for the **Zooplankton Scientific Collecting Permit**.

Table 6-Zooplankton Monitoring Station Locations and Descriptions

Station Name	Location	Region	Habitat Type	Accessed By
EZ2	Entrapment Zone - Location determined when bottom SpC values occur at approx. 2,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ2-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ2	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6	Entrapment Zone - Location determined when bottom SpC values occur at approx. 6,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ6	n/a	Estuarine Channel (Brackish Water)	Vessel
NZ002	Carquinez Strait at Glen Cove Harbor- tow conducted when surface SpC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ004	Carquinez Straight 46-91 m off Ozol Pier- tow conducted when surface SpC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ028	Grizzly Bay SE of Dolphin near Suisun Slough	Suisun Bay	Estuarine Embayment (Brackish Water)	Vessel
NZ032	Montezuma Slough, 2nd bend from mouth	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel
NZ048	Suisun Bay channel off Middle Point	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
NZ054	Sacramento River at mouth of Mallard Slough near Chipps Island	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
NZ060	Sacramento River above Point Sacramento	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel

NZ064	Sacramento River at Emmaton	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
NZ068	Sacramento River at US Coast Guard Station	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
NZ074	San Joaquin River at Antioch Ship Channel	Western Delta	Tidal River Channel (Brackish Water)	Vessel
NZ086	San Joaquin River at Potato Point	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
NZ092	San Joaquin River at Buckly Cove	Southern Delta	Tidal River Channel (Freshwater)	Vessel
NZ325	San Pablo Bay near Light 15- tow conducted when surface SpC values occur below 20,000 µS	San Pablo Bay	Estuarine Channel (Brackish Water)	Vessel
NZ41A	San Pablo Bay near Mouth of Petaluma River	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
NZD06	Suisun Bay at Bulls Head Point near Martinez	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
NZD16	San Joaquin River at Twitchell Island	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
NZD28	Old River near Rancho Del Oro, south end of Holland Tract	Central Delta	Tidal River Channel (Freshwater)	Vessel
NZD41	San Pablo Bay near Pinole Point	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
NZEZ2	Entrapment Zone- Location determined when bottom SpC values occur at approx. 2,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
NZEZ6	Entrapment Zone- Location determined when bottom SpC values occur at approx. 6,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
NZM10	Disappointment Slough near Bishop Cut	Eastern Delta	Tidal River Channel (Freshwater)	Vessel
NZS42	Suisun Slough at mouth of Volanti Slough	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel

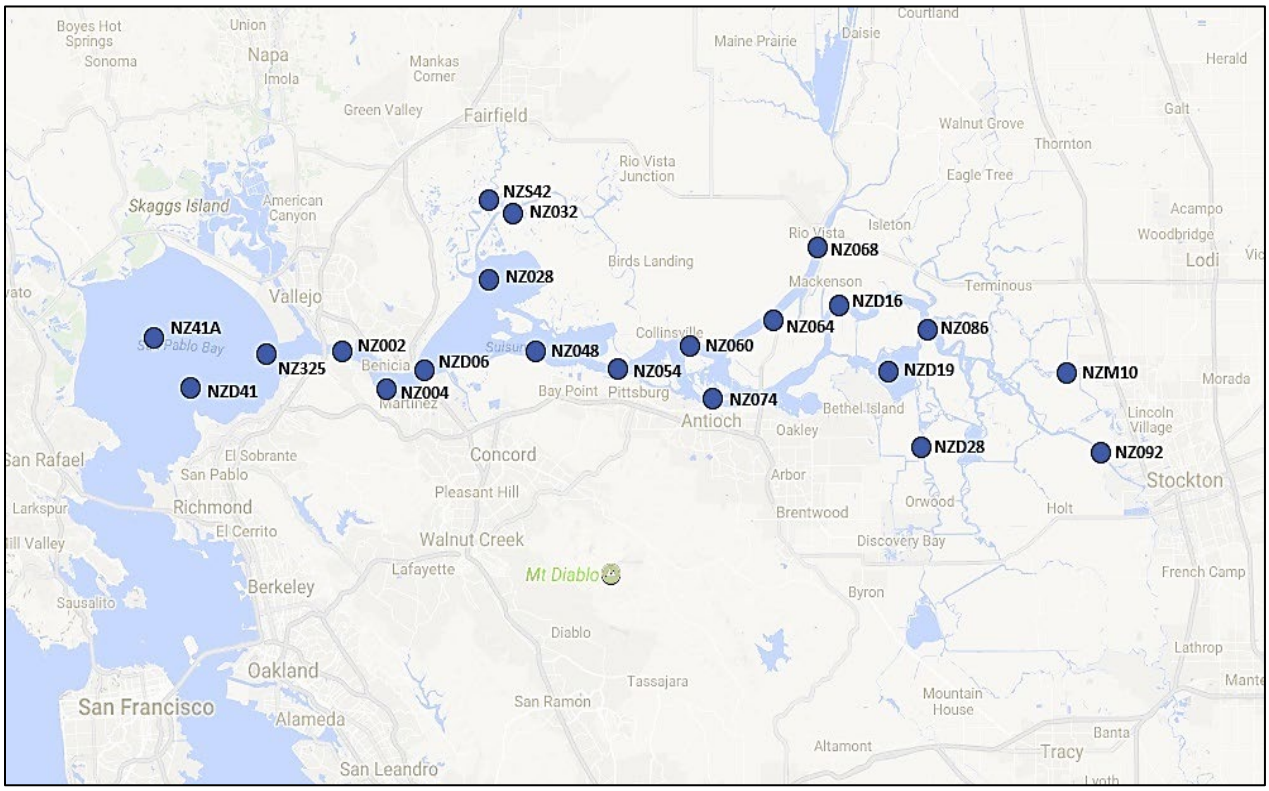


Figure 4-Map of Zooplankton Monitoring Stations

PRE-SAMPLING PREPARATION

Loading Equipment

Most equipment used for zooplankton monitoring is kept in the lockup in Antioch. CDFW prepares the sampling jars and drops them off prior to the monthly water quality field run in the lockup directly behind the equipment lockup. Before departing the marina, make sure all items on the **Field Equipment Checklist** are located on the vessel.

Field Data Sheets/Labels

On the first day of the monthly water quality field run, print out the field data sheets on waterproof paper located on the shared drive here: S:\M & A BRANCH\Discrete EMP\Zooplankton\Blank Field Sheets (and also in the "Field Data Sheets" folder on the desktop of the RV Sentinel computer). The labels for the sample containers are also located in the same folder. Update the date on the labels for the current month and print them out on waterproof paper.

Field Equipment Checklist

- ☐ Tow Sled
    - Clarke-Bumpus Net
    - Mysid Net
    - Flow Meters (2)
- ☐ Line for Zooplankton Tow
- ☐ Bucket for Rinsing
- ☐ Rotifer Net
- ☐ Pump Tank
- ☐ Pump with Hose
- ☐ Sample Jars with Formalin (4 tubs)
- ☐ Rotifer Sample Bottles (1 tub)
- ☐ Formalin Squirt Bottle
- ☐ Extra Formalin Bottles
- ☐ Field Data Sheets
- ☐ Clipboard
- ☐ Zooplankton Tow Schedule
- ☐ Rotifer Pump Schedule
- ☐ Timer
- ☐ Secchi Disk
- ☐ Box of Sampling Supplies
- ☐ Writing Utensil
- ☐ Standard Operating Procedures
- ☐ Drinking Water
- ☐ Identification Guide
- ☐ Scientific Collection Permit (CDFW)

SAMPLING PROCEDURES

Field Data Collection

1. Upon arriving to a station, record the date and station number.

   *Note: "Survey" at the top refers to the month.

2. Take the Secchi reading (performed the same as **Secchi Disk Reading** under **Discrete Water Quality Monitoring**) and record the value.
3. Record the starting flow meter readings on both the Clarke-Bumpus and mysid nets before starting the **Zooplankton Tow**.
4. While the **Zooplankton Tow** is being performed, record the "Time" from the boat in PST.

   *Note: The time for the station is exactly when the timer is started.

5. Once the tow is completed, record the "Tow Duration" (in minutes) on the data sheet.
6. After the sample has been collected from the **Rotifer Pump**, record the "Pump Volume" on the field data sheet.

Sample Collection

Zooplankton Tow

A ten-minute oblique tow is conducted using a tow sled that holds two types of nets. The smaller net located on top is a 160-micron mesh Clarke-Bumpus net that targets adult and juvenile copepods and cladocerans. The larger net located on bottom is a 500-micron mesh mysid net. The zooplankton tow is typically started after the vertical sonde readings have been recorded upon arriving to a station. The target time for the zooplankton tow is ten minutes and the target angle (warp angle) for the line is 65˚ ±2°. If there is a lot of algae or vegetation present at a station, the tow time can be decreased as necessary.

1. On the first day of the monthly water quality field run, use a fine-tipped squirt bottle to fill up the flow meters on the tow sled with DI water.

   *Note: The flow meter on the Clarke-Bumpus net can be completely removed with a flathead screwdriver. The flow meter on the mysid net stays attached.

2. Before starting the tow, make sure the cod end of the Clarke-Bumpus net is hanging on the outside of the tow sled and the cod end of the mysid net is hanging in the middle of the tow sled.
3. Check the depth reading for the station and use the zooplankton tow schedule to determine the starting length measurement under the "Warp Out" column.

*Note: For shallow stations (D7, and D41A), a horizontal tow can be conducted so that the tow sled remains at a constant depth for the entire ten minutes.

4. Get the boat captain's approval, then use the crane controls to carefully lower the tow sled into the water, while making sure to swing out the crane enough to clear the boat.
5. Using the ten-foot line markers, lower the tow sled to the appropriate depth and then immediately start the timer (ten minutes). Record the time (in PST) on the data sheet.
6. Follow the zooplankton tow schedule so that the tow sled gets raised in ten feet increments at each time listed next to the appropriate depth range.
7. When there are 30 seconds remaining, raise the tow sled to where the bridle shackle is just above the surface.

   *Note: At the 30 second mark, give notice to the individual responsible for **Sonde Measurements** under **Discrete Water Quality Monitoring** so they can assist in bringing the tow sled up onto the back deck of the vessel.
8. Once the timer goes off, raise the tow sled up and out of the water while making sure to swing out the crane enough the clear the boat.
9. While the tow sled is still raised over the side of the boat, use a hose to rinse down the sides of the mesh on both nets so that the sample contents get rinsed into the cod ends.
10. Use the crane controls to lower the tow sled onto the back deck.
11. Record the ending flow meter reading on the field data sheet.

    *Note: Place a zero in the first space of the ending flow meter reading. If the flow meter reset to zero during the tow, put a "1" in the first space before the reading. This will account for the reset during the calculation.

Rotifer Pump

After the zooplankton tow has been performed, a pump is used to sample the vertical water column and sample contents are collected into a 35-micron mesh rotifer net. This method targets adult and juvenile cyclopoid copepods, copepod nauplii, and rotifers. The pumping starts at the bottom of the water column, is brought up to the surface, and then lowered back down to the bottom. The target volume for the total amount of water pumped is 19.8 gallons.

1. Place the rotifer net inside the PVC part of the tank.

2. Place the output end of the pump hose over the side of the boat and the input end into the water. Turn on the pump to allow any remaining water in the hose to be pumped out until you hear the air bubble being removed from the hose.
3. Check the rotifer pump schedule to determine the starting depth for the appropriate depth range for the station.
4. Use the tape marks on the hose to lower the pump to the starting depth.

   *Note: The red lines on the pump hose are placed every three feet while the yellow lines are placed every ten feet.

5. Hold down the button on the flow meter until it resets to zero, then immediately place the output end of the hose into the net opening.
6. Follow the rotifer pump schedule by raising or lowering the hose in 3-foot increments at each of the listed volumes for the appropriate depth range.

   *Note: The hose is raised for the volumes to the left of the vertical line on the rotifer pump schedule. The hose is lowered for those to the right of the vertical line. The volume value directly to the left of the vertical line indicates the top of the water column and is sampled twice.

7. Once 19.8 gallons (final volume) has been pumped, take the output end of the hose out of the rotifer net and place it over the side of the boat.
8. Bring up the hose until it is only about a foot below the surface. Turn off the pump and bring the hose back up onto the boat.

   *Note: Use caution as to not hit the hull of the boat when bringing the weighted end of the hose close to the surface.

9. Record the total volume pumped on the field data sheet.

Rinsing

Once the samples have been collected into the three nets, the contents are transferred into the appropriate containers for collection. The samples are preserved in a 10% formalin solution containing Rose Bengal dye. When rinsing down a net, do not let the water go over the top and into the net. Rather, rinse from the sides of the mesh.

Clarke-Bumpus Net

1. Obtain the glass jar labeled "CB" containing preservative for the appropriate station.
2. Take the Clarke-Bumpus (smaller) net and rinse down the sides of the mesh so that the sample contents fall into the collection bottle at the cod end.

3. Unscrew the collection bottle from the net (making sure the bottle is not completely full) and dump the contents into the glass "CB" jar. Screw the collection bottle back onto the net.
4. Repeat the previous two steps two more times so that the net gets rinsed down a total of three times. Be cautious not to fill the glass jar higher than the line.
5. After the third rinse, dunk the bottom half of the collection bottle into a bucket filled with water from the same station so that any material remaining on the mesh gets rinsed off. Then pour the contents into the glass jar. Continue to use this method if more water is needed in the sample jar to reach a ~10% formalin mixture.
6. Place the appropriate label for that station into the jar and secure the lid tightly. Then place the jar back into the storage container.

Mysid Net

1. Obtain the glass jar labeled "M" containing preservative for the appropriate station.
2. Take the mysid (larger) net and rinse down the sides of the mesh so that the sample contents fall into the collection bottle at the cod end.
3. Unscrew the collection bottle from the net and pour the contents into the glass "M" jar (orient the bottle so that the mesh is facing upward). Screw the collection bottle back onto the net.
4. Repeat the previous two steps two more times so that the net gets rinsed down a total of three times. Be cautious not to fill the glass jar higher than the line.
5. After the third rinse, dunk the bottom half of the collection bottle into a bucket filled with water from the same station so that any material remaining on the mesh gets rinsed off. Then pour the contents into the glass jar. Continue to use this method if more water is needed in the sample jar to reach a ~10% formalin mixture.
7. Place the appropriate label for that station into the jar and secure the lid tightly. Then place the jar back into the storage container.

Rotifer Net

1. Remove the rotifer net from the tank and rinse down the sides of the mesh so that the sample contents fall into the collection bottle at the cod end.
2. If extra rinsing is needed, pour some of the water in the cod end back out, allowing it to drain through the net mesh. Then rinse the sample back down into the collection bottle.

*Note: Do not fill the bottle completely, as formalin will need to be added to the sample.

3. Open the tub containing the rotifer sample bottles and remove the empty bottle for that station (labeled on cap) from its spot. Unscrew the cap and place both off to the side.
4. Carefully unscrew the collection bottle (containing the sample) from the net and place into the spot of the bottle that was just removed.
5. Use the squirt bottle to add enough formalin to the collected sample so that it creates a 10% formalin solution.
6. Place the appropriate label into the bottle. Then take the labeled cap that was removed from the empty bottle and tightly secure it onto the bottle now containing the preserved sample.
7. Take the empty bottle that was removed from the tub and screw it onto the rotifer net to be used for the next station.

POST-RUN PROCEDURES

Unloading Equipment

After completing the final day of the monthly water quality field run, transport all zooplankton monitoring equipment on the **Field Equipment Checklist** back into their original locations. Place the completed field data sheets and storage tubs containing the samples in the lockup to be picked up by CDFW.

Benthic Monitoring

BENTHIC MONITORING STATIONS

The Discrete EMP unit monitors the benthic communities and sediment composition at ten monitoring stations in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay (**Table 7**, **Figure 5**). These stations are accessed by research vessel and are sampled over the course of two days split up by region between bay sites and Delta sites. A Boston Whaler is used to sample 2-3 of the farther sites, which are then transported to the larger vessel for processing. See Appendix E for **Field Safety**, Appendix F for **Job Hazard Analysis**, Appendix G for **Navigation** to the Antioch marina, and Appendix N for the **Benthic Scientific Collecting Permit**.

Table 7-Benthic Monitoring Station Locations and Descriptions

Station Name	Location	Region	Habitat Type	Accessed By
C9	Old River upstream of Clifton Court Forebay Intake (left)	Southern Delta	Tidal River Channel (Freshwater)	Whaler
D16	San Joaquin River at Bradford Island (left)	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
D24	Sacramento River downstream of Rio Vista Bridge (left)	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D28A	Old River upstream of Rock Slough (left)	Central Delta	Tidal River Channel (Freshwater)	Vessel or Whaler
D4	Sacramento River at Sherman Island Upstream of Point Sacramento (left)	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D41	San Pablo Bay near Pinole Point (center)	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
D41A	San Pablo Bay near Pinole Point- north central (center)	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
D6	Suisun Bay upstream of I-680 bridge (right)	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
D7	Grizzly Bay at Dolphin near Suisun Slough (center)	Suisun Bay	Estuarine Embayment (Brackish Water)	Vessel
P8	San Joaquin River at Buckley Cove (right)	Southern Delta	Tidal River Channel (Freshwater)	Whaler

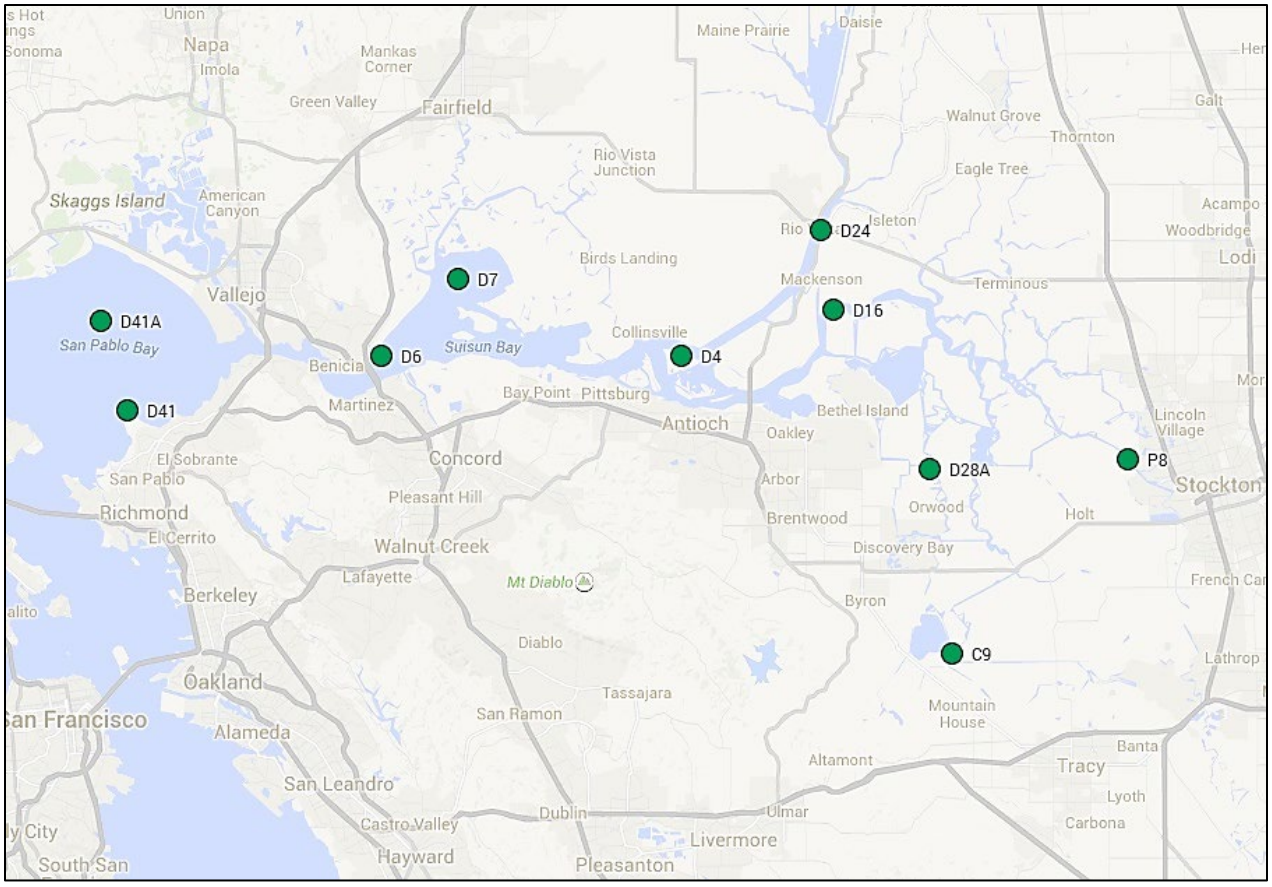


Figure 5-Map of Benthic Monitoring Stations

PRE-SAMPLING PREPARATION

Pre-Weigh Foil Boats

All *Corbicula fluminea* and *Potamocorbula amurensis* picked in the live sort samples are sorted and weighed in small round foil boats. The boats are typically weighed one to two days prior to the monthly benthic run so that the weight of the empty boat can be logged before the clams are distributed into each boat and then subtracted from the final calculation to determine biomass.

1. If the scale is powered off, press the red power button on the bottom far left and let it warm up for 15-30 minutes. If at any point when nothing is on the scale and it displays any number besides zero, click "TARE" to zero it.

    *Note: If the bubble at the back of the scale on the right-hand side is not contained in the circle, adjust the scale using the round feet on the bottom. Then press the CAL button to calibrate.

2. Obtain the appropriate amount of un-weighed trays of regular and plus size boats from the left side of the cabinet above the biomass computer in the downstairs lab.

    *Note: To estimate how many trays of boats to pre-weigh, open the live sort data file from same month of the previous year to see how many trays were used (underlined rows indicate the end of a tray). This will typically be an indicator of how many trays are necessary for that particular month.

3. Open the "Sartorius Scale Input" software and the "MASTER Live Sort" excel spreadsheet template (found on the desktop of the biomass computer) and "Save As" to the desktop with the appropriate year, month, and "Live Sort" in the title (ex. 2015 June Live Sort).
4. Before weighing the boats, use the calibration log book and weigh the 1, 5, and 50 gram weights (located in the top cabinet to the left of the analytical scale). This will verify and document that the scale is working efficiently.
5. For each tray of boats to be pre-weighed, enter in the appropriate boat numbers on the left hand column of the spreadsheet in the same order as they appear from left to right in the tray.

    *Note: Place a bottom border underneath the row of the last boat number in that tray.

6. Select the cell for the first boat number of the tray under the "Pan Weight" column. Using large forceps, place the corresponding boat inside the clear doors of the analytical scale.
7. Once the weight reading equilibrates, click the button resembling an underlined disc on the bottom far right of the scale to automatically enter the reading on the spreadsheet. Check to make sure the reading transferred to the appropriate cell.
8. Repeat this process for each boat of every tray being used for that month. Attach a sticky note to each pre-weighed tray to indicate that it has been pre-weighed and include the range of boat numbers in that tray, the date it was pre-weighed, and your initials.
9. Put all pre-weighed trays on the right side of the cabinet above the biomass computer to separate from those trays that have not been pre-weighed.

Mixing Formalin

There are two 20-liter jugs that contain the formalin for sample preservation. One holds a solution with 10% formalin and the other holds a solution with 20% formalin. These jugs are kept in the storage lockup in Antioch and the solutions are typically mixed on the morning of the first day of the benthic run. Gloves and goggles are to be worn when handling the chemicals and the procedure must be performed in a ventilated area. When

transporting the formalin jugs, ensure that the caps are secured tightly. The 20% formalin solution is used to preserve those samples that have a lot of organic matter in them, while the 10% formalin solution is used for all other samples.

Table 8-Conversions for Mixing Formalin

10% Formalin Solution		20% Formalin Solution	
Total amount to be made	**Amount of formalin to add**	**Total amount to be made**	**Amount of formalin to add**
4 L	0.4 L	4 L	0.8 L
5 L	0.5 L	5 L	1.0 L
6 L	0.6 L	6 L	1.2 L
7 L	0.7 L	7 L	1.4 L
8 L	0.8 L	8 L	1.6 L
9 L	0.9 L	9 L	1.8 L
10 L	1.0 L	10 L	2.0 L
11 L	1.1 L	11 L	2.2 L
12 L	1.2 L	12 L	2.4 L
13 L	1.3 L	13 L	2.6 L
14 L	1.4 L	14 L	2.8 L
15 L	1.5 L	15 L	3.0 L
16 L	1.6 L	16 L	3.2 L
17 L	1.7 L	17 L	3.4 L
18 L	1.8 L	18 L	3.6 L
19 L	1.9 L	19 L	3.8 L
20 L	2.0 L	20 L	4.0 L

10% Formalin

1. Obtain the 10% formalin jug and determine how much solution (in liters) is needed to reach the "Fill Line". Divide that number by ten to determine how much formalin to add to the jug (**Table 8**).
2. Add one heaping round scoop of Rose Bengal.
3. Add two heaping round scoops of the sodium borate buffer.
4. Fill the jug with enough water to reach the "Fill Line".

20% Formalin

1. Obtain the 20% formalin jug and determine how much solution (in liters) is needed to reach the "Fill Line". Divide that number by five to determine how much formalin to add to the jug (**Table 8**).

2. Add two heaping round scoops of Rose Bengal (less if there is less than 10 L of formalin to be made).
3. Add two heaping round scoops of the sodium borate buffer.
4. Fill the jug with enough water to reach the "Fill Line".

Loading Equipment

All equipment is kept in the storage lockups in Antioch and is transported onto the boat on the morning of the first day of the benthic run. Before departing the marina, make sure all items on the **Field Equipment Checklist** is on the appropriate boat.

Taping/Labeling Bottles

Bottles are typically taped before arriving at the first station with blue painter's tape.

1. Place a piece of tape about two to three inches long on both the lid and side of all bottles that have been loaded on the vessel.
2. Label both pieces of tape on seven medium sized bottles with each station name (excluding P8, C9, and D28A, which will be collected by the Whaler crew) and "Live Sort" along with the dates those stations will be sampled.
3. Label the sediment bottles with the station name designating a bottle for all stations except P8 and C9.

Field Equipment Checklist

Research Vessel

- ☐ YSI EXO2 Sonde
- ☐ Ponar
- ☐ Tubs (12-16)
- ☐ Lids for Tubs (12+)
- ☐ 20 L Formalin Jugs (10% and 20%, full)
- ☐ Bottles (3 crates of small 1 L, two crates of medium 2 L, one crate of large 4L)
- ☐ 500 mL Sediment Bottles (10)
- ☐ Nets (4)
- ☐ Strainer Lids (small and large)
- ☐ Brush for Sieve
- ☐ Squirt Bottles (2)
- ☐ Yellow Scraper
- ☐ Sharpie
- ☐ Blue Painters Tape
- ☐ Gloves
- ☐ Safety Goggles
- ☐ Foul Weather Gear
- ☐ PFD
- ☐ Coolers for Live Sort Samples (2)
- ☐ Drinking Water
- ☐ Safety Binder
- ☐ Scientific Collection Permit (CDFW)
- ☐ Identification Guide

Boston Whaler

- ☐ Ponar with Line
- ☐ Tubs (3 deep, 2-3 regular)
- ☐ Nets (15+)
- ☐ Live Sort Bottles (3+)
- ☐ Sediment Bottles (3+)
- ☐ Sharpie
- ☐ Writing Utensil
- ☐ Blue Painters Tape
- ☐ Paper for Sediment Description

SAMPLING PROCEDURES

Field Data Collection

Field measurements are taken at each monitoring station from an EXO2 sonde located in a flow-through chamber on the research vessel that pulls water from a depth of one meter. Field data is obtained from the horizontal EXO2 sonde and GPS using the MOPED application.

1. At the beginning of each sampling day, setup the horizontal sonde and the MOPED application by following the procedures outlined in the **Setup** section under **Sampling by Vessel** for **Discrete Water Quality Monitoring**.

   *Note: Only the horizontal sonde and the GPS are used for benthic monitoring. Disregard those instructions involving the vertical sonde. In the "Cruise Info" tab, select "Benthic" under Purpose.

2. Upon arriving to each station, select the appropriate station name in the dropdown menu in the Horizontal Profile tab.
3. When the incoming data is stable, click "Data Snapshot" in the Horizontal Tab to copy the data over to the Data Entry tab.
4. In the Data Entry tab, check to make sure the readings from the horizontal sonde transferred correctly and enter the collection time (in PST).
5. In the Data Entry tab, click "Check GPS" to obtain the depth reading, enter in the weather observations, and document the sediment composition and organisms observed in the Field Notes section (ex. 75% soft gray clay on bottom and 25% light brown silt on top with a moderate amount of live *Potamocorbula* and amphipods). Then click "Save".
6. At the end of the day, follow the procedures outlined in **Saving Sonde Data and MOPED Shutdown** to save the field data sheet and close the application. The MOPED file does not need to be saved.
7. Put away the horizontal sonde according to the information in **EXO2 Sonde Cleanup**.

Sample Collection

Six samples are obtained at each site using a hydraulic winch and a ponar dredge to collect a sediment "grab". Four of the six grabs are rinsed in a 595-micron sieve, preserved with formalin, and sent to the Hydrozoology lab for taxonomic classification and quantification of benthic macroinvertebrates. One of the six samples is used for live sort where it is rinsed in the sieve and brought back to the EMP lab in which *Corbicula* and *Potamocorbula* are picked and sorted into individual size classes to determine biomass. Five hundred mL of

the final grab is collected into a sediment bottle and sent to Bryte lab to determine sediment composition.

Operating the Hydraulic Winch

The person responsible for operating the winch needs to wait until the boat captain has given permission to turn on the hydraulics when it is safe to deploy the equipment. Extreme caution should be taken on days of inclement weather conditions. Always use the winch controls to slowly maneuver the ponar when near the boat.

1. When approval is given from the boat captain and the field crew is ready, turn on the hydraulics. Use the winch controls to raise the ponar off the stand and up over the side of the boat and into the water about three feet away from the boat.
2. When the ponar is over the side, the individual operating the ponar will place a tub on the stand to hold the sample.
3. Keep lowering the ponar down towards the bottom until you see slack in the line when it hits the substrate. Raise the ponar up out of the water and carefully bring it back above the stand and lower it into the tub.

   *Note: Once the ponar is in the tub, feed more slack into the line to allow the ponar operator to open it completely.

4. The ponar operator will then open the ponar, latch it to keep from closing, and then hold the line to create tension.
5. At this point, use the winch controls to raise the ponar clear of the sample but still keeping the lower portion of it inside the tub.

   *Note: Avoid raising the ponar completely over the tub so that the sample will not miss the tub when it gets rinsed out.

6. Wait for the ponar operator to rinse the sample out of the ponar, then raise it up over the side to obtain another grab by repeating the previous steps.
7. Keep repeating this procedure until six samples have been collected.
8. Once the sixth sample has been rinsed into the tub and the tub is off the stand, carefully lower the ponar back onto the stand so that the ponar operator can rinse it down before the next station is sampled. Then turn off the hydraulics.

   *Note: At this point, the individual operating the winch will typically start rinsing nets if they were used at the station (see **In the Nets** under **Rinsing**).

Operating the Ponar

Never operate the ponar unless you have been trained by an experienced crew member. The ponar is very heavy and has the potential to be dangerous. Never place fingers/hands

inside the triangular opening of the latch or inside the ponar interior and always wear gloves when operating. Keep eyes on the ponar at all times and take extreme caution on days of inclement weather conditions.

1. When the hydraulics have been turned on and the winch operator is ready to deploy, pull the line near the ponar to one side to create tension. Then lift up the free-moving arm from the bottom of the collapsible hinge (triangular opening) so that it catches on the notch. Guide the ponar up and over the side of the boat by holding the side blocks until it is out of reach.

   *Note: Do not push the ponar to prevent it from swinging side to side.

2. While the winch operator is lowering the ponar to collect the sample, place a tub on the ponar stand.

   *Note: At sites with sticky clay/mud or a lot of organic material, place a mesh net inside-out over the top of the tub so that the sample can fall into the center of the net and the tub catches the water that flows through the mesh. Four of the six grabs should be collected in nets (nets are not needed for the live sort or sediment samples).

3. When the winch operator brings the ponar back up after the sample has been collected, guide the ponar back over the boat and over the top of the tub with the latch facing towards you.

4. The winch operator will then lower the ponar into the tub and provide slack in the line when it hits the bottom. Grip the blocks on the side of the ponar and lift upward to open so that the contents empty into the tub.

   *Note: If using a net, make sure the edges of the net do not get caught in the ponar when it is lowered. Before opening the ponar, make sure all edges of the net are outside of it.

5. Once the ponar is open, pull the line to one side to create tension and then lift up the free-moving arm from the bottom of the collapsible hinge (triangular opening) so that it catches on the notch.

   *Note: DO NOT place hands or fingers inside of the collapsible hinge.

6. The winch operator will raise the ponar right above the top of the tub. Use the hose to spray the two screens on the outside of the ponar to rinse out the contents of the sample into the tub.

   *Note: Look through the screens to ensure all of the sample has been rinsed into the tub. If some of the sample is still caught inside, slide out the screen and spray the hose directly into the ponar to rinse it out.

7. The winch operator will raise the ponar back up to collect another sample (guide the ponar over the side) and the person responsible for rinsing will take the tub off of the stand.
8. Once the ponar stand is empty, place another tub onto the stand to collect the next sample.
9. Repeat the previous steps until six samples have been collected.
10. Once all samples have been collected and the winch operator lowers the ponar onto the stand, use the hose to rinse down all surfaces and crevices of the ponar so that it is clean for the next station.

    *Note: At this point, the individual operating the winch will typically start rinsing nets if they were used at the station (see **In the Nets** under **Rinsing**).

Rinsing

Once collected, the samples are rinsed down so that all organisms collected are free from mud, clay, peat, etc. and can be identified as easily as possible. The rinsing will typically occur while the boat is traveling between sites. Always be aware of surroundings when the boat is moving, especially in inclement weather conditions.

In the Nets

Nets are used as a pre-rinse method to save time if samples contain a large amount of material that does not rinse easily in the sieve. If nets are used at a station, the individuals responsible for operating the winch and ponar will typically rinse out the four nets over the side of the boat while the third individual begins rinsing the first sample in the sieve. Do not place the net near the boat props. Once the net is over the side, be careful not to let the net go or to let the sample overtop the net. Be aware that peaty samples will fill up with water at a faster rate and will inhibit the water from escaping through the mesh.

1. Bring a tub containing a sample inside of a net over to one side of the boat and untie the slipknot of the rope.

    *Note: It is easiest to place the tub on a chair so that nets containing heavier samples do not have to be lifted as high. This also helps with rinsing the sample back into the tub once the net has been rinsed over the side to avoid back strain.

2. Grab the rope near the mesh with one hand and loop the free end of the rope across your palm on the opposite hand, without wrapping it around the opposite hand. This ensures that the net will not slip out of your hands when being rinsed.

    *Note: If the distance from the water surface to the top of the boat railing is large (i.e., like on the RV Sentinel), secure a line to the boat railing and attach a carabiner to the end of the line. Then clip the carabiner to the net line.

3. Carefully lower the net over the side of the boat just above the surface of the water. Use the railing as a point of contact for the rope to relieve some of the weight of the net.
4. If in calmer water, position the net so that only the bottom of it is coming in contact with the water and glide along the surface until the material coming out of the net runs clear.
5. If in rougher water, carefully dunk the bottom half of the net every few seconds until the net runs clear, while being cautious of incoming waves. The net can also be put over the back rail of the Endeavor to rest on the swim platform and hosed off there until the sample is small enough to put safely over the side.
6. Once the sample has been completely rinsed, lift the net up over the railing and onto the deck floor, then tie the rope in a loose knot and set off to the side.
7. Dump the water left over in the tub over the side of the boat and use a hose to rinse down the remaining material. Place the tub back on the chair.
8. Untie the rope of the net and invert the net over the tub so that the sample dumps out into the tub.
9. While still inverted in the tub, use a hose to rinse down the net from the outside to remove the material left on the mesh.
10. Carefully flip the net inside out, fold so the net is in quarters, and use the hose to rinse down any material on the inside edges. Then fold the other way and rinse.
11. Place a lid on the tub and stack the tub near the other samples from the same station to be rinsed in the sieve.
12. Spray the net down on the deck floor on high water pressure for a final time and place under the ponar stand to be used at the next station.

    *Note: After rinsing all nets, proceed with the steps under **In the Sieve** to continue processing all samples.

In the Sieve

The individual not operating the winch or ponar is responsible for removing the tubs from the stand and starting on the rinsing. Live sort samples can be rinsed with high water pressure while the remaining four samples that require rinsing need to be rinsed with low water pressure to keep soft-bodied organisms intact.

1. Upon arriving to a station, place an empty tub on the opposite side of the back deck as the ponar and place the hose in it to collect water for the live sort sample from the same station.

2. After the first sample has been rinsed into the tub by the individual operating the ponar and the ponar is raised by the winch operator to collect another sample, take the tub off the ponar stand and pour the entire contents into the sieve (rinsing down any material stuck to the tub). Be careful not to spill any of the sample over the side of the sieve. This first sample can be designated for live sort.
3. For the remaining five samples, take the tub off the ponar stand with the sample inside and place off to the side with a lid on top to prevent from spilling.

    *Note: If the sample is collected into a net, tighten the rope on the net to cinch the edges together and tie into a simple knot. Leave the tub uncovered for the nets to be rinsed by the individuals operating the winch and ponar.

4. For the live sort sample that was just rinsed into the sieve, use the hose on high water pressure to rinse the sample as much as possible so that all sediment material is removed (excluding peaty material that does not rinse through).
5. Prop the sieve up on one side so that the open corner is on the lower half. Then rinse the contents of the sample into the open corner.
6. Obtain a medium sized bottle with the appropriate station name, "Live Sort", and the collection date on it. Rinse out the bottle with a hose to remove trace formalin.
7. Remove the cap and set aside. Take the yellow scraper and use it to transfer as much of the sample as possible from the sieve to the bottle. Spray any sample material stuck to the scraper, gloves, and outside of the sample bottle back into the sieve.

    *Note: Keep the bottle inside the sieve when transferring sample material to avoid spilling any of the sample outside of the sieve.

8. If the other two individuals are still rinsing nets, ask for help with lifting the sieve.
9. At this point, one person will lift the sieve so that the open corner is pointed towards the other person with the sample bottle while that person rinses the remainder of the sample into the bottle from the backside of the screen.

    *Note: Be careful not to put too much water into the bottle so that the sample overflows.

10. Use the water collected into a tub from the same station to completely fill the sample bottle. Screw the cap back on and put in the refrigerator.
11. Pour the contents of the next sample from the tub into the sieve (rinsing down any material stuck to the tub). Be careful not to spill any of the sample over the side of the sieve.
12. Use the hose on low water pressure to rinse the sample as much as possible so that all sediment material is removed (excluding peaty material that does not rinse through).

13. Obtain an appropriately sized bottle for the amount of material in the sample. Sample volume should be no more than half the bottle volume. Label it with the station name using a Sharpie on the two pieces of tape on the lid and side of the bottle.
14. Remove the cap and set aside. Take the yellow scraper and use it to transfer as much of the sample as possible from the sieve to the bottle. Spray any sample material stuck to the scraper, gloves, and outside of the sample bottle back into the sieve.

    *Note: Keep the bottle inside the sieve when transferring sample material to avoid spilling any of the sample outside of the sieve.

15. At this point, one person will lift the sieve so that the open corner is pointed towards the other person with the sample bottle while that person rinses the remainder of the sample into the bottle from the backside of the screen.

    *Note: Be careful not to put too much water into the bottle so that the sample overflows.

16. Screw the appropriately sized mesh cap onto the bottle with the sample in it. Invert and squeeze the bottle to remove all the water from the sample.
17. Unscrew the mesh cap and use a rinse bottle (filled with water from the same site) to rinse the sample material remaining on the mesh cap into the sample bottle using a little water as possible.
18. Fill the sample with 10% formalin, or 20% formalin if there is a lot of organic matter in the sample, up to about twice the amount of sample material to ensure all material is exposed to the preservative.
19. Secure the original (labeled) lid tightly on the bottle and invert/swirl the sample to suspend any sample material that is not in contact with the formalin. Place the sample bottle back into the crate it was obtained from.
20. Repeat steps 12-20 for the next three samples from that station.
21. Once all samples have been processed for a station, turn the sieve upside down and use the brush and hose to remove any remaining material left on the screen.

Sediment Collection

The sixth sample collected is designated for the sediment sample and does not require rinsing. Sediment samples are collected into the smaller, square Nalgene bottles.

1. Using your hands, transfer the sediment material from the tub into a labeled sediment bottle so that a representative sample is collected.
2. Before screwing the cap back on, use a hose to rinse the outside of the bottle as well as the threads around the opening.

3. Screw the cap back on and place in the small tub with the other sediment bottles.

POST-RUN PROCEDURES

Unloading Equipment

1. Upon returning to the marina, transport all equipment items on the **Field Equipment Checklist** from the vessel back into the lockup in its appropriate location.
2. Place the live sort samples in a cooler on ice and bring them back to the office along with the horizontal sonde (in the sonde bag) to undergo a **Sonde Post-Measurement Calibration Check**.
3. Load the crates of collected sample bottles in the bed of the vehicle and transport back to the office.

   *Note: Do not put the samples inside the cab of the vehicle to avoid formalin exposure.

Live Sort

Live sort samples collected in the field are brought back to the lab where all *Corbicula* and *Potamocorbula* are picked from the sample. Live sort is performed the day after the samples have been collected. See **Clam ID Guide** (Appendix I) for information on how to identify these two species and which stations each species is expected to be found at.

1. Obtain a sample from the fridge in the downstairs lab, a 500-micron sieve, and a white tray.
2. Place the sieve in the white tray and empty the contents from the sample bottle into the sieve.
3. Remove the sieve (with sample contents) and rinse the sample in the sink.

   Note: If a sample is large and heterogeneously sized, you can use a graduated series of sieves on top of the 500-micron sieve to separate sediment classes, which makes detecting clams easier.
4. Take the water in the tray and pour it back into the original sample bottle to save until the entire sample has been processed.
5. Rinse all of the sample material in the sieve into the white tray (or a fraction at a time if the sample is large) and fill a petri dish with water from the site.

   *Note: If the sample has a lot of organic matter, see **Floating** section. Then continue with step 6.

6. Carefully transport the tray (with the sample) into the sorting room and place under a lamp on the counter.
7. Using forceps, sort through the sample one quadrant of the tray at a time placing each clam in the petri dish until all *Corbicula* and *Potamocorbula* are picked out of the sample.
8. Once all clams of interest are picked out of the sample, the remaining material from the sample can be discarded in the trash.
9. Lay a sorting cloth out on the counter and use calipers or the micrometer on the dissection microscope to measure each clam (in mm) at its widest point. Place each clam on the appropriate square depending on its size class.

    *Note: Size classes are determined by the whole numbers of a measurement. For example, if a measurement is 5.17 mm, the size class is 5. If a clam is too small for the smallest reading on the calipers, place it under the microscope and take the reading from the right eye piece, then convert it to the appropriate size class using the conversion on the wall.

10. On the desktop of the biomass computer, print out the "Live Sort" file for the current year and month and obtain a pre-weighed tray of foil boats (done in **Pre-Weigh Foil Boats**).
11. Separate each size class of clams into its own foil boat. Then fill in the printed live sort data sheet with the station name, collection date, species, number of individuals, and size class for the corresponding boat number.
12. Once all size classes have been distributed into a boat, place the entire tray of boats into the oven, which should be set to 140 degrees. Repeat the previous steps until all samples are picked.

Floating

Live sort samples that have a large amount of organic matter need to be "floated", which will separate the lighter organic matter from the heavier material (i.e. clams).

1. Place an empty sieve inside of an empty white tray and put at the bottom of the sink.
2. Take the white tray containing the sample from step 5 of **Live Sort** and hold it over the sink at a slight angle with the lowest corner over the sieve at the bottom of the sink.
3. Place the faucet over the highest corner of the tray and turn the water on low to allow the water to flow over and through the contents of the sample. Heavier material (rocks and clams) will stay at the bottom and lighter material like peat will

be suspended by the movement of water to the top and over the edge of the tray into the sieve.

4. Keep the water flowing through the sample until most or all of the organic material has floated off.
5. Add some water to the original tray with heavier sample material and proceed with step 6 of **Live Sort**.
6. Remove the sieve with lighter sample material from the tray at the bottom of the sink and place off to the side.
7. Dump out the water collected into the tray at the bottom of the sink and then rinse the contents of the sieve with lighter material into the tray.
8. Pick through this tray of lighter sample material (just in case any clams were floated off) after step 8 of **Live Sort**.

Benthic Sample Submission

The four samples preserved with formalin at each station will be processed by Logical Zoology (Sarah Pearson) where they will be identified and quantified. The samples will be picked up from the downstairs lab and must have the COC with them or sent immediately after pickup.

1. Open the most recent COC file on the shared drive here: S:\M & A BRANCH\Discrete EMP\Benthic\COCs and "Save As" with the current year and month.
2. Update the "Benthic" tab with the correct collection dates and lab IDs for each station. Save the document and print it out.
3. Place the COC in one of the crates of collected samples in the downstairs lab to be picked up.

Sediment Sample Submission

Sediment samples are submitted to Bryte lab and are accompanied by the COC. See **Navigation** (Appendix G) for driving directions to Bryte Lab.

1. Open the current COC file that was created in **Benthic Sample Submission** on the shared drive here: S:\M & A BRANCH\Discrete EMP\Benthic\COCs.
2. Update the "Sediment" tab with the correct collection dates for each station. Save the document and print it out.
3. Bring the sediment samples and COC to Bryte lab and drop them off in the Soils Lab.

Live Sort Data

The live sort data is entered on the days following live sort and is used to perform biomass calculations.

1. On the biomass computer desktop, open up the "Live Sort" file for the current year and month (created in **Pre-Weigh Foil Boats**).
2. Using the printed live sort data sheet that was filled out during live sort, enter in the date, species, number of individuals, and size class next to each corresponding boat number. Save the updated file.
3. QA/QC the live sort data (performed by someone other than the person who entered the data) by checking that all values in the spreadsheet match those on the printed data sheet.

Dry Weights

Dry weight measurements are obtained from the clams picked and sorted into the foil boats during live sort after they have been in the oven for at least two weeks.

1. If the scale is powered off, press the red power button on the bottom far left and let it warm up for 15-30 minutes. If at any point when nothing is on the scale and it displays any number besides zero, click "TARE" to zero it.

   *Note: If the bubble at the back of the scale on the right-hand side is not contained in the circle, adjust the scale using the round feet on the bottom. Then press the CAL button to calibrate.

2. Before weighing the boats, use the calibration log book and weigh the 1, 5, and 50-gram weights (located in the top cabinet to the left of the analytical scale). This will verify and document that the scale is working efficiently.
3. On the biomass computer desktop, open up the "Sartorius Scale Input" and the "Live Sort" file for the current year and month (created in **Pre-Weigh Foil Boats**).
4. Obtain a tray from the oven using the tray carrier with two desiccant packets and select the cell under the "Dry weight + pan" column corresponding to the first boat number of that tray.
5. Using large forceps, place the corresponding boat inside the clear doors of the analytical scale.

   *Note: All doors to the scale should be closed to get an accurate reading.

6. Once the reading equilibrates, click the button resembling an underlined disc on the bottom far right of the scale to automatically enter the reading on the spreadsheet. Check to make sure the reading transferred to the appropriate cell.

7. Place the boat back into its original spot in the tray and repeat steps 4 and 5 until you have weighed all boats in the tray.

    *Note: Do not throw away the clams in the boat after the reading has been recorded in the spreadsheet.

8. When all boats in the tray have been measured and recorded, close the doors to the scale and save the changes made to the file. Put the tray in the furnace (to the right of the oven) and close the furnace door.

    *Note: Two trays can fit in the furnace at any one time, so dry weights can be measured two trays at a time on any given day.

9. Flip the switch on the furnace to turn it off and then flip it again to turn it back on. Once the numbers stop blinking, hold down the "Run" button until you hear a click.

Ash Weights

Ash weight measurements are obtained from the clams picked and sorted into the foil boats during live sort after they have been in the furnace for at least 16 hours.

1. If the scale is powered off, press the red power button on the bottom far left and let it warm up for 15-30 minutes. If at any point when nothing is on the scale and it displays any number besides zero, click "TARE" to zero it.

    *Note: If the bubble at the back of the scale on the right-hand side is not contained in the circle, adjust the scale using the round feet on the bottom. Then press the CAL button to calibrate.

2. Before weighing the boats, use the calibration log book and weigh the 1, 5, and 50 gram weights (located in the top cabinet to the left of the analytical scale). This will verify and document that the scale is working efficiently.

3. On the biomass computer desktop, open up the "Sartorius Scale Input" and the "Live Sort" file for the current year and month (created in **Pre-Weigh Foil Boats**).

4. Obtain a tray from the furnace using a tray carrier with two desiccant packets and select the cell under the "Ash-free weight + pan" column corresponding to the first boat number of that tray.

5. Using large forceps, place the corresponding boat inside the clear doors of the analytical scale.

6. Once the reading equilibrates, click the button resembling an underlined disc on the bottom far right of the scale to automatically enter the reading on the spreadsheet. Check to make sure the reading transferred to the appropriate cell.

7. Look at the "Average weight per individual" column and ensure that the value is greater than zero. Discard the clams and ashes in the boat and move onto the next one.

   *Note: If the value is zero or less, re-weigh the boat up to two more times. If there is a reading above zero, record that one. If after three weighs the value is still zero or less, type "re-weighed three times, same result" and put your initials in the comments column for that boat number and then discard the clams and ashes in the boat and move on.

8. Place the boat back into its original spot in the tray and repeat steps 4 through 6 until you have weighed all boats in the tray.
9. When all boats in the tray have been measured and recorded, save the changes made to the file. Put the tray on the left side of the cabinet above the computer to be pre-weighed for the following month's benthic run.

Central Valley Project and State Water Project

Long-Term Monitoring Plan for Harmful Algal Blooms

Appendices

February 15, 2023 Final

Appendix D

DWR Division of Integrated Science and Engineering. 2022. Quality Assurance Project Plan for the Continuous Environmental Monitoring Program (CEMP). Document number: DES-3-QAP-001, Version 1.0. 49 pp.

Quality Assurance Project Plan for the Continuous Environmental Monitoring Program (CEMP)

Environmental Water Quality and Estuarine Studies Branch
Office of Water Quality
Division of Environmental Sciences
California Department of Water Resources
July
2021

1.0 Approval Signatures

DES Office of Water Quality Chief:

X:	Date:

DES EWQES Branch Chief:

X:	Date:

DES Continuous Environmental Monitoring Program Manager:

X:	Date:

DES Continuous Environmental Monitoring Program Project Leader:

X:	Date:

DES Quality Assurance Officer:

X:	Date:

SWRCB Contract Manager:

X:	Date:
SWRCB Quality Assurance Officer:	
X:	Date:

2.0 Table of Contents

2.1 List of Figures

2.2 List of Tables

2.3 List of Abbreviations

BDO	Bay Delta Office
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEMP	Continuous Environmental Monitoring Program
CVP	Central valley Project
DES	Division of Environmental Services
DO	Dissolved Oxygen
DQI	Data Quality Indicator(s)
DQO	Data Quality Objective(s)
DTS	Division of Technology Services
DWR	Department of Water Resources
EPA	Environmental Protection Agency
EWQES	Environmental Water Quality and Estuarine Studies
FLIMS	Field and Laboratory Information Management System
IEP	Interagency Ecological Program
MQO	Minimum Quality Objective(s)
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RWQCB	Regional Water Quality Control Board
SOP	Standard Operating Procedure
SWAMP	Stream Water Ambient Monitoring Program
SWP	State Water Project
SWRCB	State Water Resources Control Board
USBR	US Bureau of Reclamation
USGS	United States Geological Survey
WDL	Water Data Library
WQP	Water Quality Portal
YSI	Yellow Springs Inc.
BDO	Bay Delta Office
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEMP	Continuous Environmental Monitoring Program

3.0 Distribution List

Project staff in the Department of Water Resources Continuous Environmental Monitoring Program and State Water Resources Control Board (SWRCB) staff are provided copies of this Quality Assurance Project Plan (QAPP) and any approved revisions of the plan. This plan will be available online so other interested parties also can benefit from its content.

4.0 Project-Task Organization

- A coordinated monitoring program has operated since the 1970's between the California Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) in cooperation with the U.S. Bureau of Reclamation (USBR). This also includes assistance from the California Department of Fish and Wildlife (CDFW), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS) under the Interagency Ecological Program (IEP) umbrella. Ultimately, they will provide information for water resource management in compliance with flow-rated water quality standards set forth in a series of Water Right Decisions (D-1379, D-1485, and D-1641). Since 1975, the DWR Bryte Laboratory has been responsible for laboratory analyses of both organic/inorganic and conventional analysis. The DWR Bryte Lab has maintained certification by the Environmental Protection Agency and the California Department of Health Services for water analysis since 1978. The laboratory results from Real-Time Monitoring Section are entered into the Field and Laboratory Information Management System (FLIMS) data base. On a regular basis data from the FLIMS database are loaded into DWR's Water Data Library (WDL) database. Real-Time Monitoring laboratory results are retrieved from the WDL and entered into the Discrete Water Quality database. The continuous water quality database Water Quality Portal (WQP) is loaded automatically every 15 minutes. The data is quality control edited approximately every month and the database is updated with edited data.

- The **EWQES Branch Chief** manages all DWR designated tasks and people related to the project. The Branch Chief is responsible for various project audits at their discretion to ensure the QAPP directives are met.
- The **CEMP Section Chief** is responsible for all contract management tasks including: invoicing and reporting, oversight of project progress, and for collaboration with other agencies and stakeholders active in the area.
- The **CEMP Section Leader** of this project is responsible for the scientific integrity of the data collection effort throughout the duration of the project. The Technical Leader responsibilities include maintaining the QAPP. The Section Lead is also responsible for technical dialogs with advisors and experts involved in the project.
- The DWR **Quality Assurance (QA) Officer** works independently from the CEMP Section Chief and the CEMP Section Lead, and is responsible for the implementation and management of DWR's QA program.
- **CEMP Staff Field Data Collectors, Laboratory Personnel, and Data Managers** will provide the workforce for all field collection activities, laboratory analyses, and data management functions of the project.

The Project Organizational Chart (Figure 4) and job descriptions for the key project personnel are provided below. Each position assures collection of quality data and timely delivery of reliable monitoring data.

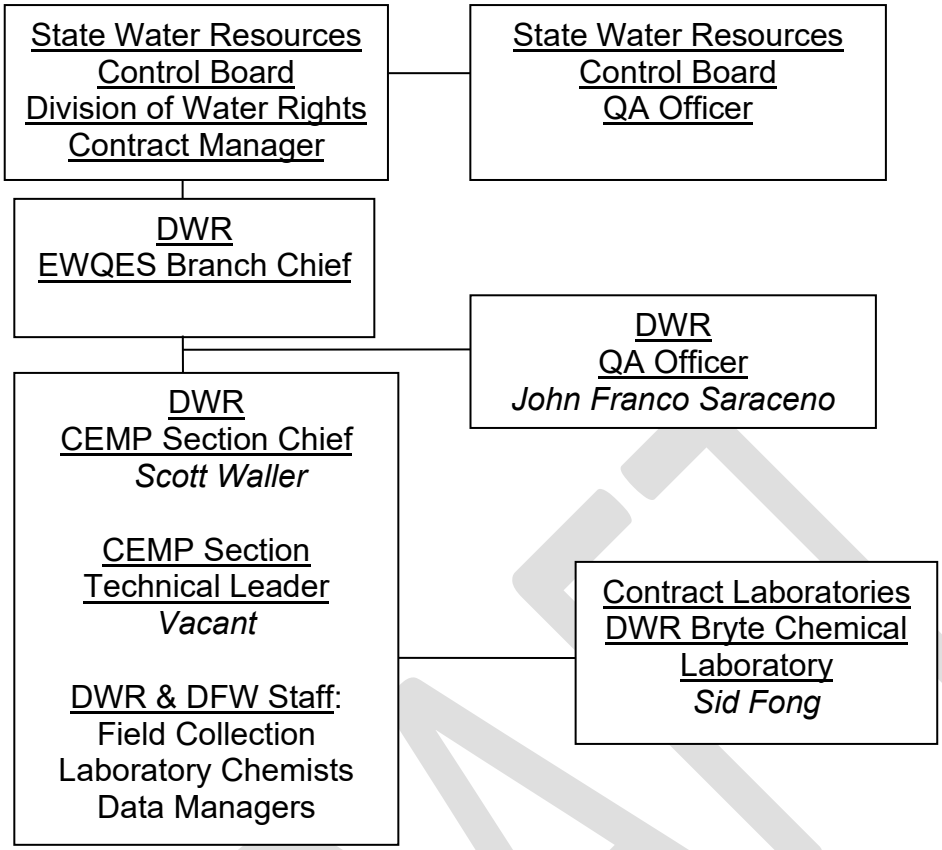


Figure 1 Project Organizational Chart

5.0 Problem Definition and Background

5.1 Project Background

Since 1983, the Department of Water Resources (DWR) has funded and staffed water quality and biological investigations in order to comply with existing and emerging regulatory requirements. Currently IEP funding for staff and contracts for DWR resides in the Division of Environmental Services, specifically in the Office of Water Quality, Environmental Water Quality Estuarine Studies Branch (EWQES). At the core of IEP compliance is Water Rights Decision D-1641. The summation of the mandated work in D-1641 is an ongoing assessment of the Sacramento San Joaquin Delta (Delta) and the impacts of water exports on the ecosystem, specifically the State and federal projects. The CEMP Section is one element of the Environmental Monitoring Program (EMP) which provides near real-time continuous water quality information for D-1641 compliance, State Water Project (SWP) operations, environmental issues and flood forecasting via telemetry to the Departments CDEC web portal and maintains a comprehensive database of water quality data (WQP). As we know, water quality can change frequently over time, necessitating frequent, repeated measurements to adequately characterize variations in quality. When the time interval between repeated measurements is sufficiently small, the resulting water-quality record can be considered continuous (typically every 15 min or every hour). A device that measures water quality in this way is called a continuous water-quality monitor (All our instruments are manufactured by the Yellow Springs Instruments (YSI), we are presently using the EXO2). The YSI EXO sondes have sensors and recording systems to measure physical and chemical water-quality field parameters at discrete time intervals at point locations. Operation of a water-quality monitoring station provides a nearly continuous record of water quality that can be processed and published or distributed directly by telemetry to the Internet (Selected data from all fifteen continuous sites is remotely telemetered through Campbell Scientific Data Loggers (CR-1000) to the California Data Exchange Center (CDEC) in Sacramento). The water-quality record provides a nearly complete record of changes in water quality that can also serve as the basis for computation of constituent loads at a site. Data from the sensors also can be used to estimate other constituents if a significant correlation can be established, often using regression analyses.

Continuous monitoring of water-quality field parameters, such as temperature, specific conductance, pH, dissolved oxygen, and turbidity, takes place in a wide variety of aquatic environments, ranging from clear, pristine, freshwater streams to biologically productive estuaries. Procedures for continuous monitoring in pristine, freshwater streams differ from those needed in coastal environments. Continuous monitoring in coastal environments can be challenging because of rapid biofouling from microscopic and macroscopic organisms, corrosion of electronic components from salt and high humidity, and wide ranges in values of field parameters associated with changing weather and tidal conditions such as our Martinez and Mallard stations.

Temperature and conductivity are physical properties of water bodies, whereas DO and pH are concentrations, and turbidity is an expression of the optical

properties of water (ASTM International, 2003). For the purposes of this report, all of these properties or constituents and the sensor values recorded by the EXO sonde are referred to as field parameters. Sensors also are available to measure other field parameters, such as water level, depth, chloride, and fluorescence. In addition to the measured field parameters, some monitors include algorithms to report calculated parameters, such as specific conductance. Emerging sensor technology broadens the variety of measurable chemical constituents and reduces the limits of detection. Because it has become possible to make near real- time water-quality monitoring data available on the Internet, continual progress is being made to improve applications and refine quality-control procedures.

5.2 Regulatory Information

Water quality data collected by DWR is used by a wide range of stakeholders including private individuals, public and private agencies, and is ultimately the foundation on which these agencies base water planning and management decisions. This monitoring provides data and reports that are used to investigate long-term changes in water quality and determine if water quality parameters are meeting Basin Plan Objectives established by SWRCB.The SWRCB sets water quality objectives to protect beneficial uses of water in the Sacramento-San Joaquin Delta and Suisun Bay. These objectives are met by establishing standards mandated in water right permits issued to the DWR and USBR by the SWRCB. The standards set minimum Delta outflows, limits to Delta water export by the State Water Project (SWP) and the Central Valley Project (CVP), and maximum allowable salinity levels. In 1971, the SWRCB established Water Right Decision 1379 (D-1379). This Decision contained new water quality requirements for the San Francisco Bay-Delta Estuary. D-1379 was also the first water right decision to provide terms and conditions for a comprehensive monitoring program to routinely determine water quality conditions and changes in environmental conditions within the estuary. The monitoring program described in D-1379 was developed by the Stanford Research Institute through a contract with the SWRCB. Implementation of the monitoring program began in 1972, as SWRCB, DWR, and USBR met to define their individual responsibilities for various elements of the monitoring program. In 1978, amendments to water quality standards were implemented and resulted in Water Right Decision 1485 (D-1485). More recently these standards were again amended under the 1995 Water Quality Control Plan and Water Right Decision 1641 (D-1641) established in 1999. The SWP and CVP are currently operated to comply with the monitoring and reporting requirements described in D-1641. D-1641 requires DWR and USBR to conduct a comprehensive environmental monitoring program to determine compliance with the water quality standards and also to submit an annual report to SWRCB discussing data collected. The original set of stations included both continuous recorders for salinity and temperature at shore stations. Discrete sampling sites reached by boat or by road. The original number of discrete stations was expanded in 1978 to accommodate compliance monitoring

for new water quality standards. The Real Time Monitoring Section started in 1983 with a goal to have continuous water quality monitoring to help with the water diversions at the Byron Pumping Plant by Tracy. The stations included Martinez, Mallard Island located on the Pittsburg power plant, Antioch, Rio Vista, and Stockton located on the Rough and Ready Island of the Port of Stockton, Mossdale landing located in Lathrop. These six main water quality stations collect stage, water temperature, specific conductivity, dissolved oxygen, pH, chlorophyll, and turbidity. Sacramento River at Hood station was started in 1998 to get a non-tidal 'rim' station on the Sacramento River. Prisoner's Point located on Mandeville Island was a temporary station that started in 1999 but became a full-time monitoring station in 2004. San Joaquin River at Vernalis was started in July 2005 to get a non-tidal 'rim' station for the San Joaquin to bring our total to nine main compliance stations. As the program expanded, meteorological instruments were added to collect air temperature, solar radiation, wind velocity, and wind direction.

These multi-parameter land-based compliance monitoring stations give a continuous record of hourly data, and now currently 15-minute data, on a real-time basis over a 30-year period. Prior to 2008, data on our database (Water Quality Portal) was only available in hourly intervals. For a short period of time (from 6/2/2005 to 10/06/2008), we were cross- checking our old Schneider instrument measurements with the new YSI Sonde instrument to ensure that their readings were close to each other.

IEP's 2003 Program Review recommended additions of continuous monitoring at four non-mandated EMP stations to improve monitoring efficiency and identifying the effects of State Water Project (SWP) operations and other factors on the Delta ecosystem. As a result, the CEMP Section installed four new pile monitoring stations that began operation on Jan 26, 2006 until Oct. 31, 2007 **(please see Section 6.2 for more detailed information on these 4 historic pile stations)**. In early June 2015, the California Department of Water Resources installed 10 new monitoring stations that were established for the Emergency Drought Barriers due to the four years of drought in California. As of now, all 10 new stations are funded for another year with most being funded longer term by Division of Environmental Services (DES), Bay Delta office (BDO), etc. As a result, the Real-time Section is in charge of the six out of ten pile stations, which are now permanent stations. These new pile stations are also operated under Decision 1641 which is mandated by State Water Resources Control Board (SWRCB) for San Francisco / Sacramento / San Joaquin Delta Estuary (Bay-Delta) Program. DWR now has the ability to analyze a wide range of physical, chemical, and biological parameters with its own in-house lab, Bryte Laboratory, located in West Sacramento.
As the importance and scope of water quality regulations increase over time in the California, we will need to provide the State and its constituents with easily accessible, current, and defensible water quality data in the DWR's Water Data

Library (WDL). The WDL database is managed by DWR which has streamlined the process of organizing and distributing water quality data. **(www.wdl.water.ca.gov)**.

5.3 Project Objectives

The program objectives approved by the SWRCB are included in their Bay-Delta Plan. Specifically, the program objectives are to:

1. Document compliance with Bay-Delta water quality objectives;
2. Provide information necessary to achieve compliance with revised salinity and flow standards as well as with dissolved oxygen standards
3. Document compliance with the State Water Resources Control Board Water Right Decision 1641 (D-1641), which permits DWR and USBR to operate the State Water Project and Central Valley Project.
4. Coordinate IEP and Non-IEP Bay-Delta monitoring programs to minimize duplication and facilitate the exchange of data
5. Develop and improve predictive tools (models) to evaluate project and non-project effects
6. Maintain a long-term baseline record and provide a consistent, long term record of trends;
7. Increase the current understanding of large-scale characteristics and functions of the Delta ecosystem to better predict system-wide responses to management options
8. Develop and improve predictive tools to assess changes within the Bay-Delta System (System) including impacts from operation of the SWP and CVP;
9. Provide accurate and validated water quality information on a timely basis in a format appropriate for a variety of users;
10. Respond to the findings of ongoing monitoring, changing conditions within the System, and the needs of Management with special studies to provide needed information in a timely manner.
11. Produce an annual water quality conditions report as required by the SWRCB and to write annual status and trend articles for the Interagency Ecological Program.

CEMP emphasizes capturing large quantities of data on continuous multi-parameter elements (specific conductance, dissolved oxygen, pH, water temperature, turbidity, and chlorophyll. At eight of the nine land-based stations the additional constituents of air temperature, wind velocity and direction, and solar radiation will also be measured. Data from the continuous monitoring sites are telemetered to DWR's CDEC web portal. All data collected from the stations are ultimately stored in a comprehensive Water Quality Portal database where quality assurance and quality control is performed by CEMP staff. DES staff continues to develop a database that is expected to be a major upgrade over what we have ever had. The WQP database will include a public web portal with

a map driven front end to help users access the data more easily. CEMP staff also responds to operational needs as they arise.

6.0 Project/Task Description

6.1 Summary of Work

The Continuous Environmental Monitoring Program (CEMP) monitors Delta water 24 hours a day, every day. Currently, CEMP sites are sampled continuously every quarter hour with *in-situ* sampling equipment. Data is transmitted to the California Data Exchange Center (CDEC) and Water Quality Portal (WQP) database via telemetry real-time data to provide information on Delta conditions. At the three bay stations: Martinez, Mallard Island, and Antioch, there are bottom sensors (Deployed at the fixed depth of 2 m above the river bottom) to monitor water temperature and specific conductivity that could be different from the surface due to stratification. The Rough and Ready station in the Stockton Deep Water Channel has a middle and bottom sonde to measure all parameters, but it is especially for the dissolved oxygen stratification. All of the water quality data are collected at a one-meter depth regardless of the stage level. At critical locations, redundant instruments are installed to ensure the constant availability of quality data.

6.2 Sampling Schedule

Continuous Sonde Sampling: Time-series data for all constituents will be collected at 15-minute intervals.

Field Sampling: Staff conduct station visits monthly (every 3-5 weeks) to verify and exchange sampling equipment. Equipment exchanges may be more frequent during the summer months, or when needed, due to increased fouling of the instruments.

6.3 Sampling Locations

The area monitored includes the Sacramento River from Hood downstream and San Joaquin River from Vernalis downstream, the Delta and Suisun Bay to Carquinez Straight **(Figure 2)** and click on each station code for the station Meta Data lookup (D6A, in Suisun Bay; D12A, D16A, P8A, C7A, C10A on the San Joaquin River; C3A, D10A, D24A, D11A on the Sacramento River; D29, D19A, D7A, D8A, D9A in the Delta).

These fifteen multi-parameter water quality monitoring stations continuously measure specific conductance, dissolved oxygen, pH, water temperature, turbidity, and chlorophyll samples throughout the Sacramento San Joaquin Delta at 15-minute interval. Eight of the nine land-based stations (With exception of the Prisoners Point site) measure the air temperature, wind velocity and direction, and solar radiation. . Bottom specific conductance and temperature are collected at the 3 (Martinez, Mallard, and Antioch) of the 15 multi parameter stations in support of X2 monitoring. In addition, CEMP is recording the water surface elevation at two (Martinez and Mallard Island) out of the fifteen multi-parameter stations in the Delta.

6.4 Constraints

While making the best effort to collect data, project constraints include:

- Equipment failures caused by the sensors, data loggers or support equipment. This has been reduced by our simplification of the stations and redundant equipment but will never be eliminated.
- Fouling of the sensors, drifting of the sensors, or a mis-calibration caused by a technician. The fouling is reduced by remotely monitoring the stations on a daily basis and exchanging equipment on a monthly basis. The calibration and drifting issues can be reduced by following established Quality Assurance/Quality Control (QA/QC) procedures.
- Vandalism or theft of equipment will result in loss of continuous data.

In the event one of these project constraints or unforeseen constraints occur the CEMP Chief will be notified immediately. The problem will be addressed and recorded in the project notes.

Table 1 Current Continuous Environmental Monitoring Program Stations with GPS Coordinates

Code	Name	CDEC Code	Longitude	Latitude
C10A	San Joaquin River near Vernalis @ SJR Club	SJR	-121.2637	37.67920
C3A	Sacramento River @ Hood	SRH	-121.5194	38.36780
D10A	Sacramento River @ Mallard Island	MAL	-121.91897	38.04310
D12A	San Joaquin River @ Antioch Ship Channel	ANH	-121.8063	38.01770
D24A	Sacramento River @ Rio Vista	RVB	-121.6853	38.16016
D6A	Sacramento River at Martinez	MRZ	-122.13903	38.02750
D29	San Joaquin River at Prisoners Point	PPT	-121.55736	38.05793
P8A	San Joaquin River @ Rough and Ready Island	RRI	-121.36587	37.96277
C7A	San Joaquin River @ Mossdale	MSD	-121.30666	37.78604
D7A	Grizzly Bay	GZL	-122.038120	38.124250
D8A	Suisun Cutoff near Ryer Island	RYC	-121.9958780	38.083971
D9A	Honker Bay	HON	-121.939200	38.072400

D11A	Sacramento River Near Sherman Lake	SSI	-121.761736	38.074097
D16A	San Joaquin River near Twitchell Island	TWI	-121.669100	38.096900
D19A	Franks Tract	FRK	-121.598100	38.046417

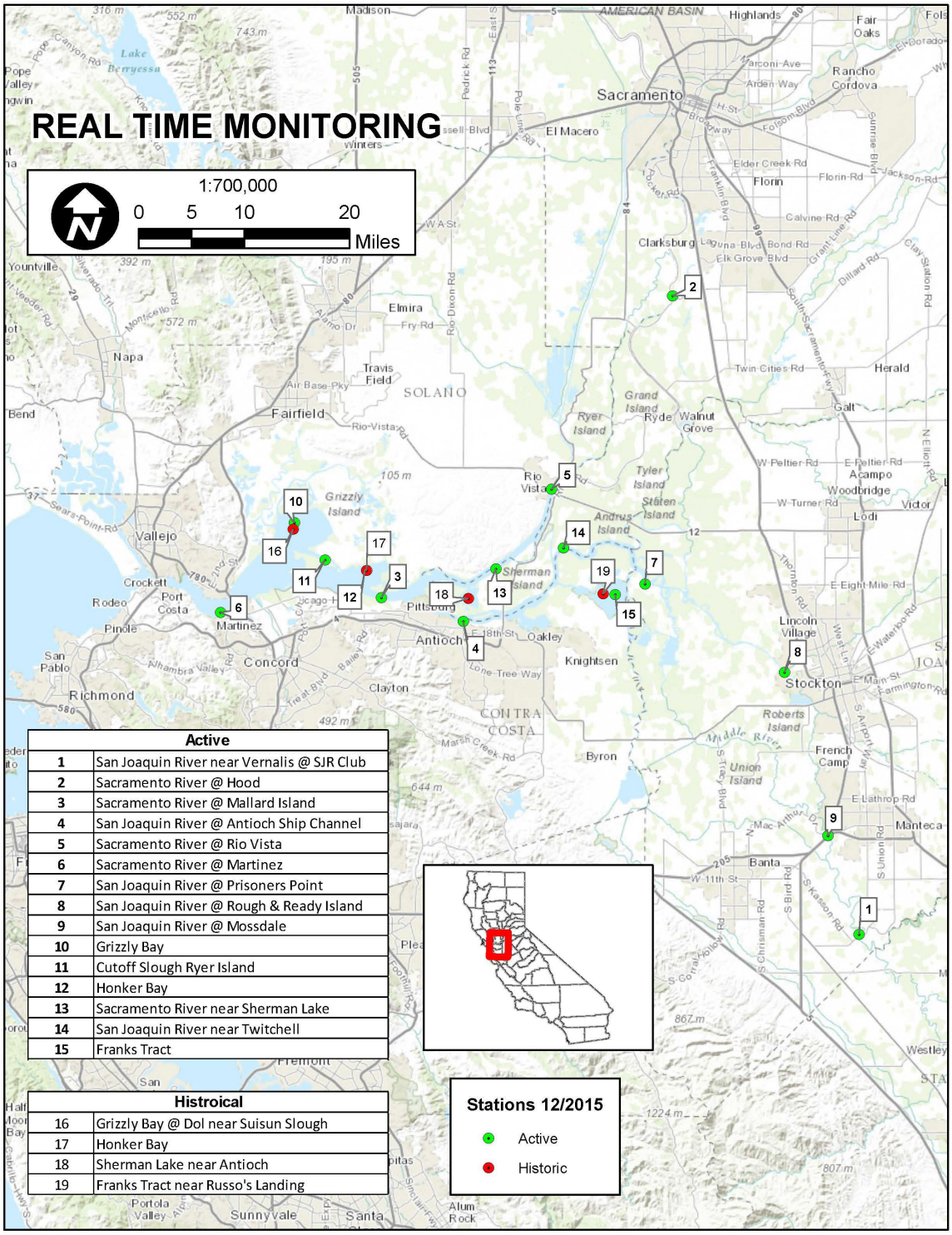


Figure 2 Map of Continuous Environmental Monitoring Program Stations

From 1978 to the later part of 2008 water samples were acquired hourly with meteorological variables sampled every quarter hour. Since 2008 all parameters are sampled every quarter hour.

6.5 Data availability in Water Quality Portal (WQP) Continuous Water Quality database

Although water quality data have been collected for some stations since 1968 under various programs, only data gathered by the EMP continuous water quality since 1983 are available in this database.

7.0 Quality Objectives and Criteria

7.1 Data quality indicators and data quality objectives

There are two types of quality objectives met by the CEMP. Measurement Quality Objectives (MQOs) relate to the quality of the measurement itself (e.g. accuracy or precision). The Data Quality Objectives (DQOs) relate to the entire data set its ability to answer a study question (e.g. completeness or representativeness).

The MQOs for field measurements are listed in Section 14. MQOs for the equipment used as secondary measurements for the water temperature, dissolved oxygen, specific conductivity, pH, and turbidity in this project are detailed in **Table 5**. With proper calibration as indicated in the Field Manual and relevant manufacturer guidance, the range, accuracy, and resolution of each instrument will meet the manufacturer's specifications and meet the MQOs for individual parameters. These parameters are:

- **Accuracy**: A measure of confidence that the data collected in the field and in the laboratory reflect the true value of a given parameter.
- **Range**: Expected values of environment to determine range for instrument calibration used to obtain a range of water quality parameters.
- **Resolution**: Fineness to which on instrument can be read

Adherence to the three data quality objectives of accuracy, range, and precision is essential to the QA/QC objectives of the project. These objectives will be monitored by CEMP staff to maintain the dataset of known and accepted quality.

7.2 Action Limits

An Action Limit is a measurement threshold at which a decision is made to take management action.

The primary objective of CEMP is to maintain a network of real-time telemetered water quality stations for monitoring compliance with water quality objectives established in the State Water Resources Control Board's (SWRCB) Water Rights Decision 1641 (D-1641), and Water Quality Control Plan 95-1 and Biological Opinions. The program provides baseline environmental information

for State Water Project (SWP) operations and special studies. Although no management actions will be directly taken by staff from CEMP, other groups in DWR use this information and check for compliance. In case, potential concerns are detected in the assessment, the information is reported with possible follow-up with the appropriate SWRCB or Regional Board staff.

As an example, adequate dissolved oxygen is required for the respiration of aquatic organisms, including fish. The 1995 Bay-Delta Plan contains a Dissolved Oxygen (DO) objective of 6.0 mg/L from September through November in the lower San Joaquin River between Stockton and Turner Cut to protect fall-run chinook salmon. The Central Valley Regional Water Quality Control Board (RWQCB) Basin Plan contains a DO objective for the entire Delta region of 5.0 mg/L throughout the year. Exceedances will be determined by the criteria in The Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin and the listing criteria for the current Integrated Report cycle. CEMP measures dissolved oxygen to document oxygen levels in order to maintain compliance with the mandated water quality objectives in the Bay-Delta and Basin Plans. If the CEMP Section has observed any DO values that exceed defined objectives (assuming instrumentation errors are ruled out), then the CEMP Chief must report his/her findings to the appropriate Regional Board program in a timely manner.

Additionally, the electrical conductivity and water temperature of water measured by CEMP should comply with D-1641 objectives. The SWP and CVP are currently required to comply with the monitoring and reporting requirements described in D-1641 and is required to submit an annual report to SWRCB to discuss the data collected and to report and discuss any exceedances.

7.3 Acceptance Criteria for Previously Collected Information

All previous data must meet the acceptance criteria outlined in this plan. Data that fails to meet the minimum requirements or cannot be substantiated due to lack of documentation is flagged in the database as unreliable.

7.4 Bias

Bias describes the tendency for under or over prediction of sampled or measured values relative to the true value. Bias is assessed using positive controls such as certified standards of known value and negative controls, such as de-ionized water (DIW) or air, and comparison to a reference sonde”

7.5 Representativeness

Representativeness describes how relevant the data are to the actual environmental conditions. An important role of the DWR Technical Leader is to actively participate in sample design development, training, and assessment of representativeness of the resulting data. Instrument deployments are determined to be representative by comparison to field meters.

Representativeness is controlled by strict adherence to all standard operating procedures that describe instrument calibration, handling, and deployment.

7.6 Completeness

Completeness is expressed as percent of valid usable data actually obtained compared to the amount that was expected. Sometimes, due to a variety of circumstances, either not all samples scheduled to be collected can be collected or else the data from samples cannot be used (for example, equipment failure or malfunction, or a *force majeure* event). The minimum percent of completed analyses defined in this section depends on how much information is needed for decision making. Generally, completeness goals rise the fewer the number of samples taken per event or the more critical the data are for decision making. Goals in the 75-95% range are typical.

8.0 Special Training Requirements/Certifications/Safety

8.1 Required Training and Certifications

Specialized training required is a combination of on-the-job training, following the Standard Operating Procedures for a project, using technical manuals, and periodic specialized classes (i.e. a class given by YSI / Xylem).

Other specialized training includes a QA/QC class, boat handling, CPR/First Aid, along with scientific workshops and conferences. Monthly safety meetings are required by the Department of Water Resources. All State employees who operate motor vehicles are required to attend Defensive Driver Training.

Field staff are required to periodically review the Field Sampling Procedures (Appendix A), Field Safety Manual, and EXOs Calibration Procedure (Appendix D), and etc.

Field staff are also required to read and review the appropriate tailgate field safety plan and Job Hazard Analysis (JHA) prior to conducting field work for any new project.

8.2 Training Schedule

The required course is provided by the Department of Water Resources on an annual or semi-annual basis.

8.3 Individuals Responsible

The CEMP Section Chief and the CEMP Technical Leader will ensure all field collection personnel are appropriately trained in field collection techniques, protocols, and the use of equipment in the field and laboratory as well as their personal safety

8.4 Training Documentation

A certification is provided to staff when they complete required training. Once a staff member receives their certificate, they are required to provide a scanned copy of the document to the Technical Leader for documentation purposes. Additionally, DWR administrative staff uploads the completed course information into the employee's training history record, which is accessible online. The Technical Leader or their designated leadsperson is responsible for keeping scanned copies of class certifications and the completed checklist for each employee.

9.0 Documentation and Records

Documents and records generated by CEMP will be organized and stored in compliance with this QAPP. This will allow for future retrieval, and to specify the location and holding times of all records.

9.1 QAPP Updates and Distribution

The Technical staff will be responsible for developing, maintaining, and updating the Quality Assurance Project Plan (QAPP) and it will be held by CEMP staff. This QAPP and its revisions will be distributed to all parties involved with the project. Copies will also be sent to the Bryte Laboratory manager for internal distribution. Upon revision, the replaced QAPPs will be kept on file for reference.

9.2 Data Records

CEMP collects data that can be generally divided into two groups:
1) Field data measurements,
2) Continuous sonde data.

Discrete field data measurements are collected and written onto field sheets. Hard copies of field sheets will be stored by CEMP and scanned sheets will be stored as PDFs on CEMP servers. All field measurements are entered into the WQP database, which is backed up daily and will be stored indefinitely.

Continuous sonde data is downloaded from the sondes when the sondes are exchanged, and the original file is stored on the CEMP data server for an indefinite amount of time. The data recorded from each CEMP station is automatically transmitted to the WQP database. QA/QC'd data is maintained by the staff and will be available to the public, upon request, for an indefinite amount of time.

The Technical staff will be responsible for making sure that personnel identified in **Figure 1** will receive the most current copy of the approved Quality Assurance Program Plan (QAPP).

9.3 Assessment Records

Inspection or assessment reports, corrective action reports, interim progress reports, final reports, evaluation summaries, and copies of presentations made during and after the project will all be stored digitally in a dedicated directory on CEMP servers. These documents will be organized and kept up-to-date by the CEMP Section Chief or designated DWR staff.

Annually, CEMP will prepare a brief report summarizing the data analyzed to date. This report will be submitted to the State Water Resources Control Board in compliance with D-1641.

9.4 Records Responsibility

The CEMP Section Chief will oversee the maintenance of all records and will arbitrate any issues related to records retention.

9.5 Archive Location and Duration

All records generated by this section will be stored at the CEMP office located on 3500 Industrial Way in West Sacramento. Data files and records made by CEMP will be maintained indefinitely.

9.6 Records Responsibility

The CEMP Section Chief or other assigned DWR staff will be responsible for archiving all other records.

9.7 Electronic Records Responsibility

All field operation records will be entered into electronic formats and maintained in a dedicated directory or databases.

The California Division of Technology Services (DTS) is responsible for back up of the DES servers. Incremental backups are done daily, and full backups are done once a week.

10.0 Sampling Process Design

Continuous monitoring multiparameter sondes measure water quality *in-situ*. A water quality sonde will be deployed at every station, and depending on the project and station objective, each sonde may have 1-6 probes and a depth sensor installed.

Each station sonde will be programmed to take measurements every quarter hour collecting continuous (also known as time-series) data. Stations will be serviced every 2-6 weeks, depending on the project objectives, weather conditions, equipment availability, seasonality, and staff schedules. Each station will be maintained indefinitely.

Generally, station accessibility is limited when water levels are exceptionally high, or inclement weather prevents station maintenance. Stations will be serviced when the station becomes accessible again (weather passes and/or water level decreases) and because sondes will be deployed with battery levels excessive to what they need for the minimum deployment time, so continuous/time series data will not be lost. However, field readings may not be taken, and this will be noted on the field sheet.

Potential sources of bias or misrepresentation include faulty calibrations, faulty probes and sondes. Additionally, due to site-specific constraints, some sites may be shallower or deeper than the desired depth due to varying water levels. These potential sources of bias will be included in field notes. Generally, staff attempt to minimize bias or misrepresentation by installing stations in the main flow of the channel. Section 7 addresses bias as well.

11.0 Sampling Methods

11.1 Continuous Sampling methods

Continuous sonde *in-situ* water quality and meteorological measurements are logged once every quarter hour by a Campbell data logger. Table 2 lists equipment and sampling method for each CEMP station. The data are transmitted via cellular modem the CEMP telemetry server, where the data are ingested and archived. Data are uploaded to the CEMP WQP database and to CDEC.

Support equipment is usually installed in a weather-tight aluminum “Traffic Box” containing a data logger, wireless cellular modem, deep cycle battery, and a solar charge controller. Solar panels are installed for battery charging purposes.

Station sondes are deployed in a PVC deployment tube that is attached to support structures. PVC deployment tubes have evenly spaced holes for the entire length of the tube at and below the high tide of record to allow water to flow across the sensors. CEMP surface sonde deployments are set up in two types of configuration: floating or fixed. Floating deployments keep the sonde at a constant depth, approximately 1 meter below the surface. Fixed deployments keep the sonde at a constant location in the deployment tube and the depth of the sonde varies with stage.

At some stations, a sonde is deployed at the bottom of the water column at a fixed depth, approximately 2 meters from the channel bottom. The sonde is connected to a wire that is held in place by a weight resting on the channel bed. A station may also have a sonde deployed in the middle of the water column, fixed approximately 3 meters above the channel bottom.

Meteorological measurements are taken from equipment (**Table 4**) mounted on masts above the station, typically 5 meters above the deck, and clear from any obstruction that may affect wind measurements.

11.2 Sampling Corrective Action

For all sampling, if equipment fails, a sample is not collected, or a measurement is missed, the incident will be documented on the field sheet along with any relevant information (batteries appear to be dead, equipment malfunctioning, etc.). Corrective measures will be taken by staff in the field doing the sampling if possible, otherwise staff will inform the Section Lead, who will take corrective measures if possible.

If a probe on a sonde is out of acceptance criteria, the sonde will be replaced with a calibrated backup. The malfunctioning probe will be repaired in the laboratory or returned to the manufacturer for repair. All information related to the

probe inspection must be recorded on a field form, which is the basis for data corrections made during the QA/QC data review.

Table 2 Types of Equipment Deployed at CEMP Stations

Station	Location	Surface Equipment	Bottom Equipment	Meteorological Equipment	Stage Equipment
C10A	San Joaquin River near Vernalis @ SJR Club	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
C3A	Sacramento River @ Hood	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D10A	Sacramento River @ Mallard Island	YSI EXO2	YSI EXO1	-RM Young 5106 -Met One air temp -Li-COR 200R	Bubbler
D12A	San Joaquin River @ Antioch Ship Channel	YSI EXO2	YSI EXO1	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D24A	Sacramento River @ Rio Vista	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D6A	Sacramento River at Martinez	YSI EXO2	YSI EXO1	-RM Young 5106 -Met One air temp -Li-COR 200R	Bubbler
D29	San Joaquin River at Prisoners Point	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
P8A	San Joaquin River @ Rough and Ready Island	YSI EXO2	YSI EXO2 YSI EXO2 (middle)*	-RM Young 5106 -Met One air temp -Li-COR 200R	None

C7A	San Joaquin River @ Mossdale	YSI EXO2	None	-RM Young 5106 -Met One air temp -Li-COR 200R	None
D7A	Grizzly Bay	YSI EXO2	None	-RM Young 5106	None
D8A	Suisun Cutoff near Ryer Island	YSI EXO2	None	None	None
D9A	Honker Bay	YSI EXO2	None	None	None
D11A	Sacramento River Near Sherman Lake	YSI EXO2	None	None	None
D16A	San Joaquin River near Twitchell Island	YSI EXO2	None	None	None
D19A	Franks Tract	YSI EXO2	None	-RM Young 5106	None

Surface Water Quality Parameters: Water Temperature, Specific Conductivity, Dissolved Oxygen, pH, Turbidity, Fluorescence

Bottom Water Quality Parameters: Water Temperature, Specific Conductivity. Note: The bottom sonde at P8A, San Joaquin River @ Rough and Ready Island, collects the six parameters listed in surface measurements. Station P8A also collects the same six parameters in the middle of the water column.

Meteorological Parameters:
Wind Speed and Wind Direction (RM Young 05106), Air Temperature (Met One Temperature Sensor), Solar Radiation (Li-COR 200R).

12.0 Sample Handling and Custody

Water quality is measured *in-situ* via multi-parameter sonde. See Section 19 for management of CEMP data. Laboratory samples are not generated as part of this project.

13.0 Analytical Methods and Field Measurements

13.1 Water Quality Measurements

Water quality measurement methods used by CEMP are based on the following procedures:

- YSI EXOs Multiparameter Water Quality Sondes User Manual **(Appendix C)**
- Continuous Environmental Monitoring Program Field and Lab Manual **(Appendix D)**

Sondes are deployed in the field for 2-6 weeks, depending on the season, to prevent excess biofouling and to ensure that calibrations of the probes do not drift outside acceptable limits. During summer months, biofouling tends to be more prevalent, so sondes exchanges may be more frequent. EXO2 sondes are equipped with wipers to prevent biofouling on the sensor faces. Sondes are configured to store raw data on internal memory.

Table 3 outlines the types of sensors used for each water quality parameter sampled, as well as their range, accuracy, and resolution.

Table 3 CEMP Water Quality Sensors

Parameter	Sensor Type	Units	Range	Accuracy	Resolution
Temperature	EXO,Thermistor	°C	-5 to 50 °C	±0.2°C	0.001°C
Dissolved Oxygen	EXO, Optical Luminescence lifetime	mg/L	0 to 20 mg/L, 20 to 50 mg/L	± 0.1 mg/L or 1% of reading, ±5% of reading	0.01 mg/L
Specific Conductance	EXO, 4 AC electrode	µS/cm	0 to 100,000 µS/cm	±2 µS/cm or 1%	0.1 to 10 µS/cm, (range dependent)
pH	EXO, Glass Electrode	pH units	0 to 14	±0.2 pH units	0.01
Turbidity	EXO, Optical Nephelometric	NTU	0 to 999 FNU, 1000 to 4,000 FNU	±0.3 FNU or 2% of reading, ±5% of reading	0.01 FNU, 0.1 FNU
Chlorophyll	EXO, Optical Fluorescence	µg/L	0 to 400 µg/L	Linearity: $r^2 \geq 0.999$ for Rhodamine WT across full range	0.1 µg/L

13.2 Meteorological and Stage Measurements

Meteorological and Stage measurements used by CEMP are based on the Continuous Environmental Monitoring Program Field and Lab Manual. Raw data from these sensors are stored on the Campbell datalogger.

Table 4 outlines the types of sensors used for meteorological and stage measurements, as well as its range, accuracy, and resolution.

Table 4 Meteorological and Stage Sensors

Parameter	Instrument	Units	Range	Accuracy	Resolution
Stage	YSI Amazon Bubbler	ft.	0 to 34.6 ft	0.007 ft	0.01 ft
Air Temperature	HygroVue 10	°C	-20 to +60°C	±0.1°C	0.001°C
Wind Direction	R.M. Young 05106	Degrees	0 to 360°	±3° of reading	0.1°
Wind Velocity	R.M. Young 05106	m/s	0 to 100 m/s	± 0.3 m/s or 1% of reading	0.1 m/s
Solar Radiation	Li-COR 200R	Watts/m^2	0 to 3000 Watts/m^2	±2% of reading	0.1 Watts/m^2

14 Quality Control

Quality Control includes activities that measure the attributes and performance of the sampling and analysis process against defined standards to verify that they meet the needs of the project.

14.1 Probe Fouling and Drift

USGS-based drift measurement calculations measure the combined effect of fouling and calibration drift that naturally occurs during an extended *in-situ* sonde deployment.

Total drift is calculated by combining fouling drift and calibration drift. This measurement is used to validate station data over the course of the sonde deployment and assign a data quality rating to the measured parameter (Table 5).

$$T = |F| + |C|$$

Where:
T = total drift
F = fouling drift
C = calibration drift

Fouling drift is assessed by calculating the difference between an initial measurement and a measurement taken after any fouling has been removed. During this procedure, an additional verification sonde is deployed at the same location, with measurements taken at the same times. Verification sonde measurements are used to correct for any changes that may occur during the fouling drift procedure.

$$F = (P_i - P_f) - (V_i - V_f)$$

Where:
P_i = Probe initial (not cleaned)
P_f = Probe final (cleaned)
V_i = Verification initial
V_f – Verification final

Calibration drift is assessed at the conclusion of deployment after the probe has been brought back to the lab. Measurements are taken in calibration standards and the difference between the measurement and standard value is calculated.

$$C = P_v - S_v$$

Where:
P_v = probe value
S_v = standard value

Table 5 Data Quality Ratings Table for Total Drift

Parameter	Excellent	Good	Fair	Poor	Max. Limit	Units
Water temperature	≤±0.2	±0.2-0.5	±0.5-0.8	±0.8-2.0	>±2.0	°C
Specific Conductivity	≤±3%	±3-10%	±10-15%	±15-30%	>±30%	µS/cm
Dissolved Oxygen	≤±0.3 or ≤±5%	±0.3-0.5 or ±5-10%	±0.5-0.8 or ±10-15%	±0.8-2.0 or ±15-20%	>±2.0 or >±20%	mg/L
pH	≤±0.2	±0.2-0.5	±0.5-0.8	±0.8-2.0	>±2.0	pH units
Turbidity	≤±0.5 or ≤±5%	±0.5-1.0 or ±5-10%	±1.0-1.5 or ±10-15%	±1.5-3.0 or ±15-30%	>±3.0 or >±30%	FNU

15.0 Instrument/Equipment Testing, Inspection, and Maintenance

15.1 Field Equipment Testing, Inspection and Maintenance

Field equipment is typically calibrated monthly. During hotter, drier months, bio-fouling can be higher so sondes are exchanged for newly calibrated sondes bi-weekly. Batteries are replaced when voltage drops below 50% battery life as determined by YSI KorEXO software, or as needed. Equipment that is not operating within the manufacturer's specifications will be shipped back to the manufacturer for testing and repair. Instruments are calibrated according to the Calibration and Maintenance for YSI Multi-parameter Water Quality Instruments (Xylem EXO and ProDSS) document created by the Quality Assurance- Real-Time Data Subcommittee. Malfunctions while in the field will be noted on the site visit records. Spare sensors, sondes, and batteries are stored at the CEMP water quality lab. Probes, sondes, and batteries are purchased as needed, at least once a year.

15.2 Sonde Equipment Testing, Inspection and Maintenance

In addition to the routine station visits, the maintenance frequency is also governed by the fouling rate of the sensors. This rate varies by sensor type, hydrologic and environmental conditions, and season. The performance of temperature and specific conductance sensors tends to be less affected by fouling than DO, pH, and turbidity sensors. The use of a wiper on modern turbidity, dissolved oxygen, and chlorophyll instruments has substantially decreased equipment fouling in some aquatic environments. For sites with data-quality objectives that require a high degree of accuracy, maintenance is done bi-weekly or more often. In addition to fouling problems, monitoring disruptions of data collection to the CEMP server and CDEC which can occur from the recording equipment, sedimentation, electrical disruption, debris, or vandalism also may require additional site visits. Specific maintenance requirements depend on the site configuration and equipment.

Sonde and sonde probes will be checked for cleanliness, calibrated, and batteries will be replaced as needed See Appendix D for calibration methods.

Repairs will be tracked by CEMP Section Lead. CEMP staff are responsible for keeping track of equipment and spare probes associated with the sondes. Spare probes, batteries, and parts are stored in the CEMP water quality lab.

Sonde instruments and their specifications are listed in Table 3. Field instrument maintenance will be performed every 2-6 weeks.

Table 6 General maintenance tasks at a water-quality monitoring station

Daily maintenance tasks

- Daily review of station operational status to include station power, sensor performance, and data transfer to telemetry server and WQP - If station operational status or sonde data appears questionable, prepare a freshly calibrated sonde and schedule a station visit for investigation and possible sonde replacement
Maintenance tasks during field visits
- Inspection of the site for signs of physical damage or issues in need of repair - Inspection and cleaning of float and other instrument infrastructure - Battery (or power) check - Check time; verify time on logger and adjust if needed. - Verify water quality instruments with calibrated verification instrument using the Wagner Method for QA

16.0 Instrument/Equipment Calibration and Frequency

CEMP staff are responsible for calibrating sondes for their stations. Sondes will be calibrated prior to each deployment. CEMP's Standard Operating Procedure, Calibration and Maintenance for YSI Multi-Parameter Water Quality Instruments (Appendix D), which describes how calibrations should be performed and documented, and how deficiencies should be resolved and documented.

17.0 Inspection/Acceptance of Supplies and Consumables

All supplies are examined for damage as they are received and then again as they are put into use. Containers are inspected for breakage and proper sealing of caps. Standards and other consumables are inspected for conformance with any labeled expiration dates and lot numbers are tracked on sonde calibration forms and consumable manufacturer certification sheets are tracked in binders in the CEMP lab. Reusable supplies are examined for acceptable cleaning and reuse. Any supplies deemed to be in unacceptable condition are replaced. The CEMP Section Lead is responsible for tracking, storing, and retrieving supplies.

A complete list of supplies used by CEMP can be found in the Calibration and Maintenance for YSI Multi-Parameter Water Quality Instruments Standard Operating Procedure (Appendix D).

18.0 Non-direct Measurements

This QAPP does not include the use of routine data obtained from non-direct measurement sources.

19.0 Data Management

19.1 Data Management Scheme

Continuous water quality data, meteorological data, and stage data are sent via a cellular modem from the stations to the CEMP telemetry server every 15 minutes. Data are stored directly on the server and then imported into the WQP database. Provisional data (non-quality assured) is also uploaded directly to the California Data Exchange Center (CDEC) and made available online.

Site visit, instrument drift, fouling, and calibration information are recorded on field data sheets, instrument calibration sheets, and instrument post-deployment sheets. These sheets are stored on the CEMP network drive.

19.2 Continuous Monitoring Raw Data

When sampling equipment is brought back from the field, data files are downloaded from the sonde in the original raw format and stored on a networked folder. To ensure data are easily accessible, sonde data are also stored as a csv file on the network drive.

19.3 Responsibility for Data Management

CEMP staff are responsible for the data management of the stations they maintain.

19.4 Acceptability of Hardware and Software Configurations

Hardware and software are updated as recommended by the manufacturer or as needed. Each entity is responsible for the necessary updates or upgrades, whether provided regularly through an Information Technology department or otherwise.

20.0 Assessments and Response Actions

Assessment and oversight ensure that the QA Project Plan is being implemented as planned and that the project activities are on track. By implementing proper assessment and oversight, critical problems with any of the stations are minimized.

The Section Lead will report any problems detected and the corrective measures taken to the Section Chief and these are discussed by staff and Section Lead during the weekly Section meeting under the “Station Status Update” in the agenda.

20.1 Readiness Reviews

The staff member conducting a field visit will review all field equipment, instruments, supplies, and paperwork to ensure that everything is ready prior to each field visit. Equipment will be checked to make sure that it has been cleaned and in working order. Equipment maintenance records will be checked to ensure that it has been properly maintained and all calibrations are current. Supplies will be checked to ensure that there are adequate supplies to support the field visit. If a problem is discovered during a readiness review, it will be corrected prior to the field visit and documented along with the actions taken to correct the problem.

20.2 Post Sampling Event Reviews

Post sampling event reviews are conducted following each sampling event to ensure that all data information is complete and any deviations from planned methodologies are documents. The staff member conducting a field visit is responsible for the post sampling event review. Any problems noted during the sampling event are documented along with recommendations for correcting the problem. Reports for each post sampling event will be used to identify areas that may be improved prior to the next sampling event.

20.3 Field assessments

Periodically, the QA Officer or other delegated QA Program staff will review program data, records, and field process, in person or remotely. In addition to a written assessment, any and all findings will be communicated verbally first to CEMP field staff involved in the assessment, the CEMP Section Chief and the QA Officer. Depending on the significance of the finding, additional management may be informed.

21.0 Reports to Management

21.1 Project quality assurance reports

On a semi-annual basis, a short-written report documenting any QA/QC deficiencies (missing data, outliers, replicate data that doesn't meet the data quality objectives, etc.) will be submitted to the CEMP Section Chief. The report will also discuss the data validity and completeness.

21.2 Responsible individuals

- CEMP technical lead – responsible for drafting report
- CEMP Section Chief guidance will finalize report.
- The final report will be sent the EWQES Branch Chief and the QA/QC officer for joint approval.

22.0 Data Review, Verification, and Validation

Data review, verification, and validation procedures helps to ensure that the data will be reviewed in an objective and consistent manner. Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. The Section Lead is responsible for data review. This includes checking that all technical criteria have been met, documenting any problems that are observed and, if possible, ensuring that deficiencies noted in the data are corrected.

22.1 Checking for Typical Errors

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

22.2 Checking Against Method Quality Objectives (MQOs)

Data generated by field activities will be reviewed against MQOs. This will ensure that the data will be of acceptable quality and that it will be comparable with respect to minimum expected MQOs.

22.3 Checking Against QA/QC

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

22.4 Checking Field Data

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

22.5 Data Verification

Data verification is the process of evaluating the completeness, correctness, and conformance / compliance of a specific data set against the method, procedural, or contractual specifications. We will conduct data verification, as described in the Quality Control section, in order to ensure that it is comparable with respect to completeness, correctness, and conformance with minimum requirements. CEMP Staff are responsible for verification of data going into WQP.

22.6 Data Validation

Data validation is an analytic 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. CEMP Staff will conduct data validation in order to ensure that the data are comparable with respect to their end use. CEMP Staff are responsible for validation of data going into WQP.

22.7 Data Separation

Data will be separated into three categories for use with making decisions based upon it. These categories are:

1. data that meets all acceptance requirements,
2. data that has been determined to be unacceptable for use, and
3. data that may be conditionally used and that is flagged as per QA/OC specification.

23.0 Verification and Validation Methods

The station operator documents any problems identified during a station visit in WQP that detail any anomalies and affected data. Data validators may qualify data based on this information.

Each business day, the station operators and the assigned data validator monitor water quality measurements, sample depth measurements, and station communications for anomalies. Data validators may qualify data based on this information.

The WQP database automatically flags data as Unchecked as it comes into the database. WQP will automatically flag data as Missing when it is not retrieved from the data logger because of power outages, equipment malfunction, etc.

After each sonde deployment period, station operators perform a post-deployment check to determine total drift for each probe. If a probe fails the check with a total error beyond the Maximum Allowable Limit (See Section 14), data collected by that probe is flagged as Bad for the deployment period.

On a monthly basis, data validators perform data review using the WQP interface to graphically display the data. Data are reviewed for integrity, continuity, and reasonableness. Any data deemed questionable by the data validator due to inexplicable extreme values, data dropouts, flat-lined data, etc. may be flagged as Bad data.

Data that pass the above checks are flagged as Good data by the data validator. See Table 7 for a list of QA/QC flags and their definitions.

Table 7 QA/QC Flags

Flag	Definition
G	Good Data - These data have been reviewed and it was determined that they reflect measurements made by equipment that was calibrated to a standard and was operating normally.
X	Bad Data - These data have been reviewed and it was determined that they reflect measurements made when equipment that was out of calibration or was not operating normally.
M	Missing Data - These data are known to be missing for one of the following reasons: logging was off (during a visit for instance), logger failure, etc.
U	Unchecked - These data have not yet been reviewed and may include measurements made by equipment that was out of calibration or was not operating normally.

24.0 Reconciliation with User Requirements

The data quality is evaluated according to this document, with respect to sampling method, field and laboratory analysis, and quality control. Data will be evaluated using Sections 7 through 23. By properly following the guidelines in each of these sections, the data quality will be validated—if samples fail to meet these guidelines, the data quality will be questioned and flagged (**Table 5**). Flagged data (**Table 7**) will be carefully scrutinized to determine if the data can be included in the final analysis.

24.1 Reporting of Data Limitations

Data limitations are reported to data users through a combination of flags for suspect data and metadata files available upon request. Metadata files include information such as the methods used, method detection limits, scope of the project, etc. Additionally, fields will be included in the data that indicate information pertinent to data users, such as the method used, method detection limits, units, etc.

21.2 Data use in SWAMP context

Not Applicable.

-END OF DOCUMENT-

Revision History

Revision	Effective Date	Section	Description of Change	Justification of Change

References

A. Methodological Texts

1. Bryte Chemical Laboratory Quality Assurance Manual. 2021. DES-1-MNL-001. Department of Water Resources Publications, Sacramento, California. 48 pp.
2. Methods for Chemical Analyses of Water and Wastes. 1983. EPA-600/4-79-020.

Appendices

Appendix A: CEMP Field and Lab Manual

CEMP Field & Lab Manual_workingdra

Appendix B: Site Visit Record

CEMP Site Visit Sheet.xlsx

Appendix C: YSI EXO User Manual

exo-user-manual.pdf

Appendix D: Calibration and Maintenance for YSI Multi-Parameter Water Quality Instruments (Xylem EXO and ProDSS)

Maintenance and Calibration for Mult

Appendix E: Calibration Sheet

CEMP Sonde Calibration Sheet.xls

Appendix E

DWR Division of Integrated Science and Engineering. 2022. Discrete Environmental Monitoring Program field and laboratory manual. Version 6. 83 pp.

CALIFORNIA DEPARTMENT OF WATER RESOURCES
DIVISION OF INTEGRATED SCIENCE AND ENGINEERING

DISCRETE ENVIRONMENTAL MONITORING PROGRAM

FIELD AND LABORATORY MANUAL

SEPTEMBER 2022

VERSION 6.0

STATUS: APPROVED
LAST UPDATED: 9/8/22

APPROVAL SIGNATURES

Discrete EMP Supervisor: Theodore Flynn

Signature: _____ Date: 9/8/2022

Discrete Water Quality Lead: Morgan Battey

Signature: Morgan Battey Date: 9/8/2022

Discrete Water Quality Lead: Sarah Perry

Signature: Sarah Perry Date: 9/12/2022

Discrete Water Quality Lead: Julianna Manning

Signature: Julianna Manning Date: 9/8/2022

Zooplankton Lead: Arthur Barros

Signature: Arthur Barros Date: 9/8/2022

Benthic Lead: Betsy Wells

Signature: Elizabeth Wells Date: 9/8/2022

Phytoplankton Lead: Tiffany Brown

Signature: Tiffany Brown Date: 9/8/2022

Crew Members

Signature: Laurel Richardson Date: 9/8/2022

Signature: Allegra Rocha Date: 9/12/2022

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TABLES

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ACRONYMS AND ABBREVIATIONS

CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
COC	Chain of Custody
DEMP	Discrete Environmental Monitoring Program
DI	De-ionized
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DWR	California Department of Water Resources
EMP	Environmental Monitoring Program
EPA	Environmental Protection Agency
EZ	Entrapment Zone
FLIMS	Field and Laboratory Information Management System
FNU	Formazin Nephelometric Unit
GPS	Global Positioning System
IEP	Interagency Ecological Program
L	Liters
MCE	Mixed Cellulose Ester
MD	Mid Delta
mL	milliliter
mm	millimeter
µm	micrometer
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
NIST	National Institute of Standards and Technology
ODO	Optical Dissolved Oxygen
PFD	Personal Flotation Device
QAPP	Quality Assurance Project Plan
RFU	Relative Fluorescence Units
RV	Research Vessel
SFE	San Francisco Estuary
SOP	Standard Operating Procedures
SpC	Specific Conductance
SR	Sacramento River
TOC	Total Organic Carbon
VOA	Volatile Organic Analysis
YSI	Yellow Springs Instrument

BACKGROUND

Under the Interagency Ecological Program (IEP), the Environmental Monitoring Program (EMP) monitors the water quality conditions and biological communities in the San Francisco Estuary (SFE). The water quality, zooplankton, and benthic components of the program are mandated by Water Right Decision 1641 and provide necessary information for compliance with flow-related water quality standards associated with the operations of the California water projects. Zooplankton data collection is performed for the California Department of Fish and Wildlife (CDFW).

The objectives of the Environmental Monitoring Program are:

- to obtain consistent and accurate monthly data at established monitoring stations
- to provide and document information necessary to achieve compliance with salinity, flow, and dissolved oxygen standards
- to analyze data that enhances understanding of estuarine ecology
- to report this information to other state/federal/local agencies, as well as the public, enabling the management and conservation of the upper SFE

This field and laboratory manual is a guide and collection of Standard Operating Procedures (SOPs) specific to mandated projects undertaken by the Discrete EMP (DEMP) unit and does not include continuous monitoring or special studies protocols. This manual undergoes a full revision process annually to incorporate any changes made to the procedures outlined and is reviewed and approved by all members of the DEMP unit.

A Quality Assurance Project Plan (QAPP) details the procedures required to carry out a specific sampling project and may reference a protocol included in this manual. Field crews should review specific project plans for additional information specific to their study that may not be included in this manual.

Discrete Water Quality Monitoring

DISCRETE WATER QUALITY MONITORING STATIONS

The Discrete EMP unit collects discrete water quality data monthly at 24 fixed stations, three of which are accessible from shore by vehicle, while the remaining 21 are accessed via vessel (**Table 1**). These monitoring stations range from San Pablo Bay east through the upper estuary to the mouths of the Sacramento, Mokelumne, and San Joaquin rivers (**Figure 1**). DEMP also samples 2-4 stations each month that have varying geographic locations. These locations are determined by specific conductance values that indicate the presence of the entrapment zone (EZ). All stations are sampled within approximately one hour of high slack tide.

Table 1-Discrete Water Quality Monitoring Station Locations and Descriptions

Station Name	Location	Region	Habitat Type	Accessed By
C10A	San Joaquin River near Vernalis	Southern Delta	Tidal River Channel (Freshwater)	Vehicle
C3A	Sacramento River at Hood	Northern Delta	Tidal River Channel (Freshwater)	Vehicle
C9	West Canal at Clifton Court	Southern Delta	Tidal River Channel (Freshwater)	Vehicle
D10	Sacramento River at Chipps Island	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
D12	San Joaquin River at Antioch Ship Channel	Western Delta	Tidal River Channel (Brackish Water)	Vessel
D16	San Joaquin River at Twitchell Island	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
D19	Franks Tract near Russo's Landing	Lower San Joaquin	Flooded Island/Shallow Lake (Freshwater)	Vessel
D22	Sacramento River at Emmaton	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D26	San Joaquin River at Potato Point	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
D28A	Old River opposite Rancho Del Rio	Central Delta	Tidal River Channel (Freshwater)	Vessel
D4	Sacramento River above Point Sacramento	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D41	San Pablo Bay near Pinole Point	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
D41A	San Pablo Bay near Mouth of Petaluma River	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel

D6	Suisun Bay off Bulls Head near Martinez	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
D7	Grizzly Bay at Dolphin near Suisun Slough	Suisun Bay	Estuarine Embayment (Brackish Water)	Vessel
D8	Suisun Bay off Middle Point near Nichols	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
EZ2	Entrapment Zone - Location determined when bottom SpC values occur at approx. 2,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ2-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ2	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6	Entrapment Zone - Location determined when bottom SpC values occur at approx. 6,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ6	n/a	Estuarine Channel (Brackish Water)	Vessel
MD10A	Disappointment Slough near Bishop Cut	Eastern Delta	Tidal River Channel (Freshwater)	Vessel
NZ002	Carquinez Strait near Glen Cove-tow conducted when surface SpC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ004	Ozol near Martinez and Light 25-tow conducted when surface EC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ032	Montezuma Slough, 2nd bend from mouth	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel
NZ068	Sacramento River at US Coast Guard Station	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
NZ325	San Pablo Bay near Light 15- tow conducted when surface SpC values occur below 20,000 µS	San Pablo Bay	Estuarine Channel (Brackish Water)	Vessel
NZS42	Suisun Slough 300' south of Volanti Slough	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel
P8	San Joaquin River at Buckly Cove	Southern Delta	Tidal River Channel (Freshwater)	Vessel

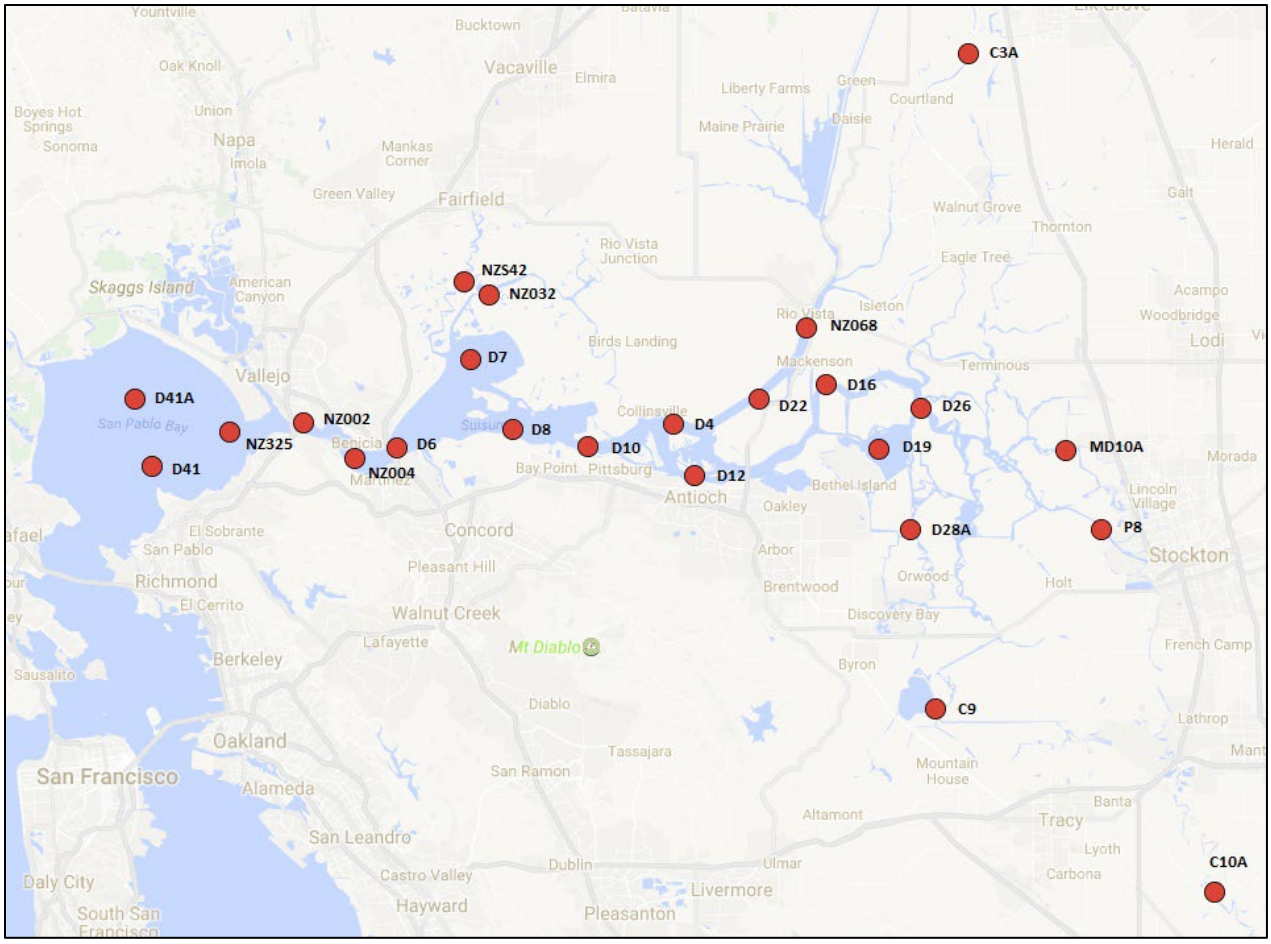


Figure 1-Map of Discrete Water Quality Monitoring Stations

PRE-SAMPLING PREPARATION

Monthly Water Quality Field Runs

Each discrete water quality monitoring station is sampled once a month during the discrete water quality field run (**Figure 1**). The fixed stations are broken up into seven sampling days according to the following order:

Van Run (vehicle): C3A, C9, C10A

Mid Delta Day 1 (vessel): D12, D19, D28A

Mid Delta Day 2 (vessel): D16, D26, MD10A, P8

Sacramento River (vessel): D4, D22, NZ068

Suisun Bay (vessel): D6, D8, D10

Grizzly Bay (vessel): D7, NZS42, NZ032

San Pablo Bay (vessel): D41A, D41, NZ325, NZ002, NZ004

*Note: The EZ stations are sampled on the day they fall into that specific conductance range. Both EZ6 and EZ2 must be sampled on the same day (with the exception of the EZ-SJR stations).

Sampling Containers

All sampling containers (excluding phytoplankton) are obtained from Bryte Laboratory. Before sample collection, containers without preservative are rinsed three times with sample water (either filtered or unfiltered, depending on the analytes in question). All sampling containers are filled to the neck of the container, excluding those analytes that require no headspace or those that have markings requiring an exact volume. Details for each laboratory constituent are shown in **Table 2**.

Containers that are pre-preserved do not require rinsing before filling with sample water. Caution should be taken when processing these samples to not overfill the containers. Nitrile gloves and eye protection should be worn for safety and ensure that bottle caps are secured tightly before storing and transporting. Acid spilled on skin or clothes must be rinsed and diluted immediately with clean water. See Appendix A for additional details on **Laboratory Safety**.

Table 2-Sample containers and storage information for Bryte Laboratory analysis

Analyte Name	Analysis Method	Filter Type	Container	Volume	Storage	Holding Time
Total Alkalinity	SM 2320B	Unfiltered	Polyethylene half pint	250 mL	Unpreserved, 6˚C	14 days
Dissolved Bromide	EPA 300.0	0.45 µm MCE	Polyethylene pint	500 mL	Unpreserved, 6˚C	28 days
Dissolved Ammonia	EPA 350.1	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Dissolved Calcium	EPA 200.7	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL nitric acid, 6˚C	6 months
Dissolved Chloride	EPA 300.0	0.45 µm MCE	Polyethylene pint	500 mL	Unpreserved, 6˚C	28 days
Chlorophyll *a*	SM 10200H	1 µm Glass Fiber	Manila envelope	500 mL	Unpreserved, frozen, dark	28 days
Total Kjeldahl Nitrogen	EPA 351.2	Unfiltered	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Dissolved Nitrate + Nitrite	SM 4500-NO3-F	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Dissolved Organic Carbon	SM 5310C	0.45 µm MCE	Amber glass VOA vial	40 mL	0.2 mL phosphoric acid, 6˚C	28 days
Total Organic Carbon	SM 5310C	Unfiltered	Amber glass VOA vial	40 mL	0.2 mL phosphoric acid, 6˚C	28 days
Dissolved Organic Nitrogen	EPA 351.2/EPA 350.1	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days

Dissolved Ortho-phosphate	EPA 365.1	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Pheophytin *a*	SM 10200H	1 µm Glass Fiber	Manila envelope	500 mL	Unpreserved, frozen, dark	28 days
Total Phosphorus	EPA 365.4	Unfiltered	Polyethylene half pint	250 mL	1 mL sulfuric acid, 6˚C	28 days
Phytoplankton	N/A	Unfiltered	Boston round amber glass	60 mL	2 mL Lugol's Iodine, room temperature	31 days
Dissolved Silica (SiO2)	EPA 200.7	0.45 µm MCE	Polyethylene half pint	250 mL	1 mL nitric acid, 6˚C	6 months
Total Dissolved Solids	SM 2540C	0.45 µm MCE	Polyethylene pint	500 mL	Unpreserved, 6˚C	7 days
Total Suspended Solids	EPA 160.2	Unfiltered	Polyethylene quart	1000 mL	Unpreserved, 6˚C	7 days
Volatile Suspended Solids	EPA 160.4	Unfiltered	Polyethylene quart	1000 mL	Unpreserved, 6˚C	7 days

FLIMS

All seven sampling events for the monthly water quality field run are created in the FLIMS database prior to going out in the field.

1. On the main menu in FLIMS, click "Schedule a Run".

   *Note: Make sure you are using the most updated version of FLIMS. To update, click "Update FLIMS Field" on the desktop of the computer being used.

2. From the Run Name dropdown menu, select the sampling run you would like to create a plan for. The monthly water quality field run includes the following sampling run names:

Van Run	Mid Delta Day 2	Suisun Bay
Mid Delta Day 1	Sacramento River	Grizzly Bay
Entrapment Zone in SJR	Entrapment Zone	San Pablo Bay

   *Note: Entrapment Zone in San Joaquin River should only be created when the SFE is under dry conditions.

3. Under the "Sampler(s)" dropdown menu, choose the appropriate crew lead that is scheduled for that day (this can be found on the monthly DEMP field schedule under each sampling day).

   *Note: If the desired crew lead is not listed in FLIMS, they will need to be created and added to the database by clicking "New Field Crew" and entering their first and last name and phone number.

4. Change the date of the sampling day to reflect the date found on the DEMP field schedule for that month.

5. Once the run window pops up, highlight the station that is titled "(None)" at the bottom of the station list. Click on the "Collection Details" tab and then type in the name of the duplicate station for that day under the "Station Name" box. Assign the corresponding parent station ID to the duplicate from the dropdown menu.

   *Note: The duplicate schedule can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Duplicate and Blank Schedules). The Entrapment Zone runs do not have duplicate or blank samples.

6. Once all sampling runs are created for the month, go back to the main menu and click "Paperwork".
7. Highlight all sampling runs, making sure it says "Yes" next to each run in the "Print Label" column. Then click "Print Labels". Print off the container labels on waterproof label paper (Avery Weatherproof 5520 Labels) and make sure they print in color.
8. After all labels are printed out, amber glass phytoplankton bottles need to be removed from the container list for every station. To do this, highlight a station and click on the "Containers" tab, then right click on the "Phytoplankton" row and click "cut".

   *Note: The phytoplankton samples do not go to Bryte lab, but FLIMS is used to generate labels for the bottles. Blank and duplicate samples do not have phytoplankton bottles.

9. In the "Paperwork" window, highlight the first run listed and click "Chain of Custody". Print off only the first page of the COC form for that run.

   *Note: Printing out the first page of all COCs will allow the crew lead to relinquish the samples upon returning from the field to the person submitting the samples to the lab.

10. Repeat the previous step so that the first page of the COCs for all runs have been printed. Then use a magnet to place the stack of first pages of COCs on the sample refrigerator.

Sampling Checklist

A duplicate sample and a blank sample are processed each day of the water quality field run. A sampling checklist is created each month to identify which station to collect the duplicate sample at. Blank samples should always be listed at the bottom of each day on the sampling checklist and are processed after all stations have been collected.

1. The DEMP Sampling Checklist template can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\WQ Run Sheets.
2. Using the Duplicate and Blank Schedule (found here: S:\M & A BRANCH\Discrete EMP\Water Quality\Duplicate and Blank Schedules) as a reference, update the DEMP Sampling Checklist to highlight which stations have duplicates and what additional samples (if any) need to be collected.

   *Note: Additional samples are typically only collected during special studies.

3. Update the "Sample ID" column with those that were generated for each station when the runs were created in **FLIMS**.

   *Note: For duplicate stations, enter in a "/" at the end of the parent station's sample ID followed by the last two digits of the duplicate sample ID.

4. Once the DEMP Sampling Checklist is updated, print off two copies (one for the crew lead and one for the individual/s processing samples) for the boat run and one copy for the Van Run on Rite in the Rain paper.
5. Place the checklists in the appropriate clipboard to be taken out in the field.

Labeling Containers

Sampling containers are labeled according to station name prior to the monthly water quality field run.

1. Place each label on the appropriate container (specified on the label generated from FLIMS for Bryte sampling) for all samples collected at each station (See **Table 3**).
2. Label the caps of the polyethylene and phytoplankton bottles with the corresponding station name in black Sharpie. Label filtered sample bottles with a red "FF" to indicate field filtration.

   *Note: Write "Dup" next to the station name on the caps for duplicate stations to differentiate from the normal station. Write "B" and the abbreviation for the run name on the caps of blank sample containers (example: "B-MD2").

3. Bottles should be placed in order of station collection for each day into a storage bin to be taken out in the field.

Table 3 – Structure of Sampling Containers for Laboratory Analysis

Sample Type	Container Type	Total Number of Containers
Normal	1 quart 1 pint 1 unpreserved half pint 1 nitric acid half pint 2 sulfuric acid half pints 1 round amber glass bottle 2 amber glass VOA vials 1 manila envelope	10
Duplicate	1 quart 1 pint 1 unpreserved half pint 1 nitric acid half pint 2 sulfuric acid half pints 2 amber glass VOA vials 1 manila envelope	9
Blank	1 quart 1 pint	9

	1 unpreserved half pint 1 nitric acid half pint 2 sulfuric acid half pints 2 amber glass VOA vials 1 manila envelope	

Cleaning Churn Buckets

Prior to the water quality field run each month, churn buckets are washed with Liquinox laboratory detergent to remove any residual material from previous sampling. Every six months, churn buckets are acid washed to ensure complete decontamination. See Appendix B for **Cleaning Protocol for EMP Water Quality Sampling Equipment**.

1. Wet all surfaces of the churn bucket with tap water and use a plastic pipette to add three drops of 1% Liquinox solution to the churn bucket.
2. Scrub the interior and exterior surfaces with a sponge, making sure not to abrade the surface.

   *Note: Pay attention to cleaning the paddle and the area around the spigot.

3. Make sure the churn spigot opening and funnel are free of sediment, including fine particulates (clay), organic matter, and stains.
4. Drain some of the cleaning solution through the spigot before discarding the remaining solution.
5. Fill churn bucket about one-third full of tap water; swirl and shake the churn vigorously to remove detergent residues. Allow tap water to pass through the spigot.
6. Repeat rinse procedure with tap water until no bubbles remain in rinse water after the water is agitated.
7. When there are no bubbles remaining, triple rinse all three parts of the churn bucket with DI water.

Sonde Pre-Measurement Calibration

The DEMP unit collects water quality measurements using EXO2 sondes, which are calibrated prior to each monthly water quality field run using calibration standards. Three sondes are designated for sampling by vessel (vertical, horizontal, and backup) and one sonde is designated for sampling by vehicle. Sondes are calibrated up to 72 hours prior to the run start date and dissolved oxygen sensors are verified for accuracy each morning before data collection. Blank electronic calibration forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Blank Calibration Sheets\Electronic Forms. If a probe is replaced during the calibration process, the information needs to be documented on the DEMP EXO Probe Tracking file located on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde & Probe Tracking. For

information on changing probes or general sonde maintenance, see Appendix C for **EXO User Manual**.

Preparing Calibration Standards

To prevent dilution, standards should be used to calibrate no more than five sondes. A Standards Use Log is posted at each calibration station in the lab to track the lot number and expiration date for each standard and the number of times it has been used to calibrate a sonde.

1. Clean each calibration cup with DI water and triple rinse with its corresponding standard. Calibration cups and lids should be labeled with the standard it holds. Standards will be prepared for the following parameters:

    -Turbidity (124 FNU)

    -Specific Conductance (6668 µS/cm)

    -pH (7 and 10)

2. Record all standard lot numbers and expiration dates on the Pre-Measurement Calibration form and the Standards Use Log.
3. Fill a 5-gallon bucket about 60% full of tap water for the DO calibration. Use an aquarium pump and air stone to aerate the bucket and allow the bucket to aerate for at least one hour to reach full saturation.

Dry Specific Conductance and Water Temperature

A sonde's temperature sensor cannot be calibrated so it must be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST) or a thermometer that has been tested against a NIST thermometer within the last year. This accuracy check should be performed before other sensor calibrations, as temperature can influence other parameters. The serial number for the thermometer and calibration due date is recorded on the Pre-Measurement Calibration form. Each sonde's temperature sensor undergoes a Thermometer Accuracy Verification using a water bath twice a year. See Appendix D for **Thermometer Accuracy Verification SOP**. Temperature checks using the water bath need to be documented on the DEMP Probe Tracking file located on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde & Probe Tracking.

1. Remove the field guard and field wiper from the sonde.
2. Use a paper towel to dry the sonde's sensors completely (you can blow compressed air through the holes of the Conductivity/Temperature sensor).

3. Connect the sonde to a computer with the latest version of KorEXO software using an adapter or via Bluetooth.
4. In Kor, press the "LIVE DATA" tab. Record the value for Specific Conductance Dry under the Pre-Cal column on the Pre-Measurement Calibration form (ideally it should be 0.0).
5. Install the clean calibration wiper and calibration guard onto the sonde. Rinse the sensors, guard, and wiper with DI water and insert the sonde in a clean calibration cup filled with enough DI water to completely cover all the probes.
6. In the "LIVE DATA" tab, press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
7. Insert the thermometer next to the Conductivity/Temperature probe and allow to stabilize.

   *Note: A laboratory stand is useful to hold up the sonde so that the thermometer can fit inside the calibration cup alongside it.

8. Record the temperature values from the thermometer under the Standard column and the sonde under the Pre-Cal column on the Pre-Measurement Calibration form. The values should not have a difference greater than 0.2 ºC.

   *Note: If the values differ greater than 0.2 °C, the temperature sensor may be due for a Thermometer Accuracy Verification. If the sensor does not satisfy the passing criteria during the Thermometer Accuracy Verification process, install a new temperature sensor and repeat the previous procedure.

Chlorophyll

Chlorophyll is measured on the Total Algae sensor. It is normal for the chlorophyll values to fluctuate within a small range during calibration. The chlorophyll sensor needs to be calibrated for both RFU and µg/L. DEMP does not calibrate for Blue Green Algae even though it is listed on the Pre-Measurement Calibration form.

1. Keep the sonde in DI water and remove the thermometer from the calibration cup. Go to the "CALIBRATION" tab, double click the "TAL-PC" box, then press "Calibrate" for Chlorophyll (RFU).
2. Enter "0.00 RFU" (if it is not already set).
3. Press "Apply" when the Data Stability is Stable.
4. Press "Complete Calibration" and record the Pre- and Post-Cal values on the Pre-Measurement Calibration form. Then press "Exit".
5. Keep the sonde in DI water and double click the "TAL-PC" box again in the "CALIBRATION" tab, then press "Calibrate" for Chlorophyll (µg/L).

6. Enter "0.00 µg/L" (if it is not already set).
7. Press "Apply" when the Data Stability is Stable.
8. Press "Complete Calibration" and record the Pre- and Post-Cal values on the Pre-Measurement Calibration form. Then press "Exit".

Turbidity

It is normal for the turbidity values to fluctuate within a small range. A two-point calibration is completed using 0 and 124 FNU standards to bracket the environmental conditions in which the sonde will be deployed.

1. Keep the sonde in DI water.
2. In the "CALIBRATION" tab, double click the "Turbidity" box, then press "Calibrate" for Turbidity (FNU).
3. Enter "0.00" (if it is not already set) for Calibration Point 1.
4. Press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
5. Press "Apply" when the Data Stability is Stable.
6. Press "Add Another Cal Point" and enter 124 FNU as the standard value.
7. Remove the sonde from the water, dry off the sonde's guard and sensors, and shake off any excess water.
8. Rinse the guard and sensors with the 124 FNU rinse bottle and then place the sonde in the 124 FNU standard. Be careful not to agitate the standard.
9. Click "ADVANCED" and then press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
10. Press "Apply" when the Data Stability is Stable.
11. Press "Complete Calibration" and record the Pre- and Post-Cal values for the low and high turbidity on the Pre-Measurement Calibration form. Then press "Exit".

Specific Conductance

1. Remove the sonde from the 124 FNU turbidity standard and rinse the guard and sensors with DI water.
2. Remove the calibration guard and wiper to prevent contamination of the remaining standards.
3. Dry off the sonde's sensors and shake off any excess water.

4. Rinse the sensors with the specific conductance (6668 µS/cm) rinse bottle. Then place the sonde in the specific conductance (6668 µS/cm) standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

5. In the "CALIBRATION" tab, double click the "Conductivity" box, press "Calibrate" for Sp Cond (µS/cm).
6. Enter "6668 µS/cm" (if it is not already set).
7. Press "Apply" when the Data Stability is Stable.
8. Press "Complete Calibration" and record the Pre- and Post-Cal values and the Cell Constant on the Pre-Measurement Calibration form. Then press "Exit".

pH

A two-point calibration is completed using pH 7 and 10 to bracket the environmental conditions in which the sonde will be deployed.

1. Remove the sonde from the specific conductance standard and rinse the sensors with DI water.
2. Dry off the sonde's sensors and shake off any excess water.
3. Rinse the sensors with the pH 7 rinse bottle. Then place the sonde in the pH 7 standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

4. In the "CALIBRATION" tab, double click the "pH" box, then press "Calibrate" for pH.
5. Click on "ADVANCED", press "Auto pH Compensation", then check "USA" (if it is not already checked).
6. Press "Apply" when the Data Stability is Stable.
7. Press "Add Another Cal Point". Then use the drop-down arrow on the 2nd point to change it from 4 pH to 10 pH.

   *Note: EMP does not calibrate to 4 pH.

8. Remove the sonde from the pH 7 standard and rinse the sensors with DI water.
9. Dry off the sonde and shake off any excess water.
10. Rinse the sensors with the pH 10 rinse bottle. Then place the sonde in the pH 10 standard.

    *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

11. Press "Apply" when the Data Stability is Stable.

12. Press "Complete Calibration" and record the Pre- and Post-Cal values for pH 7 and 10, and the pH mV for both. Then press "Exit".
13. The Pre-Measurement Calibration Check form will auto-populate the Delta Slope. Ensure that this value is within the recommended range.

    *Note: If the Delta Slope is outside of the recommended range, the pH module needs replacing.

Dissolved Oxygen

While the DO sensor is calibrated prior to the monthly water quality field run, it also needs to be verified each morning before data is collected. For instructions on how to verify the DO sensor, see **Dissolved Oxygen Verification.**

1. Remove the sonde from the pH 10 standard and rinse the sensors with DI water.
2. Install the field wiper and field guard and place the sonde in the 100% air saturated bucket for at least 5 minutes, then press the "LIVE DATA" tab.
3. Record the DO (mg/L) value under the Pre-Cal column on the Pre-Measurement Calibration form.
4. In the "CALIBRATION" tab, double click the "DO" box, then press "Calibrate" for DO (% Sat).
5. Enter the local Barometer reading from a YSI handheld on the Pre-Measurement Calibration form and in Kor.
6. Press "Apply" when the Data Stability is Stable.
7. Press "Complete Calibration" and record the Pre- and Post-Cal values for DO%, DO Gain, DO mg/L (Post-Cal), Barometer mmHg, and Temperature (°C) from the sonde in the bucket on the Pre-Measurement Calibration form.
8. Calculate the DO (% Sat) and the DO (mg/L) standard values by using the Dissolved Oxygen Solubility Tool (located on the Shared Drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources). Record these values under the Standard column on the Pre-Measurement Calibration Check form.

   *Note: It is not necessary to enter in the specific conductance value when calculating the standard values in the Dissolved Oxygen Solubility Tool. You can also find the DO (% Sat) standard value by dividing the Barometer reading by 7.6.

Depth

1. Remove the sonde from the bucket and place it on the counter.

   *Note: It does not matter if it is positioned upright or laying on its side.

2. In the "CALIBRATION" tab, double click the "Depth" box, then press "Calibrate" for Depth (ft).
3. Enter "0.00" (if it is not already set).
4. Press "Apply" when the Data Stability is Stable.
5. Press "Complete Calibration" and check the "Calibrate depth to 0 feet" box on the Pre-Measurement Calibration form. Then press "Exit".
6. Ensure that there is enough battery voltage on the sonde in the "LIVE DATA" tab and check the "Verify sufficient battery voltage for use" box on the Pre-Measurement Calibration form.

   *Note: Replace batteries if the value is less than 5 volts.

7. Go to the "HOME" tab and disconnect the sonde from Kor. Remove the adaptor or turn off the Bluetooth (whichever was used). Place the sonde back in its original calibration cup with ½ inch of tap water and store upright with a sonde bag to be taken out in the field.

Archiving

Sonde calibration forms get saved to the shared drive and archived in record binders.

1. Save the completed Pre-Measurement Calibration form to the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Saved Calibration Sheets.
2. Print off the completed form and make a black and white copy of it.
3. Place the copy in the plastic sleeve to go out in the field with the sonde.
4. Place the original Pre-Measurement Calibration form inside the EXO Calibration Sheets binder and file it according to sonde ID.

Field Equipment Checklist

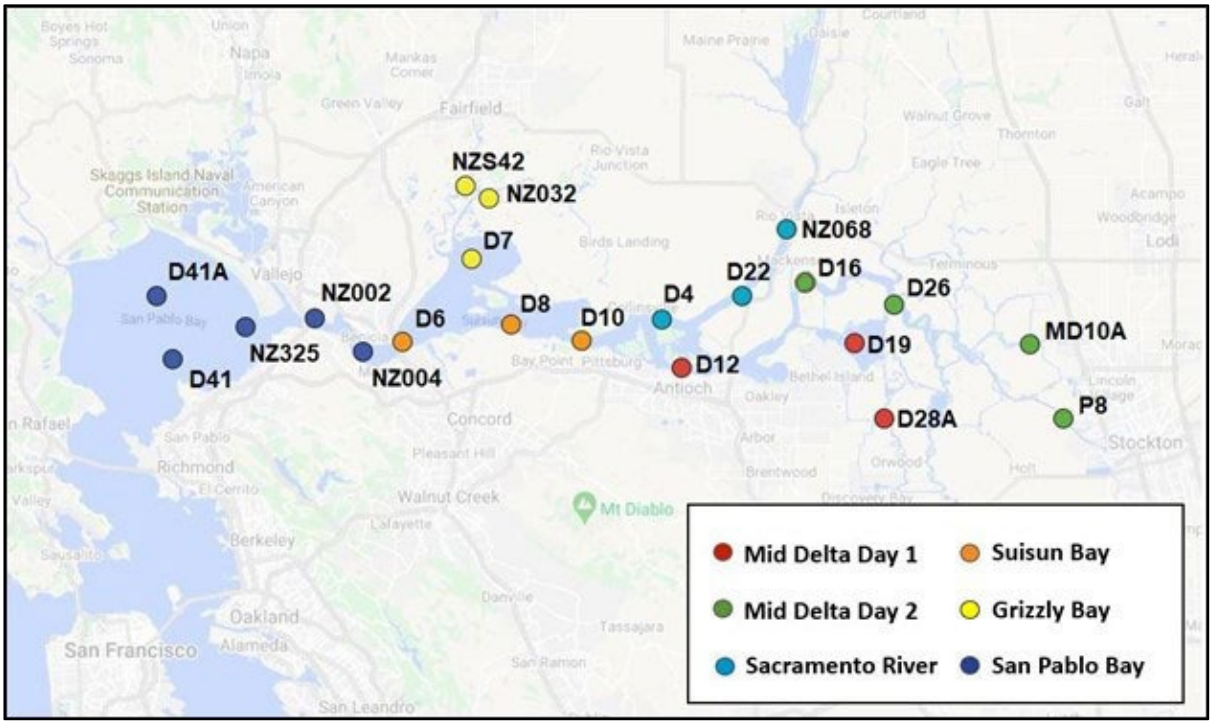
- ☐ Clipboards
- ☐ Sampling Checklist
- ☐ Coolers
- ☐ Sondes
    - Horizontal
    - Vertical
    - Backup
- ☐ Weighted Sonde Guard
- ☐ YSI Handheld
- ☐ 12V Battery (Van Run only)
- ☐ Secchi Disk (Boat Run only)
- ☐ DI Water
- ☐ Churn Buckets
- ☐ Cubitainers (Van Run only)
- ☐ DI Squirt Bottles
- ☐ DI Dispenser
- ☐ Labeled Sampling Containers:
    - Polyethylene Bottles
    - Glass Vials/Bottles
    - Manila Envelopes
- ☐ Filters
    - 0.45 µm Millipore
    - 1.0 µm Glass Fiber
- ☐ Glassware
    - 400 mL Beaker
    - 500/250 mL Volumetric Flask
    - Erlenmeyer Flask
    - Pipette
- ☐ Vacuum Pump Assembly
    - Vacuum Pump
    - Tubing
    - Chlorophyll Filtering Stand with Filtering Cups
    - Nutrient Filtering Stand with Filtering Cups and Bases
- ☐ Stainless Steel Filtering Apparatus
- ☐ Magnesium Carbonate
- ☐ Bucket for DO Checks
- ☐ Bubbler & Air Stone
- ☐ Thermometer
- ☐ Forceps
- ☐ Vacuum Grease
- ☐ Ziploc Bags
- ☐ Paper Towels & Kimwipes
- ☐ Writing Utensil
- ☐ Drinking Water
- ☐ Nitrile Gloves
- ☐ PFDs
- ☐ Safety Glasses
- ☐ First Aid/Emergency Kits
- ☐ Standard Operating Procedures

SAMPLING PROCEDURES

Sampling by Vessel

DEMP samples 21 fixed monitoring stations monthly aboard a research vessel over the course of six sampling days (**Figure 2**). These stations are located offshore and have specific GPS coordinates and landmarks associated with each. There are also 2-4 stations that are sampled each month with varying geographic locations indicating the presence of the Entrapment Zone (see **Entrapment Zone Stations**). The RV Sentinel is equipped with a flow-through system that pulls the surrounding water from three feet below the surface into a collection chamber for the horizontal sonde and into tubing that drains into laboratory sinks for sample collection. See Appendix E for **Field Safety**, Appendix F for **Job Hazard Analysis**, and Appendix G for **Navigation** to the Antioch and Benicia marinas.

Figure 2-EMP Discrete Water Quality Monitoring Stations Accessed by Vessel



Field Data Collection

Field measurements are taken from horizontal and vertical profile sondes that have been calibrated up to 72 hours prior to the monthly water quality field run (**Sonde Pre-Measurement Calibration**). The vertical profile sonde measures water quality parameters at one-second intervals from the surface to the bottom of the water column at each monitoring station. Surface readings are obtained when the sonde is three feet below the surface and bottom readings are obtained three feet above the total depth of the water column. This sonde is operated manually using a crane on the back deck of the research

vessel. The horizontal profile sonde remains stationary inside a flow-through chamber on the vessel that pulls water from a depth of three feet. This sonde measures continuous water quality parameters every five seconds for the entire duration of each sampling day. The protocols below are specific to sampling conducted on the RV Sentinel and may differ on other vessels. See Appendix K for **Sentinel Cheat Sheet**.

Dissolved Oxygen Verification

Because daily changes in local barometric pressure can impact the calibration of the DO sensor, every sonde used needs to be verified each morning before any data is collected (excluding the first day of the run due to aeration time). On the vessel, fill a 5-gallon bucket about 60% full of tap water and place an aquarium pump and air stone in the bucket. Allow the bucket to aerate for at least one hour to reach full saturation. Dissolved Oxygen Calibration Check forms can be found on the Sentinel computer and on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Blank Field Sheets\E-Forms.

1. Fill out the field run and sonde information for the day on the Dissolved Oxygen Calibration Check form.
2. For each sonde, remove the calibration cup and place the sonde (with the guard on) in the 100% air saturated bucket for at least 5 minutes. Connect the sonde to the KorEXO software on the computer via bluetooth. Click the "LIVE DATA" tab.
3. Enter the temperature (°C) reading in the bucket from a NIST traceable thermometer and the local barometric pressure (mmHg) from a YSI handheld. In doing so, the Dissolved Oxygen Calibration Check form will auto-populate the DO standard values for mg/L and % Sat.

   *Note: You can also find the DO standard values by using the Dissolved Oxygen Solubility Tool, located on the desktop of the Sentinel lab computer and on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources.

4. From the data on the "LIVE DATA" screen in Kor, record the DO (% Sat) and DO (mg/L) values under the Reading column on the Dissolved Oxygen Calibration Check form.
5. Calculate the difference between the Standard value and the Reading for both DO (% Sat) and the DO (mg/L). If the deviation falls within the Passing Criteria, disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket and begin **Setup**.
6. If the deviation does not pass, go to the "Calibration" tab, double click the "DO" box, then press "Calibrate" for DO (% Sat).

7. Enter the local Barometer reading from the YSI handheld in Kor.
8. Press "Apply" when the Data Stability is Stable.
9. Press "Complete Calibration" and record the new values for DO%, DO mg/L, and the ODO Gain in the Post-Cal column on the Dissolved Oxygen Calibration Check form. Then disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket and begin **Setup**.

Setup

EXO2 Sonde Setup

1. To assemble the flow-through setup, remove the calibration cup and sonde guard from the horizontal sonde and carefully screw the sonde into the flow-through chamber of the vessel. Connect the cable to the sonde connector.
2. To assemble the vertical sonde, remove the calibration cup and sonde guard from the vertical sonde and carefully screw on the weighted sonde guard. Connect the cable attached to the crane on the back deck of the vessel to the sonde connector and attach the strain relief connector to the handle. Place the sonde in the sleeve on the back deck, making sure there is enough water in it to cover all probes.
3. Set up the crane on the back deck of the vessel by using the crane controls to position the arm in the direction of deployment.
4. Check with the boat captain for permission to turn on the flow-through system. When permission is granted, open the cabinet under the sink to the right of the horizontal sonde setup and turn and hold the switch towards "Open" for approximately 30 seconds until the green light turns on. Then press "Start", which will start the water flow into the sinks.
5. Open the valve on the flow-through manifold to allow water into the horizontal sonde chamber by turning the bottom red nozzle so that it is positioned parallel to the pipe.

*Note: Ensure there are no leaks in the flow-through system. If a leak occurs, close the horizontal sonde valve and make sure the sonde is secured to the flow-through cup.

FluoroProbe Setup

The FluoroProbe is an instrument that determines the concentration of chlorophyll in water and is designed to take continuous measurements. This is set up is within the same flow-through system as the horizontal sonde but does not sync to MOPED. The FluoroProbe reads in data to its own software and runs simultaneously with MOPED for the entire duration of each sampling day. For information on cleaning, calibrations, and general maintenance, see Appendix J for **FluoroProbe User Manual**.

1. Open the valve on the flow-through manifold to allow water into the FluoroProbe chamber by turning the second from the bottom red nozzle so that it is positioned at a 45-degree angle.

    *Note: Ensure there are no leaks in the flow-through system. If a leak occurs, close the FluoroProbe valve and make sure the flow-through rings are secured tightly.

2. Open the "bbe" FluoroProbe software on the desktop and click the "Start" button in the upper left-hand corner.
3. Ensure sequential lines of data are being displayed every few seconds and are also being plotted on the graph in the lower half of the screen.
4. The program can be minimized, but total concentrations of chlorophyll should be compared to the fluorescence readings from the sonde at each station.

MOPED Setup

MOPED is a data acquisition program that communicates with field instrumentation (vertical and horizontal profile sondes, and GPS) and compiles all data into a single format. The protocols listed in this manual are specific to the MOPED version 2.2. For information on how to modify crew members, boat operators, cruise extensions, or for general troubleshooting, see Appendix H for **MOPED User Guide**.

1. Turn the computer on in the lab of the vessel, then turn on the GPS unit just below the computer.
2. Open the MOPED V2 program on the desktop and select the "Cruise Info" tab.
3. Under the "Cruise Information", select the appropriate Operator, Field Crew, Vessel Name, Purpose, and Cruise Extension for the day from the dropdown menus.
4. Under "Cruise Commands", click "Start Cruise". The Cruise ID box will light up green when the cruise has started.

    *Note: There may be a few second delay before the box lights up green.

5. Ensure that the latitude, longitude, depth, and sonde information (serial number and sonde ID) is displayed at the top.

    *Note: If the sonde information is missing, click "Stop/Pause Cruise" and "Load Equipment". Then start the cruise again. If the latitude and longitude are missing, ensure that the GPS unit below the computer is turned on.

6. Select the "Horizontal Profile" tab and check to make sure sequential lines of data are being displayed every five seconds.
7. Verify that the vertical data is coming in by selecting the "Vertical Profile" tab and selecting the "Check" under the station dropdown menu. Click "Start Profile" and make sure sequential lines of data are being displayed every second, then click "Stop Profile".

*Note: There may be a few second delay before data appears.

8. At this point, the back deck monitors can be turned on. To do this, flip the "Port Aft Deck Monitor" and "Starboard Aft Deck Monitor" switches on the breaker panel to "On". Check to ensure that the computer screen in the lab is being mirrored on the port side back deck monitor and that the starboard side back deck monitor shows the navigational information.
9. Once all programs are up and running and all crew members have the necessary equipment on board, let the boat captain know you are ready to go.

Sonde Measurements

Field data is obtained from the vertical and horizontal sondes at each monitoring station before the zooplankton tow is conducted. The field parameters recorded at each station can be found in **Table 5**.

Pre-Check

A Pre-Check is performed at the beginning of each sampling day upon departing the marina (excluding Mid Delta Day 1 due to the close proximity of the first station to the marina). The purpose of the Pre-Check is to verify that the horizontal and vertical sondes are reading within range of each other.

1. Place the vertical sonde over the side of the boat once it has come to a complete stop. Make sure the sonde is positioned approximately three feet below the surface.
2. Under "Vertical Options" in the Vertical Profile tab, select "Pre-Check" and the "No tow Surface" options in the dropdown menus. Then click "Start Profile".

*Note: There may be a few second delay before data appears.

3. When the horizontal and vertical sonde data has stabilized, click "Data Snapshot" in the Vertical Profile tab to copy the data over to the Data Entry tab.
4. In the Data Entry tab, check to make sure the readings from the horizontal and vertical sondes transferred correctly.
5. Enter the time (in PST) to the nearest five-minute increment in the Data Entry tab, then click "Save".

Pre-Tow Measurements

1. Upon arriving to each monitoring station, place the vertical sonde over the side of the boat once it has come to a complete stop. Make sure the sonde is positioned approximately three feet below the surface.

2. Under "Vertical Options" in the Vertical Profile tab, select the appropriate station name and the "Pre-tow Surface" option in the dropdown menus. Then click "Start Profile".

   *Note: There may be a few second delay before data appears. If using a PAR sensor on the vertical sonde, click "Start PAR" instead of "Start Profile" to allow the PAR readings to display in MOPED.

3. When the horizontal and vertical sonde data are stable, click "Data Snapshot" in the Vertical Profile tab to copy the data over to the Data Entry tab.
4. In the Data Entry tab, check to make sure the readings from the horizontal and vertical sondes transferred correctly and enter the time (in PST) to the nearest five-minute increment. Relay the collection time and the surface turbidity value to the person responsible for the sample collection.
5. In the Data Entry tab, enter in the churn bucket number used to collect the sample, the sample ID (found on the sampling checklist), the Secchi reading given by the person responsible for the **Secchi Disk Reading**, the air temperature (°F), wind speed (mph), sky conditions, wave scale, precipitation (if any), and the *Microcystis* score. Then click "Check GPS" to obtain the depth reading and the GPS coordinates.
6. Use the crane controls on the back deck to lower the sonde three feet above the bottom of the water column while watching depth readings on the port side back deck monitor in the Vertical Profile tab.
7. Under "Vertical Options" in the Vertical Profile tab, select the "Pre-tow Bottom" option in the dropdown menu. When the vertical data is stable, click "Data Snapshot" and ensure the readings transferred over to the Data Entry tab correctly. Then click "Save".
8. In the Vertical Profile tab, click "Stop Profile", then raise the sonde back up to three feet below the surface using the crane controls. Manually pull up the sonde the rest of the way and place it back in the sleeve.

   *Note: If using a PAR sensor on the vertical sonde, click "Stop PAR".

<u>Blanks and Duplicates</u>

Blank sampling is a way to test for contamination in sampling equipment and takes place at the end of each day of the water quality run. When blank sampling occurs, enter in the time (in PST, to the nearest five-minute increment) in which the churn bucket was filled, the churn bucket number used, and the sample ID (found on the sampling checklist) in the Equipment Blank box located in the Data Entry tab. Then click "Save".

Duplicate sampling is a method commonly used to assess precision and takes place at one station per day during the water quality run. When sampling a duplicate station,

check the "Duplicate" box in the Data Entry tab, enter in the churn bucket number used to collect the duplicate sample, the sample ID for that duplicate station (found on the sampling checklist), then click "Save".

Secchi Disk Reading

A Secchi disk is used to measure water clarity. Secchi measurements are typically performed upon arriving to each monitoring station by the individual responsible for **Zooplankton Monitoring**.

1. Lower the Secchi disk into the water in a shaded area. Remove sunglasses if you are wearing any.
2. Continue lowering until the white sections of the Secchi disk are no longer visible, then make note of what measurement mark is closest to the surface of the water.

   *Note: Twisting the Secchi can make it easier to see underwater.

3. Determine what the measurement is (in centimeters) for the portion that was below the surface of the water if each tape mark is spaced every 20 cm and the lines in between tape marks are spaced every 4 cm. Then relay this reading to the person responsible for **Sonde Measurements**.

Entrapment Zone Stations

The location of the Entrapment Zone stations is determined by specific conductance values and therefore varies in geographic location each month. If the specific conductance at the bottom is between 5400 and 6600 µS/cm, that location can be designated as EZ6 (or EZ6-SJR, if in the San Joaquin River). If the specific conductance at the bottom is between 1800 and 2200 µS/cm, that location can be designated as EZ2 (or EZ2-SJR, if in the San Joaquin River). EZ2-SJR and EZ6-SJR are only sampled during dry conditions when the entrapment zone is pushed upstream and splits into both the Sacramento and San Joaquin Rivers, creating two disparate zones.

Finding an EZ Station

1. Calculate the difference between the surface and bottom SpC values from the previous station. This will be used to estimate the stratification to help predict the location of the EZ station.
2. Take the desired bottom EZ range (5400-6600 µS/cm for EZ6 or 1800-2200 µS/cm for EZ2) and subtract the value obtained in the previous step to determine the estimated surface SpC range.

   *Note: If the difference calculated in the previous step was 1,000 µS/cm and you are trying to find EZ6, then the estimated surface SpC range to look for would be 4400-5600 µS/cm.

3. Monitor the incoming horizontal sonde readings in MOPED until it reaches the desired surface SpC range. Then notify the captain to stop the boat to perform a check.
4. When the boat has come to a complete stop, place the vertical sonde over the side of the boat.
5. Under "Vertical Options" in the Vertical Profile tab, select "Check" for the station dropdown. Then click "Start Profile".

   *Note: You do not need to have a tow type selected. There may be a few second delay before data appears.

6. Use the crane controls on the back deck to lower the sonde three feet above the depth of the water column while watching depth readings on the port side back deck monitor in the Vertical Profile tab.
7. If the bottom SpC value falls within the range for the desired EZ station, proceed with the collection of field measurements and samples in the same manner as **Pre-Tow Measurements** and **Sample Collection**.

   *Note: It is easiest to collect bottom readings first, before collecting surface readings, since the sonde is already at the bottom of the water column. You will need to click "Stop Profile" and then click start again with the appropriate dropdown options selected. Write in a descriptive name for the location (e.g. "located 100 yards downstream of the Antioch bridge) in the "Field Notes" section of the Data Entry tab and ensure that the GPS coordinates are captured correctly.

8. If the bottom SpC value is outside of the range for the desired EZ station, click "Stop Profile" in the Vertical Profile tab and bring the sonde back on board the vessel.
9. Repeat this procedure again using the surface and bottom SpC values just obtained to calculate the new desired surface SpC range.

<u>Doubling Up</u>

It is possible for the location of the EZ stations to overlap with that of a fixed station, which is referred to as "doubling up", and only one zooplankton tow is conducted. This can happen in one of three ways:

- **Scenario 1** – The EZ station is found at the pre-tow location of the fixed station
- **Scenario 2** – The fixed station's tow ends at an EZ station or passes through an EZ station during the tow
- **Scenario 3** – The EZ station's tow ends at a fixed station or passes through a fixed station during the tow

For Scenario 1:

1. Take the pre-tow surface and bottom sonde readings for the fixed station.
2. Collect an additional churn bucket for the EZ station immediately following the collection of the fixed station churn bucket.
3. At the top of the "Data Entry" tab, select the appropriate EZ station under the "Copy selected to station" dropdown menu.
4. Select "Pre-Tow Surf" under the "Copy selected from tow type" dropdown menu and "Pre-tow Surf" under the "Copy selected to tow type" dropdown menu. Then click "Copy".

    *Note: This will tell MOPED that the pre-tow surface readings are the same for the fixed station and the EZ station.

5. Select "Pre-Tow Bot" under the "Copy selected from tow type" dropdown menu and "Pre-tow Bot" under the "Copy selected to tow type" dropdown menu. Then click "Copy".

    *Note: This will tell MOPED that the pre-tow bottom readings are the same for the fixed station and the EZ station.

6. Select "Horizontal" under the "Copy selected from tow type" dropdown menu and "Horizontal" under the "Copy selected to tow type" dropdown menu. Then click "Copy".

    *Note: This will tell MOPED that the horizontal readings are the same for the fixed station and the EZ station.

7. Select the EZ station from the "Station" dropdown menu in the upper left corner of the "Data Entry" tab and ensure that all readings were copied over correctly.
8. Enter in the churn bucket number used for the EZ station sample and the Lab ID, then click "Check GPS" and ensure that the GPS coordinates are captured correctly.
9. In the "Field Notes" section, write in that the EZ station was located at the fixed station (e.g. "EZ6 was located at station D4").
10. The collection time, secchi reading, weather information, and MC score can be copied over from the fixed station.

For Scenario 2:

1. At the fixed station's post-tow location, collect a horizontal sonde reading, surface and bottom vertical sonde readings, a secchi reading, and fill up a churn bucket for the EZ station. Ensure these are recorded in the "Data Entry" tab with the new collection time.

    *Note: Since an additional zooplankton tow is not conducted, choose "No tow Surf" and "No tow Bot" when collecting the vertical sonde readings.

2. Enter in the remaining data in the "Data Entry" tab, click "Check GPS" and ensure that the GPS coordinates are captured correctly.

3. In the "Field Notes" section, write in where the EZ station was located relative to the fixed station (e.g., "EZ6 was located at the end of the D4 tow" or "Passed through EZ6 during the D4 tow").

For Scenario 3:

4. In the instance of passing through the fixed station, fill up a churn bucket while physically passing through the fixed station. Use the navigation screen to determine when the boat is directly over the station.
5. At the EZ station's post-tow location, collect a horizontal sonde reading, surface and bottom vertical sonde readings, a secchi reading, and fill up a churn bucket (if ending at the fixed station) for the fixed station. Ensure these are recorded in the "Data Entry" tab with the new collection time.

   *Note: Since an additional zooplankton tow is not conducted, choose "No tow Surf" and "No tow Bot" when collecting the vertical sonde readings.

6. Enter in the remaining data in the "Data Entry" tab, click "Check GPS" and ensure that the GPS coordinates are captured correctly.
7. In the "Field Notes" section, write in where the EZ station was located relative to the fixed station (e.g., "D4 was located at the end of the EZ6 tow" or "Passed through D4 during the EZ6 tow").

Carquinez Straight Stations

Since CDFW is only interested in zooplankton data from the Carquinez Straight during high outflow events, a zooplankton tow is not conducted at stations NZ325, NZ002, and NZ004 when the specific conductance is above 20,000 µS/cm on the surface. In this case, only water quality samples and field measurements (including secchi) are collected upon arriving to the station. When obtaining sonde measurements for these stations under dry conditions, select the "No Tow Surface" and "No Tow Bottom" options in the dropdown menu under the Vertical Profile tab in MOPED and document that a zooplankton tow was not conducted in the "Field Notes" section in the Data Entry tab.

Shutdown

<u>Saving Sonde Data and MOPED Shutdown</u>

At the end of each sampling day, the data sheet and data file generated from MOPED is saved before the application is shut down.

1. In the Data Sheet tab, click the "Export" icon and select "PDF" from the list of download options.

   *Note: If the dropdown menu does not appear, switch the date to the previous one listed and then switch back to the current date. The dropdown menu should now appear.

2. Save the data sheet to the appropriate water quality folder on the desktop of the Sentinel computer according to the month and year. Name the file in the following format: "EMP Data Sheet_MD1_May21.pdf", depending on the run name.

    *Note: If it is the first day of the run, a new folder needs to be created with the current month. All files for that month are saved in this new folder.

3. Under "Cruise Commands" in the Cruise Info tab, click "Pause/Stop Cruise".
4. Click "Export Cruise Data as CSV" and save the file to the same folder as the data sheet. Name the file in the following format: "MOPED_Export_#_MMDDYYYY_MD1.csv" depending on the run name.

    *Note: MOPED will automatically generate the first part of the file name.

5. Exit out of the MOPED application.

FluoroProbe Shutdown

1. In the "bbe" FluoroProbe software, click the "Stop" button in the upper left-hand corner of the screen.
2. Click "File", hover over "Export (ASCII)", then click "Export all".
3. In the Export Options pop-up window, ensure that the "Export all data sets" is checked, and then click "OK".
4. Save the file to the same folder as the data sheet and MOPED file. Name the file in the following format: "Fluoroprobe_MD1_May21" depending on the run name and date.

    *Note: The FluoroProbe's flow cell needs to be cleaned every other month. To do this, remove the FluoroProbe from the flow-through setup and clean the flow cell according to the manufacturer guidelines. See Appendix J for **FluoroProbe User Manual**.

EXO2 Sonde Cleanup

The horizontal and vertical sondes are kept on the vessel in the field for the entire duration of the monthly water quality field run. If it is the end of the monthly water quality field run, sondes are transported back to the office where they will undergo a **Sonde Post-Measurement Calibration Check** in the calibration lab.

1. Turn off the flow-through system by opening the cabinet under the sink to the right of the horizontal sonde setup. Press "Stop" and then turn and hold the switch towards "Close" for approximately 30 seconds until the red light turns on. Close the valve of the FluoroProbe and horizontal sonde flow-through chambers by turning the bottom and second to bottom red nozzles so that they are positioned perpendicular to the pipes.

2. Making sure there is no water feeding into the horizontal flow-through, disconnect the cable from the horizontal sonde connector and unscrew the horizontal sonde from the flow-through cup.
3. Gently rinse the probes on the horizontal sonde with DI water over the sink in the lab. Carefully screw on the original sonde guard and calibration cup (with ½ inch of tap water) and put the cable connector plug back on.
4. Drain the remaining water in the flow-through cup by removing the latch that secures the cup in place and discarding the water in the sink (use an empty container).
5. Use the crane controls on the back deck to move the crane back to its original position.
6. Disconnect the field cable from the vertical sonde by unscrewing the cable connector from the sonde and strain relief connector from the handle.
7. Carefully remove the weighted sonde guard and gently rinse the probes on the vertical sonde with DI water over the sink in the lab. Carefully screw on the original sonde guard and calibration cup (with about ½ inch of tap water) and put the cable connector plug back on.
8. Store the vertical and horizontal sondes upright in the appropriately labeled spots of the sonde stand located near the flow-through setup.

*Note: Do not store the sondes on their side because the tap water will leak out of the calibration cup, which can cause the probes to dry out.

SharePoint Upload

At the end of each day of the run, all files that were generated are saved to the EMP SharePoint site.

1. Once all files are saved to the Sentinel computer, open up the EMP SharePoint site and navigate to the following folder: "Water Quality" > "Field Data" > "Water Quality (current year)" and select the folder for the current month.
2. Click "Upload" and then click the "Choose Files" button in the pop-up window.
3. Find the appropriate water quality folder on the computer and highlight the data sheet, MOPED file, and FluoroProbe file from that day. Click "Open" and then click "OK".

*Note: If it is the final day of the water quality run, the Crew Lead Report and all DO Calibration Check Attachment forms need to be saved to the same SharePoint folder.

Sample Collection

Upon arriving to each station, samples are immediately collected, processed, and preserved on the vessel. Sample water is obtained via a flow-through system taken at a depth of

approximately three feet below the surface that drains out of tubing in the laboratory sinks and is collected into a churn bucket. The churn bucket is rinsed three times with the sample water prior to collection. Churning the sample before dispensing is required to homogenize the particulates in the water. When filling up a container with sample water from the churn bucket, pumping approximately ten times is adequate for homogenization. All samples for any given site can be obtained from a single, full churn bucket. Nitrile gloves should be worn at all times for the entire duration of the sample collection and filtration process. Individuals performing this role will be responsible for checking to see which station has a duplicate for any given sampling day, and when the blank samples need to be processed. This information can be found on the **Sampling Checklist**.

Unfiltered Analytes

Unfiltered analytes do not require filtration and are collected directly from the churn bucket. Samples that require pre-preserved containers do not require rinsing prior to collection. Caution should be taken when collecting sample water into these containers so as not to overfill. See **Table 2** for a list of unfiltered analytes.

1. Churn the sample water with three pumps in the churn bucket and collect a small amount of sample water into the polyethylene quart container that will be analyzed for total suspended solids and volatile suspended solids.
2. Cap the quart and shake to ensure that the sample water covers all inside surfaces of the container (and cap) and then dump the water out. Repeat this procedure two more times so that the container gets rinsed a total of three times.
3. Churn the sample water ten times and fill the entire contents of the quart.

   *Note: This unfiltered sample container will be used to transfer sample water from the churn bucket to the sterafil cups (see **Dissolved Nutrients**).
4. Triple rinse the unfiltered half pint container that will be analyzed for alkalinity and specific conductance directly from the churn bucket. Fill the container all the way up to the top with no headspace. Secure the cap tightly and store in the refrigerator.
5. Triple rinse a clean beaker with water from the churn bucket and then fill to the 250 mL line. Carefully pour the contents into the unfiltered sulfuric acid half pint container that will be analyzed for total kjeldahl nitrogen and total phosphorus. Fill exactly to the 250 mL line. Secure the cap tightly and store in the refrigerator.

   *Note: This container is pre-preserved with 1 mL of sulfuric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.
6. Churn the sample water in the churn bucket with ten pumps and carefully fill up the round amber glass phytoplankton sample up to the neck of the container. Cap tightly

and invert the bottle a few times to create a uniform mixture of the sample water and the preservative. Write the collection time on the label of the bottle and store at room temperature.

*Note: This container is pre-preserved with 2 mL of Lugol's iodine and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

7. Churn the sample water again and carefully fill up the TOC sample to the neck of the container. Store in the refrigerator.

*Note: This container is pre-preserved with 0.2 mL of phosphoric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

Filtered Analytes

Dissolved Nutrients

Dissolved nutrient samples are filtered through a 0.45 µm mixed cellulose ester (MCE) membrane filter using a vacuum pump assembly and collected into an array of polyethylene containers. Pre-acidified containers should never be placed inside this vacuum pump assembly to avoid overspilling into the vacuum base. See **Table 2** for a list of dissolved analytes.

1. Prepare the vacuum pump assembly by connecting the vacuum base to the tubing that connects to the vacuum pump.

*Note: On the first day of the monthly water quality field run, vacuum grease can be applied around the edges of the vacuum base to allow for easy removal of the sterafil bases while filtering.

2. Rinse the two sets of sterafil bases and cups three times with DI water. Dry with a Kimwipe and attach the sterafil bases to the vacuum base.
3. Using forceps, place one 0.45 µm MCE membrane filter on each of the sterafil bases and then screw the cups onto the sterafil bases to secure the filter.
4. Remove the cap of the polyethylene pint container that will be analyzed for total dissolved solids, dissolved chloride, and dissolved bromide and place the container into the vacuum base. Then secure the sterafil bases/cups with the filter on top.
5. Remove the cap of an extra polyethylene pint container and place it into the vacuum base. Then secure the sterafil bases/cups with the filter on top.

*Note: Since pre-preserved containers cannot be placed inside the vacuum base for direct filtration, this pint bottle will act as a vessel to collect filtered sample water, which will be poured into the acidified half pint bottles.

6. Turn on the vacuum pump, shake the contents of the quart container collected with the **Unfiltered Analytes**, and pour a small amount of sample water into both sterafil cups to filter into the pint containers. When the water filters through completely, remove one of the rubber stoppers to release the seal.
7. Remove the pint containers from the vacuum base, replace the caps, and then shake them to rinse all surfaces with the filtered sample water. Then discard the water.
8. Uncap and replace the pint containers into their respective vacuum bases, place the sterafil bases and cups on top, and replace the rubber stopper. Repeat the previous two steps two more times so that both containers are rinsed with filtered sample water for a total of three times.

    *Note: Make sure to shake the contents of the quart container each time before pouring sample water into the sterafil cups to ensure homogenization.

9. Once the containers have been triple rinsed, pour the sample water from the quart to the tops of the sterafil cups. The water will filter into the pint containers. Stop filtering when the water reaches the necks of the pint bottles.

    *Note: In turbid conditions (e.g. above 20 FNU), fill the sterafil cups halfway to prevent clogging.

10. Remove the pint container that will be analyzed for total dissolved solids, dissolved chloride, and dissolved bromide from the vacuum base. Secure the cap tightly and store in the refrigerator.
11. Remove the extra pint container from the vacuum base and carefully pour the filtered contents into the sulfuric acid half pint container that will be analyzed for dissolved nitrate+nitrite, dissolved ortho-phosphate, dissolved ammonia, and dissolved organic nitrogen. Fill exactly to the 250 mL mark. Secure the cap tightly and store in the refrigerator.

    *Note: This container is pre-preserved with 1 mL of sulfuric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

12. Carefully pour the remaining filtered contents into the nitric acid half pint container that will be analyzed for dissolved calcium and dissolved silica. Fill to the neck of the container. Secure the cap tightly and store in the refrigerator.

    *Note: This container is pre-preserved with 1 mL of nitric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

13. Refill the quart a final time from the churn bucket to the neck of the container. Secure the cap tightly and store in the refrigerator.

14. Discard the used filters and triple rinse extra pint container and the sterafil cups and bases with DI water. Let dry before using at the next station.

    *Note: If it is the final day of the water quality run, open the red valve under the counter to empty the collection tank and rinse the tubing of the filtering apparatus with DI water.

Chlorophyll *a* and Pheophytin *a*

Chlorophyll *a* and pheophytin *a* samples are submitted in the form of a 1.0 µm glass fiber filter that has had 500 mL (or 250 mL if the surface turbidity is higher than 20 FNU) of sample water pass through it.

1. Prepare the vacuum pump assembly by connecting the tri-manifold vacuum base via the tubing that connects to the vacuum pump.

   *Note: This can also be within the same assemblage as the **Dissolved Nutrients** setup.

2. Place a 47 mm glass fiber filter with the smooth side face down onto the vacuum base. Carefully screw the filtering cup onto the base to secure the filter.
3. Churn the sample in the churn bucket with three pumps and add a small amount of sample water to a 500/250 mL volumetric flask. Swirl the water around to cover all surfaces and then dump the water out. Repeat two more times to rinse the flask for a total of three times.
4. Once the flask has been triple rinsed, churn the sample water with ten pumps and fill up the volumetric flask to just above the 500/250 mL mark. Use the pipette to remove enough water to where the bottom of the meniscus is in line with the 500/250 mL mark.
5. Pour the 500/250 mL of sample water into the filtering cup and turn on the vacuum pump. Add a small amount of the magnesium carbonate solution and open the valve to allow all of the sample water to pass through the filter.

   *Note: The vacuum pump should be set to a pressure no higher than 5 psi (or 10 in Hg), as the cells of the filter can lyse and affect the laboratory analysis.

6. While the sample water is filtering, rinse the volumetric flask three times with DI water and discard into the filtering cup. Once all of the water has passed through the filter, rinse the filtering cup three times with DI water to rinse off any residual sample particles.
7. Turn the pump off and unscrew the (now clean) filtering cup to expose the filter. Use forceps to carefully fold the filter in half and remove it from the pump base. Avoid coming in contact with the top surface of the filter where the particulates are collected.
8. Place the folded filter inside of the labeled manila envelope and write the collection time and volume (500 or 250 mL) of sample water used in the corner of the envelope. Seal the envelope and store in the freezer.
9. Clean the exposed vacuum base by turning on the pump and rinsing it with DI water.

*Note: If it is the final day of the monthly water quality field run, open the red valve under the counter to empty the collection tank and rinse the tubing of the filtering apparatus with DI water.

Dissolved Organic Carbon

Dissolved organic carbon (DOC) samples are filtered with a 0.45 µm MCE membrane filter using a gravity filter and collected into a 40 mL glass vial. These sample containers are pre-preserved and do not require rinsing prior to collection.

1. Triple rinse the stainless-steel filtering reservoir and filtering spout with DI water.
2. Use forceps to place a 0.45 µm MCE membrane filter onto the mesh face of the filtering spout. Attach the reservoir to the top by lining up the conjunction notches and twisting to secure it in place.
3. Place the stainless-steel filtering apparatus onto a clean glass Erlenmeyer flask with tubing hooked up to a vacuum pump.
4. Fill up a clean beaker with approximately 100 mL of DI water and pour it into the stainless-steel reservoir. Turn on the pump and let the DI water filter into the flask.
5. Turn off the pump and remove the filtering apparatus from the flask. Then discard the water in the flask. Place the filtering apparatus back on the flask.
6. Triple rinse the beaker with sample water from the churn bucket and then fill with approximately 30 mL of sample water.
7. Pour the sample water from the beaker into the stainless-steel reservoir and turn on the pump, letting the water filter into the flask. Turn off the pump and remove the filtering apparatus from the flask. Discard the water in the flask.

   *Note: The filter has now been adequately rinsed to remove any potential contaminants.
8. Fill the beaker with another 30 mL of sample water. Pour approximately 10 mL into the stainless-steel reservoir. Turn off the pump and remove the filtering apparatus from the flask. Swirl and discard the water in the flask. Repeat two more times to adequately rinse the flask with the sample water.

   *Note: The flask has now been adequately rinsed to remove any residual DI water.
9. Fill up the beaker a final time with approximately 50 mL of sample water and pour it into the stainless-steel reservoir. Turn on the pump and let the water filter into the flask.
10. Turn off the pump and remove the filtering apparatus from the flask. Carefully pour the filtered sample water from the flask into the DOC sample bottle. Secure the cap tightly and store in the refrigerator.

*Note: This container is pre-preserved with 0.2 mL of phosphoric acid and does not require rinsing prior to collection. Make sure enough ventilation is available when performing this step.

11. Discard the used filter and triple rinse the filtering apparatus and glassware with DI water. Let dry before using for the next station.

Quality Control Samples

Equipment Blanks

Blank sampling is performed to ensure that samples have been processed, transported, and stored properly and to detect any contamination introduced into the sample by the sampling containers and/or equipment, or by exposure to ambient conditions. Equipment blanks are collected each day of the water quality run after all stations have been collected and processed. This type of sampling consists of collecting a churn bucket of DI water, which is processed, stored, and submitted in the same manner as normal surface water samples for all analytes (excluding phytoplankton).

Duplicates

Duplicate sampling is performed to assess the precision of sampling methods and the ability to replicate results. Concurrent duplicate samples are collected at one station per day during the water quality run, which is previously determined by an alternating schedule. Upon arriving to a duplicate station, an additional churn bucket is collected immediately after the normal (or parent) churn bucket is collected. This second set of samples is processed in the same manner as the parent samples for all the same analytes (excluding phytoplankton). The duplicate samples will have their own lab ID that is separate from the parent samples.

Sample Transport, Storage, and COC Relinquishing

At the end of each sampling day, samples collected on the vessel are transported back to the West Sacramento office where they are stored until they are submitted to the lab. Sample temperature must be maintained at < 6º until delivery to the laboratory. See **Table 2** for storage requirements for each analyte.

1. Upon arriving back to the marina, place all samples collected that day into a cooler.

   *Note: Chlorophyll envelopes should be double bagged and DOC/TOC vials should be single bagged prior to putting them into a cooler.

2. Cover the samples with sufficient ice to keep the temperatures from rising during transport.
3. Upon returning to the office from the field, transfer samples from the coolers into either the refrigerator or freezer in the DEMP lab, making sure there are no missing or damaged sample containers.

*Note: It is easiest to see that all samples are accounted for if they are grouped by station in the fridge.

4. The Crew Lead will then formally relinquish the samples to the person submitting them to the laboratory by filling out the "Sampled/Relinquished By" section on the first page of the COC for that run (located on the sample fridge).

   *Note: The first page of all COCs were printed in the **FLIMS** section. If the Crew Lead is submitting the samples to the lab, then the middle "Received By" and "Relinquished By" sections do not need to be filled out.

5. If the samples were filtered immediately following collection, write "Same as Collection" at the bottom of the page below the Container Summary,
6. If the samples were not filtered immediately following collection (e.g., Van Run), write in the filtration time at the bottom of the page below the Container Summary.

Sampling by Vehicle

The DEMP unit samples three monitoring stations by vehicle, referred to as the Van Run (**Figure 3**). Two of these stations (C3A and C10A) are sampled from a pier positioned above the edge of the Sacramento and San Joaquin rivers. The third station (C9) is sampled from a dock near the intake of Clifton Court Forebay. See Appendix L for **Van Run Cheat Sheet** Appendix F for **Job Hazard Analysis** and Appendix G for **Navigation** to the Van Run stations.

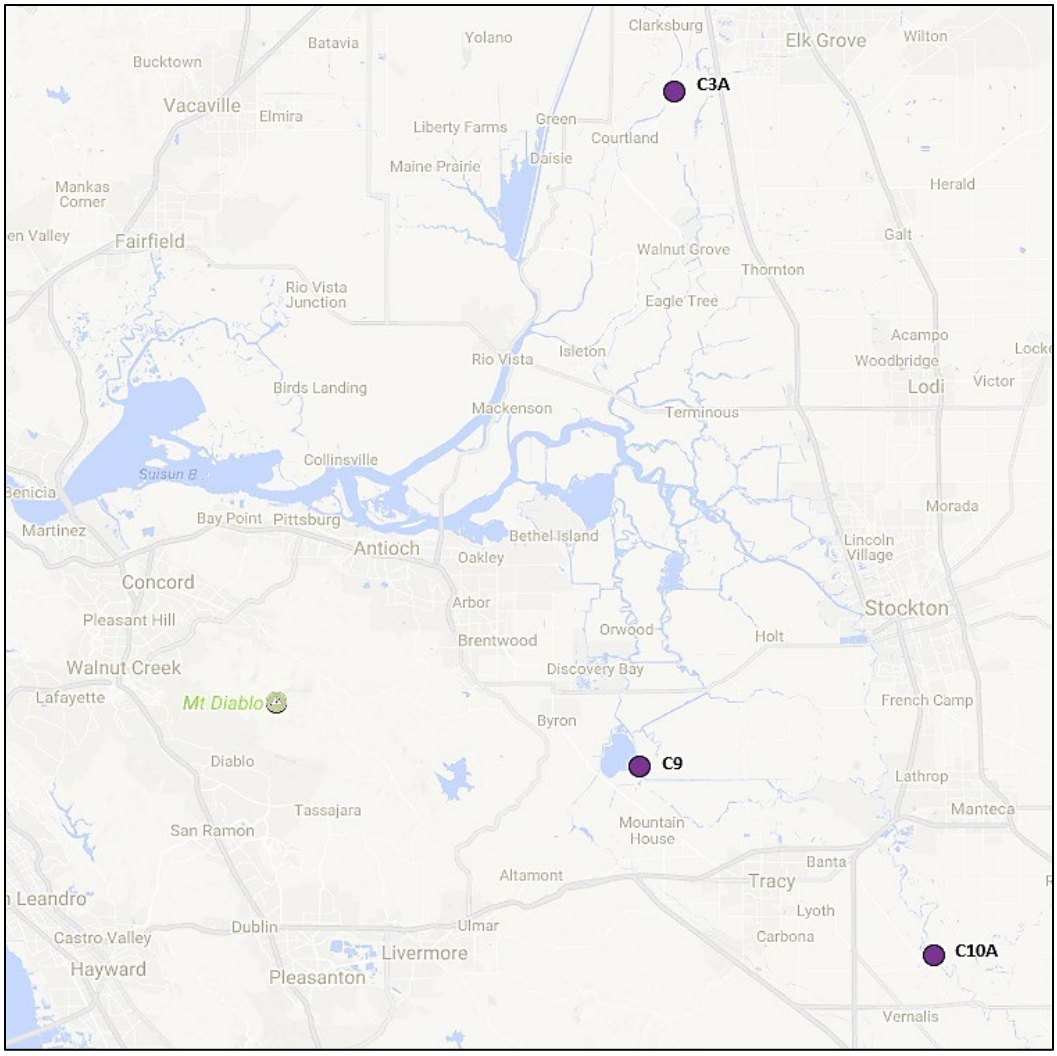


Figure 3-EMP Discrete Water Quality Monitoring Stations Accessed by Vehicle

Field Data Collection

Dissolved Oxygen Verification

Before leaving the office on the morning of the Van Run, a Dissolved Oxygen Verification needs to be performed on the sonde going out in the field. In the calibration lab, fill a 5-gallon bucket about 60% full of tap water and place an aquarium pump and air stone in the bucket. Allow the bucket to aerate for at least one hour to reach full saturation (if it is not already done). Dissolved Oxygen Calibration Check forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Blank Field Sheets\E-Forms.

1. Fill out the field run and sonde information for the day on the Dissolved Oxygen Calibration Check form.

2. Remove the calibration cup and place the sonde (with the guard on) in the 100% air saturated bucket for at least 5 minutes. Connect the sonde to the KorEXO software using an adapter or via Bluetooth. Click the "LIVE DATA" tab.
3. Enter the temperature (°C) reading in the bucket from a NIST traceable thermometer and the local barometric pressure (mmHg) from a YSI handheld. In doing so, the Dissolved Oxygen Calibration Check form will auto-populate the DO standard values for mg/L and % Sat.

   *Note: You can also find the DO standard values by using the Dissolved Oxygen Solubility Tool, located on the desktop of the Sentinel lab computer and on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources.

4. From the data on the "LIVE DATA" screen in Kor, record the DO (% Sat) and DO (mg/L) values under the Reading column on the Dissolved Oxygen Calibration Check form.
5. Calculate the difference between the Standard value and the Reading for both DO (% Sat) and the DO (mg/L). If the deviation falls within the Passing Criteria, disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket. Store it upright with a sonde bag to go out in the field.
6. If the deviation does not pass, go to the "Calibration" tab, double click the "DO" box, then press "Calibrate" for DO (% Sat).
7. Enter the local Barometer reading from the YSI handheld in Kor.
8. Press "Apply" when the Data Stability is Stable.
9. Press "Complete Calibration" and record the new values for DO%, DO mg/L, and the ODO Gain in the Post-Cal column on the Dissolved Oxygen Calibration Check form. Then disconnect the sonde from Kor, turn off the Bluetooth, and remove the sonde from the bucket. Store it upright with a sonde bag to go out in the field.
10. Name the file with "DO Calibration Check Attachment" followed by the month and year (ex. DO Calibration Check Attachment_Jul22) and save it to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

EXO2 Sonde Readings

Field measurements are obtained using an EXO 2 Sonde and are recorded at quarter-hourly time intervals for data verification using CDEC readings (http://cdec.water.ca.gov). The sonde is placed in the river within approximately 10 feet of the deployed continuous sonde (for C3A and C10A).

1. Upon arriving to a station, connect the cable to both the sonde and the handheld.

2. Remove the calibration cup and sonde guard from the sonde and screw on the weighted sonde guard, being careful to avoid coming in contact with the sensors.
3. Five to ten minutes before the quarter-hour, lower the sonde into the river three feet below the surface (near the deployed continuous sonde) to allow for equilibration.
4. At the quarter hour, record the time (in PST) and surface field measurements on the EMP Water Quality electronic data sheet (documented field parameters can be found in **Table 5**).
5. When all surface measurements have been recorded, slowly lower the sonde down to the bottom of the water column. When the sonde reaches the bottom, record the depth reading on the data sheet.
6. After the depth measurement has been recorded, bring the sonde up three feet above that bottom depth measurement. Once equilibrated, record the bottom field measurements on the data sheet at this depth.
7. Once all surface and bottom readings have been recorded, bring the sonde back up to the station. Remove the weighted sonde guard and replace it with the field guard and calibration cup (with ½ inch of tap water). Disconnect the cable from both the sonde and the handheld and put the cable connector plug back on.
8. Upon arriving back to the office, use AirDrop to send the completed data sheet from the iPad to a phone and then email the data sheet to be saved on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

Sample Collection

Start out with properly cleaned sample collection equipment. Samples are collected directly from the water body using a peristaltic pump (or a Van Dorn during low water events) and are obtained at the same time as the field data is being recorded. Duplicate samples are collected immediately after the parent sample. All samples collected are stored on ice and transported back to the office where they are processed for the full suite of laboratory analytes. The procedures outlined in the **Sample Transport, Storage, and COC Relinquishing** section should be followed.

1. Attach the peristaltic pump to a battery and lower the input end of the tubing 3 feet below the surface of the water.
2. Turn on the pump and allow sufficient time (5 to 10 minutes) to flush out the system before collecting any water.

> *Note: During low water events when the pump is not able to carry water up to the station, lower a Van Dorn water sampler three feet below the surface and release the weighted messenger to collect the sample.

3. At the quarter hour, triple rinse a clean sample container (and lid) and then fill up the container to collect the sample.
4. Place the container in a cooler on ice.

Unfiltered Analytes

Unfiltered analytes are to be processed in the same manner as **Sampling by Vessel** and takes place upon arrival back to the office.

Filtered Analytes

Filtered analytes are to be processed in the same manner as **Sampling by Vessel** and takes place upon arrival back to the office.

Quality Control Samples

Equipment blanks and concurrent duplicates are to be processed in the same manner as **Sampling by Vessel** and takes place upon arrival back to the office.

POST-RUN PROCEDURES

Sonde Post-Measurement Calibration Check

After a field run has been completed, a Post-Measurement Calibration Check is performed within 24 hours of returning from the field. This determines the amount of drift the sonde's sensors experienced while being out in the field. The data collected during deployment is not valid without this record, because the accuracy and precision of the data cannot be verified. Blank electronic calibration forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Blank Calibration Sheets\Electronic Forms. For information on changing probes or general sonde maintenance, see Appendix C for **EXO User Manual**.

Dry Specific Conductance and Water Temperature

1. Prepare the calibration standards in the same manner as **Sonde Pre-Measurement Calibration**. Make sure to document the lot numbers and expiration dates for the standards used and the serial numbers and calibration due dates for the instruments used.
2. Remove the field guard and field wiper from the sonde.
3. Use a paper towel to dry the sondes sensors completely (you can blow compressed air through the holes of the Conductivity/Temperature sensor).
4. Connect the sonde to a computer with the latest version of KorEXO software using an adapter or via Bluetooth.
5. In Kor, press the "LIVE DATA" tab. Record the value for Dry Specific Conductance under the Reading column on the Post-Measurement Calibration Check form (ideally it should be 0.0). The difference between the Standard value and the Reading will auto-populate in the Deviation column.
6. Install the clean calibration wiper and calibration guard onto the sonde. Rinse the sensors, guard, and wiper with DI water and insert the sonde in a clean calibration cup filled with enough DI water to completely cover all the probes.
7. In the "LIVE DATA" tab, press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
8. Insert the thermometer next to the Conductivity/Temperature probe and allow to stabilize. A laboratory stand is useful to hold up the sonde so that the thermometer can fit inside the calibration cup alongside it.
9. Record the temperature values from the thermometer under the Standard column and the sonde under the Reading column on the Post-Measurement Calibration

Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

*Note: If the deviation between the standard value and the reading is greater than 0.2 °C, the temperature sensor may be due for a **Thermometer Accuracy Verification** (Appendix D).

Chlorophyll

1. Keep the sonde in DI water and remove the thermometer from the calibration cup.
2. In the "LIVE DATA" tab, record the value for chlorophyll (µg/L) and chlorophyll (RFU) under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard values and the Readings will auto-populate in the Deviation column.

Turbidity

1. Keep the sonde in DI water and press the "Start Wiping" button in the "LIVE DATA" tab to wipe the sensors. Check that the wiper parks correctly in the garage.
2. Record the value for turbidity (FNU) in DI water under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.
3. Remove the sonde from the DI water. Dry off the sonde's guard and sensors and shake off any excess water.
4. Rinse the guard and sensors with the 124 FNU rinse bottle and then place the sonde in the 124 FNU standard. Be careful not to agitate the standard.
5. In the "LIVE DATA" tab, press the "Start Wiping" button to wipe the sensors. Check that the wiper parks correctly in the garage.
6. Record 124 under the Standard column and the value for turbidity (FNU) in standard under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

Specific Conductance

1. Remove the sonde from the 124 FNU turbidity standard and rinse the guard and sensors with DI water.
2. Remove the calibration guard and wiper to prevent contamination of the remaining standards.
3. Dry off the sonde's sensors and shake off any excess water.

4. Rinse the sensors with the specific conductance (6668 µS/cm) rinse bottle. Then place the sonde in the specific conductance (6668 µS/cm) standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

5. Record 6668 under the Standard column and the value for specific conductance (µS/cm) in standard under the Reading column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

pH

1. Remove the sonde from the specific conductance standard and rinse the sensors with DI water.
2. Dry off the sonde's sensors and shake off any excess water.
3. Rinse the sensors with the pH 7 rinse bottle. Then place the sonde in the pH 7 standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

4. The pH standard value needs to be adjusted to the temperature of the solution, which is 7.02 for room temperature. Record this value under the Standard column for pH 7.
5. Record the value for pH and pH mV under the Reading and Additional Info columns on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.
6. Remove the sonde from the pH 7 standard and rinse the sensors with DI water.
7. Dry off the sonde and shake off any excess water.
8. Rinse the sensors with the pH 10 rinse bottle. Then place the sonde in the pH 10 standard.

   *Note: A laboratory stand is useful to hold up the sonde since a guard is not used.

9. The pH standard value needs to be adjusted to the temperature of the solution, which is 10.05 for room temperature. Record this value under the Standard column for pH 10.
10. Record the value for pH and pH mV under the Reading and Additional Info columns on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.
11. The Post-Measurement Calibration Check form will auto-populate the Delta Slope. Ensure that this value is within the recommended range.

*Note: If the Delta Slope is outside of the recommended range, the pH module needs replacing.

Dissolved Oxygen

1. Remove the sonde from the pH 10 standard and rinse the sensors with DI water.
2. Install the field wiper and field guard and place the sonde in the 100% air saturated bucket for at least 5 minutes.
3. In the "LIVE DATA" tab, record the DO (% Sat) and DO (mg/L) values under the Reading column and the Temperature (°C) from the sonde in the bucket on the Post-Measurement Calibration Check form.
4. Record the local Barometer reading from a YSI handheld.
5. Calculate the DO (% Sat) and the DO (mg/L) standard values by using the Dissolved Oxygen Solubility Tool (located on the Shared Drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Resources). Record these values under the Standard column on the Post-Measurement Calibration Check form. The difference between the Standard value and the Reading will auto-populate in the Deviation column.

   *Note: It is not necessary to enter in the specific conductance value when calculating the standard values in the Dissolved Oxygen Solubility Tool. You can also find the DO (% Sat) standard value by dividing the Barometer reading by 7.6.
6. Go to the "HOME" tab and disconnect the sonde from Kor. Remove the adaptor or turn off the Bluetooth (whichever was used). Place the sonde back in its original calibration cup with ½ inch of tap water and store upright in the calibration lab until the next use.

Archiving

Sonde calibration forms get archived in record binders and saved to the shared drive.

1. Save the completed Post-Measurement Calibration Check form to the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Calibration Sheets\Saved Calibration Sheets.
2. Print off the completed form and make a black and white copy of it. Place the copy in the plastic sleeve to be stored with the sonde.
3. Place the original Post-Measurement Calibration Check form inside the EXO Calibration Sheets binder and file it according to sonde ID.

Sonde Rating

After completion of each post-measurement calibration check, the sonde readings are rated based on criteria developed by the USGS (see **Table 4**). These ratings are used to assess the validity of the data that was collected in the field.

1. Open the current sonde rating file found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Sonde Documentation\Sonde Rating Sheets.

   *Note: If this is the first sonde rating for the month, open up the most recent file and save it as a new file with the current month (Ex. 04_April Sonde Ratings).

2. Make a copy of the Template tab and name the new tab based on the run the sonde was used for (and the sonde's position, if more than one sonde was used on the run).
3. Fill out the information at the top of the worksheet, which includes the sonde ID, information about the run the sonde was used on, and information about the post-measurement calibration check.
4. Use the information on the Post-Measurement Calibration Check form to fill in the boxes under "Post-Deployment". The error boxes will automatically calculate, and a rating will be generated based on those calculations.
5. If ratings fall into the Fair or Poor range for any parameter, the data collected by that sonde needs to be flagged in the database and the probe should be investigated for any issues.

Table 4-Acceptance Criteria for Sonde Rating

	Excellent	Good	Fair	Poor	Max Limit
Water Temperature °C	≤±0.2	±0.2-0.5	±0.5-0.8	>±0.8-2.0	>±2.0
Spec. Conductance µS/cm	≤±3%	±3-10%	±10-15%	>±15-30%	>±30%
Dissolved Oxygen mg/L	≤±0.3 or ≤±5%	±0.3-0.5 or ±5-10%	±0.5-0.8 or ±10-15%	>±0.8/2.0 or >±15-20%	>±2.0 or >±20%
pH	≤±0.2	±0.2-0.5	±0.5-0.8	>±0.8-2.0	>±2.0
Turbidity FNU	≤±0.5 or ≤±5%	±0.5-1.0 or ±5-10%	±1.0-1.5 or ±10-15%	>±1.5-3.0 or >±15-30%	>±3.0 or >±30%

Enter Field Data

Following each sampling day, the field data collected needs to be entered into the FLIMS database before the samples are submitted to the lab. See Appendix O for **FLIMS Data Entry Best Practices**.

1. Go to the main menu in FLIMS and click "Runs and Field Data".
2. Select the sampling day for which you would like to enter field data and click "Edit Run".
3. Highlight the first station in the Collection Events box in the top left corner. Enter in the correct collection time under Sample Collection Date and Time and make sure the collection date is accurate.
4. Use the field data sheet to fill in all data entry fields for that station. This includes the surface and bottom sonde measurements for the parameters listed in **Table 5**, secchi reading, weather information, MC score, field notes (if any), and chlorophyll volume (determined from surface turbidity value).

   *Note: Only the collection times and chlorophyll volumes are entered for the blanks and duplicates. GPS coordinates only need to be entered for EZ stations.

5. Repeat the previous two steps for the remaining stations listed in the Collection Events box.

Table 5-Field Parameters and Accuracy Ranges for YSI EXO Sensors

Parameter	Units	Sensor	Model Number	Accuracy
Water Temperature	˚C	Conductivity/Temperature	599870	±0.01 ˚C
Specific Conductance	µS/cm	Conductivity/Temperature	599870	±0.5% of reading or 0.001 mS/cm
pH	pH units	pH and pH module	599701	±0.1 within 10 ˚C of calibration temp
Dissolved Oxygen	mg/L and % Saturation	Optical DO	599100-01	±1% or 0.1 mg/L

Turbidity	FNU	Turbidity	599101-01	±2% or 0.3 FNU
Chlorophyll	µg/L and RFU	Total Algae	599759-01	n/a
Depth	feet	N/A	N/A	± 0.04%

Chain of Custody

COC forms need to be printed out and accompany the samples when taken into Bryte lab for submission.

1. Go to the main menu in FLIMS and click "Paperwork".
2. Select the sampling day for which you would like to print off the COC. Make sure it says "Yes" on the left-hand column next to the run name, then print all pages except the first page.

   *Note: The first page of all COCs should have already been printed and the phytoplankton bottles should have been removed from the COC in the **FLIMS** section.

3. On the first page of the COC, fill out the first "Received By" section (if you did not collect the samples) and the second "Relinquished By" section with your information.
4. Go through the "Checklist for Sample Submittal to Bryte" and initial each line as it is confirmed correct. This will include writing down the lot numbers for all acidified containers and indicating whether samples were processed on site or at a later time.
5. Write in the date and time samples were filtered at the bottom of the "Container Summary" box and initial to confirm the total container count.

   *Note: If samples were filtered immediately after collection, write in "Same as collection date and time".

Sample Submission

Samples from each sampling event are submitted to Bryte lab (with the exception of phytoplankton) typically the day after they are collected. See **Navigation** (Appendix G) for driving directions to Bryte Lab.

1. Using the **Chain of Custody** as a guide, pack up all necessary samples from the refrigerator and freezer in the downstairs lab into a blue cooler.
2. Cover the samples with ice from the ice maker in the warehouse to keep the temperatures from rising.
3. Transport the samples with the corresponding COC to Bryte lab and place all samples on the counter at the receiving desk in order of lab IDs and grouped by station.

   *Note: See Sid Fong or Allan Wong to get a Bryte lab staff member to check in the samples.

4. After the samples have been processed, the receiving department will email a copy of the COC, which is to be saved on the shared drive located here: S:\M & A BRANCH\Discrete EMP\Water Quality\Lab COCs.

    * Bryte Chemical Laboratory
      Department of Water Resources
      1450 Riverbank Road
      West Sacramento, CA 95605
      Phone: (916) 375-6008
      Contact: Sid Fong

Van Run CDEC Verification

The accuracy of the sonde readings collected on the Van Run needs to be verified with the corresponding continuous station readings on CDEC. These CDEC station IDs are SRH for C3A Hood, SJR for C10A Vernalis, and ORI for C9. Blank Van Run CDEC Verification forms can be found on the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Blank Field Data Sheets\E-Forms.

1. Fill in the Sonde ID, Field Crew, and collection date for the Van Run on the CDEC Verification form.
2. Copy the collection time and surface sonde readings from the Van Run field data sheet for each station.
3. Write in the non-PST time for each CDEC station.
4. Go to cdec.water.ca.gov and hover over "Query Tools" at the top of the page. Then click "Real Time Data".
5. Enter in the station ID (either SRH, ORI, or SJR) and click "Get Data".
6. Locate the desired time stamp that corresponds to the Van Run sampling time. Use the "Earlier" button to get past data.
7. Copy the corresponding line of surface sonde readings onto the CDEC Verification form for that station.

    *Note: Be sure to record the water temperature, not the air temperature. Water temperature values taken from CDEC need to be converted from Fahrenheit to Celsius.

8. Compare the Van Run sonde readings with the CDEC readings to ensure they are within range of each other and document any large discrepancies in the "Notes" section.
9. Save the CDEC Verification form to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets and enter the month and year in the file name (e.g., Van Run CDEC Verification_Jul22).

Compile and Print Field Data Sheets

After completion of the monthly water quality field run, the electronic field data sheets need to be compiled and archived. Field data sheets should be checked for errors or missing data prior to printing.

1. In Adobe Acrobat, combine the electronic field data sheets in the following run order:

    -Van Run
    -Mid Delta Day 1
    -Mid Delta Day 2
    -Sacramento River
    -Suisun Bay
    -Grizzly Bay
    -San Pablo Bay

2. Name the file according to month and year followed by "Field Data Sheets" (ex. February 2020 Field Data Sheets) and save it to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

    *Note: You will need to flatten the Van Run data sheet before combining them. To do this, go to "Print" and then click "Adobe PDF" and save it as a new file.

3. In Adobe Acrobat, combine the Dissolved Oxygen Calibration Check forms with the Van Run CDEC Verification form. Name the file according to month and year followed by "QA Data Sheets" (ex. February 2020 QA Data Sheets) and save it to the shared drive here: S:\M & A BRANCH\Discrete EMP\Water Quality\Archived Field Data Sheets.

    *Note: You will need to flatten the data sheets before combining them.

4. Save the Crew Lead Report as a separate pdf and save the file to the same folder on the shared drive as the rest of the data sheets for that month. Use the month and year to name the file (ex. February 2020 Crew Lead Report).

5. Print off all data sheets for the month (field data sheets, QA data sheets, and Crew Lead Report). Three hole punch the stack of field data sheets and place them in the water quality data binder for the appropriate year and month.

Zooplankton Monitoring

ZOOPLANKTON MONITORING STATIONS

The Discrete EMP unit monitors the zooplankton abundance monthly at 19-24 stations in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay (**Table 6**, **Figure 4**). These stations overlap with the **Discrete Water Quality Monitoring** stations and are sampled over the course of six days. See Appendix E for **Field Safety**, Appendix F for **Job Hazard Analysis**, Appendix G for **Navigation** to the Antioch and Benicia marinas, and Appendix M for the **Zooplankton Scientific Collecting Permit**.

Table 6-Zooplankton Monitoring Station Locations and Descriptions

Station Name	Location	Region	Habitat Type	Accessed By
EZ2	Entrapment Zone - Location determined when bottom SpC values occur at approx. 2,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ2-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ2	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6	Entrapment Zone - Location determined when bottom SpC values occur at approx. 6,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
EZ6-SJR	Entrapment Zone in the San Joaquin River – Location determined similarly to EZ6	n/a	Estuarine Channel (Brackish Water)	Vessel
NZ002	Carquinez Strait at Glen Cove Harbor- tow conducted when surface SpC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ004	Carquinez Straight 46-91 m off Ozol Pier- tow conducted when surface SpC values occur below 20,000 µS	Carquinez Strait	Estuarine Channel (Brackish Water)	Vessel
NZ028	Grizzly Bay SE of Dolphin near Suisun Slough	Suisun Bay	Estuarine Embayment (Brackish Water)	Vessel
NZ032	Montezuma Slough, 2nd bend from mouth	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel
NZ048	Suisun Bay channel off Middle Point	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
NZ054	Sacramento River at mouth of Mallard Slough near Chipps Island	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
NZ060	Sacramento River above Point Sacramento	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel

NZ064	Sacramento River at Emmaton	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
NZ068	Sacramento River at US Coast Guard Station	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
NZ074	San Joaquin River at Antioch Ship Channel	Western Delta	Tidal River Channel (Brackish Water)	Vessel
NZ086	San Joaquin River at Potato Point	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
NZ092	San Joaquin River at Buckly Cove	Southern Delta	Tidal River Channel (Freshwater)	Vessel
NZ325	San Pablo Bay near Light 15- tow conducted when surface SpC values occur below 20,000 µS	San Pablo Bay	Estuarine Channel (Brackish Water)	Vessel
NZ41A	San Pablo Bay near Mouth of Petaluma River	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
NZD06	Suisun Bay at Bulls Head Point near Martinez	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
NZD16	San Joaquin River at Twitchell Island	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
NZD28	Old River near Rancho Del Oro, south end of Holland Tract	Central Delta	Tidal River Channel (Freshwater)	Vessel
NZD41	San Pablo Bay near Pinole Point	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
NZEZ2	Entrapment Zone- Location determined when bottom SpC values occur at approx. 2,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
NZEZ6	Entrapment Zone- Location determined when bottom SpC values occur at approx. 6,000 µS	n/a	Estuarine Channel (Brackish Water)	Vessel
NZM10	Disappointment Slough near Bishop Cut	Eastern Delta	Tidal River Channel (Freshwater)	Vessel
NZS42	Suisun Slough at mouth of Volanti Slough	Suisun Marsh	Tidal Marsh Channel (Brackish Water)	Vessel

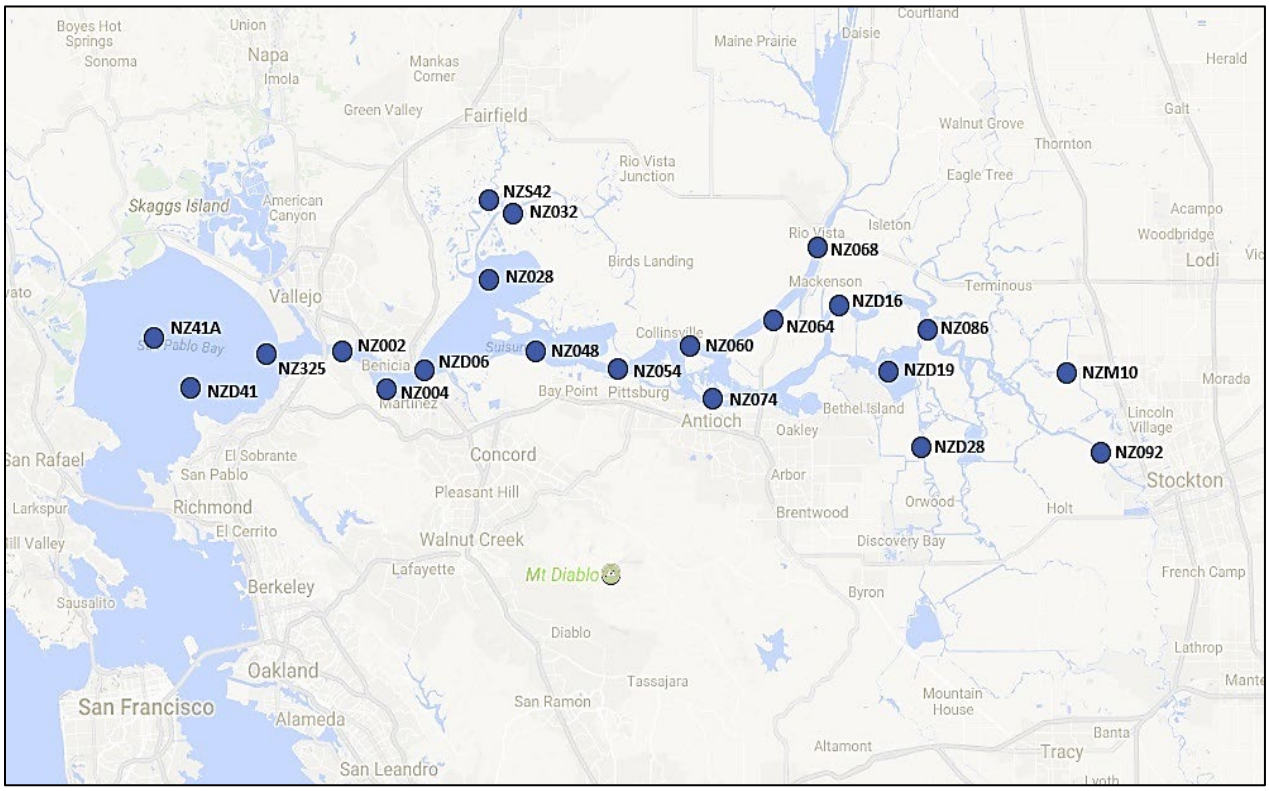


Figure 4-Map of Zooplankton Monitoring Stations

PRE-SAMPLING PREPARATION

Loading Equipment

Most equipment used for zooplankton monitoring is kept in the lockup in Antioch. CDFW prepares the sampling jars and drops them off prior to the monthly water quality field run in the lockup directly behind the equipment lockup. Before departing the marina, make sure all items on the **Field Equipment Checklist** are located on the vessel.

Field Data Sheets/Labels

On the first day of the monthly water quality field run, print out the field data sheets on waterproof paper located on the shared drive here: S:\M & A BRANCH\Discrete EMP\Zooplankton\Blank Field Sheets (and also in the "Field Data Sheets" folder on the desktop of the RV Sentinel computer). The labels for the sample containers are also located in the same folder. Update the date on the labels for the current month and print them out on waterproof paper.

Field Equipment Checklist

- ☐ Tow Sled
    - Clarke-Bumpus Net
    - Mysid Net
    - Flow Meters (2)
- ☐ Line for Zooplankton Tow
- ☐ Bucket for Rinsing
- ☐ Rotifer Net
- ☐ Pump Tank
- ☐ Pump with Hose
- ☐ Sample Jars with Formalin (4 tubs)
- ☐ Rotifer Sample Bottles (1 tub)
- ☐ Formalin Squirt Bottle
- ☐ Extra Formalin Bottles
- ☐ Field Data Sheets
- ☐ Clipboard
- ☐ Zooplankton Tow Schedule
- ☐ Rotifer Pump Schedule
- ☐ Timer
- ☐ Secchi Disk
- ☐ Box of Sampling Supplies
- ☐ Writing Utensil
- ☐ Standard Operating Procedures
- ☐ Drinking Water
- ☐ Identification Guide
- ☐ Scientific Collection Permit (CDFW)

SAMPLING PROCEDURES

Field Data Collection

1. Upon arriving to a station, record the date and station number.

   *Note: "Survey" at the top refers to the month.

2. Take the Secchi reading (performed the same as **Secchi Disk Reading** under **Discrete Water Quality Monitoring**) and record the value.
3. Record the starting flow meter readings on both the Clarke-Bumpus and mysid nets before starting the **Zooplankton Tow**.
4. While the **Zooplankton Tow** is being performed, record the "Time" from the boat in PST.

   *Note: The time for the station is exactly when the timer is started.

5. Once the tow is completed, record the "Tow Duration" (in minutes) on the data sheet.
6. After the sample has been collected from the **Rotifer Pump**, record the "Pump Volume" on the field data sheet.

Sample Collection

Zooplankton Tow

A ten-minute oblique tow is conducted using a tow sled that holds two types of nets. The smaller net located on top is a 160-micron mesh Clarke-Bumpus net that targets adult and juvenile copepods and cladocerans. The larger net located on bottom is a 500-micron mesh mysid net. The zooplankton tow is typically started after the vertical sonde readings have been recorded upon arriving to a station. The target time for the zooplankton tow is ten minutes and the target angle (warp angle) for the line is 65˚ ±2°. If there is a lot of algae or vegetation present at a station, the tow time can be decreased as necessary.

1. On the first day of the monthly water quality field run, use a fine-tipped squirt bottle to fill up the flow meters on the tow sled with DI water.

   *Note: The flow meter on the Clarke-Bumpus net can be completely removed with a flathead screwdriver. The flow meter on the mysid net stays attached.

2. Before starting the tow, make sure the cod end of the Clarke-Bumpus net is hanging on the outside of the tow sled and the cod end of the mysid net is hanging in the middle of the tow sled.
3. Check the depth reading for the station and use the zooplankton tow schedule to determine the starting length measurement under the "Warp Out" column.

*Note: For shallow stations (D7, and D41A), a horizontal tow can be conducted so that the tow sled remains at a constant depth for the entire ten minutes.

4. Get the boat captain's approval, then use the crane controls to carefully lower the tow sled into the water, while making sure to swing out the crane enough to clear the boat.
5. Using the ten-foot line markers, lower the tow sled to the appropriate depth and then immediately start the timer (ten minutes). Record the time (in PST) on the data sheet.
6. Follow the zooplankton tow schedule so that the tow sled gets raised in ten feet increments at each time listed next to the appropriate depth range.
7. When there are 30 seconds remaining, raise the tow sled to where the bridle shackle is just above the surface.

   *Note: At the 30 second mark, give notice to the individual responsible for **Sonde Measurements** under **Discrete Water Quality Monitoring** so they can assist in bringing the tow sled up onto the back deck of the vessel.
8. Once the timer goes off, raise the tow sled up and out of the water while making sure to swing out the crane enough the clear the boat.
9. While the tow sled is still raised over the side of the boat, use a hose to rinse down the sides of the mesh on both nets so that the sample contents get rinsed into the cod ends.
10. Use the crane controls to lower the tow sled onto the back deck.
11. Record the ending flow meter reading on the field data sheet.

    *Note: Place a zero in the first space of the ending flow meter reading. If the flow meter reset to zero during the tow, put a "1" in the first space before the reading. This will account for the reset during the calculation.

Rotifer Pump

After the zooplankton tow has been performed, a pump is used to sample the vertical water column and sample contents are collected into a 35-micron mesh rotifer net. This method targets adult and juvenile cyclopoid copepods, copepod nauplii, and rotifers. The pumping starts at the bottom of the water column, is brought up to the surface, and then lowered back down to the bottom. The target volume for the total amount of water pumped is 19.8 gallons.

1. Place the rotifer net inside the PVC part of the tank.

2. Place the output end of the pump hose over the side of the boat and the input end into the water. Turn on the pump to allow any remaining water in the hose to be pumped out until you hear the air bubble being removed from the hose.
3. Check the rotifer pump schedule to determine the starting depth for the appropriate depth range for the station.
4. Use the tape marks on the hose to lower the pump to the starting depth.

   *Note: The red lines on the pump hose are placed every three feet while the yellow lines are placed every ten feet.

5. Hold down the button on the flow meter until it resets to zero, then immediately place the output end of the hose into the net opening.
6. Follow the rotifer pump schedule by raising or lowering the hose in 3-foot increments at each of the listed volumes for the appropriate depth range.

   *Note: The hose is raised for the volumes to the left of the vertical line on the rotifer pump schedule. The hose is lowered for those to the right of the vertical line. The volume value directly to the left of the vertical line indicates the top of the water column and is sampled twice.

7. Once 19.8 gallons (final volume) has been pumped, take the output end of the hose out of the rotifer net and place it over the side of the boat.
8. Bring up the hose until it is only about a foot below the surface. Turn off the pump and bring the hose back up onto the boat.

   *Note: Use caution as to not hit the hull of the boat when bringing the weighted end of the hose close to the surface.

9. Record the total volume pumped on the field data sheet.

Rinsing

Once the samples have been collected into the three nets, the contents are transferred into the appropriate containers for collection. The samples are preserved in a 10% formalin solution containing Rose Bengal dye. When rinsing down a net, do not let the water go over the top and into the net. Rather, rinse from the sides of the mesh.

Clarke-Bumpus Net

1. Obtain the glass jar labeled "CB" containing preservative for the appropriate station.
2. Take the Clarke-Bumpus (smaller) net and rinse down the sides of the mesh so that the sample contents fall into the collection bottle at the cod end.

3. Unscrew the collection bottle from the net (making sure the bottle is not completely full) and dump the contents into the glass "CB" jar. Screw the collection bottle back onto the net.
4. Repeat the previous two steps two more times so that the net gets rinsed down a total of three times. Be cautious not to fill the glass jar higher than the line.
5. After the third rinse, dunk the bottom half of the collection bottle into a bucket filled with water from the same station so that any material remaining on the mesh gets rinsed off. Then pour the contents into the glass jar. Continue to use this method if more water is needed in the sample jar to reach a ~10% formalin mixture.
6. Place the appropriate label for that station into the jar and secure the lid tightly. Then place the jar back into the storage container.

Mysid Net

1. Obtain the glass jar labeled "M" containing preservative for the appropriate station.
2. Take the mysid (larger) net and rinse down the sides of the mesh so that the sample contents fall into the collection bottle at the cod end.
3. Unscrew the collection bottle from the net and pour the contents into the glass "M" jar (orient the bottle so that the mesh is facing upward). Screw the collection bottle back onto the net.
4. Repeat the previous two steps two more times so that the net gets rinsed down a total of three times. Be cautious not to fill the glass jar higher than the line.
5. After the third rinse, dunk the bottom half of the collection bottle into a bucket filled with water from the same station so that any material remaining on the mesh gets rinsed off. Then pour the contents into the glass jar. Continue to use this method if more water is needed in the sample jar to reach a ~10% formalin mixture.
7. Place the appropriate label for that station into the jar and secure the lid tightly. Then place the jar back into the storage container.

Rotifer Net

1. Remove the rotifer net from the tank and rinse down the sides of the mesh so that the sample contents fall into the collection bottle at the cod end.
2. If extra rinsing is needed, pour some of the water in the cod end back out, allowing it to drain through the net mesh. Then rinse the sample back down into the collection bottle.

*Note: Do not fill the bottle completely, as formalin will need to be added to the sample.

3. Open the tub containing the rotifer sample bottles and remove the empty bottle for that station (labeled on cap) from its spot. Unscrew the cap and place both off to the side.
4. Carefully unscrew the collection bottle (containing the sample) from the net and place into the spot of the bottle that was just removed.
5. Use the squirt bottle to add enough formalin to the collected sample so that it creates a 10% formalin solution.
6. Place the appropriate label into the bottle. Then take the labeled cap that was removed from the empty bottle and tightly secure it onto the bottle now containing the preserved sample.
7. Take the empty bottle that was removed from the tub and screw it onto the rotifer net to be used for the next station.

POST-RUN PROCEDURES

Unloading Equipment

After completing the final day of the monthly water quality field run, transport all zooplankton monitoring equipment on the **Field Equipment Checklist** back into their original locations. Place the completed field data sheets and storage tubs containing the samples in the lockup to be picked up by CDFW.

Benthic Monitoring

BENTHIC MONITORING STATIONS

The Discrete EMP unit monitors the benthic communities and sediment composition at ten monitoring stations in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay (**Table 7**, **Figure 5**). These stations are accessed by research vessel and are sampled over the course of two days split up by region between bay sites and Delta sites. A Boston Whaler is used to sample 2-3 of the farther sites, which are then transported to the larger vessel for processing. See Appendix E for **Field Safety**, Appendix F for **Job Hazard Analysis**, Appendix G for **Navigation** to the Antioch marina, and Appendix N for the **Benthic Scientific Collecting Permit**.

Table 7-Benthic Monitoring Station Locations and Descriptions

Station Name	Location	Region	Habitat Type	Accessed By
C9	Old River upstream of Clifton Court Forebay Intake (left)	Southern Delta	Tidal River Channel (Freshwater)	Whaler
D16	San Joaquin River at Bradford Island (left)	Lower San Joaquin	Tidal River Channel (Freshwater)	Vessel
D24	Sacramento River downstream of Rio Vista Bridge (left)	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D28A	Old River upstream of Rock Slough (left)	Central Delta	Tidal River Channel (Freshwater)	Vessel or Whaler
D4	Sacramento River at Sherman Island Upstream of Point Sacramento (left)	Lower Sacramento	Tidal River Channel (Freshwater)	Vessel
D41	San Pablo Bay near Pinole Point (center)	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
D41A	San Pablo Bay near Pinole Point- north central (center)	San Pablo Bay	Estuarine Shoal (Brackish Water)	Vessel
D6	Suisun Bay upstream of I-680 bridge (right)	Suisun Bay	Estuarine Channel (Brackish Water)	Vessel
D7	Grizzly Bay at Dolphin near Suisun Slough (center)	Suisun Bay	Estuarine Embayment (Brackish Water)	Vessel
P8	San Joaquin River at Buckley Cove (right)	Southern Delta	Tidal River Channel (Freshwater)	Whaler

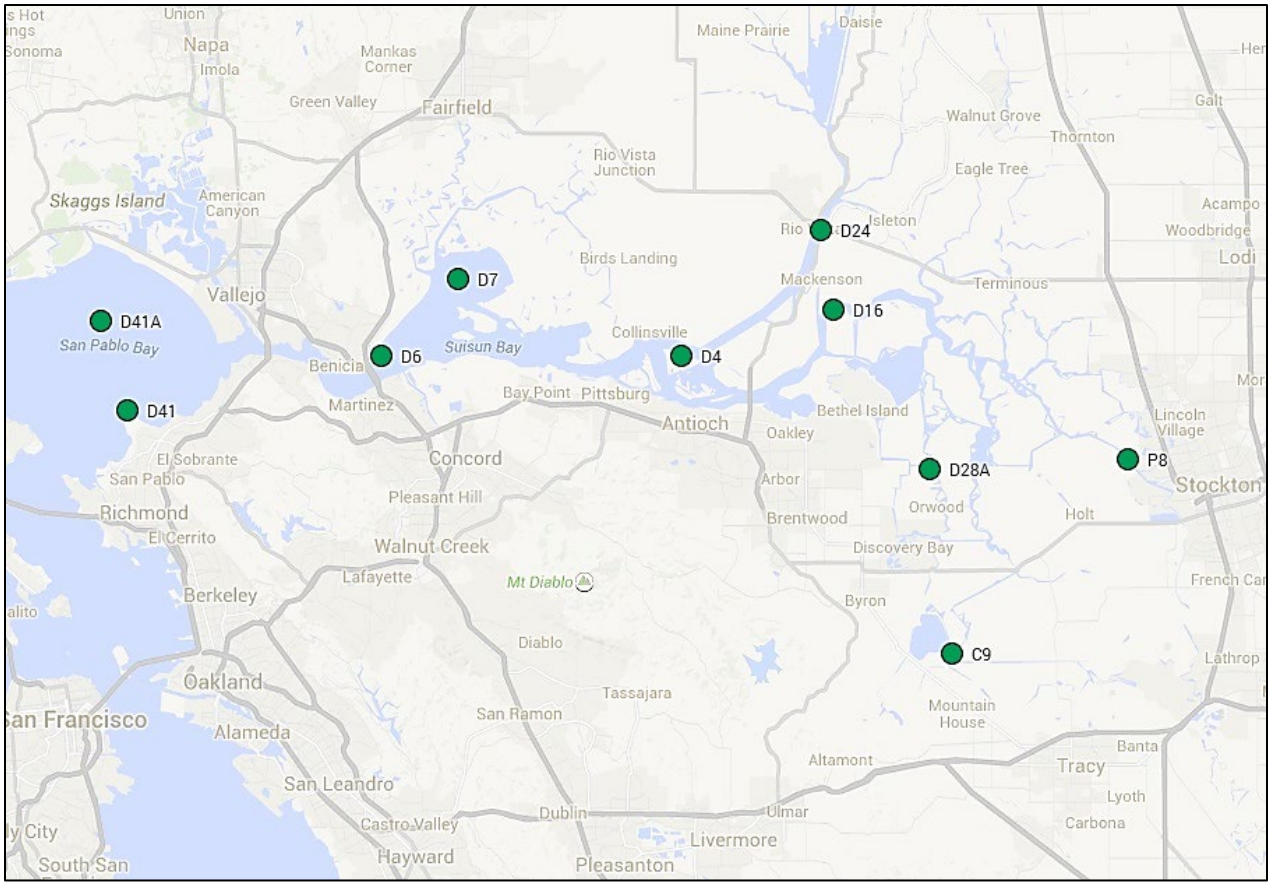


Figure 5-Map of Benthic Monitoring Stations

PRE-SAMPLING PREPARATION

Pre-Weigh Foil Boats

All *Corbicula fluminea* and *Potamocorbula amurensis* picked in the live sort samples are sorted and weighed in small round foil boats. The boats are typically weighed one to two days prior to the monthly benthic run so that the weight of the empty boat can be logged before the clams are distributed into each boat and then subtracted from the final calculation to determine biomass.

1. If the scale is powered off, press the red power button on the bottom far left and let it warm up for 15-30 minutes. If at any point when nothing is on the scale and it displays any number besides zero, click "TARE" to zero it.

    *Note: If the bubble at the back of the scale on the right-hand side is not contained in the circle, adjust the scale using the round feet on the bottom. Then press the CAL button to calibrate.

2. Obtain the appropriate amount of un-weighed trays of regular and plus size boats from the left side of the cabinet above the biomass computer in the downstairs lab.

    *Note: To estimate how many trays of boats to pre-weigh, open the live sort data file from same month of the previous year to see how many trays were used (underlined rows indicate the end of a tray). This will typically be an indicator of how many trays are necessary for that particular month.

3. Open the "Sartorius Scale Input" software and the "MASTER Live Sort" excel spreadsheet template (found on the desktop of the biomass computer) and "Save As" to the desktop with the appropriate year, month, and "Live Sort" in the title (ex. 2015 June Live Sort).
4. Before weighing the boats, use the calibration log book and weigh the 1, 5, and 50 gram weights (located in the top cabinet to the left of the analytical scale). This will verify and document that the scale is working efficiently.
5. For each tray of boats to be pre-weighed, enter in the appropriate boat numbers on the left hand column of the spreadsheet in the same order as they appear from left to right in the tray.

    *Note: Place a bottom border underneath the row of the last boat number in that tray.

6. Select the cell for the first boat number of the tray under the "Pan Weight" column. Using large forceps, place the corresponding boat inside the clear doors of the analytical scale.
7. Once the weight reading equilibrates, click the button resembling an underlined disc on the bottom far right of the scale to automatically enter the reading on the spreadsheet. Check to make sure the reading transferred to the appropriate cell.
8. Repeat this process for each boat of every tray being used for that month. Attach a sticky note to each pre-weighed tray to indicate that it has been pre-weighed and include the range of boat numbers in that tray, the date it was pre-weighed, and your initials.
9. Put all pre-weighed trays on the right side of the cabinet above the biomass computer to separate from those trays that have not been pre-weighed.

Mixing Formalin

There are two 20-liter jugs that contain the formalin for sample preservation. One holds a solution with 10% formalin and the other holds a solution with 20% formalin. These jugs are kept in the storage lockup in Antioch and the solutions are typically mixed on the morning of the first day of the benthic run. Gloves and goggles are to be worn when handling the chemicals and the procedure must be performed in a ventilated area. When

transporting the formalin jugs, ensure that the caps are secured tightly. The 20% formalin solution is used to preserve those samples that have a lot of organic matter in them, while the 10% formalin solution is used for all other samples.

Table 8-Conversions for Mixing Formalin

10% Formalin Solution		20% Formalin Solution	
Total amount to be made	**Amount of formalin to add**	**Total amount to be made**	**Amount of formalin to add**
4 L	0.4 L	4 L	0.8 L
5 L	0.5 L	5 L	1.0 L
6 L	0.6 L	6 L	1.2 L
7 L	0.7 L	7 L	1.4 L
8 L	0.8 L	8 L	1.6 L
9 L	0.9 L	9 L	1.8 L
10 L	1.0 L	10 L	2.0 L
11 L	1.1 L	11 L	2.2 L
12 L	1.2 L	12 L	2.4 L
13 L	1.3 L	13 L	2.6 L
14 L	1.4 L	14 L	2.8 L
15 L	1.5 L	15 L	3.0 L
16 L	1.6 L	16 L	3.2 L
17 L	1.7 L	17 L	3.4 L
18 L	1.8 L	18 L	3.6 L
19 L	1.9 L	19 L	3.8 L
20 L	2.0 L	20 L	4.0 L

10% Formalin

1. Obtain the 10% formalin jug and determine how much solution (in liters) is needed to reach the "Fill Line". Divide that number by ten to determine how much formalin to add to the jug (**Table 8**).
2. Add one heaping round scoop of Rose Bengal.
3. Add two heaping round scoops of the sodium borate buffer.
4. Fill the jug with enough water to reach the "Fill Line".

20% Formalin

1. Obtain the 20% formalin jug and determine how much solution (in liters) is needed to reach the "Fill Line". Divide that number by five to determine how much formalin to add to the jug (**Table 8**).

2. Add two heaping round scoops of Rose Bengal (less if there is less than 10 L of formalin to be made).
3. Add two heaping round scoops of the sodium borate buffer.
4. Fill the jug with enough water to reach the "Fill Line".

Loading Equipment

All equipment is kept in the storage lockups in Antioch and is transported onto the boat on the morning of the first day of the benthic run. Before departing the marina, make sure all items on the **Field Equipment Checklist** is on the appropriate boat.

Taping/Labeling Bottles

Bottles are typically taped before arriving at the first station with blue painter's tape.

1. Place a piece of tape about two to three inches long on both the lid and side of all bottles that have been loaded on the vessel.
2. Label both pieces of tape on seven medium sized bottles with each station name (excluding P8, C9, and D28A, which will be collected by the Whaler crew) and "Live Sort" along with the dates those stations will be sampled.
3. Label the sediment bottles with the station name designating a bottle for all stations except P8 and C9.

Field Equipment Checklist

Research Vessel

- ☐ YSI EXO2 Sonde
- ☐ Ponar
- ☐ Tubs (12-16)
- ☐ Lids for Tubs (12+)
- ☐ 20 L Formalin Jugs (10% and 20%, full)
- ☐ Bottles (3 crates of small 1 L, two crates of medium 2 L, one crate of large 4L)
- ☐ 500 mL Sediment Bottles (10)
- ☐ Nets (4)
- ☐ Strainer Lids (small and large)
- ☐ Brush for Sieve
- ☐ Squirt Bottles (2)
- ☐ Yellow Scraper
- ☐ Sharpie
- ☐ Blue Painters Tape
- ☐ Gloves
- ☐ Safety Goggles
- ☐ Foul Weather Gear
- ☐ PFD
- ☐ Coolers for Live Sort Samples (2)
- ☐ Drinking Water
- ☐ Safety Binder
- ☐ Scientific Collection Permit (CDFW)
- ☐ Identification Guide

Boston Whaler

- ☐ Ponar with Line
- ☐ Tubs (3 deep, 2-3 regular)
- ☐ Nets (15+)
- ☐ Live Sort Bottles (3+)
- ☐ Sediment Bottles (3+)
- ☐ Sharpie
- ☐ Writing Utensil
- ☐ Blue Painters Tape
- ☐ Paper for Sediment Description

SAMPLING PROCEDURES

Field Data Collection

Field measurements are taken at each monitoring station from an EXO2 sonde located in a flow-through chamber on the research vessel that pulls water from a depth of one meter. Field data is obtained from the horizontal EXO2 sonde and GPS using the MOPED application.

1. At the beginning of each sampling day, setup the horizontal sonde and the MOPED application by following the procedures outlined in the **Setup** section under **Sampling by Vessel** for **Discrete Water Quality Monitoring**.

   *Note: Only the horizontal sonde and the GPS are used for benthic monitoring. Disregard those instructions involving the vertical sonde. In the "Cruise Info" tab, select "Benthic" under Purpose.

2. Upon arriving to each station, select the appropriate station name in the dropdown menu in the Horizontal Profile tab.
3. When the incoming data is stable, click "Data Snapshot" in the Horizontal Tab to copy the data over to the Data Entry tab.
4. In the Data Entry tab, check to make sure the readings from the horizontal sonde transferred correctly and enter the collection time (in PST).
5. In the Data Entry tab, click "Check GPS" to obtain the depth reading, enter in the weather observations, and document the sediment composition and organisms observed in the Field Notes section (ex. 75% soft gray clay on bottom and 25% light brown silt on top with a moderate amount of live *Potamocorbula* and amphipods). Then click "Save".
6. At the end of the day, follow the procedures outlined in **Saving Sonde Data and MOPED Shutdown** to save the field data sheet and close the application. The MOPED file does not need to be saved.
7. Put away the horizontal sonde according to the information in **EXO2 Sonde Cleanup**.

Sample Collection

Six samples are obtained at each site using a hydraulic winch and a ponar dredge to collect a sediment "grab". Four of the six grabs are rinsed in a 595-micron sieve, preserved with formalin, and sent to the Hydrozoology lab for taxonomic classification and quantification of benthic macroinvertebrates. One of the six samples is used for live sort where it is rinsed in the sieve and brought back to the EMP lab in which *Corbicula* and *Potamocorbula* are picked and sorted into individual size classes to determine biomass. Five hundred mL of

the final grab is collected into a sediment bottle and sent to Bryte lab to determine sediment composition.

Operating the Hydraulic Winch

The person responsible for operating the winch needs to wait until the boat captain has given permission to turn on the hydraulics when it is safe to deploy the equipment. Extreme caution should be taken on days of inclement weather conditions. Always use the winch controls to slowly maneuver the ponar when near the boat.

1. When approval is given from the boat captain and the field crew is ready, turn on the hydraulics. Use the winch controls to raise the ponar off the stand and up over the side of the boat and into the water about three feet away from the boat.
2. When the ponar is over the side, the individual operating the ponar will place a tub on the stand to hold the sample.
3. Keep lowering the ponar down towards the bottom until you see slack in the line when it hits the substrate. Raise the ponar up out of the water and carefully bring it back above the stand and lower it into the tub.

   *Note: Once the ponar is in the tub, feed more slack into the line to allow the ponar operator to open it completely.

4. The ponar operator will then open the ponar, latch it to keep from closing, and then hold the line to create tension.
5. At this point, use the winch controls to raise the ponar clear of the sample but still keeping the lower portion of it inside the tub.

   *Note: Avoid raising the ponar completely over the tub so that the sample will not miss the tub when it gets rinsed out.

6. Wait for the ponar operator to rinse the sample out of the ponar, then raise it up over the side to obtain another grab by repeating the previous steps.
7. Keep repeating this procedure until six samples have been collected.
8. Once the sixth sample has been rinsed into the tub and the tub is off the stand, carefully lower the ponar back onto the stand so that the ponar operator can rinse it down before the next station is sampled. Then turn off the hydraulics.

   *Note: At this point, the individual operating the winch will typically start rinsing nets if they were used at the station (see **In the Nets** under **Rinsing**).

Operating the Ponar

Never operate the ponar unless you have been trained by an experienced crew member. The ponar is very heavy and has the potential to be dangerous. Never place fingers/hands

inside the triangular opening of the latch or inside the ponar interior and always wear gloves when operating. Keep eyes on the ponar at all times and take extreme caution on days of inclement weather conditions.

1. When the hydraulics have been turned on and the winch operator is ready to deploy, pull the line near the ponar to one side to create tension. Then lift up the free-moving arm from the bottom of the collapsible hinge (triangular opening) so that it catches on the notch. Guide the ponar up and over the side of the boat by holding the side blocks until it is out of reach.

   *Note: Do not push the ponar to prevent it from swinging side to side.

2. While the winch operator is lowering the ponar to collect the sample, place a tub on the ponar stand.

   *Note: At sites with sticky clay/mud or a lot of organic material, place a mesh net inside-out over the top of the tub so that the sample can fall into the center of the net and the tub catches the water that flows through the mesh. Four of the six grabs should be collected in nets (nets are not needed for the live sort or sediment samples).

3. When the winch operator brings the ponar back up after the sample has been collected, guide the ponar back over the boat and over the top of the tub with the latch facing towards you.

4. The winch operator will then lower the ponar into the tub and provide slack in the line when it hits the bottom. Grip the blocks on the side of the ponar and lift upward to open so that the contents empty into the tub.

   *Note: If using a net, make sure the edges of the net do not get caught in the ponar when it is lowered. Before opening the ponar, make sure all edges of the net are outside of it.

5. Once the ponar is open, pull the line to one side to create tension and then lift up the free-moving arm from the bottom of the collapsible hinge (triangular opening) so that it catches on the notch.

   *Note: DO NOT place hands or fingers inside of the collapsible hinge.

6. The winch operator will raise the ponar right above the top of the tub. Use the hose to spray the two screens on the outside of the ponar to rinse out the contents of the sample into the tub.

   *Note: Look through the screens to ensure all of the sample has been rinsed into the tub. If some of the sample is still caught inside, slide out the screen and spray the hose directly into the ponar to rinse it out.

7. The winch operator will raise the ponar back up to collect another sample (guide the ponar over the side) and the person responsible for rinsing will take the tub off of the stand.
8. Once the ponar stand is empty, place another tub onto the stand to collect the next sample.
9. Repeat the previous steps until six samples have been collected.
10. Once all samples have been collected and the winch operator lowers the ponar onto the stand, use the hose to rinse down all surfaces and crevices of the ponar so that it is clean for the next station.

    *Note: At this point, the individual operating the winch will typically start rinsing nets if they were used at the station (see **In the Nets** under **Rinsing**).

Rinsing

Once collected, the samples are rinsed down so that all organisms collected are free from mud, clay, peat, etc. and can be identified as easily as possible. The rinsing will typically occur while the boat is traveling between sites. Always be aware of surroundings when the boat is moving, especially in inclement weather conditions.

In the Nets

Nets are used as a pre-rinse method to save time if samples contain a large amount of material that does not rinse easily in the sieve. If nets are used at a station, the individuals responsible for operating the winch and ponar will typically rinse out the four nets over the side of the boat while the third individual begins rinsing the first sample in the sieve. Do not place the net near the boat props. Once the net is over the side, be careful not to let the net go or to let the sample overtop the net. Be aware that peaty samples will fill up with water at a faster rate and will inhibit the water from escaping through the mesh.

1. Bring a tub containing a sample inside of a net over to one side of the boat and untie the slipknot of the rope.

    *Note: It is easiest to place the tub on a chair so that nets containing heavier samples do not have to be lifted as high. This also helps with rinsing the sample back into the tub once the net has been rinsed over the side to avoid back strain.

2. Grab the rope near the mesh with one hand and loop the free end of the rope across your palm on the opposite hand, without wrapping it around the opposite hand. This ensures that the net will not slip out of your hands when being rinsed.

    *Note: If the distance from the water surface to the top of the boat railing is large (i.e., like on the RV Sentinel), secure a line to the boat railing and attach a carabiner to the end of the line. Then clip the carabiner to the net line.

3. Carefully lower the net over the side of the boat just above the surface of the water. Use the railing as a point of contact for the rope to relieve some of the weight of the net.
4. If in calmer water, position the net so that only the bottom of it is coming in contact with the water and glide along the surface until the material coming out of the net runs clear.
5. If in rougher water, carefully dunk the bottom half of the net every few seconds until the net runs clear, while being cautious of incoming waves. The net can also be put over the back rail of the Endeavor to rest on the swim platform and hosed off there until the sample is small enough to put safely over the side.
6. Once the sample has been completely rinsed, lift the net up over the railing and onto the deck floor, then tie the rope in a loose knot and set off to the side.
7. Dump the water left over in the tub over the side of the boat and use a hose to rinse down the remaining material. Place the tub back on the chair.
8. Untie the rope of the net and invert the net over the tub so that the sample dumps out into the tub.
9. While still inverted in the tub, use a hose to rinse down the net from the outside to remove the material left on the mesh.
10. Carefully flip the net inside out, fold so the net is in quarters, and use the hose to rinse down any material on the inside edges. Then fold the other way and rinse.
11. Place a lid on the tub and stack the tub near the other samples from the same station to be rinsed in the sieve.
12. Spray the net down on the deck floor on high water pressure for a final time and place under the ponar stand to be used at the next station.

    *Note: After rinsing all nets, proceed with the steps under **In the Sieve** to continue processing all samples.

In the Sieve

The individual not operating the winch or ponar is responsible for removing the tubs from the stand and starting on the rinsing. Live sort samples can be rinsed with high water pressure while the remaining four samples that require rinsing need to be rinsed with low water pressure to keep soft-bodied organisms intact.

1. Upon arriving to a station, place an empty tub on the opposite side of the back deck as the ponar and place the hose in it to collect water for the live sort sample from the same station.

2. After the first sample has been rinsed into the tub by the individual operating the ponar and the ponar is raised by the winch operator to collect another sample, take the tub off the ponar stand and pour the entire contents into the sieve (rinsing down any material stuck to the tub). Be careful not to spill any of the sample over the side of the sieve. This first sample can be designated for live sort.
3. For the remaining five samples, take the tub off the ponar stand with the sample inside and place off to the side with a lid on top to prevent from spilling.

    *Note: If the sample is collected into a net, tighten the rope on the net to cinch the edges together and tie into a simple knot. Leave the tub uncovered for the nets to be rinsed by the individuals operating the winch and ponar.

4. For the live sort sample that was just rinsed into the sieve, use the hose on high water pressure to rinse the sample as much as possible so that all sediment material is removed (excluding peaty material that does not rinse through).
5. Prop the sieve up on one side so that the open corner is on the lower half. Then rinse the contents of the sample into the open corner.
6. Obtain a medium sized bottle with the appropriate station name, "Live Sort", and the collection date on it. Rinse out the bottle with a hose to remove trace formalin.
7. Remove the cap and set aside. Take the yellow scraper and use it to transfer as much of the sample as possible from the sieve to the bottle. Spray any sample material stuck to the scraper, gloves, and outside of the sample bottle back into the sieve.

    *Note: Keep the bottle inside the sieve when transferring sample material to avoid spilling any of the sample outside of the sieve.

8. If the other two individuals are still rinsing nets, ask for help with lifting the sieve.
9. At this point, one person will lift the sieve so that the open corner is pointed towards the other person with the sample bottle while that person rinses the remainder of the sample into the bottle from the backside of the screen.

    *Note: Be careful not to put too much water into the bottle so that the sample overflows.

10. Use the water collected into a tub from the same station to completely fill the sample bottle. Screw the cap back on and put in the refrigerator.
11. Pour the contents of the next sample from the tub into the sieve (rinsing down any material stuck to the tub). Be careful not to spill any of the sample over the side of the sieve.
12. Use the hose on low water pressure to rinse the sample as much as possible so that all sediment material is removed (excluding peaty material that does not rinse through).

13. Obtain an appropriately sized bottle for the amount of material in the sample. Sample volume should be no more than half the bottle volume. Label it with the station name using a Sharpie on the two pieces of tape on the lid and side of the bottle.
14. Remove the cap and set aside. Take the yellow scraper and use it to transfer as much of the sample as possible from the sieve to the bottle. Spray any sample material stuck to the scraper, gloves, and outside of the sample bottle back into the sieve.

    *Note: Keep the bottle inside the sieve when transferring sample material to avoid spilling any of the sample outside of the sieve.

15. At this point, one person will lift the sieve so that the open corner is pointed towards the other person with the sample bottle while that person rinses the remainder of the sample into the bottle from the backside of the screen.

    *Note: Be careful not to put too much water into the bottle so that the sample overflows.

16. Screw the appropriately sized mesh cap onto the bottle with the sample in it. Invert and squeeze the bottle to remove all the water from the sample.
17. Unscrew the mesh cap and use a rinse bottle (filled with water from the same site) to rinse the sample material remaining on the mesh cap into the sample bottle using a little water as possible.
18. Fill the sample with 10% formalin, or 20% formalin if there is a lot of organic matter in the sample, up to about twice the amount of sample material to ensure all material is exposed to the preservative.
19. Secure the original (labeled) lid tightly on the bottle and invert/swirl the sample to suspend any sample material that is not in contact with the formalin. Place the sample bottle back into the crate it was obtained from.
20. Repeat steps 12-20 for the next three samples from that station.
21. Once all samples have been processed for a station, turn the sieve upside down and use the brush and hose to remove any remaining material left on the screen.

Sediment Collection

The sixth sample collected is designated for the sediment sample and does not require rinsing. Sediment samples are collected into the smaller, square Nalgene bottles.

1. Using your hands, transfer the sediment material from the tub into a labeled sediment bottle so that a representative sample is collected.
2. Before screwing the cap back on, use a hose to rinse the outside of the bottle as well as the threads around the opening.

3. Screw the cap back on and place in the small tub with the other sediment bottles.

POST-RUN PROCEDURES

Unloading Equipment

1. Upon returning to the marina, transport all equipment items on the **Field Equipment Checklist** from the vessel back into the lockup in its appropriate location.
2. Place the live sort samples in a cooler on ice and bring them back to the office along with the horizontal sonde (in the sonde bag) to undergo a **Sonde Post-Measurement Calibration Check**.
3. Load the crates of collected sample bottles in the bed of the vehicle and transport back to the office.

   *Note: Do not put the samples inside the cab of the vehicle to avoid formalin exposure.

Live Sort

Live sort samples collected in the field are brought back to the lab where all *Corbicula* and *Potamocorbula* are picked from the sample. Live sort is performed the day after the samples have been collected. See **Clam ID Guide** (Appendix I) for information on how to identify these two species and which stations each species is expected to be found at.

1. Obtain a sample from the fridge in the downstairs lab, a 500-micron sieve, and a white tray.
2. Place the sieve in the white tray and empty the contents from the sample bottle into the sieve.
3. Remove the sieve (with sample contents) and rinse the sample in the sink.

   Note: If a sample is large and heterogeneously sized, you can use a graduated series of sieves on top of the 500-micron sieve to separate sediment classes, which makes detecting clams easier.
4. Take the water in the tray and pour it back into the original sample bottle to save until the entire sample has been processed.
5. Rinse all of the sample material in the sieve into the white tray (or a fraction at a time if the sample is large) and fill a petri dish with water from the site.

   *Note: If the sample has a lot of organic matter, see **Floating** section. Then continue with step 6.

6. Carefully transport the tray (with the sample) into the sorting room and place under a lamp on the counter.
7. Using forceps, sort through the sample one quadrant of the tray at a time placing each clam in the petri dish until all *Corbicula* and *Potamocorbula* are picked out of the sample.
8. Once all clams of interest are picked out of the sample, the remaining material from the sample can be discarded in the trash.
9. Lay a sorting cloth out on the counter and use calipers or the micrometer on the dissection microscope to measure each clam (in mm) at its widest point. Place each clam on the appropriate square depending on its size class.

    *Note: Size classes are determined by the whole numbers of a measurement. For example, if a measurement is 5.17 mm, the size class is 5. If a clam is too small for the smallest reading on the calipers, place it under the microscope and take the reading from the right eye piece, then convert it to the appropriate size class using the conversion on the wall.

10. On the desktop of the biomass computer, print out the "Live Sort" file for the current year and month and obtain a pre-weighed tray of foil boats (done in **Pre-Weigh Foil Boats**).
11. Separate each size class of clams into its own foil boat. Then fill in the printed live sort data sheet with the station name, collection date, species, number of individuals, and size class for the corresponding boat number.
12. Once all size classes have been distributed into a boat, place the entire tray of boats into the oven, which should be set to 140 degrees. Repeat the previous steps until all samples are picked.

Floating

Live sort samples that have a large amount of organic matter need to be "floated", which will separate the lighter organic matter from the heavier material (i.e. clams).

1. Place an empty sieve inside of an empty white tray and put at the bottom of the sink.
2. Take the white tray containing the sample from step 5 of **Live Sort** and hold it over the sink at a slight angle with the lowest corner over the sieve at the bottom of the sink.
3. Place the faucet over the highest corner of the tray and turn the water on low to allow the water to flow over and through the contents of the sample. Heavier material (rocks and clams) will stay at the bottom and lighter material like peat will

be suspended by the movement of water to the top and over the edge of the tray into the sieve.

4. Keep the water flowing through the sample until most or all of the organic material has floated off.
5. Add some water to the original tray with heavier sample material and proceed with step 6 of **Live Sort**.
6. Remove the sieve with lighter sample material from the tray at the bottom of the sink and place off to the side.
7. Dump out the water collected into the tray at the bottom of the sink and then rinse the contents of the sieve with lighter material into the tray.
8. Pick through this tray of lighter sample material (just in case any clams were floated off) after step 8 of **Live Sort**.

Benthic Sample Submission

The four samples preserved with formalin at each station will be processed by Logical Zoology (Sarah Pearson) where they will be identified and quantified. The samples will be picked up from the downstairs lab and must have the COC with them or sent immediately after pickup.

1. Open the most recent COC file on the shared drive here: S:\M & A BRANCH\Discrete EMP\Benthic\COCs and "Save As" with the current year and month.
2. Update the "Benthic" tab with the correct collection dates and lab IDs for each station. Save the document and print it out.
3. Place the COC in one of the crates of collected samples in the downstairs lab to be picked up.

Sediment Sample Submission

Sediment samples are submitted to Bryte lab and are accompanied by the COC. See **Navigation** (Appendix G) for driving directions to Bryte Lab.

1. Open the current COC file that was created in **Benthic Sample Submission** on the shared drive here: S:\M & A BRANCH\Discrete EMP\Benthic\COCs.
2. Update the "Sediment" tab with the correct collection dates for each station. Save the document and print it out.
3. Bring the sediment samples and COC to Bryte lab and drop them off in the Soils Lab.

Live Sort Data

The live sort data is entered on the days following live sort and is used to perform biomass calculations.

1. On the biomass computer desktop, open up the "Live Sort" file for the current year and month (created in **Pre-Weigh Foil Boats**).
2. Using the printed live sort data sheet that was filled out during live sort, enter in the date, species, number of individuals, and size class next to each corresponding boat number. Save the updated file.
3. QA/QC the live sort data (performed by someone other than the person who entered the data) by checking that all values in the spreadsheet match those on the printed data sheet.

Dry Weights

Dry weight measurements are obtained from the clams picked and sorted into the foil boats during live sort after they have been in the oven for at least two weeks.

1. If the scale is powered off, press the red power button on the bottom far left and let it warm up for 15-30 minutes. If at any point when nothing is on the scale and it displays any number besides zero, click "TARE" to zero it.

   *Note: If the bubble at the back of the scale on the right-hand side is not contained in the circle, adjust the scale using the round feet on the bottom. Then press the CAL button to calibrate.

2. Before weighing the boats, use the calibration log book and weigh the 1, 5, and 50-gram weights (located in the top cabinet to the left of the analytical scale). This will verify and document that the scale is working efficiently.
3. On the biomass computer desktop, open up the "Sartorius Scale Input" and the "Live Sort" file for the current year and month (created in **Pre-Weigh Foil Boats**).
4. Obtain a tray from the oven using the tray carrier with two desiccant packets and select the cell under the "Dry weight + pan" column corresponding to the first boat number of that tray.
5. Using large forceps, place the corresponding boat inside the clear doors of the analytical scale.

   *Note: All doors to the scale should be closed to get an accurate reading.

6. Once the reading equilibrates, click the button resembling an underlined disc on the bottom far right of the scale to automatically enter the reading on the spreadsheet. Check to make sure the reading transferred to the appropriate cell.

7. Place the boat back into its original spot in the tray and repeat steps 4 and 5 until you have weighed all boats in the tray.

    *Note: Do not throw away the clams in the boat after the reading has been recorded in the spreadsheet.

8. When all boats in the tray have been measured and recorded, close the doors to the scale and save the changes made to the file. Put the tray in the furnace (to the right of the oven) and close the furnace door.

    *Note: Two trays can fit in the furnace at any one time, so dry weights can be measured two trays at a time on any given day.

9. Flip the switch on the furnace to turn it off and then flip it again to turn it back on. Once the numbers stop blinking, hold down the "Run" button until you hear a click.

Ash Weights

Ash weight measurements are obtained from the clams picked and sorted into the foil boats during live sort after they have been in the furnace for at least 16 hours.

1. If the scale is powered off, press the red power button on the bottom far left and let it warm up for 15-30 minutes. If at any point when nothing is on the scale and it displays any number besides zero, click "TARE" to zero it.

    *Note: If the bubble at the back of the scale on the right-hand side is not contained in the circle, adjust the scale using the round feet on the bottom. Then press the CAL button to calibrate.

2. Before weighing the boats, use the calibration log book and weigh the 1, 5, and 50 gram weights (located in the top cabinet to the left of the analytical scale). This will verify and document that the scale is working efficiently.

3. On the biomass computer desktop, open up the "Sartorius Scale Input" and the "Live Sort" file for the current year and month (created in **Pre-Weigh Foil Boats**).

4. Obtain a tray from the furnace using a tray carrier with two desiccant packets and select the cell under the "Ash-free weight + pan" column corresponding to the first boat number of that tray.

5. Using large forceps, place the corresponding boat inside the clear doors of the analytical scale.

6. Once the reading equilibrates, click the button resembling an underlined disc on the bottom far right of the scale to automatically enter the reading on the spreadsheet. Check to make sure the reading transferred to the appropriate cell.

7. Look at the "Average weight per individual" column and ensure that the value is greater than zero. Discard the clams and ashes in the boat and move onto the next one.

   *Note: If the value is zero or less, re-weigh the boat up to two more times. If there is a reading above zero, record that one. If after three weighs the value is still zero or less, type "re-weighed three times, same result" and put your initials in the comments column for that boat number and then discard the clams and ashes in the boat and move on.

8. Place the boat back into its original spot in the tray and repeat steps 4 through 6 until you have weighed all boats in the tray.
9. When all boats in the tray have been measured and recorded, save the changes made to the file. Put the tray on the left side of the cabinet above the computer to be pre-weighed for the following month's benthic run.

Comment	Response
EPA 1. The bulk of the Report is dedicated to describing ongoing work by others and does not describe what monitoring will be completed by DWR and BOR to respond to Condition 9 of the Order. While EPA supports efficiency and coordination with others' monitoring efforts, the Report does not identify "*long-term monitoring needs and implementation options for HABs (including but not limited to cyanobacteria and cyanotoxins) to generate baseline information needed to evaluate potential effects of future drought response actions, including the trends in HABs, potential adverse impacts of HABs on beneficial uses of water in the Delta, and the environmental factors that may influence the variability of HABs in the Delta, including but not limited to flow circulation, residence time, and nutrient concentrations.*" The Report, as noted in the excerpts below, in effect transfers the work of developing a monitoring framework for HABs to others including the future efforts by the Delta Science Program (which hosted a November 2022 HABs Workshop) and the California Water Board's Freshwater HAB (FHAB) Program. However, neither the Delta Science Program nor the State FHAB Program are responsible for or funded to address the Condition 9 elements. "The details of how, where, and by whom [existing activities that need to be supplemented] will occur will be planned through the inter-agency workshop to be held by the Delta Science Program." (Pg 13) "Currently, DWR and Reclamation are participating in the Delta Science Program's HAB Workshop. The goal of this workshop is to develop a comprehensive, tiered monitoring framework for HABs in the Delta. …Once this framework is fully developed and finalized, DWR and Reclamation can ensure that sample collection, analysis, and data management are compatible with other HABs monitoring programs, participate in sensor intercalibration, and, as potential resources allow, add cyanotoxin sampling at locations and times that fit within the overall program needs." (Pg 30) "The Central Valley Water Board has some capacity for event response when blooms are reported." (Pg 31) "Targeted research studies may be important to compliment baseline monitoring to better understand mechanisms behind observed patterns of HABs, determine	Reclamation and DWR have described surveys they fund and undertake to monitor HABs under baseline and TUCO conditions. Funding is a matter of anti-deficiency and outside the requirement of Condition 9. Reclamation and DWR work with their partner agencies to address long-term regional monitoring for HABs.

the impacts of HABs on wildlife and humans, identify responses to short-term actions such as TUCOs, and develop control strategies. This targeted research will be developed on an as-needed basis with the collaboration of agency partners or universities." (Pg 31)	
EPA 2. The Report acknowledges that current "HABs monitoring in the Delta includes a wide variety of agencies and organizations that have different missions, objectives, and technical resources, and operate at different spatial and temporal scales" (pg 10). Many of these other programs do not have as an objective the monitoring for HABs or related parameters to assess baseline conditions, public health threats or potential adverse impacts of HABs on beneficial uses of water in the Delta. Lacking an objective to assess HABs means data may not be representative and appropriate for assessing HAB impacts.	HAB monitoring in the Delta is a regional scientific endeavor, which Reclamation and DWR participate in as one of many agencies working on this issue. We welcome EPA leadership in designing objectives for monitoring in appropriate programs such as California Water Board's Freshwater HAB (FHAB) Program and other cooperative scientific endeavors.
EPA 3. Identifying long-term monitoring needs should include identification of data quality objectives (DQOs) necessary to address each of the elements of Condition 9. DQOs identify what questions need to be answered to inform the type and quality of data needed. The Report has not identified DQOs. Monitoring objectives, as well as monitoring scope, scale, frequency, parameters, methods and other factors, need to be clearly identified to ensure collected data would be appropriate to evaluate the Condition 9 elements.	The report describes monitoring efforts that capture many of the priority indicators and metrics for responses and environmental drivers identified in the California Water Board's FHAB Framework and Strategy (Smith et al 2021). Smith et al. (2021) does not describe a framework and strategy including DQOs and they are not required in Condition 9. The report and its appendices accurately describes the spatial and temporal scales, frequency, and other information necessary to ensure collected data will be appropriate for the Plans goals and objectives.
EPA 4. The Report summarizes and proposes to leverage "existing relevant water quality, chlorophyll, and phytoplankton monitoring across programs in the Delta," including various sampling efforts by Reclamation and others. However, those monitoring programs were not designed to assess HABs, so the currently generated data does not adequately assess the Condition 9 elements. Further, the Report does not assess the limitations of the existing data or evaluate where gaps exist with regard to assessing the Condition 9 elements.	Reclamation and DWR accurately and fully describe long-term monitoring needs and implementation options for HABs. This comment does not identify specific deficiencies in the report's identification of Reclamation and DWR environmental monitoring.
EPA 5. Goal and Objectives - The TUPC Order, Condition 9 is not limited to SWP and CVP operations; however, Goals 1 and 3 focus on evaluating "the likely impact of CVP and SWP operations on the Delta ecosystem," specifically "how SWP and CVP operations, including drought actions, may impact the locations and conditions under which FHABs are likely to form in the Delta." The final Report should address all Condition 9 elements and not be limited to the impacts of the SWP and CVP operations. Additionally, Condition 9 requires assessing "potential adverse impacts of HABs on beneficial uses (BUs) of water in the Delta." However, several Delta BUs	Assessing potential adverse effects is not part of the report for HABs. The final Monitoring Report submitted as part of Condition 8 will assess potential adverse effects on multiple beneficial uses related to HABs.

commonly impacted by HABs (REC1, REC2, WARM, COLD, SPWN and SHELL) are omitted and should be included in the final Report submitted for Condition 9.	
EPA 6. Spatial Scope – Several locations referenced in the Report are not identified on figures, including the locations of TUCP barriers and other drought actions. Additionally, the Report does not address how existing sampling locations address assessment of drought response actions but says only that "regional monitoring design allows resources to be focused on areas most impacted by CVP and SWP operations and annual or seasonal water management decisions (e.g., Temporary Urgency Change Petitions [TUCP]) while still monitoring core indicators across the Delta."	Potential barrier locations and drought response actions may be unique to each TUCP, thus the Long-Term Monitoring report for HABs does not include these. This comment does not identify specific locations in the report's identification of Reclamation and DWR barriers and other drought actions. Reclamation and DWR accurately and fully describe long-term monitoring needs and implementation options for HABs.
EPA 7. Temporal Scope – Condition 9 calls for the generation of baseline information needed to evaluate potential effects of future drought response actions; however, the proposed monitoring design suggests resources be deployed during HABs occurrence through senescence (e.g., summer through mid- to late fall). This will not provide information on baseline conditions or the early and late phases of HAB occurrence.	The Reclamation and DWR accurately and fully describe long-term monitoring needs and implementation options for HABs. This comment does not identify specific deficiencies in the report's identification of Reclamation and DWR environmental monitoring.
Use of Visual Index - For several current monitoring programs proposed for leveraging to meet Condition 9 (e.g., Department of Water Resources FHAB monitoring in the south and central Delta and monitoring adjacent to the West False River drought barrier), sampling of HABs is triggered by the Visual Index (VI), when the VI score is >4 (out of 5). Using this threshold, sampling does not begin until a HAB is fully developed. Baseline conditions and other Condition 9 elements including early public health warning are not achieved by using a VI of >4. Additionally, the Visual Index system was developed for blooms dominated by *Microcystis*; however, the composition of HABs in the Delta has changed and blooms now include several different types of HABs that do not present in the same way (e.g., may not form scums at the surface, etc.). At the November 2022 Delta Science Program HAB workshop, the developer of the Microcystis Visual Index, Dr. Peggy Lehman (recently retired from California Department of Water Resources), noted that HAB community composition has changed, and the Visual Index is no longer representative. For these reasons, EPA does not support use of the Visual Index to determine when sampling for cyanotoxins would occur to meet Condition 9 elements.	Reclamation and DWR work with their partner agencies to assess the potential for modifying current monitoring efforts or adding new methods to better monitoring FHABs. We welcome EPA participation in these discussions about modifying and revising methods used for monitoring FHABs.