



Monitoring Workplan

Fiscal Year 2026-2027

Submitted to the Central Valley Regional Water Quality Control Board on
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Prepared By:



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LIST OF ACRONYMS

ASC	Aquatic Science Center
BGC	Biogeochemical
BOD	Board of Directors
CCR	Coastal Conservation and Research, Inc.
CDFW	California Department of Fish and Wildlife
CEC	Constituent of Emerging Concern
CEDEN	California Environmental Data Exchange Network
CHAB	Cyanobacterial Harmful Algal Bloom
Chl	Chlorophyll a

CUP	Current Use Pesticides
CV RDC	Central Valley Regional Data Center
CVRWQCB	Central Valley Regional Water Quality Control Board
DIN	Dissolved Inorganic Nitrogen
DMAC	Data Management Advisory Committee
DMCP	Delta Mercury Control Program
DMT	Data Management Team
DRMP	Delta Regional Monitoring Program
DO	Dissolved Oxygen
EC	Electrical Conductivity
EDD	Electronic Data Deliverable
EO	Executive Officer
EPA	United States Environmental Protection Agency
F _v /F _m	Chlorophyll Fluorescence Parameter
FY 23-24	Fiscal Year 2023-2024
FY 24-25	Fiscal Year 2024-2025
FY 25-26	Fiscal Year 2025-2026
FY 26-27	Fiscal Year 2026-2027
FY 27-28	Fiscal Year 2027-2028
FY 28-29	Fiscal Year 2028-2029
HAB	Harmful Algal Bloom
IEP	Interagency Ecological Program
MLML	Moss Landing Marine Laboratories
MQO	Measurement Quality Objective
MVI	<i>Microcystis</i> Visual Index
N	Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NRB	Nutrient Reduction Bioassay
P	Phosphorus
pH	Potential of Hydrogen
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
SEP	Supplemental Environmental Project
SFEI	San Francisco Estuary Institute
SOP	Standard Operating Procedure
SOW	Scope of Work
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TN	Total Nitrogen
TMDL	Total Maximum Daily Load

WY

Water Year

LIST OF UNITS

°C	degrees Celsius
cm	centimeter
L	Liter
m	meter
mg	milligram
NTU	Nephelometric Turbidity Unit
pH	potential of Hydrogen
RFU	Relative Fluorescence Units
µg	microgram
µm	micrometer
µmol	micromole
µS	micro-Siemens
W	Watt

EXECUTIVE SUMMARY

The Delta Regional Monitoring Program (DRMP) is submitting the annual Monitoring Workplan for fiscal year 2026 – 2027 (FY 26-27) in accordance with Resolution R5-2021-0054. The purpose of this Monitoring Workplan is to identify the projects that will be implemented in the next fiscal year (July 1 through June 30). This Monitoring Workplan includes an initial draft budget estimate for each project (**Table 1**); a final budget will be submitted by June 30 as a separate document. The DRMP non-profit funds projects in the following monitoring sectors: Current Use Pesticides (CUP), Constituents of Emerging Concern (CEC), Nutrients (including harmful algal blooms), and Mercury. Projects to be implemented within each monitoring sector include a study design to address monitoring and assessment questions. Not all monitoring sectors will have monitoring projects funded during this fiscal year. The DRMP non-profit also funds work for planning, data management, and reporting in addition to monitoring.

This document describes the work to be funded by the DRMP non-profit for planning, monitoring, data management, and reporting for the next fiscal year (FY 26-27) including initial budget estimates.

CURRENT USE PESTICIDES

During FY 26-27, the DRMP will finalize the Current Use Pesticide (CUP) Interlaboratory Special Study design and contract with laboratories to implement the special study. In addition, the Steering Committee will provide direction on the development of a CUP Interpretive Report. The DRMP will continue to explore the use of a third-party to evaluate the useability of previous pesticide data collected as part of the CUP monitoring program relative to future interpretive reports and monitoring designs. The third-party review will be done prior to the development of the CUP Interpretive Report.

CONSTITUENTS OF EMERGING CONCERN

In FY 26-27, the DRMP will focus on completing the Constituent of Emerging Concern (CEC) Interpretive Report which will initiate the long-term planning process for CECs. Drafting of the CEC Interpretive Report began during FY 25-26 and is expected to be completed in fall 2026. After the CEC Interpretive Report is completed, the CEC TAC and Steering Committee will begin the long-term planning process utilizing recommendations from the CEC Interpretive Report.

NUTRIENTS / HABS

In FY 26-27, the DRMP will continue implementation of the Nutrient Multi-Year Study Plan (**Appendix I**). During FY 26-27, modeling performed by San Francisco Estuary Institute – Aquatic Science Center (SFEI-ASC) as part of Focus Area #1 will continue. For the Focus Area #2, Phase 1 of the Nutrient Reduction Bioassay study design will continue (pilot experiments and ambient monitoring). The DRMP will continue to look for opportunities to collaborate or leverage funding to better understand harmful cyanobacteria blooms in the Delta including participation in effort to improve monitoring collaboration.

MERCURY

The Steering Committee developed direction to the Mercury TAC for a multi-year study design as part of its long-term planning for mercury in FY 25-26 using the information provided in the Mercury Interpretive Report. The DRMP Mercury Interpretive Report, which was completed in FY 24-25, provided critical information and analysis that informs DRMP stakeholders on the status and trends of aqueous and fish methylmercury concentrations in the Delta. The Mercury TAC has utilized this direction to develop the Mercury Study Plan (2027-2031) (**Appendix IV**) with the plan to finalize a Quality Assurance Project Plan (QAPP) in FY 26-27 and begin monitoring in spring 2027.

SUMMARY BUDGET

Table 1. FY 26-27 Preliminary Budget Executive Summary.

BUDGET CATEGORY / MONITORING SECTOR	EXPENSES ESTIMATE
Operational Costs	\$36,025
General Administration	\$96,679
Collaboration	\$126,210
Governance Documentation	\$4,920
Resolution Requirements	\$66,833
Current Use Pesticides	\$23,752
Constituents of Emerging Concern	\$59,385
Nutrients	\$553,333
Mercury	\$104,419
Data Management & Quality Assurance (QA)	\$8,352
Expenses Total	\$1,079,908

INTRODUCTION

The Delta Regional Monitoring Program (DRMP) non-profit is submitting the annual Monitoring Workplan for fiscal year 2026 – 2027 (FY 26-27) in accordance with Resolution R5-2021-0054. The purpose of this Monitoring Workplan is to identify the projects that will be implemented in the next fiscal year (July 1 through June 30). This Monitoring Workplan includes an initial draft budget estimate for each project (**Table 1**); a final budget will be submitted by June 30 as a separate document. The DRMP non-profit funds projects in the following monitoring sectors: Current Use Pesticides (CUP), Constituents of Emerging Concern (CECs), Nutrients (including harmful algal blooms), and Mercury. Projects to be implemented within each monitoring sector include a study design to address monitoring and assessment questions. Not all monitoring sectors will have monitoring projects funded during this fiscal year. The DRMP non-profit also funds work for planning, data management, and reporting in addition to monitoring.

This document describes the work to be funded by the DRMP non-profit for planning, monitoring, data management, and reporting for the next fiscal year (FY 26-27) including initial budget estimates.

BACKGROUND

DRMP STRUCTURE AND ORGANIZATION

The purpose of the DRMP is to educate and inform decisions on how to protect and, where necessary, restore beneficial uses of water in the Sacramento-San Joaquin River Delta area of California by producing objective and cost-effective scientific information critical to understanding regional water quality conditions and trends. The Implementing Entity DRMP is a California nonprofit public benefit corporation (hereafter called the DRMP non-profit) under which the Board of Directors (BOD) oversees program operations.

The DRMP pursues the following objectives:

- a) Improve the efficiency of water quality data collection and management in the Delta.
- b) Generate information that informs and educates the public, agencies, and decision makers.
- c) Raise awareness of Delta water quality conditions and how they impact beneficial uses.

- d) Foster independent science, objective peer review, and a transparent review process.

The DRMP is implemented with stakeholder participation of various coordinated monitoring, resource, regulatory, and regulated entities. These groups give technical and program policy recommendations to the DRMP BOD through participation in the Steering Committee and various project-specific Technical Advisory Committees (TACs). The program structure is illustrated below in **Figure 1**.

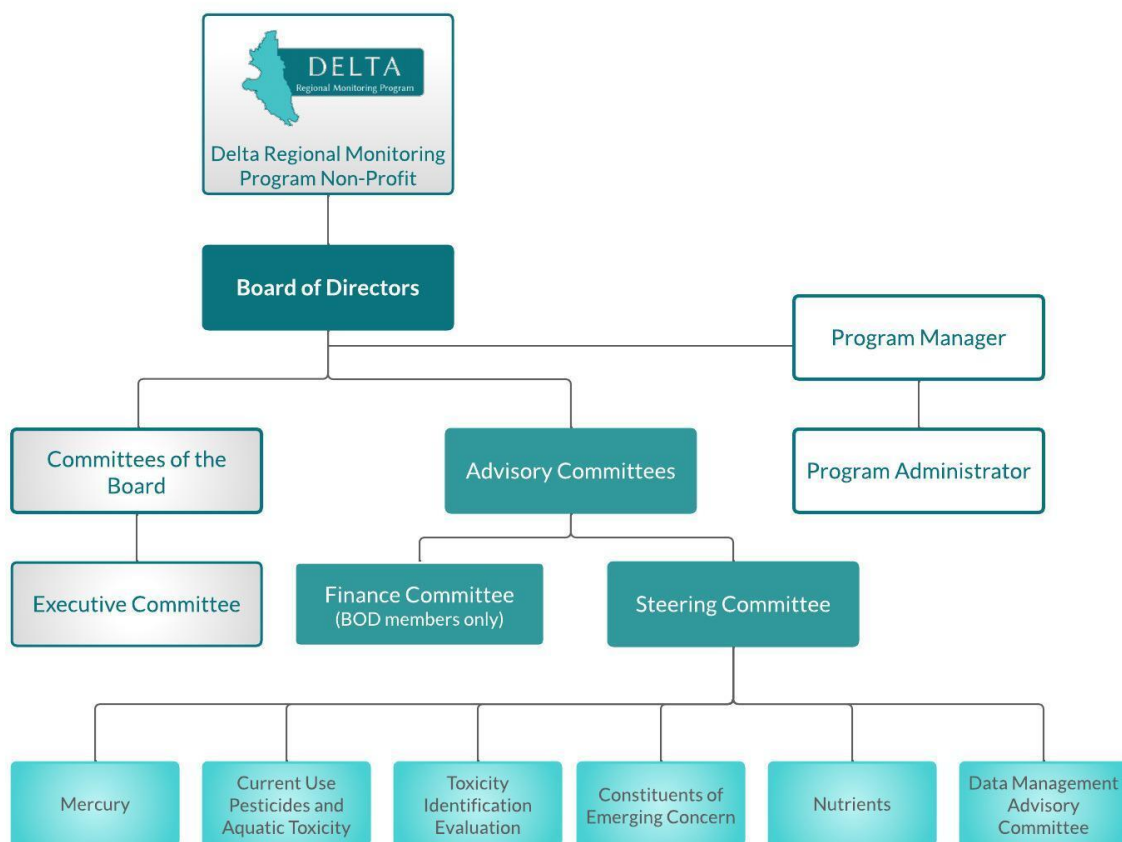
The implementation of the DRMP non-profit is done in close coordination with the Central Valley Regional Water Quality Control Board (CVRWQCB) and permitted dischargers. Other stakeholders who may be involved with this program who are not dischargers include but are not limited to the State Water Resources Control Board (State Board or SWRCB), United States Environmental Protection Agency (EPA), California Department of Fish and Wildlife (CDFW), National Oceanic and Atmospheric Administration (NOAA), Interagency Ecological Program (IEP), Delta Science Program, State Water Contractors, and Tribal members.

The funds contributed to the DRMP non-profit are used to support the collection of scientific data in the Delta region to support the goals of the Program. To ensure these goals are met, the data generated under the DRMP must be managed and governed in a consistent way and be of consistent quality such that the assessments and decisions made are effective at protecting and improving the water quality in the Delta.

ORGANIZATIONAL STRUCTURE AND GOVERNANCE

The program is implemented by the DRMP non-profit, a California nonprofit public benefit corporation, and guided by a governing board and advisory committees. The makeup of the DRMP BOD, Executive Committee, Steering Committee, and TACs is described on the [DRMP website](#).

Figure 1. DRMP Non-profit Structure.



RESOLUTION REQUIREMENTS

A variety of permittees throughout the Central Valley, regulated by the CVRWQCB, contribute and participate in the DRMP non-profit. In 2013, the CVRWQCB passed Resolution R5-2013-0130 allowing DRMP participation in lieu of some receiving water monitoring/special study requirements. As such, close collaboration with the CVRWQCB is essential to ensure the continued value and effectiveness of regional monitoring in lieu of individual monitoring and special studies that otherwise might be required by CVRWQCB for participating permittees.

In October 2021, the CVRWQCB passed Resolution R5-2021-0054 approving the updated DRMP non-profit governance structure as a vehicle for this modified monitoring to occur. Future refinements to the DRMP non-profit governance structure including changes to policy and procedure and foundational documents, must be reported to the CVRWQCB according to the reporting requirements of Attachment A of Resolution R5-2021-0054. The CVRWQCB Executive Officer (EO) will review any changes to ensure the

effectiveness of regional monitoring and adequate monitoring and assessment of cumulative impacts that alter water quality. It is the responsibility of the DRMP non-profit to submit the documents outlined in Attachment A according to the timelines and requirements therein to maintain approval by the CVRWQCB.

Attachment A of Resolution R5-2021-0054 outlines the reporting requirements of the implementing entity to the CVRWQCB to ensure added value of the coordinated efforts under the Program are adequate to investigate water quality issues in lieu of individual monitoring and special studies.

The requirements in Resolution R5-2021-0054 for the annual Monitoring Workplan are:

- Identify the projects the DRMP non-profit will implement over the next fiscal year (July 1 through June 30).
- Develop and provide the initial draft budget estimate for each project. The final budget shall be submitted as a separate document by June 30.
- Identify management, monitoring, and assessment questions to be addressed by each project in the Monitoring Workplan.
- Provide a study design to address monitoring and assessment questions. The study design shall include the following information:
 - Specific hypothesis to be tested
 - Sample locations
 - Sample collection frequency
 - Sample analytes
 - Analysis methods
 - Preliminary data deliverables
 - Planned reports to summarize results
 - Timeline and schedule

LONG TERM STRATEGIC PLANNING

The DRMP stakeholders met on December 8, 2021, to discuss an overall strategy for implementing a long-term monitoring program. The DRMP decided to move forward with a long-term planning strategy that allows for a staggered approach across monitoring sectors between planning, monitoring, and reporting with the goal of maximizing resources. Long-term planning is now focused on developing multiyear monitoring workplans for each focused monitoring sector.

In 2024, the DRMP revisited and updated the five-year long-term plan for 2024 - 2029. The updated long-term planning direction was developed with input from the Steering Committee stakeholders, including representatives on the TACs. During a Steering Committee meeting on August 8, 2024, the Steering Committee provided feedback on a

Strawman Five-Year Priorities proposal; key takeaways from that meeting are captured in **Figure 2**. The feedback was incorporated into **Figure 3**, an illustration of how the DRMP will prioritize resources across monitoring sectors for the next five years with the flexibility to adjust annually.

The DRMP has developed a general strategy for guiding long term planning (**Figure 4**). The DRMP intends to refine this general strategy per monitoring sector as it moves through long-term planning across the Program focus areas.

The DRMP continues to work with other monitoring programs such as the IEP and the Delta Science Program to identify areas where monitoring coordination can occur to maximize resources and fill data gaps.

DRMP Key Takeaways 2024 LT Planning

Figure 2. DRMP 2024 Long-Term Planning Key Takeaways.

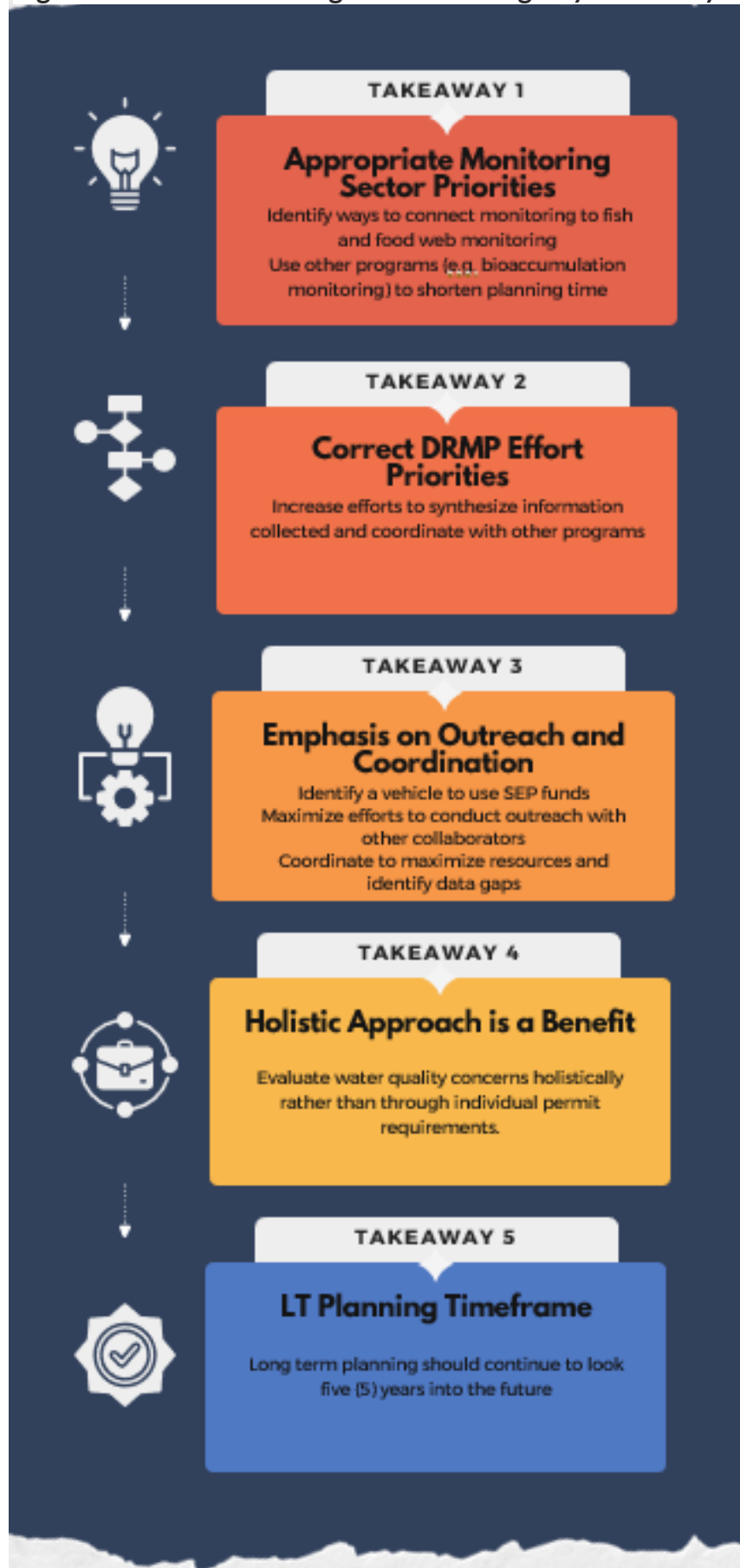


Figure 3. Staggered approach for long-term planning across monitoring sectors (2024 – 2029).

This figure was updated and recommended by the Steering Committee in September 2024; specifics for years after FY 26-27 may change.

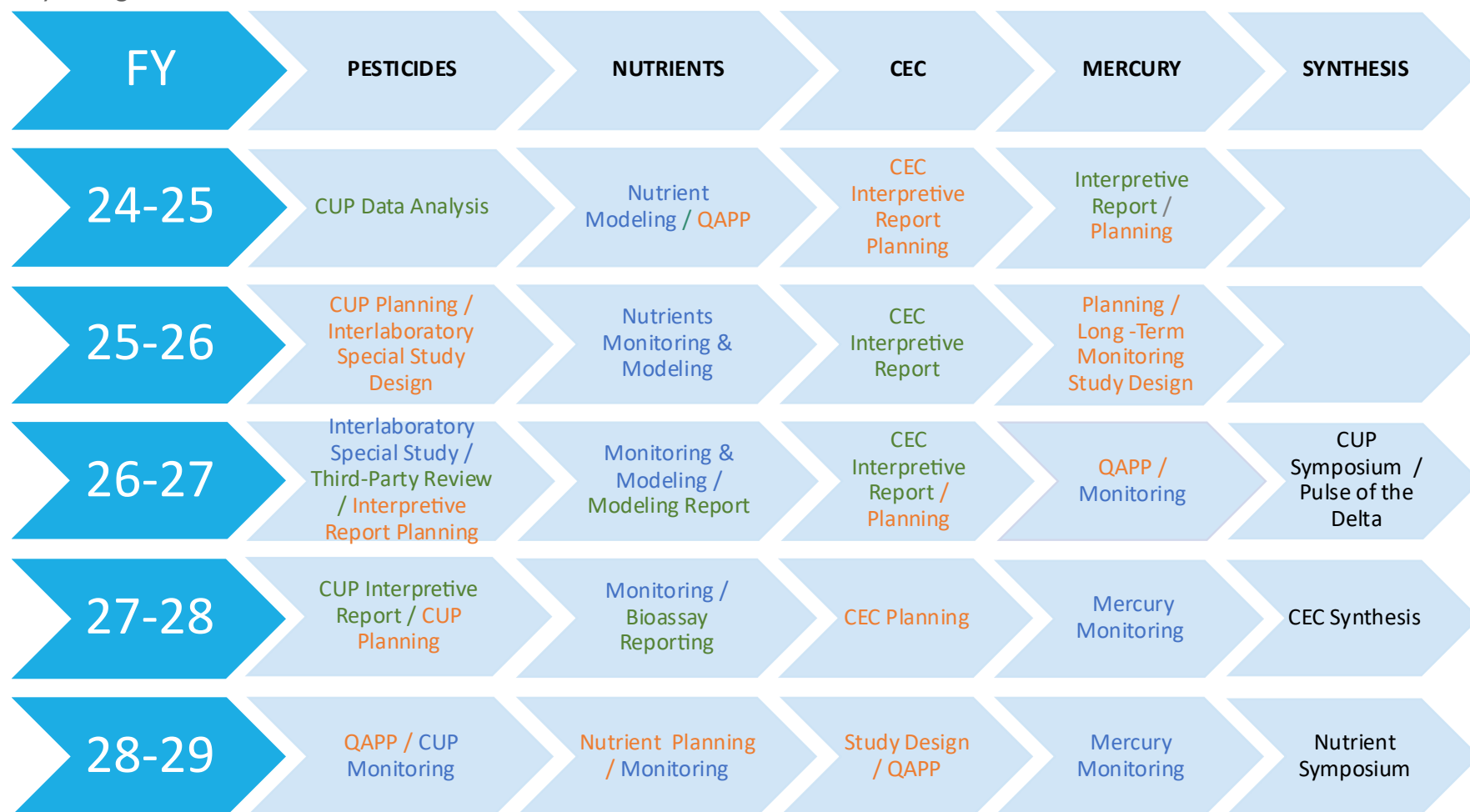
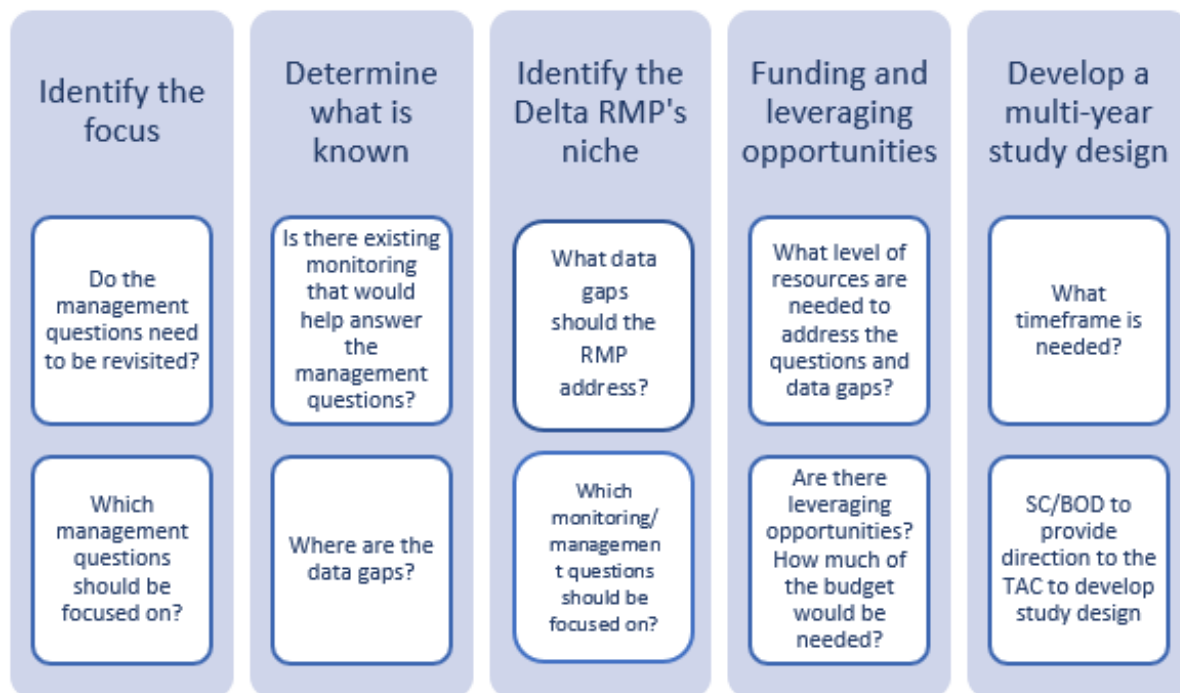


Figure 4. General strategy for developing multi-year study designs as part of the DRMP long term planning strategy.



FY 26-27 OVERVIEW

For FY 26-27, the DRMP non-profit is continuing to implement existing monitoring designs, perform data synthesis and reporting, and conduct planning for multi-year projects. **Table 2** and **Figure 5** include an overview of the monitoring sectors and what will occur in terms of planning, monitoring, and data synthesis/reporting during the upcoming fiscal year. This is in addition to the deliverables identified within the Resolution which includes Quarterly and Annual Reports. The TAC meetings in **Figure 5** are estimates and not all of these meetings have been scheduled yet.

Table 2. FY 26-27 work to be performed in the four DRMP monitoring sectors.

MONITORING SECTOR	PLANNING	MONITORING	DATA SYNTHESIS / REPORTING
Current Use Pesticides	Planning for an Interpretive Report	Interlaboratory Special Study	Third-Party Data Review / CUP Symposium
Constituents of Emerging Concern Pilot Study	Long-Term Planning	--	CEC Interpretive Report
Nutrients / Harmful Algal Blooms (HABs)	Focus Area #3 Collaborative Studies Development	Biogeochemical Modeling and Bioassay Studies	Modeling Report, Bioassay Data Report
Mercury	QAPP Development	Spring Water Monitoring	--

Figure 5. Summary of anticipated DRMP planning, monitoring, and reporting activities for FY 26-27.

These are tentative timelines and milestones that will be adjusted as necessary to reflect direction from the Steering Committee.

		2026												2027											
		January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
DRMP	FY	FY 25-26						FY 26-27												FY 27-28					
	Planning		SC/ TAC		SC		SC			SC			SC		SC		SC		SC/ TAC			SC			SC
	Reporting		FY/ Q2			WP/ Q3			Q4			Q1	DMP		FY/ Q2			WP/ Q3			Q4			Q1	
Mercury	Year	No Monitoring / Study Design						Quality Assurance Project Plan (QAPP) Development / Spring Monitoring												Monitoring					
	Planning	TAC	TAC		TAC	DES		TAC		TAC	QAPP/ SUB				TAC				TAC						
	Monitoring														MON						MON				
Nutrients	Year	Focus Area 1 & 2						Nutrient Multi-Year Study Plan - Focus Area 1 & 2												Focus Area 2					
	Planning	TAC	TAC	TAC/ QAPP		TAC	TAC	TAC	TAC	TAC		TAC	TAC	TAC	TAC	QAPP			TAC	TAC					
	Monitoring	MOD	MOD	MOD	MOD	MOD	MOD/ BIO	MOD/ BIO	MOD/ BIO	MOD/ BIO	MOD/ BIO	MOD	MOD							BIO	BIO	BIO	BIO		
Pesticides & Toxicity	Year	No Monitoring / Special Study Design						CUP Interlaboratory Special Study												No Monitoring					
	Planning	TAC	SC/ TAC		TAC		TAC	TAC		DES					TAC			TAC							
	Monitoring													ISS	ISS										
CECs	Year	No Monitoring / CEC Interpretive Report						CEC Interpretive Report / No Monitoring												No Monitoring					
	Planning			TAC		TAC		TAC	TAC																
	Reporting									RPT															

FY: FY Annual Report
Q: Quarterly Report

WP: Annual Workplan
TAC: TAC Meeting(s)

SC: Steering Comm. Mgt
SC/TAC: Joint Meeting

CEDEN: Data upload to CEDEN
RPT: Data or Study Report
ISS: Interlaboratory Study

MOD: Modeling
BIO: Bioassay Exp.
DMP: Data Management Plan

DES: Study Design
SUB: Submittal

SUMMARY OF BUDGETS

The FY 26-27 Monitoring Workplan includes a preliminary budget reflecting estimated expenses for the upcoming fiscal year (**Table 3**). The DRMP non-profit will provide an updated budget for the program by June 30, 2026. The current estimates do not include in-kind contributions, matching funds, or contributions from Surface Water Ambient Monitoring Program (SWAMP) funds from the CVRWQCB (maximum of \$205,600 of in-kind contributions). At the time of this Workplan submittal, SWAMP funds are not available for the foreseeable future. The June 30, 2026, budget will include in-kind contributions and updated estimates in preparation for FY 26-27.

For FY 26-27, Melissa Turner (MLJ Environmental) will be the Program Manager for the program with assistance from Jennifer Glenn (MLJ Environmental) as the Program Administrator and Sammantha Soto (MLJ Environmental) as support staff. Their time is included in the cost estimate for General Administration, Collaboration, Governance Documentation, and Resolution Requirements. In addition, their responsibilities include scheduling Steering Committee and TAC meetings and providing meeting notes. The Program Manager and Program Administrator work closely with the Board of Directors (including the Executive Committee) and Steering Committee Chair(s) to implement the program.

Table 3. FY 26-27 preliminary budget for expenses.

MONITORING SECTOR	PLANNING	MONITORING	DATA MANAGEMENT	DELIVERABLES	EXPENSES ESTIMATE
Operational Costs					\$36,025
General Administration	Yearly planning, communication between stakeholders, attending conferences & workshops		Droplet - File Sharing	Website, Annual Meeting Schedule	\$96,679
Collaboration	BOD meetings, EC meetings, SC meetings, RB coordination				\$126,210
Governance Documentation				Policies and Procedures	\$4,920
Resolution Requirements				Quarterly Report, Annual Report, Workplan	\$66,833
Current Use Pesticides	TAC meetings, Interlaboratory study planning, Symposium coordination	Interlaboratory Special Study		Interlaboratory Special Study QA Documentation, Third Party Review	\$23,752
Constituents of Emerging Concern	TAC meetings, Long-Term Planning			CEC Interpretive Report	\$59,385
Nutrients	TAC meetings, QAPP Amendment	Biogeochemical Modeling, NRB Pilot Study	Pilot Study Data	NRB Data Report, Modeling Report	\$553,333
Mercury	TAC meetings, QAPP Development	Spring Water Monitoring		QAPP	\$104,419

MONITORING SECTOR	PLANNING	MONITORING	DATA MANAGEMENT	DELIVERABLES	EXPENSES ESTIMATE
Data Management & Quality Assurance (QA)	DMAC meetings			Data Management Plan Amendment	\$8,352
				Expenses Total	\$1,079,908

BOD – Board of Directors

CEC – Constituents of Emerging Concern

DMAC – Data Management Advisory Committee

EC – Executive Committee

NRB - Nutrient Reduction Bioassay

RB – Regional Board

SC – Steering Committee

TAC – Technical Advisory Committee

QA – Quality Assurance

QAPP – Quality Assurance Project Plan

DATA MANAGEMENT PLAN

The DRMP BOD formed a Data Management Advisory Committee (DMAC) on December 16, 2021, with a charge to develop a Quality Assurance Project Plan (QAPP) Template and Data Management Plan. Participation in the DMAC includes CVRWQCB staff, SWRCB staff, and representatives from the regulated groups.

As required by Resolution R5-2021-0054, a Data Management Plan was submitted on October 3, 2022. However, based on comments at the Steering Committee meeting on September 8, 2022, it was determined that the Data Management Plan would still require revisions and additional language to meet Water Boards' expectations. The DRMP non-profit was granted an initial extension of February 14, 2023, which was then revised to December 23, 2023. The revised Data Management Plan was recommended by the Steering Committee on December 12, 2023, and approved by the DRMP BOD on December 12, 2023. The revised Data Management Plan ([version 2.0](#)) was submitted to the CVRWQCB EO on December 15, 2023, for approval. The DRMP plans to submit an amendment to the Data Management Plan in December 2026 to reflect minor changes to reflect changes in EPA QAPP guidelines and, if applicable, incorporate received feedback from the CVRWQCB. The intention is to review and amend (if necessary) the Data Management Plan, a minimum of every three years.

The QAPP Template was finalized in March 2022 and was used to develop the CUP QAPP; during the process of finalizing the CUP QAPP some of the template language was adjusted to include additional recommendations from the CVRWQCB and SWRCB. In FY

24-25, the QAPP Template was revised to incorporate EPA updated requirements and ensure consistency with approved Data Management Plan language. The DRMP DMAC recommended the approval of the revised QAPP Template; “Quality Assurance Project Plan for [Project] Monitoring under the Sacramento-San Joaquin Delta Regional Monitoring Program, Version 3.3” on October 7, 2024. The revised QAPP Template was reviewed and recommended by the DRMP Steering Committee on December 10, 2024, and approved by the DRMP BOD on December 16, 2024. The DRMP will be working on an amendment to the Data Management Plan in FY 26-27.

The QAPP Template outlines the role of the Program Quality Assurance (QA) Officer relative to the roles of the SWRCB QA Officer and the CVRWQCB QA Representative. The DRMP Program QA Officer is Will Hagen from Moss Landing Marine Laboratories (MLML) who will provide QA oversight for field and laboratory procedures, and final data review and assessment of completeness, accuracy, and precision of data generated by this project. The DRMP QA Officer is independent of any direct data generation, such as sample collection, field parameter recording, or laboratory analysis. In addition to procedural QA/Quality Control (QC), the Program QA Officer, in coordination with the Program Manager, is responsible for reviewing laboratory protocols to confirm laboratory compliance with the overall requirements of the DRMP and is ultimately responsible for reviewing project data both for accuracy and comparability with the SWRCB’s SWAMP guidance. Quality assurance oversight for the implementation of DRMP projects and studies is conducted in coordination with the CVRWQCB QA Representative. The SWRCB QA Officer will also be consulted to ensure consistency with SWRCB data management policies.

The DRMP expects data management items, policies, and procedure updates to be discussed and addressed during FY 26-27. Therefore, budget has been allocated for these discussions as part of Collaboration, Governance Documentation, and Resolution Requirements (**Table 3**). As per Resolution R5-2021-0054, any changes or refinements to the Data Management Plan will require approval from the CVRWQCB EO prior to implementation.

MONITORING STUDY DESIGNS

CURRENT USE PESTICIDES

During FY 26-27, the DRMP will finalize the Current Use Pesticide (CUP) Interlaboratory Special Study design and contract with laboratories to implement the special study. In addition, the Steering Committee will provide direction on the development of a CUP Interpretive Report. The DRMP will continue to explore the use of a third-party to evaluate the useability of previous pesticide data collected as part of the CUP monitoring program relative to future interpretive reports and monitoring designs. The third-party review will be done prior to the development of the CUP Interpretive Report.

Study Design

The DRMP will finalize the Interlaboratory Special Study Design in fall 2026. The project implementation will begin in FY 26-27.

Schedule of Deliverables – Interlaboratory Special Study

The deliverables and submission schedule will be included in the final study design which is expected to be approved by the DRMP Steering Committee in fall 2026. The deliverables will be developed to meet the requirements of Resolution R5-2021-0054.

A comprehensive technical report will be developed summarizing all aspects of the interlaboratory proficiency and method comparability study. The report will include:

1. Study design and objectives – description of study rationale, hypothesis, laboratory selection, sample matrices, and analyte selection criteria.
2. Methods and QA/QC results – detailed documentation of analytical procedures, instrument configurations, calibration approaches, method validation results, and laboratory quality control performance.
3. Analytical results with summary tables and graphics – presentation of individual laboratory results, comparisons across laboratories, and visualizations of variability and trends.
4. Statistical comparison of results – analysis of precision, accuracy, and comparability, including identification of outliers or sources of variability.
5. Recommendations - guidance for:
 - a. Improving interlaboratory comparability and consistency;
 - b. Standardizing analytical methods across monitoring programs;
 - c. Using data to support regulatory decision-making, trend analyses, and water quality evaluations.

Final Data in California Environmental Data Exchange Network

Data deliverables associated with the Interlaboratory Special Study for FY 26-27 will be outlined in the final study design (to be approved in fall 2026).

Data Report and QC Report

Data deliverables associated with the Interlaboratory Study for FY 26-27 will be outlined in the final study design (to be approved in fall 2026).

FY Annual Report

The DRMP Annual Report for the previous FY is due on February 1 of each year. According to the requirements outlined in R5-2021-0054, this report must include the following for each project:

- A list and description of all deviations to the QAPP.
- The corrective action(s) taken to address the deviation(s).
- A description of how the DRMP monitors the effectiveness of any corrective actions and ensures any deviations do not occur frequently in the future.
- Summary of dataset completeness, precision, and accuracy.
- A list and description of sample comparisons or tests that did not meet minimum test acceptability criteria for analyses or were considered invalid.
- Results for all analyses completed during the reporting period and comparison of results to previous year's observations, if applicable.
- List of monitoring data (and associated metadata) that do not meet predetermined QC measures and measurement quality objectives.

There will be CUP data from the Interlaboratory Special Study included in the FY 26-27 Annual Report due February 1, 2028.

Long Term Planning

The CUP monitoring sector is rotating into the reporting and planning phase of long-term planning; the next monitoring time period, after the special study implementation, is FY 28-29 (**Figure 3**).

The Steering Committee voiced a desire to do a smaller, special study project while waiting to implement next steps for CUP long-term planning. The finalization of the Interlaboratory Special Study Design (a CUP special study effort) has been included as part of the CUP planning process in FY 26-27 based on feedback from the long-term planning efforts that occurred in August 2024.

The Steering Committee will be responsible for determining the process for providing direction to the CUP TAC on requirements of a CUP Interpretive Report in FY 26-27. For previous Interpretive Reports, the Steering Committee has developed a subgroup comprised of Steering Committee members and TAC with expertise in the area to develop this direction. It is anticipated that this direction for the CUP Interpretive Report will be finalized by the end of FY 26-27. In parallel to this effort, the DRMP is evaluating the use of a third-party entity to review previously collected pesticide data to make recommendations regarding the useability of these data for reporting and analysis efforts such as an interpretive report. The DRMP is developing a draft scope of work for a third-party review. Before the Steering Committee reviews the scope of work for recommendation, the CVRWQCB and State Board will provide feedback on the draft. Once feedback has been received and addressed, the draft will be brought to the next Steering Committee meeting that takes place at least two weeks after the draft is finalized to allow adequate time for review. The earliest the scope of work will be brought to the Steering Committee for review and recommendation is the Steering Committee meeting scheduled for September 26, 2026.

It is expected that the CUP Interpretive Report will answer the previously prioritized core management questions for status and trends and provide recommendations for future monitoring designs. The Interpretive Report is the segue from completed monitoring to planning for the next multi-year monitoring study design and is expected to be developed during FY 27-28.

Long Term Planning Strategy & Milestones

Planning for a CUP Interpretive Report will take place in FY 26-27. Initial activities will focus on developing the process for providing Steering Committee direction on the development of the CUP Interpretive Report, and then developing a Scope of Work and Report Outline that will be used to implement the development of the report. The timing of developing the report will be contingent on the status of the third-party review of the existing DRMP CUP data. Both the CUP Interpretive Report and the third-party review are important deliverables in the long-term planning process to “Determine what is known” (**Figure 4**). Once those are completed, the DRMP will be able to assess the next step, “Identify the DRMP’s niche” which will center on revisiting the management questions and determining which data gaps are of highest priority.

Long Term Planning Schedule

The activities, milestones, and timeframes for completing the long-term planning will be developed in future years after the CUP Interpretive Report has been completed.

Budget

The high-level draft budget for tasks associated with the DRMP CUP project for FY 26-27 is provided in (**Table 3**). The CUP budget is estimated at \$23,752. This does not include costs for the Interlaboratory Special Study, which will be determined in conjunction with the study design finalization. All budgets provided with this Workplan are considered preliminary, with a finalized budget to be submitted prior to the beginning of the FY by June 30, 2026; it is anticipated that the budget amounts will vary by approximately 15% from actuals.

CONSTITUENTS OF EMERGING CONCERN

In FY 26-27, the DRMP will focus on completing the CEC Interpretive Report which will initiate the long-term planning process for CECs. Drafting of the CEC Interpretive Report began during FY 25-26 and is expected to be completed in Fall 2026. After the CEC Interpretive Report is completed, the CEC TAC and Steering Committee will begin the long-term planning process utilizing recommendations from the CEC Interpretive Report.

Study Design

The CEC monitoring program concluded the implementation of the [Central Valley Pilot Study for Monitoring CECs Work Plan](#), referred to as the “CEC Pilot Study”, in FY 23-24. The finalization of data and a final Data Report were completed in FY 24-25. Monitoring for CECs is on pause until the CEC Interpretive Report and long-term planning are complete.

Final Data in CEDEN

There are no expected data deliverables in FY 26-27.

Data Report and QC Report

There are no expected data reports in FY 26-27.

FY Annual Report

The DRMP Annual Report for the previous FY is due on February 1 of each year. As monitoring is paused, there will not be any new data to address in the FY Annual Report due February 1, 2027.

Long Term Planning

Development of the CEC Interpretive Report is the first step of the long-term planning process for CECs. Drafting of the CEC Interpretive Report began during FY 25-26 based on the scope of work and report outline developed by the CEC Report Subgroup (a subgroup of the Steering Committee) and is expected to be completed in September 2026 (FY 26-27).

As part of the long-term planning process, the Steering Committee and CEC TAC will work together to discuss goals and objectives for future monitoring and how the CEC Interpretive Report will help inform future monitoring hypotheses and study design. It is expected that the Steering Committee will provide direction on a CEC multi-year study design in FY 27-28. Long-term planning activities and milestones are outlined in **Table 4**.

Long Term Planning Strategy & Milestones

An Interpretive Report will be completed in FY 26-27. Long-term planning will begin after the completion of the Interpretive Report and continue into FY 27-28.

Table 4. CEC long-term planning activities and milestones (tentative).

GENERAL PLANNING STEPS	FY 26-27 ACTIVITIES	FY 26 -27 MILESTONES	MILESTONE TIME PERIOD
Identify the focus	Review of management and assessment questions	Identify Focus of CEC Long-Term Planning	February 2027
Determine what is known	Review of CEC Interpretive Report	CEC Interpretive Report	September 2026
Prioritize Management & Assessment Questions	Not Applicable	Not Applicable	September 2027
Decide how much to budget	Not Applicable	Not Applicable	September 2027
Provide direction to the TAC	Not Applicable	Not Applicable	December 2027
Develop a multi-year study design	Not Applicable	Not Applicable	December 2028

Long Term Planning Schedule

The activities, milestones, and timeframes for completing the long-term planning will be further detailed in the FY 27-28 Monitoring Workplan. A multi-year study plan for CECs is not expected to be developed until FY 28-29.

Budget

The FY 26-27 budget for CECs includes time for planning and preparing for TAC meetings, a joint Steering Committee and CEC TAC meeting, and finalization of the Interpretive Report. The initial cost estimate for CECs is \$59,385 (**Table 3**).

NUTRIENTS / HABS

In FY 26-27, the DRMP will continue implementation of the Nutrient Multi-Year Study Plan (**Appendix I**). During FY 26-27, modeling performed by San Francisco Estuary Institute – Aquatic Science Center (SFEI-ASC) as part of Focus Area #1 will continue. For the Focus Area #2, Phase 1 of the Nutrient Reduction Bioassay (NRB) study design will begin (pilot experiments and ambient monitoring). The DRMP will continue to look for opportunities to collaborate or leverage funding to better understand harmful cyanobacteria blooms in the Delta including participation in effort to improve monitoring collaboration.

Nutrient Multi-Year Study Plan

The DRMP developed the Nutrient Multi-Year Study Plan to guide long-term studies of the effects of nutrients on the ecology of the Delta. After discussion between the DRMP Steering Committee and the Nutrient TAC, three primary questions (also referred to as focus areas) were developed to guide the development of the Study Plan.

1. Following a reduction in nutrient loading from different point and nonpoint sources, what ranges of nutrient concentrations are expected to occur throughout the Delta, and how might they be affected by climate change, wetland restorations, and water management and routing?
2. What are the thresholds for nutrients (nitrogen (N) and phosphorus (P) and their ratios) that can limit HAB biomass and cyanotoxin accumulation to safe levels, limit the abundance and distribution of nuisance macrophytes, and support robust growth of desirable phytoplankton and macrophytes throughout the Delta?
3. How are the characteristics of harmful cyanobacteria blooms and cyanotoxins in the Delta changing (e.g., species, magnitude, geographic extent, and timing) and what factors contribute to these changes?

The Nutrient Multi-Year Study Plan addresses these three questions or focus areas using a combination of modeling, field/experimental studies, and monitoring. It is not the objective of this Nutrient Multi-Year Study Plan to completely address all three focus area questions. The intent of the studies included in this Study Plan is to begin a multi-year process that begins to address these questions with a hypothesis driven approach and prioritizing data gaps identified by the Steering Committee and Nutrient TAC.

Management and Assessment Questions

The DRMP has agreed upon a set of management questions that reflect specific concerns about multiple aspects of the Delta and the impacts of human activities.

Since each of the management questions is quite broad, it is important to first identify a set of more specific “assessment questions” to guide a future monitoring or special study design. **Table 5** lists the management questions that were developed by the Steering Committee and the assessment questions that were developed by the Nutrient Subcommittee in 2018. When the DRMP Steering Committee prioritized planning for a multi-year study plan, these questions were used as a starting point for the three primary questions or focus areas.

FOCUS AREA #1

Biogeochemical (BGC) modeling efforts will be used to answer the following question by conducting a series of model scenarios based on hypothesis testing to address the following Focus Area #1 question:

- Following a reduction in nutrient loading, what ranges of nutrient concentrations are expected to occur throughout the Delta, and how might they be affected by climate change, wetland restorations, and water management and routing?

In pursuing the above question, the study targets a number of questions the DRMP has identified as priorities (**Table 5**), including Management Questions 2a, 2b, 2c, 3a, and 3b; and Assessment Questions 2.1.A-F and 3.1.

FOCUS AREA #2

To assist with understanding the ecological effects of nutrient reductions, a bioassay study will be used to answer the following Focus Area #2 question:

- What are the thresholds for nutrients (N and P and their ratios) that can limit HAB biomass and cyanotoxin accumulation to safe levels, limit the abundance and distribution of nuisance macrophytes, and support robust growth of desirable phytoplankton and macrophytes throughout the Delta?

The bioassay experiment is an exploratory study that seeks to inform the broad questions listed below using nutrient dilution assays.

- Would nitrogen (N) and phosphorus (P) reductions decrease *Microcystis* growth, biomass accumulation, and toxin production? If so, what level of N and P reduction relative to starting phytoplankton biomass is needed to significantly reduce cyanobacterial harmful algal bloom (CHAB) growth, biomass, and cyanotoxin concentrations?
- Would N and P reductions decrease accumulation of biomass of desirable phytoplankton in the Delta? If so, what is the interaction between N and P reduction and decrease in biomass of *Microcystis* species. versus other phytoplankton species?

- How would other environmental factors, such as change in irradiance, mixing, aquatic plant growth, and clam grazing, alter the effects of N and P reductions on *Microcystis* sp. and/or phytoplankton populations?

Table 5. DRMP management and assessment questions for nutrients.

TYPE	CORE MANAGEMENT QUESTIONS	NUTRIENT ASSESSMENT QUESTIONS
1. Status & Trends	Is there a problem or are there signs of a problem? 1a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? 1b. Which constituents may be impairing beneficial uses in subregions of the Delta? 1c. Are trends similar or different across different subregions of the Delta?	[1.1] How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally? A. Are trends similar or different across subregions of the Delta? B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? C. Are there important data gaps associated with particular water bodies within the Delta subregions?

TYPE	CORE MANAGEMENT QUESTIONS	NUTRIENT ASSESSMENT QUESTIONS
2. Sources, Pathways, Loadings & Processes	Which sources and processes are most important to understand and quantify? 2a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? 2b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? 2c. What are the magnitudes of internal sources and/or pathways (e.g., benthic flux) and sinks in the Delta?	[2.1] Which sources, pathways, and processes contribute most to observed levels of nutrients? A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters? B. What are the loads from tributaries to the Delta? C. What are the sources and loads of nutrients within the Delta? D. What role do internal sources play in influencing observed nutrient levels? E. What are the types and sources of nutrient sinks within the Delta? F. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects? [2.2] How are nutrients linked to water quality concerns such as harmful algal blooms, low dissolved oxygen, invasive aquatic macrophytes, low phytoplankton productivity, and drinking water issues? A. Which factors in the Delta influence the effects of nutrients on the water quality concerns listed above?
3. Forecasting Scenarios	3a. How do ambient water quality conditions respond to different management scenarios. 3b. What constituent loads can the Delta assimilate without impairment of beneficial uses? 3c. What is the likelihood that the Delta will be water quality-impaired in the future?	[3.1] How will nutrient loads, concentrations, and water quality concerns from <i>Sources, Pathways, Loadings & Processes Question #2</i> respond to potential or planned future source control actions, restoration projects, water resource management changes, and climate change?

TYPE	CORE MANAGEMENT QUESTIONS	NUTRIENT ASSESSMENT QUESTIONS
4. Effectiveness Tracking	4a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? 4b. Are loadings changing as a result of management actions?	[4.1] How did nutrient loads, concentrations, and water quality concerns from <i>Sources, Pathways, Loadings & Processes Question #2</i> respond to source control actions, restoration projects, and water resource management changes?

Focus Area #1 – Biogeochemical Modeling

The DRMP has contracted with SFEI-ASC to conduct modeling for Focus Area #1 as outlined in the Nutrient Multi-Year Study Plan (**Appendix I**) and detailed in the Scope of Work (SOW, **Appendix II**).

Study Design

Focus Area #1 modeling began in FY 24-25 including hydrodynamic model setup, calibration and evaluation, and the incorporation of initial biogeochemical model updates and improvements. The Nutrient TAC has been working with the modelers to refine the model including the evaluation and assessment of the importance of both Delta island return flows and aquatic vegetation as part of the calibration and model improvement efforts. Discussion regarding modeling scenarios will continue into FY 26-27 in coordination with the Steering Committee. The FY 26-27 efforts will include biogeochemical model calibration and subsequent model application to simulate proposed load reduction scenarios and the investigation of priority mechanistic hypotheses. In FY 26-27, model application analysis, interpretation, and report drafting and write-up will occur. Progress updates with the Nutrient TAC will occur throughout the year and a summary of work performed in all three focus areas will be provided in the FY 26-27 Annual Report, which is due the following FY (February 1, 2028).

Hypothesis

The Nutrient TAC will work with the modeling team to identify the most relevant set of load reduction scenarios to simulate. Approaches for establishing reduction scenarios include i) identifying a set of percentage reductions to dissolved inorganic nitrogen (DIN) and total nitrogen (TN) from source areas and determine the relative impact on DIN, TN, and chlorophyll a (Chl) concentrations at locations in the Delta, and/or ii) establishing target DIN/TN concentrations at specific locations in the Delta and determining the percentage reduction and the location of the reductions needed to achieve the target concentrations.

Focus Area #2 – Nutrient Reduction Bioassays

Study Design

The DRMP has contracted with Mine Berg at Coastal Conservation and Research, Inc. (CCR) to implement the NRB study design outlined in the Nutrient Multi-Year Study Plan (**Appendix I**). A QAPP Amendment for the NRB project has been submitted to the CVRWQCB and SWRCB on March 3, 2026 (amended on April 1, 2026) and is pending

approval prior to Phase 1 implementation; a copy of the QAPP Amendment is included as **Appendix III**.

Due to delays in FY 25-26, the initial set of pilot studies (Phase 1) will be performed in FY 26-27 to test different variables of the study design, such as source water location, optimal length of incubation duration, how to attain nutrient limited conditions in the treatments and not in the control, how to add a consistent amount of *Microcystis* biomass across treatments and controls, how to best provide mixing of the vessels for a mixing treatment, how to provide different light intensities for an irradiance treatment, and type of macrophyte species and biomass to include.

PHASE 1: SOURCE WATER MONITORING AND PILOT STUDIES

Phase 1 monitoring of the sites listed in **Table 6** will be used to determine a suitable source water location for the Phase 2 full-scale NRB Experiments (FY 27-28). The locations of source water sites to be monitored for the presence of *Microcystis* in the Delta are shown in **Figure 6** and **Table 6**.

Each source water site will be sampled every two weeks over the course of four months, from June through September, providing a total of eight sampling events. Although every effort will be made to sample all three sites every two weeks, source water monitoring can be delayed for equipment failure, excessive heat, or other reasons. The total number of samples anticipated to be collected for source water monitoring including analyte counts are outlined in **Table 7**. During each sampling event, vertical sonde profiles of basic water quality parameters will be recorded and grab samples will be collected for the constituents list in **Table 8**. The *Microcystis* Visual Index (MVI) ranking of the water will be performed visually giving a ranking of 1 (*Microcystis* absent) to 5 (contiguous *Microcystis* colonies) of the source water in accordance with Flynn et al. (2022). Photos (digital images) will also be taken of the water and the MVI rank will be associated with the digital image.

The prime determinant of the suitability of the location to be used as source water for the NRB experiments will be the consistency of the occurrence of a relatively high MVI ranking of the water coupled with a relatively high fluorescence yield, i.e. F_v/F_m , indicating a physiologically healthy *Microcystis* population. A ranking between 3-5 will be considered adequate for using the location for collection of source water for the experiments. In addition to MVI ranking and F_v/F_m , the concentrations of Chl and N (as nitrate) will be determined. A location with relatively high Chl concentration and low N concentration will be preferred. The target concentration of Chl will be above 10 ug/L and the target nitrate concentration will be below 0.1 mg/L. The NRB source water constituents must meet the target concentrations listed in **Table 9**. If the nitrate concentration is above 0.1 mg/L, it may be necessary to dilute the source water with N and P-free water to achieve

the target starting nitrate concentration. In that case, the background phytoplankton community biomass will also be diluted together with the N and P concentrations (and all other macro- and micro-nutrients).

If *Microcystis* is absent during the source water monitoring at all three sampling locations during the summer of 2026, then monitoring of all three sites during July of 2027 will also be performed to check whether *Microcystis* is present in order to determine if the full NRB experiments can be performed in the summer of 2027. If *Microcystis* is absent at the three source water locations in the summer of 2027, then the Phase 2 NRB experiments may have to be delayed until appropriate conditions are present. If *Microcystis* is not observed at the three field sites in the summer of 2026, the QAPP may be amended to include monitoring of additional or alternate sites in the summer of 2027.

The site with the highest MVI score and F_v/F_m (indicating a healthy community) will be used for the pilot NRB experiments. The pilot experiments include tests to be performed in replicate containers suspended *in situ* at the location where the samples are collected. Tests may include 1) examining differences in container type (i.e. material, size, and shape), 2) optimal incubation duration, 3) how to add a consistent amount of *Microcystis* biomass across treatments, 4) differences in starting *Microcystis* concentration on growth, 5) optimal additions of daily nutrient stocks, 6) best method for mixing containers and optimal light intensities for irradiance treatments, and 7) how to best add clams and macrophytes as treatments.

During pilot tests, daily samples will be taken for Chl and nutrient concentrations and the time series will be examined for length of lag and exponential growth phases, and maximum biomass accumulation. Based on the time series data, optimal container(s) type, incubation duration, starting biomass concentrations, nutrient additions, methods of mixing, exposure to light, and best procedure to add macrophytes and clams will be determined.

Samples from the Phase 1 NRB containers will be collected for each treatment following the timing and constituent requirements outlined in **Table 10**. The projected analyte counts for the bioassay monitoring are listed in **Table 11** to reflect a maximum of three NRBs that are up to four-days in length; however, the optimal incubation period will be determined during the Phase 1 pilot studies and is therefore subject to change. Samples will be collected from the Phase 1 NRB containers during each day of the study for each treatment as outlined in **Table 10**.

Table 6. Phase 1 source water monitoring locations.

STATION NAME	CEDEN CODE	LATITUDE	LONGITUDE	DATUM	MATRIX
Big Break Public Pier at East Bay Regional Park	544BGBRPP	38.012598	-121.728338	WGS84	Water
Discovery Bay Boat Launch	544DISBBL	37.905428	-121.587845	WGS84	Water
McLeod Lake at Stockton Downtown Marina	544SJC531	37.95335	-121.29919	NAD83	Water

Table 7. Phase 1 number of ambient water grab sample laboratory analyte counts per location.

Analyte counts represent counts for samples collected for laboratory analyses.

STATION NAME	NUMBER OF EVENTS	ANALYTE COUNT PER EVENT	ANALYTE COUNT TOTAL
Big Break Public Pier at East Bay Regional Park	6	29 ¹	174
Discovery Bay Boat Launch	6	29 ¹	174
McLeod Lake at Stockton Downtown Marina	6	29 ¹	174
Totals		116	522

¹ Phytoplankton abundance and biovolume taxonomy data each count as one analyte count and *Microcystis* chlorophyll (analyte count of three) will only be measured if visually present in the *Microcystis* sample.

Table 8. Constituents to be measured in the field (in situ) or in the NRBs.

CONSTITUENT	AGENCY	MATRIX	METHOD	TECHNOLOGY	FRACTIONS/ ENDPOINTS	REPORTING UNITS
Photo Documentation ¹	CCR	--	Digital Capture	Phone/ digital camera	--	--
Microcystis Visual Index ¹	CCR	Water	Visual Assessment	--	--	Scale Scoring (1-5)
Temperature ¹	CCR	Water	EPA 170.1	AquaTroll Sonde	--	°C
Dissolved Oxygen ¹	CCR	Water	SM 4500-O G	AquaTroll Sonde	--	mg/L
Dissolved Oxygen ¹	CCR	Water	SM 4500-O G	AquaTroll Sonde	--	% saturation
pH ¹	CCR	Water	EPA 150.1	AquaTroll Sonde	--	pH units
Specific Conductivity ¹	CCR	Water	EPA 120.1	AquaTroll Sonde	--	µS/cm
Turbidity ¹	CCR	Water	EPA 180.1	AquaTroll Sonde	--	NTU
Irradiance ^{2,3}	CCR	Water	SM 10200 H	LI-COR quantum sensor	--	W/m2
Active Fluorescence ^{1,2}	CCR	Water	Berg et al. 2017	Phytoflash	Total	RFU
Temperature ²	CCR	Water	EPA 170.1	Hand-held	Total	°C
Dissolved Oxygen ²	CCR	Water	SM 4500-O G	Hand-held	Total	mg/L
Dissolved Oxygen ²	CCR	Water	SM 4500-O G	Hand-held	Total	% saturation
pH ²	CCR	Water	EPA 150.1	Hand-held	Total	pH units
Specific Conductivity ²	CCR	Water	EPA 120.1	Hand-held	Total	µS/cm
Turbidity ^{1,2}	CCR	Water	EPA 180.1	Portable Turbidity Meter	Total	NTU
Ammonia as N	MLML Nutrient Lab	Water	EPA 350.1	Flow Injection Analysis	Dissolved	mg/L
Nitrate as N	MLML Nutrient Lab	Water	EPA 353.4	Flow Injection Analysis	Dissolved	mg/L

CONSTITUENT	AGENCY	MATRIX	METHOD	TECHNOLOGY	FRACTIONS/ ENDPOINTS	REPORTING UNITS
Nitrite as N	MLML Nutrient Lab	Water	EPA 353.4	Flow Injection Analysis	Dissolved	mg/L
Nitrogen, Total	MLML Nutrient Lab	Water	Valderrama 1981	Persulfate digestion followed by flow injection analysis	Dissolved	mg/L
Nitrogen, Organic	MLML Nutrient Lab	Water	EPA 440.0	Elemental Analysis	Particulate	mg/L
Nitrogen, Organic ⁴	MLML Nutrient Lab	Water	NA	Calculation	Dissolved	mg/L
Particulate Organic Carbon	MLML Nutrient Lab	Water	EPA 440.0	Elemental Analysis	Particulate	mg/L
OrthoPhosphate as P	MLML Nutrient Lab	Water	EPA 365.5	Flow Injection Analysis	Dissolved	mg/L
Phosphorus as P	MLML Nutrient Lab	Water	Valderrama 1981	Persulfate digestion followed by flow injection analysis	Dissolved	mg/L
Silicate as Si	MLML Nutrient Lab	Water	EPA 366	Flow Injection Analysis	Dissolved	mg/L
Phosphorus as P, Organic ⁵	MLML Nutrient Lab	Water	NA	Calculation	Dissolved	mg/L
Chlorophyll-a	MLML Nutrient Lab	Water	EPA 445.0	Turner Fluorometer	Particulate	µg/L
Phytoplankton Abundance	BSA Environmental	Water	Beaver et al. 2013	Inverted Microscope	Total	Cells/L
Phytoplankton Biovolume	BSA Environmental	Water	Beaver et al. 2013	Inverted Microscope	Total	µm ³ /L

CONSTITUENT	AGENCY	MATRIX	METHOD	TECHNOLOGY	FRACTIONS/ ENDPOINTS	REPORTING UNITS
<i>Microcystis</i> Colony Geometry	MLML EBL	Water	Göröcs et al. 2018	Aqusens Imaging Flow Cytometry	Total	µm
<i>Microcystis</i> Colony Enumeration	MLML EBL	Water	Göröcs et al. 2018	Aqusens Imaging Flow Cytometry	Total	Colonies/L
<i>Microcystis</i> Chlorophyll-a ⁶	MLML Nutrient Lab	Water	EPA 445.0	Turner Fluorometer	Total	µg/L
Microcystins, Total	MLML EBL	Water	ELISA Abraxis 520011	Enzyme-Linked Immunosorbent Assay (ELISA)	Total	µg/L

¹ Field measurement of ambient water

² Field measurement taken from experimental containers

³ Field measurement of ambient water measured concurrently with NRB experimental container measurements to determine the difference. The reported value will represent the irradiance inside the experimental container.

⁴ Organic Nitrogen = TN – Ammonia – Nitrate – Nitrite

⁵ Organic Phosphorus = Total phosphorus - Orthophosphate

⁶ Measured only if visually present in the collected *Microcystis* sample

Table 9. Source water constituent target concentrations.

CONSTITUENT	TARGET SCORE/CONCENTRATION
<i>Microcystis</i> density / MVI ranking score	3-5 MVI score
Chl concentration at bloom peak	10-30 µg/L
Nitrate concentration	0.05-0.1 mg/L
Phosphate concentration	0.005-0.02 mg/L

Table 10. Phase 1 NRB experiment sample collection days for each test constituent.

CONSTITUENT	SOURCE WATER ¹	PILOT EXPERIMENTAL CONTAINER MEASUREMENTS				
	Day 0 - Initial	Day 0	Day 1	Day 2	Day 3	Day 4
Irradiance ²	--	X	--	--	--	--
Active Fluorescence ²	X	--	X	X	X	X
Temperature ²	X	--	--	--	--	--
Dissolved Oxygen ²	X	--	--	--	--	--
pH ²	X	--	--	--	--	--
Specific Conductivity ²	X	--	--	--	--	--
Turbidity ²	X	--	--	--	--	--
Ammonia as N	X	--	X	X	X	X
Nitrate as N	X	--	X	X	X	X
Nitrite as N	X	--	X	X	X	X
Nitrogen, Total	--	--	--	--	--	--
Nitrogen, Organic (particulate)	--	--	--	--	--	--
Nitrogen, Organic (dissolved)	--	--	--	--	--	--
Particulate Organic Carbon	--	--	--	--	--	--
OrthoPhosphate as P	X	--	X	X	X	X
Phosphorus as P	--	--	--	--	--	--
Phosphorus as P, Organic	--	--	--	--	--	--
Silicate as Si	X	--	X	X	X	X
Chlorophyll-a	X	--	X	X	X	X
Phytoplankton Abundance	--	--	--	--	--	--
Phytoplankton Biovolume	--	--	--	--	--	--
<i>Microcystis</i> Colony Geometry	--	--	--	--	--	--
<i>Microcystis</i> Colony Enumeration	--	--	--	--	--	--
<i>Microcystis</i> Chlorophyll-a	--	--	--	--	--	--
Microcystins, Total	--	--	--	--	--	--

¹ Measurements taken from barrel prior to mixing.

² Field measurement.

Table 11. Phase 1 NRB Experimental container monitoring samples and laboratory analyte counts.

PROJECT PHASE	NUMBER OF NRB EXPERIMENTS	DAYS PER NRB EXPERIMENT	TOTAL NUMBER OF NRB CONTAINERS ²	ANALYTE COUNT
Phase 1 ¹	3	4	45	1,281

¹ The number of NRBs and the optimal incubation period (days per NRB) will be determined during the study. The values presented represent the maximum projected estimates for this pilot phase and are subject to change.

² Phase 1 NRB experiment counts are calculated with 15 containers per experiment (total of 45 containers).

HYPOTHESIS

Below are initial hypotheses to test the questions outlined under Management and Assessment Questions.

To investigate the efficacy of nutrient reductions on growth and biomass accumulation of CHABs, focus will be put on hotspot regions which reliably develop *Microcystis* blooms annually to answer the three broad questions with associated hypotheses listed in **Table 12**.

Table 12. NRB Experiment questions and hypotheses.

QUESTION	HYPOTHESIS	
Would N and P reductions decrease <i>Microcystis</i> growth, biomass accumulation, and toxin production? If so, what level of N and P reduction relative to starting phytoplankton biomass is needed to significantly reduce CHAB growth, biomass, and cyanotoxin concentrations?	1	Growth of <i>Microcystis</i> will cease (i.e. become zero or negative) and biomass accumulation will cease when the ratio of <i>Microcystis</i> Chl concentration (µg/L) to N concentration (µmol/L) in the growth medium (i.e. Chl:N ratio g:mol) is above or equal to 1 in the Nutrient Reduction Bioassays (NRBs).
	2	The P concentration will modulate <i>Microcystis</i> growth rate at a Chl:N ratio (g:mol) above 1, but not at a ratio below 1 in the NRBs.
	3	Cyanotoxin production will cease when growth rate of <i>Microcystis</i> is no longer positive (i.e. zero or negative).

QUESTION	HYPOTHESIS	
Would N and P reductions decrease accumulation of biomass of desirable phytoplankton in the Delta? If so, what is the interaction between N and P reduction and decrease in biomass of <i>Microcystis</i> species. versus other phytoplankton species?	1	Growth of all phytoplankton, including <i>Microcystis</i> , will cease (i.e. become zero or negative) and biomass accumulation will cease when the community Chl:N ratio (g:mol) is above or equal to 1 in the NRBs.
How would other environmental factors, such as change in irradiance, mixing, aquatic plant growth, and clam grazing, alter the effects of N and P reductions on <i>Microcystis</i> sp. and/or phytoplankton populations?	1	Effects of N and P reductions would impact all phytoplankton, including <i>Microcystis</i> , equally and not be altered by a secondary environmental factor because nutrient limitation takes precedence over other physiological impacts.

MONITORING LOCATIONS

Beginning June 2026 and continuing into FY 26-27, Phase 1 of the Nutrient Bioassay Reduction study (Focus Area #2) will take place. Phase 1 will consist of field monitoring at hot spot locations and a pilot NRB study.

Three field sites, Stockton Waterfront, Big Break, and Discovery Bay (**Table 6**) will be monitored. Field monitoring of source water will occur two times per month from June through September. Monitoring will include the field measurements and analysis of grab samples for the constituents listed in **Table 8**. Grab samples will be analyzed for the constituents indicated in **Table 8**, which also specifies the agencies responsible for analyzing each sample. Timing of sample collections at each site will be coordinated such that samples collected by various project personnel will be transported together to the assigned laboratories for analysis.

Figure 6. Map of the Delta highlighting potential CHAB hot spots with markers at Big Break, Discovery Bay, and the Stockton waterfront.



MONITORING EVENTS

Field monitoring will occur two times per month from June through September and include taking digital photos and recording the MVI score (**Table 9**). In addition, grab samples and vertical water profiles by sonde will be collected. Alternatively, sondes may be deployed permanently for continuous water quality measurements, including temperature, electrical conductivity (EC), potential of hydrogen (pH), dissolved oxygen (DO), and Chl fluorescence. Sonde deployment will be combined with collection of grab samples two times per month. Grab samples will be analyzed for Chl concentration (extracted), nutrient concentrations (panel will include nitrate, nitrite, ammonium, ortho-phosphate, and silica), phytoplankton species identification and enumeration, and sampling for active fluorescence determination (i.e. photosynthetic efficiency) and the Aqusens phytoplankton imager by the MLML collaborator Dr. Holly Bowers. The latter measurements will enable determination of phytoplankton health and sizing/biomass determination of *Microcystis* colonies. All grab samples will be analyzed by MLML.

The MLML Nutrient Analysis Laboratory specializes in low concentration nutrient analyses, can provide quick sample turnaround if specifically requested, and is therefore an ideal choice for the proposed project. For the NRBs, very low nutrient concentrations (i.e. $\sim 0.5 \mu\text{mol/L}$ for nitrate) will need to be accurately measured in the experimental containers. Additionally, a guaranteed analysis turnaround time of one day will be necessary at the start of the experiment. Both these conditions can be met by the MLML Nutrient Laboratory.

MONITORING CONSTITUENTS

At each source water sampling event, vertical sonde profiles of basic water quality parameters will be recorded and grab samples will be collected for the constituents specified in **Table 8**. **Table 13** summarizes how many replicates will be collected for each constituent. Replicates are counted in the analyte counts included in **Table 7** and **Table 11** and will not be counted separately as field QC.

For each Phase 1 NRB treatment, samples will be collected from the experimental containers according to the schedule and constituent list provided in **Table 10**. The total number of samples anticipated to be collected for source water monitoring, and analyte counts are outlined in **Table 7**. The projected analyte counts for the bioassay monitoring are listed in **Table 11** to reflect a maximum of three NRBs that are up to four days in length; however, the optimal incubation period will be determined during the Phase 1 pilot studies and is therefore subject to change.

For this project, all ambient water samples will be collected in duplicate or triplicate to enhance data reliability and account for sampling variability. The average of the replicate

samples will be used for project data reporting and interpretation, incorporating the inherent variability. Variability in sample results is expected from multiple sources, including but not limited to, environmental heterogeneity, field sampling procedures, and matrix effects. By averaging replicate samples, variability from these sources is incorporated into reported values, reducing the impact of outliers and improving representativeness.

Table 13. Summary of replicates collected per constituent.

CONSTITUENT	METHOD	FRACTIONS/ ENDPOINTS	REPLICATES PHASE 1 SOURCE WATER MONITORING	REPLICATES PHASE 1 NRB EXP CONTAINER MONITORING
Photo Documentation ¹	Digital Capture	--	3	NA
Microcystis Visual Index ¹	Visual Assessment	--	1	NA
Temperature ¹	EPA 170.1	--	NA	NA
Dissolved Oxygen ¹	SM 4500-O G	--	NA	NA
pH ¹	EPA 150.1	--	NA	NA
Specific Conductivity ¹	EPA 120.1	--	NA	NA
Turbidity ¹	EPA 180.1 (Sonde)	--	NA	NA
Irradiance ³	SM 10200 H	--	NA	1
Active Fluorescence ^{1,2}	Berg et al. 2017	Total	2	1
Temperature ²	EPA 170.1	Total	NA	1
Dissolved Oxygen ²	SM 4500-O G	Total	NA	1
pH ²	EPA 150.1	Total	NA	1
Specific Conductivity ²	EPA 120.1	Total	NA	1
Turbidity ^{1,2}	EPA 180.1 (portable meter)	Total	3	1
Ammonia as N	EPA 350.1	Dissolved	2	1
Nitrate as N	EPA 353.4	Dissolved	2	1
Nitrite as N	EPA 353.4	Dissolved	2	1
Nitrogen, Total	Valderrama 1981 / EPA 353.4	Dissolved	2	NA
Nitrogen, Organic	EPA 440.0	Particulate	NA	NA
Nitrogen, Organic	Calculation	Dissolved	2	1
Particulate Organic Carbon	EPA 440.0	Particulate	NA	NA
OrthoPhosphate as P	EPA 365.5	Dissolved	2	1
Phosphorus as P	Valderrama 1981 / EPA 365.5	Dissolved	2	NA

CONSTITUENT	METHOD	FRACTIONS/ ENDPOINTS	REPLICATES PHASE 1 SOURCE WATER MONITORING	REPLICATES PHASE 1 NRB EXP CONTAINER MONITORING
Phosphorus as P, Organic	Calculation	Dissolved	2	1
Silicate as Si	EPA 366	Dissolved	2	1
Chlorophyll-a	EPA 445.0	Particulate	3	2
Phytoplankton Abundance	Beaver et al. 2013	Total	1	NA
Phytoplankton Biovolume	Beaver et al. 2013	Total	1	NA
<i>Microcystis</i> Colony Geometry	Göröcs et al. 2018	Total	1	NA
<i>Microcystis</i> Colony Enumeration	Göröcs et al. 2018	Total	1	NA
<i>Microcystis</i> Chlorophyll- a	EPA 445.0	Particulate	3	NA
Microcystins, Total	ELISA Abraxis 520011	Total	1	NA

¹ Field measurement of ambient water.

² Field measurement taken from experimental container.

³ Field measurement of ambient water measured concurrently with NRB experimental container measurements to determine the difference. The reported value will represent the irradiance inside the experimental container.

Focus Area #3 – HAB Monitoring

During FY 24-25, the DRMP developed a Focus Area #3 Request for Proposals (RFP) document that provides guidance for potential applicants seeking funding for research projects focused on understanding changes in the status of HABs in the Delta. The DRMP will continue to work with other monitoring groups to evaluate projects that meet the objectives of Focus Area #3 to determine if the DRMP should contribute funds. The DRMP is actively collaborating with Delta CHAB Strategy Implementation Team (CHABs-IT) of the IEP Water Quality and Phytoplankton Project Work Team which is a multi-agency effort including DWR, SWRCB, California Fish and Wildlife, and USGS. If a project under Focus Area #3 is identified and funded, the FY 26-27 Workplan will be amended to include the study design, deliverables, and project-specific budget.

Schedule of Deliverables

The overall schedule of deliverables for FY 26-27 nutrient monitoring is outlined below.

QAPP Amendment

The QAPP Amendment for the upcoming FY must be submitted to the CVRWQCB by May 1 of each year, per the requirements outlined in R5-2021-0054. The QAPP Amendment must:

- Meet guidance and requirements from both the Water Boards and EPA,
- Include a documentation process for deviations and an assessment of corrective action process, and
- Be reviewed and approved by the State Water Board QA Officer or the Central Valley Water Board's QA Officer before project implementation can occur.

A QAPP Amendment for the Focus Area #2 NRB project was submitted on March 3, 2026 (amended on April 1, 2026); a copy of the QAPP is included as **Appendix III**. Any deviations or amendments to the Workplan and/or QAPP(s) during FY 26-27 will be documented and reported to the CVRWQCB as required in the Resolution.

Preliminary Data

According to the requirements outlined in Resolution R5-2021-0054, preliminary data in the form of unverified/raw results provided by the project laboratories will be submitted within 60 days of the sample analysis date for each sampling event. Raw data and laboratory reports (where applicable) are provided to the Nutrient TAC and CVRWQCB staff via upload to a shared file storage site. The DRMP will also email the following CVRWQCB staff with the preliminary data attached to the email when the files are uploaded to the file storage site: Executive Officer Patrick Pulupa, Program Manager Daniel Ellis, and Environmental Scientist Ryan Brown.

Final Data in Central Valley Regional Data Center

Field data from Focus Area #2 will be processed by the Central Valley Regional Data Center (CV RDC) Data Management Team (DMT) and loaded into the CV RDC for storage and analysis prior to being published to CEDEN. The DMT is responsible for reviewing reports and electronic data deliverables (EDDs) to ensure completeness, assessing whether project measurement quality objectives (MQOs) were met, and ensuring CEDEN/SWAMP comparability. The DMT is responsible for uploading data to the CV RDC, performing final checks, and transferring data to CEDEN annually within 6 months of the last sampling date per Resolution R5-2021-0054. The CV RDC will track completion of monitoring events and data received; this information will be used to complete the QA Report at the end of the monitoring year.

Stage 1 data are reviewed by DMT staff during the data loading process for each individual EDD received. Data verification by the CV RDC DMT according to the

approved Data Management SOP occurs as close to receipt of the EDD as possible to ensure that any analytical issues identified during review can be communicated with laboratories and resolved in a timely manner. Once loaded into the CV RDC, an additional data verification is conducted by Program QA Officer (or a delegate) on a result and batch level for individual results sets. The QA Officer applies the appropriate compliance codes to each reviewed record, indicating the data are finalized on the result and batch level. These Stage 2 data are considered final data and are then exported and provided to the TAC, stakeholders, and CVRWQCB staff. Per Resolution R5-2021-0054, this is done within six months of sample analysis.

Per the Resolution R5-2021-0054 requirement, a QA assessment for samples collected in the previous fiscal year must be included in the DRMP Annual Report. This assessment will include all of the QA section elements identified in R5-2021-0054 and is considered an intermediate QA Assessment if not all samples will have been received, verified, and finalized. The Program QA Officer will conduct a final review and assessment of the data prior to transferring to CEDEN.

Data that cannot be published on CEDEN will be hosted on DRMP servers for access by stakeholders.

Data and Reporting Deliverables

Modeling work associated with Focus Area #1 is being conducted with open-source/public-domain tools, and all data, model output, and scripts. For Focus Area #1, the key deliverable will be the Final Technical Report which is expected in FY 26-27 (**Table 14**).

All data and reporting deliverables for work conducted in FY 26-27 for Focus Area #2 are outlined in **Table 15**.

Table 14. Focus Area #1 project deliverable schedule timeline.

DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
Resolution Deliverables				
DRMP FY 26-27 Annual Report	February 1, 2028	July 1, 2026 – June 30, 2027	Annually	Annual Report for FY 26-27 (Progress on modeling efforts)
Additional Study Deliverables				
Draft and Final Technical Report	January 2027	January 2025 – November 2026	Once	Draft and final report on the results of the Base-Case and Scenario simulations including analysis and interpretation of model outputs; includes technical appendices.

Table 15. Focus Area #2 project deliverable schedule timeline.

DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
Resolution Deliverables				
Preliminary Data (Phase 1 and Phase 2)	60 calendar days	Sample analysis	Per sample event	Preliminary data collected during Phase 1 and 2 delivered within 60 calendar days of the sample analysis date.
Final Data: CHAB Hot Spot Field Data (Phase 1)	6 months / October 2026	Sample analysis / June-September 2026	Per event	Spreadsheet containing nutrient, Chl, MVI ranking, phytoplankton, and basic water quality data, collected from the 3 CHAB hot spot locations in the Delta.
Final Data: Pilot NRB (Phase 1)	6 months / November 2026	Sample analysis / July – September 2026	Per event (experiment)	Spreadsheet containing results of NRB pilot tests and analyses of various test parameters.
Final Data: NRB Experiment 1 Data (Phase 2)	6 months/ October 2027	Sample analysis / August 2027	Per event (experiment)	Spreadsheet containing all data collected from first NRB experiment.
Final Data: NRB Experiment 2 & 3 Data (Phase 2)	6 months / November 2027	Sample analysis / September 2027	Per event (experiment)	Spreadsheet containing all data collected from second and potentially third NRB experiments.
DRMP FY 26-27 Annual Report	February 1, 2028	July 1, 2026 – June 30, 2027	Annually	Annual Report for FY 25-26 (Phase 1 efforts)
DRMP FY 27-28 Annual Report	February 1, 2029	July 1, 2027 – June 30, 2028	Annually	Annual Report for FY 27-28 (Phase 2 efforts)
Additional Study Deliverables				
Technical Memo	October 2026	October 2026	Once	Report on Phytoplankton Community Parameters at 3 CHAB Hot Spot Locations in the Delta

DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
Phase 1 Data Report and QA Assessment	December 2026	November-December 2026	Once	Draft and final report on Pilot Experiment Results including Phytoplankton Community Parameters at 3 CHAB Hot Spot Locations in the Delta
Phase 2 Data Report and QA Assessment	April 2028	October 2027-April 2028	Once	Draft and final report on NRB experiment results

Budget

The high-level draft budget for tasks associated with the DRMP Nutrient Focus Area #1 and Focus Area #2, and funds allocated for potential studies under Focus Area #3 is provided in (Table 3). The Nutrient budget is estimated at \$553,333. All budgets provided with this Workplan are considered preliminary, with a finalized budget to be submitted prior to the beginning of the FY by June 30, 2026; it is anticipated that the budget amounts will vary by approximately 15% from actuals.

MERCURY

The Steering Committee developed direction to the Mercury TAC for a multi-year study design as part of its long-term planning for mercury in FY 25-26 using the information provided in the Mercury Interpretive Report. The DRMP Mercury Interpretive Report, which was completed in FY 24-25, provided critical information and analysis that informs DRMP stakeholders on the status and trends of aqueous and fish methylmercury concentrations in the Delta. The Mercury TAC has utilized this direction to develop the Mercury Study Plan (2027-2031) (**Appendix IV**) with the plan to finalize a Quality Assurance Project Plan (QAPP) in FY 26-27 and begin monitoring in spring 2027.

Study Design

The Mercury Study Plan (2027-2031) is designed to track progress toward achieving mercury reduction goals as outlined in the Delta Mercury Control Program (DMCP) and monitor mercury concentrations in fish tissue and surface water samples to establish long-term trends and assess variability over time.

The objectives, study questions, and hypotheses collectively define the rationale for data collection and the expected outcomes. All details can be found in the Mercury Study Plan (2027-2031) included as outlined in **Appendix IV**.

A QAPP for the Mercury Study Plan (2027-2031) will be developed during FY 26-27.

Management and Assessment Questions

The Mercury Study Plan (2027-2031) is focused on the sub-questions outlined in **Table 16**.

Table 16. DRMP mercury management and assessment status and trends questions addressed or informed by each mercury monitoring element.

CORE MANAGEMENT QUESTIONS	ASSESSMENT QUESTIONS	SUB-QUESTIONS	
		SUBREGIONAL TRENDS IN BASS	SUBREGIONAL TRENDS IN WATER
Is there a problem or are there signs of a problem? a) Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b) Are trends similar or different across different subregions of the Delta?	What are the status and trends in ambient concentrations of total mercury and methylmercury (MeHg) in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large-scale restoration projects)?	Are trends over time in MeHg in sport fish similar or different among Delta subareas?	Are trends over time in MeHg in water similar or different among Delta subareas?

Hypothesis

The Mercury Study Plan (2027-2031) is guided by the following hypotheses:

Hypothesis #1:

H₀ (Null Hypothesis): There is no statistically significant change over time in annual mean methylmercury concentrations in surface waters within or among Delta subregions.

H₁ (Alternative Hypothesis): methylmercury concentrations in surface waters exhibit statistically significant temporal trends and/or spatial differences among Delta subregions.

Hypothesis #2:

H₀ (Null Hypothesis): There is no statistically significant change over time in annual mean methylmercury concentrations in fish tissue within or among Delta subregions.

H₁ (Alternative Hypothesis): Methylmercury concentrations in fish tissue exhibit statistically significant temporal trends and/or spatial differences among Delta subregions.

Monitoring Locations

Sampling sites consist of seven fixed core monitoring stations. All seven stations will be sampled for water in the spring, and for fish tissue and water in the fall. Core monitoring

stations represent open-water habitats and provide long-term baseline data for assessing status and trends in mercury concentrations across the Delta. Planned mercury sampling stations are listed in **Table 17**.

Table 17. Core monitoring stations for mercury in water and fish.

#	CEDEN STATION CODE	STATION NAME	LATITUDE	LONGITUDE	FISH SAMPLING	WATER SAMPLING
1	510ADVLIM	Cache Slough at Liberty Island Mouth ¹	38.24213	-121.68539	X	X
2	544LILPSL	Little Potato Slough	38.09627	-121.49602	X	X
3	544MDRBH4	Middle R @ Borden Hwy (Hwy 4)	37.89083	-121.48833	X	X
4	544ADVLM6	Lower Mokelumne R 6	38.25542	-121.44006	X	X
5	510ST1317	Sacramento R @ Freeport	38.45556	-121.50189	X	X
6	541SJR2AW	San Joaquin River 2 miles upstream of Airport Way	37.665367	-121.246050	X	X
7	510ST1666	Sherman Island ¹	38.0431	-121.8044	X	X

¹ The existing permit does not allow for electrofishing at these locations; sampling crews will collect fish using hook and line sampling methods.

CEDEN = California Environmental Data Exchange Network

Monitoring Events

Two monitoring events will be conducted each project year. A spring monitoring event will target March (with flexibility to extend into April if needed) and will include surface water sampling only. A fall monitoring event will target September (with flexibility to occur as early as August or as late as October, if needed), and will include both fish tissue and surface water sampling. An outline of the entire project schedule is included in **Appendix IV**. Monitoring for the Mercury Study Plan (2027-2031) is expected to begin with the spring water monitoring during FY 26-27.

Monitoring Constituents

The specific constituents to be measured are listed in **Table 18**.

Table 18. Constituents to be measured.

CONSTITUENT	FRACTIONS/ ENDPOINTS	MATRIX	SAMPLE TYPE	PROJECT DETECTION LIMIT	REPORTING UNITS
Oxygen, Dissolved	NA	Water	In situ	0 to 20 mg/L: ± 0.1 mg/L or 1% of reading, whichever is greater; 20 to 50 mg/L: $\pm 5\%$ of reading	mg/L
Oxygen, Dissolved	NA	Water	In situ	0 to 200%: $\pm 1\%$ of reading or 1% saturation, whichever is greater; 200 to 500%: $\pm 5\%$ of reading	% saturation
pH	NA	Water	In situ	± 0.1 pH units within $\pm 10^\circ\text{C}$ of calibration temp; ± 0.2 pH units for entire temp range	pH
Specific Conductivity	NA	Water	In situ	0 to 100: $\pm 0.5\%$ of reading or 0.001 mS/cm, whichever is greater; 100 to 200: $\pm 1\%$ of reading	$\mu\text{S}/\text{cm}$
Temperature	NA	Water	In situ	5 to 35°C : $\pm 0.01^\circ\text{C}$ 35 to 50°C : $\pm 0.05^\circ\text{C}$	$^\circ\text{C}$
Turbidity	NA	Water	In situ	0 to 999 FNU: 0.3 FNU or $\pm 2\%$ of reading, whichever is greater; 1000 to 4000 FNU: $\pm 5\%$ of reading	FNU or NTU
Chlorophyll a	Particulate	Water	Grab	1	$\mu\text{g}/\text{L}$
Dissolved Organic Carbon (DOC)	Dissolved	Water	Grab	0.23	mg/L
Total Suspended Solids (TSS)	Total	Water	Grab	NA	mg/L
Volatile Suspended Solids (VSS)	Total	Water	Grab	NA	mg/L
Mercury, total	Dissolved	Water	Grab	0.14	ng/L
Mercury	Total	Water	Grab	0.14	ng/L
Mercury, Methyl	Dissolved	Water	Grab	0.015	ng/L
Mercury, Methyl	Total	Water	Grab	0.015	ng/L

CONSTITUENT	FRACTIONS/ ENDPOINTS	MATRIX	SAMPLE TYPE	PROJECT DETECTION LIMIT	REPORTING UNITS
Total Length	NA	Tissue	Individual	NA	mm
Fork Length	NA	Tissue	Individual	NA	mm
Weight	NA	Tissue	Individual	NA	g
Sex	NA	Tissue	Individual	NA	male/ female/ unknown
Moisture	NA	Tissue	Individual	NA	%
Mercury, total	NA	Tissue (fillet muscle)	Individual	0.004	µg/g ww

NA = Not Applicable

Schedule of Deliverables

The overall project schedule for the Mercury Study (2027-2031) covering sampling timeframe, QAPP documentation, and data reporting are outlined in **Table 21** and **Figure 7**. More details regarding QAPP timelines, preliminary and final data timelines, and data and reporting deliverables are included in the sections below.

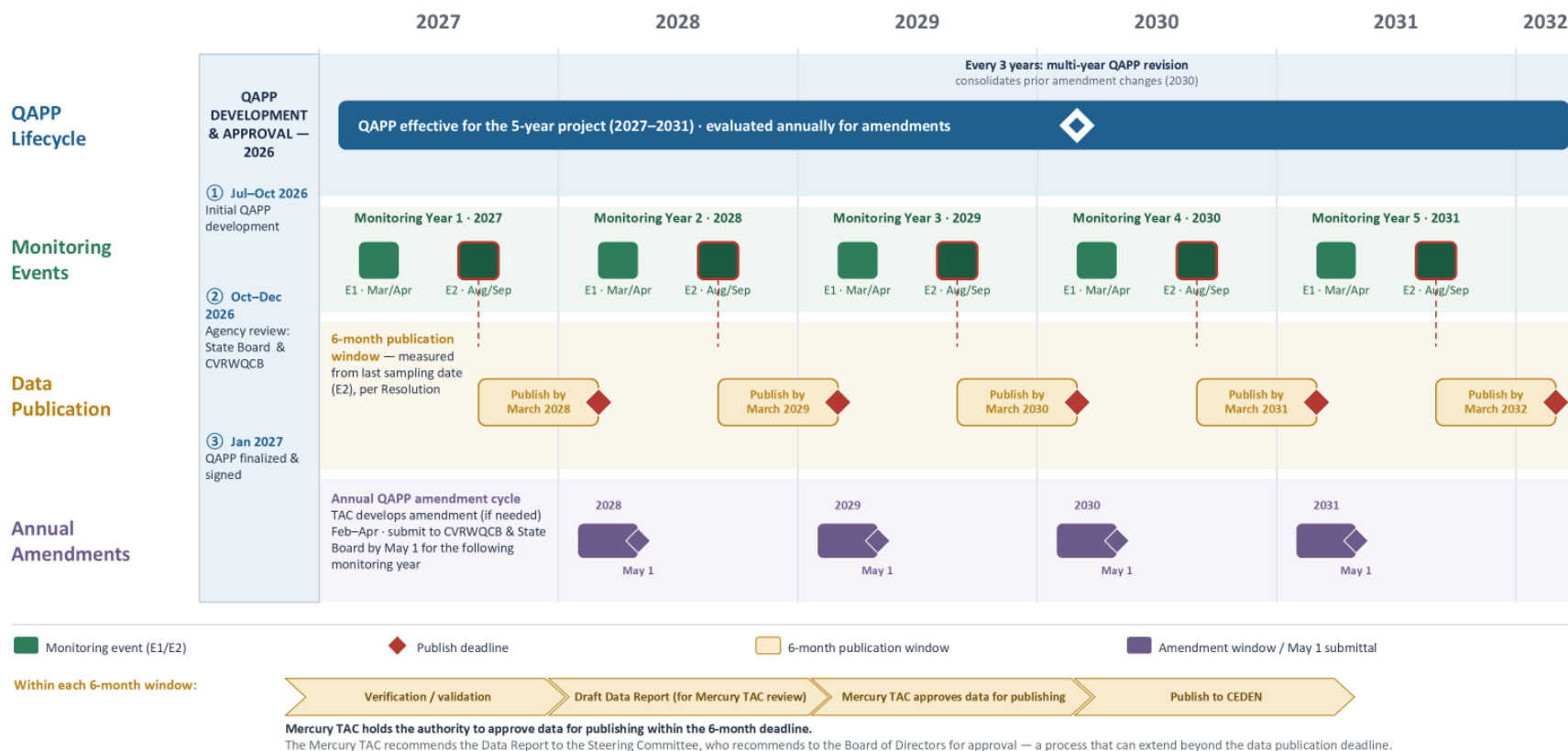
Table 19. Mercury Study (2027-2031) project year milestones.

PROJECT YEAR	SAMPLING TIMEFRAME	QAPP/QAPP AMENDMENT	FINAL DATA (PUBLICLY AVAILABLE)	ANNUAL REPORT
Year 1	March – September 2027	October 16, 2026	February/ March 2028	Spring event: February 1, 2028 Fall event: February 1, 2029
Year 2	March – September 2028	May 1, 2027	February/ March 2029	Spring event: February 1, 2029 Fall event: February 1, 2030
Year 3	March – September 2029	May 1, 2028	February/ March 2030	Spring event: February 1, 2030 Fall event: February 1, 2031
Year 4	March – September 2030	May 1, 2029	February/ March 2031	Spring event: February 1, 2031 Fall event: February 1, 2032
Year 5	March – September 2031	May 1, 2030	February/ March 2032	Spring event: February 1, 2032 Fall event: February 1, 2033

Figure 7. Mercury QAPP five-year timeline, data finalization, and QAPP amendments relative to Resolution deadlines.

Delta RMP Mercury Monitoring — QAPP & Data Publication Timeline

Five-year QAPP lifecycle (2026–2032): development & approval, monitoring events, 6-month data-publication windows, and the annual amendment cycle



QAPP

A QAPP for the Mercury Study Plan (2027-2031) will be developed and finalized during FY 26-27, with a goal to have the report under review by SWRCB and CVRWQCB in October 2026. The QAPP will be developed to cover the entire monitoring timeframe of 2027 – 2031 with planned amendments and revisions as outlined in **Table 21** and **Figure 7**. See **Table 20** for a summary of deliverables and submissions pertaining to QAPPs.

Table 20. QAPP deliverable due dates associated with the Mercury Study Plan (2027-2031).

RESOLUTION DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
Mercury Study (2027-2031) QAPP	October 16, 2026	All project years.	Initial submittal and approval required prior to the start of the project.	Documents study objectives, project organization, data quality objectives, field and laboratory methods, sample handling, analytical procedures, QA/QC requirements, data management, and reporting protocols.
QAPP Amendment	May 1	Any change or update needed to QAPP details prior to upcoming project year.	Annually.	Document any changes or updates needed to the QAPP to reflect current practices, laboratory QC, changes in project personnel leading into the next project year.
QAPP Deviation Reports	Within 7 days of Project Personnel becoming aware of the deviation.	Occurrence of deviation from QAPP.	As needed.	Report of any deviations from the QAPP that can prevent project and data quality objectives from being met that were not previously approved by the CVRWQCB in the QAPP.

Preliminary Data

According to the requirements outlined in Resolution R5-2021-0054, preliminary data in the form of unverified/raw results provided by the project laboratories will be submitted within 60 days of the sample analysis date for each sampling event. Raw data and laboratory reports (where applicable) are provided to the Mercury TAC and CVRWQCB staff via upload to a shared file storage site. The DRMP will also email the following CVRWQCB staff with the preliminary data attached to the email when the files are uploaded to the file storage site: Executive Officer Patrick Pulupa, Program Manager Daniel Ellis, and Environmental Scientist Ryan Brown.

Final Data in CEDEN

Field data from the Mercury Study Plan (2027-2031) will be processed by the CV RDC DMT and loaded into the CV RDC for storage and analysis prior to being published to CEDEN. The DMT is responsible for reviewing reports and EDDs to ensure completeness, assessing whether project MQOs were met, and ensuring CEDEN/SWAMP comparability. The DMT is responsible for uploading data to the CV RDC, performing final checks, and transferring data to CEDEN annually within 6 months of the last sampling date per Resolution R5-2021-0054. The CV RDC will track completion of monitoring events and data received; this information will be used to complete the QA Report at the end of the monitoring year.

Stage 1 data are reviewed by DMT staff during the data loading process for each individual EDD received. Data verification by the CV RDC DMT according to the approved Data Management SOP occurs as close to receipt of the EDD as possible to ensure that any analytical issues identified during review can be communicated with laboratories and resolved in a timely manner. Once loaded into the CV RDC, an additional data verification is conducted by the Program QA Officer (or a delegate) on a result and batch level for individual results sets. The QA Officer applies the appropriate compliance codes to each reviewed record, indicating the data are finalized on the result and batch level. These Stage 2 data are considered final data and are then exported and provided to the TAC, stakeholders, and CVRWQCB staff. Per Resolution R5-2021-0054, this is done within six months of sample analysis.

Per the Resolution R5-2021-0054 requirement, a QA assessment for samples collected in the previous fiscal year must be included in the DRMP Annual Report. This assessment will include all of the QA section elements identified in R5-2021-0054 and is considered an intermediate QA Assessment if not all samples will have been received, verified, and finalized. The Program QA Officer will conduct a final review and assessment of the data prior to transferring to CEDEN.

Data and Reporting Deliverables

There are no expected final data, QC report deliverables, or data reporting in the FY Annual Report during FY 26-27. All data and reporting deliverables for work under the Mercury Study Plan (2027-2031) will occur as outlined in **Table 21**.

Table 21. Data and reporting deliverable due dates associated with the Mercury Study Plan (2027-2031).

RESOLUTION DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
DRMP Annual Monitoring Workplan	May 1	Next fiscal year (July 1 through June 30)	Annually	Identifies projects the DRMP will implement over the next FY (July 1 through June 30), including budget and study design, among other elements.
DRMP Annual Report	February 1	Previous fiscal year (July 1 – June 30)	Annually	Report FY progress on monitoring effort.
Quarterly Report	November 1	July 1 – September 30	Quarterly	Summarizes all decisions made by the DRMP organization, all challenges the program encounters that could cause deviations to the Monitoring Workplan, Data Management Plan, and QAPP, and any changes to foundational DRMP policy and procedure documents.
Quarterly Report	February 1	October 1 – December 31	Quarterly	
Quarterly Report	May 1	January 1 – March 31	Quarterly	
Quarterly Report	August 1	April 1 – June 30	Quarterly	
Preliminary Data	60 calendar days from date of sample analysis	Sample analysis	Per sample event	Preliminary data collected during the 27-31 mercury study delivered within 60 calendar days of sample analysis date.
Finalized Data Submittal to CVRWQC	6 months from date of	Sample analysis	Per sample event	Spreadsheet containing results of the 27-31 mercury

RESOLUTION DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
	sample analysis			study monitoring results and analyses of various test parameters.
Publish Finalized Data	6 months from the last sampling date	Sample collection	Annually	Finalized data published to CEDEN.
Mercury Interpretive Report	2 years from completion of project (October 2033)	All project years.	Once	Draft and final report on the results of the 27-31 mercury study including analysis and interpretation of monitoring data; includes technical appendices.

Budget

The FY 26-27 budget for mercury is estimated at \$104,419 (**Table 3**). All budgets provided with this Workplan are considered preliminary, with a finalized budget to be submitted prior to the beginning of the FY by June 30, 2026; it is anticipated that the budget amounts will vary by approximately 15% from actuals.

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Appendix I – Nutrient Multi-Year Study Plan



Nutrient Multi-Year Study Plan

Version 1.0
Approved on March 18, 2024

Prepared By:



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LIST OF ACRONYMS

ACRONYM	DEFINITION
ANOVA	Analysis of Variance
ASC	Aquatic Science Center
BGC	Biogeochemical
chl-a	Chlorophyll-a
CSC	Cache Slough Complex
CVRWQCB	Central Valley Regional Water Quality Control Board

DCC	Delta Cross Channel
Delta RMP	Delta Regional Monitoring Program
DICU	Delta Island Consumptive Use
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
DWR	Department of Water Resources
EMP	Environmental Monitoring Program
HAB	Harmful Algal Bloom
HPLC	High-Performance Liquid Chromatography
IAV	Invasive Aquatic Vegetation
IEP EMP	Interagency Ecological Program's Environmental Monitoring Program
N	Nitrogen
NH ₄	Ammonium
NO ₃	Nitrate
nSFE-BGCM	northern San Francisco Estuary Biogeochemical Model
O ₂	Oxygen
P	Phosphorus
PO ₄	Phosphate
POTW	Publicly Owned Treatment Works
RMA	Resource Management Associates
RMSE	Root Mean Square Error
SC	Steering Committee
SEP	Supplemental Environmental Project
SFE	San Francisco Estuary
SFEI	San Francisco Estuary Institute
Si	Silicon
TAC	Technical Advisory Committee
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
USGS	United States Geological Survey
WY	Water Year

LIST OF UNITS

cm	centimeter
L	liter
m	meter
mg	milligram
mL	milliliter
µg	microgram
µmol	micromole
s	second

1 INTRODUCTION

1.1 BACKGROUND

The Delta Regional Monitoring Program (Delta RMP) is developing a Multi-Year Nutrient Study Plan to guide long-term studies of the effects of nutrients on the ecology of the Delta. After discussion between the Delta RMP Steering Committee (SC) and the Nutrient Technical Advisory Committee (TAC), three primary questions (also referred to as focus areas) were developed to guide the development of the Study Plan.

1. Following a reduction in nutrient loading from different point and nonpoint sources, what ranges of nutrient concentrations are expected to occur throughout the Delta, and how might they be affected by climate change, wetland restorations, and water management and routing?
2. What are the thresholds for nutrients (nitrogen (N) and phosphorus (P) and their ratios) that can limit Harmful Algal Bloom (HAB) biomass and cyanotoxin accumulation to safe levels, limit the abundance and distribution of nuisance macrophytes, and support robust growth of desirable phytoplankton and macrophytes throughout the Delta?
3. How are the characteristics of harmful cyanobacteria blooms and cyanotoxins in the Delta changing (e.g., species, magnitude, geographic extent, and timing) and what factors contribute to these changes?

The Multi-Year Nutrient Study Plan addresses these three questions or focus areas using a combination of modeling, field/experimental studies, and monitoring. It is not the objective of this Multi-Year Nutrient Study Plan to completely address all three focus area questions. The intent of the studies included in this Study Plan is to begin a multi-year process that begins to address these questions with a hypothesis driven approach and prioritizing data gaps identified by the Steering Committee and Nutrient TAC.

1.2 DELTA RMP MANAGEMENT QUESTIONS

The Delta RMP has agreed upon a set of management questions that reflect specific concerns about multiple aspects of the Delta and the impacts of human activities.

Since each of the management questions is quite broad, it is important to first identify a set of more specific “assessment questions” to guide a future monitoring or special study design. **Table 1** lists the management questions that were developed by the SC and the assessment questions that were developed by the Nutrient Subcommittee in 2018. When the Delta RMP SC prioritized planning for a multi-year study plan, these questions were used as a starting point for the three primary questions or focus areas.

Table 1. Delta RMP management and assessment questions for nutrients.

TYPE	CORE MANAGEMENT QUESTIONS	NUTRIENT ASSESSMENT QUESTIONS
1. Status & Trends	Is there a problem or are there signs of a problem? 1a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? 1b. Which constituents may be impairing beneficial uses in subregions of the Delta? 1c. Are trends similar or different across different subregions of the Delta?	1.1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally? A. Are trends similar or different across subregions of the Delta? B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? C. Are there important data gaps associated with particular water bodies within the Delta subregions?

TYPE	CORE MANAGEMENT QUESTIONS	NUTRIENT ASSESSMENT QUESTIONS
2. Sources, Pathways, Loadings & Processes	Which sources and processes are most important to understand and quantify? 2a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? 2b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? 2c. What are the magnitudes of internal sources and/or pathways (e.g., benthic flux) and sinks in the Delta?	2.1. Which sources, pathways, and processes contribute most to observed levels of nutrients? A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters? B. What are the loads from tributaries to the Delta? C. What are the sources and loads of nutrients within the Delta? D. What role do internal sources play in influencing observed nutrient levels? E. What are the types and sources of nutrient sinks within the Delta? F. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects? 2.2. How are nutrients linked to water quality concerns such as harmful algal blooms, low dissolved oxygen, invasive aquatic macrophytes, low phytoplankton productivity, and drinking water issues? A. Which factors in the Delta influence the effects of nutrients on the water quality concerns listed above?

TYPE	CORE MANAGEMENT QUESTIONS	NUTRIENT ASSESSMENT QUESTIONS
3. Forecasting Scenarios	3a. How do ambient water quality conditions respond to different management scenarios? 3b. What constituent loads can the Delta assimilate without impairment of beneficial uses? 3c. What is the likelihood that the Delta will be water quality-impaired in the future?	3.1. How will nutrient loads, concentrations, and water quality concerns from <i>Sources, Pathways, Loadings & Processes Question #2</i> respond to potential or planned future source control actions, restoration projects, water resource management changes, and climate change?
4. Effectiveness Tracking	4a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? 4b. Are loadings changing as a result of management actions?	4.1. How did nutrient loads, concentrations, and water quality concerns from <i>Sources, Pathways, Loadings & Processes Question #2</i> respond to source control actions, restoration projects, and water resource management changes?

1.3 THREE-YEAR PLANNING BUDGET

This section presents a comprehensive three-year planning budget. A nutrient budget of roughly \$500,000 is allocated for each fiscal year (FY), for a total budget of \$1,500,000 (FY 24-25, FY 25-26, FY 36-27). **Table 2** outlines how funds will be spent for each of the three focus areas over the course of three fiscal years. The planning budget allows for a 10% contingency (\$150,000) as scopes and contracts are finalized in preparation of project implementation. The Delta RMP Annual Monitoring Workplan and final budget will include actual allocated funds for the upcoming fiscal year.

Table 2. Three-year budget for the Nutrient Multi-Year Study Plan focus areas.

FISCAL YEAR	FOCUS 1	FOCUS 2	FOCUS 3	FY BUDGET	FY ALLOCATED FUNDS	DIFFERENCE
FY 24-25	\$167,500	\$50,000	\$150,000	\$367,500	\$500,000	\$132,500
FY 25-26	\$232,500	\$265,252	\$150,000	\$647,752	\$500,000	-\$147,752
FY 26-27	\$0.00	\$225,252	\$150,000	\$375,252	\$500,000	\$124,748
Totals	\$400,000	\$490,504	\$450,000	\$1,349,500	\$1,500,000	\$109,496

2 FOCUS AREA #1

Biogeochemical (BGC) modeling efforts will be used to answer the following question by conducting a series of model scenarios based on hypothesis testing to address the following Focus Area #1 question:

- Following a reduction in nutrient loading, what ranges of nutrient concentrations are expected to occur throughout the Delta, and how might they be affected by climate change, wetland restorations, and water management and routing?

In pursuing the above question, the study targets a number of questions the Delta RMP has identified as priorities (**Table 1**), including: Management Questions 2a, 2b, 2c, 3a, and 3b; and Assessment Questions 2.1.A-F and 3.1.

2.1 PROJECT SUMMARY AND OBJECTIVES

The proposed project's high-level goals and approaches are summarized below, with details covered in subsequent sections.

High-Level Project Goals

1. Quantify the effects of nutrient source load reductions on nutrient concentrations throughout the Delta, including how those effects vary spatially, temporally (seasonally, interannually), and as a function of water management or flow-routing.
2. Evaluate in greater detail and provide visualizations of changes in nutrient concentrations within, or nutrient delivery to, regions of the Delta that are impacted by HABs and invasive aquatic vegetation (IAV).
3. Investigate additional priority hypotheses, including one or more of the following:
 - a) Quantify the importance of remaining nutrient sources (beyond those included in scenarios) within HAB- and IAV- prone regions, including Delta non-point sources;
 - b) Assess the relative importance of IAV on nutrient concentrations and cycling; and/or
 - c) Characterize the relative importance of factors regulating phytoplankton biomass or productivity, including potential effects of decreased nutrient availability due to load reductions on 'beneficial production'.

Approach

To address these goals, the project will:

- Simulate hydrodynamics and biogeochemistry during water year 2022 (WY2022) and water year 2016 (WY2016), using actual nutrient loads during those years ('Base'), to predict nutrient transport, cycling, and concentrations throughout the Delta. The Base conditions include the nutrient loading rate that occurred in 2022 for both water years; see section **Model Updates, Calibration, and Validation** for more details.
- Re-simulate WY2022 and WY2016 biogeochemistry for a priority set of load reduction scenarios to forecast nutrient concentrations under each of those conditions.
- Quantify differences in nutrient concentrations between the Base and Scenario simulations, including their variability spatially (map-view concentrations), temporally (time-series at specific locations), and interannually.
- Test additional priority hypotheses (Project Goal #3) by undertaking targeted analyses of model output, including through, e.g., mass-budgets/control-volume analyses, numerical tracers (source-tracking, age/travel-time tracers), or sensitivity analyses.

Early work will include a set of tasks to extend hydrodynamic and biogeochemical simulations to WY2022 and improve model performance during low-flow conditions and reduced-load scenarios. The hydrodynamic and biogeochemical models will then be calibrated and validated for WY2022 and WY2016, and the updated model used for Base and Scenario simulations.

2.2 WHY IS THIS A PRIORITY?

Potential future regulation of N discharges could set allowable concentrations at levels meant to reduce or eliminate the proliferation of cyanobacteria and the production of cyanotoxins that are harmful to humans, companion animals, and wildlife. It is also anticipated that reductions of nutrients will lead to reductions in the growth of nuisance aquatic macrophytes. The desire is to determine if the anticipated outcomes will be realized without any adverse impacts such as decreases in the growth of desirable phytoplankton.

The goal of the modeling element of the Multi-Year Nutrient Study Plan is to identify the effects of changing Dissolved Inorganic Nitrogen (DIN) and Total Nitrogen (TN) concentrations from source areas inside and outside the Delta on the DIN and TN concentrations and chlorophyll-a (chl-a) concentrations at targeted areas in the Delta. The targeted areas include:

- Locations where beneficial algal production occurs, which can support zooplankton growth (an important food resource for zooplankton and native fishes, such as Delta Smelt) locally or distally through advection and dispersion including but not limited to:
 - Liberty Island and the North Delta
- Locations where Harmful Algal Blooms occur including but not limited to:
 - Stockton Waterfront
 - Discovery Bay
 - Franks Tract
 - Old and Middle Rivers

This project will model reductions in DIN and TN inputs to the Delta from various sources to determine if and how these reductions can affect the delivery of DIN and TN to or concentrations within regions of the Delta, in particular regions that experience HABs or IAV, and/or locations that are critical to the survival of pelagic fish in the Delta (primarily the north Delta). In pursuing the Focus Area #1 question, the study targets a number of Delta RMP priority Management Questions (2a, 2b, 2c, 3a, 3b) and Assessment Questions (2.1.A-F, 3.1) (Table 1). The proposed work focuses in particular on the first half of the Focus Area #1 question, addressing knowledge gaps related to the relative contributions, or zones of influence, of nutrient sources within the Delta and the degree to which nutrient management options (individually, or in combination) could affect nutrient concentrations within or mass fluxes to priority management regions. There is also the potential for the modeling results to complement findings from the Focus Area #2 field studies in addressing the Focus Area #2 question. The proposed work will not directly investigate how load reduction scenario results would be influenced by factors like climate change, wetland restoration, or water management. Pursuing those topics would

require investigating additional layers of scenarios (e.g, climate change scenarios could include changes in temperature, sunlight (i.e., cloud-cover), flow, and sea-level-rise changes to flooded areas). However, some of those factors could be pursued through follow-up work that builds on this project's scenario results.

2.3 HYPOTHESES AND MODELING QUESTIONS

Nitrogen enters the Delta from point and nonpoint sources in the Sacramento Valley, San Joaquin Valley, and internal Delta from such sources as atmospheric deposition, agricultural discharges, urban runoff, and Public Owned Treatment Works (POTWs). Although regulatory actions are being considered to further reduce these inputs, it is currently unknown what the ecological responses of reduced N inputs will be. Decreased occurrences of HABs and IAV have been identified as plausible or hypothesized beneficial ecosystem responses to decreased Delta nutrient loads (Senn et al. 2020). However, thus far few studies (field or modeling) have directly investigated these potential responses. Since modules for mechanistically simulating cyano-HABs or IAV have not yet been incorporated into the northern San Francisco Estuary Biogeochemical Model (nSFE-BGCM), this project will focus on quantifying nutrient delivery to or predicted concentrations within priority management areas, and changes to those deliveries and concentrations in response to load reduction scenarios. Through continued discussions with Delta RMP stakeholders, additional priority hypotheses or management questions will be identified (example options summarized under **Analysis & Interpretation** below). Coupled with other studies and monitoring funded by the Delta RMP, it may be possible to estimate the amount of harmful cyanobacteria and cyanotoxins produced at low N concentrations throughout the Delta. These studies hopefully will assess if the Delta responds similarly to other waterbodies and inform the development of nutrient regulation.

The Nutrient TAC will work with the Modeling Team to identify the most relevant set of load reduction scenarios to simulate. Approaches for establishing reduction scenarios include i) identifying a set of percentage reductions to DIN and TN from source areas and determine the relative impact on DIN, TN, and chl-a concentrations at locations in the Delta, and/or ii) establishing target DIN/TN concentrations at specific locations in the Delta and determining the percentage reduction and the location of the reductions needed to achieve the target concentrations.

Below are four initial hypotheses (null and alternative) that can be used to build model scenarios for testing the hypotheses. The hypotheses use the terminology of substantial change as a way to test the hypotheses; the Nutrient TAC will work with the modelers to define substantial (e.g., larger than background variation) as modeling is implemented and include this definition in the interpretation and reporting of model results.

2.3.1 BGC Model Hypothesis 1

H₀: Reducing the nonpoint and point source inputs of N from the Sacramento River to the Delta will have no effect on the concentration of DIN, TN, P, or chl-a at any targeted location or region in the Delta at any time during the year.

H₁: At least one targeted location/region in the Delta will experience a substantial change in the concentration of DIN, TN, P, or chl-a after reductions from point and nonpoint sources in the Sacramento Valley at some time during the year.

2.3.2 BGC Model Hypothesis 2

H₀: Reducing the nonpoint and point source inputs of N from within the Delta will have no effect on the concentration of DIN, TN, P, or chl-a at any targeted location or region in the Delta at any time during the year.

H₁: At least one targeted location in the Delta will experience a substantial change in the concentration of DIN, TN, P, or chl-a for a sustained period (e.g., days to weeks) after reductions from point and nonpoint sources in the Delta at some time during the year.

2.3.3 BGC Model Hypothesis 3

H₀: Reducing the nonpoint and point source inputs of N from the San Joaquin Valley will have no effect on the concentration of DIN, TN, P, or chl-a at any targeted location or region in the Delta at any time during the year.

H₁: At least one targeted location in the Delta will experience a substantial change in the concentration of DIN, TN, P, or chl-a for a sustained period (e.g., days to weeks) after reductions from point and nonpoint sources in the San Joaquin Valley at some time during the year.

2.3.4 BGC Model Hypothesis 4

H₀: Reducing the nonpoint and point source inputs of N simultaneously from the Sacramento River, the San Joaquin River, and internal Delta sources will have no effect on the concentration of DIN, TN, P, or chl-a at any targeted location or region in the Delta at any time during the year.

H₁: At least one targeted location/region in the Delta will experience a substantial change in the concentration of DIN, TN, P, or chl-a for a sustained period (e.g., days to weeks) after N reductions simultaneously from the Sacramento River, the San Joaquin River, and internal Delta sources at some time during the year.

2.3.5 BGC Model Scenarios

To test Hypotheses 1-4, the nSFE-BGCM will be used to simulate a series of load reduction scenarios (**Table 3**) during two proposed water years, WY2016 and WY2022. In the central and south Delta, nutrient concentrations in the winter and spring can be

higher than those in the summer and fall (Beck et al. 2018, Jabusch et al 2018). However, HABs typically occur in the summer through fall (Berg and Sutula 2015), so DIN reduction modeling scenarios were developed from Interagency Ecological Program (IEP) Environmental Monitoring Program (EMP) data collected July through October in 2022. The US EPA has recommended that states consider criteria of total N of 0.31 mg/L and total P of 0.047 mg/L for EcoRegion 1 which includes parts of Washington, Oregon, and California (EPA 2001). These concentrations are not directly related to the Delta but provide context for concentrations being evaluated for nutrient criteria in the Delta.

Internal nutrient concentrations were calculated as the difference in average DIN between Buckley Cove (1.1 mg/L-N) and Vernalis (0.36 mg/L-N) = 0.74 mg/L-N. The first two modeling scenarios reduce DIN from all sources to yield reduced concentrations (0.1 mg/L-N and 0.2 mg/L-N) that match those proposed in the Delta RMP N reduction bioassay study and reflect lowest observed concentrations detectable during the fall in the system (see section **3.3.2 N and P Reduction Bioassay Treatments** for more specifics). Scenarios 3 to 6 test percent DIN loading reductions to understand the importance of individual sources vs. a standard 20% reduction from all sources. The final scenario(s) evaluates nutrient concentrations based on the feasible limit of reductions in N loading from individual loading sources such as POTWs, municipal stormwater, and agriculture. A set of feasible N load reduction scenarios will be developed by Nutrient TAC and SC members with assistance from San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC).

Two potential phosphorus reduction scenarios may be added to the study. The Nutrient TAC will work with the modelers to identify scenario details and related hypotheses.

Table 3. Potential BGC modeling scenarios.

DIN CONCENTRATIONS IN 2022 (JULY-OCT)	DIN (MG/L-N)	REDUCTION
Sacramento River (Hood)	0.26	0%
San Joaquin River (Vernalis)	0.36	0%
Internal sources	0.74	0%
Model Scenario 1	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	0.1	61%
San Joaquin River (Vernalis)	0.1	72%
Internal sources	0.1	86%
Model Scenario 2	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	0.2	22%
San Joaquin River (Vernalis)	0.2	45%
Internal sources	0.2	73%

DIN CONCENTRATIONS IN 2022 (JULY-OCT)	DIN (MG/L-N)	REDUCTION
Model Scenario 3	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	0.13	50%
San Joaquin River (Vernalis)	0.36	0%
Internal sources	0.74	0%
Model Scenario 4	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	0.26	0%
San Joaquin River (Vernalis)	0.18	50%
Internal sources	0.74	0%
Model Scenario 5	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	0.26	0%
San Joaquin River (Vernalis)	0.36	0%
Internal sources	0.37	50%
Model Scenario 6	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	0.21	20%
San Joaquin River (Vernalis)	0.29	20%
Internal sources	0.59	20%
Model Scenario 7 (or more)	DIN (mg/L-N)	Reduction
Sacramento River (Hood)	Lowest feasible	TBD
San Joaquin River (Vernalis)	Lowest feasible	TBD
Internal sources	Lowest feasible	TBD

2.4 APPROACH

2.4.1 Model Overview

The core Modeling Team will consist of hydrodynamic and biogeochemical modelers from SFEI and Resource Management Associates (RMA).

Modeling work will be pursued using the nSFE-BGCM, a 3-D coupled hydrodynamic-biogeochemical model capable of simulating nutrient transport, nutrient cycling, and an array of relevant ecosystem responses (e.g., phytoplankton production). The hydrodynamic and biogeochemical models are described in detail elsewhere (SFEI 2019, 2020, 2021a), and are summarized briefly here. The SFE-BGCM uses the public-domain/open-source models D-Flow Flexible Mesh (DFM, Deltares 2019a) to simulate hydrodynamics; D-Water Quality (DWAQ; Deltares 2019b) to simulate water quality; and a suite of Python-based utilities to facilitate model setup and postprocessing. Two branches of the SFE-BGCM are maintained, emphasizing different regions of the San Francisco Estuary (SFE): the San Francisco Bay (SFB-BGCM); and the northern San Francisco Estuary (Delta, Suisun; nSFE-BGCM). The biogeochemical modules for each of the regional models have similar baseline capabilities, and refinements implemented within one regional model have been routinely transferred to other branches when relevant. For this Delta-Suisun focused analysis, the nSFE-BGCM model will be used. The model domain includes the Delta and San Francisco Bay, and extends into the Pacific Ocean to approximately Point Reyes to the north and Half Moon Bay to the south (**Figure 1**). The model has ~75,000 horizontal cells and 10 vertical layers (sigma layers). The nSFE-BGCM incorporates flows and nutrient loads from all known point sources (POTWs, refineries), along with flows and loads from upstream watersheds.

The nSFE-BGCM was developed to simulate the array of biogeochemical processes and state variables depicted in **Figure 2**, and summarized in the extended figure caption. Through recent Delta-Suisun focused projects (SFEI 2021a, 2021b) a number of substantial improvements were made, including (see also **Figure 3**): water column transformations and sediment diagenesis; adjustments to clam and zooplankton initial conditions and grazing rates informed by comparisons with biomass and grazing data from a complementary modeling effort; refining boundary conditions for nutrient loading from both freshwater sources and POTWs; developing spatially varying initial conditions for nutrient concentrations; calculating space-time varying light-attenuation coefficients using the network of high frequency turbidity sensors throughout the Delta; and developing a “global” calibration that performed well at predicting N, P, and silica (Si) concentrations across two water years with strongly differing physical conditions (WY2011, wet; WY2016, dry) and biogeochemical responses. Through those projects the Modeling Team have expanded capacity for processing model output, including establishing regional and sub-regional control volumes and quantifying mass budgets over

relevant time periods (**Figure 4**). Using this modeling framework, it is also possible to introduce several types of numerical ‘tracer’ techniques (conservative tracers, age tracers, habitat exposure tracers) and track their movement over space and time. These tracers can provide valuable information about, e.g., a point-source's zone of influence, and recent tracer applications in the Delta have demonstrated great promise at, for example, estimating rates of N loss in regions with dense growth of IAV, and detecting and tracking signals of ag-return-flow waters.

An important limitation of the prior version of the nSFE-BGCM also emerged during the WY2016 simulation, with results indicating that transport was under-resolved within the Cache Slough Complex (CSC) which affected the reliability of nutrient concentration predictions in the upper CSC. That issue will be remedied during this project by incorporating an improved bathymetry dataset and model grid within the CSC that were recently implemented as part of another related project (see below in section **Model Updates, Setup, and Calibration for WY2022 and WY2016**).

Model Updates, Calibration, and Validation

For this project, two water years will be simulated, WY2016 and WY2022. Of the two years that were previously calibrated (WY2016, WY2011), WY2016 is recommended because of the ample water quality monitoring data available for model calibration and validation (water quality moorings, high-resolution mapping, in addition to monthly discrete data). Key reasons for simulating WY2022 include: i) comparable or greater water quality monitoring as WY2016; and ii) the EchoWater Resource Recovery Facility's upgrades were completed and online during WY2022, allowing for a post-upgrade time-period to be included in model calibration/validation.

Model Updates, Setup, and Calibration for WY2022 and WY2016

Initial work will include incorporating several major improvements to the model grid and bathymetry (CSC, Suisun Bay, and portions of the Sacramento River, near the Delta Cross Channel (DCC)) (**Figure 5**). The grid and bathymetry improvements were developed through a recent project and have already been merged with the broader nSFE-BGCM domain. Remaining steps include updating model set-up scripts (re-plumbing boundary conditions or inputs into appropriate new grid cells) and post-processing scripts (analysis, plotting) to align with the altered grid, and incorporating any minor refinements that emerge during early test runs.

Hydrodynamic runs will be set up for WY2022 and WY2016, using the new grid and bathymetry. Hydrodynamic input files (boundary conditions, forcings) will be developed for WY2022, including river flows, point source flows, meteorological data, and gate and pump operations (WY2016 data already compiled). Model setup for WY2022 will also

require incorporating flow alterations at the Old River Drought Barrier (trial runs, iterations to fine-tune). During dry and critically dry years like WY2016 and WY2022, interior-Delta water withdrawals/returns (i.e., 'ag return flows', Delta Island Consumptive Use (DICU)) can affect both flow routing and biogeochemistry. The influence of interior-Delta flow withdrawals/returns will be estimated by incorporating spatially distributed daily flows from the Delta Channel Depletion dataset (DCDv1.0; CA DWR 2018). A major focus of the hydrodynamic calibration work will be on accurately representing discharge and water elevations at structures/drought-barriers, within the CSC, and within regions affected by HABs and IAV.

Biogeochemical model input files will be developed for WY2022, including (see SFEI 2021b): nutrient concentrations at model boundaries for estimating loads entering the Delta (e.g., Battey and Perry 2023); spatially and temporally (hourly to daily) varying light attenuation coefficients, estimated through interpolating turbidity data from the Delta's network of continuous turbidity sensors (DWR and USGS networks); and abundances of benthic (clam) (e.g., Wells et al., 2023; Zierdt et al. 2021); and pelagic (zooplankton) grazers (Burdi et al., 2023). Additional information on model boundary condition and forcing data can be found in SFEI 2021b. The Delta-focused biogeochemical model will be updated with relevant improvements made through recent Bay modeling work, including refinements to the sediment biogeochemical module (nutrient fluxes), and phytoplankton production and grazing modules. A major focus of effort will then be on developing an updated global biogeochemical calibration for water years 2022 and 2016.

Model Validation

The hydrodynamic model will be validated for WY2016 and WY2022 by comparing time series of modeled and observed discharge, gauge height, salinity, and temperature at approximately 60 measurement stations across the Delta and Suisun Bay, and assessing performance using a suite of validation statistics (e.g., bias, root mean square error (RMSE), skill, r^2 , tidal amplitude ratio, lag) (see SFEI 2019).

The biogeochemical model will be validated for WY2022 and WY2016 by comparing model-predicted concentrations of priority water quality parameters (e.g., nitrate, ammonium, phosphate, silica, chl-a) with observed data. For the above parameters, discrete monthly and semi-monthly data are available from 10-15 sites across the Delta and Suisun Bay (see **Figure 4**; Battey and Perry 2023]. Modeled nitrate and chl-a concentrations will be compared with the USGS's extensive network of moored monitoring stations in this region. Lastly, modeled nitrate and chl-a values will also be compared with data from USGS high-speed mapping surveys conducted during 2016 and 2022. Additional information on data sources for model validation can be found in SFEI 2021b.

2.4.2 Load Reduction Scenario Simulations

As noted in Section 2.3.1, the calibrated biogeochemical model will be used to simulate load reduction scenarios to assess the influence of load reductions on nutrient availability within the Delta. The final set of scenarios will be identified through consultation with the Nutrient TAC. In addition to the nitrogen-focused scenarios in **Table 3** at least one phosphorus reduction scenario will also be simulated.

Load reduction scenarios will be simulated and compared with 'Base' conditions. Two Base Cases will be established:

- WY2022_{base}: results from the WY2022 biogeochemical simulation, using actual loads during WY2022.
- WY2016_{base}: After model calibration (using actual WY2016 loads), WY2016 biogeochemistry will be re-simulated using post-upgrade loads at the EchoWater Facility, along with other upgrade-related changes to Delta point-source loads, with those model results serving as WY2016_{base} (For nonpoint-source loads, WY2016 loads will be used).

Load reduction scenarios will be set up and simulated as follows (for each scenario):

- *Scenario Load Estimates*: For each source that will be changed, nutrient concentrations or loads will be translated into a daily time-series.
- *Scenario Simulations*:
 - The updated load time-series will be substituted for the actual load time-series used for the Base case.
 - WY2022 and WY2016 biogeochemistry will be re-simulated using the scenario loads, with all other model inputs/boundary conditions/forcings the same as the base case, except as noted below.
 - Changes in nutrient concentrations will be quantified by comparing scenario conditions (WY2022_{scenario}, WY2016_{scenario}) with either WY2022_{base} or WY2016_{base}.
- *Other Model Adjustments for Scenario Runs*: As needed, water column initial conditions (i.e., starting concentrations assigned throughout the domain) will be adjusted from the Base Case values. In some cases, adjustments to sediment conditions (and/or nutrient flux rates) may also be relevant to consider. The proposed approach to sediment-adjustments will involve: i) Assess the importance of sediment fluxes to water column nutrient concentrations or budgets (for Base case); ii) When necessary (i.e., flux is both quantitatively important and may overestimate fluxes under the scenario), a basic proportional adjustment to

sediment fluxes will be implemented. *Note:* More nuanced sediment-flux adjustments may be warranted for some cases, including considering the zones of influence of the altered sources, or the contribution of particulate nutrients from upstream (allochthonous organic matter) to the sediment nutrient pool.

The current budget is based on an assumption that four (4) load reduction scenarios will be explored, with each scenario simulated for WY2022 and WY2016 (8 year-scenario simulations).

2.4.3 Analysis & Interpretation

One of the primary outputs from this work will be the quantification of pre-/post-Scenario differences in N concentrations or fluxes (spatially, temporally), as described above.

Where relevant, changes in P concentrations and fluxes will also be evaluated. Analysis of model output for the scenarios will include (for each scenario and water year):

- Delta-wide map-views of nutrient concentrations, at relevant times of the year:
 - Base concentrations, Scenario concentrations, Difference = Base-Scenario
 - Time period: plots can be developed for e.g., weekly- or monthly averages for representative times of the year, or daily average examples.
- For high-priority regions (e.g., HAB- or IAV-prone regions), changes in nutrient availability will also be investigated in greater detail.
 - Time-series of nutrient concentrations at specific stations or spatially averaged within areas of interest (Base, Scenario, Difference = Base-Scenario).
 - Changes in nutrient transport (mass flux, kg/d) into an area of interest (e.g., difference in the kg/d of DIN entering a region between WY2022_{base} and WY2022_{scenario}).

Five of the seven priority regions (HAB- or IAV-prone regions) highlighted in **Section 2.2 Why is this a priority?** (Franks Tract, Old River, Middle River, Liberty Island, North Delta) are in the interior of the model domain, and are well-resolved by the grid. For each of these regions, load reduction scenarios will be examined by comparing DIN concentrations within, and mass fluxes into, the region. Both the Stockton Waterfront and Discovery Bay are positioned at or near the boundary of the model domain. For the Stockton Waterfront, the model grid extends along the majority of the Stockton Ship Channel (~2.8 km), but the region is not gridded at high-resolution, and data are relatively sparse for biogeochemical model validation. Discovery Bay is connected to the model grid at the boundary; however, the grid does not extend into Discovery Bay. For the Stockton Waterfront and Discovery Bay, the influence of load reduction scenarios will be examined primarily by characterizing changes in DIN mass fluxes into these regions (relative to the

Base simulations). These regions and relevant scenarios could be investigated further in follow-up modeling studies, informed by the results from this project.

The final technical report will include relevant graphics along with descriptive analysis of results. The current budget is based on the assumption that four load reduction scenarios will be simulated and analyzed for each water year (8 year-scenario simulations).

A second central aim of this work is to investigate one or more additional priority nutrient-related hypotheses, leveraging the same simulations, through using mass-budgets/control-volume analyses, numerical tracers, or other approaches. Examples include:

- Characterizing the relative importance of physical/biological/biogeochemical factors regulating phytoplankton biomass or productivity, including potential effects of lower nutrient availability due to load reductions.

Quantifying the importance of remaining nutrient sources (beyond those included in scenarios) within HAB- and IAV- prone regions, including Delta non-point sources; and/or assessing the relative importance of IAV on nutrient concentrations and cycling. This work could focus on regions where beneficial algal production occurs (Liberty Island, North Delta); or regions where HABs and/or IAV impact water quality and habitat quality (Stockton Waterfront; Franks Tract; Old and Middle Rivers). The specific combination of techniques used to investigate these issues will vary by topic, and may include some or all of the following: analysis of additional model output within regions of interest (e.g., changes to primary productivity or evidence of nutrient-limited growth rates within regions of interest); quantification of nutrient source contributions or additional nutrient losses within a region, using mass balance and various tracer approaches. The specific focus of this component of the project will be finalized with input from the Nutrient TAC. The current project cost estimate includes budget to pursue one of the above analysis-directions, with the potential to pursue additional hypotheses depending on their depth of analysis.

2.5 DATA DELIVERABLES AND REPORTS

2.5.1 Data Management & Data Deliverables

Modeling work is being conducted with open-source/public-domain tools, and all data, model output, and scripts.

2.5.2 Reporting

The primary deliverable will be a Technical Report, presenting the following:

1. Hydrodynamic and biogeochemical model validation, along with description of the model and relevant model updates.

2. Results of Base-Case and Scenario simulations, with the current budget based on an assumption of four scenarios (simulated during both water years). Analyses will include:
 - a. Delta/Suisun-wide: analysis/interpretation of differences in nutrient concentrations, over space and time (seasonal, interannual).
 - b. Additional focus or depth of analysis within priority regions, i.e., regions that are considered HAB-prone, IAV-prone, or where fostering beneficial production is a management priority.
3. Analysis/Interpretation of additional priority hypotheses or science/management questions.
4. For #3 (and potentially other components), the technical report may be written in the form of manuscript (time-permitting) for submission to a peer-reviewed journal, with additional analyses/figures/documentation that are relevant to the Delta RMP included in appendices as needed.

2.6 STUDY TIMELINE AND SCHEDULE

Project work will begin in July 2024, aligned with the start of the Delta RMP's FY2025. Assuming a 2-year project, work would proceed as follows (approximate):

- *0-6 months* hydrodynamic model setup and initial calibration work, initial biogeochemical model setup;
- *7-12 months* finalize hydrodynamic calibration and validation, setup/calibrate/validate biogeochemical model, and initial scenario/analysis work;
- *13-18 months* complete scenario simulations/visualizations and analysis;
- *19-24 months* report preparation.

2.7 BUDGET ESTIMATE

The cost estimates below (**Table 4**) are approximate and may vary depending on decisions related to the number of scenarios, and the breadth and depth of additional hypotheses to pursue.

Table 4. Cost estimates for hydrodynamic and biogeochemical modeling, and subsequent analysis, interpretation, and writing of a final technical report.

TASK	COST
1. Hydrodynamic: model updates, setup, calibration & validation	\$90,000
2. Biogeochemical: model updates, setup, calibration & validation	\$135,000
<i>2a. Optional Phosphorus reduction scenarios</i>	<i>\$20,000</i>

TASK	COST
3. Analysis, Interpretation, Write-up	\$155,000
Total	\$380,000
<i>Total with Optional Phosphorus reduction scenarios</i>	<i>\$400,000</i>

The above budget (**Table 4**) is based on an estimate of eight load reduction scenarios (8 scenarios simulated for two years each) being explored in depth, as opposed to all seven in **Table 3**, considering that there may be substantial information-overlap among some of the scenarios and not all will be required. Scenarios can be added as needed, at an estimated cost of \$7,000-\$10,000/scenario (for example, if only four scenarios are needed the cost would be reduced by approximately \$30,000).

Figure 1. Model domain of the current nSFE-BGCM.

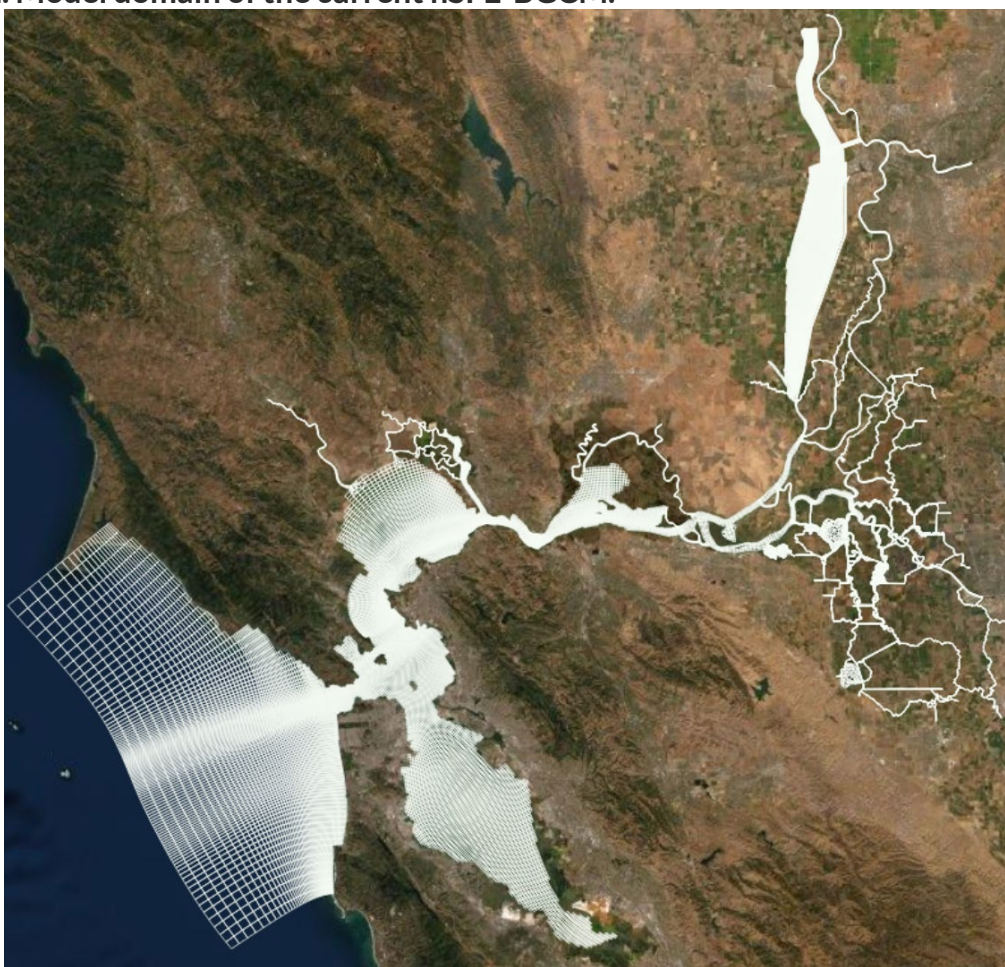
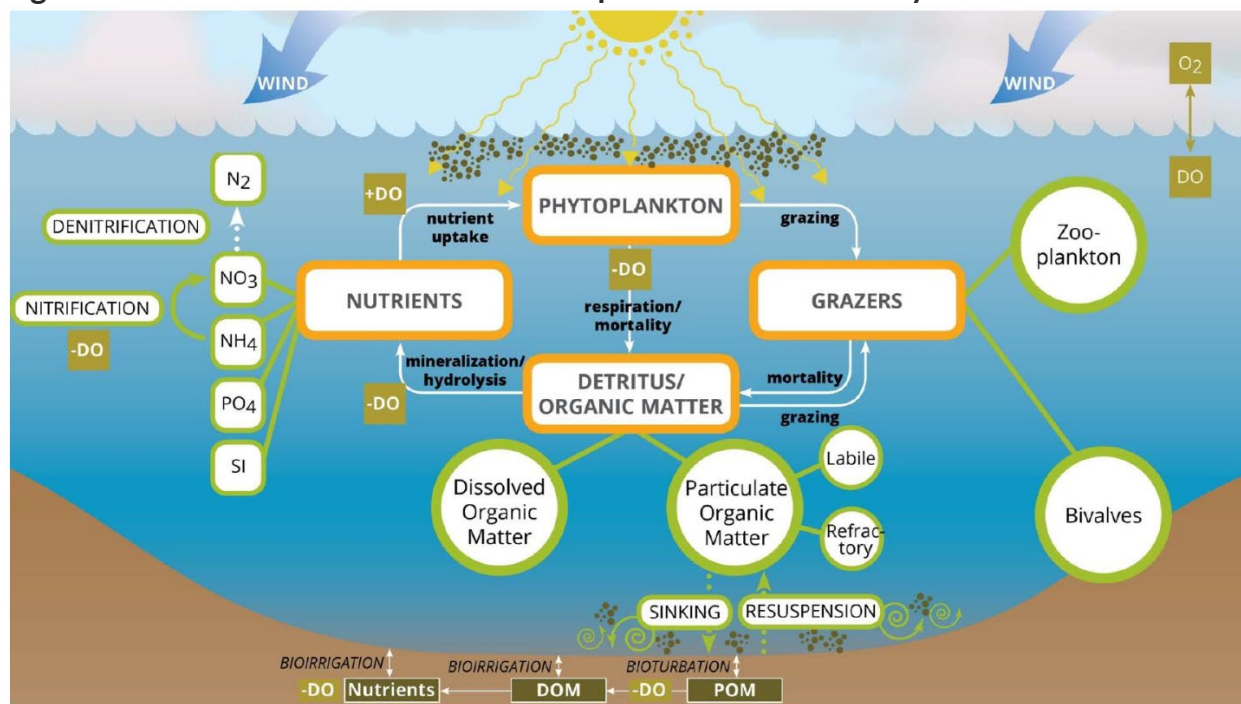


Figure 2. Schematic of state variables and processes simulated by the nSFE-BGCM.



Important water column and sediment-compartment processes include:

Water Column Processes

- Microbial: nitrification; respiration (dissolved oxygen [DO] consumption) and remineralization of organic matter (converting organic forms of nutrients, including dead phytoplankton, to inorganic forms).
- Phytoplankton: growth (production of new biomass), uptake/assimilation of nutrients, respiration, mortality.
- Grazers: grazing (consumption of phytoplankton), excretion of nutrients, growth (increased biomass), respiration, mortality
- Oxygen (O₂) exchange between the water column and atmosphere.
- Light attenuation by suspended sediment and phytoplankton.

Sediment Processes

- Microbial: nitrification, denitrification, aerobic respiration (DO consumption), and mineralization of organic matter (converting organic forms of nutrients to inorganic forms).
- Benthic grazing: filtration/consumption of phytoplankton and detritus, excretion of nutrients, growth (increased biomass), reproduction, and death.
- Accumulation of organic matter (settling from the water column) and mixing/bioturbation of sediments.
- Sediment ↔ Water: flux of Ammonium (NH₄), Nitrate (NO₃), Phosphate (PO₄), and Si from the sediments to the water column, flux of NO₃ and O₂ from the water column to the sediments (denitrification and oxygen consumption, respectively, at the sediment-water interface).

Figure 3. Summary of major updates and improvements to the nSFE-BGCM incorporated during recent projects, including the recent DRMP-funded modeling project.

Additional biogeochemical model refinements (developed through on-going Bay modeling work) will be incorporated into the nSFE-BGCM during this project and applied to WY2022 and WY2016 simulations.

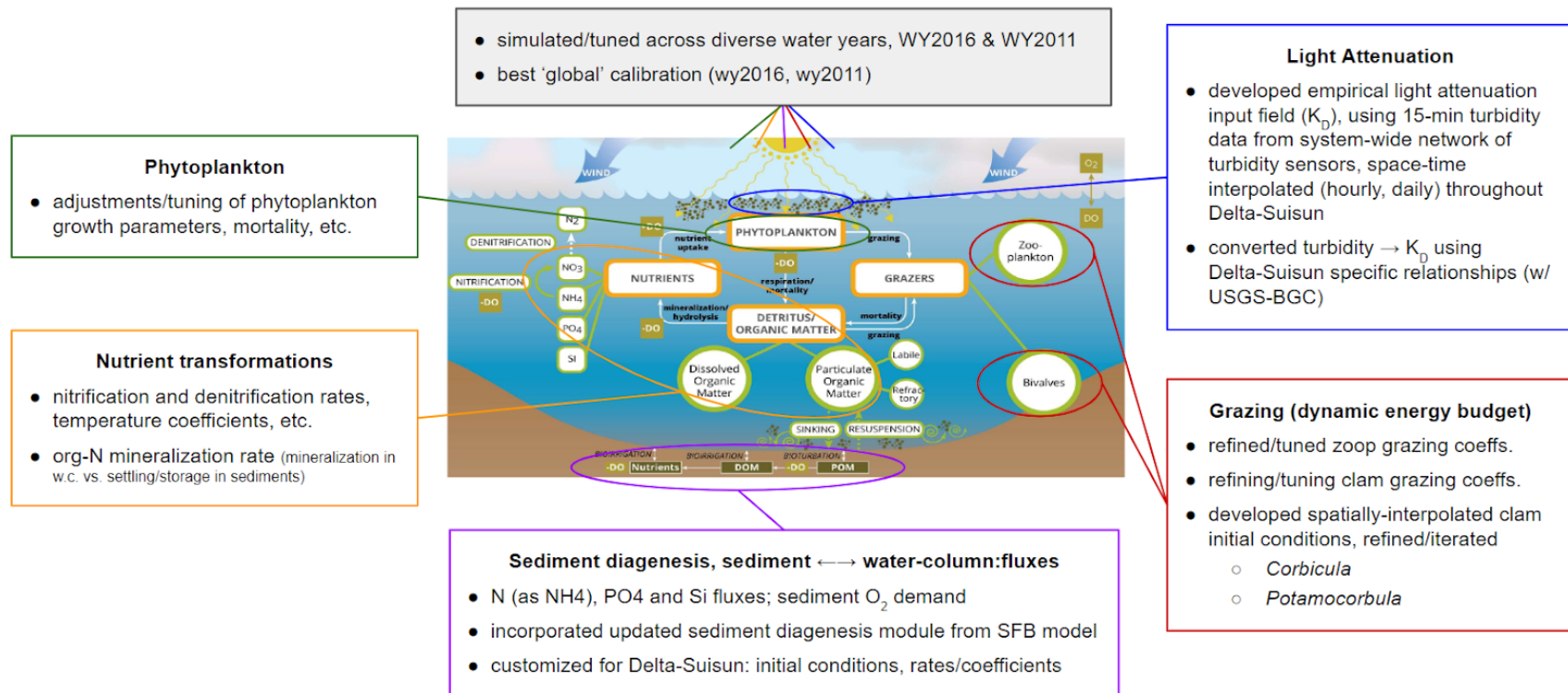


Figure 4. Regional control volumes used in nSFE-BGCM simulation for WY2016.

A set of finer resolution control volumes was also established (5-20 per region), allowing for more targeted analyses and interpretations. Simulations are run at full-spatial and full-temporal resolutions, and internal transformation rates are daily-integrated and spatially averaged. (Red circles indicate the locations of some of the monthly discrete monitoring stations used for model validation).

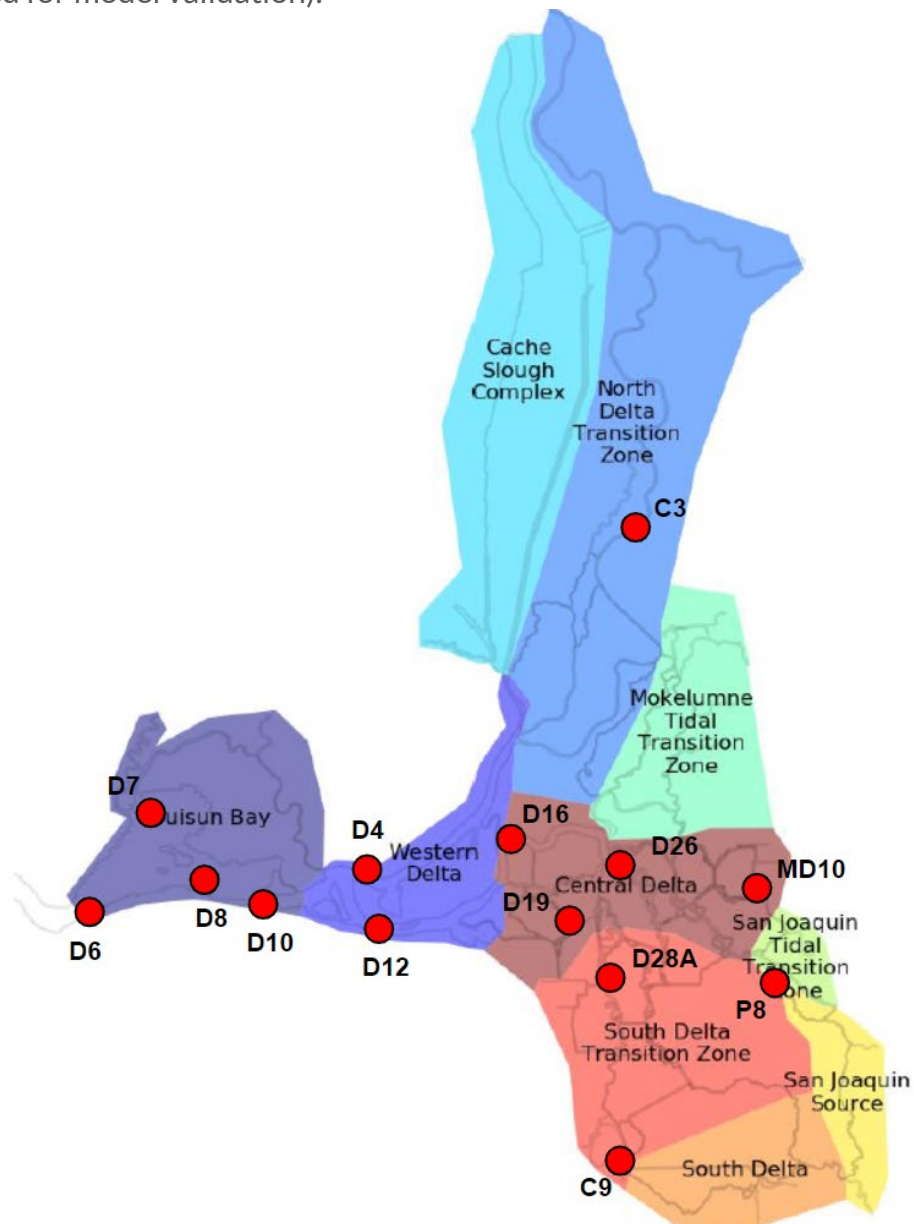
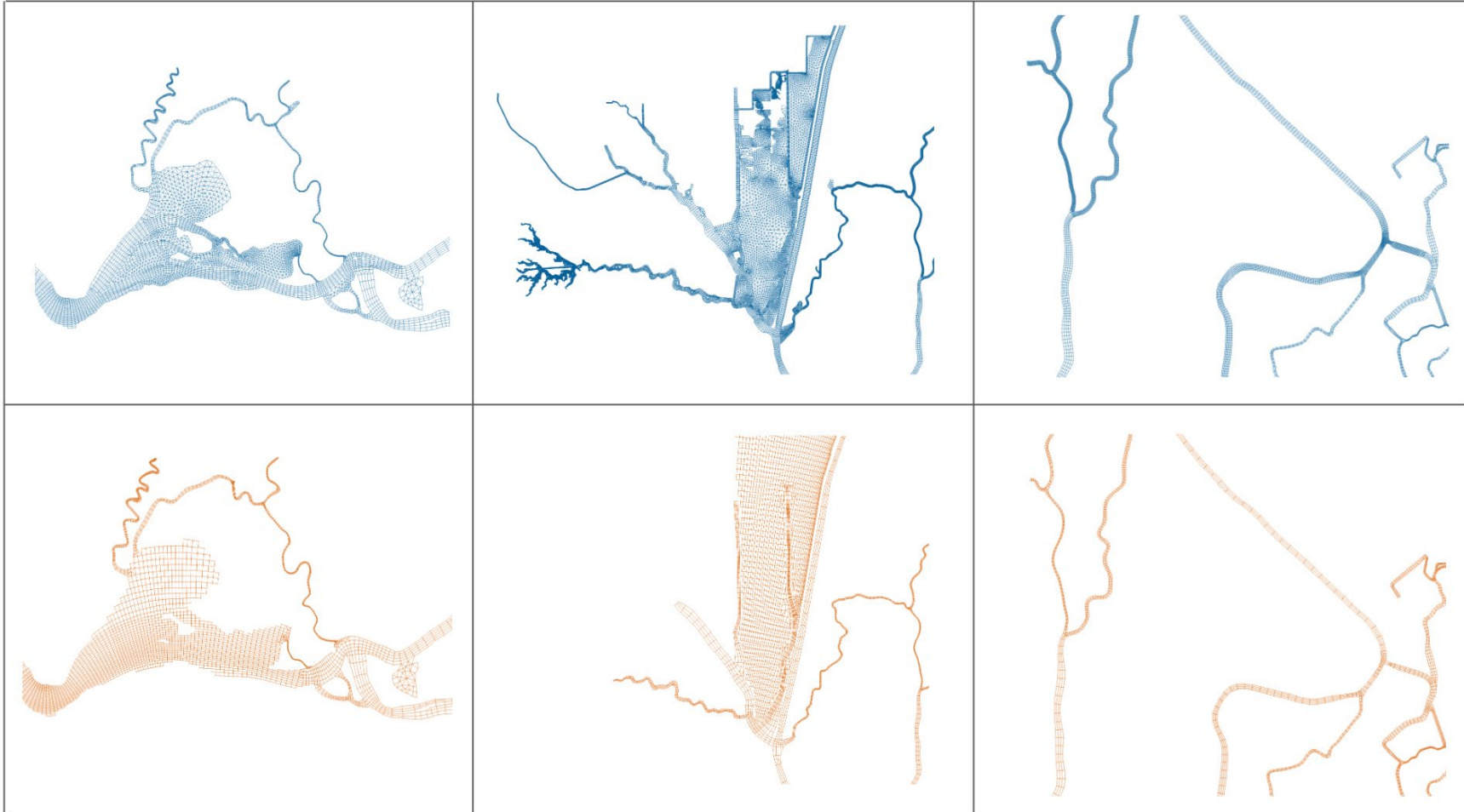


Figure 5. Current and new nSFE-BGCM grids.

Bottom: Subsets of grid used for prior nSFE-BGCM work; Top: Updated grid (Holleman, et al., in prep.), to be used for the proposed project. The grid updates have already been merged with the rest of the domain in **Figure 1**. The remaining work includes ‘re-plumbing’ boundary conditions/forcings, and updating model set-up (control-volume or transect boundaries) and post-processing scripts (analysis, plotting), etc.



3 FOCUS AREA #2

To assist with understanding the ecological effects of nutrient reductions, a bioassay study will be used to answer the following Focus Area #2 question:

- What are the thresholds for nutrients (N and P and their ratios) that can limit HAB biomass and cyanotoxin accumulation to safe levels, limit the abundance and distribution of nuisance macrophytes, and support robust growth of desirable phytoplankton and macrophytes throughout the Delta?

3.1 STUDY OBJECTIVES

The study objective is to understand how reductions in N and P concentrations might affect phytoplankton species composition, biomass, and cyanotoxin production in the Delta and to identify if other environmental factors will influence phytoplankton growth at low N or P concentrations (potentially altering the outcomes of nutrient reduction actions). This study is designed to partially inform one of the management questions identified as a high priority by the Delta RMP SC. “What are the thresholds for nutrients (N and P and their ratios) that can limit HAB biomass and cyanotoxin accumulation to safe levels, limit the abundance and distribution of nuisance macrophytes, and support robust growth of desirable phytoplankton and macrophytes throughout the Delta?” It also follows a research recommendation in the Delta Nutrient Research Plan (Cooke et al. 2018), to perform a “Study of potential for changes in nutrients or physical drivers to reduce frequency and magnitude of harmful cyanobacteria blooms and toxins”.

This study will use controlled and replicated bioassay experiments to investigate how phytoplankton sourced from the south Delta responds to limited N or P availability. Bioassay experiments simplify complex natural processes by controlling specific factors and can be used to test a hypothesis in a similar but controlled environment. However, there are limitations to bioassay experiments focused on phytoplankton communities, including unintended impacts of the study design such as: deleterious impacts of the enclosure on physiological performance of phytoplankton, potential changes in species composition, and the potential of inducing the limitation of other nutrients when adding another macronutrient (Beardall et al 2001). Results of these types of studies should be used in context of the limitations of the study design recognizing that they will not be a perfect representation of the Delta. More details regarding limitations of the bioassay design are included in section **Limitations of the Bioassay Design**.

Dilution bioassay studies allow the effects of low nutrient concentrations on phytoplankton to be evaluated in waterways where low nutrient concentrations rarely

occur. A recent bioassay testing Sandusky Bay water from Western Lake Erie determined that a 40% P reduction prevented the increase of microcystin concentrations in 3-day experiments compared to undiluted treatments where Microcystin concentrations roughly doubled (Barnard et al. 2021). These bioassay experiments also determined that in August low N concentrations limited chl-a production and production of the cyanotoxin anatoxin in Sandusky Bay water.

It is also important to recognize that the Delta is a complex ecosystem and many factors other than nutrient concentrations can influence phytoplankton growth, such as light limitation, salinity, water temperature, nutrient competition with macrophytes, grazing losses to clams, and differences in water residence times. Therefore, a second set of mesocosm studies is proposed to examine how phytoplankton respond to nutrient reductions in combination with some of these other common environmental variables that can be manipulated in the bioassay containers (additional details are provided in the methods section). The goal for the second set of treatments is to determine if other environmental factors can have a large influence on phytoplankton community responses at low N concentrations. It is recommended that all of the multiple-factor treatments be conducted at a single low nitrate (DIN) concentration, such as 0.1 mg/L-N, allowing direct comparisons between treatments and control. If one of these environmental factors shows a strong effect on phytoplankton biomass, HAB biomass, or cyanotoxin production, compared to that of the low N concentration control, then the factor should be tested further in separate (future) sets of experiments across a range of low N concentrations. Future studies would be necessary to further understand how phytoplankton responses to a range of low nutrient reductions might differ in the presence of other common environmental factors.

This study is a first step in understanding how phytoplankton communities in the Delta can respond to low nutrient concentrations. It is currently unknown which species will dominate phytoplankton communities grown at low nutrient concentrations. The findings from this study will guide future research investigating the potential ecological effects of reduced nutrient loading into the Delta. Additional manipulative studies, comparisons to samples collected in the waterway, and biogeochemical and hydrological modeling are also needed to continue the development of nutrient objectives for the Delta and Suisun Bay.

The bioassay experiment is an exploratory study that seeks to inform the broad questions listed below using nutrient dilution assays.

- Would N or P reduction reduce HAB growth in the Delta? If so, what level of N or P reduction is needed to significantly reduce HAB growth and cyanotoxin concentrations to acceptable levels in the Delta?

- Would N or P reduction reduce the biomass of desirable phytoplankton in the Delta? If so, is the reduction significant and meaningful?
- Would N or P reduction significantly alter the growth of specific cyanobacteria that cause taste and odor problems for drinking water systems?
- How do other environmental factors, such as light limitation, aquatic plant growth, or clam grazing, alter the effects of N or P reductions on HABs and/or phytoplankton populations?

3.1.1 Why is this a priority?

The Central Valley Regional Water Quality Control Board's (CVRWQCB or Central Valley Water Board) Delta Nutrient Research Plan identified research recommendations for further research to better address nutrient management questions in the Sacramento-San Joaquin Delta (Delta) (Cooke et al. 2018). The top-ranking special study recommendation was to determine the roles of nutrients and other drivers in controlling the growth rate, maximum biomass, and toxin production of HABs. The Central Valley Water Board noted that they anticipate the possible development of nutrient benchmarks and/or reduction goals during the Delta Nutrient Research Plan implementation. Accordingly, the Delta RMP Nutrient TAC has developed a study to evaluate the potential effects of nutrient reductions on phytoplankton in the Delta. Reduced nutrient concentrations in the Delta might help control the occurrence and severity of HABs, such as *Microcystis* sp., *Aphanizomenon* sp., and *Dolichospermum* sp. and reduce cyanotoxin concentrations, such as microcystin, anatoxin, saxitoxins, and cylindrospermopsin. However, nutrient reduction also has the potential to reduce the growth of desirable phytoplankton species, such as diatoms, which provide an important base to the Delta's pelagic food web.

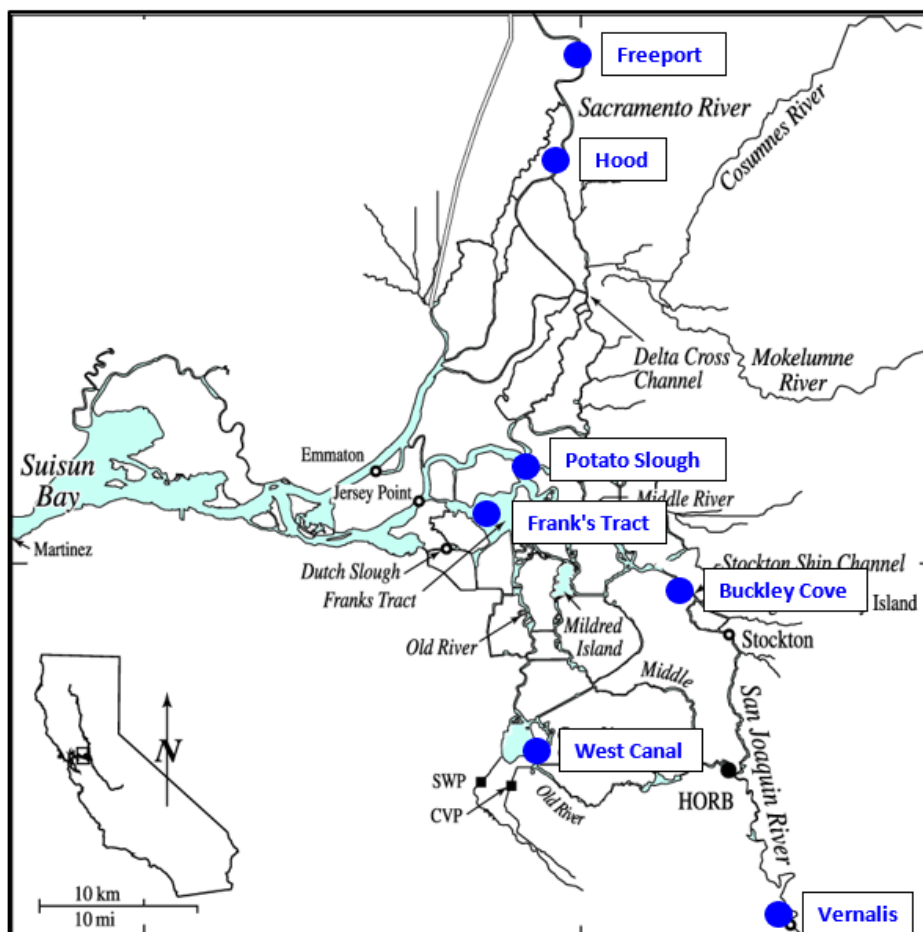
Low concentrations of nutrients, including N and P, can limit phytoplankton and cyanobacteria growth. In the summer and fall periods of 2022, the average ratio of N:P in the Delta ranged from 6:1 to 24:2 (Battey and Perry 2023, **Table 5**), indicating that N supply might become depleted before P during phytoplankton blooms at some stations. If N is depleted in the early stages of a bloom, it might reduce the HAB biomass, shorten the HAB duration, and decrease the cyanotoxin concentration produced. Limiting nitrogen concentrations might also allow N-fixing cyanobacteria to become more prevalent in the Delta phytoplankton community, although N-fixing cyanobacteria can also supply N to other cyanobacteria species when they die (Molot et al. 2017).

Table 5. Average monthly N and P concentrations and standard errors at Delta locations measured by the IEP Environmental Monitoring Program between June and October 2022.

Samples with concentrations below the analytical minimum detection level were averaged using the detection limit. The less than symbol indicated that all sample concentrations in the data set are less than the analytical minimum detection level. Values are concentrations +/- (1 standard error). Standard errors were not calculated for stations where all values were below the analytical minimum detection level and are marked with "n/a".

LOCATION	STATION ID	LATITUDE	LONGITUDE	DIN MG/L-N	ORTHO-P MG/L-P	TOTAL N MG/L-N	TOTAL P MG/L-P	TOTAL N μMOL/L	TOTAL P μMOL/L	TN:TP MOLAR RATIO
Vernalis	C10A	37.679	-121.265	0.33 (0.07)	< 0.05 (n/a)	0.43 (0.08)	0.04 (0.004)	31.1 (5.8)	1.3 (0.1)	24.2
Hood	C3A	38.367	-121.521	0.24 (0.02)	< 0.05 (n/a)	0.31 (0.02)	0.03 (0.002)	22.3 (1.4)	1.0 (0.1)	23.1
West Canal	C9	37.830	-121.554	0.16 (0.03)	0.08 (0.007)	0.40 (0.07)	0.09 (0.009)	28.8 (4.9)	3.0 (0.3)	9.5
Buckley Cove	P8	37.978	-121.382	1.60 (0.51)	0.35 (0.03)	2.08 (0.51)	0.35 (0.03)	148.6 (36.7)	11.4 (1.0)	13.0
Frank's Tract	D19	38.043	-121.615	< 0.1 (n/a)	0.05 (0.002)	0.25 (0.01)	0.06 (0.003)	17.6 (0.7)	1.9 (0.1)	9.1
Potato Slough	D26	38.076	-121.567	0.13 (0.01)	0.05 (0.003)	0.26 (0.02)	0.10 (0.04)	18.7 (1.6)	3.1 (1.2)	6.1

Figure 6. A map of selected IEP EMP Monitoring Program station locations.



3.1.2 Background

During 2022, California was in a prolonged drought and *Microcystis* sp. blooms were common in the South Delta from June to October (Battey and Perry 2023). Phytoplankton grew using the dissolved fraction of N in the water (DIN), which was mostly in the form of nitrate from June to October of 2022 (Battey and Perry 2023). Water quality monitoring (IEP EMP) in the Delta (at the stations indicated in **Figure 6**) determined that ammonium was often below the detection limit of 0.05 mg/L-N from June to October in 2022, with the only detectable ammonium concentrations of 0.06 and 0.07 occurring at Buckley Cove in September and October, respectively (Battey and Perry 2023).

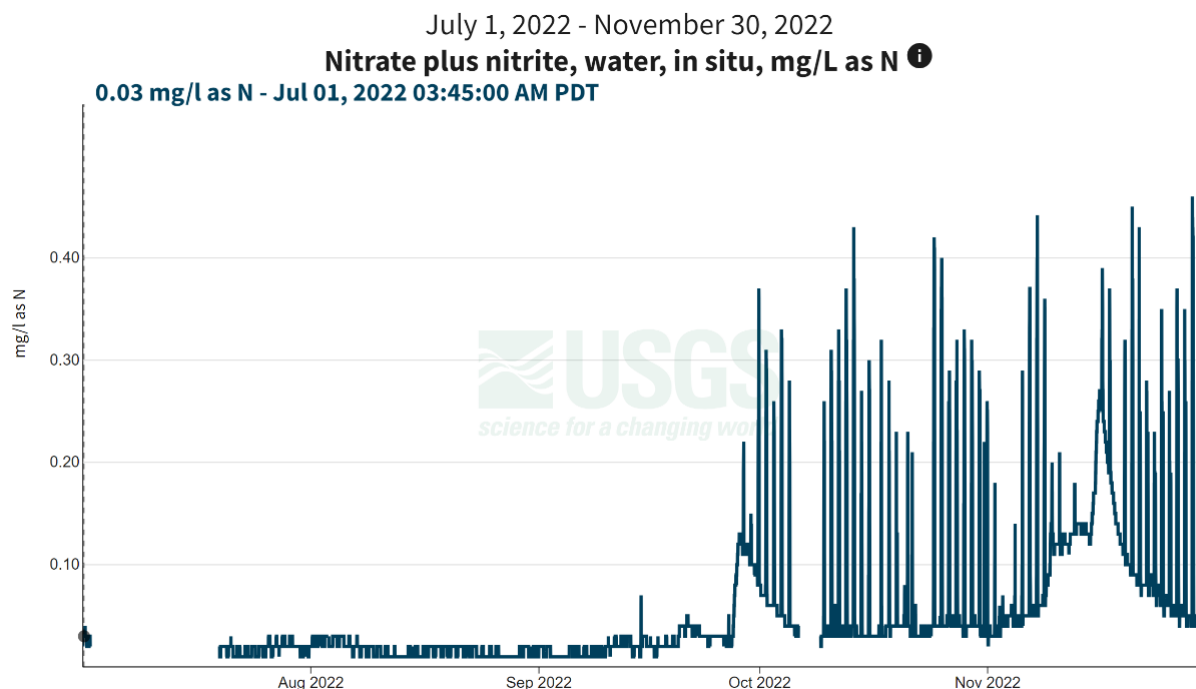
In general, the average DIN concentrations were lower in stations receiving Sacramento River water compared to those receiving San Joaquin River water (**Table 5**). Potato Slough N concentrations were lower than that supplied by Sacramento or San Joaquin Rivers, suggesting that nutrient drawdown had occurred before the water reached this station. The average concentration of N in July through August 2022 at Freeport Bridge in the Sacramento River was < 0.05 mg/L-N (**Figure 7**, USGS 2023). The Freeport monitoring

station is located just upstream of the Sacramento Area Sewer District's (SacSewer) discharge location, so reverse flows occurring in late September and November created short-term spikes in N. At the Hood monitoring station, which is downstream of SacSewer's discharge location, the effluent was well mixed with Sacramento River water and the average N was approximately 0.2 mg/L-N (**Table 5**). Therefore, the range in DIN occurring throughout the Delta in 2022, from 0.05 mg/L-N to 1.0 mg/L-N, provides a good range of DIN concentrations to evaluate phytoplankton response to differing N availability.

During this same period, the average of total P observed at monitored sites ranged from 0.03 to 0.35 mg/L-P, which serves as a benchmark for identifying a range of potential P reductions and N:P ratios suitable for evaluation along with DIN in nutrient reduction experiments.

Figure 7. Nitrate plus Nitrite concentrations at the USGS Freeport monitoring station on the Sacramento River from 7/1/2022 to 11/30/2022.

Concentration spikes in October and November are caused by Sacramento River flow reversals briefly transporting wastewater effluent to the Freeport Station.



3.2 HYPOTHESES

This study tests multiple N and P concentrations that occurred throughout the Delta during the 2022 drought when nutrient dilution was likely minimal. *Microcystis sp.* was common in the south Delta during this time (Battey and Perry 2023). The findings from this study should be compared to nutrient, chl-a, HAB, and phytoplankton enumerations

data collected from the Delta in 2022 to determine if similar chl-a concentrations and phytoplankton species occur in Delta locations with matching environmental parameters. Particularly strong interacting factors should be further investigated across a range of low N concentrations in future experiments.

The bioassay addresses an important question for nitrogen management; which phytoplankton species and how much phytoplankton biomass are likely to grow in the Delta at low N and P concentrations under ideal growing conditions? Phytoplankton (and HAB) management strategies also need to identify expected nutrient concentrations throughout the Delta under reduced nutrient loading (investigated by Focus Area 1) and how other factors known to reduce phytoplankton growth might interact with low dissolved inorganic nitrogen (DIN) to affect phytoplankton species biomass and occurrence.

Other important factors that should be studied in combination with nutrient limitation include light or silica limitation, reduced growth periods due to increased flows, temperature effects, herbicide effects, salinity effects, stratification, competition with macrophytes, grazing by herbivores, and mortality from disease and parasites. If a model can combine all the known outcomes of these interacting factors on phytoplankton growth, and estimate the biogeochemical nitrogen cycle, it should provide reasonable predictions for how phytoplankton would respond to nutrient loading reductions in the Delta.

The proposed bioassay study provides a useful first step by identifying the upper limit of phytoplankton biomass that might occur in the Delta at different low DIN and P concentrations in the absence of these other regulating factors. The study will also help evaluate if light limitation, competition with a submerged macrophyte, or grazing by clams might have substantial impacts on phytoplankton growth at low nutrient concentrations.

The findings from this study will help California State regulators and stakeholders estimate the upper limit of cyanobacteria biomass and cyanotoxins that can be produced at low N or P concentrations, under conditions promoting phytoplankton growth. This information will help California State regulators and stakeholders evaluate the level of nutrient reduction that might result in material reductions in cyanobacteria populations. The findings will also help determine if low N or P concentrations might limit the biomass of beneficial phytoplankton produced in the Delta. Chlorophyll-a concentrations above 10 µg/L have been shown to support maximal zooplankton growth rates (Müller-Solger et al. 2002). The study also provides an initial investigation into potential interactions between low N concentrations and other factors known to affect phytoplankton biomass in the Delta, including light limitation, nutrient competition with macrophytes, and grazing losses to clams, to assess the importance of combined effects. Detailed descriptions of these multi-factor treatments are provided in the methods section.

The proposed hypotheses to be tested are:

1. Low N or low P concentrations will prevent cyanobacteria from growing to nuisance concentrations and producing harmful concentrations of cyanotoxins.
2. Low N or low P concentrations will prevent beneficial phytoplankton species from growing to concentrations that support robust zooplankton growth (i.e., 10 $\mu\text{mol chl-a}$).
3. Low N or low P concentrations will reduce the biomass of specific planktonic cyanobacteria to concentrations that may not cause taste and odor problems for drinking water systems.
4. Phytoplankton species grown at a low N concentration and low light levels will differ from those grown at a low N concentration with moderate light levels.
5. At a low N concentration, nutrient competition with *Egeria densa* and its associated periphyton will result in lower cyanobacteria biomass, cyanotoxin concentrations, and beneficial phytoplankton biomass.
6. At a low N concentration, the presence of clams will reduce the accumulation of cyanobacteria, cyanotoxins, and beneficial phytoplankton biomass compared to phytoplankton grown at a low N concentration without clams.

3.3 MONITORING STRATEGY

The methods described here are provided for discussions of the study design which will be adjusted and refined by the Principal Investigator in close coordination with the Nutrient TAC members. All parameters and procedures will be adjusted to best evaluate the research questions and hypotheses. The final study design will be included in the Delta RMP Monitoring Workplan.

3.3.1 Pilot Scoping Studies

An initial set of pilot studies, testing different variables of the project design, such as sampling locations, water volumes, incubation duration, dilution water chemistry, N and P concentrations, salinities, light levels, clam biomass, and macrophyte biomass, should be performed prior to running the fully replicated study.

3.3.2 N and P Reduction Bioassay Treatments

Bioassay Treatments 1-8

Target N and P concentrations in the N reduction and P reduction bioassays (Treatments #1-8, **Table 6**) were selected to represent the range of average DIN and P concentrations occurring from June to October at different stations in the Delta in 2022. The highest average DIN and P concentrations occurred at Buckley Cove (roughly 1.6 mg/L-N and 0.35 mg/L-P, **Table 5**). The lowest DIN concentration occurred at Freeport (roughly 0.05 mg/L-N, **Figure 7**), while the lowest P concentration occurred at Hood (0.03 mg/L-P, **Table 5**). The N and P concentrations used in treatments #1-8 represent different levels of nutrient change, reduction or increase, at comparative stations across the Delta (**Table 7**). For example, a DIN value of 0.1 mg/L-N (treatment #3) would represent a 22% reduction at Potato Slough, a 58% reduction in average DIN at Hood, a 69% reduction at Vernalis, and a 94% reduction at Buckley Cove (**Table 7**). Similarly, a total P value of 0.03 mg/L-N (treatment #7) would represent a 70% reduction at Potato Slough, a 0% reduction in total P at Hood, a 25% reduction at Vernalis, and a 91% reduction at Buckley Cove (**Table 6**). The nitrate concentration in treatment #4 (0.05 mg/L-N) is representative of DIN concentrations in the Sacramento River from July through August upstream of SacSewer's discharge (**Figure 7**).

Treatment 9 is a river control treatment. Water will be collected directly from the source water location in the Delta during all three days of the experiment. This treatment will compare changes in phytoplankton biomass and assemblage occurring in the Delta waterway during the experimental period to those occurring in each of the bioassay treatments.

Treatment 10 is an ambient nutrient control treatment. Source water will be filtered with 100-200 µm Nitex screening, to remove large zooplankton and larval clams, and then be poured directly into the bioassay cubitainers without dilution or the addition of supplemental nutrients. This treatment will evaluate phytoplankton growth in the cubitainer environment at the ambient nutrient concentrations present in the source water.

Table 6. Treatments, bioassay descriptions, and target nitrate concentrations used in nitrogen reduction (#1-4), phosphorus reduction (#5-8), controls (9-11), and multi-factor (#12-14) bioassays. All treatments are tested in triplicate.

TREATMENT #	TREATMENT CATEGORY	TREATMENT DESCRIPTION	NITRATE (MG/L-N) OR PHOSPHORUS (MG/L-P)	NITRATE OR PHOSPHORUS (μMOL/L)
1	N Reduction Bioassay	Nitrogen reduction, Unlimited P	0.4	29
2	N Reduction Bioassay	Nitrogen reduction, Unlimited P	0.2	14
3	N Reduction Bioassay	Nitrogen reduction, Unlimited P	0.1	7
4	N Reduction Bioassay	Nitrogen reduction, Unlimited P	0.05	4
5	P Reduction Bioassay	P reduction, Unlimited N	0.12	4
6	P Reduction Bioassay	P reduction, Unlimited N	0.06	2
7	P Reduction Bioassay	P reduction, Unlimited N	0.03	1
8	P Reduction Bioassay	P reduction, Unlimited N	0.015	0.5
9	Control	River control treatment	TBD	TBD
10	Cubitainer Control	Ambient nutrient control treatment	TBD	TBD
11	Duplicate Control	Duplicate of treatment 4 (control)	0.1	7
12	Multi-factor Bioassay	50% light reduction + nutrient reduction	0.1	7
13	Multi-factor Bioassay	<i>Egeria densa</i> addition + nutrient reduction	0.1	7
14	Multi-factor Bioassay	<i>Corbicula fluminea</i> addition + nutrient reduction	0.1	7

Table 7. The percent change in nutrient concentration reductions (negative values are reductions) per treatment (#1-8) based on average DIN and TP concentrations in the Delta from June to October in 2022 (Table 5).

LOCATION	DIN REDUCTION				TP REDUCTION			
	Treatment							
	1	2	3	4	5	6	7	8
Frank's Tract	300%	100%	0%	-50%	100%	0%	-50%	-75%
Potato Slough	213%	57%	-22%	-61%	20%	-40%	-70%	-85%
West Canal	157%	28%	-36%	-68%	33%	-33%	-67%	-83%
Hood	68%	-16%	-58%	-79%	300%	100%	0%	-50%
Vernalis	23%	-39%	-69%	-85%	200%	50%	-25%	-63%

LOCATION	DIN REDUCTION				TP REDUCTION			
	Treatment							
	1	2	3	4	5	6	7	8
Buckley Cove	-75%	-88%	-94%	-97%	-66%	-83%	-91%	-96%

Multiple-Factor Bioassay Treatments

The Delta is a complex ecosystem and many factors other than DIN and total phosphorus concentrations are known to influence phytoplankton growth, such as light limitation, nutrient competition with macrophytes, grazing losses to clams, and differences in residence times. This second set of mesocosm studies investigates how phytoplankton might respond to nutrient reductions in combination with other common environmental variables (summarized in **Table 6**). These experiments are intended to evaluate if other factors with the potential to regulate phytoplankton biomass and species composition might cause substantial changes to the experimental results. If these factors significantly impact phytoplankton growth in the bioassay, they also need to be considered in future phytoplankton management strategies.

- In low light, phytoplankton growth may be slower, but low light might also support phytoplankton species that are better adapted to living at low light levels.
- If nutrients are taken up by aquatic vegetation, then higher nutrient concentrations might be required to reach desirable levels of beneficial phytoplankton growth.
- Clam grazing might exclude some phytoplankton species, allowing a different phytoplankton assemblage to be dominant under nutrient-limited conditions in regions where clam grazing is common.

If phytoplankton in the multi-factor bioassays show substantial differences from the control, it is an indication that additional research on these factors will be necessary before the effects of nutrient reductions on phytoplankton biomass can be estimated for the Delta.

The goal is to determine if interactions between low N concentrations and any of these factors might significantly alter the outcome of nutrient reductions in phytoplankton communities. It is recommended that all multiple-factor cubitainer studies be conducted at the low nitrate concentration of 0.1 mg/L-N. A control treatment duplicating the conditions present in Treatment #4 should be conducted and used for comparisons in the multiple-factor studies. If one of these factors shows a strong effect on phytoplankton biomass, HAB biomass, or cyanotoxin production, then the interaction should be tested to a greater extent in a separate (future) sets of experiments across a range of low N concentrations.

The multiple-factor bioassay treatments will require 18 cubitainers per day, so the full study (Treatments 1 through 14) will use 42 cubitainers per day. The sampling frequency and test parameters used in the multiple-factor bioassay treatments will follow those listed in **Table 8**.

CONTROL (TREATMENT #11)

This treatment is a duplicate of treatment #4 and will be used for statistical comparisons with the other treatments in the multifactor bioassay treatments. Comparing the multifactor treatment results with treatment #4 would require a Bonferroni correction to be used in the Analysis of Variance (ANOVA) tests for each study.

LIGHT REDUCTION (TREATMENT #12)

Insufficient light is known to limit phytoplankton growth in the main channels of the Delta (Cloern 1987), where the water column is often turbid, deep, and well-mixed. The PAR levels in other treatments are intended to simulate the light available within the first meter of water depth and should be sufficient for rapid phytoplankton growth. However, it is important to also understand the combined effects of reduced N concentrations and limited light on phytoplankton growth. Lower light may allow slower-growing phytoplankton to become the competitively dominant species in the bioassays. Cubitainers in this treatment should be wrapped with an extra layer of neutral density screening to reduce light levels so they are at 50% of the PAR received in other treatments.

EGERIA Densa ADDITION (TREATMENT #13)

Egeria densa (*E. densa*, also known as Brazilian waterweed) is an invasive submerged aquatic plant that is common throughout the Delta. *E. densa* stalks have whorls of leaves that create a bottle-brush appearance and can live free-floating (without roots) by absorbing nutrients directly from the water. The competition between *E. densa* and phytoplankton for scarce levels of nutrients has not been tested in the Delta. Periphyton can also grow on the surface of *E. densa* and take up additional nutrients. The study will not attempt to differentiate between the nutrients utilized by *E. densa* or its associated periphyton because they regularly occur together, and the goal is to understand their combined effect on phytoplankton biomass and species composition. It is also possible that some periphyton on *E. densa* stalks might propagate out into the suspended algae during the experiments.

E. densa stems will be harvested from the Delta and trimmed to a length of 25 cm from the stem tip. Stems should be gently rinsed with river water to remove built-up sediments. Stems should be visually inspected, and all macroinvertebrates removed (such as snails and insects). Non-branching stems that include at least one double node should be

selected to allow the cutting to grow into a new plant (GISD 2023). A double node consists of two single nodes separated by a greatly shortened internode. Two 25 cm-long *E. densa* stems (tip to cutting) should be added to each cubitainer in this treatment and moved between cubitainers during the daily water transfers. At the end of the experiment, the length of the cutting should be remeasured as an indicator of growth (measuring plant weights and marking the top leaves at the start of the experiment might also help measure and visualize plant growth, respectively). Under ideal light and nutrient conditions, *E. densa* can grow up to 3 cm per day.

CORBICULA FLUMINEA ADDITION (TREATMENT #14)

Small *Corbicula fluminea* (*C. fluminea*, 10-mm shell width) can be collected from the Delta using clam dredges (or by hand) the day preceding the experiment and transported to the collection site in chilled coolers, using an approved California Department of Fish and Wildlife scientific collecting permit. *C. fluminea* is resilient to brief periods of air exposure. In the 10L cubitainers, a single clam of this size represents a moderately-high clam biomass-to-water volume ratio for the Delta. The clam's filtering range will cover a larger proportion of the cubitainer than it would in a deep Delta channel, therefore the treatment only simulates phytoplankton growth in shallow water habitats inhabited by clams. *C. fluminea* frequently targets diatoms for consumption and may avoid ingesting cyanobacteria, which could promote cyanobacteria abundance in the phytoplankton community (Bolam et al. 2019). Diatoms might also sink to the bottom of the cubitainer in the relatively still water and be more easily grazed by clams compared to positively buoyant cyanobacteria, such as *Microcystis* sp. This would also promote a taxonomic shift to cyanobacteria in the bioassays.

3.4 SAMPLE COLLECTION FREQUENCY AND TIMING

Samples will be collected during each day of the study for each treatment as outlined in Table 8.

Table 8. Sample collection days for each test parameter. The initial day is listed as day 0 and will be evaluated with six replicate samples collected from the source water.

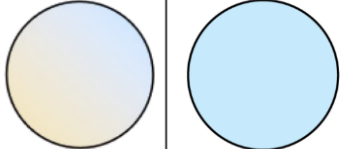
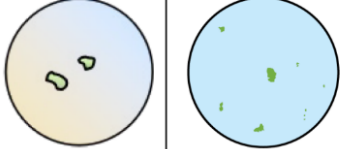
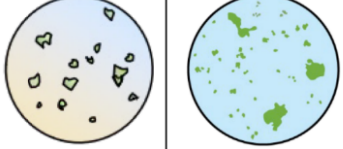
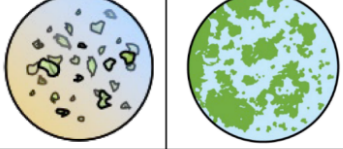
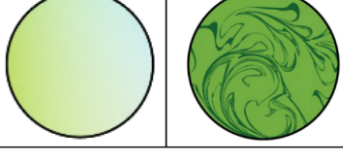
PARAMETER	MEASUREMENTS DAYS			
	0	1	2	3
Temperature	x	x	x	x
Dissolved oxygen	x	x	x	x
pH	x	x	x	x
Specific conductivity	x	x	x	x
Turbidity	x	x	x	x
Pesticides	x			
Nitrate + nitrite	x	x	x	x
Ammonium	x	x	x	x
Unfiltered Total Kjeldahl Nitrogen (TKN)	x	x	x	x
Dissolved TKN	x	x	x	x
Total phosphate	x	x	x	x
Dissolved Silica	x	x	x	x
Chlorophyll-a	x	x	x	x
High-Performance Liquid Chromatography (HPLC) phytoplankton pigment concentrations	x	x	x	x
Cyanotoxin concentrations	x			x
Taste and odor compounds	x			x
Phytoplankton enumeration	x			x

3.5 SAMPLING LOCATIONS AND METHODS

Water will be collected from one location in the south Delta where HABs are known to occur. Two collections will be made, the first occurring during the spring (March-April) before HABs develop and the second during the summer/fall, with water sources from an actively growing HAB bloom (July-August). If a bloom is not present in the late summer, then the second round of the study will be postponed, potentially until the following year. As these bioassay experiments are influenced by the starting conditions at the sampling location, it is recommended that the full experiment be repeated during the following year to evaluate how phytoplankton responses to N and P reductions change under different starting conditions.

Water samples will be collected from the Delta by boat, 0.5 m below the surface, at midday, at a location where *Microcystis* sp. populations are known to occur. If there is low cyanobacteria biomass, it is likely the experiment will be postponed. Sampling will be coordinated with Division of Boating and Waterways to avoid time periods when spraying is occurring within the Delta. Samples will also be collected in triplicate for pesticide analysis to understand background pesticide concentrations of the source water. During the late summer/fall collection, researchers should visually ensure that *Microcystis* sp. is at medium to high concentration at the time of collection based on the DWR visual assessment methodology (**Figure 8**, Flynn et al. 2022) or using another analytical method. All surface water samples should be collected from the same location on the same day during each sampling event. Source water should be filtered with 100-200 µm Nitex screening to prevent large zooplankton and clam veligers from being added to cubitainers. However, phagotrophic protists are likely to pass through the Nitex screening, due to their small cell sizes, and are expected to consume a substantial proportion of phytoplankton's daily production in all treatments (Nogueira et al. 2014).

Figure 8. Microcystis scale for visual index of *Microcystis* sp., *Aphanizomenon* sp., and *Dolichospermum* sp. used by monitoring programs in the Delta (Flynn et al. 2022).

	1 – Absent No visible <i>Microcystis</i> colonies
	2 – Low Visible but widely scattered <i>Microcystis</i> colonies.
	3 - Medium Adjacent colonies of <i>Microcystis</i> .
	4 - High Contiguous colonies of <i>Microcystis</i> .
	5. Very High Concentrated contiguous colonies of <i>Microcystis</i> forming mats or scum.

Surface water will be diluted to achieve the lowest N and P concentrations that are to be tested in the experiment (0.05 mg/L-N and 0.015 mg/L-P), using deionized water supplemented with other essential nutrients and major ions to match the initial river concentrations, following the methods of Barnard et al. (2021). Diluted river water should be mixed gently (to ensure that *Microcystis* sp. and other floating or sinking phytoplankton species are well distributed throughout the sample) and transferred to individual 10L containers. Nitrate and/or potassium dihydrogen phosphate (KH_2PO_4) will be added to cubitainers to achieve the initial target nitrate and phosphorus concentrations in each treatment (**Table 6**). Sodium bicarbonate (NaHCO_3) and Silica (Na_2SiO_3) should be added to the source water to prevent carbon or Si limitation from occurring during the incubation in the sealed containers. Cubitainers will also receive any other amendments required when they are filled, such as clams or macrophyte cuttings, as discussed below, in the Multiple-Factor bioassay treatments section. Cubitainers will be placed in flowing water baths for temperature control, either by utilizing laboratory water baths or by using floating enclosures attached to a dock located within the Delta waterway (**Figure 9**). Neutral-density screening should be used as enclosure covers to ensure there is moderate

illumination for phytoplankton growth. Light levels should approximately match the light present at 0.5 m depth at the collection location during the time of sampling (likely near $120 \mu\text{mol photons m}^{-2} \text{s}^{-1}$) to prevent photo-inhibition. Measurements of photosynthetically active radiation (PAR) should be made using an underwater quantum sensor.

Figure 9. Example of 10L containers housed in floating encloses attached to a dock in the Delta. A neutral-density screening cover is shown on the right (Mussen et al., unpublished study).



3.5.1 Bioassay Monitoring Methods

The source water will be sampled (six times) prior to filling individual cubitainers, to avoid unnecessary duplication of samples. Triplicate samples should be collected from the water source on the following days of the experiment for comparison with the phytoplankton incubated in the cubitainers. Source water measurements should follow those shown in **Table 8**. The source water concentrations can be compared to those in the ambient treatment to understand how phytoplankton growth was affected by the cubitainer environment.

Initial nitrate and phosphorus levels in the cubitainers should match the concentrations outlined in **Table 6**. The ambient treatment will measure phytoplankton growth of filtered source water without any dilution, to determine how phytoplankton growth in the cubitainers compares throughout the experiment to the growth happening in the source water throughout the experiment. Three replicate cubitainers will be tested for each treatment. Water quality parameters should be measured during each day of the experiment, including temperature, dissolved oxygen, pH, specific conductivity, and turbidity. At low N concentrations, it is predicted that most of the available N will be taken up by phytoplankton after three days. Phytoplankton in treatments receiving higher N

concentrations are expected to have higher phytoplankton biomass at the conclusion of the experiment.

Measurements will also include discrete samples for nitrate + nitrite, ammonium, unfiltered total Kjeldahl nitrogen (TKN), dissolved TKN, total P, dissolved silica, and chl-a (**Table 8**). Water samples for phytoplankton enumeration (taxonomy, cell count, and biovolume) and cyanotoxins (microcystin, anatoxin, saxitoxins, and cylindrospermopsin) concentrations should be collected from the source water at the start of the experiment and from each cubitainer at the end of the experiment. Total N concentration can be calculated from TKN plus nitrate and nitrite. Each day, cubitainers will be mixed by turning them upside down and gently shaking, repeated three times, prior to sampling.

3.6 DATA DELIVERABLES AND REPORTS

3.6.1 Predictions and Evaluation Methods

Analysis of Variance (ANOVA) will be used to identify significant differences in the final chl-a concentrations, the biovolume of specific phytoplankton (such as HAB species, species producing taste and odor compounds, and diatom species), and cyanotoxin concentrations among the various treatments. Chlorophyll a is expected to reach relatively stable concentrations by the end of the experiment, with higher biomass occurring in treatments with higher N concentrations and P concentrations. Zooplankton population sizes are not expected to increase dramatically during the 3-day experiments. The final biovolume of HABs and cyanotoxins can be compared to established national and state thresholds. The final biovolume of diatoms, chlorophytes, and other desirable phytoplankton species should be compared to chl-a restoration targets in the Delta, which are intended to increase zooplankton populations as a food source for fish. The biomass of cyanobacteria known to cause drinking water taste and odor challenges (or taste and odor compounds such as geosmin and 2-methylisoborneol (MIB)) should be evaluated against known benchmarks of impairment (DNDWW 2017). However, many taste and odor-causing cyanobacterial species are epibenthic or periphytic, so they are unlikely to grow to high pelagic biomass in this experiment.

The multifactor cubitainer treatments will provide initial insight into understanding how other environmental factors might alter phytoplankton responses to nutrient reductions. Analysis of Variance (ANOVA) will be used to identify significant differences among the treatments in final chl-a concentrations, the biovolume of specific phytoplankton (such as HAB and diatom species), and cyanotoxin concentrations among treatments. Phytoplankton biomass is expected to be lower in treatments with lower nutrient concentrations. Reduced light levels might reduce the increase in phytoplankton biomass over time or allow a different phytoplankton species to dominate the bioassay. The

presence of *E. densa* has the potential to reduce phytoplankton growth due to nutrient competition, shading, and the release of allelochemicals. *C. fluminea* is expected to have a strong grazing effect on the phytoplankton in the test chambers. These clams can deplete diatom abundance while potentially excluding cyanobacteria through selective filtration or consumption (Bolam et al. 2019). A refuge from clam grazing may also be established at the top of the cubitainer for motile or positively buoyant phytoplankton species (including *Microcystis* sp) because the filtering range of *C. fluminea* is unlikely to extend to the top of the 10L cubitainers. This study is intended to provide a starting point for understanding how phytoplankton in the Delta would respond to low N or to low P concentrations. Low N concentrations were rare in the system historically so the phytoplankton species that grow at low N concentrations are unknown. The study can inform how cyanobacteria in the Delta respond relative to low N concentrations, which might suppress the magnitude and duration of HABs and cyanotoxins production, and the growth of cyanobacteria causing taste and odor issues. The results also help evaluate if beneficial phytoplankton species biomass will grow to sufficient levels to support the Delta's food web at low N concentrations. Importantly, this study helps to determine if other environmental factors might significantly alter phytoplankton responses to nutrient reductions and if they should be included in nutrient management strategies. It is believed that the results from this study will guide future research questions and models predicting the outcome of N and P reduction management strategies in the Delta. However, it is not expected that the study findings will directly establish thresholds for nutrient benchmarks because other environmental effects, such as water flow rates (residence times), temperature, light availability (influenced by water and water depth), nutrient competition with macrophytes, and grazing effects from invertebrates should all be accounted for in the development of nutrient thresholds.

3.6.2 Limitations of the Bioassay Design

The findings from this study should be interpreted cautiously as many environmental conditions in cubitainers are different from those present in the Delta waterways. Cubitainers are beneficial for isolating and evaluating mechanistic effects of environmental factors, but they may not accurately represent phytoplankton growth under natural conditions in the Delta. Additionally, phytoplankton responses to N and P reductions are likely to differ due to interactions with other organisms and environmental variables. Future field monitoring studies may be needed to investigate and verify the bioassay findings of this proposed study.

It is assumed that the phytoplankton community is healthy at the start of the bioassay and that the water does not contain high levels of herbicides or other contaminants that can

inhibit phytoplankton growth. It is particularly important that all essential nutrients and major ions required for phytoplankton growth are included in the constructed dilution and exchange water. High phytoplankton production should be confirmed in pilot studies using constructed dilution water and tested using a high nitrate addition (and non-limiting P) prior to running the full bioassay testing low N and low P concentrations. Water in Delta channels is frequently turbid, well-mixed, and unlikely to stratify compared to that in the containers. Heavy particulate matter is likely to settle out of suspension in the cubitainers, increasing water clarity and potentially allowing the water to thermally stratify. Frequent rotation of the cubitainers should reduce the potential for stratification. Relatively stable water conditions in the cubitainers might select for the growth of motile phytoplankton species that are adapted to calmer environments than are typical for Delta channels. Tidal currents in the Delta also exchange water with shallow wetlands, which likely affects phytoplankton growth, grazing losses, and residence time in the waterway.

This experiment does not evaluate the taxonomy and biomass of invertebrates that develop when phytoplankton are grown at low N and low P concentrations, so the effects of N and P reduction on other trophic levels must be estimated using other techniques. Zooplankton can reduce phytoplankton biomass through grazing and zooplankton grazing might promote cyanotoxin production. The bioassay design also does not fully account for shading or nutrient competition with floating macrophytes, which are likely to impact phytoplankton growth at low N and/or P concentrations in the Delta.

This bioassay does not evaluate salinity effects on phytoplankton growth, but salinity can be a highly regulating factor for many phytoplankton and cyanobacteria species. Salinity is elevated in the Delta where river water mixes with Pacific Ocean water, and also in some backwater sloughs with minimal tidal exchange, where salinity is elevated due to evaporation. Water temperature also regulates phytoplankton growth and community composition. Therefore, the findings from this study will only represent phytoplankton growth at the salinity and water temperature that were present in the bioassay which generally are more ideal growth environments than the actual conditions outside of a cubitainer.

Effective nutrient management strategies need to be based on a strong scientific understanding of the mechanisms regulating phytoplankton growth and biomass in the Delta. Identifying the phytoplankton species, and predicted biovolumes, that will grow at different low N and P concentrations, the quantity of cyanotoxin or food resources generated, and interactions with other common environmental factors, will provide a solid foundation for future nutrient management discussions.

3.7 STUDY TIMELINE AND SCHEDULE

It is anticipated that the pilot study will be conducted in late summer / early fall of 2024 to allow for the first bioassay experiment to occur in spring of 2025 and the second bioassay experiment to occur in fall of 2025.

3.8 COST ESTIMATE

This experiment will require approximately 2,400 discrete samples to be collected and analyzed, plus those included in the pilot study. A rough estimate of the study's total cost is \$490,504 as described in **Table 9**, which includes the costs of discrete sample analysis, field sampling and monitoring equipment, labor for conducting the experiment and reporting the findings, and overall project management and interactions with the Delta RMP Nutrient TAC and SC. The list of samples from each set of experiments and the total number of samples are shown in **Table 10**.

Table 9. Estimated nutrient reduction bioassay study costs (this estimate is for a pilot study in 2024, and two experiments conducted in the spring and late summer of 2025).

TASK	COST
Pilot Study	\$40,000
Discrete samples	\$262,080
Materials and equipment	\$8,424
Operations	\$90,000
Reporting	\$60,000
Project management	\$30,000
Total	\$490,504

Table 10. Discrete analyte counts for one bioassay in one season. Treatments share initial data for the water source, with six replicates collected per analyte.

DISCRETE SAMPLES	SAMPLE DAYS	TREATMENTS	REPLICATES	INITIAL	TOTAL
Nitrate + nitrite	3	14	3	6	132
Ammonium	3	14	3	6	132
Unfiltered TKN	3	14	3	6	132
Dissolved TKN	3	14	3	6	132
Total phosphorus	3	14	3	6	132
Dissolved silica	3	14	3	6	132
HPLC phytoplankton pigment concentrations	3	14	3	6	132
Chlorophyll-a	3	14	3	6	132
Cyanotoxin concentrations	1	14	3	6	48
Taste and odor compounds	1	14	3	6	48
Phytoplankton enumeration	1	14	3	6	48

4 FOCUS AREA #3

The Delta RMP will look for opportunities to collaborate or leverage funding to address the question for Focus Area #3:

- How are characteristics of harmful cyanobacteria blooms in the Delta changing over time including the status of cyanobacteria blooms and cyanotoxins in the Delta and factors that affect their magnitude, geographic extent, and timing?

The Delta RMP will explore partnerships and funding opportunities with existing monitoring programs such as Department of Water Resources for Environmental Monitoring Program's discrete phytoplankton monitoring and regular fixed monitoring station maintenance crews, California Department of Fish and Wildlife for Interagency Ecological Program fish trawls and the Fish Restoration Program, and USGS Water Science Center studies. The Delta RMP is receptive to providing funds toward sample supplies, laboratory analyses, and shipping to add cyanotoxins and cyanobacteria to existing efforts.

4.1 STUDY OBJECTIVES

The study objective is to support the collection of data to better understand changes in cyanobacteria status and risks in the Delta. There is no comprehensive monitoring of cyanotoxins currently in place in the Delta. The Delta RMP has effectively contributed to HABs science by adding funding to studies led by others. The Delta RMP has added Focus

Area #3 into the Nutrient Multi-Year Study Plan with the objective to monitor cyanobacteria blooms and toxins by collaborating with, and/or augmenting other data collection efforts, or funding Supplement Environmental Project (SEP) studies (pending the ability for Delta RMP to use SEP funds in the future). Cyanotoxin analyses are relatively expensive, and bloom conditions vary significantly over space and seasons. Therefore, leveraging Delta RMP funds by collaborating with other efforts is important to expand the scope of information that will be gained. Likely methods include collecting water and/or passive sampler media for analyses of cyanotoxins. Other analytes (water samples) could include chl-a, phytoplankton community composition, and genetic analyses for cyanotoxin production potential. An ideal study would measure multiple factors potentially affecting HAB blooms such as water temperature, salinity, depth, light availability, turbidity, water column mixing and flows, dissolved oxygen, pH, nutrient concentrations, and zooplankton abundance and assemblage. These are desirable factors to be measured but may not always be included in a study design; the Delta RMP may decide to fund studies to supplement factors measured to better understand HAB bloom mechanics.

4.1.1 Why is this a priority?

The Delta RMP SC identified status and trends of HABs as a priority area as part of the long-term planning process. This priority aligns with the Central Valley Water Board Delta Nutrient Research Plan special study recommendations to determine the roles of nutrients and other drivers in controlling the growth rate, maximum biomass, and toxin production of HABs, as mentioned above. Focus Area #3 works to address status and trends questions outlined by the Delta RMP in a set of management and assessment questions for nutrients (Table 1). The priority is to support studies looking to gain additional information to help understand what can be done to prevent and/or minimize harmful algal blooms.

4.2 HYPOTHESIS

There is no predetermined hypothesis for Focus Area #3. Hypothesis testing will be determined based on the specific project(s) funded for study.

4.3 MONITORING STRATEGY

Monitoring strategies could include but are not limited to collection of water, sediment, biota, and/or passive sampler media for analysis of cyanotoxins. Priority study areas include the impact of sediment resuspension, light and turbidity effects, HAB cyanotoxin concentrations and potential impacts, and transport (such as residence time effect on

HAB growth or movement of HABs across locations). Studies could focus on genetic analysis of cyanotoxin production potential, molecular assays, phytoplankton community compositions, and chl-a concentrations.

4.4 MONITORING STUDY PLAN REQUIREMENTS

Following the Delta RMP Data Management Plan and proposal or study plan requirements established by the Delta RMP, each project must include details specific to the monitoring design, including hypotheses to be tested, sample collection locations, sampling frequency, sample collection and analytical methods, data deliverables and data management, project schedule, and budget. Study plans approved by the Delta RMP will be incorporated into the Annual Monitoring Workplan which requires the following study design information:

- a. Specific hypothesis(es) to be tested;
- b. Sample locations;
- c. Sample collection frequency;
- d. Sample analytes;
- e. Analysis methods;
- f. Preliminary data deliverables;
- g. Planned reports to summarize results;
- h. Timeline and schedule for all the study design elements to be complete.

As described in the Data Management Plan, associated data management and quality assurance documentation will also be required and approved prior to implementation. The components of the study design should be implemented in a timeline that complements the other studies included within this Study Plan and meets the objectives of Focus Area #3.

4.5 SAMPLE COLLECTION METHODS, ANALYTES AND ANALYTICAL METHODS

Specific sample collection methods, analytes, and analytical methods will be included with the study plan and/or proposal and evaluated to ensure that the study plan meets the objectives of Focus Area #3. Analytes for Focus Area #3 could include factors potentially affecting HAB blooms such as water temperature, salinity, depth, light availability, turbidity, water column mixing and flows, dissolved oxygen, pH, and nutrient concentrations. Analytes could also include chl-a, phytoplankton community composition, and genetic analyses for cyanotoxin production potential.

4.6 DATA DELIVERABLES AND REPORTS

4.6.1 Data Management

Data management associated with the study plan or proposal must follow the outlined requirements for Collaborative Studies in the Delta RMP Data Management Plan.

4.6.2 Data Deliverables and Reporting

Data deliverables and reporting must meet the requirements of Resolution R5-2021-0054 and the Data Management Plan. This includes data being publicly available and reporting of data within the timelines prescribed by Resolution R5-2021-0054.

4.7 STUDY TIMELINE, SCHEDULE, AND BUDGET

The study plan or proposal must include a project timeline, schedule, and budget. There is no prescribed timeline for project completion for Focus Area #3 and studies may range from months up to 3 years. It is most likely that these collaborative studies will be funded on an annual basis to correspond with the Delta RMP fiscal year Annual Monitoring Workplan timeline; however, it is possible that the Delta RMP would commit to multiple years of collaborative funding depending on the project, if the project's objectives align with the overall Nutrient Multi-Year Study Plan.

4.8 PROJECT APPROVAL PROCESS

The Delta RMP's Data Management Plan outlines the current proposal process which will be followed when reviewing project proposals. The process includes review of the initial proposal with the entity proposing the project and the Delta RMP Program Manager to ensure that the project meets the objectives of Focus Area #3, the overall Nutrient Multi-Year Study Plan objectives, is consistent with the Data Management Plan, and includes enough details to meet the Delta RMP study design requirements. The next step is for the Nutrient TAC to review the proposal using the proposal process outlined in the Data Management Plan. The Nutrient TAC review of the proposal will be provided to the Steering Committee for review and recommendation to the DRMP Board of Directors (BOD). The DRMP BOD will decide if they wish to fund the project. Once the project is funded, it will be integrated into the Annual Monitoring Workplan, and associated data management documentation will be developed.

In cases where multiple proposals are being presented, the Steering Committee may ask to review pre-proposals to determine which projects should move forward into a complete proposal for review by the Nutrient TAC. This may require a joint discussion of the Steering Committee and Nutrient TAC.

The DRMP BOD is allocating approximately \$150,000 a year for projects that fall within Focus Area #3 with a total amount of \$450,000 over three years (**Table 2**).

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Appendix II – Biogeochemical Model Amended Scope of Work (Focus Area #1)

Scope of Work

Delta Biogeochemical Modeling: Simulating Nutrient Loads, Cycling, and Fate Under Actual-Load and Load-Reduction Scenarios

September 13, 2024 (v3)

Amendment 1: September 11, 2025

I. AMENDMENT SUMMARY

This Scope of Work (SOW) has been amended due to project delays in getting initiated. This has translated into the need to extend the end date of the project and some of the deliverable timing within. In addition, some tasks have required additional funding to reflect the following:

1. TAC meetings: increased TAC meetings from 12 to 13
2. Working meetings with the DRMP TAC: increased from 5 to 8 meetings
3. Timeline adjustments (Table 1a and Table 1b)
4. Extension of the finalized products through February 2027
5. Addition of funding for Optional Subtask 4.4

This amendment increases the original budget from \$436,091 to \$465,071 across FY 24-25, FY 25-26, and FY 26-27 (see Table 3 for amended budget).

II. PROJECT BACKGROUND AND DESCRIPTION

The proposed project's high-level goals and approaches are summarized below:

High-Level Project Goals

1. Quantify the effects of nutrient load reductions on nutrient concentrations throughout the Delta, including how those effects vary spatially, temporally (seasonally, interannually), and as a function of water management or flow-routing.
2. Evaluate in greater detail and provide visualizations of changes in nutrient concentrations within, or nutrient delivery to, regions of the Delta that are impacted by HABs and invasive aquatic vegetation (IAV).
3. Investigate additional priority hypotheses, including one or more of the following: a) Quantify the importance of remaining nutrient sources (beyond those included in scenarios) within HAB- and IAV- prone regions, including Delta non-point sources; b) Assess the relative importance of IAV on nutrient concentrations and cycling; and/or c) Characterize the relative importance of factors

regulating phytoplankton biomass or productivity, including potential effects of decreased nutrient availability due to load reductions on ‘beneficial production’.

Approach: To address these goals, the project will:

- Simulate hydrodynamics and biogeochemistry during water years 2022 (WY2022) and WY2016, using actual nutrient loads during those years (‘Base’), to predict nutrient transport, cycling, and concentrations throughout the Delta.
- Re-simulate WY2022 and WY2016 biogeochemistry for a set of load reduction scenarios to forecast nutrient concentrations under each of those conditions.
- Quantify differences in nutrient concentrations between the Base and Scenario simulations, including their spatial, temporal, and interannual variability.
- Investigate one or more priority hypotheses related to ecosystem response(s) to nutrients through targeted analysis of model output.

Early work will include model updates and modifications to improve model performance during the low-flow conditions encountered in both water years and under reduced-load scenarios. The hydrodynamic and biogeochemical models will then be calibrated for WY2022 and WY2016 and used for Base and Scenario simulations.

III. PROJECT SCOPE

1. TASKS

The tasks included in this SOW pertain to work on the Delta RMP project *Numerical Simulations of Delta Nutrient Loads, Cycling, and Fate Under Actual-Load and Load-Reduction Scenarios*, that will be carried out by the San Francisco Estuary Institute (SFEI), Resource Management Associates (RMA), and Four Peaks Environmental Science & Data Solutions (Four Peaks) over the period of September 1, 2024 through February 28, 2027 (Fiscal Year 24-25, 25-26, and 26-27).

Modeling work will be carried out using the northern San Francisco Estuary Biogeochemical Model (nSFE-BGCM), a 3-D coupled hydrodynamic-biogeochemical model developed for simulating nutrient loads, transport, and cycling, and ecosystem responses (e.g., phytoplankton, grazers, dissolved oxygen).

The scope below summarizes the project’s main work activities, organized under four main Tasks (and their subtasks). The timing of work, milestones, and work products for the Tasks and Subtasks are summarized in Tables 1A and 1B. Additional details about the model platform and context about work elements can be found in the DRMP Nutrient Multi-Year Study Plan.

Task 1 Project Management

This task covers project management activities, organized under the following subtasks:

Subtask 1.1 Progress update meetings with the DRMP Nutrient TAC

Members of the project team will participate in regular Nutrient TAC meetings. The budget is based on the assumption of 13 meetings with update materials prepared in the form of presentations (9 meetings

attended by two team members, 8-hour prep per meeting; 4 meetings attended by one team member, 2 hour prep per meeting).

Subtask 1.2 Working meetings with the DRMP TAC

We will participate in working meetings with TAC members to establish details related to a set of priority load reduction scenarios. The budget is based on the assumption of up to 8 meetings, approximately 2 hours long, and attended by 1-2 members of the team that are most closely related to the discussion topics in the meeting.

Subtask 1.3 Monthly progress summaries

We will prepare monthly brief progress summaries for submission with invoices. The progress summaries will provide a bulleted list of key activities completed during the invoicing period and capture the status of any major deliverables that were developed during that period.

For Subtasks 1.1 and 1.2, the budget assumes meetings with the TAC will be virtual and will be scheduled by the DRMP. Local members of the project team are also able to attend in-person meetings; however, additional costs have not been included in the budget.

Task 2 Hydrodynamics: Model Updates, Setup, and Calibration

Subtask 2.1 Incorporating improvements to grid and bathymetry

Work includes incorporating several major improvements to the model grid and bathymetry in the Cache Slough Complex (CSC), portions of the Sacramento River near the Delta Cross Channel, and Suisun Bay. Components of the grid and bathymetry improvements have already been accomplished in prior UC Davis and RMA projects, but still require integration into the nSFE-BGCM, pre-processing pipelines, and post-processing tools. These changes will be tested and, as needed, adapted to the specific conditions in WY2022 and WY2016.

Subtask 2.2 Hydrodynamics: model setup, WY2022 & WY2016

Hydrodynamic input files (boundary conditions, forcings) will be developed for WY2022, including: river flows; point source flows; meteorological forcings; gate and pump operations; space-time varying interior-Delta flow withdrawals/returns (using the Delta Channel Depletion dataset, DCDv1.0; CA DWR 2018); timing and/or operation of drought barrier installation, parameterizing barrier-related flow (e.g., weir equations). The Central Valley Clean Water Association will use existing data to provide information on POTW flows and water quality data to update the hydrodynamic input files. The scope and budget assume up to 8 smaller POTWs that discharge to the Delta, and that the flow and concentration data would be provided or are readily available.

Input files for WY2016 already exist from prior nSFEI-BGCM studies and will be updated as needed to maintain a consistent approach across the two simulation periods.

During dry and critically dry years like WY2016 and WY2022, interior-Delta withdrawals/returns and drought barriers can exert substantial influence on flow routing and biogeochemistry in some regions of the Delta. Model setup for WY2022 will also require incorporating flow alterations at the Old River Drought Barrier, which will involve testing and some iterative refinements to assess and improve model

performance. A major focus of the hydrodynamic calibration will be on accurately representing discharge and water elevations at structures/drought-barriers, within the CSC, and within regions affected by Harmful Algal Blooms (HABs) and Invasive Aquatic Vegetation (IAV).

The overall budget for Task 2 uses a mid-range estimate for the potential effort required to represent these low-flow/drought years. It is possible that additional resources may need to be directed toward Task 2 to reach the level of hydrodynamic performance necessary to reliably simulate water quality in Task 3. We will keep the TAC apprised as work progresses.

Table 1A. Project Timeline for tasks and subtasks, including interim milestones. Letters indicate anticipated timing of interim milestones. Blue cells indicate final milestones, and for some subtasks the timing of work products (Subtask 2.3, 3.3, and 4.3). Descriptions of milestones and work products are summarized in Table 1B. The timing of TAC meetings under Subtask 1.1 are placeholders, and do not necessarily represent actual planned meeting months, and will be adjusted as the meeting dates become available.

Tasks and Subtasks	2025												2026												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
	FY2025						FY2026						FY2027												
Task 1 Project Management																									
1.1 Progress update meetings with the DRMP Nutrient TAC (approximate dates)	a		a		a		a		a			a		a		a		a		a		a		a	a
1.2 Working meetings with the DRMP TAC				b	b'	b''			c		d			d'				e			f				
1.3 Monthly progress memos																									
Task 2 Hydrodynamic model																									
2.1. Incorporating improvements to grid and bathymetry			a			b																			
2.2 Model setup, WY2022 & WY2016						c			d																
2.3. Calibration, performance evaluation, WY2022 & WY2016							e		f																
Task 3 Biogeochemical model																									
3.1 Incorporate model updates/improvements, & model setup, WY2022 & WY2016						a				b															
3.2 Calibration, performance evaluation, WY2022 & WY2016										c			d		e				f						
Task 4 Model Applications: Analysis, Interpretation, and Write-up																									
4.1 Application #1: Simulate load reduction scenarios											a						b				c				
4.2 Application #2: Investigate priority mechanistic hypotheses										d							e				f				
4.3 Analysis, interpretation, and write-up																	g				h		i	j	
4.4 (Optional) - Phosphorous Load Reduction Scenario																					k				

Table 1B. Description of milestones or products (from Table 1A); the original dates compared to the amended new dates are included.

	Milestone or Work Product	Amended Dates	Original Dates
1a	Join quarterly DRMP Nutrient TAC meetings, project update (13 meetings, approximate dates)	quarterly	
1b	1st scenario meeting with TAC members, identify initial set (set #1) of scenarios to pursue	Apr2025	Nov2024
1b'	1st scenario meeting continued with TAC members, identify initial set (set #1) of scenarios to pursue	May2025	NA
1b''	1st scenario meeting continued with TAC members, identify initial set (set #1) of scenarios to pursue	Jun2025	NA
1c	2nd scenario meeting, refinements to scenario set #1 based on further discussion and/or test-run results	Aug-Sep2025	Sep2025
1d	3rd scenario meeting, finalize scenario set#1	Nov2025	Jun2025
1d'	3rd scenario meeting continued, finalize scenario set#1	Feb2026	NA
1e	4th scenario meeting, evaluate results from scenario set #1, identify next round of scenarios (set #2)	Jun2026	Jan2026
1f	Finalize specifics of scenario set #2	Sep2026	May2026
2a	first round of hydrodynamic model setup complete (uncalibrated) , starting hydrodynamic test simulations	Mar2025	Nov2024
2b	Refinements to grid/bathymetry finalized	Jun2025	Jan2025
2c	Develop initial set of boundary conditions, forcings, drought barrier settings, etc.	Jun2025	Jan2025
2d	Final set of boundary conditions, forcings, barrier settings, etc.	Sep2025	May2025
2e	Initial hydrodynamic model output (2022, 2016), comparison with observations	Jul2025	Mar2025
2f	Final hydrodynamic model output (2022, 2016), hydrodynamic model performance memo (technical appendix)	Sep2025	May2025
3a	Biogeochemical model improvements incorporated, Round 1, initial boundary conditions /forcings	Jun2025	Feb2025
3b	Finalized model improvements & boundary conditions	Nov2025	Jul2025
3c	v1 biogeochemical model output (2022, 2016)	Nov2025	Jul2025
3d	v2 biogeochemical model output (2022, 2016) + example scenario results (set #1)	Mar2026	Nov2025
3e	v3 biogeochemical model output (2022, 2016) + example scenario results (set #2)	Jun2025	Feb2025
3f	Final biogeochemical model output (2022, 2016), Base case	Aug2025	Apr2025
4a	Incorporate scenario changes (e.g., load reductions), test runs/simulations with scenario set #1	Dec2025	Aug2025
4b	Incorporate scenario changes , test runs/simulations with scenario set #2	Jun2026	Feb2026
4c	Final scenario runs, draft graphics	Oct2026	Jun2026
4d	First round of exploraty analysis results, application #2	Oct2025	Jun2025
4e	Interim results, application #2	Jun2026	Feb2026
4f	Final results, application #2	Oct2026	Jun2026
4g	Initial analysis/interpretation of results, Application 1; early results Application 2	Jun2026	Feb2026
4h	Interim/near-final interpretation of results, Application 1 and 2	Oct2026	Jun2026
4i	Final interpretation of results, draft report complete	Dec2026	Aug2026
4j	Final report complete	Jan2027	Sep2026
4k	(Optional) Final phosphorous scenario runs, draft graphics	Oct2026	NA

Subtask 2.3 Hydrodynamics: calibration, performance evaluation, WY2022 & WY2016

The hydrodynamic model will be calibrated for WY2016 and WY2022, with iterative refinements made to improve performance where needed (e.g., as described in Subtask 2.3). Hydrodynamic model performance will be evaluated by comparing modeled and predicted data (discharge, gauge height, salinity, temperature) at sentinel stations throughout the Delta and Suisun Bay.

The performance evaluation will be written up in the form of a technical appendix to the project's overall final report (Task 4), including key graphics, performance metrics (e.g., bias, root mean square error (RMSE), skill, r^2 , tidal amplitude ratio, lag), and documentation of relevant datasets and techniques used in updating and adapting the model for WY2016 and WY2022. The hydrodynamic technical appendix will be written early in the project (expected September 2025) and shared with the DRMP.

Assumptions:

1. If low-flow/drought related model development requires extensive redevelopment or recalibration of the model, then rescoping/rebudgeting will be discussed with TAC to prioritize essential elements for the intended applications of the model. This will be identified by the June 2025 TAC meeting.
2. The hydrodynamic performance evaluation write-up is planned as a technical appendix and model documentation, as opposed to a stand-alone document.

Task 3 Biogeochemical model & scenario simulations

Subtask 3.1 Incorporate model updates/improvements & model setup (WY2022, WY2016)

The biogeochemical component of the nSFE-BGCM will be updated with relevant improvements from recent Bay modeling work, including refinements to the sediment biogeochemical module (nutrient fluxes), and phytoplankton production and grazing modules. Biogeochemical model input files for WY2022 (and, as needed, WY2016 updates) will be assembled or produced, including: nutrient concentrations at model boundaries for estimating loads entering the Delta; POTW effluent concentrations; spatially and temporally (hourly to daily) varying light attenuation coefficients (estimated through interpolating turbidity data from the Delta's network of continuous turbidity sensors (DWR and USGS networks)); and abundances of benthic (clam) (e.g., Wells et al., 2023; Zierdt et al. 2021) and pelagic (zooplankton) grazers (see SFEI 2021b for additional information on boundary condition and forcing data), to the extent those data are available for 2022.

Subtask 3.2 Biogeochemical model refinements and calibration

The updated model will then be refined to develop an updated, 'global' biogeochemical model calibration for predicting observed conditions WY2016 and WY2022 (baseline simulations) and forecasting conditions under reduced load scenarios. The baseline simulations will be tested and if necessary refined for improved representation of relevant processes or sources (e.g., sediment fluxes within the Delta; concentrations/loads entering the Delta via so-called 'ag-return flows'). Further refinements may be needed to support load reduction scenario forecasts. For example, water column initial conditions (i.e., starting concentrations assigned throughout the domain) will need to be adjusted from those used for the Base Case values. Adjustments to sediment conditions (i.e., nutrient flux rates) will likely also be needed for some load reduction scenarios, because conditions in the model's sediment compartment are influenced by simulated conditions in the water column.

Biogeochemical model performance for WY2022 and WY2016 (i.e., Base conditions, actual loads) will be evaluated by comparing model predictions with measured data for a set of relevant water quality parameters (e.g., nitrate, ammonium, phosphate, silica, chl-a). Model results will be compared with measurements from discrete sample measurements (10–15 sites across the Delta and Suisun Bay, monthly or biweekly), high-frequency moorings, and measurements from high-speed mapping surveys.

Biogeochemical model performance will be documented within a biogeochemical technical appendix (key graphics, performance metrics), along with descriptions of model updates, key datasets, etc.

Assumptions:

1. Data necessary for model refinements (nutrient concentrations, grazer density etc.) will be available at the time these simulations are performed (anticipated to be in 2025).
2. Biogeochemical model recalibration will require a moderate level of effort including the Yolo/CSC region.
3. The biogeochemical model performance and model refinements will be written up in the form of a technical appendix intended for model documentation, as opposed to a standalone document, and there will be limited comments/revisions.

Task 4 Model Applications: Analysis, Interpretation, and Write-up

Subtask 4.1 Application #1: Simulate load reduction scenarios

The calibrated biogeochemical model will be used to simulate load reduction scenarios to assess the influence of load reductions on nutrient availability within the Delta. An initial set of nitrogen load reduction scenarios was developed by the Nutrient TAC (see Table 3 in the Multi-Year Study Plan). The final set of **nitrogen** reduction scenarios to be simulated will be identified through consultation with the Nutrient TAC during the first year of the project (see Subtask 1.2).

Load reduction scenarios will be simulated and compared with **baseline** conditions. Two Base Cases will be established: 1) WY2022_{base}: results from the WY2022 biogeochemical simulation, using actual loads during WY2022. 2) WY2016_{base}: after model calibration (using actual WY2016 loads), WY2016 biogeochemistry will be re-simulated using post-upgrade loads at the Sacramento POTW (SacSewer), along with other upgrade-related changes to Delta point-source loads, with those results serving as WY2016_{base}.

Each of the load reduction scenarios will be set-up and simulated as follows:

- *Scenario Load Estimates*: For each source that will be changed, nutrient concentrations or loads will be translated into a daily time-series (for WY2016 and WY2022).
- *Scenario Simulations*: 1) The load time-series used for the Base simulation will be replaced with the corresponding scenario load time-series. 2) All other model inputs/boundary conditions/forcings will remain the same as the base case. 3) Changes in simulated nutrient concentrations will be quantified by comparing load reduction scenario conditions (WY2022_{scenario}, WY2016_{scenario}) to the corresponding Base case (WY2022_{base}, WY2016_{base}).

Task 4.1 includes the work related to setting-up and running the load reduction simulations and initial analysis and visualization (i.e., plots) of results (discussed further under Task 4.3). (Additional work on analysis and interpretation of the scenario results and report preparation are included under Task 4.3.)

The current budget is based on an assumption of up to 8 N-load reduction scenarios, each simulated for WY2022 and WY2016 (fewer may ultimately be pursued depending on consultation with the TAC after early results).

Subtask 4.2 Application #2: Investigate priority mechanistic hypotheses

Model output from the **Base** simulations (and/or load reduction scenarios) will also be **used** to investigate one or more priority nutrient-related hypotheses, using mass-budgets/control-volume analyses, numerical tracers, or other approaches. Examples priority science topics include:

- Characterizing the relative importance of physical/biological/biogeochemical factors regulating phytoplankton biomass or productivity, including potential effects of lower nutrient availability due to load reductions.
- Quantifying the importance of remaining nutrient sources (beyond those included in scenarios) within HAB- and IAV- prone regions, including Delta non-point sources; or assessing the relative importance of IAV on nutrient concentrations and cycling.

- Potential focus regions: regions where HABs and/or IAV impact water and/or habitat quality (Stockton Waterfront; Franks Tract; Old and Middle Rivers); regions where encouraging beneficial algal production is a management priority (e.g., Liberty Island, North Delta).

The combination of analytical/post-processing approaches will differ depending on the question/hypothesis pursued. The specific technical focus of Subtask 4.2 will be informed by results from early model runs (September to December 2025) and finalized in consultation with the Nutrient TAC (approximately September 2025). Work under Subtask 4.2 includes the early exploratory analysis, and the in-depth post-processing/analysis work on the specific application(s) decided upon (additional analysis and write-up are included under Task 4.3). The current budget estimate is intended to cover the cost of pursuing one of the above analysis-directions (with the potential to explore additional hypotheses if funding is sufficient, or under a modified scope/budget).

Subtask 4.3 Analysis, interpretation, and write-up

A draft and final modeling report will be developed to document two technical sections describing results and interpretations from the work pursued under Subtasks 4.1 and 4.2, along with the two technical appendices described in Subtasks 2.3 and 3.2.

The main report will describe the following:

Technical Section #1: A primary output from this work will be the quantification of Base/Scenario differences in N concentrations or fluxes (spatially, temporally), for the load reduction scenarios simulated in Section 4.1. Where relevant, changes in P concentrations and fluxes will also be evaluated. Analysis of model output for the scenarios will include (for each scenario and water year):

- Delta-wide maps of nutrient concentrations (e.g., Base concentrations, Scenario concentrations, Scenario–Base difference), evaluated during relevant time periods.
- For high-priority regions (such as HAB- or IAV-prone regions), changes in nutrient availability will be investigated in greater detail, e.g., time-series of nutrient concentrations at discrete locations or regionally averaged values; changes in nutrient transport (mass flux, kg/d) into an area of interest. The Multi-Year Study Plan identifies potential high-priority areas to evaluate in greater detail.

Section #1 will include key graphics (see above) along with descriptive analysis and interpretation of results.

Technical Section #2: Section #2 will focus on the analysis/interpretation of the results from Task 4.2, investigating priority nutrient-related mechanistic hypotheses. The work under Task 2.3 includes the further analysis/interpretation of the in-depth work pursued under Task 2.2, and writing up Technical Section #2.

Subtask 4.4 (Optional) - Phosphorus Load Reduction Scenario

If requested by the DRMP TAC, one or more phosphorus load reduction scenarios will be simulated following the same approach identified under Task 4.1 for the nitrogen load reduction scenarios. The

specific phosphorus load-reduction scenario(s) will be developed in consultation with DRMP TAC. Visualizations and interpretations will be developed similar to those for the nitrogen reduction scenarios.

Assumptions under Task 4:

1. Up to 8 nitrogen load reduction scenarios will be performed under Task 4.1; fewer may be pursued depending on the TAC's priorities after reviewing results from initial scenario runs. Phosphorus reduction scenarios may be performed as an optional task if requested by the DRMP TAC.
2. The budget for Task 4.3 (analysis, interpretation, write-up) is based on the assumption of *a*) one round of comments revisions on the draft modeling report, addressed either through revisions to the final report or via response to comments; and *b*) comments and/or revisions to the draft report will be minor.
3. The hydrodynamic and biogeochemical model documentation and performance evaluation will be written up in the form of two technical appendices to the main project report.

IV. PROJECT SCHEDULE AND DELIVERABLES

Table 1A-1B summarizes the estimated timing of the major subtasks, along with timing for reaching interim milestones and completion work product(s). The deliverables are summarized below, beginning with the main deliverable.

1. Draft and Final Technical Report

A. Technical Section 1: Results of Base-Case and Scenario simulations for WY2022 and WY2016 (scenarios described in Tasks 2.3 and 3.3). Analyses will include: i) Delta/Suisun-wide assessment, differences in nutrient concentrations throughout the system and over time (seasonal, interannual); ii) additional in-depth exploration of these relationships within priority regions, e.g., regions that are considered HAB-prone, IAV-prone, or where fostering beneficial priority production is a management priority.

B. Technical Section 2: Analysis and interpretation of model output to investigate priority hypotheses and/or science & management questions in the Delta. The focus area will be finalized through discussions with the Nutrient TAC and informed by early model results (example focus areas are summarized under Task 4.3).

C Technical appendices documenting model refinements/improvements and model performance for the i) Hydrodynamic Model and the ii) Biogeochemical Model.

Due Dates:

- The draft technical report will be shared with the DRMP in December 2026. After a reasonable comment period (~1 month), comments will be addressed by i) response to comments; and ii) making any necessary revisions to the draft report.
- The final report and response to comments will be completed within approximately 1 month of receiving comments and reviewing the comments with the TAC and agreeing on a plan for addressing priority edits.

2. Hydrodynamic model technical appendix. The Hydrodynamic Technical Appendix, included above as one component of the Technical Report, will be produced and shared early with DRMP. (The other technical appendix, documenting biogeochemical model updates and performance, will be prepared with and submitted along with Technical Sections 1 & 2.)

Due Date:

- September 2025

3. Progress updates at 13 TAC meetings.

4. Set of priority load reduction scenarios developed through 8 TAC working meetings and related planning.

5. Presentation on final results to the Steering Committee.

6. Monthly brief progress updates accompanying monthly invoices.

Note: The nSFE-BGCM has been developed using an open-source model, with the aim of ultimately making calibrated model versions, and model input/output files publicly available. The model setup, input, and output files along with the executable are available to be shared with the DRMP. In order for those to be useful, some effort would need to be put toward documenting files, and transferring materials. That has not been included in the current budget.

V. BUDGET

Table 2A presents the multi-year budget and its breakdown across fiscal years at the Task, and Subtask levels. The distributions of work activities and budget across the modeling team's institutions and key staff are captured in Table 2B, with hours estimated based on 2024 hourly rates (row 3). Estimated hourly rates for 2025 and 2026 are presented in Table 2B. Any changes in hourly rates over the course of the project will not alter the project total cost or Task-level subtotals.

No other direct costs are included in the current budget. If a subset of TAC meetings will be held in-person or hybrid, local (Bay-Delta region) members of the modeling team are willing/able to join in-person. In that case, additional (modest) funding may be needed to cover within-region travel costs.

Invoices will be submitted to the DRMP Program Manager and the DRMP Treasurer monthly.

Table 2A. Project Budget, broken down by Task and Subtask, and by institution and key staff (job categories). The rates shown in row 3 are 2024 hourly rates. See Table 3B for estimated hourly rates for 2024, 2025, 2026. While some hourly rates may change over the course of the project, those changes will not alter the Task-level subtotals over the 24-month project.

Task/Subtask	SFEI				RMA				Four Peaks				Total Labor Hours	Total
	Prog Director, Sen. Scientist	Senior Env Scientist	Env Scientist	Sub-Total	Vice President	Senior Water Res. Analyst	Water Res. Analyst	Sub-Total	Senior Principal	Staff Scientist	Admin Support	Sub-Total		
Hourly Billing Rate	\$278	\$190	\$173		\$300	\$229	\$200		\$250	\$160	\$91			
Task 1 Project Management														
1.1. Progress update meetings with the DRMP Nutrient TAC	52	25		\$ 19,206	5	34	12	\$ 11,686	12			\$ 3,000	140	\$ 33,892
1.2. Working meetings with the DRMP TAC	17	17		\$ 7,956		17		\$ 3,893	9			\$ 2,250	60	\$ 14,099
1.3. Monthly progress memos		25		\$ 4,750		15		\$ 3,435	5			\$ 1,250	45	\$ 9,435
Sub-Total	69	67	0	\$ 31,912	5	66	12	\$ 19,014	26	0	0	\$ 6,500	245	\$ 57,426
Task 2 Hydrodynamic Model														
2.1 Incorporating improvements to grid and bathymetry				\$ -		25	50	\$ 15,725				\$ -	75	\$ 15,725
2.2 Model setup, WY2022 & WY2016		20		\$ 3,800	25	65	90	\$ 40,385				\$ -	200	\$ 44,185
2.3 Calibration, performance evaluation, WY2022 & WY2016	5	10		\$ 3,290	25	40	80	\$ 32,660	5			\$ 1,250	165	\$ 37,200
Sub-Total	5	30	0	\$ 7,090	50	130	220	\$ 88,770	5	0	0	\$ 1,250	440	\$ 97,110
Task 3 Biogeochemical Model														
3.1 Incorporate model updates/improvements, & model setup	30	135	20	\$ 37,450		20		\$ 4,580	30			\$ 7,500	235	\$ 49,530
3.2 Model calibration, performance evaluation, WY2022 & WY2016	30	160	25	\$ 43,065		25		\$ 5,725	30			\$ 7,500	270	\$ 56,290
Sub-Total	60	295	45	\$ 80,515	0	45	0	\$ 10,305	60	0	0	\$ 15,000	505	\$ 105,820
Task 4 Model Applications: Analysis, Interpretation, Write-up														
4.1 Application #1: Simulate load reduction scenarios	20	160	30	\$ 41,150		10		\$ 2,290	30			\$ 7,500	250	\$ 50,940
4.2 Application #2: Investigate priority mechanistic hypotheses	20	70		\$ 18,860	25	100		\$ 30,400	20			\$ 5,000	235	\$ 54,260
4.3 Analysis, interpretation, and write-up	25	80	40	\$ 29,070	25	120	25	\$ 39,980	30		40	\$ 11,140	385	\$ 80,190
4.4 Optional phosphorus reduction scenarios	10	60		\$ 14,180		5		\$ 1,145	16			\$ 4,000	91	\$ 19,325
Sub-Total	75	370	70	\$ 103,260	50	235	25	\$ 73,815	96	0	40	\$ 27,640	961	\$ 204,715
Total	209	762	115	\$ 222,777	105	476	257	\$ 191,904	187	0	40	\$ 50,390	2151	\$ 465,071

Table 2B. Hourly rates by organization (SFEI, RMA, Four Peaks) and Title, for 2024, 2025, and 2026. Rates for 2024 are actual current rates. Rates for 2025 and 2026 are estimated assuming 5% salary increase each year.

	2024 rate	est. 2025 rate	est. 2026 rate
SFEI - Program Director, Senior Scientist	\$278	\$292	\$306
SFEI - Senior Environmental Scientist	\$190	\$200	\$210
SFEI - Environmental Scientist	\$173	\$181	\$190
RMA - Vice President	\$300	\$315	\$331
RMA - Senior Water Resources Analyst	\$229	\$240	\$252
RMA - Water Resources Analyst	\$200	\$210	\$221
Four Peaks - Senior Principal	\$250	\$263	\$276
Four Peaks - Staff Scientist	\$160	\$168	\$176
Four Peaks - Admin Support	\$91	\$96	\$100

Table 3. project Budget, distributed across fiscal years by Task and Subtask.

Task/Subtask	Total Labor Hours	Total	FY2025	FY2026	FY2027
Title					
Hourly Billing Rate					
Task 1 Project Management					
1.1. Progress update meetings with the DRMP Nutrient TAC	140	\$ 33,892	\$ 13,557	\$ 16,268	\$ 4,067
1.2. Working meetings with the DRMP TAC	60	\$ 14,099	\$ 5,640	\$ 6,768	\$ 1,692
1.3. Monthly progress memos	45	\$ 9,435	\$ 3,774	\$ 4,529	\$ 1,132
Sub-Total	245	\$ 57,426	\$ 22,970	\$ 27,564	\$ 6,891
Task 2 Hydrodynamic Model					
2.1 Incorporating improvements to grid and bathymetry	75	\$ 15,725	\$ 15,725	\$ -	\$ -
2.2 Model setup, WY2022 & WY2016	200	\$ 44,185	\$ 44,185	\$ -	\$ -
2.3 Calibration, performance evaluation, WY2022 & WY2016	165	\$ 37,200	\$ 37,200	\$ -	\$ -
Sub-Total	440	\$ 97,110	\$ 97,110	\$ -	\$ -
Task 3 Biogeochemical Model					
3.1 Incorporate model updates/improvements, & model setup	235	\$ 49,530	\$ 45,027	\$ 4,503	\$ -
3.2 Model calibration, performance evaluation, WY2022 & WY2016	270	\$ 56,290	\$ 16,083	\$ 40,207	\$ -
Sub-Total	505	\$ 105,820	\$ 61,110	\$ 44,710	\$ -
Task 4 Model Applications: Analysis, Interpretation, Write-up					
4.1 Application #1: Simulate load reduction scenarios	250	\$ 50,940	\$ -	\$ 50,940	\$ -
4.2 Application #2: Investigate priority mechanistic hypotheses	235	\$ 54,260	\$ 7,751	\$ 46,509	\$ -
4.3 Analysis, interpretation, and write-up	385	\$ 80,190	\$ -	\$ 58,320	\$ 21,870
4.4 Optional phosphorus reduction scenarios	91	\$ 19,325	\$ -	\$ 19,325	\$ -
Sub-Total	870	\$ 204,715	\$ 7,751	\$ 175,094	\$ 21,870
Total	2060	\$ 465,071	\$ 188,942	\$ 247,368	\$ 28,761

Appendix III – Nutrient Reduction Bioassay QAPP Amendment

QAPP Amendment Form

PROGRAM: Delta Regional Monitoring Program (DRMP)
PROJECT: Nutrient Reduction Bioassay Experiments
PREVIOUS QAPP VERSION: Version 1.1
AMENDED QAPP VERSION: Version 1.2
PREPARED BY: MLJ Environmental
AMENDMENT DATE: Prepared on February 13, 2026
Submitted on March 3, 2026
Resubmitted on April 1, 2026
Approved on May 11, 2026

Title: Amendment to the *Quality Assurance Project Plan for the Nutrient Reduction Bioassay Experiments under the Sacramento-San Joaquin Delta Regional Monitoring Program*

Section of QAPP affected:

This amendment applies to the following sections:

- **A.2 Approval Signatures**
- **A.3.6.2 Revision History**
 - **Table 1. Document revision history.**
- **A.5.1 Work Statement and Deliverables**
- **A.5.4 Project Schedule**
 - **Table 4. Project deliverable schedule timeline.**
- **A.7 Distribution List**
 - **Table 7. QAPP distribution list.**
- **A.10 Organization Chart and Communications**
 - **Figure 3. Project organizational chart for oversight of project data generation.**
- **B.1.1 Monitoring and Experimental Design**
 - **Table 12. Source Water Monitoring Locations and Number of Ambient Water Grab Sample Laboratory Analyte Counts**
- **B.2.1 Field and Experimental Measurements**
 - **Table 19. Sample Handling and Custody.**
- **B.2.2 Laboratory Analyses**
 - **Table 20. Field and laboratory analytical methods.**
- **Appendix III – Laboratory SOPs**

Reason for Changes:

Under Resolution R5-2021-0054, the DRMP must develop and/or maintain a QAPP for all monitoring activities. Any proposed amendments to the approved QAPP must receive program and State Water Resources Control Board Quality Assurance Officer approval prior to implementation. The modifications made are of limited scope and meet or exceed the baseline program requirements.

The following amendments have been made:

1. The revision history has been updated to capture this amendment.
2. The approval signatures, distribution list, and organizational chart reflect a change in CVRWQCB Environmental Program Manager, which is vacant at the time of this amendment. Additionally, the Project Manager was added to the distribution list, and the organizational chart was updated to reflect Mine Berg's change of agency from Environmental Science Associates (ESA) to Coastal Conservation and Research (CCR).
3. The monitoring design has been updated to reflect optimization of site locations based on recent visits, the assignment of project-specific CEDEN site codes, and the allowable distance from the designated site location within which sampling may occur.
4. Laboratory and details associated with updated method detection limits and reporting limits.
5. Updates have been made to the deliverable dates, study design, and project schedule to reflect a shift of the start of Phase 1 from summer of 2025 to summer of 2026, and subsequently the start of Phase 2 from summer of 2026 to the summer of 2027.
6. Appendix III – Laboratory SOPs has been updated to include the Moss Landing SOP for Determination of Nutrients by Flow Injection Analysis.
7. The Chain of Custody template has been updated to capture additional samples details.

Detail of Changes:

This amendment form includes only the sections of the QAPP relevant to capturing updated project information. Sections updated in previous amendments are carried forward and considered accepted; these prior edits are not re-tracked. A timeline and summary of all amendments are provided in the **Revision History** table below. Additional sections, tables, or figures are included in subsequent amendments as necessary. This format provides a cumulative record of prior accepted updates while clearly distinguishing new changes, ensuring that the history of QAPP modifications remains traceable between amendments. New updates are clearly indicated below, with additions highlighted in yellow and deletions shown using yellow highlights with strikethrough.

A.2 APPROVAL SIGNATURES

This is a contractual document. The signature dates indicate the earliest date when the project can start. Signatures will be obtained once the Central Valley Regional Water Quality Control Board and State Water Resources Control Board Quality Assurance (QA) Officer have indicated the QAPP is ready for approval.

Delta Regional Monitoring Program

PROGRAM ROLE	NAME	AFFILIATION	SIGNATURE	DATE
Board of Directors President	Debbie Mackey	DRMP		
Program Manager	Melissa Turner	MLJ Environmental		
Quality Assurance Officer	Will Hagan	MPSL-MLML		
Data Manager	Cassandra Lamerdin	MLJ Environmental		

Central Valley Regional Water Quality Control Board

PROGRAM ROLE	NAME	AFFILIATION	SIGNATURE	DATE
Environmental Program Manager	Meredith Howard Daniel Ellis	CVRWQCB		
Quality Assurance Representative	Vacant	CVRWQCB	NA	NA

State Water Resources Control Board

PROGRAM ROLE	NAME	AFFILIATION	SIGNATURE	DATE
Quality Assurance Officer	Ranita Prasad	SWRCB		

Project Personnel

PROJECT ROLE	NAME	AFFILIATION	SIGNATURE	DATE
Project Manager/Field Lead	Mine Berg	Coastal Conservation and Research		
Project Collaborator/Sampling Personnel	Holly Bowers	Moss Landing Marine Laboratories		

Laboratory Personnel

PROJECT ROLE	NAME	AFFILIATION	SIGNATURE	DATE
Laboratory Project Manager	Steven Cunningham	Moss Landing Marine Laboratories		
Laboratory Project Manager	John Beaver	BSA Environmental Services		

A.3.6.2 Revision History

Table 1. Document revision history.

VERSION	DATE	REVISION DESCRIPTION
1.0	May 1, 2025	Original submittal to the CVRWQCB
1.1	August 26, 2025	Resubmittal incorporating comments from CVRWQCB and SWRCB.
1.2	March 3, 2026	Amendment submitted to reflect updates to regulatory oversight staff, project schedule, laboratory method details and laboratory nutrients SOP.
	Resubmitted April, 1, 2026	Amendment resubmitted to reflect updates to the project sampling locations and define allowable distance from the designated sampling locations.

A.5.1 WORK STATEMENT AND DELIVERABLES

As part of project management, the Project Manager (PM) will attend meetings with the DRMP Nutrient TAC. Over two years of the project, attendance at 24 Nutrient TAC meetings will be assumed. Upon completion of analysis of results from a particular phase of the project, these will be presented by the PM at an appropriate Nutrient TAC meeting. From the first phase of the project (Phase 1) during year one, two presentations will be prepared. One presentation will summarize field monitoring results, and a second will summarize results of the pilot studies. In the second year of the project (Phase 2), between one and three full-scale NRB experiments will be completed, and results from these experiments will be summarized in two separate presentations. Additionally, monthly progress reports will be submitted with monthly invoices, for a total of 24 progress reports over the course of two years.

Phase 1: Source Water Monitoring and Pilot Studies

Phase 1 monitoring and pilot studies ~~will~~ are scheduled to occur during the summer of ~~2025~~ 2026. Monitoring of the three field sites, Stockton Waterfront, Big Break, and Discovery Bay (**Table 12**) will be divided among three groups. Coastal Conservation and Research (CCR) and its collaborating partner Moss Landing Marine Laboratories (MLML) will sample Big Break, Discovery Bay, and the Stockton Waterfront. The Stockton Waterfront will also be sampled by the Department of Water Resources (DWR) who already has a project at that site as their schedule allows. Field monitoring of source water will occur two times per month from July through September. If DWR staff are unable to sample Stockton Waterfront according to the schedule, project personnel will complete the sampling. Monitoring will include the field measurements and analysis of grab samples for the constituents listed in **Table 3**. Grab samples will be analyzed for the constituents indicated in **Table 3**, which also specifies the agencies responsible for analyzing each sample. Timing of sample collections at each site will be coordinated such that samples collected by various project personnel will be transported together to the assigned laboratories for analysis.

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~~Method performance validation will begin concurrently with the start of Phase 1, with the intent of completing validation prior to the analysis of project samples. Any project data generated prior to completion of method validation will be considered preliminary and will undergo evaluation for confidence, validity, and usability, with appropriate qualifiers assigned to indicate its status. All data deficiencies will be assessed by the~~

experts of the TAC in coordination with the Program Manager, Program QA Officer, and CVRWQCB QA Representative, as prescribed in the Data Management Plan. Deficient or rejected data generated during Phase 1 may still be utilized by the project team to help inform the design and planning of Phase 2. Any data generated after the completion of method validation will be processed, finalized, and made publicly available in accordance with this QAPP. As part of the validation process, laboratory-specific SOP(s) will be developed to standardize calibration and low-level nutrient analysis, supplementing the reference methods currently in use as SOPs.

This QAPP was originally approved with the condition that method performance validation would begin concurrently with Phase 1 and be completed prior to the analysis of project samples, and that any data generated prior to validation completion would be considered preliminary.

Due to a subsequent project schedule delay, method validation activities and development of laboratory-specific SOP(s) have been completed prior to the initiation of Phase 1. The finalized validation documentation and SOP(s) are submitted with this amendment. Phase 1 activities will not commence until this amendment is approved.

One sampling event was conducted to support the method validation process. The associated analytical results were evaluated and finalized only after completion of validation activities. No Phase 1 project data were generated prior to validation completion. Accordingly, the previously described contingency provisions regarding preliminary data are no longer applicable.

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Phase 2: Full-Scale Nutrient Reduction Bioassays

The full-scale NRB (Phase 2) will be performed the summer following the completion of the pilot experiments and is scheduled to occur during the summer of 2026-2027. The design of the NRBs will reflect lessons learned from the 2025 pilot experiments.

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A.5.4 PROJECT SCHEDULE

The project schedule is determined based on the study design, which may vary in duration and timing. Monitoring priorities and designs are assessed on an annual basis based on recommendations from the Steering Committee as part of developing annual Workplans and associated budgets which are developed on a fiscal year basis (July 1 through June 30). Workplans outlining the study goals, designs, and budgets for all projects in the upcoming fiscal year are provided to the CVRWQCB by May 1 annually and must be approved by the CVRWQCB prior to implementation. In addition to the annual workplan process, the DRMP may develop and approve multi-year study designs and QAPPs that include deliverables extending across several years. Anticipated project activities for the entirety of the project are outlined below. Individual QAPPs will be reviewed annually to determine if a revision is necessary; however, a QAPP must be revised every three years at a minimum. Ongoing project updates are documented through QAPP amendments and reviewed and revised as outlined in Section 4.4 of the DRMP Data Management Plan.

All deliverable dates will, at a minimum, meet the reporting requirements outlined in Resolution R5-2021-0054. Preliminary data must be reported to the CVRWQCB within 60 calendar days of the sample analysis and Annual Reports are due on February 1 each year for the previous fiscal year.

Table 4 summarizes the schedule of work to be performed under Phase 1 and 2, and deliverables to be submitted.

Table 2. Project deliverable schedule timeline.

DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
Resolution Deliverables				
Preliminary Data (Phase 1 and Phase 2)	60 calendar days	Sample analysis	Per sample event	Preliminary data collected during Phase 1 and 2 delivered within 60 calendar days of the sample analysis date.
Final Data: CHAB Hot Spot Field Data (Phase 1)	6 months / ~~October 2025~~	Sample analysis / ~~July - September 2025~~	Per event	Spreadsheet containing nutrient, Chl, MVI ranking, phytoplankton, and basic water quality data, collected from the 3 CHAB hot spot locations in the Delta
Final Data: Pilot NRB (Phase 1)	6 months / ~~November 2025~~	Sample analysis / ~~July - September 2025~~	Per event (experiment)	Spreadsheet containing results of NRB pilot tests and analyses of various test parameters
Final Data: NRB Experiment 1 Data (Phase 2)	6 months / ~~October 2026~~	Sample analysis / ~~August 2026~~	Per event (experiment)	Spreadsheet containing all data collected from first NRB experiment
Final Data: NRB Experiment 2 & 3 Data (Phase 2)	6 months / ~~November 2026~~	Sample analysis / ~~September 2026~~	Per event (experiment)	Spreadsheet containing all data collected from second and potentially third NRB experiments
DRMP FY 25-26 Annual Report	February 1, 2026	Previous FY (~~July 1, 2025 - June 30, 2026~~)	Annually	~~Annual Report for FY 25-26 (Phase 1 efforts)~~ Report for FY progress on monitoring effort.
~~DRMP FY 25-26 Annual Report~~	~~February 1, 2026~~	~~July 1, 2025 - June 30, 2026~~	~~Annually~~	~~Annual Report for FY 25-26 (Phase 1 efforts)~~

DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
DRMP FY 26-27 Annual Report	February 1, 2027	July 1, 2026 – June 30, 2027	Annually	Annual Report for FY 26-27 (Phase 2 efforts)
Additional Study Deliverables				
Technical Memo	October 2025-2026	October 2025-2026	Once	Report on Phytoplankton Community Parameters at 3 CHAB Hot Spot Locations in the Delta
Phase 1 Data Report and QA Assessment	December 2025-2026	November-December 2025-2026	Once	Draft and final report on Pilot Experiment Results including Phytoplankton Community Parameters at 3 CHAB Hot Spot Locations in the Delta
Phase 2 Data Report and QA Assessment	April 2027-2028	October 2026-2027-April 2027-2028	Once	Draft and final report on NRB experiment results

A.7 DISTRIBUTION LIST

The individuals and groups listed in **Table 7**. QAPP distribution list. will receive a final, executed copy of this document and any subsequent revisions. Copies of this document will be made available to the public via the DRMP website, <https://DeltaRMP.org/>.

Table 3. QAPP distribution list.

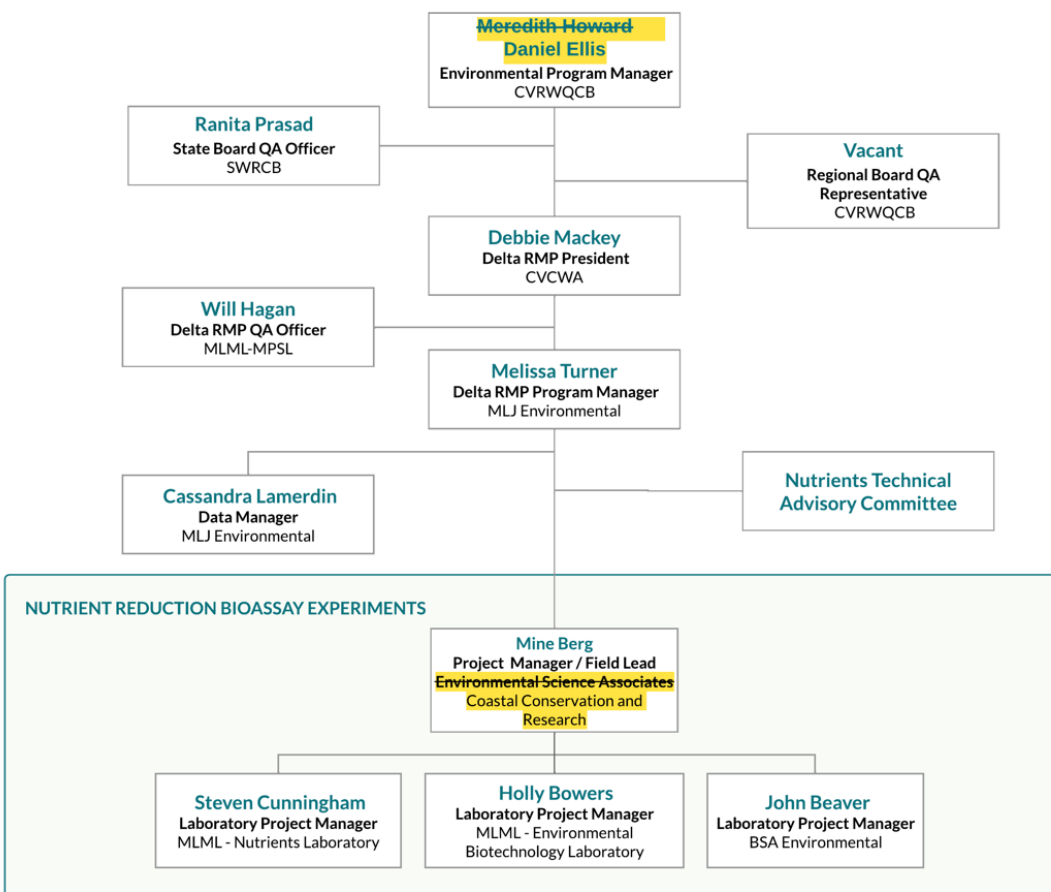
TITLE	NAME	ORGANIZATION
DRMP Steering Committee	Distribution List	NA
Nutrient Technical Advisory Committee	Distribution List	NA
DRMP Board of Directors President	Debbie Mackey	DRMP
DRMP Program Manager	Melissa Turner	MLJ Environmental
DRMP Quality Assurance Officer	Will Hagan	MPSL-MLML
DRMP Data Manager	Cassandra Lamerdin	MLJ Environmental
CVRWQCB Environmental Program Manager	Meredith Howard Daniel Ellis	CVRWQCB
CVRWQCB Quality Assurance Representative	Vacant ¹	CVRWQCB
SWRCB Quality Assurance Officer	Ranita Prasad	SWRCB
Project Manager	Mine Berg	CCR
Nutrient Laboratory Manager	Steven Cunningham	MLML
Environmental Biotechnology Laboratory Manager	Holly Bowers	MLML
Director	John Beaver	BSA Environmental Services

¹At the time of this QAPP, the CVRWQCB does not have a Quality Assurance Representative.

A.10 ORGANIZATION CHART AND COMMUNICATIONS

The generation of data under the NRB project is conducted under the operations of the DRMP. The DRMP, regulatory oversight staff, and project-specific personnel, including contractors, subcontractors, and sub-grantees are identified in **Figure 3** with their associated reporting relationships. Communication procedures should adhere to the DRMP Data Management Plan, and the project structure outlined in **Project Organization**. The process for addressing deviations is detailed under the **Response Actions** section. The process for identifying, communicating, and documenting data rejection decisions is outlined in **Figure 7**.

Figure 1. Project organizational chart for oversight of project data generation. Changes to personnel listed in the organization chart must be communicated to the DRMP Program Manager and documented with a QAPP amendment.



B.1.1 MONITORING AND EXPERIMENTAL DESIGN

An initial set of pilot studies testing different variables of the project design, such as source water location, optimal length of incubation duration, how to attain nutrient limited conditions in the treatments and not in the control, how to add a consistent amount of *Microcystis* biomass across treatments and controls, how to best provide mixing of the vessels for a mixing treatment, how to provide different light intensities for an irradiance treatment, type of macrophyte species and biomass to include, and others, will be performed in summer of 2025 2026, prior to running the fully replicated study in the summer of 2026 2027.

Phase 1: Source Water Monitoring and Pilot Studies

Phase 1 monitoring of the sites listed in **Table 12** will be used to determine a suitable source water location for the Phase 2 NRB Experiments. The locations of source water sites to be monitored for the presence of *Microcystis* in the Delta are shown in **Figure 1** and **Table 12**.

Sampling sites will be identified by the coordinates provided in Table 12. Samples will be collected within 100 meters of the target coordinates. The sampling site must be recorded at the time of sample collection. If the Sampling Lead determines that a sample cannot be collected within 100 meters of the target coordinates, the DRMP Program Manager will be notified (phone call or text) to determine appropriate actions and inform the CVRWQCB of a deviation (move the sample location, not collect a sample, etc.); a deviation from this QAPP must be reported to the CVRWQCB QA Representative (or other designee) within seven calendar days of the event.

Each source water site will be sampled every 2 weeks over the course of 3-4 months, from July June through September, providing a total of 6 sampling events. Although every effort will be made to sample all three sites every 2 weeks, source water monitoring can be delayed or canceled for equipment failure, excessive heat, or other reasons. The total number of samples anticipated to be collected for source water monitoring, and analyte counts are outlined in **Table 12**. During each sampling event, vertical sonde profiles of basic water quality parameters will be recorded and grab samples will be collected for the constituents list in **Table 3**. The replicates to be collected for each constituent are included in **Table 21**. The MVI ranking of the water will be performed visually giving a ranking of 1 (*Microcystis* absent) to 5 (contiguous *Microcystis* colonies) of the source water in accordance with Flynn et al. (2022). Photos (digital images) will also be taken of the water and the MVI rank will be associated with the digital image.

The prime determinant of the suitability of the location to be used as source water for the NRB experiments will be the consistency of occurrence of a relatively high MVI ranking of the water coupled with a relatively high fluorescence yield, i.e. F_v/F_m , indicating a physiologically healthy *Microcystis* population. A ranking between 3-5 will be considered adequate for using the location for collection of source water for the experiments. In addition to MVI ranking and F_v/F_m , the concentrations of Chl and N (as nitrate) will be determined. A location with relatively high Chl concentration and low N concentration will be preferred. The target concentration of Chl will be above 10 ug/L and the target nitrate concentration will be below 0.1 mg/L. The NRB source water constituents must meet the target concentrations listed in **Table 11**. If the nitrate concentration is above 0.1 mg/L, it may be necessary to dilute the source water with N and P-free water to achieve the target starting nitrate concentration. In that case, the background phytoplankton community biomass will also be diluted together with the N and P concentrations (and all other macro- and micro-nutrients). However, for the NRB experiments, a target Chl concentration will still be achieved through addition/equalization of *Microcystis* colonies across treatments (see NRB experiment description below for Phase 2).

If *Microcystis* is absent during the source water monitoring at all three hotspot sampling locations during the summer of 2025, then monitoring of all three sites during July of 2026 will also be performed to check whether *Microcystis* is present in order to determine if the full NRB experiments can be performed in the summer of 2026. Then additional monitoring or alternate sites may be monitored during Phase 1. The Project Manager will communicate with staff at agencies that monitor for *Microcystis*, such as DWR and CVRWQCB, in order to keep abreast of bloom occurrences. The QAPP will be amended to include approved alternate monitoring sites. Alternate sites will be determined based on observation of *Microcystis* occurrence and approved by the Nutrients TAC.

If *Microcystis* is absent at the three source water locations in the summer of 2026, then the Phase 2 NRB experiments may have to be delayed until appropriate conditions are present. If *Microcystis* is not observed at the three field sites in the summer of 2025, the QAPP may be amended to include monitoring of additional or alternate sites in the summer of 2026, such as Willow Berm, Korth's Pirates Lair Marina, and Tiki Lagoon Marina. If *Microcystis* is not observed at the three hotspot locations or alternate locations during Phase 1, then monitoring for the presence of *Microcystis* at hotspot and alternate locations will also be undertaken at the beginning of Phase 2, in order to determine if the full NRB experiments may have to be delayed until appropriate

conditions are present. The QAPP will be amended prior to Phase 2 to document updates to monitoring locations and schedules.

The site with the highest MVI score and Fv/Fm (indicating a healthy community) will be used for the pilot NRB experiments. The pilot experiments include a number of different tests to be performed in replicate containers suspended *in situ* at the location where the samples are collected. Tests that may include 1) examining differences in container type (i.e. material, size, and shape), 2) optimal incubation duration, 3) how to add a consistent amount of *Microcystis* biomass across treatments, 4) differences in starting *Microcystis* concentration on growth, 5) optimal additions of daily nutrient stocks, 6) best method for mixing containers and optimal light intensities for irradiance treatments, and 7) how to best add clams and macrophytes as treatments.

During pilot tests, daily samples will be taken for Chl and nutrient concentrations and the time series will be examined for length of lag and exponential growth phases, and maximum biomass accumulation. Based on the time series data, optimal containers type, incubation duration, starting biomass concentrations, nutrient additions, methods of mixing, exposure to light, and best way to add macrophytes and clams will be determined.

Samples from the Phase 1 NRB containers will be collected for each treatment following the timing and constituent requirements outlined **Table 11**. The projected analyte counts for the bioassay monitoring are listed in **Table 13** to reflect a maximum of three NRBs that are up to four days in length, however, the optimal incubation period will be determined during the Phase 1 pilot studies and is therefore subject to change. Samples will be collected from the Phase 1 NRB containers during each day of the study for each treatment as outlined in **Table 14**.

Table 4. Source Water Monitoring Locations and Number of Ambient Water Grab Sample Laboratory Analyte Counts

Analyte counts represent counts for samples collected for laboratory analyses.

STATION NAME	CEDEN STATION CODE	STATION TYPE	LATITUDE	LONGITUDE	DATUM	MATRIX	NUMBER OF EVENTS	ANALYTE COUNT PER EVENT ¹	ANALYTE COUNT TOTAL
Big Break 1- 544ST0125 Big Break Public Pier at East Bay Regional Park	544ST0125 544BGBRPP	Marina	38.0141 38.012598	-121.72971 -121.728338	NR WGS84	Water	6	29 ¹	174
Yacht Club in Discovery Bay Discovery Bay Boat Launch	544CCC005 544DISBBL	Marina	37.90287 37.905428	-121.58801 -121.587845	NAD83 WGS84	Water	6	29 ¹	174
McLeod Lake at Stockton Downtown Marina	544SJC531	Marina	37.95335	-121.29919	NAD83	Water	6	29 ¹	174
TBD (selected Phase 2 NRB source water location) ¹	TBD	TBD	TBD	TBD	TBD	Water	15	29 ¹	261
Totals								116	783

¹Phytoplankton abundance and biovolume taxonomy data each count as one analyte count.

²*Microcystis* chlorophyll (analyte count of three) will only be measured if visually present in the *Microcystis* sample

B.2.1 FIELD AND EXPERIMENTAL MEASUREMENTS

Table 5. Sampling, Sample handling and custody.

ANALYTICAL PARAMETER	METHOD	MATRIX/ FRACTION	SAMPLE CONTAINER MATERIAL AND VOLUME	INITIAL PRESERVATION/ HOLDING REQUIREMENTS	EXTRACTION/ PREPARATION HOLDING TIME	ANALYSIS HOLDING TIME
Ammonia as N	EPA 350.1	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter and Store at $\leq -20^{\circ}\text{C}$	NA	1 year
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Nitrate as N	EPA 353.4	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter and Store at $\leq -20^{\circ}\text{C}$	NA	1 year
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Nitrite as N	EPA 353.4	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter and Store at $\leq -20^{\circ}\text{C}$	NA	1 year
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Nitrogen, Total	Valderrama 1981/ EPA 353.4	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter and Store at $\leq -20^{\circ}\text{C}$	NA	1 year
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Orthophosphate as P	EPA 365.5	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter within 15 minutes and Store at $\leq -20^{\circ}\text{C}$	NA	1 year
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Phosphorus as P	Valderrama 1981/ EPA 365.5	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter within 15 minutes and Store at $\leq -20^{\circ}\text{C}$	NA	1 year

ANALYTICAL PARAMETER	METHOD	MATRIX/ FRACTION	SAMPLE CONTAINER MATERIAL AND VOLUME	INITIAL PRESERVATION/ HOLDING REQUIREMENTS	EXTRACTION/ PREPARATION HOLDING TIME	ANALYSIS HOLDING TIME
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Silicate as Si	EPA 366	Water/ Dissolved	2 x 50 mL polypropylene tube	Field-filter and Store at $\leq$ -20°C	NA	1 year
				Field-filter and Store at $\leq 6^{\circ}\text{C}$		48 hours
Nitrogen, Organic	EPA 440.0	Water/ Particulate	60 mL volume through a GF/F filter in field; transport in sterile single use petri dish	Store filter in desiccator after drying at $103-105^{\circ}\text{C}$ for 24hrs	NA	100 days
Particulate Organic Carbon	EPA 440.0	Water/ Particulate	60 mL volume through a GF/F filter in field; transport in sterile single use petri dish	Store filter in desiccator after drying at $103-105^{\circ}\text{C}$ for 24hrs	NA	100 days
Chlorophyll a	EPA 445.0	Water / Particulate	Place filter into 3 mL plastic cryovial in foil	Field-filter and Store filter in dark at $\leq -80^{\circ}\text{C}$	Store frozen in dark at $\leq -80^{\circ}\text{C}$; store extraction for up to 6 months	6 months
Phytoplankton Abundance	Beaver et al. 2013	Water/ Total	250 ml amber glass or dark brown HDPE	Lugol's Iodine, store refrigerated at $2-6^{\circ}\text{C}$ in the dark	NA	6 months
Phytoplankton Biovolume	Beaver et al. 2013	Water/ Total	250 ml amber glass or dark brown HDPE	Lugol's Iodine, store refrigerated at $2-6^{\circ}\text{C}$ in the dark	NA	6 months

ANALYTICAL PARAMETER	METHOD	MATRIX/ FRACTION	SAMPLE CONTAINER MATERIAL AND VOLUME	INITIAL PRESERVATION/ HOLDING REQUIREMENTS	EXTRACTION/ PREPARATION HOLDING TIME	ANALYSIS HOLDING TIME
<i>Microcystis</i> Colony Geometry	Göröcs et al. 2018	Water/ Total	250 ml amber glass with Teflon-lined cap	Lugol's Iodine	Refrigeration 2-6°C	3-6 months
				None		~~1 hour~~ 24 hours
<i>Microcystis</i> Colony Enumeration	Göröcs et al. 2018	Water/ Total	250 ml amber glass with Teflon-lined cap	Lugol's Iodine	Refrigeration 2-6°C	3-6 months
				None		~~1 hour~~ 24 hours
Microcystins, Total	ELISA Abraxis 520011	Water/ Total	250 ml amber glass with Teflon-lined cap	Store at ≤ - 20 °C within 48 hours	Store at ≤ - 20 °C	6 months

B.2.2 LABORATORY ANALYSES

Table 6. Field and laboratory analytical methods.

Field SOPs are included in **Appendix I**; Laboratory SOPs are included in **Appendix III**

CONSTITUENT	MATRIX	LABORATORY	PREPARATION METHOD	ANALYTICAL METHOD/ EQUIVALENCY	FRACTION	UNITS	MDL	RL	WATER QUALITY METRIC ⁶
Temperature ¹	Water	CCR	--	EPA 170.1	None	°C	NA	0.1	NA
Dissolved Oxygen ¹	Water	CCR	--	SM 4500-O H	Total	mg/L	NA	0.1	NA
Dissolved Oxygen ¹	Water	CCR	--	SM 4500-O H	Total	% saturation	NA	0.1	NA
pH ¹	Water	CCR	--	EPA 150.1	None	pH units	NA	0.1	NA
Specific Conductivity ¹	Water	CCR	--	EPA 120.1	Total	µS/cm	NA	100	NA
Irradiance ^{2,3}	Water	CCR	--	SM 10200 H	None	W/m ²	NA	NA	NA
Active Fluorescence ^{1,2}	Water	CCR	--	Berg et al. 2017	Total	RFU	NA	NA	NA
Temperature ²	Water	CCR	--	EPA 170.1	Total	°C	NA	0.1	NA
Dissolved Oxygen ²	Water	CCR	--	SM 4500-O G	Total	mg/L	NA	0.1	NA
Dissolved Oxygen ²	Water	CCR	--	SM 4500-O G	Total	% saturation	NA	0.1	NA
Turbidity ^{1,2}	Water	CCR	--	SM 2130 B	Total	NTU	NA	0.7	NA

CONSTITUENT	MATRIX	LABORATORY	PREPARATION METHOD	ANALYTICAL METHOD/ EQUIVALENCY	FRACTION	UNITS	MDL	RL	WATER QUALITY METRIC ⁶
Ammonia as N	Water	MLML – Nutrient Lab	--	QuikChem 31-107-06-1-B / EPA 350.1	Dissolved	mg/L	0.000346 0.000359	0.005	NA
Nitrate as N	Water	MLML– Nutrient Lab	--	QuikChem 31-107-04-1-E / EPA 353.4	Dissolved	mg/L	0.000323 0.000381	0.017 0.0085	NA
Nitrite as N	Water	MLML– Nutrient Lab	--	QuikChem 31-107-05-1-A / EPA 353.4	Dissolved	mg/L	0.000361 0.000292	0.007	NA
Nitrogen, Total	Water	MLML– Nutrient Lab	Valderrama 1981	QuikChem 31-107-04-1-E / EPA353.4	Dissolved	mg/L	0.000323 0.000381	0.017 0.0085	NA
Nitrogen, Total	Water	MLML– Nutrient Lab	--	EPA 440.0	Particulate	mg	0.00114	0.05 0.21	NA
Nitrogen, Organic	Water	MLML– Nutrient Lab	--	Calculated	Dissolved	mg/L	NA	0.017	NA
Particulate Organic Carbon	Water	MLML– Nutrient Lab	--	EPA 440.0	Particulate	mg	0.000685 0.000614	0.05 0.54	NA
OrthoPhosphate as P	Water	MLML– Nutrient Lab	--	QuikChem 31-115-01-1-I / EPA 365.5	Dissolved	mg/L	0.0000102 0.0000110	0.001	NA
Phosphorus as P	Water	MLML– Nutrient Lab	Valderrama 1981	QuikChem 31-115-01-1-I / EPA 365.5	Dissolved	mg/L	0.0000102 0.0000110	0.001	NA

CONSTITUENT	MATRIX	LABORATORY	PREPARATION METHOD	ANALYTICAL METHOD/ EQUIVALENCY	FRACTION	UNITS	MDL	RL	WATER QUALITY METRIC ⁶
Phosphorus as P, Organic	Water	MLML – Nutrient Lab	NA	Calculated	Dissolved	mg/L	NA	0.001	NA
Silicate as Si	Water	MLML– Nutrient Lab	--	QuikChem 31-114-27-1-D / EPA366	Dissolved	mg/L	0.000155 0.000127	0.010	NA
Chlorophyll a	Water	MLML– Nutrient Lab	--	EPA 445.0	Particulate	µg/L	0.5	0.5	NA
Phytoplankton Abundance	Water	BSA	--	Beaver et al. 2013	Total	Cells/L	NA	NA	NA
Phytoplankton Biovolume	Water	BSA	--	Beaver et al. 2013	Total	µm ³ /L	NA	NA	NA
<i>Microcystis</i> Colony Geometry	Water	MLML EBL	--	Göröcs et al. 2018	Total	µm	NA	NA	NA
<i>Microcystis</i> Colony Enumeration	Water	MLML EBL	--	Göröcs et al. 2018	Total	Colonies/L	NA	NA	NA
<i>Microcystis</i> Chlorophyll-a ⁴	Water	MLML Nutrients Lab	--	EPA 445.0	Particulate	µg/L	0.5	0.5	NA
Microcystins, Total	Water	MLML EBL	--	ELISA Abraxis 520011	Total	µg/L	NA	0.1	NA

¹Field measurement of ambient water

²Field measurement taken from experimental container

³Field measurement of ambient water measured concurrently with NRB experimental container measurements to determine the difference. The reported value will represent the irradiance inside the experimental container.

⁴Organic Nitrogen = TN – Ammonia – Nitrate – Nitrite

⁵Measured only if visually present in the collected *Microcystis* sample

⁶Due to this study design being an experimental bioassay, no water quality metrics are applicable.

B.3.1 SAMPLE HANDLING AND CUSTODY

Figure 2. Chain of custody form.

Project ID: Nutrient Reduction Bioassays				Client Contact: [Name]						
PO #:				Address: [Laboratory address]						
Results to: ☐ ESA ☐ Client										
ESA Contact: Mine Berg				Phone: [phone number]						
Email: mberg@esassoc.com				Email: [email]						
Sample ID / Site Name	Sample Matrix	Date	Time	Analyses						Comments
				Nutrient Panel	Chlorophyll					
[Name Loc 1]	[Whole freshwater]	[date]			X					
[Name Loc 2]	[Filtered freshwater]	[date]		X						
Relinquished by:		Date:	Time:	Shipping: ☐ Delivered by ESA ☐ Picked up by lab ☐ Fedex / Other Tracking # _____						
Received by:		Date:	Time:							
# coolers:										

Project ID:						Client Contact:							
PO #:						Address: 							
Results to: ☐ CC&R ☐ Client													
CC&R Contact: Mine Berg													
Email: berg@ccandr.org						Phone:							
						Email:							
Sample ID	Site Name	Date/Time Collected	Field Filtered? (Yes / No)	Date/Time Frozen	Analyses						Matrix	Sample Temp	
					Bottles #	Nutrient Panel							
Relinquished by:		Date:		Time:		Shipping: ☐ Delivered by CC&R ☐ Picked up by lab ☐ Fedex / Other Tracking# _____							
Received by:		Date:		Time:									
Sample Condition (frozen/unfrozen): frozen													

APPENDIX I – LABORATORY SOPS

Proprietary – Do Not Distribute

The following SOPs are on kept file and only available for regulatory review and approval of this QAPP.

SECTION	SUBSECTION	REFERENCE	SOP	TITLE
III.A	III-A.1	EPA 350.1	QuikChem Method 31-107-06-1-B	Determination of Ammonia in Brackish or Seawater by Flow Injection Analysis
	III-A.2	EPA 353.4	QuikChem 31-107- 04-1-E	Determination of Nitrate/Nitrite in Brackish or Seawater by Flow Injection Analysis Colorimetry
	III-A.3	EPA 353.4	QuikChem 31-107- 05-1-A	Determination of Nitrite in Brackish or Seawater by Flow Injection Analysis
	III-A.4	EPA 365.5	QuikChem 31-115- 01-1-I	Orthophosphate in Seawaters
	III-A.5	EPA 366	QuikChem 31-114- 27-1-D	Determination of Silicate in Brackish or Seawater by Flow Injection Analysis
	III.A.1	EPA 350.1 EPA 353.4 EPA 353.4 EPA 365.5 EPA 366	MLML SOP NRB 1.0	Determination of Nutrients by Flow Injection Analysis
	III-A.6 III.A.2	Valderrama 1981	Valderrama 1981	The Simultaneous Analysis of Total Nitrogen and Total Phosphorus in Natural Waters
	III-A.7 III.A.3	EPA 440.0	EPA 440.0	Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis
	III-A.8 III.A.4	EPA 445.0	EPA 445.0	<i>In Vitro</i> Determination of Chlorophyll <i>a</i> and Pheophytin <i>a</i> in Marine and Freshwater Algae by Fluorescence

SECTION	SUBSECTION	REFERENCE	SOP	TITLE
III.B	III-B.1	Beaver et al. 2013	Beaver et al. 2013	Response of phytoplankton and zooplankton communities in six reservoirs of the middle Missouri River (USA) to drought conditions and a major flood event
	III-B.2	Göröcs et al. 2018	Göröcs et al. 2018	A deep learning-enabled portable imaging flow cytometer for cost-effective, high throughput, and label-free analysis of natural water samples
	III-B.3	ELISA Abraxis 520011	ELISA Abraxis 520011	ABRAXIS® Microcystins-ADDA OH ELISA Microtiter Plate

Amendment Approval:

The amendment(s) detailed within this document shall be effective upon signature completion of all parties listed below. By signing this amendment, all parties listed below acknowledge and accept these changes. A copy of this document shall be distributed to all parties within the QAPP distribution list and shall be included and/or attached to all distributed copies of the original QAPP. The amendment(s) will be incorporated into the full QAPP document when a formal QAPP revision takes place.

Debbie Mackey
DRMP Board of Director President

Date

Melissa Turner
DRMP Program Manager

Date

Will Hagan
DRMP Quality Assurance Officer

Date

Cassandra Lamerdin
DRMP Data Manager

Date

Daniel Ellis
CVRWQCB Environmental Program Manager

Date

Vacant
CVRWQCB Quality Assurance Representative

Date

Ranita Prasad
SWRCB Quality Assurance Officer

Date

Mine Berg Project Manager/Field Lead	Date
Holly Bowers Project Collaborator/Sampling Personnel	Date
Steven Cunningham MLML Laboratory Project Manager,	Date
John Beaver BSA Laboratory Project Manager	Date

Appendix IV – Mercury Study Plan (2027-2031)



Final Mercury Study Plan (2027-2031)

Version 1.0

Approved on April 27, 2026

Prepared By:



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IV. LIST OF ACRONYMS

ACRONYM	DEFINITION
BOD	Board of Directors

BPA	Basin Plan Amendment
CEDEN	California Environmental Data Exchange Network
CV RDC	Central Valley Regional Data Center
CVRWQCB	Central Valley Regional Water Quality Control Board
DOC	Dissolved Organic Carbon
DMT	Data Management Team
DMCP	Delta Mercury Control Program
DRMP	Delta Regional Monitoring Program
DQI	Data Quality Indicator
EDD	Electronic Data Deliverables
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency
FD	Field Duplicate
FY	Fiscal Year
ICP	Inductively Coupled Plasma
IPR	Initial Precisions and Recovery
LCR	Linear Calibration Range
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicates
LRB	Laboratory Reagent Sample
MDL	Method Detection Limit
MeHg	Methylmercury
MLML	Moss Landing Marine Laboratories
MPSL	Marine Pollution Studies Laboratory
MQO	Measurement Quality Objective
MS	Matrix Spike
MS4	Municipal Separate Storm Sewer System
NA	Not Applicable
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Weather Information System
POTW	Publicly Owned Treatment Works
PR	Percent Recovery
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
%R	Percent Recovery
%RE	Relative Error
%RSE	Relative Standard Error
RL	Reporting Limit
RLV	Reporting Limit Verification

RPD	Relative Percent Difference
%RSD	Relative Standard Deviation
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency
VSS	Volatile Suspended Solids

V. LIST OF UNITS

UNIT	DEFINITION
FNU	Formazin Nephelometric Units
g	grams
mm	millimeters
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
ng/L	nanograms per liter
NTU	Nephelometric Turbidity Units
pH	power of Hydrogen
µg/L	micrograms per liter
µg/ g ww	Micrograms per gram of wet weight
µS/cm	microsiemens per centimeter

1 BACKGROUND, PURPOSE, AND STUDY QUESTIONS

This Mercury Study Plan (2027-2031) is designed to evaluate specific water quality conditions within the project area and provide data to support management and regulatory decisions. The objectives, study questions, and hypotheses collectively define the rationale for data collection and the expected outcomes.

1.1 STUDY BACKGROUND AND REGULATORY CONTEXT

Mercury contamination, particularly in the form of methylmercury (MeHg), is a longstanding water quality concern in the Sacramento–San Joaquin Delta (Delta) due to its persistence, bioaccumulation in aquatic food webs, and risk to human and ecological health. Elevated methylmercury concentrations in fish tissue have resulted in beneficial use impairments and fish consumption advisories throughout the Delta. This study is intended to provide additional data that can be used to further characterize ambient mercury and methylmercury conditions in the Delta and evaluate spatial and temporal patterns relevant to Total Maximum Daily Load (TMDL) attainment; it is not designed to identify or apportion specific point or nonpoint sources of methylmercury.

The primary regulatory driver for the Delta Regional Monitoring Program (DRMP) Multi-Year Mercury Monitoring Study (Mercury Study (2027-2031)) is the 2010 Basin Plan Amendment (BPA) which was adopted by the Central Valley Regional Water Quality Control Board (CVRWQCB or Regional Board). The 2010 BPA established the Delta Mercury Control Program (DMCP) and Delta Methylmercury TMDL ([r5-2010-0043](#)). The TMDL establishes implementation goals for methylmercury concentrations in fish tissue and water, and emphasizes the use of control studies, pilot projects, and monitoring to evaluate management practices for reducing mercury bioaccumulation in the Delta.

Concentrations of methylmercury in fish tissue from the Delta exceed thresholds established for the protection of human and wildlife health. Beginning in 2016, the DRMP designed and implemented a mercury monitoring program to address priority management questions and support implementation of the Delta Methylmercury TMDL. These priority status and trends management questions are listed in **Table 1**. This Mercury Study Plan (2027-2031) is focused on the sub-questions outlined in Table 1, and further details can be found in **Section 1.3** below.

Table 1. DRMP mercury management and assessment status and trends questions addressed or informed by each mercury monitoring element.

CORE MANAGEMENT QUESTIONS	ASSESSMENT QUESTIONS	SUB QUESTIONS	
		SUBREGIONAL TRENDS IN BASS	SUBREGIONAL TRENDS IN WATER
Is there a problem or are there signs of a problem?	What are the status and trends in ambient concentrations of total mercury and methylmercury (MeHg) in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large-scale restoration projects)?	Are trends over time in MeHg in sport fish similar or different among Delta subareas?	Are trends over time in MeHg in water similar or different among Delta subareas?
a) Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta?			
b) Are trends similar or different across different subregions of the Delta?			

This monitoring program was designed as an ambient water quality and fish tissue monitoring effort, focused on characterizing regional conditions and subregional variability across the Delta, rather than source-specific water quality monitoring. The monitoring design emphasized cost-effective, subregional sampling of fish and water and included measurement of mercury and methylmercury, along with relevant ancillary parameters. Data generated through this effort provided a foundational dataset for assessing status and trends between aqueous and tissue methylmercury in the Delta.

From 2016-2022, the DRMP designed and implemented a program of mercury monitoring to address priority management questions and support implementation of the Methylmercury TMDL for the Sacramento-San Joaquin Delta. The goal of monitoring was to characterize ambient concentrations of total mercury and methylmercury in fish and water with an emphasis on evaluating spatial patterns and subregional variability. An important element of this work was the co-location of fish and water sampling stations to support evaluation of the relationship between aqueous methylmercury and mercury bioaccumulation in fish. The monitoring generated a high-quality dataset on mercury in fish and water, along with supporting ancillary parameters, and contributed to improved understanding of mercury impairment in the Delta.

Following the first three years of mercury monitoring (August 2016-October 2019), the DRMP developed an Interpretive Report which summarized monitoring findings and

evaluated spatial and temporal trends, tributary inputs, and relationships between methylmercury in water and fish.

In March 2025, a second Mercury Interpretive Report and a Mercury Fact Sheet were published. The overall objective of these products is to support implementation of the DMCP, including assessment of trends in fish tissue and aqueous methylmercury concentrations and evaluation of factors influencing those trends.

- The 2016-2019 Interpretive Report can be found here: [DRMP Mercury Interpretive Report Year 1-3](#)
- The 2016-2025 Interpretive Report can be found here: [DRMP Mercury Interpretive Report Year 1-6](#)
- The Mercury Fact Sheet can be found here: [DRMP Mercury Factsheet](#)

In May 2025, the DRMP Steering Committee issued the Mercury Monitoring Long-Term Planning Direction, which guided the Mercury Technical Advisory Committee (TAC) on developing a multi-year mercury study.

1.2 STUDY PURPOSE

The purpose of this Mercury Study Plan (2027-2031) is to collect and evaluate mercury and methylmercury concentrations in fish tissue and water to support implementation and evaluation of the Delta Methylmercury TMDL and inform future monitoring and management under the DMCP.

The primary objectives outlined by the DRMP Steering Committee are to:

1. Support TMDL attainment,
2. Track status and trends in mercury concentrations (particularly in fish tissue and Delta waters (water column), and
3. Provide relevant data to inform public health initiatives and resource management decisions.

The results of this study will inform regulatory oversight, adaptive management decisions, and future monitoring and modeling efforts associated with the DMCP.

1.3 STUDY QUESTIONS AND DECISION NEEDS

The Mercury Study Plan (2027-2031) has been developed to determine if there are trends in mercury concentrations (both fish and water) over time and whether those trends suggest future attainment of existing fish tissue objectives. As listed in **Table 1**, the Mercury Study Plan (2027-2031) aims to answer the following sub questions:

1. Are trends over time in MeHg in sport fish similar or different among Delta subareas?
2. Are trends over time in MeHg in water similar or different among Delta subareas?

1.4 STUDY OBJECTIVES

In February 2025, the DRMP Steering Committee identified a set of long-term primary and supporting monitoring objectives. These objectives provide the overarching framework for long-term mercury monitoring under the DRMP.

While these objectives represent the long-term monitoring goals established by the Steering Committee, the Mercury Study Plan (2027-2031) is not intended to address all primary and supporting objectives in their entirety. Rather, it is designed to advance a subset of these objectives that are feasible within the scope, timeframe, and resources of the current effort. In particular, activities related to source identification and public health risk assessment are outside the scope and will not be conducted as part of the Mercury Study Plan (2027-2031). Therefore, the Mercury Study Plan (2027-2031) is focused on the following objectives which can assist with public health risk assessment:

- TMDL Attainment: Track progress toward achieving mercury reduction goals as outlined in the DMCP.
- Status and Trends: Monitor mercury concentrations in fish tissue and surface water samples to establish long-term trends and assess variability over time.

1.5 HYPOTHESIS

The Mercury Study Plan (2027-2031) is guided by the following hypotheses:

Hypothesis #1:

H₀ (Null Hypothesis): There is no statistically significant change over time in annual mean methylmercury concentrations in surface waters within or among Delta subregions.

H₁ (Alternative Hypothesis): methylmercury concentrations in surface waters exhibit statistically significant temporal trends and/or spatial differences among Delta subregions.

Hypothesis #2:

H₀ (Null Hypothesis): There is no statistically significant change over time in annual mean methylmercury concentrations in fish tissue within or among Delta subregions.

H₁ (Alternative Hypothesis): Methylmercury concentrations in fish tissue exhibit statistically significant temporal trends and/or spatial differences among Delta subregions.

2 DATA QUALITY REQUIREMENTS

This section defines the data quality requirements that establish the measurement performance expectations necessary to produce usable and defensible data for the objectives of the Mercury Study Plan (2027-2031). These requirements provide the framework for evaluating whether data are of sufficient quality to support interpretation, comparison, and decision-making within the intended regulatory and technical context.

Data are considered defensible when they are generated, documented, and evaluated using technically sound and transparent practices that allow results to withstand independent technical review and potential regulatory or legal scrutiny. Defensibility is achieved through appropriate study design; the use of validated or otherwise demonstrated analytical methods; implementation of documented quality control measures; and application of predefined, objective decision logic for data review and usability determinations. Together, these elements ensure that data quality is not inferred post hoc, but established through planned, auditable procedures.

The data quality requirements described in this section translate study objectives into measurable performance criteria, including applicable data quality indicators (DQIs), acceptance limits, and evaluation approaches. These criteria are used to assess data precision and accuracy; representativeness; comparability; completeness; and sensitivity and resolution, and to support consistent determinations regarding data usability and limitations.

2.1 DATA QUALITY REQUIREMENTS AND PERFORMANCE CRITERIA

To account for the inherent level of uncertainty that can occur from the sampling design process through the result documentation, it is important for the project to have set limits of allowable error to ensure data are useable and supportive of the project goals.

Data quality indicators are the quantitative statistics and qualitative descriptors used to interpret the degree of acceptability or utility of data to the user (US EPA QA/G-5, 2002). The principal DQIs are precision and accuracy; representativeness; comparability; completeness; and sensitivity and resolution.

Program definitions for each DQI are provided below, and the minimum performance targets associated with each DQI must be defined in the Quality Assurance Project Plan (QAPP).

2.1.1 Precision and Accuracy

Precision measures the agreement among repeated measurements of the same property under identical or substantially similar conditions. The closer the values obtained from replicate measurements, the higher the precision. Precision reflects both inherent limitations of the measurement system and potential operator error. Laboratory precision is assessed with the ongoing analysis of laboratory control samples (LCS) and laboratory control sample duplicates (LCSD). Precision may be expressed as Relative Percent Difference (RPD) between two duplicate results (e.g., LCS and LCSD), or Relative Standard Deviations (%RSD) of multiple replicate measurements.

Accuracy is defined as the degree of agreement between an observed measurement and its accepted reference value. It reflects the combined influence of random error (precision) and systematic error (bias) arising from both sampling and analytical processes. Accuracy serves as a key data quality indicator, providing insight into how closely reported results represent the true value. Laboratory accuracy is assessed with the ongoing analysis of check standards (e.g., LCS and LCSD). Accuracy may be expressed as Percent Recovery (%R) and Relative Error (%RE) or Relative Standard Error (%RSE).

The accuracy and precision of lab measurements must be evaluated based on Measurement Quality Objectives (MQOs) defined in the QAPP.

2.1.2 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness for the DRMP can be

defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represents actual environmental conditions. For this project, representativeness is addressed by the overall study design, adherence with sampling Standard Operating Procedures (SOPs), and meeting holding times. Assuring that the data are representative of the program objectives is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection.

2.1.3 Comparability

Comparability is a measure of the confidence with which one data set or method can be compared to another. Project data are comparable when evaluated against similar quality objectives and when utilizing similar methodology and reporting requirements. All projects contributing to the DRMP must maintain comparability by following the provisions outlined in the DRMP Data Management Plan.

2.1.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system. This assessment is typically expressed as a percentage of measurements reported within the prescribed limits associated with the respective DQIs, compared to those initially planned. Completeness evaluations ensure program requirements for data generation and reporting are met by contributing projects. Program completeness is assessed on three levels: field and transport, analytical, and batch completeness. Field completeness requires that sampling crews successfully visit each site, document the visit, and collect the field information and samples as outlined in the QAPP. Transport completeness requires that the samples collected by field crews are successfully transported to the laboratories. Analytical completeness is based on the number of samples successfully analyzed by the laboratory and for which valid results are generated. Batch completeness is based on whether batches were processed with the appropriate quality control (QC) samples, as prescribed by the method or defined by the laboratory. Minimum QC sample frequency requirements must be defined in the QAPP.

2.1.5 Sensitivity and Resolution

Analytical sensitivity is commonly defined as the lowest value an instrument or method can measure with reasonable degree of certainty. Resolution is the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest. These limits are important to know when evaluating the appropriateness of a method or instrument for the requirements of a given study.

Reporting limits represent the level at which a method or instrument can accurately measure a target compound. Wherever analytically feasible, reporting limits should be lower than the required project action limit to be appropriate for the project.

Analytical reporting limits sufficient to evaluate attainment with project goals are included in **Section 4- Parameters, Analytical Methods, and Quality Control**.

Analytical reporting limits will be sufficient to evaluate attainment with TMDL implementation goals:

- 0.24 mg/kg methylmercury wet weight in 350 mm largemouth bass.
- 0.06 ng/L unfiltered aqueous methylmercury.

In addition to the TMDL implementation goals, the staff report includes the following fish tissue objectives:

- 0.08 mg/kg methylmercury wet weight in fish tissue for large trophic level 3 fish (150-500 mm total length).
- 0.24 mg/kg methylmercury wet weight in fish tissue for large trophic level 4 fish (150-500 mm total length).
- 0.03 mg/kg, wet weight, for small trophic level 2 and 3 fish (less than 50 mm).

2.1.6 Performance Criteria

Measurement quality objectives are the specific criteria to which environmental or quality control measures are compared to determine acceptability. The MQO's for accuracy, precision, completeness, recovery, and contamination are assessed through a combination of instrument calibration and the analysis of duplicates, blanks, and spikes. Completeness is assessed based on the number of samples successfully obtained and validated for use and the proportion of quality control samples that are within acceptance criteria. All MQO's must be defined in the QAPP and utilized as the performance criteria to evaluate whether the data quality objectives were met.

2.2 APPLICABILITY OF DATA QUALITY REQUIREMENTS TO STUDY QUESTIONS

The data quality requirements are designed to ensure that the monitoring results are sufficient to answer the Mercury Study Plan (2027-2031) questions and support regulatory decision-making under the Delta Methylmercury TMDL. Sensitivity and comparability criteria allow direct comparison of observed concentrations to TMDL

implementation goals and historic datasets. Accuracy and precision requirements support reliable detection of spatial differences among subregions and temporal trends over time.

The targeted fish size classes and sampling frequency are critical for evaluating status, and trends in fish tissue, while surface water sampling supports assessment of aqueous methylmercury conditions.

Collectively, these performance criteria ensure that the data are suitable for evaluating progress toward TMDL goals and DRMP monitoring and assessment questions.

3 STUDY AREA, SITE SELECTION, AND SAMPLING DESIGN

This section describes the geographic area covered by the Mercury Study Plan (2027-2031) and the rationale for selecting each sampling site. It outlines the sampling design, timing, and frequency needed to generate representative data aligned with the study objectives.

3.1 STUDY AREA DESCRIPTION

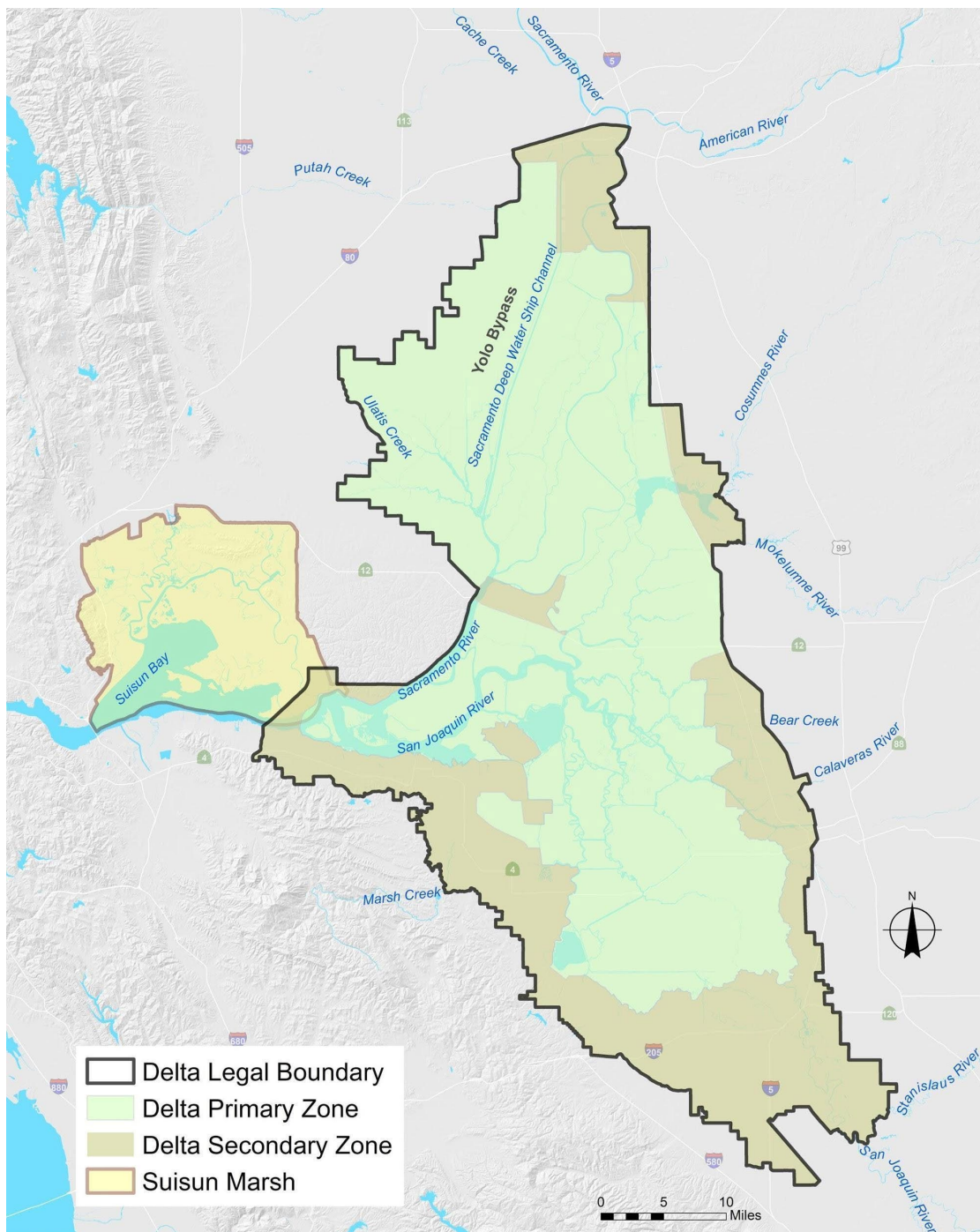
The Mercury Study Plan (2027-2031) area encompasses the Delta and associated waters monitored under the DRMP. The geographic scope includes the legal Delta, as defined by Section 12220 of the California Water Code, as well as water bodies that directly drain into the Delta, the Yolo Bypass, and Suisun Bay (see **Figure 1**).

The DRMP monitoring area is organized into a Primary Zone and a Secondary Zone. The Primary Zone includes approximately 500,000 acres of waterways, levees, flooded islands, and agricultural lands within the legal Delta and the Yolo Bypass. The Secondary Zone includes approximately 250,000 acres surrounding the Primary Zone and subject to increasing urban and suburban development. Suisun Marsh, located on the northern side of Suisun Bay, encompasses approximately 110,000 acres of managed wetlands, while the southern shoreline of Suisun Bay includes additional tidal wetlands as well as urban, suburban, and industrial areas.

Hydrologic conditions in the Delta and Suisun Bay are governed by inflows from the Sacramento and San Joaquin rivers, tidal exchange with the Pacific Ocean, and water withdrawals for municipal and agricultural uses. Flows are highly seasonal and typically peak in spring and early summer due to snowmelt from upstream watersheds. These hydrologic dynamics, combined with extensive land use modification and habitat

alteration, influence mercury transport, transformation, and bioaccumulation across the Delta.

Figure 1. The geographic scope of the DRMP encompasses the legal Delta (as defined by Section 12220 of the Water Code), including water bodies that directly drain into the Delta, Yolo Bypass, and Suisun Bay.



3.2 SITE SELECTION AND RATIONALE

The CVRWQCB has divided the Delta into eight subregions for purposes of assessing and managing methylmercury impairment. The sampling design for the Mercury Study Plan (2027-2031) was developed to distribute monitoring stations across these subregions to support evaluation of spatial patterns and interannual trends in mercury concentrations and is consistent with previous DRMP monitoring to be able to continue baseline datasets and evaluate trends over time.

Fish tissue sampling stations and surface water sampling stations are generally co-located to support analysis of relationships between aqueous methylmercury concentrations and methylmercury concentrations in fish tissue. Stations were selected to represent different subareas of the Delta, align with existing DRMP monitoring infrastructure, and support subregional comparisons.

Sampling sites consist of seven fixed core monitoring stations. All seven stations will be sampled for water in the spring, and for fish tissue and water in the fall. Core monitoring stations represent open-water habitats and provide long-term baseline data for assessing status and trends in mercury concentrations across the Delta. Planned mercury sampling stations are listed in **Table 2** and shown in **Figure 2**.

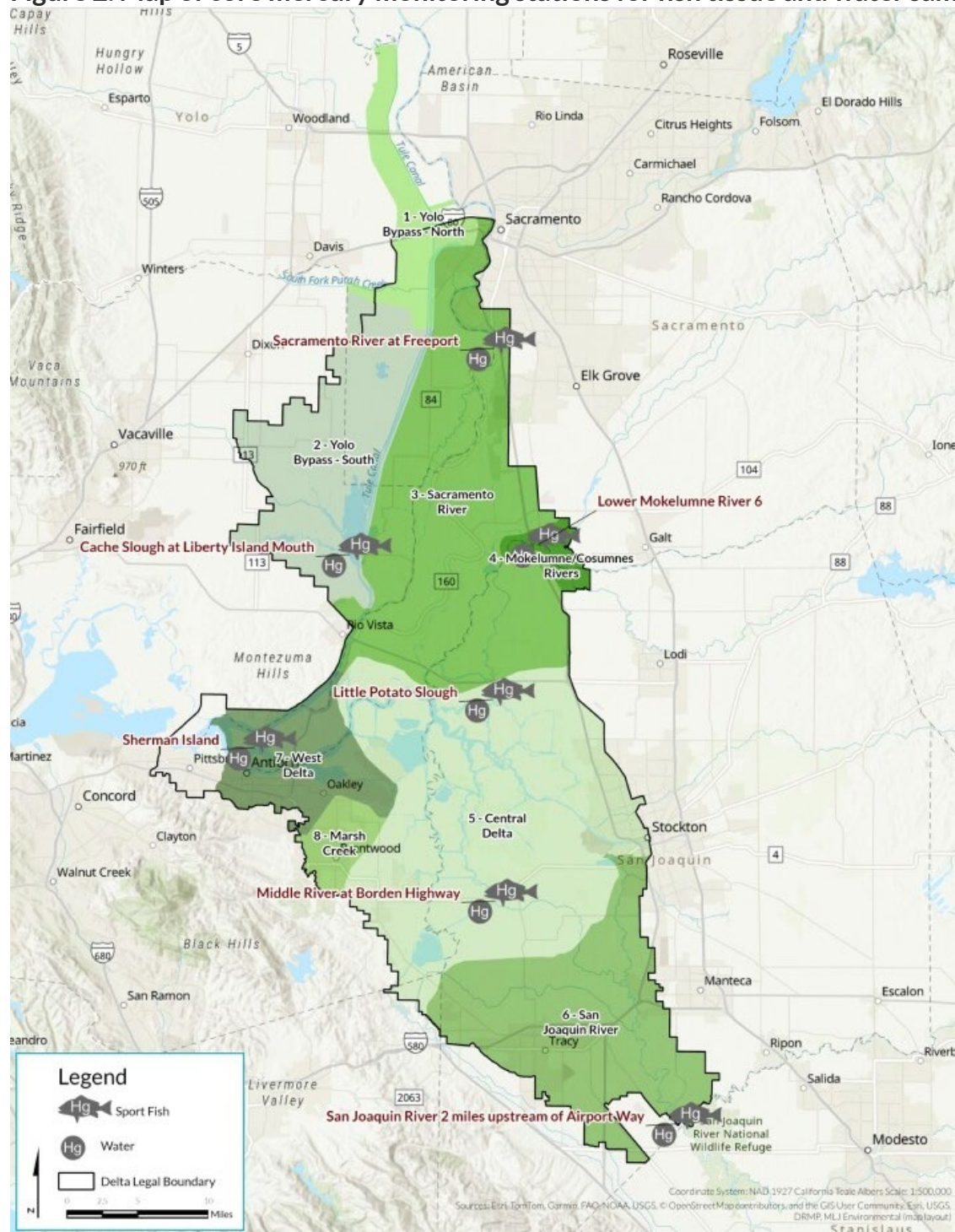
Table 2. Core monitoring stations for mercury in water and fish.

#	CEDEN STATION CODE	STATION NAME	LATITUDE	LONGITUDE	FISH SAMPLING	WATER SAMPLING
1	510ADVLM	Cache Slough at Liberty Island Mouth ¹	38.24213	-121.68539	X	X
2	544LILPSL	Little Potato Slough	38.09627	-121.49602	X	X
3	544MDRBH4	Middle R @ Borden Hwy (Hwy 4)	37.89083	-121.48833	X	X
4	544ADVLM6	Lower Mokelumne R 6	38.25542	-121.44006	X	X
5	510ST1317	Sacramento R @ Freeport	38.45556	-121.50189	X	X
6	541SJR2AW	San Joaquin River 2 miles upstream of Airport Way	37.665367	-121.246050	X	X
7	510ST1666	Sherman Island ¹	38.0431	-121.8044	X	X

¹ The existing permit does not allow for electrofishing at these locations; sampling crews will collect fish using hook and line sampling methods.

CEDEN = California Environmental Data Exchange Network

Figure 2. Map of core mercury monitoring stations for fish tissue and water sampling.



3.3 SAMPLING FREQUENCY, TIMING, AND DURATION

The Mercury Study Plan (2027-2031) is a multi-year mercury monitoring study conducted under the DRMP. Sampling is designed to support long-term trend detection and subregional comparisons.

Two monitoring events will be conducted each project year (Fiscal Year [FY] 26-27 through FY 31-32). A spring monitoring event will target March (with flexibility to extend into April if needed) and will include surface water sampling only. A fall monitoring event will target September (with flexibility to occur as early as August or as late as October, if needed) (**Table 3**), and will include both fish tissue and surface water sampling. For additional information regarding sampling contingencies, see **Section 7.3 Contingency Planning**.

Annual fall fish tissue sampling is intended to characterize methylmercury concentrations in fish tissue and assess variability and trends across subregions and years. Concurrent fall surface water sampling, together with spring surface water sampling, will support evaluation of ambient aqueous methylmercury conditions and subregional trends across years. The spring and fall sampling windows were selected to reduce the potential for seasonal sampling bias associated with surface water monitoring during a single season.

Black bass (*Micropterus salmoides*, *Micropterus dolomieu*, and *Micropterus punctulatus*) are the primary indicator species for evaluating mercury bioaccumulation. This Mercury Study Plan (2027-2031) does not include prey fish or sediment sampling. Prey fish monitoring and sediment sampling were considered in earlier mercury monitoring designs but are excluded from the current study due to permitting constraints, resource limitations, and the prioritization of fish tissue and surface water monitoring to address the study objectives.

Table 3. Annual monitoring sampling schedule.

PROJECT YEAR	FISCAL YEAR	SAMPLING WINDOW	DESCRIPTION
1	26-27	March – April 2027	One water sampling event will occur within the sampling window.
	27-28	August - October 2027	One concurrent fish tissue and water sampling event will occur within the sampling window.
2		March – April 2028	One water sampling event will occur within the sampling window.
	28-29	August – October 2028	One concurrent fish tissue and water sampling event will occur within the sampling window.
3		March - April 2029	One water sampling event will occur within the sampling window.
	29-30	August - October 2029	One concurrent fish tissue and water sampling event will occur within the sampling window.
4		March – April 2030	One water sampling event will occur within the sampling window.
	30-31	August - October 2030	One concurrent fish tissue and water sampling event will occur within the sampling window.
5		March – April 2031	One water sampling event will occur within the sampling window.
	31-32	August – October 2031	One concurrent fish tissue and water sampling event will occur within the sampling window.

4 PARAMETERS, ANALYTICAL METHODS, AND QUALITY CONTROL

This section identifies the parameters to be measured, and the field and laboratory methods used to generate data. It also summarizes quality control measures that ensure data meet the Mercury Study Plan (2027-2031) performance expectations and are suitable for their intended use.

Detailed field, laboratory, and quality assurance procedures will be documented in a project-specific QAPP to be developed following approval of this study plan.

4.1 PARAMETERS AND MEASUREMENTS TO BE COLLECTED

The monitoring program includes fish tissue and water sampling designed to address the Mercury Study Plan (2027-2031) questions listed in **Section 1.3 Study Questions and Decision Needs**. The specific constituents to be measured are listed in **Table 4**.

Table 4. Constituents to be measured.

CONSTITUENT	FRACTIONS/ ENDPOINTS	MATRIX	SAMPLE TYPE	PROJECT DETECTION LIMIT	REPORTING UNITS
Oxygen, Dissolved	NA	Water	In situ	0 to 20 mg/L: ± 0.1 mg/L or 1% of reading, whichever is greater; 20 to 50 mg/L: $\pm 5\%$ of reading	mg/L
Oxygen, Dissolved	NA	Water	In situ	0 to 200%: $\pm 1\%$ of reading or 1% saturation, whichever is greater; 200 to 500%: $\pm 5\%$ of reading	% saturation
pH	NA	Water	In situ	± 0.1 pH units within $\pm 10^\circ\text{C}$ of calibration temp; ± 0.2 pH units for entire temp range	pH
Specific Conductivity	NA	Water	In situ	0 to 100: $\pm 0.5\%$ of reading or 0.001 mS/cm, whichever is	$\mu\text{S}/\text{cm}$

CONSTITUENT	FRACTIONS/ ENDPOINTS	MATRIX	SAMPLE TYPE	PROJECT DETECTION LIMIT	REPORTING UNITS
				greater; 100 to 200: $\pm 1\%$ of reading	
Temperature	NA	Water	In situ	5 to 35°C: $\pm 0.01^\circ\text{C}$ 35 to 50°C: $\pm 0.05^\circ\text{C}$	$^\circ\text{C}$
Turbidity	NA	Water	In situ	0 to 999 FNU: 0.3 FNU or $\pm 2\%$ of reading, whichever is greater; 1000 to 4000 FNU: $\pm 5\%$ of reading	FNU or NTU
Chlorophyll a	Particulate	Water	Grab	1	$\mu\text{g/L}$
Dissolved Organic Carbon (DOC)	Dissolved	Water	Grab	0.23	mg/L
Total Suspended Solids (TSS)	Total	Water	Grab	NA	mg/L
Volatile Suspended Solids (VSS)	Total	Water	Grab	NA	mg/L
Mercury, total	Dissolved	Water	Grab	0.14	ng/L
Mercury	Total	Water	Grab	0.14	ng/L
Mercury, Methyl	Dissolved	Water	Grab	0.015	ng/L
Mercury, Methyl	Total	Water	Grab	0.015	ng/L
Total Length	NA	Tissue	Individual	NA	mm
Fork Length	NA	Tissue	Individual	NA	mm
Weight	NA	Tissue	Individual	NA	g
Sex	NA	Tissue	Individual	NA	male/ female/ unknown
Moisture	NA	Tissue	Individual	NA	%
Mercury, total	NA	Tissue (fillet muscle)	Individual	0.004	$\mu\text{g/g ww}$

NA = Not Applicable

4.1.1 Photo Documentation

Site photos are taken at each monitoring location where samples are scheduled to be collected (i.e. every event).

4.1.2 Habitat Observations

In addition to the samples and measurements collected in the field, sampling crews shall record habitat parameters documenting the qualitative site condition information at the time that samples were collected. The required habitat observations are consistent with surface water sample collection protocols and are defined on the field sheets used for this project. The field sheet will be tailored to the specific needs of the project; an example of a field sheet will be provided in the QAPP.

Field site observations to be recorded in accordance with surface water sample collection protocol:

- Site odor
- Sky code
- Other presence
- Water clarity
- Water odor
- Water color
- Wind speed (Beaufort scale)
- Wind direction
- Precipitation (at time of sampling)
- Precipitation (last 24 hours)
- Occupation Method
- Location

4.2 FIELD METHODS AND SAMPLE COLLECTION PROCEDURES

Samples for mercury (including methylmercury) and supporting parameters will be collected by trained field crews using standardized trace-metal clean techniques. Sample containers will meet United States Environmental Protection Agency (US EPA) contaminant-free specifications, and trace metal clean techniques (clean hands/dirty hands) will be followed during water collections and field fish processing.

Spring surface water sampling will be conducted in March, with flexibility to extend into April, if needed. Fall fish and surface water sampling will be conducted concurrently in September, with flexibility to extend into August or October. Sampling events will be

scheduled to ensure that site access, including docks and boat launch locations, is safe for field personnel. Weather conditions, hydrologic conditions, and other site-specific safety considerations (e.g., flooding, major storm events, or elevated flows) may affect the timing of sampling activities. Sampling will be conducted only under conditions that allow for safe boat launch and operation, and periods of high flow or other unsafe conditions will be avoided. If unsafe conditions occur, sampling may be delayed or rescheduled to ensure personnel safety while maintaining data quality objectives.

Specific collection methods, equipment cleaning procedures, and tissue processing steps will be detailed in the QAPP.

4.2.1 Water Sampling

Water samples will be collected as depth-integrated samples using trace-metal clean techniques to minimize contamination. Clean sampling equipment and containers will be used at each site, and equipment will be stored and handled to avoid contact with potential contamination sources. One field duplicate and one field blank will be collected per monitoring event.

4.2.2 Fish Tissue Sampling

Fish tissue is collected annually during the fall sampling period. Collection methods may include electrofishing or hook-and-line sampling, depending on site-specific access and permit constraints (**Table 2**).

The Mercury Study Plan (2027-2031) focuses on collecting Black Bass as a high-trophic level fish. The target species are Largemouth bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), and Spotted Bass (*Micropterus punctulatus*) with a goal of collecting individuals across a defined size range to support trend analysis and length-mercury relationships. Where necessary, similar predatory species may be collected as substitutes. The requirements for fish sampling are included in **Table 5**. Additional contingencies related to fish tissue sampling are discussed in **Section 7.3 Contingency Planning**.

Table 5. Requirements for collection of fish tissue samples.

TARGET SPECIES	NUMBER OF FISH PER EVENT	ELECTROFISHING TARGET LENGTHS:	HOOK AND LINE FISHING TARGET LENGTHS:
Black Bass (Largemouth, Smallmouth, and Spotted)		3 x (200-249 mm)	2 x (200-249 mm)

TARGET SPECIES	NUMBER OF FISH PER EVENT	ELECTROFISHING TARGET LENGTHS:	HOOK AND LINE FISHING TARGET LENGTHS:
	16 fish at each electrofishing site or 11 fish at each hook and line site at 7 sites (112 fish per event)	3 x (250-304 mm)	2 x (250-304 mm)
		7 x (305-407 mm)	5 x (305-407 mm)
		3 x (>407 mm)	2 x (>407 mm)

4.2.3 Habitat Observations

Field crews will document sampling conditions, methods, and observations using standardized field sheets. An example field sheet will be included in the QAPP.

4.2.4 Sample Handling, Preservation, and Custody

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

Sample handling procedures ensure sample integrity from collection through laboratory analysis. Samples will be labeled, preserved, and transported in accordance with method-specific requirements. Storage and holding time requirements for each parameter will be defined in the QAPP.

Chain of custody procedures will be followed throughout the sample collection, transport, and laboratory handling to maintain sample integrity and traceability; chain of custody procedures will be defined in the QAPP.

4.3 LABORATORY ANALYTICAL METHODS

Laboratory analyses will be performed using US EPA or laboratory-approved methods appropriate for low-level mercury analysis.

Laboratory analyses will be performed according to the US EPA methods and SOPs approved in the QAPP. The QAPP must identify all methods utilized by the laboratory for each constituent and list the laboratory Method Detection Limit (MDLs) and Reporting Limits (RLs) to demonstrate the laboratory meets the project detection requirements listed in **Table 4**.

The laboratory analytical methods employed for this Mercury Study Plan (2027-2031) are defined in **Table 6**.

Table 6. Laboratory Analytical Methods

CONSTITUENT	FRACTION	MATRIX	SAMPLE TYPE	ANALYTICAL METHOD NAME	ANALYTICAL METHOD NUMBER
Oxygen, Dissolved	NA	Water	Field	Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California	MPSL Field SOP v1.1
pH	NA	Water	Field	Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California	MPSL Field SOP v1.1
Specific Conductivity	NA	Water	Field	Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California	MPSL Field SOP v1.1
Temperature	NA	Water	Field	Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California	MPSL Field SOP v1.1
Turbidity	NA	Water	Field	Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California	MPSL Field SOP v1.1
Chlorophyll a	Particulate	Water	Grab	In Vitro Determination of Chlorophyll a and Pheophytin a in Marine and Freshwater Algae by Fluorescence	EPA 445.0M

CONSTITUENT	FRACTION	MATRIX	SAMPLE TYPE	ANALYTICAL METHOD NAME	ANALYTICAL METHOD NUMBER
Dissolved Organic Carbon (DOC)	Dissolved	Water	Grab	TOC Determination by Persulfate-Ultraviolet Oxidation Method	SM 5310 C
Total Suspended Solids (TSS)	Total	Water	Grab	Gravimetric Determination of Solids (ASTM D-3977, SM 2540 C, D AND E)	MPSL-108
Volatile Suspended Solids (VSS)	Total	Water	Grab	Gravimetric Determination of Solids (ASTM D-3977, SM 2540 C, D AND E)	MPSL-108
Mercury, total	Dissolved	Water	Grab	Modifications to EPA Method 1631 Revision E	EPA 1631eM
Mercury	Total	Water	Grab	Modifications to EPA Method 1631 Revision E	EPA 1631eM
Mercury, Methyl	Dissolved	Water	Grab	Modifications of EPA Method 1630 for Freshwater	EPA 1630M
Mercury, Methyl	Total	Water	Grab	Modifications of EPA Method 1630 for Freshwater	EPA 1630M
Total Length	NA	Tissue	Individual	NA	NA
Fork Length	NA	Tissue	Individual	NA	NA
Weight	NA	Tissue	Individual	NA	NA
Sex	NA	Tissue	Individual	NA	NA
Moisture	NA	Tissue	Individual	Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry Modified	EPA7473M

CONSTITUENT	FRACTION	MATRIX	SAMPLE TYPE	ANALYTICAL METHOD NAME	ANALYTICAL METHOD NUMBER
Mercury, total	NA	Tissue	Individual	Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry Modified	EPA7473M

NA = Not Applicable

4.4 QUALITY CONTROL REQUIREMENTS

This project will comply with the QC guidelines and corrective actions described below. Quality control activities and requirements are determined to ensure that the DQIs identified in **Section 2 - Data Quality Requirements** are met for all project activities. The quality control samples defined below are assessed according to the specific performance criteria defined in QAPP.

4.4.1 Laboratory Accreditation

Per the DRMP Data Management Plan, all commercial contract laboratories must maintain the appropriate accreditation with the California Environmental Laboratory Accreditation Program (ELAP). Wherever possible, the laboratories must be accredited in the specific analytical methods used for performing analysis under this QAPP or provide the appropriate performance verification information as outlined in the QAPP.

Commercial laboratories will be accredited by ELAP to perform all analyses according to the methods listed in the QAPP, wherever possible. In the event that ELAP accreditation is not available or applicable due to the use of non-standard methods or alternate test procedures, the laboratory will demonstrate their performance and ability to achieve project reporting requirements by submitting the performance study information outlined below.

4.4.2 Laboratory Standard Operating Procedures

Each participating laboratory is required to maintain laboratory-specific SOPs that govern all analytical methods, sample handling, quality control, and data management activities performed under the Mercury Study Plan (2027-2031). Standard Operating Procedures

must be current, approved, and clearly document the procedures used to ensure consistent, reliable, and traceable laboratory operations.

Laboratory SOPs must include, at a minimum:

- Method identification and scope, including applicable sample matrices and analytes
- Method detection limits, reporting limits, and calibration range
- Detailed step-by-step analytical procedures, including sample preparation, extraction, and analysis
- Calibration and continuing calibration verification procedures
- Quality control requirements, including blanks, laboratory control samples, matrix spikes, surrogates, and internal standards
- Data handling, analysis, and calculation procedures
- Criteria for precision, accuracy, and method performance evaluation
- Documentation and recordkeeping requirements
- Revision history and approval signatures

Laboratories are expected to maintain records demonstrating compliance with their written SOPs. All records, including raw data, calibration logs, QC results, and method validation documentation, must clearly show that laboratory personnel followed SOP procedures, and that quality objectives and acceptance criteria were met. Deviations from SOPs must be documented, justified, and addressed in accordance with the laboratory's quality management system.

4.4.3 Method Validation and Initial Precision and Recovery Elements and Requirements

This section defines the QC procedures for establishing the validity of a test method. Validation is the confirmation by examination and the provision of objective evidence that the requirements for a specific intended use are fulfilled (2016 TNI V1M2 §5.4.5.1).

All test methods used by non ELAP accredited laboratories must be validated according to this procedure which is as extensive as necessary to meet the needs of the laboratory application and ensure capability of employing the method for its intended use (2016 TNI V1M2 §5.4.5.4).

Methods are initially and periodically validated by demonstration of linear calibration range, determination of method detection limits and reporting limits; and evaluation of precision, bias, and selectivity as outlined below.

Linear Calibration Range

The Linear Calibration Range (LCR) must be determined initially and verified periodically as defined in the EPA-approved reference method. The initial demonstration of linearity must use sufficient standards to ensure that the resulting calibration curve is linear. The verification of linearity must meet the calibration requirements defined in the QAPP. If any verification data exceeds the method defined criteria, linearity must be reestablished. If any portion of the range is shown to be nonlinear, sufficient standards must be used to clearly define the nonlinear portion.

Method Detection Limit

The MDL is defined as the minimum measure concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from laboratory reagent blank results. Method detection limits are determined according to [EPA 821-R-16-006](#). The laboratory must recalculate MDLs at the frequency required by the EPA-approved reference methods. If the re-calculated MDL is within 0.5 – 2.0 times the existing MDL, and fewer than 3% of the laboratory reagent blank results (for the individual analyte) have numerical results above the existing MDL, then the existing MDL may optionally be left unchanged. Otherwise, the laboratory must adjust the MDL to the newly re-determined MDL and notify the appropriate project personnel as defined in the QAPP.

Reporting Limit

The RL is the lowest quantified level within an analytical method's operational range deemed reliable enough, and therefore appropriate, for reporting by the laboratory. Reporting Limits may be established by regulatory mandate or client specifications, or arbitrarily chosen based on a preferred level of acceptable reliability. The laboratories are required to demonstrate their ability to reliably report to the project RLs defined in the QAPP. An RL is required for each quality system matrix of interest, technology, method, and analyte. The RL must be set higher than the MDL and must be set at or above the lowest corresponding calibration standard. The RL must be verified daily through analysis of a Reporting Limit Verification (RLV) spike at or below the RL concentration. The RL verification criteria are defined in QAPP.

Evaluation of Precision and Bias

The demonstration of Initial Precisions and Recovery (IPR) is a procedure to establish the ability of the laboratory to generate analytical results of acceptable accuracy and precision. Laboratories must demonstrate IPR with the analysis of four replicates of reagent water spiked with the analytes of interest between one and five times the RL. The concentration of the spiked samples and their acceptance criteria must be defined in the laboratory SOP. The laboratory must demonstrate the ability to meet the study IPR criteria defined in the QAPP.

Evaluation of Selectivity

Selectivity is the capability of a test method or instrument to respond to a target constituent in the presence of a non-target substance. Laboratories must assess selectivity in accordance with the method's specified procedures, which may involve techniques such as mass spectral tuning, confirmation using a secondary column, Inductively Coupled Plasma (ICP) inter-element interference assessments, retention time verification, analysis of sample blanks, evaluation of spectrochemical absorption or fluorescence patterns, co-precipitation tests, and measurement of electrode response factors. All selectivity evaluations must be performed and documented in accordance with the established procedural requirements.

4.4.4 Quality Control for Laboratory Analyses

Samples are analyzed alongside quality QC samples for which the data are evaluated against the MQOs defined in the QAPP to ensure that data are valid, usable, and supportive of project goals. Analytical QC samples must be analyzed at a frequency of one per preparation batch; a preparation batch is limited to no more than 20 environmental samples.

The laboratory demonstrates method performance periodically (i.e., every 20 environmental samples) with analysis of applicable QC samples, which include laboratory reagent blank (LRB), LCS, LCSD and surrogate standards.

A laboratory blank is an aliquot of reagent water or another blank matrix that matches the method-specified sample matrix and is free from the analytes of interest. It is processed simultaneously with and under the same conditions as the samples through all steps of the analytical procedure, including exposure to all glassware, equipment, reagents, and standards used with other samples. The results of laboratory blanks demonstrate the presence or absence of contamination in the field process and laboratory environment,

respectively. Blank data is evaluated to ensure contamination does not compromise sample results.

Precision in this project is assessed through a combination of field duplicate samples and laboratory duplicate samples. Precision of a pair of samples is measured as the relative percent difference (RPD) between a sample and its duplicate - a LCS and its duplicate (i.e., LCSD), a matrix spike (MS) and matrix spike duplicate (MSD), an environmental sample and field duplicate (FD), or an environmental sample and its associated laboratory duplicate. It is calculated as follows:

$$RPD(\%) = \left| \frac{2(V_i - V_D)}{V_i + V_D} \right| \times 100$$

V_i = The measured concentration of the initial sample

V_D = The measured concentration of the sample duplicate

For precision assessment purposes any laboratory duplicate, including a matrix spike duplicate or a laboratory control spike duplicate, may function as the laboratory duplicate in any batch. Samples evaluated for toxicity in the water column and sediment, do not require laboratory duplicates to be performed; however, test replicates are generated as prescribed in the associated method.

Accuracy in this project is assessed using a laboratory blank and either an LCS or MS. For an LCS, laboratory blank water is spiked with a known concentration of a target analyte and the percent recovery (PR) is reported. Percent recovery in an LCS is calculated as follows:

$$\% Recovery = \left(\frac{V_{LCS}}{V_{Spike}} \right) \times 100$$

V_{LCS} = The measured concentration of the spiked control sample

V_{Spike} = The expected spike concentration

For an MS, environmental water is spiked with a known concentration of a target analyte and the PR is reported. The PR in an MS is calculated as follows:

$$\% Recovery = \left(\frac{V_{MS} - V_E}{V_{Spike}} \right) \times 100$$

V_{MS} = The measured concentration of the spiked matrix sample

V_{Spike} = The concentration of the spike added

V_E = The measured concentration of the original (unspiked) matrix sample

The MS should not be used solely to assess accuracy due to the likelihood of matrix interference. However, if an LCS does not fall within acceptance criteria, an MS may be used to validate a batch if the MS is within acceptance criteria.

If results for analytical precision or accuracy samples do not meet the MQOs provided in the QAPP, the data are flagged accordingly. If positive control or duplicate samples are outside of limits, the instruments are recalibrated, and all suspect samples are reanalyzed, or all suspect data are flagged. Detections in blanks must be sourced and analytical, or cleaning practices must be modified to reduce the risk of further contamination. Excessive RPD values or percent recoveries outside of criteria may also require a change of laboratory practices. Exceedances of analytical control limits must be reported in the appropriate laboratory report. If the results repeatedly fail to meet the objectives, then the laboratory is obligated to halt the analysis of samples, identify the source of the imprecision, and make corrections where appropriate before proceeding.

4.4.5 Laboratory Measurement Quality Objectives

The MQOs defined in the QAPP are the specific criteria to which quality control samples are compared to determine adequacy and acceptability of results. When the defined criteria are not met, appropriate actions must be taken in accordance with the procedures detailed in the QAPP.

4.4.6 Laboratory Corrective Actions

Immediate corrective actions are taken by the laboratory during routine analysis when QC results fall outside of established acceptance criteria, as defined in the QAPP. These corrective actions are intended to promptly address issues that may impact data quality, method performance, or the validity of ongoing analyses. The laboratory is responsible for identifying the potential cause, making necessary adjustments, and documenting the response in accordance with internal procedures. The QAPP summarizes the types of immediate corrective actions associated with each QC sample type, as well as the related notification and reporting requirements.

5 DATA MANAGEMENT, DOCUMENTATION, AND DELIVERABLES

This section outlines how project data will be recorded, stored, managed, validated, and transmitted. Documentation requirements ensure transparency and traceability, while data deliverables ensure timely communication of project results.

Detailed data management procedures, validation workflows, electronic data deliverable formats, and metadata requirements will be documented in a project-specific QAPP developed following approval of the Mercury Study Plan (2027-2031).

5.1 DATA ORGANIZATION AND STORAGE

5.1.1 High-Level Summary

Mercury monitoring data generated under this study will be managed in accordance with DRMP data management standards to ensure consistency, traceability, and long-term accessibility. Data management responsibilities will be coordinated through the DRMP Data Management Team.

Data will be stored in standardized electronic formats compatible with California Environmental Data Exchange Network (CEDEN). Version control procedures and secure backups will be maintained throughout the project lifecycle to protect data integrity.

5.1.2 Laboratory Reporting Requirements

Analytical laboratories will submit electronic data deliverables (EDDs) in standardized formats compatible with CEDEN requirements. Reported data will include sufficient information to support interpretation and quality evaluation, including sample identifiers, analytical methods, results, detection limits, and applicable data qualifiers.

Laboratories will provide associated quality control results and case narratives describing any deviations from method or quality objectives. Only data meeting established measurement quality objectives, or data with documented and justified deviations, will be accepted for inclusion in study analyses.

5.2 DATA DOCUMENTATION AND METADATA REQUIREMENTS

Comprehensive documentation will be maintained to support transparency, reproducibility, and appropriate data use. Required documentation will include field data

sheets, chain-of-custody records, laboratory reports, EDDs, and metadata describing sampling locations, collection methods, analytical methods, and quality assurance results.

All documentation will be retained as part of the permanent DRMP project record and will support data validation, interpretation, and long-term accessibility.

5.3 DATA VALIDATION AND SCREENING PRIOR TO REPORTING

Data will undergo verification and validation prior to reporting to ensure completeness, accuracy, and consistency with study objectives. Validation will include automated and manual checks of analytical results, quality control performance, and metadata completeness.

Data usability will be assessed relative to study objectives, and any limitations or deviations affecting interpretation will be documented and communicated with reported results.

5.4 DATA DELIVERABLES AND SUBMISSION SCHEDULE

Mercury Study Plan (2027-2031) deliverables will include preliminary data summaries, annual mercury data reports, quality assurance documentation, final validated datasets, and an Interpretive Report after monitoring concludes. Deliverables will be produced in accordance with the DRMP reporting cycle and applicable regulatory requirements. See **Table 7** for a summary of data deliverables and submission schedule.

Per the CVRWQCB Order R5-2013-0120, the DRMP must submit, annually and for Regional Board approval, a monitoring workplan. The monitoring workplan shall provide a study design to address monitoring and assessment questions; and the study design shall include the following information:

1. Specific hypothesis to be tested
2. Sample locations
3. Sample collection/frequency
4. Sample analytes
5. Analysis methods
6. Preliminary data deliverables
7. Planned reports to summarize results
8. Timeline and schedule for all of the study design elements to be completed.

The Mercury Study Plan (2027-2031) will be submitted for Regional Board approval with the DRMP FY 26-27 Annual Monitoring Workplan.

Table 7. Deliverable due dates associated with the Mercury Study Plan (2027-2031).

RESOLUTION DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
Mercury Study Plan (2027-2031) QAPP	October 16, 2026	All project years.	Initial submittal and approval required prior to the start of the project.	Documents study objectives, project organization, data quality objectives, field and laboratory methods, sample handling, analytical procedures, QA/QC requirements, data management, and reporting protocols.
QAPP Amendment	May 1	Any change or update needed to QAPP details prior to upcoming project year.	Annually	Document any changes or updates needed to the QAPP to reflect current practices, laboratory QC, changes in project personnel leading into the next project year.
QAPP Deviation Reports	Within 7 days of Project Personnel becoming aware of the deviation.	Occurrence of deviation from QAPP	As needed.	Report of any deviations from the QAPP that can prevent project and data quality objectives from being met that were not previously approved by the CVRWQCB in the QAPP.
DRMP Annual Monitoring Workplan	May 1	Next fiscal year (July 1 through June 30)	Annually	Identifies projects the DRMP will implement over the next FY (July 1 through June 30),

RESOLUTION DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
				including budget and study design, among other elements.
DRMP Annual Report	February 1	Previous fiscal year (July 1 – June 30)	Annually	Report FY progress on monitoring effort.
Quarterly Report	November 1	July 1 – September 30	Quarterly	Summarizes all decisions made by the DRMP organization, all challenges the program encounters that could cause deviations to the Monitoring Workplan, Data Management Plan, and QAPP, and any changes to foundation DRMP policy and procedure documents.
Quarterly Report	February 1	October 1 – December 31	Quarterly	
Quarterly Report	May 1	January 1 – March 31	Quarterly	
Quarterly Report	August 1	April 1 – June 30	Quarterly	
Preliminary Data	60 calendar days from date of sample analysis	Sample analysis	Per sample event	Preliminary data collected during the 27-31 mercury study delivered within 60 calendar days of sample analysis date.
Finalized Data Submittal to CVRWQC	6 months from date of sample analysis	Sample analysis	Per sample event	Spreadsheet containing results of the 27-31 mercury study monitoring results and analyses of various test parameters.
Publish Finalized Data	6 months from the last sampling date	Sample collection	Annually	Finalized data published to CEDEN or NWIS, or

RESOLUTION DELIVERABLE	DELIVERABLE DUE DATE	ACTIVITY PERIOD OR TRIGGER	FREQUENCY	DESCRIPTION
				another approved publicly accessible database or platform.
Mercury Interpretive Report	2 years from completion of project (October 2033)	All project years.	Once	Draft and final report on the results of the 27-31 mercury study including analysis and interpretation of monitoring data; includes technical appendices.

NWIS = National Weather Information Service

5.5 DATA ACCESSIBILITY

Final validated mercury monitoring data will be made publicly available through CEDEN. Data will also be shared with the Mercury TAC, DRMP SC, and regulatory agencies to support transparency and informed decision-making.

6 DATA REVIEW, INTERPRETATION, AND USE

This section describes how data will be reviewed and validated to ensure it meets the requirements for its intended use. It also outlines how results will be interpreted and applied to answer the Mercury Study Plan (2027-2031) questions or inform management decisions.

Specific analytical workflows, statistical methods, and data evaluation procedures will be further defined in supporting technical documents and, where applicable, in the project-specific QAPP developed following approval of this study plan.

6.1 DATA REVIEW, VERIFICATION, AND VALIDATION

Data generated by this project will be reviewed against the MQOs defined in the QAPP. The Program QA Officer will complete a secondary review to ensure that all data are properly qualified according to the project requirements. The DRMP has developed a Data Management Plan which will be updated at a minimum every three years. The

procedures outlined in the QAPP will be consistent with the most recent version of the approved Data Management Plan.

6.1.1 Data Reviews

Quality assurance reviews of data generated under the project will be made by the appropriate project personnel according to the QAPP. Contract laboratories are responsible for self-assessment and oversight of finalized data submitted in laboratory reports and electronic deliverables, by the data managers, and/or the laboratory QA Officer. Once data are received, they will be reviewed and flagged according to the procedures outlined in the QAPP. Project personnel, as identified in the QAPP, are responsible for ensuring the proper flagging of all data that do not meet established QA/QC criteria.

The quality of data are routinely reviewed as a whole and assessed to determine if procedural (field and analytical) changes are necessary for improved data quality. The Program QA Officer (or designee) may request to visit the laboratory to discuss the review and data quality. Laboratory visits may occur as frequently as once a year or less depending on the need. In addition to laboratory visits by the DRMP staff, laboratories maintaining ELAP accreditations are subject to periodic assessments required for the maintenance of that status. Other assessments that occur periodically will be oral or electronic via email correspondence; if no discrepancies are noted and corrective action is not required, additional records are neither maintained nor reported. If discrepancies are observed, the details of the discrepancy and any corrective action will be reported in the quarterly and final monitoring report.

6.1.2 Response Actions

If a discrepancy is discovered during an assessment, the Program Manager and Program QA Officer will discuss the discrepancy with the personnel responsible for the activity. The discussion will include the accuracy of the information, potential cause(s) leading to the deviation, how the deviation might impact data quality and the corrective actions that might be considered. Deviations from the QAPP that can prevent project and data quality objectives from being met shall be described in the QAPP and must be approved by the CVRWQCB QA Representative prior to implementation. When prior approval is not possible, deviations must be reported to the CVRWQCB QA Representative within seven calendar days, per R5-2021-0054. The Program Manager is responsible for documenting and communicating all deviations from this QAPP to the TAC and appropriate stakeholder groups. For immediate deviation notification, communication will include the following information: the applicable Workplan and/or QAPP, constituents and/or locations

affected, sampling dates, whether the deviation is affecting one or multiple events, description of the concern, the proposed solution and rationale, and a place for a final decision to be communicated.

Once QAPP deviations are identified and a resolution determined, the process is documented on a DRMP QAPP Deviation Form provided in the QAPP. Deviation forms shall be completed and included in the Quarterly Reports submitted to the CVRWQCB. At a minimum, deviation forms must document:

- A description of the deviation that occurred
- Reason for the deviation
- Impact on the present and completed work
- Corrective actions taken as a result, by when and by whom

Once completed, deviation forms are reviewed and approved by the CVRWQCB QA Representative. The Program Manager will follow up with the party responsible tasked with implementing the corrective actions and track when they are performed. Deviations and corrective actions are reported for the previous fiscal year in the DRMP Annual Report that is submitted annually to the CVRWQCB on February 1.

The Program Manager and the Program QA Officer have the power to halt all sampling and analytical work by both the field crews and contracted laboratory if the deviation(s) noted are considered detrimental to data quality.

6.1.3 Data Verification

The Data Management Team identified in the QAPP will perform all data verification according to approved methods. These minimum requirements for data verification procedures are summarized below; however, the detailed procedures defined in the Data Management SOP must conform to the data management principles of the Water Boards and the DRMP Data Management Plan. Conformity to these principles ensures that the data generated by this project are comparable and properly verified according to both the DRMP and Water Board's needs. The SOP will be attached to the QAPP and must be reviewed by the SWRCB to ensure agreement with data processing procedures and SWRCB requirements.

All field collection records are entered either directly into the database or into a CEDEN comparable EDD format. Field data is verified against the original collection records before finalized and, if necessary, exported to provide field collection details to laboratories.

The contract laboratories are responsible for the reduction of the raw data generated by the methods used to a data deliverable format determined by agreement between the laboratory and the Program Manager. Each contract laboratory's QA Officer will perform checks of all of its records at a frequency that the laboratory determines sufficient. The analytical process includes verification or a quality assurance review of the data, which includes:

- Verifying the calibration samples for compliance with the laboratory and project criteria;
- Verifying that the batch QC samples were analyzed at a proper frequency and the results were within specifications;
- Comparing the raw data (e.g., chromatogram) with reported concentration for accuracy and consistency;
- Verifying that the holding times were met and that the reporting units and quantitation limits are correct;
- Determining whether a corrective action was performed, and control was re-established and documented prior to reanalysis of QC or project samples;
- Verifying that all project and QC sample results were properly reported and flagged; and
- Preparing batch narratives that adequately identify and discuss any problems encountered.

Data verification for the DRMP will take place on two levels: initial verification (Stage 1) and secondary verification (Stage 2) as outlined in the QAPP.

6.1.4 Data Validation

Data validation steps provide a broader assessment of data compliance with project requirements, useability, and suitability for their intended use. Such assessments may be conducted in long-term interpretive reports, trend analyses, or ad hoc quality assessments as requested by the Steering Committee or Board of Directors (BOD). Any data validation requirements needed for the data generated for the project must be defined in the QAPP.

6.2 INTERPRETATION AND ANALYSIS APPROACH

Mercury concentrations in Black Bass will be evaluated for spatial patterns and interannual trends. Results will be compared to the Methylmercury TMDL

implementation goal of 0.24 mg methylmercury/kg in a standardized 350-mm Black Bass. Unfiltered, aqueous methylmercury concentrations will be compared to the TMDL implementation goal of 0.06 ng/L.

Mercury monitoring will be conducted to address the sub questions listed in **Table 1**. Results generated by the Mercury Study Plan (2027-2031) will be synthesized and evaluated in a Mercury Interpretive Report to be developed by or through the DRMP. The Interpretive Report will compile and summarize monitoring data; evaluate spatial and temporal patterns in mercury concentrations in fish and water; assess findings relative to TMDL implementation goals and objectives; assess findings relative to DRMP management and assessment questions.

6.3 APPLICATION OF STUDY FINDINGS

Validated study results will be used to assess status and trends in mercury bioaccumulation across the Delta and evaluate progress toward TMDL implementation goals. Findings may inform program-level management considerations under the DMCP and guide future monitoring design and prioritization.

7 SCHEDULE AND RESPONSIBILITIES

This section outlines the roles of participating organizations and the schedule for key activities. It provides a clear structure for project implementation and ensures accountability across the study timeline.

7.1 ROLES AND RESPONSIBILITIES

The purpose of the DRMP is to educate and inform decisions on how to protect, and where necessary, restore beneficial uses of water in the Sacramento-San Joaquin River Delta area of California, by producing objective and cost-effective scientific information critical to understanding regional water quality conditions and trends. The Implementing Entity for the DRMP is a nonprofit public benefit corporation under which the BOD oversee operations of the program.

The DRMP pursues the following objectives:

- a) Improve the efficiency of water quality data collection and management in the Delta.

- b) Generate information that informs and educates the public, agencies, and decision makers.
- c) Raise awareness of Delta water quality conditions and how they impact beneficial uses.
- d) Foster independent science, objective peer review, and a transparent review process.

The DRMP is implemented with stakeholder participation of various coordinated monitoring, resource, regulatory and regulated entities. These groups give technical and policy recommendations to the BOD through participation in the Steering Committee and various project-specific TACs. The Program structure is illustrated below in **Figure 3**.

The implementation of the Program is done in close coordination with the CVRWQCB. The expectations of these requirements are outlined in Resolution R5-2021-0054, Approval of Delta Regional Monitoring Program Governance Structure and Implementing Entity, which provides the general approval of the DRMP Implementing Entity and governance structure. All monitoring and data generation occurring under the QAPP must be in accordance with the submission requirements and due dates defined in Attachment A of the Resolution.

7.1.1 Board of Directors

The BOD consists of directors dedicated to the purposes of the DRMP and appointed by their sector's appointing agency(ies). The BOD makes all binding decisions for the DRMP. The BOD will appoint both standing committees of the Board and advisory committees to the BOD. The BOD also appoints four Board Officers from among the existing members including a President, Vice President, Secretary, and Treasurer.

On a two-year rotation, agencies will put forth a nominee for their respective seat(s) to represent them on the BOD. Currently, the Bylaws provide for 11 director seats as follows:

- Agricultural interest (2 seats).
- Publicly Owned Treatment Works (POTW– 3 seats).
- Storm Water Agencies (MS4s – 3 seats).
- Water Supply Agencies (1 seat).
- Habitat Restoration/Flood Management (1 seat).
- 'At large' seat appointed by the BOD (1 seat).

The responsibilities of the Board include (also See Article V, Section 1 of the Bylaws):

- Adopt policies, rules and procedures for the management and operation of the DRMP.
- Develop the financial operations of the nonprofit.
 - Create and approve budgets and expenditures.
 - Receive and accept contributions, grants, etc.
- Hire leadership staff, as necessary, to run the nonprofit and implement the DRMP program.
- Enter into contracts with entities and individuals as necessary to operate and implement the DRMP.
- Appoint and/or form Committees of the Board or Advisory Committees (technical and administrative) (See Section VI).
 - Under nonprofit law, committees of the Board must be comprised of only Board members. Advisory Committees can be made up of both Board members and non-Board members.
 - The Bylaws currently identify two Standing committees, the Executive Committee and the Steering Committee. All other committees (i.e., those that are not Standing Committees, either of the Board or Advisory) are formed by resolution of the Board.
- Establish and oversee the implementation of policies and priorities of the DRMP.

7.1.2 Executive Committee

The Executive Committee is a standing Committee of the Board and has the authority between Board meetings to make decisions and take action relative to the operation of the nonprofit organization on behalf of the Board following developed policies and procedures of the Board. The Executive Committee consists of the four Board officers. The Executive Committee is responsible for authorizing the daily management of the Corporation including setting agendas for Board meetings, making/approving authorized limit expenditures, and similar. The Executive Committee may develop policies for Board approval and may review and recommend to the Board changes to the bylaws and to other operating policies.

The Executive Committee consists of the following Board officers which are selected from existing members of the Board: President, Vice President, Secretary, and Treasurer.

7.1.3 Steering Committee

The Steering Committee is a standing Advisory Committee to the BOD as described in the Bylaws and consists of representatives of the same categories as those defined for the members of the BOD, and with the same number of seats per category, plus representatives of regulatory agencies. These representative categories are listed below, specifically:

- Agricultural interest - 2 seats.
- POTWs – 3 seats.
- Storm Water Agencies (MS4s) – 3 seats.
- Water Supply Agencies – 1 seat.
- Habitat Restoration/Flood Management – 1 seat.
- Dredgers – 1 seat.
- Coordinated monitoring (Interagency Ecological Program/California Department of Fish and Wildlife) - 1 seat.
- Resource Agencies (NOAA Fisheries) - 1 seat.
- Regulatory Agencies (US EPA, SWRCB, and CVRWQCB-Management level staff) - 3 seats.
- Tribal representative – 1 seat.

The Steering Committee is charged with the authority and responsibility to:

- Serve as an advisory body to the BOD;
- Advise on strategic direction and the policies and procedures to implement the DRMP in a manner consistent with regulatory conditions and priorities;
- Recommend direction for technical committees on priorities, constraints, and management questions to develop technical recommendations and products within the resource allocations determined by the BOD;
- Recommend DRMP work products and any other plans or products.

All decisions by the Steering Committee will be in the form of advice/recommendations to the Board. The Steering Committee will have no binding authority on DRMP implementation. The Board will consider all recommendations by the Steering Committee in a timely manner.

All decisions by the Steering Committee are subject to subsequent timely consideration by the Board including but not limited to pursuit of opinions by others (e.g., the Executive Director, the Program Manager and other technical specialists (as warranted).

Some decisions by the Steering Committee that are time-sensitive or less significant can be made via e-mail or telephone conference, but only if these items have previously been discussed in a Steering Committee meeting.

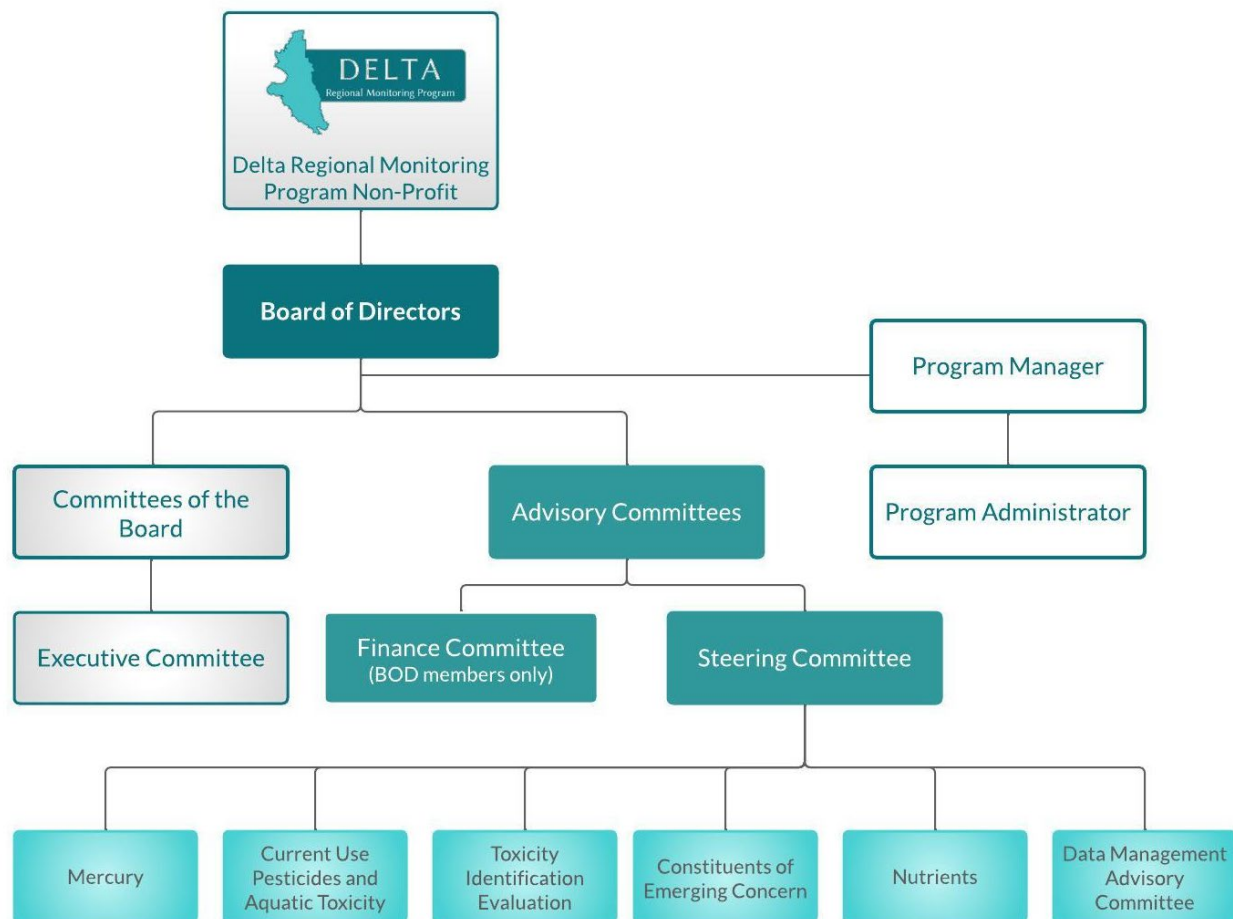
7.1.4 Technical Advisory Committee

For this project, the Mercury TAC has been established to provide recommendations to the Steering Committee and the BOD regarding technical recommendations for the implementation of this project. The Mercury TAC has been provided specific responsibilities associated with expected deliverables by the Board (e.g., the “Charge”) as also informed by Steering Committee recommendations. The TAC members serving as technical advisors for this project are identified in **Table 8**.

Table 8. Mercury Technical Advisory Committee members.

TAC MEMBER NAME	AFFILIATED ORGANIZATION
Tim Mussen	Sacramento Area Sewer District
Kelly Trunnelle	MLJ Environmental
Karen Ashby	Larry Walker Associates
Lauren Leles	CVRWQCB
Wes Heim	Moss Landing Marine Laboratories

Figure 3. DRMP Non-Profit Structure (as of August 2024).



7.1.5 Program Management

DRMP Program Manager

The BOD has hired Melissa Turner of MLJ Environmental as the Program Manager. The Program Manager oversees all technical programs and associated leadership and staff for each technical area of the DRMP. The Program Manager will be responsible for planning and overseeing DRMP projects to ensure that they are completed within a timely manner and within budget. It is the Program Manager's responsibility to plan projects, prepare budgets, monitor progress, and keep stakeholders informed.

The Program Manager is responsible for the implementation of the project in accordance with Resolution R5-2021-0054, the approved fiscal year Workplan, the DRMP Data Management Plan, and the QAPP. The Program Manager ensures the communication of

direction, decisions, and challenges to implementation between technical staff and committees, the CVRWQCB, the Steering Committee, and the BOD.

Program Quality Assurance Oversight

The DRMP Program QA Officer is Will Hagan of the Marine Pollution Studies Laboratory (MPSL) at Moss Landing Marine Laboratories (MLML). The Program QA Officer provides ultimate quality assurance oversight for field and laboratory procedures, and final data review and assessment of completeness, accuracy, and precision of data generated by this project. The DRMP QA Officer is independent of any direct data generation, such as sample collection, field parameter recording, or laboratory analysis.

In addition to procedural QA/QC, the Program QA Officer, in coordination with the Program Manager, is responsible for reviewing laboratory protocols to confirm laboratory compliance with the overall requirements of the DRMP and is ultimately responsible for reviewing project data both for accuracy and comparability with the SWRCB SWAMP. The Program QA Officer may stop all actions, including those conducted by the laboratories, if there are significant deviations from required QAPP practices or if there is evidence of a systematic failure.

Quality assurance oversight for the implementation of DRMP projects and studies is conducted in coordination with the CVRWQCB QA Representative. The SWRCB QA Officer will also be consulted to ensure consistency with SWRCB data management policies; the SWRCB QA Officer is a signatory of the QAPP, and their approval is required prior to the implementation of this project.

Program Data Management

The Central Valley Regional Data Center (CV RDC) Manager coordinates the Data Management Team (DMT), which performs data review and verification to ensure that data submitted by subcontractor laboratories are timely, complete, and properly incorporated into the Regional Data Center database. The DMT is responsible for data processing, QA/QC review, and data upload to the CEDEN. Once the data have been reviewed and processed, they will undergo a final review and qualification by the Program QA Officer and/or a delegate of the QA Officer. In the event there are changes to the data after it has been published, they will be communicated to data users in a timely manner.

7.1.6 Project Personnel

Detailed implementation schedules, task-level assignments, and contingency procedures will be documented in supporting work plans and the project-specific QAPP developed

following approval of the Mercury Study Plan (2027-2031). The QAPP will identify the staff assigned to the Project Personnel roles summarized below.

Project Manager

The Project Manager is responsible for the coordination of sampling, laboratory analysis, and data reporting as prescribed in the study design. Prior to monitoring (if applicable), the Project Manager is responsible for ensuring that all parties involved in collecting and analyzing samples are aware of both field and laboratory roles and responsibilities. The Project Manager is responsible for ensuring communication between all parties and the DRMP regarding the status of the project and any deviations from the Monitoring Workplan, QAPP, or appropriate project planning document.

Field Lead

The Field Lead is responsible for managing the generation of field sheets and related documentation, as well as coordinating sampling with field staff. The Field Lead oversees the training of all field personnel to ensure monitoring is conducted according to the procedures outlined in this QAPP. They work closely with the Project Manager to implement monitoring activities, including managing sampling logistics, coordinating with laboratories, and ensuring the timely delivery of samples. The Field Lead will ensure that all sampling personnel are adequately trained and that monitoring activities comply with QAPP protocols.

Technical Services

The contract laboratories will provide analytical services for this project in accordance with all methods and QA requirements defined in the QAPP. Laboratories will provide data in both PDF and in approved Electronic Data Deliverable (EDD) format. Laboratory QA Officers are responsible for any updates and maintenance of their respective laboratory's SOPs. When laboratory SOPs are revised, updates will be documented with a QAPP amendment to ensure the most current procedures are reflected in the project documentation and submitted to the CVRWQCB for approval. Before each monitoring period, laboratory current details will be reviewed to coordinate any updates to project analytical requirements with the associated contracted laboratory project managers and QA Officers. Laboratory staff are provided with counts of scheduled samples to be analyzed approximately every six months to ensure that there is adequate time to prepare for all prescribed analyses.

7.2 STUDY TIMELINE AND MILESTONES

This study is designed as a five-year monitoring effort with annual spring and fall sampling. Key milestones include annual sample collection, laboratory analysis within method holding times, preliminary data review within approximately 60 days of analysis, annual reporting aligned with the DRMP reporting cycle, and an Interpretive Report.

7.3 CONTINGENCY PLANNING

Mitigation measures include use of alternate sites, adjusted sampling methods, and coordination with TACs and the Steering Committee.

Potential risks to study implementation include weather-related access limitations, permitting constraints affecting fish collection, and laboratory scheduling delays. Mitigation measures include the use of alternate sampling locations where appropriate, adjustment of sampling methods consistent with permits, and coordination with the Mercury TAC and Steering Committee to address unforeseen challenges.

A contingency for fishing is included such that fishing may occur up to 1 mile from either side of the sampling point when no major water inputs to the transect exist. Additionally, for hook-and-line fishing, fish collected for mercury analysis will meet a minimum total length of 200 mm, consistent with size criteria used for electrofishing collections. No maximum fish length criterion will be applied. Target numbers of fish within specified size classes will be sought where practicable; however, the ability to collect sufficient numbers of fish within each desired size class may be limited by site conditions, sampling method (e.g., hook-and-line versus electrofishing), and fish availability. As a result, the size distribution of collected fish may vary among sampling events. If target size-class quotas cannot be met, available fish meeting the minimum length requirement will be collected and analyzed to ensure sufficient data are generated to support mercury evaluation objectives.

Variability in fish size-class representation may affect statistical comparisons; however, this approach provides a practical contingency that allows data evaluation to proceed without imposing unattainable fish collection requirements.