Response to Review Panel Comments from the Technical Advisory Committee

The Panel made many excellent points about the Delta RMP monitoring design. Responses to Review Panel comments and questions about the monitoring design and the Program in general are provided below. Some comments can be addressed by providing additional background information that was not previously communicated or available to the panel. Other comments are appreciated as valuable feedback and will be considered by the program as the long-term monitoring design is further developed.

In the following sections, quoted comments from the review are shown in italics followed by our response. The page number from the report from which the quote was taken is listed after the quote. Similar comments are grouped together with one response.

Background

One of the important goals of the Delta RMP is to engage in "joint fact-finding" between regulators and dischargers. In the first few years of the Program, the initial focus has been on assessing the status and trends for each water quality constituent of concern. Over the next few years, the focus is expected to shift toward answering other types of important management questions, such as 1) sources, pathways, loadings, and processes, 2) forecasting scenarios, and 3) tracking the effectiveness of management options.

Responses to Fundamental Questions and Comments on the Monitoring Design

The reviewers' major critiques of the Monitoring Design Summary (MDS) were (1) the lack of quantitative design and analysis details and (2) poor linkage between monitoring and management decisions. There are multiple references to these criticisms so the main points have been paraphrased here for simplicity.

> Lack of Quantitative Design and Analysis Details. *The reviewers commented that the MDS lacked details on:*
>
> - *Statistical models to be used for analysis;*
> - *Analytical protocols to be used to estimate contaminant concentrations over larger areas or periods, or of processes that management action might affect; and*
> - *The measure of "reliability", not only for estimates at a given place and time but for expanded inference in time and space.*
>
> Poor Linkage to Management Decisions. *The reviewers recommended that the monitoring designs should:*

- *Explain how each important estimate can lead to management actions, either on its own or as part of a more general assessment of the Delta or a subregion of it;*
- *Describe the protocols that might be used to decide the action; and*
- *Explain why the specified reliability is adequate for these protocols.*

These comments raise fundamental questions about the Delta RMP monitoring designs. As a result of these comments and the External Review in general, the Steering Committee directed the TAC and Pesticide Subcommittee to redesign the pesticide monitoring program immediately. In October, the committees identified three key management decisions which could be informed by Delta RMP monitoring (the Pyrethroid TMDL, Nutrient Research Plan, and Methylmercury TMDL). Planning is underway to tighten linkages to these decisions and better define design and analysis details for all aspects of the Program. The reviewers' comments also provided helpful guidance on the type of information that should be included in an updated Monitoring Design document, such as statistical analyses to demonstrate that the monitoring objectives will be achieved by implementing the sampling design.

As a first step, each of the Delta RMP's four subcommittees (Nutrients, Pesticides, Mercury, and Pathogens) have met to carefully consider what are the important management and assessment questions related to our monitoring programs. We have created a table showing where there is an intersection between the Program's assessment questions and the priority management drivers listed in the preceding paragraph (see Attachment). Questions highlighted in yellow have strong overlap with the priority management drivers. Questions (or parts of questions) that are underlined are currently being addressed by the program. One can draw two main conclusions from scanning the table. First, the current monitoring program addresses a number of management questions to some extent. Second, the table shows important areas that are not currently covered by the Program. We will resolve the gaps shown on this table as we redesign the monitoring programs in the coming year.

While the Delta RMP will strive to produce data that inform management decisions, the actual regulatory and management decisions happen by necessity outside of the Delta RMP. Regulatory decisions are made by the Water Board and other agencies. This separation prevents the Delta RMP from specifying exactly what decision will be made based on its data. However, through the stakeholder process of the Delta RMP, which includes the Water Board and other agencies, the Program will define the regulatory decision and identify how data collected by the Program will fill a data or information gap. More details on the linkages to management decisions for the current designs are provided in the other appendices to this letter with responses from the technical committees.

The main process we will use to forge better linkages between monitoring and management questions and to outline data analysis methods is the Data Quality Objectives

(DQO) Process (USEPA 2006). The DQO as defined by the USEPA is a planning tool for data collection activities, which provides a basis for balancing decision uncertainty with available resources. The DQO process will be used by the Delta RMP to establish performance and acceptance criteria for data. These criteria will serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Implementing a DQO planning process will address most of the key criticisms by the panel and provide the program with a sound scientific basis for planning and design, data evaluation, and the required QAQC criteria. The DQO Process will be established as part of the Delta RMP's standard procedures and as a key component of the program design, re-design, and evaluation. The TAC and others involved in study design and evaluation will be instructed and expected to utilize it.

Each focus area of the Delta RMP is at a different stage in applying the DQO planning process. Redesigning the pesticides monitoring design is a high priority, and we have already begun a systematic planning process following the DQO guidance. For nutrients, over the next 1-2 years we will undergo a systematic planning process before any data collection starts. The Delta RMP does not currently have its own nutrient monitoring program. For mercury, the additional information compiled for this response will be incorporated into the Monitoring Design document when it is updated on the regular 5-year schedule. For pathogens, no additional planning is needed because monitoring will cease after this year. The 2-year Delta RMP Pathogen Study was specifically designed to fulfill the requirements set forth by state regulators in the Central Valley Basin Plan Amendment.

Responses to Specific Questions and Comments on the Monitoring Design

The Panel cannot be certain that the Monitoring Design is inadequate. It is possible that appropriate summaries could be defined, and that models and methods could be developed by which they could be estimated reliably from this sampling design. Some of this work may have been done in the discussions that led to the design. However, none of this supporting information appears in the MDS. (p. 1)

Supporting information on the rationale for the initial monitoring designs have been provided in the other appendices from the different technical committees. Nonetheless, the Program is undergoing a review and redesign of the Monitoring Design to demonstrate its adequacy.

The MDS (p. 16) says "Interpretation and reporting methods will be described in a Communications Plan" but they are not. (p. 1)

One of the reviewers' main critiques was that the MDS did not have details on statistical models and analytical protocols to be used for analysis. The Program has always intended to compare sample results with state and federal water quality standards and aquatic life benchmarks. Factors such as the frequency, duration, and magnitude of concentrations above thresholds will be considered. We agree that the lack of details is a deficiency. The Program is committed to adding more of these details to an updated document through systematic planning (see response regarding the DQO process on pages 2–3).

We recommend that the monitoring team include one or more environmental statisticians, employed full-time, to refine the sampling design and develop the methods for data analysis. (p. 2)

We understand the importance of inserting and sustaining statistical services in our iterative process of design and evaluation of our various monitoring program elements, and we are committed to this going forward (see the previous paragraph on the DQO process). While we cannot just "hire a statistician," we will emulate the services of a Chief Statistician through the deployment of our available resources. During the redesign of the monitoring program we plan to use statistical expertise and services from ASC, USEPA, USGS, and other participating organizations. The level of effort required by each component of our surrogate statistical services process will be driven by the scope and types of monitoring activities that are being planned.

How well do the "lower", "midrange" and "higher" sampling levels achieve the monitoring goals? How were the prioritization decisions (shown by stars in Table 4) made? ... In some cases, the sampling may not be worth doing, because it is not tied to management goals or is too sparse to be useful. (p. 2)

In an earlier response, we acknowledge the reviewers' overall comment that the Monitoring Design should be updated with statistical analyses to demonstrate that the monitoring objectives will be achieved by implementing the sampling design. Table 4 on page 15 of the Monitoring Design is a summary of the range of costs for the monitoring designs for each focus area. The caption for Table 4 states that the recommended funding level for the first year of sampling for each focus area is marked with an asterisk. These asterisks were included when the committees were deciding about the first year of monitoring and had to prioritize which designs to implement taking into account management priorities, likelihood of success, and cost. In subsequent versions of the Monitoring Design document, the asterisks were not needed and were deleted, which has created a mismatch between the caption and the table. More details about the rationale for the initial monitoring designs are provided in the responses from each of the technical subcommittees.

What logic was invoked to justify the selection of the indicators to be measured? (p. 3)

The Delta RMP is a stakeholder effort with representatives from publicly owned treatment works, municipal storm water permittees, irrigated agriculture, coordinated monitoring groups, water supply, federal regulators, resource agencies, and staff from the Central

Valley Water Board and State Water Board. Indicators were chosen to respond to the major water quality issues faced in the Delta, namely pathogens, mercury, pesticides/toxicity, and nutrients. These focus areas are important aspects of water quality for maintaining the beneficial uses in the Delta water such as municipal water supply, irrigation, fish and wildlife, and recreation. Analyzing the status and trends of the above constituents was seen as important to understanding current conditions within the Delta and developing rational and defensible bases for regulatory and management decisions.

Justifications for the initial monitoring designs have been provided in the appendices from the technical subcommittees (Mercury, Nutrients, Pesticides, and Pathogens).

Initial management questions in the documents were usually in words, not numbers: "is there a problem?", "what is the status?", or "is toxicity too high?" These need to be restated in measurable terms, usually as means or trends over time or space (including subregions or tributaries, etc.) or both. Even when a numerical quantity is given, as for some water quality objectives, it may refer to a single observation or to an average over a sample size, area or time period which has not been specified. (p. 4)

The high-level management questions for the Delta RMP are “text-based” following the convention of other large monitoring programs, such as the Regional Monitoring Program for Water Quality in San Francisco Bay (see page 7 of the 2016 Multi-Year Plan[1]). The detailed “assessment questions” and sub-questions are more amenable to numeric goals. During the DQO planning process (see response on pages 2–3), the committees will determine how to add numeric targets to any of the assessment questions. The Program has always intended to compare sample results with state and federal water quality standards and aquatic life benchmarks (see response on page 3). Establishing analytical protocols for interpreting the data will also help to remove ambiguity about the assessment questions.

Why sample monthly if bi-monthly or annual samples would be nearly as good, and allow more sites? (p. 5)

This is a question specific to the pesticides and pathogens monitoring designs. For pesticides, the subcommittee originally decided on monitoring fewer sites more frequently to develop a baseline for trend analysis, in parts for the need to better understand temporal variability relative to flow. For pathogens, the monthly frequency was chosen to match the monitoring frequency of the LT2 Program (LT2 = EPA's Long Term 2 Enhanced Surface

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[1] http://www.sfei.org/documents/2016-rmp-multi-year-plan

Water Treatment Rule). Please see the responses from the technical committees for more information.

<u>*Earlier Programs*</u>

In what specific ways were former/current monitoring programs "not adequate"? (QAPP, p. 12). Was there a report that evaluated the programs and identified specific deficiencies and made recommendations for improvement? If so, it would be helpful to address how this plan makes up for prior monitoring program deficiencies. (p. 9)

The specific statement referenced is "that data from current monitoring programs ... were not adequate to support a rigorous analysis of the role of contaminants in the POD". This was a conclusion from:

Johnson, M.L., Werner, I., Teh, S., Loge, F. 2010. Evaluation of chemical, toxicological, and histopathological data to determine their role in the Pelagic Organism Decline. University of California, Davis, California[2].

This report revealed the following major deficiencies:

- Gaps in the historical data record. Only a few chemicals had a time series of historical data sufficient to assess their role in the POD. And for the few chemicals with longer time series, there was insufficient sampling during the presumed sensitive January to June period (except for diazinon and chlorpyrifos).
- Data quality issues associated with older data, including detection limits above toxic levels and inadequately preserved samples.
- The difficulty involved in finding, accessing and integrating data from multiple sources.

Recommendations from this report included:

- Develop a long-term water quality monitoring program that includes regionally coordinated water chemistry, toxicity, and histopathology samples and incorporates new and emerging contaminants in a multiple lines-of-evidence assessment approach;
- Develop a conceptual model of the Delta that combines critical physical forcing functions and biological elements of the ecosystem and apply this model to inform decision-making and the adaptive management process;

[2] http://www.water.ca.gov/iep/docs/contaminant_synthesis_report.pdf

- Provide for ongoing data integration and interpretation aimed at both scientists and decision-makers;
- Improve data management and integration to provide for more consistent quality control and easier access; and
- Address key research needs such as identification of unknown toxicants, the toxicity of contaminants on invertebrate prey species, improved data mining of historical data, and the role of sediment toxicity, among others.

The Delta RMP was initiated to help address some of these deficiencies as a comprehensive water quality program that would help transform existing piecemeal monitoring into a more efficient, whole-scale system through coordination with other efforts and entities. Associated objectives are to:

- Help standardize data formats and protocols;
- Improved data management systems; and
- Improved access to the wealth of collected data.

The Delta RMP explicitly chose to start small and focus on a few high priorities for participants (mercury, nutrients, pathogens, pesticides). From the beginning, it was clear that the available resources would not be able to address all the important water quality concerns of the Delta, and that therefore the program would need to build partnerships and work with other programs to achieve the goals of a more efficient, better-coordinated, more useful monitoring system to address questions on a regional level.

Water Quality Objectives

What are the time frame definitions for "acute" and "chronic" in the WQO or WQC (QAPP, p. 17)? Many of the samples in the Specific Monitoring Designs are monthly grab samples, so it is not clear that the sampling timeframes are consistent with the evaluation criteria. If they are not, then how is Delta RMP to be used for its primary objective, to assess whether Beneficial Uses are being impaired? (p. 9)

Definitions, methods, and processes to derive the criteria maximum concentrations (CMC, acute criteria) and criteria continuous concentrations (CCC, chronic criteria) for the protection of aquatic life are defined in USEPA scientific water quality criteria guidance documents and summarized in the USEPA Water Quality Standards Handbook (Chapter 3). Aquatic life criteria indicate a time period over which exposure is to be averaged, as well as an upper limit on the average concentration, thereby limiting the duration of exposure to elevated concentrations. For acute criteria, EPA recommends an averaging period of 1 hour. That is, to protect against acute effects, the 1-hour average exposure should not be higher than the CMC. For chronic criteria, EPA recommends an averaging period of 4 days. That is, the 4-day average exposure should not be higher than the CCC.

The thresholds will provide a screening tool for Delta RMP results to determine if there is a potential problem. Additional study over the time scale of the acute and chronic water quality criteria exposure periods (one hour and four days, respectively) would be required to determine actual compliance with WQOs/WQCs. Follow-up studies may occur under the umbrella of the Delta RMP, but not necessarily. The regulatory agencies and other stakeholders may decide to follow up outside of the Program. Beneficial use determinations are made by the Water Board but the data collected by the Delta RMP will be used to inform those decisions.

Lab measurements (QAPP p. 48.)

Is the plan to compare concentrations in water to water quality objectives/criteria or other benchmarks? Are these reporting limits and method detection limits sufficiently below the benchmarks that there is confidence in the quantification of the concentration? ... It is not clear from the information provided in QAPP, whether the stated analytical methods are able to accurately detect concentrations at or near the WQO or WQC. (p. 9)

Yes: applicable WQOs/WQCs and other benchmarks are listed in Tables 3.3 – 3.5. (pp.17-24) of the QAPP. MDLs and RLs (Table 4.4.) are sufficiently below lowest reported benchmarks for most constituents for which benchmarks existed when the QAPP was written. The TAC will continue to review and update these benchmarks, new or revised QQOs/WQCs, and MDL/RLs as they change. *What are the detection limits/limits of quantification for the analyses (QAPP p. 93)? These limits can be lab specific. (p. 9)*

Method Detection Limits are listed in Table 4.4. Although the MDLs are adapted from the labs in this case, the general process is that any contracted lab would need to demonstrate that they are able to meet the QAQC requirements specified in the QAPP.

Adaptive Design

QAPP (p. 78) says "Collected data are used to evaluate future data needs and adjust the sampling and analysis plan as needed to optimize data collection in an adaptive manner. The program will be continually adjusted to optimize data collection." There seems to be nothing on how this is to be done. (p. 9)

The quote from the QAPP on adaptive design refers to the incremental improvement of the Monitoring Design over time as indicators, methods, data, and priorities change. At a basic level, the Program is committed to updating the Monitoring Design at least every 5 years to make these adjustments. By following the DQO planning process (see pages 2-3), the updates will consider and incorporate the changes listed above.

The main value of plots is to convey much information clearly and succinctly, but thought and explanatory text are often needed; MDS, p. 28, contains much information but is *uninterpretable (other than high scores for Diuron). Plots on p. 52 are better, but still need summarization of both the messages and their reliability. (p. 9)*

The original intent with the plot on p.28 was to show an example of how to visualize temporal and spatial variability across different pesticides in a single graph. We acknowledge that it requires more explanation to be useful to the reader. We will update the Monitoring Design to provide more explanation, and we will likely replace this figure with something else following the DQO planning process. More refined graphs with actual Delta RMP data and more detailed explanations will be developed for the 2-year summary report. The plots on page 52 are shown as an example for how to visualize seasonal variability and long-term trends in nutrient variables. It is from a completed technical report (Novick et al. 2015) that provides the interpretation and additional detail about statistical approaches used.

To clarify the components of variance concept, we assume a design in which each site is visited in each of a set of years. Given this assumption, the key components of variation are (see expanded discussion by Scott Urquhart in chapter 7 in Gitzen et al. 2012):

1) *Spatial: variation among sample units (sites); treated as a random effect in an ANOVA model*
2) *Temporal: how much the state variable varies from year-to-year across all sample units; treated as a random effect*
3) *Space by time interaction: how much the state variable changes across time within a sample unit independent of changes in other sample units*
4) *Error variance*

Partitioning the total variance is expressed as:

$$\sigma^2_{Total} = \sigma^2_{site} + \sigma^2_{time} + \sigma^2_{site \times time} + \sigma^2_{error}$$

To estimate trend, we must first assume a model for how the response variable (e.g., indicator value at sample unit i) changes over time. For example, if we assume a simple linear time-trend model for the indicator, y, our model is:

$$y_{ij} = \mu + S_i + T_j + \varepsilon_{ij}$$

where, y_{ij} *= the value of the state variable at site i in year j*

S_i *= effect of site* T_j *= effect of year j;* $\{j = 1, 2, \ldots, t\}$

ε_{ij} *= error term. Then our estimation model for a linear trend, assuming a common trend across sample sites, is:*

$$\hat{y}_{ij} = \beta_0 + \beta_1 j + \varepsilon_{ij}$$

where, β1 estimates trend

β0 +β1(t+1)/2 estimates 'status'

The null and alternative hypotheses of interest are, respectively: H0: E[β1] = 0; Ha: E[β1] ≠ 0. That is, to detect trend we test the null hypothesis that no trend is present in the indicator against the alternative hypothesis that a trend is present. (p. 13, Appendix 1)

We agree that statistical analyses to evaluate the effectiveness of monitoring design are important. We will develop specific plans for how to analyze water quality data as a part of the Data Quality Objective planning process (USEPA 2006). As noted above, we will begin using the DQO process to amend the monitoring design in stages, beginning with the pesticides, then moving on to nutrients, and lastly mercury. The Delta RMP has already used power analysis to evaluate some of its designs monitoring designs (e.g., nutrient trends). We have also learned from the outcomes of power analyses for other programs (SWAMP, SPoT, BOG). Going forward, the technical committees will be sure to document this important step. For example, a recent ASC report documented the ability of current DWR-EMP water quality monitoring to detect long-term trends in nutrients in different subregions. As reviewers suggest, the best source of information for power analyses is from preliminary survey data. It could be said that the Delta RMP is in the stage of collecting that type of preliminary data.

References

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Response to Review Panel Comments on the Mercury Design from the Mercury Subcommittee

The Panel made many excellent points about the Delta RMP monitoring design. The comments and questions that relate to the mercury monitoring design can be addressed through a more complete summary of the design, its rationale, and the process through which it was developed. A brief overview of the design process and rationale is presented here to address many of the overarching concerns, such as linkage to management actions. Responses to specific Review Panel questions on mercury are then also provided.

Brief Overview of the Mercury Monitoring Design Process and Rationale

A Mercury Subcommittee was formed to develop the mercury monitoring design. The Subcommittee consisted of a Water Board staff member (Janis Cooke) with a lead role in implementation of the Methylmercury TMDL for the Delta, representatives of several other Delta RMP stakeholder groups, and several leading local mercury experts familiar with the Delta.

The starting point for the design was careful consideration, refinement, and prioritization of the assessment questions articulated by the Steering Committee and Technical Advisory Committee for mercury, resulting in the priorities identified in Table 1 of the Monitoring Design Summary. The top priority questions for this initial phase of monitoring are as follows:

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

Maximizing Linkage to Management

The next step was to maximize relevance to management through identification and consideration of the regulatory and management actions that were either in effect or on the horizon (Table 1). The TMDL is the dominant regulatory driver of actions to control mercury in the Delta, establishing water quality goals and directing the various discharger groups to conduct monitoring and take actions to minimize mercury impairment of beneficial uses. Critical information needs related to various elements of the TMDL were identified, and the urgency (timing) of the needs was considered.

Development of a mercury model for the Delta is an important element of TMDL implementation. In response to TMDL requirements for a control study, the Department of Water Resources (DWR) is leading development of mathematical mercury models for the Delta and Yolo Bypass. The Dynamic Mercury Cycling Model, a well-established mercury model, is being used in the Yolo Bypass, while in the Delta, mercury and other mercury-related algorithms are being added to DWR's existing Delta Simulation Model. The USGS and partners are also working to integrate methylmercury into the CASCaDE model (http://cascade.wr.usgs.gov/) to allow testing of scenarios to better understand how changes to the Delta will affect mercury impairment. The goal of these modeling efforts is to predict the cumulative effect of multiple changes in the Delta and to predict the effectiveness of regulatory requirements within scenarios of climate change and large-scale wetland restoration.

Priority Data Needs

Mercury concentrations in sport fish were established in the TMDL as the crucial measure of impairment, and a tissue-based water quality objective of 0.24 ppm in top predator sport fish was established. Monitoring of sport fish mercury as an index of mercury impairment in the Delta and as a performance measure for the TMDL was identified by the Subcommittee as the top priority data need. Based on extensive past monitoring and many desirable attributes as an indicator species, largemouth bass was specifically identified as the key species for tracking impairment.

The Subcommittee identified aqueous methylmercury concentrations as a second priority of the mercury monitoring program. In contrast to many other aquatic ecosystems, aqueous methylmercury in the Delta has been shown to correlate well with mercury in the food web, including in largemouth bass. The Delta Methylmercury TMDL describes a statistically significant relationship between the annual average concentration of methylmercury in unfiltered water and average mercury in 350 mm largemouth bass when data are organized by subarea (Figure 1). The linkage of aqueous methylmercury concentration to fish mercury concentration provides a connection, essential for management, between methylmercury inputs from various in-Delta pathways (e.g., municipal wastewater, municipal stormwater, agricultural drainage, and wetlands) and impairment of beneficial uses. Because of this linkage, the TMDL established an implementation goal of 0.06 ng/L of unfiltered aqueous methylmercury. Monitoring of aqueous methylmercury is needed to:

1) better quantify the fish-water linkage that is the foundation of the TMDL,
2) support development of a mercury model for the Delta, and
3) support evaluation of the fish data by providing information on processes and trends.

The Subcommittee then reviewed existing data to evaluate the need for monitoring by the Delta RMP and to inform decisions on details of the monitoring designs for fish and water.

A lack of data on long-term trends in sport fish mercury was identified as the most critical information gap. With a major control program being implemented, it is imperative to know whether the key indicator of interest is trending up, down, or not all across the Delta.

Significant sport fish monitoring efforts conducted in the Delta over the past 20 years include a one-year survey in 1998 (Davis et al. 2000), the CALFED Mercury Study in 1999 and 2000 (Davis et al. 2003, 2008), the Fish Mercury Project from 2005-2007 (SFEI 2007, Melwani et al. 2009), and monitoring by California's Surface Water Ambient Monitoring Program (SWAMP) in 2011 (Davis et al. 2013). The studies from 1999 and beyond benefitted from robust peer review by national experts in mercury science. The TMDL (CVRWQCB 2010) provided a synthesis of Delta fish data from 1998 to 2007. A Surface Water Ambient Monitoring Program report (Davis et al. 2013) on contaminants in fish from California rivers and streams presented results from sampling in the Delta in 2011 and provided a comparison to past data for the Delta sites. Distinct and persistent spatial patterns have been observed throughout the period of record, most notably higher concentrations on the northern and southern ends of the Delta and lower concentrations in the Central Delta. However, due to the intermittent nature of the sampling that has been performed, variation in the locations sampled, variation in fish availability, and variation in the types of sample collected, time series for evaluating interannual trends in sport fish mercury are weak and inconclusive (Figure 2). While these past efforts have firmly established robust methods for monitoring mercury in Delta sport fish, the methods have not yet been consistently applied in a sustained manner to allow for evaluation of interannual trends.

The Subcommittee identified two priority data needs for ambient water monitoring: 1) contemporaneous sampling with sport fish to better quantify the relationship of water and fish concentrations and 2) collection of input data for the mercury fate models for the Delta. The key existing water datasets are from 2000-2001 and 2003-2006: the studies of Foe et al. (2003, 2008). These studies monitored methylmercury and mercury at multiple sites in the Delta, collecting sub-surface grab samples once every 4-6 weeks. These studies provided a basis for the linkage analysis in the TMDL. However, additional water monitoring is needed to expand and update this relatively limited dataset that is of great importance for implementing the TMDL and developing predictive mercury models. There may be opportunities in the short term to increase the frequency of monitoring through Supplemental Environmental Project funds.

Sampling Design Options

Fixed station and probabilistic monitoring designs were considered for both fish and water monitoring (Table 2). Budget constraints and linkage to other data collection efforts (such as hydrology and monitoring of other basic water quality parameters) led the Subcommittee to favor the fixed station design for the lower funding level scenario.

Sport fish monitoring was the primary driver of the sampling design. For sport fish monitoring, human exposure is the ultimate concern, so locations with angler access are of particular interest (as opposed to an equal interest in the entire aquatic surface area of the Delta). The probabilistic sampling design considered for this scenario was to identify all of the popular fishing locations in the Delta, and to randomly select from this population on an annual basis. The statewide Surface Water Ambient Monitoring Program recently adopted a design of this type for monitoring largemouth bass mercury in a population of 190 reservoirs (Bioaccumulation Oversight Group 2015). The Subcommittee referred to this as a "random draw" approach. This design could generate representative estimates of the mean for the Delta as a whole and for the subareas identified in the TMDL. Disadvantages of this approach would include 1) an inability to link to other data collection efforts that occur at fixed stations, and 2) lower power for detection of interannual trend. The higher funding level design recommended by the Subcommittee included a component of this random draw sampling, with 10 sites sampled per year.

For the lower funding level, however, the Subcommittee recommended focusing on fixed station monitoring. While this approach is less representative of the region, it allows for coordinated data collection at key sites of interest (including sites important for the fate model) and it maximizes power for detection of interannual trend at the selected stations. The Mercury Subcommittee had a strong interest in monitoring at or near sites where other parameters useful for evaluating the mercury data were being collected. Ancillary parameters of interest are flow, temperature, suspended sediment, salinity, nutrients, and organic carbon. A lack of information on within-station interannual variation in concentration was identified as an important data gap that can be addressed with fixed station monitoring. An important advantage of the fixed station approach is that it retains value even at low funding levels such as the six station level that was ultimately approved by the Steering Committee (in contrast, the information yield of the random draw design diminishes more rapidly if only a few stations are sampled each year). The goal of the recommended fish sampling design at the lower funding level is to evaluate interannual trends in mean concentration at each site (11 fish are collected per year at each site to generate an annual mean). A primary aim of the initial fish sampling under the Delta RMP is to establish time series that will provide the estimates of intra- and inter-annual variance that are needed to inform a power analysis to support an optimized long-term design. This power analysis could be done after an initial period of data collection (e.g., 5 years). However, given the importance of fish concentrations as a performance measure for evaluating the effectiveness of the TMDL, the recommended design calls for development of a 10-year dataset, and then re-evaluating the design.

Responses to Specific Questions and Comments on the Mercury Design

In this section, quoted comments from the review are shown in italics followed by a response. The page number from the report from which the quote was taken is listed after the quote. Similar comments are grouped together with one response.

What is the goal of the mercury program? (p. 5)

In a management context, the goal is to provide a critical performance measure for the TMDL by comparison of fish tissue concentrations to the water quality objective. The water data:
1) provide additional data for evaluation of status relative to the TMDL and water quality objectives;
2) support evaluation of the fish data in understanding processes and trends,
3) test the fish-water linkage advanced that is the foundation of the TMDL, and
4) support development of mercury fate models for the Delta.

However, using sportfish to monitor impacts on MeHg from large restoration projects does not make sense. Large sportfish have fairly large territories/home ranges, so it would be hard to attribute change to a specific restoration action or location. Also, the change would be hard to detect, since large sportfish have higher Hg body burdens that vary more between individual fish. As a result, a small change from a management or restoration action won't stand out. Small, resident fish with small home ranges would reflect such changes more quickly and clearly. Ideally a Before-After-Control-Intervention design could be used. (p. 5)

The sport fish species selected for monitoring (largemouth bass) has been shown through extensive monitoring (Davis et al. 2000, 2003, 2008, 2013; SFEI 2007; Melwani et al. 2009) to have relatively small home ranges and to be an excellent indicator of spatial patterns across large regions such as the Delta[1]. The approach being employed to evaluate change (ANCOVA to generate annual mean length-adjusted concentrations) will likely have ample power, and has the added benefit of being the key indicator of impairment. Prey fish monitoring was also considered, but given a lower priority and could not be accommodated with currently available funds.

[1] The scale of this monitoring design is regional. It is not intended to assess conditions at individual restoration sites.

The sportfish are sampled annually. Do we know if mercury varies seasonally in sportfish, as it does in smaller fish? If so, then annual samples are unlikely be adequate unless people catch and consume the fish in only one season, or there is a way to adjust for other seasons (without sampling at those times). If mercury in sportfish varies spatially within a subregion, then sampling one location per subregion is unlikely be adequate. This could be a case where the goal is useful but the effort is far short of what is needed, and thus achieves nothing. How will the data be analyzed to compare trends among sites? (p. 5)

Annual sampling of sport fish is widely performed. There is seasonal variation, but sampling in late summer when fish feeding rates are highest, hydrology is relatively consistent, and human fishing activity is greatest is a cost-effective approach to monitoring impairment. Seasonal sampling would greatly increase the cost. Extensive data and analysis support the existence of subregions and the use of index sites to represent them. Funding is not available to sample multiple sites within subregions. Trends in annual length-adjusted means at each site will be evaluated by regression or nonparametric methods.

The mercury water samples are monthly. What connects them to the fish tissue samples? Are they at the same sites (including Mokelumne River)? Are they to be compared to the water quality (WQ) criterion of 0.06 ng/L of MeHg in unfiltered water (QAPP, p. 24, Table 3.4)? What will a monthly grab sample at 4 sites in the Delta tell you about MeHg status in the entire Delta? How were the number and locations to be sampled determined? What are the flows at these locations? Will all samples be taken under the same tide/flow conditions? (p. 5)

The water samples are collected quarterly, not monthly. The water and fish sites are co-located to support items 2 and 3 in paragraph 1 of the specific responses above. Aqueous concentrations will be compared to the TMDL implementation goal (0.06 ng/L). The water sampling is admittedly limited, but provides useful information for the limited funding available. The number was driven by the budget. The locations were determined based on co-location with fish sampling and co-location with USGS continuous monitoring stations to support model development. Flow information is available. Collecting all samples at the same point in the tidal cycle would be valuable, but prohibitively expensive. Efforts are directed at sampling on ebbing tides at sampling locations most susceptible to tidal influences such as the Sacramento River at Freeport site.

Why is there a low level of fish sampling and a medium level of water sampling? What is the value of the water sampling? How does current fish sampling data relate to previously collected sampling data? If the primary management question is trends over time, are there existing long term data sets that can be built on. The study plan mentions but does not elaborate on these points (MDS, p. 38). (p. 5)

The levels of sampling are basically equivalent (six sites for fish, five sites for water). The fish sites were selected based on extensive prior sampling. However, past sampling has not done much in establishing time series to build on (Davis et al. 2013). The sport fish design will firmly establish time series at index sites for the Delta. The value of water sampling was covered in the first paragraph of the response to "*What is the goal of the mercury program?*" above. Quarterly sampling for water (rather than annual as for sport fish) is needed to illuminate seasonal patterns and to better characterize overall variability in concentrations.

How were the bin lengths for the Largemouth Bass determined (QAPP p. 86)? The Central Valley Basin Plan has water quality objectives (WQO) for fish 150-500 mm TL, and for fish <50mm TL, so the proposal's sampling divisions (200-249, 250-304, 305-407 and > 407 mm) are not consistent with this Plan. Fish Hg will often vary by length of fish (surrogate for age). How will the data be compared to WQO? Will bins be analyzed separately? The sampled fish can be assumed random within bins, but not between them; is the plan to fit a regression of fish Hg against length? Note the Basin Plan is specific as to trophic level of fish for the WQO: any alternative predator species should be at the same trophic level. (p.6)

The bin lengths were chosen to support estimation of length-adjusted means at a size of 350 mm. This approach has been used widely across the state and over the past 15 years in the Delta. Collecting over this range of sizes provides a sound basis for ANCOVA (basically, regression of Hg versus length at each site). The length-adjusted means or a subset of the overall size range can be compared to the WQO.

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Table 1.

Mercury Monitoring Regulatory and Management Drivers

Driver	**Monitoring Element**	**Urgency**	**Notes**
TMDL – fish tissue targets monitoring	THg in TL3 and TL4 fish	For Water Board: Long-term (BPA calls for comprehensive monitoring in 2025)	Not assigned to other Delta entities. No season- or flow-based conditions associated with the allocations.
TMDL – open water control study	Aqueous MeHg; other information (e.g., flux from sediment) to support development of a MeHg transport, transformation, and bioaccumulation model	Near-term (by 2018)	Would support major (> $1M) modeling effort by DWR. Model may also inform other control measures. TMDL Phase 1 review after 2018; open water allocation is based on sediment flux
TMDL – NPDES permittee discharge monitoring	Ambient aqueous MeHg as context for discharge monitoring	Near-term. All in-Delta POTWs and Phase I MS4s are currently monitoring their discharges; Phase II MS4 monitoring requirements need to be negotiated with RegBd by summer 2014	Upgraded POTWs and improved analytical methods are portraying lower loads than estimated in the TMDL POTWs have proposed a network of stations.
TMDL – Wetland restoration projects	Ambient aqueous MeHg as context for discharge monitoring. Project-specific fish monitoring. Associated ambient fish monitoring?	Near-term? Need broad baseline for restoration project implementation	Flood control operations are considered an unquantified component of the wetlands load; BPA requires new projects to participate in or conduct control studies; BDCP accepts MeHg impacts of projects as unavoidable
TMDL – Agricultural tailwater	Ambient aqueous MeHg as context for discharge monitoring	Near term. Ongoing control studies at Yolo Wildlife Area, Cosumnes River Preserve, Twitchell Is.; Delta coalition submitted 319(h) grant application for MeHg discharge monitoring (begin in 2015, if approved)	New WDR for Delta coalition does not require MeHg discharge monitoring
TMDL – Dredging	Sediment releases into the water column from dredging activities	Near term. Applies to all new 401 WQ certifications	Dredging activities and activities that reuse dredge material in the Delta should minimize increases in MeHg and inorganic Hg discharges to Delta waterways

Table 2. Comparison of different fish monitoring design options.

	Decadal Blitz	Annual Random Draw	Annual Index Sites (Low n)	Annual Index Sites (High n)	Hybrid: Index (Low n) + Annual Random
Power to detect Whole-Delta trend	▲	▲▲▲▲	▲▲	▲▲▲	▲▲▲▲
Power to detect Subarea trend	▲	▲▲▲	▲▲	▲▲▲	▲▲▲
Power to detect Site trend	▲	▲▲	▲▲▲	▲▲▲▲	▲▲▲
Infrastructure sustainability	▲	▲▲▲▲	▲▲	▲▲▲▲	▲▲▲▲
Flexible subarea boundaries	▲▲▲▲	▲▲▲▲	▲	▲▲▲	▲▲▲▲
Information flow	▲	▲▲▲▲	▲▲	▲▲▲	▲▲▲▲
Cost per year	$40K ($400K for 40 sites every 10 yr)	$80K ($80K for 10 sites every yr)	$80K ($80K for 10 sites every yr)	$160K ($160K for 20 sites every yr)	$160K ($160K for 20 sites every yr)

Key:
▲ weak
▲▲ good
▲▲▲ better
▲▲▲▲ best

Figure 1.

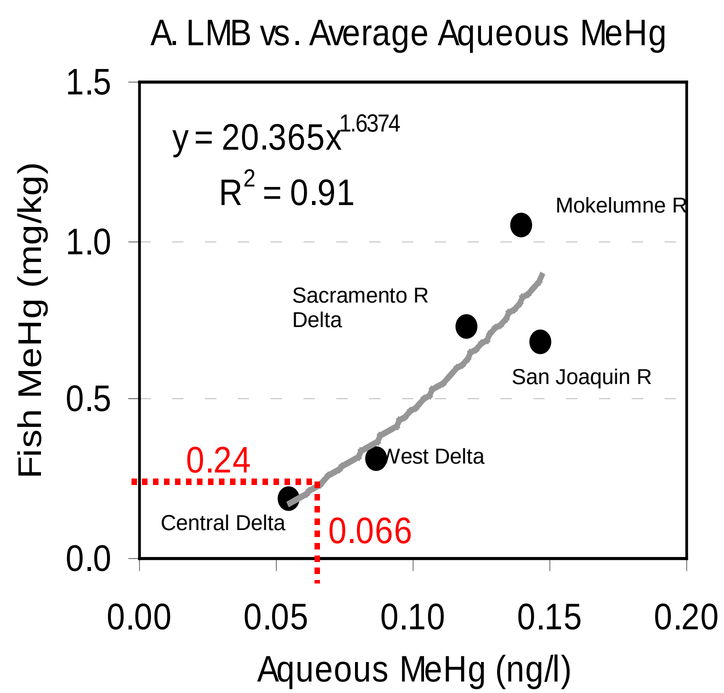
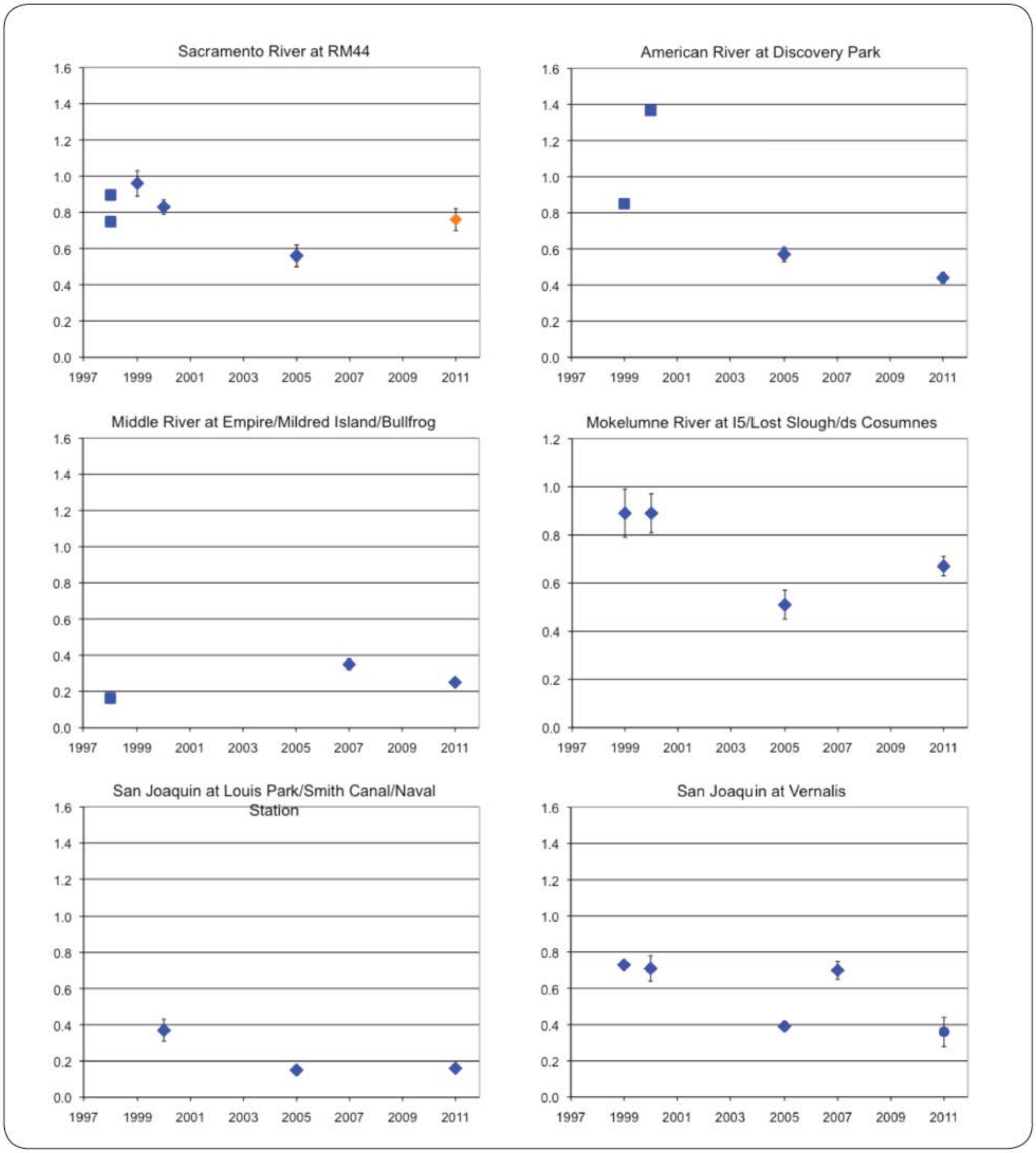


Figure 1. Relationship between Standard 350-mm Largemouth Bass (LMB) mercury and March to October 2000 Unfiltered Aqueous Methylmercury. From TMDL Report 2010, Figure 5.2.

The objective for 350-mm largemouth bass is 0.24 mg/kg.

Locations denote subareas within the legal Delta.

Figure 2. Mercury concentrations in fish for the sites with the best available time series. Largemouth bass shown in blue, smallmouth bass in orange. Diamonds represent averages based on ANCOVA-generated estimates for a size of 350 mm. Squares represent composite samples. Circles represent simple averages for cases where no length correlation was observed. Bars indicate one standard error.



Response to Review Panel Comments on the Nutrients Design from the Nutrients Subcommittee

The Panel made many excellent points about the Delta RMP monitoring design, and we appreciate the time and effort the Panel put into guiding our future efforts. Our responses to Review Panel comments and questions specific to the nutrients monitoring design are provided below. Most comments can be addressed by providing additional background information that was not previously communicated or available to the panel. Other comments are appreciated as valuable feedback and will be considered by the program as the long-term monitoring design for nutrients is being developed.

An important point that needs clarification is that the Delta RMP has not yet started monitoring for nutrients. All of the work to date has been synthesis of data from other nutrient monitoring programs to identify data gaps and information needs that the future program should address. One of the objectives for FY17/18 is to develop the long-term monitoring design for nutrients, taking into consideration the comments from the External Review, results from data syntheses, and the goals of the Program.

Similarly, the regulatory framework for nutrients in the Delta is still uncertain. The Central Valley Regional Water Quality Control Board is developing a Nutrient Research Plan to determine whether nutrient concentrations cause or contribute to water quality problems in the Delta. The Regional Board will make a decision about nutrient water quality objectives at some point in the future. The nutrient synthesis and studies conducted by the Delta RMP aim to support this decision-making process.

In lieu of a specific regulatory driver, there was consensus to focus initial efforts primarily on synthesis and analysis of existing data and information, and specifically on status and trends and mass balance for nutrients (forms of dissolved and total N and P) and nutrient-associated parameters (chlorophyll, dissolved oxygen). These parameters were identified as the most relevant, based on their significance as indicators relative to the assessment questions, conceptual understanding of biogeochemical processes, and availability and quality of existing data (Figures 1 and 2).

In the following section, quoted comments from the review are shown in italics followed by our response. The page number from the report from which the quote was taken is listed after the quote. Similar comments are grouped together with one response.

Responses to Specific Questions and Comments on the Nutrients Design

The monitoring program identifies state variables (e.g., indicators) to be measured at sample locations but does not fully explain why these indicators were selected. For example, lab analyses do not assess "pesticides" or "nutrients": they assess particular pesticides and *nutrients. Each one added can increase costs, each one ignored can increase risks, and there may be legal requirements. What logic was invoked to justify the selection of the indicators to be measured? (p. 3)*

As stated in the introduction, the Delta RMP's nutrient monitoring program has not yet been developed. Nutrient "state variables" to be measured have not yet been specified. The Monitoring Design Summary (MDS) states that the nutrient *data synthesis* would focus on the following parameters: ammonium (NH_4), nitrate (NO_3), dissolved inorganic nitrogen (DIN), total dissolved nitrogen (TDN), dissolved organic nitrogen (DON), phosphate (PO_4), chlorophyll a (chl-a), and dissolved oxygen (DO).

The nutrient subcommittee recommended focusing on the parameters above because they have been identified as the most relevant for addressing management questions and main issues of concern related to nutrients.

Monitoring design – One of the initial driving questions (p. 44) is "are there important data gaps associated with particular water bodies within the Delta subregions." It seems appropriate to answer this question before designing the sampling plan and locations for the Delta RMP. (p. 8)

We concur and this is the approach being taken by the Delta RMP. A Delta RMP nutrient monitoring planning workshop was held on September 30, 2016. The goals of this workshop were to:

- **Identify** how much of the nutrient monitoring needed to answer the Delta RMP assessment questions is already happening through **existing programs,**
- Identify critical nutrient data **gaps** for the Delta RMP and develop "no regrets" monitoring activities to fill them (beginning in Calendar year 2017), and
- Develop **budget estimates for "no regrets"** monitoring activities to facilitate multi-year budget planning for the Delta RMP multi-year plan

In preparation for the workshop, a background report was produced that summarizes existing nutrient monitoring programs, data gaps, and potential Delta RMP "no regrets" monitoring activities. This report synthesizes information and recommendations gathered in a) interviews with representatives of Delta monitoring and resource management programs, b) updating earlier information gathered on current monitoring efforts in the Delta (Central Valley Monitoring Directory, Jabusch and Gilbreath 2010), and c) conclusions and recommendations from recently completed data syntheses by ASC (Novick et al. 2015, Jabusch et al. 2016) and USGS (Bergamaschi et al., in press).

How are tides, flows, and other hydrodynamic conditions considered in choosing where and when to sample? (p. 8)

This issue will be considered for the development of the monitoring program design. It will depend on the specific question being addressed by the monitoring and the approach taken to answer it. Examples for how these important considerations are being discussed are as follows:

Efforts already underway or will be implemented in the short-term:

- To the extent possible, any new stations (both continuous and discrete) will be co-located with existing flow stations.
- The California Department of Water Resources (DWR) – Environmental Monitoring Program (EMP) has been collecting monthly data for more than 40 years with consistent timing relative to tides. Since 1975, the sampling times were planned to occur within a one-hour window of the expected occurrence of high slack tide at the sampling location. The EMP can be considered as the core data collection effort for addressing the Delta RMP Status & Trends (S&T) nutrient assessment questions. Any augmentation of the existing station network, for example, to strengthen the statistical power for long-term trend detection or increase spatial coverage, would maintain that consistency of sampling relative to the tide to minimize tidal variation as a factor affecting the long-term dataset.
- High-frequency (HF) data collection cruises have been proposed to understand nutrient transformations and potential internal loading in under-sampled Delta locations. The recommended monitoring cruises would be designed to characterize seasonal changes in flow and water quality and consist of data collection cruises under different flow scenarios.
- A data analysis that involves hydrodynamic modeling is currently underway to help identify temporal and spatial data gaps, in order to inform the future monitoring design. The goal of this analysis is to address the Delta RMP Assessment Question: "Are there important data gaps associated with particular water bodies within the Delta subregions, *relative to the potential for biogeochemical transformations to occur in those places, as inferred by transport time scales, hydrodynamic condition, and the source of the water*" The expected outcome are recommendations for representative sites for trends monitoring, high-frequency mapping sites, and informing biogeochemical models, based on hydrodynamic modeling results.

Additional efforts that have been discussed for future implementation:

- One potential Delta RMP activity that was discussed by program participants is to improve estimates of loads from upstream sources at important inflows. Nutrient load estimates for upstream sources are probably biased low, because storm events are not adequately captured. This gap could be filled and prevented from widening through storm sampling to better characterize the hydrograph.

- Additional short-term high frequency sampling to address data needs for hydrological-biogeochemical modeling would be timed for when boundary conditions (inflows and water exports) are changing rapidly.

The MDS (pp. 47–52) shows several ways to display the data, including its variation over time and space. Displays like these are informative, and might help in developing the nutrient monitoring design, or redirect or focus future sampling. However, displays are not a sufficient end point. They do not provide clear criteria for management actions. Such criteria usually need to be numerical estimates, with estimates of reliability. They will arise from comparisons to water quality objectives or other benchmarks of environmental or human health. (p. 8)

We concur with the observation. However, a nutrient assessment framework does not yet exist for the Delta and there are only a few existing water quality objectives or benchmarks that would be appropriate and meaningful in the context of the Delta RMP assessment questions. Examples for meaningful benchmarks are TMDL targets for dissolved oxygen in the lower San Joaquin River (Figure 3, from ASC 2012) or World Health Organization (WHO) thresholds of risk associated with potential exposure to cyanotoxins (Table 1, USEPA 2009). Water quality criteria also exist for ammonium and nitrate. However, these criteria are related to toxicity, whereas the primary management concern for these constituents is about their impact on ecosystem productivity and trophic status.

The Delta Stewardship Council's 2013 Delta Plan recommended that the San Francisco and Central Valley Water Board prepare study plans for the development of nutrient objectives in the Delta and Suisun Bay. In response to the Council's recommendation, Water Board staff developed a Strategic Workplan for the Delta that was presented to the Central Valley Water Board in February 2014. This Strategic Work Plan contained a nutrient strategy that included tasks, deliverables and a timeline for developing the research plan. The goal of this project is to develop a Delta Nutrient Research Plan to determine whether nutrient concentrations cause or contribute to water quality problems in the Delta. Completion of the Delta Nutrient Research Plan (by 2018) is expected to lead to the development of a nutrients assessment framework for the Delta.

We recommend that a PhD-level statistician be added to your team to help develop the nutrient monitoring design. (p. 8)

We have access to additional statistical expertise through ASC, USGS, USEPA, and other partners and will bring it in as needed to assist with the design development. The level of effort involved will depend on the scope and types of monitoring activities that are being planned.

Synthesis – An allocation of $435,000 seems high for mostly synthesizing the existing data (MDS, pp. 45–52). (p. 8)

There is agreement among scientists and managers participating in the Delta RMP Monitoring Planning Workshop that a) existing nutrient and nutrient-associated data are underutilized, and b) synthesizing, assessing, and reporting on the wealth of data generated by monitoring agencies could be a valuable function of the Delta RMP. The total annual cost for these activities was estimated at $100K–$500K, or approximately 0.5–2.5 FTEs/yr to compile data, perform data analyses, perform modeling, write reports, and interact and coordinate with stakeholder groups, collaborators, and additional technical experts.

However, the $435,000 mentioned above is not the funding level proposed in the MDS to be spent by the Delta RMP on synthesis activities alone (Table 2). This amount includes costs for coordination with related efforts and for developing the monitoring design. It also includes costs of projects that had already been funded through external sources but were expected to provide partial answers to several assessment questions related to concentrations and the mass balance of nutrients and nutrient-associated parameters. The costs listed in the column named **Shortfall (RMP funding needed)** were the funds proposed for the Delta RMP to build on these studies and address additional needs. The total proposed cost to the Delta RMP was $225K.

Restate Table 1 (Assessment Questions) of Monitoring Design to more specifically address the management questions, monitoring goals, and likelihood of achieving these goals for each constituent. (p. 2. This recommendation is for the entire design and not specific to the nutrient element.)

We concur with the need to review the assessment questions as they pertain to nutrients. The Nutrient Subcommittee is planning to review the assessment questions for nutrients at an upcoming meeting. The current plan is to discuss whether changes should be made to the assessment questions and their hierarchy that would strengthen the linkage between activities and management questions/drivers. This will be done in the context of linking the parallel efforts of the Delta RMP and the Delta Nutrient Research Plan more closely together and placing more emphasis on evaluating the linkages between nutrients as potential stressors and biological effects (Assessment Question S&T2 in Table 3). The discussion will also review and assess the scope of activities to be undertaken to address remaining data gaps under each assessment question.

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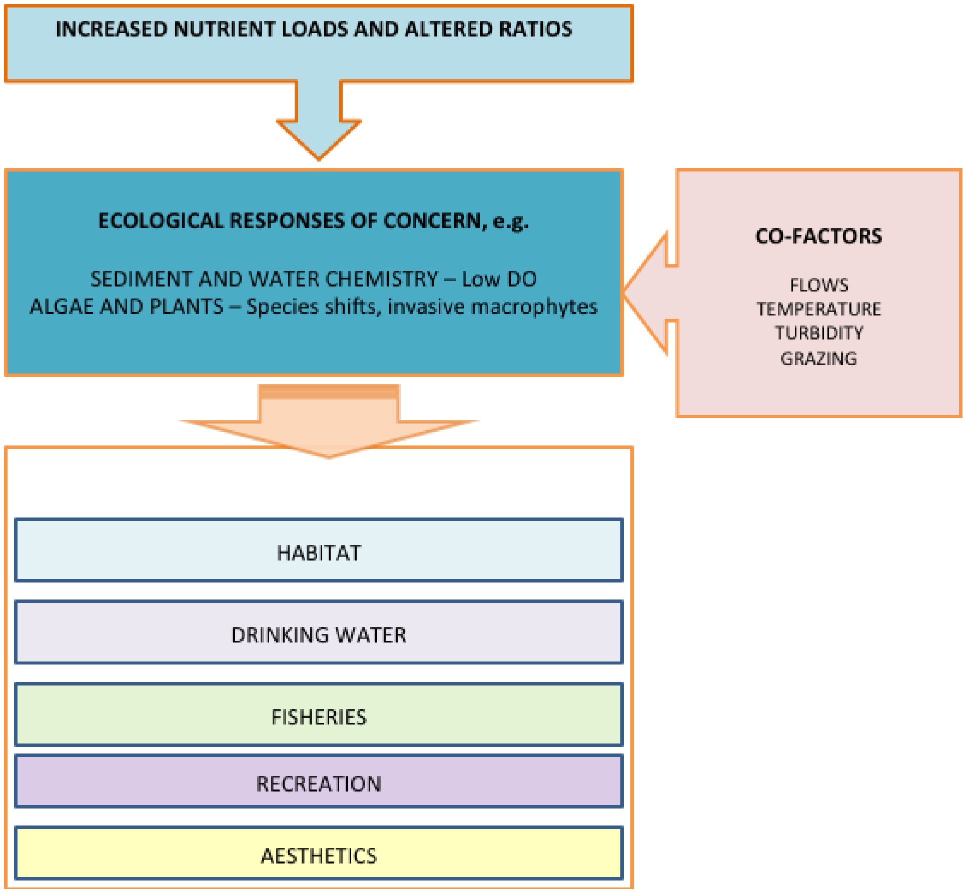

Figure 1. Simplified conceptual framework showing the linkage of nutrients loading, ecological response, co-factors modulating the ecological response, and altered ecological and human services.

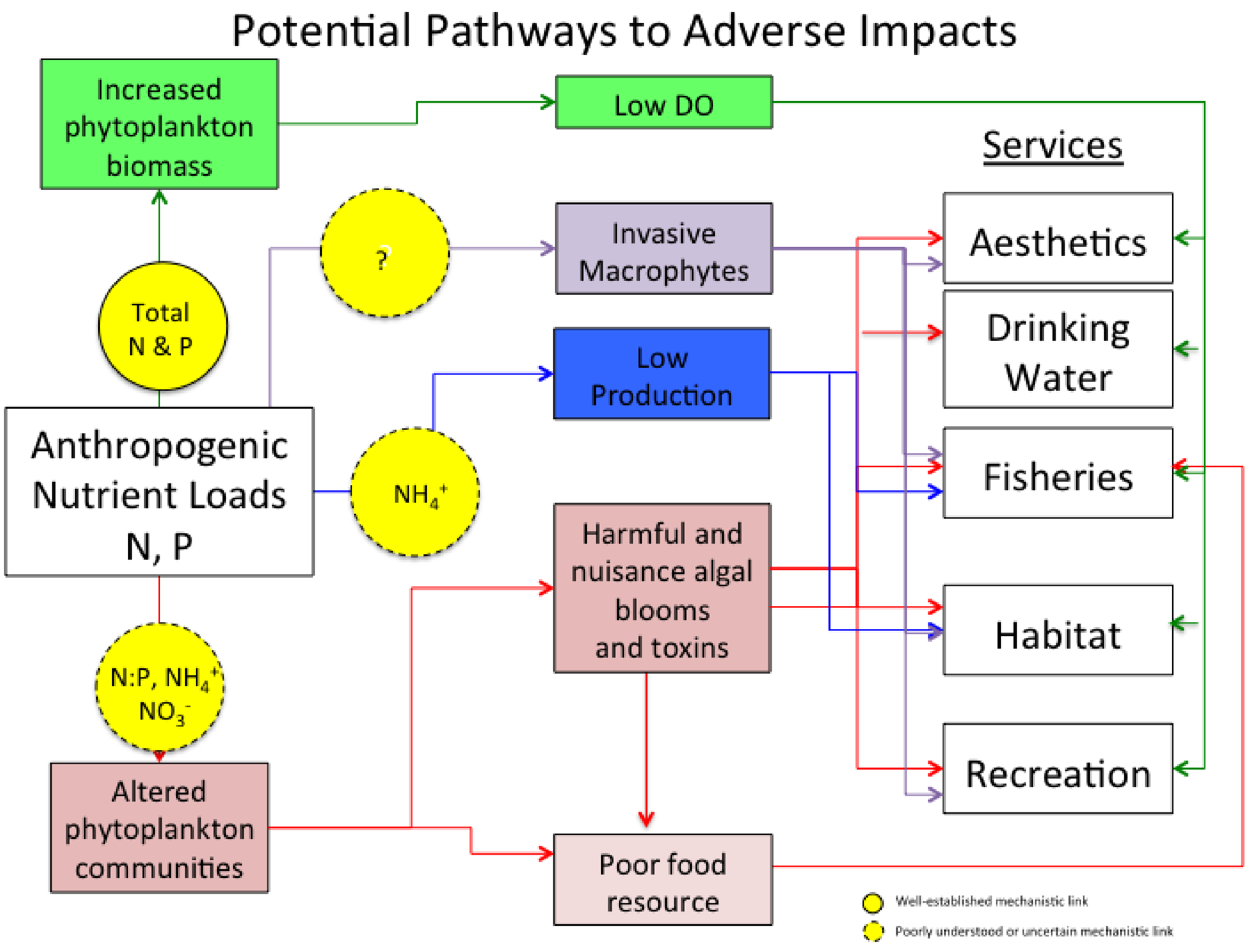

Figure 2. Conceptual diagram of potential pathways from elevated nitrogen and phosphorus loads to adverse impacts on beneficial uses.

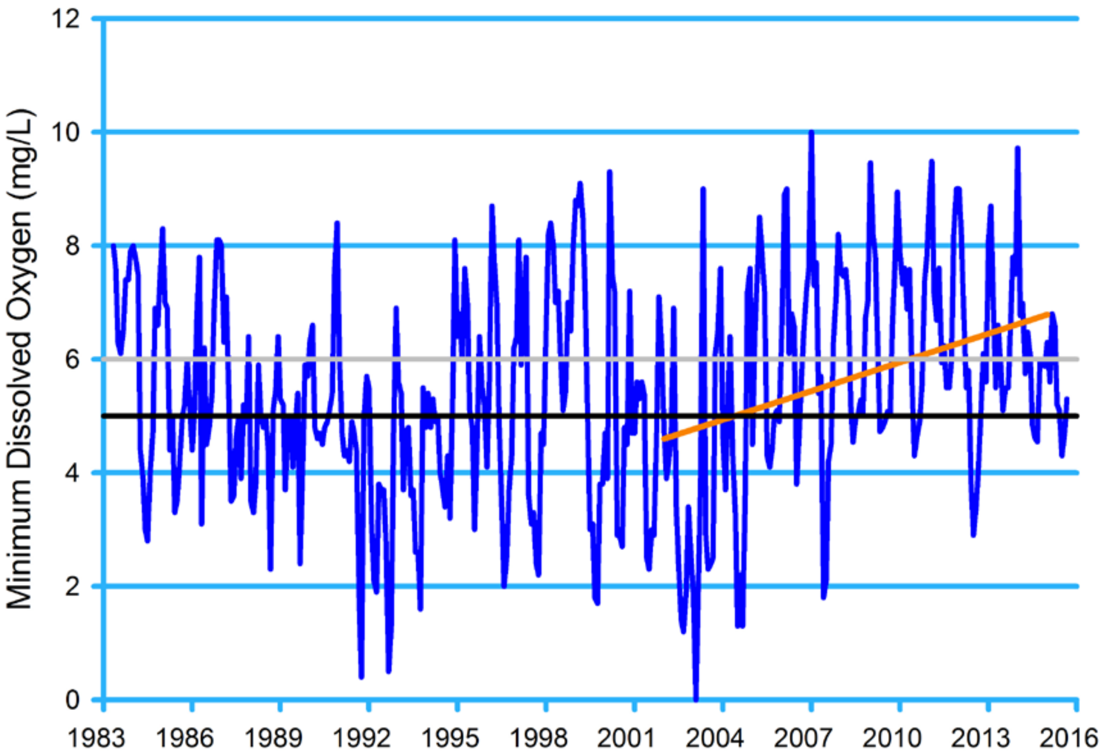

Figure 3. Dissolved Oxygen in the Lower San Joaquin River. ***Example graph and example interpretation***. Low dissolved oxygen in Delta waters pose significant migration barriers to salmon and other migrating fishes. Dissolved oxygen barriers occur in the Stockton Deep Water Ship Channel (DWSC) and on Old and Middle Rivers and have resulted in the establishment of a Total Maximum Daily Load (TMDL) to control low DO in the San Joaquin River. The deepened channel, reduced flows, decomposing algae from upstream, and oxygen-demanding substances from the City of Stockton wastewater treatment plant all contribute to the low DO issue. Seasonal variability of DO is mainly due to seasonal variability in river flow, but fluctuations in river phytoplankton and wastewater effluent also play a role. Dissolved oxygen in the lower San Joaquin River has increased since the early 2000s (see trend line), primarily due to the implementation of algae removal ponds and nitrification treatment by the City of Stockton wastewater treatment plant. However, monthly minimum values continue to fall frequently below the statutory limits of 5 mg/L (December 1 to September 30) and 6 mg/L (October 1 to November 30).
Footnotes: Minimum monthly values of dissolved oxygen measured at the Rough and Ready Island monitoring station in the Stockton DWSC. The Middle River and Old River split off from the mainstem of the San Joaquin River upstream of the DWSC. The orange trend line represents a linear regression of the annual averages of minimum monthly DO concentration 2002 – 2015 vs. time. Data are from the Continuous Multiparameter Monitoring by the IEP Environmental Monitoring Program.

Reference: Jassby & Van Nieuwenhuyse 2005.

Table 1. World Health Organization thresholds of risk associated with potential exposure to cyanotoxins (USEPA 2009).

Indicator (units)	**Low Risk of Exposure**	**Moderate Risk of**	**High Risk of Exposure**
Cyanobacteria cell counts (#/L)	< 20,000	20,000 - <100,000	≥ 100,000
Microcystin (µg/L)	<10	10 - ≤20	>20

Table 2.

The following table from the MDS shows the initial cost estimates for steps to develop the nutrient monitoring design. For projects that already have funding from outside the Delta RMP, the cost of the project is shown but is offset by the available outside funding. This table does not include the costs of routine nutrient monitoring. Costs for a longer-term nutrient monitoring will be developed after the monitoring design has been produced.

Task	Cost	Available Funding from non-RMP sources	Shortfall (RMP funding needed)
1. Synthesis and analysis of existing information and data			
a. Synthesize and analyze existing data			
Synthesis of EMP and Nutrient Loads data (ASC-DWR contract)	$82,000	$82,000	$0
Interpretation of stable isotope data (ASC-DWR contract)	$34,000	$34,000	$0
Calibration and interpretation of DSM2 nutrient models (ASC-DWR contract)	$39,000	$39,000	$0
Synthesis of high-frequency sensor data	$70,000	$0	$70,000
Compilation and synthesis of other nutrient datasets from the Delta	$40,000	$0	$40,000
b. Establish meaningful subregions			
Synthesis of Nutrient Data and Analyses to Determine Delta Segments for Nutrient Assessments and Modeling (ASC-DSP contract)	$40,000	$40,000	$0
c. Identify critical data gaps and develop initial recommendations for monitoring design	$50,000	$0	$50,000
2. Coordination			
a. Coordination with the development of the Delta Nutrient Research Plan and related efforts (ASC-DSP contract)	$15,000	$15,000	$0
3. Develop nutrient monitoring design			
a. Define sampling frame (habitats, subareas) b. Data evaluation and reconciliation c. Complete and vet a detailed monitoring and design proposal for nutrients d. Develop mechanisms for systematically compiling, assessing, and reporting data	$65,000	$0	$65,000
Total amount	***$435,000***	***$210,000***	***$225,000***

Table 3. Delta RMP assessment questions for nutrients. ***Italicized bold-faced questions*** are the highest priority for the initial program.

Type	Core Management Questions	Nutrient Assessment Questions
Status & Trends	IS THERE A PROBLEM OR ARE THERE SIGNS OF A PROBLEM? a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?	***ST1. 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?*** ST2. What is the current status of the Delta ecosystem as influenced by nutrients? A. What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?
Sources, Pathways, Loadings & Processes	WHICH SOURCES AND PROCESSES ARE MOST IMPORTANT TO UNDERSTAND AND QUANTIFY? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?	***SPLP1. Which sources, pathways, and processes contribute most to observed levels of nutrients?*** ***A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters?*** ***B. What are the loads from tributaries to the Delta?*** ***C. What are the sources and loads of nutrients within the Delta?*** ***D. What role do internal sources play in influencing observed nutrient levels?*** ***E. Which factors in the Delta influence the effects of nutrients?*** ***F. What are the types and sources of nutrient sinks within the Delta?*** ***G. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects?***
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	FS1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?

Response to Review Panel Comments on the Pesticides Design from the Pesticides Subcommittee

The Panel made many excellent points about the Delta RMP monitoring design. Responses to Review Panel comments and questions specific to the pesticides monitoring design are provided below. Some comments can be addressed by providing additional background information that was not previously communicated or available to the panel. Other comments are appreciated as valuable feedback and will be considered by the program as the long-term monitoring design for pesticides is further developed. One of the objectives for FY17/18 is to develop the long-term monitoring design for pesticides, taking into consideration the comments from the External Review, results from the first two years, and the goals of the Program.

In the following section, quoted comments from the review are shown in italics followed by our response. The page number from the report from which the quote was taken is listed after the quote. Similar comments are grouped together with one response.

Responses to Specific Questions and Comments on the Pesticides Design

At present it is proposed to conduct "Pesticide-focused TIEs for samples with > 50% reduction in the organism response compared to the lab control treatment (not to exceed 20% of samples or $40,000)" (MDS p. 21). What criteria led to these numbers? (p. 7)

The decision of when to conduct a Toxicity Identification Evaluation (TIE) is made by a subcommittee of the TAC based on a number of factors, such as details provided by the laboratory and expenses to date relative to budget. TIEs are not performed on all samples with observed toxicity because financial resources are limited for the RMP. Therefore, at the outset of the program, the Pesticide Subcommittee decided to follow other programs which have utilized the ≥50% threshold as the trigger level for when to consider conducting a TIE. If toxicity is above this value, the subcommittee will meet and thoroughly discuss the issue and make a decision. This decision process ensures that the most toxic samples, those with an observed effect greater than 50%, will be considered for a TIE to help narrow down the possible sources such as metals or organophosphate pesticides, while also controlling costs. Conducting TIEs on samples with a lower observed effect often results in the toxicity not being persistent for the duration of the multiple manipulations and the results being inconclusive due to toxicity being lost. In summary, the decision about whether to conduct a TIE is made on a case-by-case basis by a subcommittee of the TAC when a sample is above the trigger level of 50%.

The toxicity tests use "EPA, 2002, Appendix H" (QAPP, p. 61, it should be "2002a"). It is an old t-test (its formal pre-tests are not useful). How the test is to be used (what action it might lead to), and how reliable it should be (a function of sample sizes and variances) are not clearly discussed. (The aims and meaning of the measurement quality objectives column in Table 4.10 is not clear.) (p. 7)

The EPA acute toxicity testing manual explains the process to test for meeting data assumptions of normality and equal variance. The initial goals and measurement quality objectives for toxicity monitoring of the Delta RMP are related to evaluating Status and Trends, which are very similar and complementary to those of the statewide Surface Water Ambient Monitoring Program (SWAMP). Therefore, the Delta RMP has adapted the scientifically vetted approach used by the SWAMP for individual toxicity testing analysis. (It should also be noted that the discussion about the most appropriate statistical test has not been unequivocally resolved. Some pesticide subcommittee members are recommending the Test of Significant Toxicity (EPA 2010; Denton et al., 2011) with the argument that it would provide more statistical rigor).

Delta RMP data are expected to contribute to an information basis for assessing conditions at a regional scale and fill prioritized data gaps. There is a continuing discussion about how the Delta RMP should interface with regulators and other managers outside the program and the issue still needs to be resolved, especially with regards to follow-up on any observations. However, results are not "actioned" on within the Program. Regulatory and management decisions (e.g. determining beneficial use impairments, etc.) may involve participants but occur outside of the Delta RMP. The key contribution of the Delta RMP is in providing a shared dataset and serving as a forum for joint-fact finding and consensus building. The goal is broadly described in the Communications Plan goal as to develop the interpretation and potential recommendations for management in a science-based and collaborative process.

The plan is not clear about methods for sampling sediments. The QAPP has no information on sediment collection or analysis. (p. 7)

a. *Is the Stream Pollutions Trends Monitoring Program (SPoT) collection, toxicity testing and chemistry of sediments considered part of the Delta RMP? (p. 7)*

No. SPoT is a separate statewide water quality monitoring program that focuses on toxicity and concentrations of stream-borne contaminants in sediments with the goals to:

1. Determine long-term trends in stream contaminant concentrations statewide;
2. Relate water quality indicators to land-use characteristics; and
3. Establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, & federal monitoring programs.

The SPoT Delta RMP will benefit by utilizing the information generated by the SPoT program. Leveraging resources between the two programs is beneficial.

b. Where are those sample locations? (p. 7)

SPoT sampling locations were shown on the map on page 24 of the Monitoring Design Summary and listed in the table of monitoring locations following the map on pages 25 and 26. Generally, SPoT prioritizes sites with a rich history of monitoring; in highly urban watersheds; with depositional sediments; within relatively small watersheds with short sediment transit times that would react quickly to changes in pesticide loading. Current sites are:

Mokelumne River @ New Hope

San Joaquin @Vernalis

Marsh Creek @ East Cypress Crossing

American River @Discovery Park

c. A yearly grab sample seems very limited - what is known about the spatial distribution of pesticides in sediment, or their seasonal variation? (p. 7)

Effectively, not all locations are only sampled yearly as the comment suggests.

However, sediment chemical composition and toxicity does not typically change rapidly over time. Toxicity was estimated using 10-day amphipod survival tests, and contamination was characterized by measurement of pyrethroid pesticides. Pyrethroids were selected because of their pervasive use in urban and agricultural watersheds and increasing importance in driving sediment toxicity in California watersheds. The toxicity and chemistry data were analyzed by first conducting a two-factor analysis of variance on the spatial and temporal data within the 2010 sampling season. If the amphipod survival results are more variable among years than they are within a year, then it is assumed that yearly sampling is adequate to characterize long-term trends. The results from three base station samples conducted within 2010 were compared to the base station results from other years using an F-Ratio test to determine if seasonal variability was significantly greater than annual variability. Results of the F-Ratio tests indicate that annual variability was greater than seasonal variability at all three sites. These results indicate that in most instances, a single baseline sample was representative of sediment toxicity at proximate stations and in different seasons. Therefore, in answering the SPoT program objective to "Determine long term trends in sediment contaminant concentrations and effect statewide", collecting sediment samples on an annual basis is sufficient.

In addition, five years of data were evaluated to determine variability in toxicity (2008-2012). Statistical analysis was conducted at selected SPoT sites (called "variability" sites) to assess the temporal and spatial variability of toxicity and contamination. The results indicated that samples collected once per year were representative of spatial and temporal variability within the selected watersheds (same as current watersheds).

Pages 46 & 47 of this report includes power analysis:

http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/workplans/spot_%20fourteen_rpt.pdf

Based on the data from the variability study, yearly sampling was representative for toxicity and bifenthrin, but the power analysis results also suggested increasing the sampling of more variable parameters, such as total pyrethroids, to determine whether a newly adopted management practice is effective. Based on the variability of toxicity test results measured once per year for the past five years, it can take an average of 3 to 4 years to observe a 25% change in toxicity. Parameters that are more variable, such as total pyrethroids, can take 5 to 9 years to observe a 25% change.

Power analysis conducted on the data from the variability sites demonstrated that trends in total pyrethroids could be detected more quickly by sampling the sites multiple times per year. It is predicted that sampling three times per year at the variability sites could detect trends in toxicity and bifenthrin concentrations in an average of two years. In collaboration with DPR, SPoT now samples 4 sites 4 times per year to assess reductions in toxicity and pyrethroid pesticides associated with recent DPR revisions to pyrethroid label recommendations for use in urban settings. This monitoring is performed to answer the 2nd SPoT program objective, "Relate water quality indicators to land use characteristics and management efforts". In this case, the program has identified 4 "intensive" sites to collect more samples per year to facilitate answering a management practice that has been implemented. These 4 sites have replaced the "variability" sites.

d. *What will the estimated concentrations be compared to in order to evaluate the presence and degree of sediment toxicity? (p. 7)*
e. *There are no standards, criteria, or objectives for the prevalence of current use pesticides in sediment, so what would be done with this information? (p. 7)*

The information gleaned from SPoT will be used to help understand the risk level and to assist as baseline information in future monitoring. The general information is that the data would be obtained and used to evaluate the overarching management question: Is there a problem or are there signs of a problem? Results will also help inform future monitoring needs and whether adaptive changes to the monitoring design are needed (e.g., should there be additional sediment monitoring to address Delta RMP management questions? Which constituents? When? Where? How often?)

Evaluation of SpoT data within the context of the Delta RMP will draw from data evaluation procedures and analyses performed by the SPoT. However, more detailed discussions on the approach for how to assess the “risk” level within the Delta RMP contact and feedback to the Delta RMP design are still pending, i.e. the degree to which SPoT data evaluation approaches can be directly adapted or would require modification.

In SPoT evaluations, for example, amphipod survival is compared to individual chemical threshold values (also referred to as benchmarks) to determine which chemical occurred at concentrations that could cause toxicity. These toxicity benchmark concentrations are assembled from various sources. Where possible, median lethal concentrations (LC50s) derived from spiked sediment toxicity studies using *H. azteca* were used to evaluate chemistry data. Median lethal concentrations are preferable because they are derived from exposure experiments with single chemicals. The probable effects concentration (PEC) sediment quality guidelines (MacDonald et al. 1990) were used when spiked-sediment LC50s were not available. Probable effects concentrations are consensus-based guidelines that were developed from other empirically-derived sediment quality guideline values. These benchmarks identify concentrations above which adverse effects to benthic invertebrates are expected.

f. *The map on p. 26 of MDS shows there are existing sediment and/or water toxicity test locations in the Delta that have known toxicity (at least within the vague categories). Can these locations be used as negative and positive controls, respectively? (p. 7)*

There are no system positive or negative controls. The best approach in toxicity testing for a negative control is the use of standard laboratory control water to compare with the site water. Reference toxicant tests are performed as a positive control test. This is the approach that has been utilized in ambient toxicity testing for over three decades.

Some water samples are scheduled and others triggered by events. If these are to be combined over time, how will they be analyzed? Presumably "event" times have special characteristics, and wet ones are different from dry ones. (This is a question, not a criticism of taking the two types of samples.) It seems that monthly samples are not taken when "events" occur. In that case, why are the "event" sites different from the regular sites? (p. 7)

All data will be treated in the analyses as monthly samples. “Event” times represent five time periods that were selected because they were considered by the pesticide subcommittee as the most critical points or windows in time over the course of the year to evaluate temporal and spatial variability of pesticides and their effects. The pesticide subcommittee selected these five “event” times to be monitored at a minimum, if there is insufficient funding for monthly monitoring at all proposed sites. The selected “event” times include two wet-weather event types and three dry-season periods. The wet-weather event types are: (1) first flush and (2) one additional significant winter storm after first flush has occurred. The three dry-season sampling events are: (1) early spring, (2) 1st irrigation season sampling (late spring/ early summer), and (3) 2nd irrigation season sampling (late spring/ early summer).

“Event” sites were selected to increase the spatial coverage of monitoring. Ideally, these sites would also be monitored monthly. The proposed “events–only” sampling at these sites (5x/year instead of 12x/year) represents a compromise driven by budget considerations. This option is currently not implemented. The pesticides monitoring is currently only funded for the five “regular” or baseline sites. At these regular sites, monthly samples in the wet season are scheduled to capture the wet-weather events.

In the analyses, samples may be binned into periods representing different event times for comparison. For example, results from wet events may be pooled from all years and compared to data collected during dry periods.

QAPP p. 30. Are the same sites used for both pesticide analyses and toxicity testing? (p. 7)

Yes. The initial monitoring design combines chemical analysis and toxicity testing on all samples for all sites.

More detail on toxicity tests is needed. (p. 6)

The Delta RMP uses water toxicity tests that are common across numerous ambient monitoring programs, including the SWAMP and other regional monitoring programs. The Delta RMP uses the three–species freshwater tests typically used for toxicity testing of receiving waters (EPA 2002a and b) using a fish (fathead minnow, *Pimephales promelas*), a cladoceran (*Ceriodaphnia dubia*), and a green alga (*Selenastrum capricornutum*). Recently (i.e. November 2016), toxicity testing with a second invertebrate, the amphipod *Hyalella* azteca, was added to increase the response range to potential toxicants. The testing approach includes acute (i.e., survival) and chronic (i.e. growth and reproduction) endpoints:

- *Selenastrum capricornutum* (growth)
- *Ceriodaphnia dubia* (survival and reproduction)
- *Hyalella azteca* (survival)
- *Pimephales promelas* (larval survival and biomass)

Each test has specific strengths, weaknesses, and sensitivity to toxic constituents. *H. azteca* was added to the standard three species because it is most sensitive to low levels of pyrethroid pesticides. *Ceriodaphnia* are more sensitive to the presence of organophosphorus (OP) pesticides. Herbicide toxicity is detectable by testing with *Selenastrum*. Fish toxicity (represented by *Pimephales promelas*) is an important management concern in the Delta. In the selection of the test species and endpoints, the pesticides subcommittee considered the response range to potential toxicants, relevance of the test organisms, costs, feasibility, and potential test interferences and other caveats not related to toxicity.

Additional details can be found in the USEPA freshwater toxicity testing manuals (USEPA 2002a and b) and the Standard Operating Procedures for each test:

- Initiation of *Selenastrum capricornutum* 96-Hour Chronic Toxicity Test (4th Edition)
- Initiation of *Ceriodaphnia dubia* Chronic Toxicity Test (4th Edition)
- Initiation of *Pimephales promelas* (Fathead Minnow) Chronic Toxicity Test (4th Edition)
- Initiation of *Hyalella azteca* Acute 96-hour Water Column Toxicity Test

This is by far the most expensive program and has the potential to become much more so if new or unknown pesticides become an issue. Yet, at present, we do not know the answer to the basic Table 1 question: "What are the spatial and temporal extents of lethal and sub-lethal toxicity?" (p. 6)

It seems more cost-effective to document the toxicity problem first, by postponing pesticide analyses to pay for toxicity testing over more sites, more widely spread, and during times of year when pesticide use/runoff would be expected to be high. When the sites or areas experiencing toxicity, and the times of the year are known, then samples from these sites and times can be analyzed for the chemicals that might cause that toxicity. This information can then be used to determine source(s), which can then lead to control/management. (p. 6)

a. *What samples sizes will be used, and why?*
b. *In the 2-stage approach above, a decision procedure will be needed to decide which sites and times are candidates for pesticide analysis, and perhaps to choose the pesticides to look for.*
c. *Thresholds, trigger points, and estimates of reliability will be needed, especially if information from different sites or times is to be combined.*
d. *When samples are collected from locations with observed toxicity and analyzed for chemicals, will current use pesticides be the only targets?*
e. *Is there reason also to consider personal care products, PBDEs (flame retardants), pharmaceuticals, legacy pesticides in sediment (e.g., DDT) or Hg as causes or contributors to observed toxicity? (p. 7)*

This comment raises fundamental questions about the Delta RMP monitoring design for current use pesticides and toxicity. They are best addressed as part of the re-evaluation of the pesticides design that is getting underway. The Steering Committee directed the TAC and Pesticide Subcommittee to complete the re-evaluation in time for the FY18/19 Workplan. The re-evaluation is in response to the outcomes of the External Review as well as to the needs for reducing the relative proportion of program costs for pesticide monitoring and for bringing the focus on pyrethroid pesticides. This may require aligning the Delta RMP assessment questions more directly with pyrethroid TMDL-related management decisions and evaluating whether there are critical data that the Delta RMP could generate to inform the Central Valley Pyrethroid TMDL. The outcomes of the re-alignment will inform decisions about data quality criteria to be used, site selection, the list of pesticides to be analyzed, the pros and cons of a toxicity-first approach and a toxicity with paired chemistry approach, and how to best meet the updated data evaluation and information needs.

However, the issues raised here by the panel have been thoroughly discussed during the development of the initial design and the pesticide subcommittee has carefully considered various approaches for addressing them. The resulting design represents a compromise between the best possible technical design for addressing the questions, budget constraints, and data needs of different participants. At the beginning of the design development, the planning budget was uncertain and the plans had to capture a range of effort. Ultimately, a lower cost design was implemented. The following paragraphs will outline some of the pros and cons of various approaches that were considered as well as the rationale for the decisions that had been made about the design.

A key point to resolve during the design development was the question of whether the monitoring should be primarily toxicity based (with follow-up chemical analyses in toxic samples as well as some non-toxic samples as reference), primarily or exclusively chemistry-based, or involve both toxicity testing and chemical analysis on all samples from all sites. Consistent with the comment made here, a toxicity-first design was discussed as the potentially most cost-efficient option to assess whether there is a potential problem.

Toxicity testing is an integrative tool, it can determine effects of multiple constituents concurrently, and can help to understand how the combination of pesticide active ingredients (AIs) + AI degradates + formulation "inert" ingredient(s) + their degradation products + any other potential toxicants overlying in the water and sediment (e.g., heavy metals) contribute to toxicity. However, there are also significant caveats to this approach. First, chemical-analytical results are important for evaluating if the observed toxicity might potentially be related to the occurrence of pesticides. Second, there are potential issues with preserving samples such that, if samples are not immediately processed and analyzed, there may be changes in sample chemistry between collection and analysis. Third, some of the program participants required chemical results for compliance reporting purposes. (Compliance reporting requirements have since changed and this may no longer be necessary. This will be evaluated in the development of the new monitoring design.) Based on these considerations, it was decided to perform toxicity testing and chemical analysis on all samples from all sites.

As pointed out in the comments, there is a possibility of impacts from other contaminant classes and there were also extensive discussions about the range of potential chemicals that should be considered as potential sources of toxicity. The linkage of toxicity testing to pesticides monitoring does not indicate a presumption that pesticides are the sole cause of toxicity in the Delta. However, current use pesticides were identified as a monitoring priority based on previous studies indicating that these chemicals can be important for understanding toxicity in the region (e.g., Central Valley Regional Water Board 2007, Hoogeweg et al. 2011, Johnson et al. 2010, Kuivila and Foe 1995, Lundberg & Laurenson 2012, Markewicz et al. 2012, State Water Resources Control Board 2010, State Water Resources Control Board et al. 2008, Werner et al. 2010, Weston et al. 2012, Weston et al. 2005, Weston & Lydy 2010). Thus, toxicity testing is primarily being used as tool to assist in the monitoring of pesticides. If other toxicants are determined to potentially contribute more to toxicity than expected, alternate priority constituents may be proposed to the Steering Committee for consideration. Future plans are likely to include monitoring of Chemicals of Emerging Concern (CECs) as a new program element. Potential coordination opportunities between monitoring for pesticides/toxicity and CECs can be investigated at that time.

Monitoring and assessment of the state of the Delta is based on a sample of the study area—that is, not all possible locations are sampled and indicator values measured. Therefore, the ability to use the sample data to draw inferences about unmonitored sites is a key part of sample site selection. This has several components. One is to use models of flow, transport and degradation to help estimate values up- or down-stream of monitored sites. The five pesticide sampling sites may allow crucial areas to be estimated this way (but they are likely to be small and no methods are given). (p. 2)

There are two broad categories of environmental monitoring programs—design-based and model-based. Both require that the target population and the sample frame be clearly defined in order to avoid the potential for confounding arising from changing frame errors. Those programs that use design-based inference use the selection probabilities of the sample units to calculate an estimate for the statistical population and provide estimates of uncertainty. In contrast, programs that use model-based inference assume an a priori statistical model for the distribution of indicator values and do not require a probability based sample design. (p. 13)

Why are sites for monthly pesticide samples all near the edge of the Delta if these are not informative about interior sites? (Pages 24 and 38 of the MDS lists reasons for site choices but they are vague.) How would one decide whether the proposed design is better than one with half as many times and twice as many sites? The QAPP aims to ensure that results from individual (site, time) samples meet reliability criteria: how are these determined? How would one decide whether to relax some of them so as to add more sites or times, or tighten others due to health risks? (p. 5)

These comments raise fundamental questions about the Delta RMP monitoring design for current use pesticides and toxicity. As a result of these comments and the External Review in general, the Steering Committee directed the TAC and Pesticide Subcommittee to redesign the monitoring program in time for the FY18/19 Workplan.

Initial site selection and other design considerations were based on subcommittee member knowledge of important sources; what is known about where toxicity might occur and be detectable; spatial and temporal variability in pesticide concentrations based on the existing monitoring data; important influencing factors of loads and concentrations, such as flows and tides; etc. The subcommittee decided on initially monitoring fewer sites more frequently to develop a baseline for trend analysis, potentially identifying pesticide sources to the Delta, and in part for the need to better understand temporal variability relative to flow. The need to also characterize the interior Delta was discussed. However, flows in the interior Delta are more difficult to characterize and there were time and budget constraints for dealing with these challenges, and a feasible compromise was necessary to get the monitoring started in a timely way. The selected sites are critical integrator and/or representative indicator sites representing the most important sources to the inner Delta:

1. Sacramento R @ Hood: terminus site for the Sacramento River watershed, the largest tributary to the Delta. Integrator site with a variety of land uses upstream.
2. San Joaquin R @ Vernalis: terminus site for the San Joaquin River watershed. Integrator site with a variety of land uses upstream.
3. San Joaquin River @ Buckley Cove: the main stem San Joaquin River, below the influence of the Stockton urban area. Integrator site with a variety of land uses upstream.

4. Mokelumne R @ New Hope Rd: represents the most important tributary influences (Mokelumne and Cosumnes Rivers) at the eastside boundary. Integrator site with a variety of land uses upstream.
5. Ulatis Creek @ Brown Road: represents agricultural and urban influences in the North Delta discharging to the ecologically significant Cache/Prospect Slough complex.

These integrator sites were selected by the Pesticide Subcommittee with an understanding of the hydraulics of the Delta, the upstream land uses, and results from previous pesticide and toxicity monitoring by other programs. Documentation of all the existing data on which these decisions were formed was beyond the scope of the initial design effort.

The rationale behind selecting the peripheral "integrator" sites was to characterize the spatial and temporal variations in loadings to the inner Delta as a first step. A monitoring design to measure loads of pesticides to the Delta is an appropriate first step toward understanding conditions in the inner Delta. Interior Delta sampling locations were intended to be included in future work plans after a 1-2 year baseline was established for these integrator sites.

We concur that an alternative sampling design could be based on modeling or probabilistic surveys and the committees will consider these alternatives for the redesign. Both of these options have the advantage of covering more of the surface area of the Delta and being more amenable to analytical techniques to optimize data quality objectives, sampling locations, and frequency. A probabilistic design was discussed as an option for monitoring the interior of the Delta in the next program phase, once the spatial and temporal variability of contributions from important sources to the inner Delta would be better characterized. Next planned steps in the re-design are expected to involve a re-evaluation of the assessment questions (and their linkage to monitoring questions). When completed, decisions on the best monitoring design to address the new or refined questions can be made.

<u>*Data products*</u>

a. The vague categories used (non-toxic, some, moderate and high: MDS p. 26, 27) are not useful. (p. 7)

Proposed data products will be re-evaluated, based on the outcomes of the re-design, refined assessment questions, and pending decisions on thresholds to be used for comparison.

The pie charts referred to here are shown as an example for a potential format to communicate complex toxicity data to a non-expert audience. The pie charts and categories are those used by the SWAMP and the California Water Quality Monitoring Council's MyWaterQuality Portals for assessment and graphical display of toxicity data. Some program participants consider them as useful for summarizing toxicity data for managers. However, the committees haven't reached consensus on what would constitute useful data products and this issue needs to be resolved as part of the re-design process.

b. *The main value of plots is to convey much information clearly and succinctly, but thought and explanatory text are often needed;* ***MDS****, p. 28, contains much information but is uninterpretable (other than high scores for Diuron). (p. 9)*

This plot served as an example for how to visualize temporal and spatial variability across different pesticides in a single graph. More refined graphs with actual Delta RMP data and more detailed explanations will be developed for the 2-year summary report.

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Table 1. Summary of Delta RMP Pesticide Monitoring (implemented in FY15-17).

Component	**Water Sampling**
Design	"Bare Bones" 5 baseline sites
Frequency	Monthly (captures 2 wet events: first flush and 2nd significant winter storm)
Toxicity	All samples
Chemistry	All samples
Pesticide-focused TIEs	Up to 20% of samples found ≥50% toxic for at least one endpoint (not to exceed $40,000)

Response to Review Panel Comments on the Pathogen Design from the Pathogen Subcommittee

We appreciate the thoughtful and thorough review of the Delta RMP monitoring design by the Panel. Responses to Review Panel comments and questions specific to the pathogen monitoring design are provided below. We feel that most of the Panel's comments can be addressed by providing the Panel will additional background information about the *Central Valley Drinking Water Policy Basin Plan Amendment*[1] (Basin Plan Amendment), which is the regulatory driver for the pathogen study. The Basin Plan Amendment was adopted by the Central Valley Regional Water Quality Control Board on July 26, 2013, to protect drinking water source quality. The Policy includes a narrative water quality objective for two pathogens, *Cryptosporidium* and *Giardia*, with associated implementation and monitoring provisions, as well as language addressing other constituents of potential concern to drinking water. The proposed Pathogen Study is intended to satisfy the data needs and monitoring for any follow-up required if Basin Plan "trigger" values are exceeded. The Basin Plan Amendment specified an implementation program designed to maintain existing conditions for public water systems, and included the Long Term 2 Enhanced Surface Water Treatment Rule (LT2)[2] bin levels and an 80% "trigger." The trigger is the *Cryptosporidium* concentration reaching 80% of the next highest bin level at a drinking water intake.

In the following section, quoted comments from the review are shown in italics followed by a response. The page number from the report from which the quote was taken is listed after the quote. Similar comments are grouped together with one response.

Responses to Specific Questions and Comments on the Pathogen Design

How are the sites called "general characterization" (MDS, p. 61) to be used? The Fact Sheet for Pathogens (p. 6-7) says monitoring for ambient levels and sources "should entail representative discharge /effluent locations such as wetlands, urban runoff, POTWs, agricultural/farmland animal areas." It is not apparent that the locations selected for the study are near such areas (see Figure, MDS, p. 62). (p. 8)

The "general characterization" sites (Sacramento River at Hood, Rock Slough, Old River) are "integrator sites," and are representative of multiple sources (e.g., Hood is downstream of urban runoff, POTWs, and agriculture). They are representative of conditions in the Delta between potential sources of interest and existing or proposed water intake or export locations. When considered in conjunction with the source-specific sites, they can inform

[1] http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2013-0098_res.pdf#page=7

[2] https://www.gpo.gov/fdsys/pkg/FR-2006-01-05/pdf/06-4.pdf

the source evaluations if a follow up investigation in response to a trigger exceedance is needed (i.e., if a trigger signal persists upstream toward the sources).

MDS, p. 14. Pathogens - Cryptosporidium and Giardia only have narrative WQO - "Waters shall not contain C and G in concentrations that adversely affect ...MUN beneficial uses." What is that level? How do we know what a reasonable detection limit needs to be? (p.8)

The Basin Plan Amendment defined that the narrative objective is for the public water system component of the MUN beneficial use. The Basin Plan Amendment specification of the LT2 bin levels and the 80% "trigger" are designed to maintain existing conditions for public water systems, and therefore support the narrative water quality objective. The Basin Plan Amendment notes that a trigger exceedance is not an exceedance of the narrative water quality objective, but may prompt action from the Regional Water Board.

The Delta RMP Pathogen Study is designed to fulfill the special study requirement described in the Basin Plan Amendment. The Basin Plan Amendment specifies that the special study will be performed in conjunction with drinking water intake LT2 monitoring, and the LT2 program specifies use of EPA Method 1623. LT2 bin levels consider method performance, including factors of safety for protection of the drinking water beneficial use. A reasonable detection limit and analytical method should then be consistent with the acceptance criteria in EPA Method 1623.

MDS, p. 60. This involves "triggers". What are they and how are they determined? (p. 8)

The "trigger" is specified in the Central Valley Drinking Water Policy Basin Plan Amendment. The Basin Plan Amendment defines the trigger as the *Cryptosporidium* concentration reaching 80% of the next highest bin level at a drinking water intake. The *Cryptosporidium* concentrations corresponding with the bin level classifications are defined by the LT2. The 80% value was used in the Basin Plan Amendment to provide an additional factor of safety so that drinking water agencies may have additional time to plan for or perform management actions to prevent bin level changes.

MDS, p. 61. Fate and transport should include a consideration of hydrodynamics. How will sources be identified with this study design? (p. 8)

Special study/studies would be performed during Year 2 if a likely trigger exceedance is detected at a drinking water intake. Within the section describing the Year 2 Special Studies, the Design Summary includes a description of hydrodynamic modeling that could be performed. It is anticipated that the water quality data used in conjunction with the hydrodynamic fingerprinting would be used to identify the boundaries and inform a more detailed fate and transport evaluation, if necessary.

During the Year 2 Special Studies, sources could be discerned using the flowchart process. The process for the source evaluation includes an external data evaluation (WWTP monitoring, other monitoring, and from literature review), and microbial source tracking if there is sufficient detection at an intake or source location.

QAPP, p. 31. Another program is also collecting pathogens at different sites? Are the analytical methods, quantification limits, etc. similar between the lab that MWQI uses and that which RMP uses? (p. 8)

MWQI is collecting ambient pathogen samples for the Delta RMP, and there is no separate ambient sampling taking place. Drinking water agencies are concurrently collecting monthly samples at their intakes, and many of them are using the same labs as the RMP. The LT2 program specifies approved analytical methods and laboratories that can perform the work. Both concurrent efforts are following LT2 requirements.

"MWQI ... at each of the locations shown in Table A-1..." There is no Table A-1. (p. 8)

Thank you for the feedback. This reference is incorrect, and should refer to the table of ambient monitoring locations in the Delta RMP monitoring design study (page 63).

QAPP, p. 112. Table 3.5 lists values for Cryptosporidium only - are those values what the monthly sampling will be compared against? What will the Giardia sample results be compared against? (p. 8)

Table 3.5 contains the bin level classifications are defined by the LT2. The *Cryptosporidium* concentrations corresponding to the bin levels are the highest annual running arithmetic mean concentration. There is no similar requirement for *Giardia,* as the LT2 establishes the bin levels for *Cryptosporidium* to ensure that drinking water treatment processes will also remove other pathogens (e.g., *Giardia*, viruses) from intake water. While *Giardia* results are not specifically used for trigger values, they will be evaluated for spatial trends and co-occurrence with other factors (e.g., triggers, storm events, etc.).

Intersect of Delta RMP management and assessment questions with priority management drivers

The table shows the original RMP assessment questions. Questions highlighted in yellow have strong overlap with the priority management drivers: the Methylmercury TMDL, Pyrethroids TMDL, Nutrient Research Plan, and Pathogens Basin Plan Amendment. Questions (or parts of questions) that are underlined are currently being addressed by the Program. Unmet data needs for the management drivers are listed in the bottom row.

Type	Core Management Questions	Mercury (MeHg TMDL)	Pesticides (Pyrethroids TMDL)	Nutrients (Nutrient Research Plan)	Pathogens (Basin Plan Amendment)
Status & Trends	Is there a problem or are there signs of a problem? a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?	1. What are the status and trends in ambient concentrations of total mercury and methylmercury (MeHg) in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large-scale restoration projects)?* A. Are trends over time in MeHg in **sport fish** similar or different among Delta subareas? B. Are trends over time in MeHg in **water** similar or different among Delta subareas?	1. To what extent do current use pesticides contribute to observed toxicity in the Delta? 1.1. Which pesticides or degradates have the highest potential to be causing toxicity in the Delta and therefore should be the priority for monitoring and management? A. If samples are toxic, do detected pesticides explain the toxicity? B. If samples are not toxic, do detected pesticide concentrations exceed other thresholds of concern (e.g., water quality objectives or Office of Pesticide Programs aquatic toxicity benchmarks)? 1.2. What are the spatial and temporal extents of lethal and sublethal aquatic and sediment toxicity observed in the Delta?	1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally? A. Are trends similar or different across subregions of the Delta? B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology? C. Are there important data gaps associated with particular water bodies within the Delta subregions? 2. What is the current status of the Delta ecosystem as influenced by nutrients? A. What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?	1. Are current pathogen levels supportive of the municipal drinking water quality beneficial use as described in the Basin Plan? A. Are the current pathogen levels for each Delta water intake and those immediately upstream (i.e., Sacramento Area) different than the previous LT2 sampling? Are any drinking water intakes reclassified

Type	Core Management Questions	Mercury (MeHg TMDL)	Pesticides (Pyrethroids TMDL)	Nutrients (Nutrient Research Plan)	Pathogens (Basin Plan Amendment)
			A. Do aquatic or sediment toxicity tests at targeted sites indicate a toxic response? B. If answer to A is yes, which other toxicity indicator(s) should guide monitoring and management of pesticides in Years 2+? 2. What are the spatial/temporal distributions of concentrations of currently used pesticides identified as likely causes of observed toxicity? 2.1. Which pesticides have the highest risk potential (based on DPR's risk prioritization model[1]) and should be included in chemical analyses? A. Is the list of pesticides included in USGS pesticide scan sufficient for Delta RMP monitoring design? B. Are methods available to monitor pesticides with high-risk potential not included in USGS pesticide scan? 2.2. How do concentrations of the pesticides with the highest risk potential vary seasonally and spatially?		into a higher bin level? B. Are Basin Plan trigger values exceeded?

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

Type	Core Management Questions	Mercury (MeHg TMDL)	Pesticides (Pyrethroids TMDL)	Nutrients (Nutrient Research Plan)	Pathogens (Basin Plan Amendment)
Sources, Pathways, Loadings & Processes	Which sources and processes are most important to understand and quantify? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?	1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish? A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)? B. How do internal sources and processes influence methylmercury levels in fish in the Delta? C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct	1. What are the principal sources and pathways responsible for aquatic and sediment toxicity observed in the Delta? 2. What are the fates of prioritized pesticides and degradates in the environment? 2.1. Do physical/chemical properties of priority pesticides, application rates and processes, and ambient conditions influence the degree of toxicity observed? 3. What are the spatial/temporal use patterns of priority pesticides?	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. Which factors in the Delta influence the effects of nutrients? F. What are the types and sources of nutrient sinks within the Delta? G. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects?	1. Can any changes in bin level[2] be attributed to an identifiable event, condition, or changes in a source? A. What is the influence of sources on pathogen levels at drinking water intakes? B. What is the viability and infectiousness of pathogens at drinking water intakes? C. Are there new discharges or changes in sources or conditions that could explain the change in bin level compared to

[2] EPA has developed the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 rule), which classifies filtered water systems into one of four treatment categories (bins) based on their monitoring results for *Cryptosporidium*. Most systems are expected to be classified in the lowest bin and will face no additional requirements. Systems classified in higher bins must provide additional water treatment to further reduce *Cryptosporidium* levels by 90 to 99.7 percent (1.0 to 2.5-log), depending on the bin. From: Rule Fact Sheet - Long Term 2 Enhanced Surface Water Treatment Rule (USEPA 2005).

Type	Core Management Questions	Mercury (MeHg TMDL)	Pesticides (Pyrethroids TMDL)	Nutrients (Nutrient Research Plan)	Pathogens (Basin Plan Amendment)
		deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels in fish in the Delta?			previous LT2 monitoring? 2. What are the factors affecting decay and growth rates and can they be quantified and characterized for the purpose of modeling?
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?	1. How do pesticide concentrations respond to different management scenarios? 2. What current use pesticide loads can the Delta assimilate without exceeding water quality criteria established to protect beneficial uses? 3. How will climate change affect concentrations and/or loadings of pesticides and impacts to aquatic species?	1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?	1. What is the effect of source controls on pathogen levels at drinking water intakes? 2. How will proposed restoration projects, water operations, and future urban growth affect municipal drinking water intake bin levels?
Effectiveness Tracking	a. Are water quality conditions improving as a result of management actions such that beneficial uses will be met? b. Are loadings changing as a result of management actions?	[none]	4. Are pesticide-related toxicity impacts decreasing over time?	[none]	[none]

Type	Core Management Questions	Mercury (MeHg TMDL)	Pesticides (Pyrethroids TMDL)	Nutrients (Nutrient Research Plan)	Pathogens (Basin Plan Amendment)
Information Needs Not Addressed by the Delta RMP Assessment Questions		Aqueous methylmercury and total mercury concentrations, and concurrent data on ancillary parameters including characterization of suspended particulate matter are needed to calibrate, validate, and run DWR's models of mercury in the Delta and Yolo Bypass. The model will be useful for forecasting. In addition, multi-year aqueous data are needed in order to track trends. Ambient methylmercury wasn't monitored across the Delta since 2008 (until the DRMP started quarterly monitoring in 2016).	For the pyrethroids TMDL and Basin Plan amendment, the sampling sites need to be in or representative of impaired waters (i.e., urban creeks, small ag creeks)- . -The pyrethroids conditional prohibition is focused on meeting pyrethroid triggers in discharges (rather than in receiving waters), but if a receiving water is representative of the discharge then monitoring may be in the receiving water – this would primarily apply to effluent-dominated or smaller water bodies (i.e., not large integrator sites or the inner Delta).	- How are nutrients linked to impairments of beneficial uses and adverse ecosystem impacts in the Delta? Specific water quality concerns are harmful algal blooms, low dissolved oxygen, invasive aquatic macrophytes, and low primary productivity. - What conditions, indicate that nutrient-related impairments are occurring? Question S&T 2 could address these questions, but the effort would be most useful if prioritized or focused on status of nutrient-related problems (not ecosystem status as a whole).	

* The fish and water monitoring currently underway has limited ability to inform about effects of restoration and land use changes (e.g., significant floodplain reconnections). DWR's model for the Delta is likewise not aimed at making predictions about these changes on the scale that they are happening in the Delta. RMP has the potential to gather the data; it would mean different fish species and locations.