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San Francisco Bay Nutrient Management Strategy: Detailed Modeling Workplan for FY15-FY21

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San Francisco Bay Nutrient Management Strategy
Detailed Modeling Workplan for FY15-FY21

Final Report

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1. Introduction

San Francisco Bay has long been recognized as a nutrient-enriched estuary, but one that has exhibited resistance to some of the classic symptoms of nutrient over enrichment, such as high phytoplankton biomass and low dissolved oxygen. However, recent observations indicate that the Bay's resistance to high nutrient loads is weakening, leading regulators and stakeholders to collaboratively develop the San Francisco Bay Nutrient Management Strategy (NMS; SFBRWQCB, 2012). The NMS aims to address four overarching management questions (Table 1), and lays out an approach for building the scientific foundation to inform the related upcoming, and potentially costly, management decisions. Among its recommendations, the NMS calls for developing models to quantitatively characterize the Bay's response to nutrient loads; explore ecosystem response under future environmental conditions; and test the effectiveness of load reduction scenarios and other scenarios that mitigate or prevent impairment.

In January 2014, SFEI prepared a white paper with recommendations for developing and applying models to inform nutrient management decisions in San Francisco Bay[1] (SFEI #705, 2014). The white paper recommended using the the Deltares suite of models and a phased approach to modeling. At its June 25, 2014 meeting, the Nutrient Steering Committee, the joint stakeholder and regulator decision-making body that oversees the NMS' implementation, approved funding to begin implementing that plan in FY15 .

The purpose of this report is to present a detailed workplan for the initial stages of the NMS model development and model application, based on the recommendations from SFEI #705 (2014) and additional input from a team of technical advisors. Specifically, the objectives for this report are to:

- Outline the general approach for modeling, including quality assurance and peer review,
- Describe the specific tasks, deliverables and schedule for modeling, and how those tasks address key management questions,
- Identify the parties who will be responsible for modeling, and
- Calculate the overall budget for modeling.

The workplan covers the period FY15-FY21 in detail, a time period determined based on the estimated effort and workflow required to complete key model development and model application tasks. Additional modeling goals and activities beyond FY21 are also discussed but in lesser detail.

[1] http://www.sfei.org/sites/default/files/Nutrient_Modeling_Approach_draftFINAL_Jan212014.pdf

2. Approach

The nutrient modeling program will use a phased approach to model development and application, quality assurance protocols, and an open-source modeling platform to promote efficiency, produce quality results, and maximize the value of the modeling investment.

Phased Approach

Work on water quality model development will proceed in a phased approach. For Phase 1, models will be simplified-domain, several to tens of boxes, driven by simplified but "real" hydrodynamics obtained through grid aggregation of an existing hydrodynamic model. Those models will be developed and applied in South Bay/Lower South Bay and Suisun Bay. The simplified domain models will allow effort to be directed toward parameter sensitivity analysis, subembayment scale calibration, exploration of underlying causes of observed changes in ecosystem response, and identification of key data needs to help prioritize among other research and monitoring activities in subsequent years. For Phase 2, work will gradually move toward higher degrees of spatial resolution, building toward a whole bay model, and will provide provisional answers to key management questions about the transport, cycling, and ecological effects of nutrients in the Bay. Phase 3 modeling will involve more complicated and/or multi-year scenarios to answer management questions with a higher degree of certainty.

At a two-day model planning meeting in January 2014, technical advisors strongly recommended pursuing this path of gradual development from simplified domain to more complex and larger-scale models. The rationale for pursuing this path is that sensitivity analysis becomes increasingly computationally-intensive, and data interpretation becomes much more complex, as a model becomes larger and more highly resolved. The Phase 1 focused studies will provide output that will ultimately help to reach the goal of a calibrated/validated model more rapidly, and, along the way, will provide preliminary answers to key management questions (Table 1). Phase 1 studies will also help to prioritize among additional data collection needs that will improve model calibration. The phased approach also allows the underlying hydrodynamic model to undergo continued development while work moves forward on the water quality models.

Quality Assurance

The model development process will follow widely accepted guidelines for quality assurance to produce accurate and transparent results. A recent U.S. Environmental Protection Agency guidance document recommended four specific practices for developers of environmental models used for regulatory decision-making (USEPA, 2009 at vii):

- Subject the model to credible, objective peer review;
- Assess the quality of the data used in the model;
- Corroborate the model by evaluating the degree to which it corresponds to the system being modeled; and
- Perform sensitivity and uncertainty analysis.

SFEI will conduct peer reviews, establish data quality objectives, and follow a structured modeling process to ensure that all four of these recommended best practices are completed.

Peer Review

The modeling process and products will be peer reviewed by a Modeling Advisory Team (MAT) and, if deemed necessary for the Nutrient Management Strategy process, additional peer review.

The MAT will consist of 2-4 national experts in relevant disciplines and will be responsible for reviewing the major technical work products produced over the full length of this project. MAT members will not be involved with the modeling work directly to avoid conflict of interest. However, by being involved with the project over multiple years, the MAT members will be familiar with the study area, program goals, and prior stages of model development and refinement. The MAT will meet in person at least once per year, with the first meeting to be held in FY16.

Convening the MAT is intended to meet the Nutrient Management Strategy's need for detailed external peer review of highly technical work products. If deemed necessary for the Nutrient Management Strategy process, additional peer reviewers could also be convened at critical stages of the modeling process to provide an outside review of the work to date. The costs and time required to convene additional peer review panels are included in the budget and timeline, but these tasks are considered optional at this point.

Data Quality Objectives

The Data Quality Objective Planning Process will be used to clearly define the purpose of the models or modeling activity, the quality of input data, and model performance objectives. USEPA (2006) offers useful guidance on this planning process, with self-evident benefits (see Figure 1). The level of detail and specificity in planning documents will match both the stage of modeling and management implications of the model results.

Structured Modeling Process

Each model will be produced and documented following a three-step modeling process (Figure 2). The basic purpose and main components of the three steps are defined as (USEPA, 2009 at 6):

Model development: develop the conceptual model that reflects the underlying science of the processes being modeled, and develop the mathematical representation of that science and encode these mathematical expressions in a computer program.
Components: Conceptual Model, Code Verification, Model Calibration

Model evaluation: test that the model expressions have been encoded correctly into the computer program and test the model outputs by comparing them with empirical data.

Components: Model Corroboration (validation), Sensitivity Analysis, Uncertainty Analysis

Model application: run the model and analyze its outputs to inform a decision.
Components: Model Predictions, Assessments

By following this structured modeling process, SFEI will complete the corroboration and sensitivity/uncertainty analyses recommended for model quality assurance. The Deltares suite of models selected for the Bay nutrient modeling effort offer the advantage that they are widely-used, peer-reviewed, and open-source models. In that sense, the model development steps related to encoding mathematical expressions into a computer program and verifying that the encoding has been done correctly have already been largely completed through past efforts for the more widely-used and peer-reviewed model components. Model development and evaluation steps specific to San Francisco Bay model will, of course, still be required. In addition, there will undoubtedly be some need to verify and evaluate new modeled processes, or new approaches/parameterizations for a process, that are introduced during the Bay modeling effort.

SFEI will produce reports at key stages of the model development and application process for stakeholder review and peer review either by the MAT or external reviewers. For the whole bay models, a model development and evaluation report will be produced and reviewed first, before starting on lengthy and expensive model applications. For smaller, subembayment models, all of the modeling steps will be documented in one combined model development-evaluation-application report.

<u>Open-Source Community Modeling Platform</u>

While nutrient management decisions will remain the primary driver and focus behind model development, an additional goal is to facilitate the model's use as an open-source, community model for a broad range of applications to address both management questions and fundamental research questions. The current plan is for SFEI to serve as the hub for this model, in collaboration with USGS and Deltares. The corroborated base model will be shared freely with all interested users, and periodically updated to incorporate model refinements. The stipulation for all users will be that any refinements or improvements to the model will also be open-source and freely available, and archived at the model hub.

The "community model" approach will have benefits both for the nutrient science program and for other topics of interest to regional monitoring programs in both the Bay and the Delta, regulators, dischargers, and environmental managers/planners. Having a large user base will lower SFEI's marginal costs for model enhancements and model maintenance. Nutrient-related funding will be directed toward developing components that are essential for nutrients, and collaborators may pursue funding from other sources to develop additional model capabilities, ultimately expanding the user community.

3: Detailed Modeling Workplan

In the following section, the major modeling tasks, deliverables and schedule have been outlined. Gantt charts that illustrate the timing of the tasks and when information will be available to answer management questions are provided in Figures 3 and 4. See Table 2 for major model evaluation questions at each stage. The modeling stages and the timing of answers to management questions (rated low, medium, and highest confidence) were designed considering three major factors: realistic timelines for model development; progress in other areas of the Nutrient Management Strategy implementation (e.g., assessment framework development; data collection through monitoring and special studies); and regulatory drivers, such as the timing of Nutrient Watershed Permit reissuance, and related modeling-related information needs. Major work products will be reviewed by the MAT or external peer reviewers, as indicated in Figure 3. The project durations and deliverable dates are approximate, especially those beyond FY16, and will be updated periodically.

Phase 1 Tasks

1.1 Phase 1 Hydrodynamic Modeling

Description: As described in the modeling development plan (SFEI #705, 2014), the USGS-led CASCaDE II project represents the best starting point and opportunity for developing and sustainably maintaining a hydrodynamic model of the necessary complexity to address the range of nutrient-related modeling needs. Therefore, NMS modeling resources will be directed toward supporting and customizing the CASCaDE II products, rather than creating a separate hydrodynamic model. Specific steps include:

- Provide financial support for the USGS-led CASCaDE II project to develop a calibrated and validated hydrodynamic model for the Bay-Delta. The CASCaDE II project is scheduled to be complete by 6/30/15 with a calibrated/validated model for the Bay-Delta as the final product. In addition to hydrodynamic variables, the model will be calibrated for water temperature and salinity.
- After the CASCaDE II project is complete, NMS modeling funds will be directed toward further hydrodynamic model refinement or customization for nutrient modeling, working with key collaborators (e.g., USGS, UC Berkeley, Deltares, and other institutions).

Deliverables and Schedule:

Task	Deliverable	Completion Date
1.1a	Provide financial support to USGS and Deltares to develop the CASCaDE II Hydrodynamic Model	6/30/15
1.1b	Customize the CASCaDE II Hydrodynamic Model for Nutrient Modeling	6/30/16

1.2 Phase 1 Water Quality Modeling: Lower South Bay and South Bay Water Quality Model

Description: The goal of this task is to develop a subembayment-scale water quality/ phytoplankton/ grazing model for the South Bay and Lower South Bay. The standard DELWAQ code from Deltares contains the vast majority of the biogeochemical/ecological processes that need to be included in the base model. The goals of Task 1.2 are: (1) to develop models that produce results that are conceptually correct, internally consistent, and sufficiently accurate to carry out sensitivity analysis and hypothesis testing at subembayment scales (or in simplified space/time domains); and (2) to begin exploring several fundamental questions about factors that regulate ecosystem response (Figure 4). Specific tasks include:

- Develop a Data Quality Objectives Project Plan that contains the study objectives and model design.
- Perform simplified domain experiments for sensitivity analysis and hypothesis testing/generating (e.g., 1-box, 2-box).
- Develop aggregated models (e.g., several grid cells up to 10s of grid cells) for Lower South Bay and South Bay and carry out sensitivity analysis, initial calibrations, and focused experiments that address high priority science questions. In these studies, water quality will be driven by realistic hydrodynamic input that has been aggregated to the same grid.
- Produce a combined model development-evaluation-application report. This report will contain details of the model development (calibration), evaluation (validation), and application. A preliminary list of model evaluation questions is shown in Table 2.

Deliverables and Schedule:

Task	Deliverable	Completion Date
1.2a	Data Quality Objectives Project Plan	3/31/15
1.2b	Combined Model Development-Evaluation-Application Report	6/30/16

1.3 Feasibility Studies for Modeling Tidal Sloughs and Phytoplankton Community Composition

Description: The goal of this task is to evaluate needs and approaches for modeling processes in tidal sloughs and modeling phytoplankton community composition not directly addressed by whole Bay hydrodynamic and “basic” water quality modeling, but that are nonetheless important issues within the context of the NMS.

The tidal sloughs in South Bay are very small features compared to the whole bay. However, they may represent disproportionately valuable habitat for aquatic organisms, and data evaluated to date suggests that some sloughs experience frequent low DO events (SFEI #731, 2014). Moreover, these systems may contribute nontrivial amounts of phytoplankton biomass to the open Bay and be areas of important biogeochemical transformations (denitrification, aerobic respiration), which may need to be included in the open-Bay models. For those reason, some degree of modeling is needed in the sloughs; however, the ultimate amount of required effort for slough modeling still needs to be determined. While the whole bay model can provide boundary conditions for sloughs, it cannot be used to model dissolved oxygen dynamics, phytoplankton production, or nutrient transformations in the sloughs. Therefore, a separate set of models would be needed for tidal sloughs and connected tidal marshes.

Phytoplankton community composition (e.g., the specific species of phytoplankton present in the Bay), and conditions that may favor the proliferation of harmful or nuisance algae species, is considered a priority issue in the Nutrient Management Strategy. Developing and applying models that can yield valuable insights to this issue are expected to be a challenging undertakings, and appropriate modeling approaches need to be considered in more detail.

For Task 1.3, SFEI will explore the feasibility of and data requirements for using models to understand water quality (e.g., dissolved oxygen and phytoplankton biomass) in tidal sloughs, and the feasibility of and data requirements for using models to understand factors that regulate phytoplankton community composition. If feasible, models for these parameters will be developed during Phase 2. Specific steps in Task 1.3 include:

- Research available models for tidal sloughs, outline the strengths and weaknesses of each in a report, conduct simplified modeling of sloughs, and present recommendations for the modeling approach for Phase 2. It is possible that the Deltares suite of models remains the best choice. However, there may be more suitable models, depending on the necessary level of hydrodynamic complexity and resolution. Deltares is currently collaborating with USGS on hydrodynamic and sediment transport studies in Alviso Slough, and it is likely that DELWAQ can be scaled to simulate water quality in this habitat. However, the data requirements, both in terms of hydrodynamics and water quality, for developing a valid model are not known.
- Research available models for phytoplankton community composition, outline the strengths and weaknesses of each in a report, and present recommendations for the Phase 2 modeling approach. The goal is to identify modeling approaches (including those that are included in existing Deltares modules) and necessary data inputs that would allow a subset of management questions related to harmful algal species or shifts in species composition to be explored.

Deliverables and Schedule:

Task	Deliverable	Completion Date
1.3a	Tidal Slough Model Feasibility Study Report	6/30/16
1.3b	Phytoplankton Composition Model Feasibility Study Report	6/30/16

1.4 Update Model Development Plan

Description: Based on findings from Phase 1 modeling, peer reviews by the MAT, and potentially another external peer review, SFEI will update the Model Development Plan before starting on Phase 2 modeling. Specific steps to include:

- Update the Model Development Plan. This update will include identifying priority monitoring or research needs for Phase 2 models, revisiting the priority science questions, and developing a refined list and schedule of prioritized modeling studies.

Deliverables and Schedule:

Task	Deliverable	Completion Date
1.4	Update to Model Development Plan	3/31/17

Phase 2 Tasks

2.1 Phase 2 Hydrodynamic Modeling

Description: As specific model requirements emerge through Phase 1 work, necessary refinements of the CASCaDE II hydrodynamic model will likely become evident, including refinements that allow for more computationally-efficient (faster) simulations, to more readily support evaluating multiple scenario and performing multi-year runs. Since funding for CASCaDE II will end in June 2015, work on model refinement would need to proceed supported by NMS funding or with resources that result from additional fundraising efforts. On-going hydrodynamic model refinement will proceed through continued partnership between SFEI and established partners (USGS, UC Berkeley, Deltares, and other institutions) or new collaborations. Specific steps may include:

- Incorporate additional NMS-funded refinements into the CASCaDE II model.
- Coordinate with USGS, Deltares, and other groups on any updates to the model that occur in parallel to the NMS effort.

Deliverables and Schedule:

Task	Deliverable	Completion Date
2.1a	Further Refine and Optimize CASCaDE II Hydrodynamic Model for Nutrient Modeling Applications	6/30/18*

*While this task is noted as being sufficiently complete by 6/30/18 for Phase 2 modeling, it is likely that refinements to the hydrodynamic model will be an ongoing task.

2.2 Phase 2 Water Quality Modeling: Whole Bay Water Quality Model

Description: The goal of this task is to develop a whole bay water quality/ phytoplankton/ grazing model building upon the experience gained through the subembayment-scale models developed during Phase 1. The peer-reviewed CASCaDE II hydrodynamic model will be the hydrodynamic model used to drive the water quality model. Water quality parameters for nutrients, phytoplankton, and dissolved oxygen will be modeled by refining and scaling-up the DELWAQ-based model that was developed during Phase 1.

Due to its size and complexity, we anticipate the whole bay model will be developed in stages, although the sequencing proposed here may change based on observations from Phase 1. Specific steps may include:

- Develop a Data Quality Objectives Project Plan or Quality Assurance Project Plan that contains the study objectives and model design.
- Combine the CASCaDE II hydrodynamic model for the whole bay with a water quality model for nutrient cycling and carry out model sensitivity analysis, initial calibrations, and focused experiments that address science questions. This work will proceed in stages, with the primary focus moving methodically between the major model components (e.g., nutrients,

phytoplankton response, dissolved oxygen), among regions or habitats of the Bay or specific time periods, and the level of spatial aggregation/disaggregation. More specific sequencing and distribution of Phase 2 effort will be presented in detail in the revised Model Development Plan (Task 1.4) based on experience from Phase 1, and will be managed adaptively through regular updates to the modeling plan. Major components are noted below.

- Develop the nutrient cycling components of the water quality model and carry out sensitivity analysis, calibrations and focused experiments to answer key science questions. This phase of model development will be documented in a combined model development-evaluation report.
- Develop the phytoplankton (and potentially benthic algae) and dissolved oxygen components of the water quality model and carry out sensitivity analysis, calibrations, and focused experiments to answer key science questions. This phase of model development will be documented in a combined model development/evaluation report.
- Perform model simulations to answer key management questions related to current conditions (see Table 1). The model applications will be documented in a model application report.

Task	Deliverable	Completion Date
2.2a	Data Quality Objectives Project Plan or Quality Assurance Project Plan	9/30/17
2.2b	Model Development and Evaluation Report for Nutrient Cycling	6/30/18
2.2c	Model Development and Evaluation Report for Phytoplankton and Dissolved Oxygen	3/31/19
2.2d	Model Application Report for Single-Year Whole Bay Simulations	6/30/20

2.3 Phase 2 Water Quality Modeling: Suisun Bay Water Quality Model

Description: The goal of this task is to develop a subembayment-scale water quality/ phytoplankton/ grazing model for Suisun Bay, *if such a subembayment model is needed, beyond the whole-Bay modeling work, to answer fundamental questions about factors that regulate ecosystem response in Suisun* (Table 1). Suisun Bay is an important location for understanding the impacts of nutrients delivered from the Delta. This task would address Suisun-specific issues related to nutrient cycling or ecosystem response, to the extent that those issues are more efficiently explored in a Suisun subembayment model as opposed to the whole bay model. The timing of this task, if it is necessary, will also allow the Suisun subembayment model to take full advantage of further refined hydrodynamic model input and experience gained through the South and Lower South Bay model (Task 1.2). Specific steps to include:

- Develop a Data Quality Objectives Project Plan that contains the study objectives and model design.

- Perform simplified domain experiments for sensitivity analysis and hypothesis testing/generating (e.g., 1-box, 2-box).
- Develop fine-scale or aggregated models (e.g., several grid cells up to 10s of grid cells) for Suisun Bay and carry out sensitivity analysis, initial calibrations, and focused experiments that address high priority science questions. In these studies, water quality will be driven by real hydrodynamic input that has been aggregated to the same grid.
- Produce a combined model development-evaluation-application report. This report will contain details of the model development (calibration), evaluation (validation), and application. A preliminary list of model evaluation questions is shown in Table 2.

Deliverables and Schedule:

Task	Deliverable	Completion Date
2.3a	Data Quality Objectives Project Plan	9/30/18
2.3b	Combined Model Development-Evaluation-Application Report	6/30/19

2.4 Phase 2 Water Quality Modeling: Slough Water Quality Models

Description: The feasibility of modeling dissolved oxygen in tidal sloughs will be evaluated in Phase 1. If deemed feasible, and necessary (based on other components of the Nutrient Management Strategy), a separate set of models may be needed for sloughs. In Task 2.4, models for tidal sloughs will be developed and applied toward exploring management questions related to the relationship between nutrients, phytoplankton (or benthic) production, dissolved oxygen, and other factors that regulate water quality (e.g., stratification, exchange with restored salt ponds). This task has been assigned a long timeline to allow for workflow flexibility alongside the whole Bay water quality modeling, and recognizing that the rate of progress on slough modeling may be limited by available funds. Note: Budget estimates in Section 5 do not necessarily include all costs associated with tidal slough water modeling. Specific steps include:

- Prepare a Data Quality Objectives Project Plan that contains the study objectives and model design.
- Develop and evaluate models for one or more individual sloughs (e.g., Alviso Slough). The initial plan is to use the same model from the Bay (DFM/DELWAQ) for the sloughs but focused on a nested grid with a finer spatial resolution. However, if the DFM/DELWAQ model is not effective for this application, a different model will be used. Similar to the approach for modeling open-area regions of the Bay, slough modeling will likely also proceed in a step-wise fashion, starting with aggregated models and adding complexity as needed.
- Produce a combined model development and evaluation report. This report will contain details of the model development (calibration) and evaluation (validation). A preliminary list of model evaluation questions is shown in Table 2.

- Perform model runs to partially answer key management questions (see Table 1). The model applications will be documented in a model application report.

Deliverables and Schedule

Task	Deliverables	Completion Date
2.4a	Data Quality Objectives Project Plan	9/30/17
2.4b	Model Development and Evaluation Report	12/31/18
2.4c	Model Application Report	6/30/20

2.5 Phase 2 Water Quality Modeling: Phytoplankton Community Composition Models

Description: The feasibility of developing phytoplankton community composition models will be evaluated in Phase 1. If deemed feasible, and necessary (based on other components of the Nutrient Management Strategy), a separate set of models or custom modules may be needed for phytoplankton community composition. In Task 2.5, models for phytoplankton community composition will be developed and applied toward exploring management questions related to the relationship phytoplankton community composition, nutrients, and other influential factors (temperature, light, etc.). Similar to Task 2.4, this task has been assigned a long timeline to allow for workflow flexibility around the whole bay water quality modeling, and recognizing that the rate of progress on phytoplankton composition models may be limited by available funds and the complexity of the task. Specific steps include:

- Prepare a Data Quality Objectives Project Plan that contains the study objectives and model design.
- Develop and evaluate models for one or more subembayments. Similar to the approach for modeling open-area regions of the Bay, phytoplankton community modeling will likely proceed in a step-wise fashion, starting with tractable approaches and adding complexity as needed.
- Produce a combined model development and evaluation report. This report will contain details of the model development (calibration) and evaluation (validation). A preliminary list of model evaluation questions is shown in Table 2.
- Perform model runs to address key management questions (see Table 1). The model applications will be documented in a model application report.

Deliverables and Schedule

Task	Deliverables	Completion Date
2.5a	Data Quality Objectives Project Plan	9/30/17
2.5b	Model Development and Evaluation Report	12/31/18
2.5c	Model Application Report	6/30/20

Phase 3: Out-Year Modeling Plans

This modeling workplan covers the first six years with the goal of (1) addressing critical management questions about nutrients in the estuary during the development phase and (2) building a robust platform capable of simulating conditions under multiple future scenarios.

In the out-years, the whole bay model will be applied toward answering more complicated management questions related to ecosystem response under future scenarios (e.g., changes in flows from the Delta due to withdrawals and rerouting; decreasing suspended sediments; climate change) and exploring the effectiveness of various nutrient load reduction scenarios.

The out-years will also likely be needed for refining tidal slough and phytoplankton community models, if such models are deemed both important and feasible.

Finally, in the out-years, the Bay-Delta model could be linked to near-shore coastal models to answer questions that are being asked about the the effects of nutrient exports from the Golden Gate on coastal eutrophication and harmful algal blooms, such as:

- What is the magnitude of nutrients exported to the coastal ocean, and what are the fate(s) of nutrients once exported coastal ocean?
- What are the impacts of nutrients exported to the coastal ocean?

The modeling tasks for the out-years are beyond the scope of this workplan, and so are not described in depth here. They will be developed through subsequent planning activities as the specific needs for those modeling activities become clearer.

4. Modeling Team

Phase 1 work will be carried by Core Team members (see Table 3 for potential members), consisting of SFEI staff and close external collaborators from academic institutions, research institutions (e.g., USGS, Deltares, UC Berkeley, others), and consulting firms. The expertise of the Core Team covers the major technical areas (e.g., hydrodynamics, biogeochemistry, phytoplankton dynamics), and will be complemented by individuals with specific expertise as needed. The Core Team also contains expertise with Delta modeling efforts, which will facilitate coordination between the Bay and Delta models. Full-time modeling staff at SFEI will carry out much of the hands-on water quality modeling work, although some specific hands-on technical work may be conducted by non-SFEI Core Team members. Hydrodynamic model refinements, beyond those performed within the CASCaDE II project, will be carried out by technical collaborators who are, or will become, part of the Core Team. The non-SFEI Core Team will serve three primary functions, with individuals contributing differently based on expertise and availability:

- Technical guidance during project planning stages and project start-up, and periodic meetings for regular project updates;
- In-depth, hands-on support from some individuals on specific topics, as needed; and
- On-going technical review of progress and major work products.

For Phase 2 and Phase 3, individual projects will be completed by the Core Team, external collaborators, or a combination of the two. The approach for selecting teams to work on specific projects will vary by project, and may depend on several factors, including the required expertise, time-sensitivity of the final product, and available budget. In some cases, the Core Team may be well-positioned to carry out the work; in other cases, sole-sourcing to a specific group or putting out a request for proposals may be the best route.

5. Budget

This model development workplan has been crafted to maintain a consistent level of effort over a six-year period. Major deliverables are typically spaced 6 months apart. The only variable costs are the optional second external peer reviews which might occur during FY17 and FY20. The total cost to implement this workplan is $3.7M over six years or approximately $620K per year (the peer review in FY21 not treated as a full year). This total cost does not include the cost of nutrient monitoring and research.

Line Item	FY15	FY16	FY17	FY18	FY19	FY20	FY21
SFEI Staff	$300,000	$309,000	$318,270	$327,818	$337,653	$347,782	
Contractors	$200,000	$206,000	$212,180	$218,545	$225,102	$231,855	
MAT Honoraria	$40,000	$41,200	$42,436	$43,709	$45,020	$46,371	
Second Peer Review (optional)			$100,000				$120,000
Total	$540,000	$556,200	$672,886	$590,073	$607,775	$626,008	$120,000
FY15-FY21 Total							$3,712,941

Budget Justification:

- SFEI staff: 1 new FTE modeler @ $240,000/yr plus contributions from existing SFEI staff @ $60K. This total includes $10,000 allocated for specialized computing hardware.
- Contractors: SFEI will contract with collaborators having specialized expertise to advise on model development and application, and carry out some aspects of model development. These contractors will be part of the Core Team. In 2015, $100,000 is being directed toward the collaboration with USGS and Deltares ($50,000: hydrodynamic model development/calibration; $50,000: BLOOM model development and benthic:pelagic coupling). After 2015, approximately $100,000 is budgeted for continued hydrodynamic model refinement or customization for nutrient modeling needs. Technical assistance from Deltares on water quality model set-up, hydrodynamics, grid aggregation, etc. was estimated at $50,000/yr. Additional specialized support will be needed during detailed modeling years.
- MAT Honoraria: MAT members will be paid an annual honorarium and will have travel expenses reimbursed. This budget assumes total expenses per MAT member to be $10,000 per year and that there will be up to 4 members of the MAT.
- External Peer Reviews: If deemed necessary for the Nutrient Management Strategy, the modeling products could be subjected to an external peer review by experts not on the MAT. A payment of $25,000 per reviewer would be necessary to obtain thorough and detailed reviews from outside experts. A four person panel would, therefore, cost $100,000. The schedule of deliverables and reviews has been carefully aligned to minimize the number of times a second

external panel would need to be convened (once in FY17 and once in FY21). The cost in FY21 was assumed to be $120,000.

- Costs for FY14 have been projected to future values using 3% discount rate for FY15-FY20.

6. References

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Table 1: Priority Management Questions and Associated Modeling Questions

Management Question	Science Questions for Modeling
1. Is San Francisco Bay currently experiencing nutrient-related impairment, or is impairment likely in the future?	Not Applicable. Questions about impairment will be addressed through the assessment framework and monitoring components of the Nutrient Management Strategy.
2. If nutrient-related impairment is occurring, or future impairment is likely, what are the relative contributions of different nutrient sources to impairment, and how do these contributions vary spatially or temporally?	How much do nutrient loads from known sources contribute to ambient nutrient concentrations in: (1) each subembayment of the Bay by season; and (2) South Bay sloughs by season? How much do nutrient loads from known sources contribute to phytoplankton blooms and low dissolved oxygen in: (1) each subembayment of the Bay by season; and (2) South Bay sloughs by season? Do the models indicate that all the major sources of nutrients to the Bay are accurately being measured? What is the relative importance of ammonia inhibition of primary production on phytoplankton biomass compared to other factors? What is the relative importance of nutrient concentrations or ratios relative to harmful algal blooms compared to other factors?
3. What nutrient loads can the Bay assimilate without impairment of beneficial uses?	Under what future conditions would adverse impacts be expected? *Scenarios*:prolonged stratification, loss of clams, increased water clarity, stochastic introduction(s) of opportunistic harmful phytoplankton species, changes in nutrient load mass or speciation, water diversions.
4. What load reductions or other management strategies may be effective at mitigating current problems or preventing future problems from occurring?	What potential effects would different control measures have on mitigating current or future problems at the subembayment (or finer) scale? Scenarios: Changes in wastewater treatment, habitat restoration, water management, etc

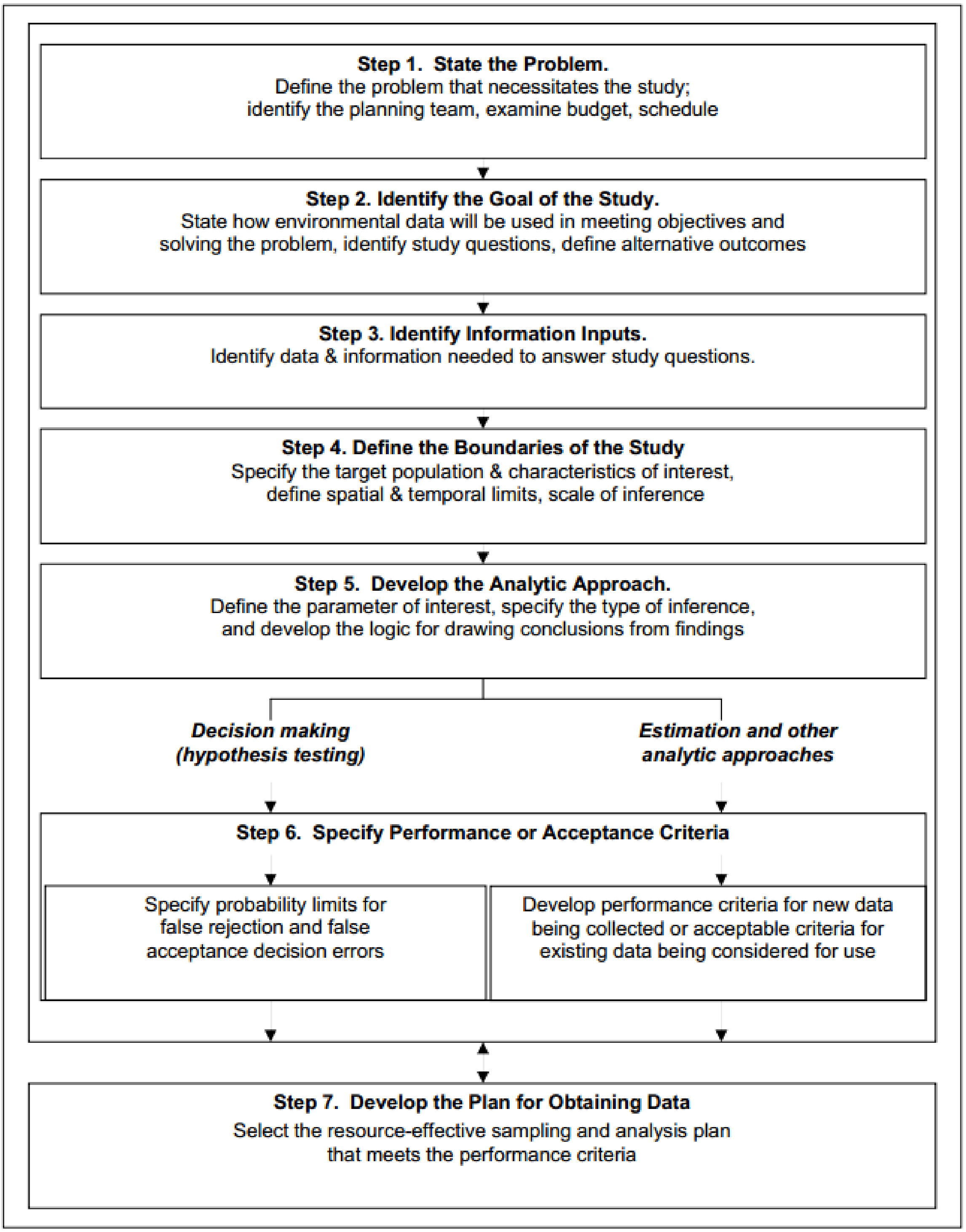
Table 2: Model Evaluation Questions

Model	Model Evaluation Questions
Phase 1 South Bay Water Quality Model	Can the parameterized model reproduce a similar (approximately three-fold) increase in phytoplankton biomass that has been observed in South Bay and Lower South Bay during summer and fall months since 1998? Can the parameterized model reproduce fall phytoplankton blooms that have been observed in South Bay and Lower South Bay after 1998? Can the parameterized model reproduce improvements in dissolved oxygen that were observed following wastewater treatment plant upgrades in the 1970s? What are the important mechanisms and highest priority data needs to improve model performance and decrease uncertainty?
Whole Bay Model or Suisun Bay Water Quality Model	Can the parameterized model reproduce a decrease in phytoplankton biomass that has been observed in Suisun Bay post-1987, and a gradual increase in biomass in Suisun Bay since the late 1990s? What are the important mechanisms and highest priority data needs to improve model performance and decrease uncertainty?
Whole Bay Model	Can the parameterized model predict the diurnal and seasonal variability in nitrogen and phosphorus that has been observed in deep water areas of each of the five subembayments of San Francisco Bay. Can the parameterized model predict the diurnal and seasonal variability in dissolved oxygen that has been observed in deep water areas of each of the five subembayments of San Francisco Bay? Can the parameterized model predict the diurnal and seasonal variability in phytoplankton biomass and composition that has been observed in deep water areas of each of the five subembayments of San Francisco Bay? What are the important mechanisms and highest priority data needs to improve model performance and decrease uncertainty?
Tidal Slough Models	Can the parameterized model predict the diurnal and seasonal variability in nitrogen and phosphorus that has been observed in South Bay sloughs? Can the parameterized model predict the diurnal and seasonal variability in dissolved oxygen that has been observed in South Bay sloughs? Can the parameterized model predict the diurnal and seasonal variability in phytoplankton biomass that has been observed South Bay sloughs? What are the important mechanisms and highest priority data needs to improve model performance and decrease uncertainty?
Phytoplankton Community Composition Model	Can the parameterized model reproduce the changes in phytoplankton community composition that have been observed in Suisun Bay post-1987?

Table 3: Potential Core Modeling Team Members (pending availability)

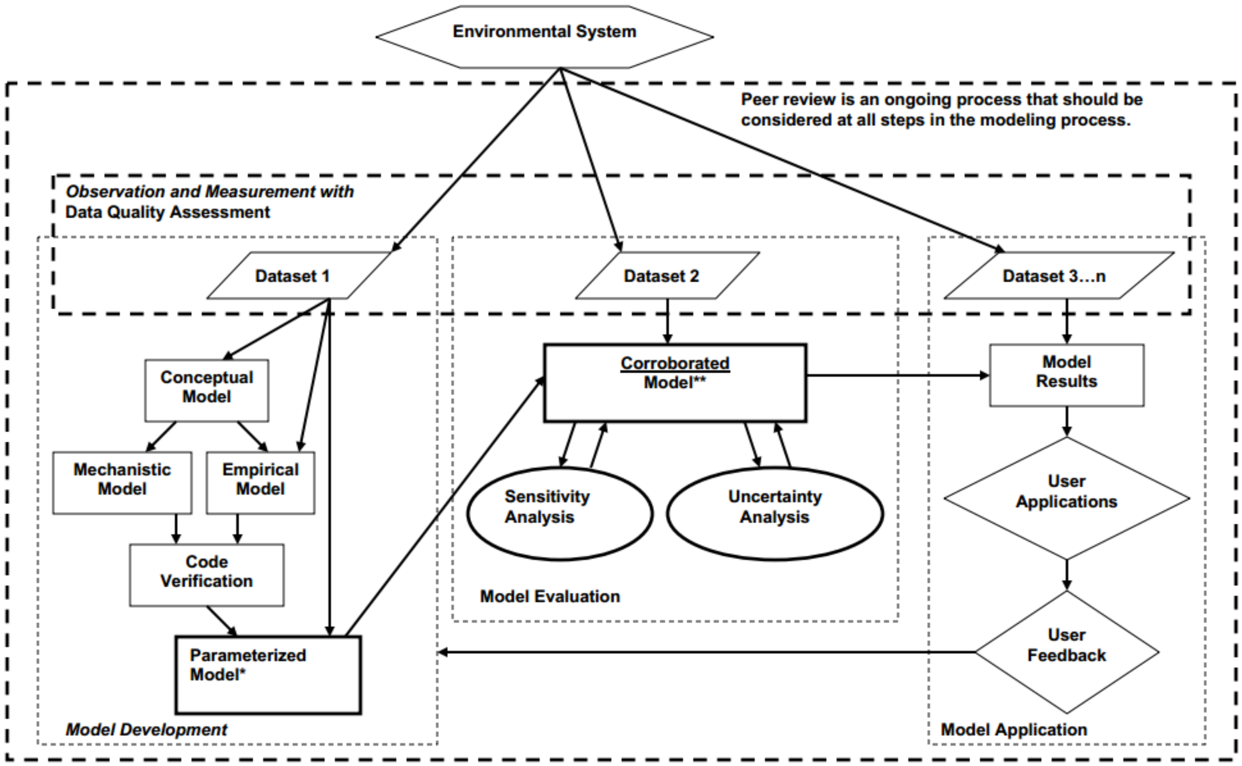
Name	Affiliation	Expertise
Mark Stacey	UC Berkeley	hydrodynamics
Lisa Lucas	USGS	hydrodynamics and phytoplankton productivity, benthic-pelagic coupling
Mick van der Wegen	Deltares, UNESCO-IHE	hydrodynamic modeling, sediment transport modeling
Ed Gross	UC Davis, RMA	hydrodynamic modeling
Craig Jones	Integral Consulting	sediment transport modeling
Jim Fitzpatrick	HDR-Hydroqual	water quality modeling
Johannes Smits	Deltares	water quality modeling
James Cloern	USGS	phytoplankton ecology, nutrients
Wim Kimmerer	SFSU-RTC	estuarine ecology, benthic and pelagic grazing
Oliver Fringer	Stanford	hydrodynamics, hydrodynamic modeling

Figure 1: Diagram of the Data Quality Objectives Planning Process



Source: USEPA (2006) at 8

Figure 2: Diagram of the Three-Step Modeling Process



Source: USEPA (2009) at 61

Figure 3: Gantt Chart for Model Development Tasks (Note: The current POTW Watershed Permit expires after FY19)

Task Name	Peer Review By
Modeling Workplan	
Phase 1: Pilot-Scale Water Quality Modeling and Feasibility Studies	
1.1 Hydrodynamic Modeling	
1.1a Complete CASCaDE II Hydrodynamic Model for the Bay-Delta (USGS/Deltares)	
1.1b Customize CASCaDE II Hydrodynamic Model for Nutrient Modeling	MAT
1.2 South Bay Water Quality Model	
1.2a. Data Quality Objectives Project Plan	MAT
1.2b. Combined Model Development-Evaluation-Application Report	MAT
1.3 Feasibility Studies	
1.3a Tidal Slough Model Feasibility Study Report	MAT
1.3b Phytoplankton Composition Model Feasibility Study Report	MAT
Second Peer Review of Phase 1 (optional)	Reviewers not on MAT
1.4 Update Model Development Plan	MAT
Phase 2: Whole Bay Water Quality Modeling and Specialized Applications	
2.1 Hydrodynamic Modeling	
2.1a Update and Optimize CASCaDE II Hydrodynamic Model for the Bay-Delta	MAT
2.2 Whole Bay Water Quality Model	
2.2a Data Quality Objectives Project Plan or QAPP	MAT
2.2b Model Development and Evaluation Report for Nutrient Cycling	MAT
2.2c Model Development and Evaluation Report for Phytoplankton and Dissolved Oxygen	MAT
2.2d Model Application Report for Single-Year, Whole Bay Simulations	MAT
2.3 Suisun Bay Water Quality Model [If Necessary]	
2.3a. Data Quality Objectives Project Plan	MAT
2.3b. Combined Model Development-Evaluation-Application Report	MAT
2.4 Tidal Slough Water Quality Model(s) [If Feasible]	
2.4a Data Quality Objectives Project Plan	MAT
2.4b Model Development and Evaluation Report	MAT
2.4c Model Application Report	MAT
2.5 Phytoplankton Community Model(s) [If Feasible]	
2.5a Data Quality Objectives Project Plan	MAT
2.5b Model Development and Evaluation Report	MAT
2.5c Model Application Report	MAT
Second Peer Review of Phase 2 (optional)	Reviewers not on MAT
Phase 3: Out-Year Model Applications	
3.1 Model Application Report for Multi-Year Simulations	MAT
3.2 Tidal Slough Water Quality Model Refinement	MAT
3.3 Phytoplankton Community Model Refinement	MAT
3.4 Linkage to Coastal Models	MAT

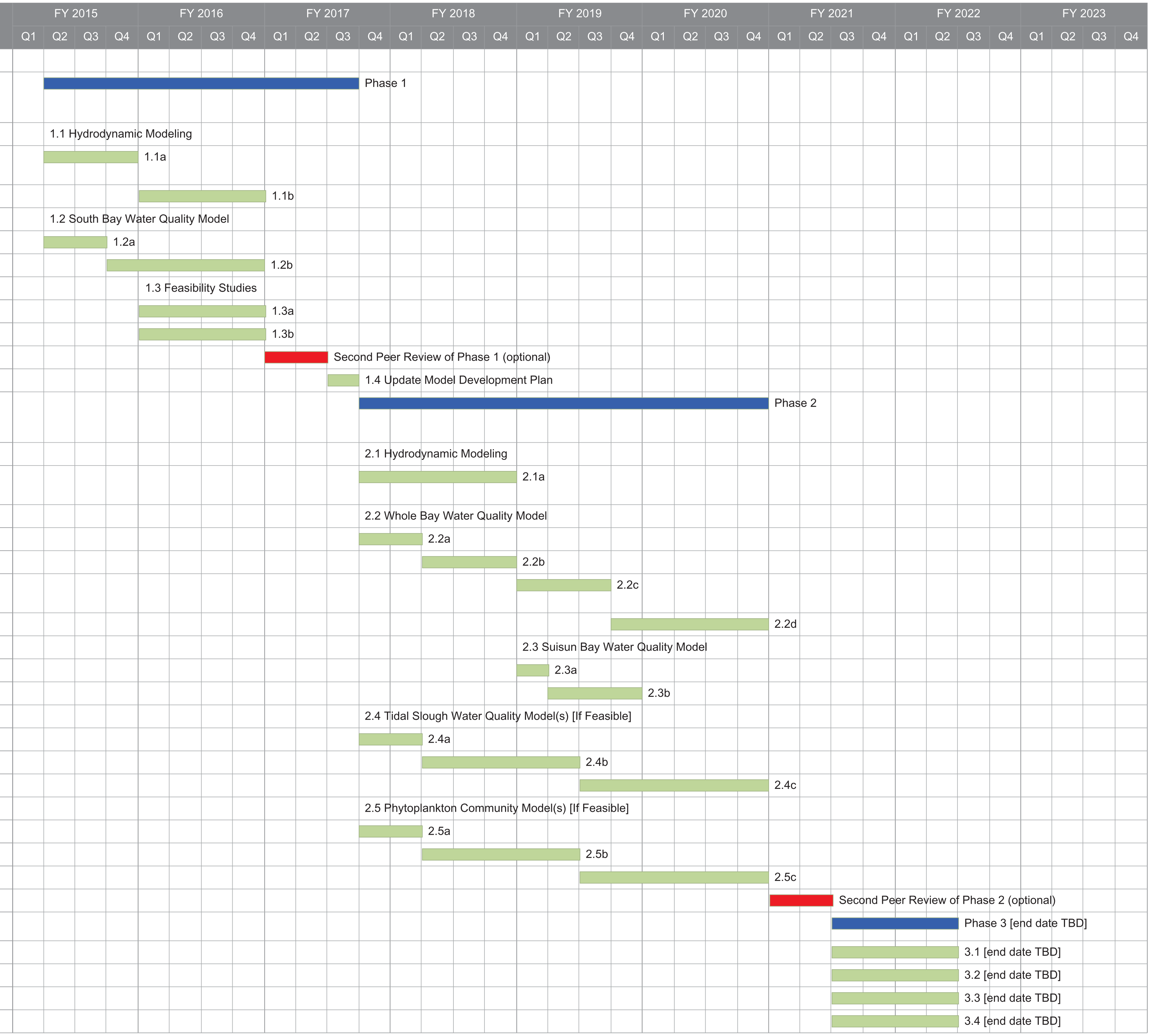
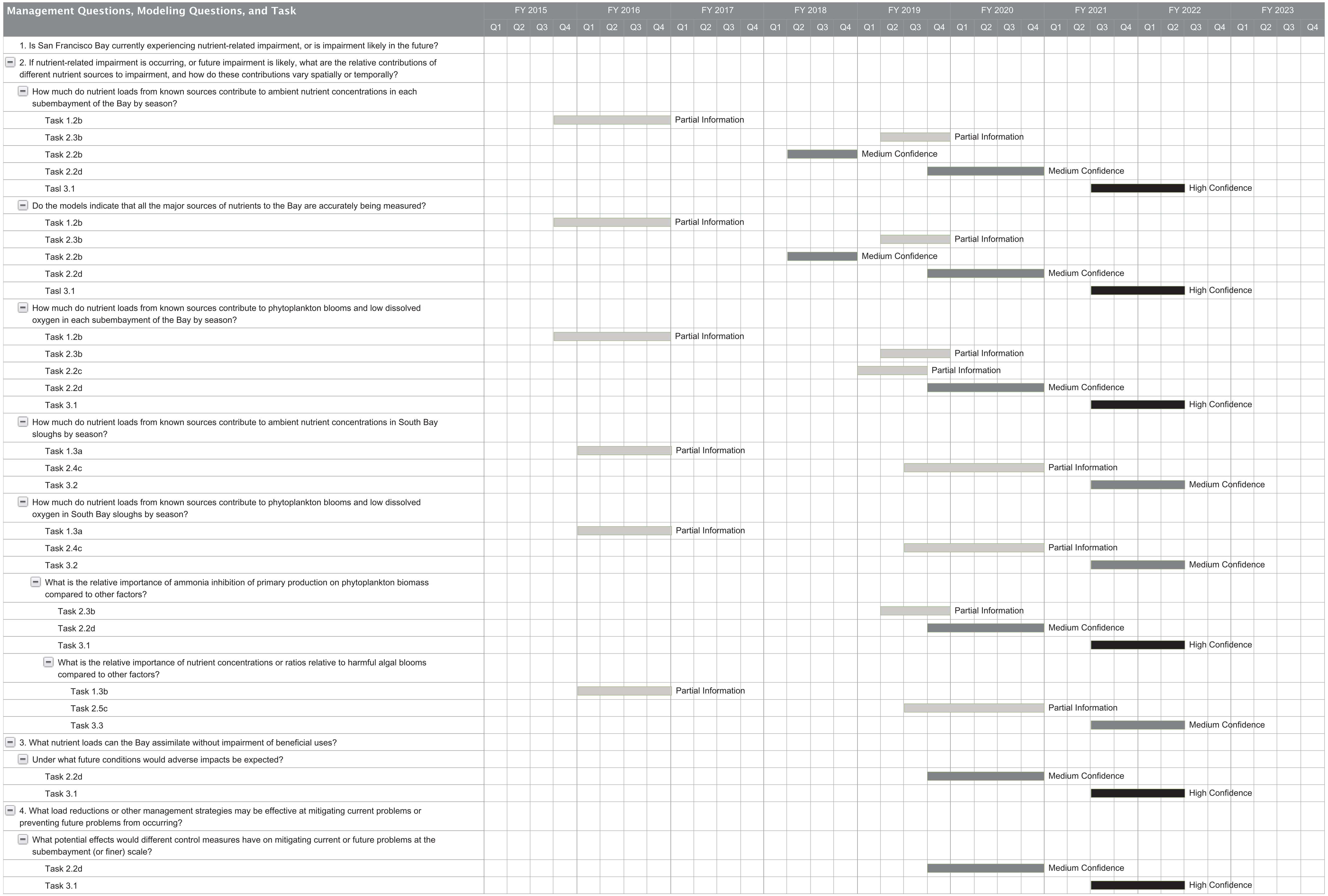


Figure 4: Gantt Chart of Management Questions, Modeling Questions, Tasks, and Quality of Information Expected by Certain Dates (Note: The current POTW Watershed Permit expires after FY19)



San Francisco Bay Nutrient Management Strategy
Detailed Modeling Workplan for FY15-FY21

Comments on 9/16/14 Draft

On September 19, 2014, SFEI sent a draft of the Detailed Modeling Workplan to the Nutrient Technical Workgroup and the RMP Technical Review Committee for review and comment. The report was also presented at the RMP Technical Review Committee meeting on September 23, 2014.

SFEI received comments on the draft workplan on the report from internal project partners and one stakeholder (Lynda Smith, Metropolitan Water District of Southern California, see attached).

In general, the commenters made the following substantive critiques of the Workplan:

- The schedule and timeline of Phase I water quality modeling tasks was too aggressive for the resources available (staff and budget).
- The modeling capacity at SFEI should be better defined. The timeline for completing deliverables depends on the skills of the modeling staff..
- The roles and responsibilities of SFEI and collaborators should be clarified, especially with regard to hydrodynamic modeling.

SFEI reviewed each comment and adjusted the Workplan accordingly. Specific, responses were prepared for each of the stakeholder comments as shown below. Comments on a common theme were combined for efficiency.

<u>Capacity</u>

- Will SFEI be able to employ and maintain adequate expertise to serve as a hub for the model? (Lynda Smith comment #1)
    - Response: SFEI intends to hire a Ph.D. level modeler whose with expertise in running and modifying water quality models. SFEI will support the USGS and other experienced modelers to complete hydrodynamic modeling and other tasks. The division of labor between SFEI staff and contractors will be optimized to complete the tasks, including serving as the model hub, as efficiently as possible.

<u>Roles and Responsibilities</u>

- Who will be responsible for maintaining the code of the hydrodynamic and water quality models? (Lynda Smith comment #4, 6)
    - Response: The current plan is for SFEI to maintain the customized code for the nutrient models (customized hydrodynamics and water quality) with assistance from USGS and Deltares. However, since the code will be freely available through an open-source, community modeling environment, identifying the exact host institution is less critical at this stage, and could be changed if a better arrangement develops.

Other

- The workplan should contain information describing how SFEI will coordinate with Delta modeling activities and staff. (Lynda Smith comment #2, 3)
    - Response: Members of the Core Team for the project will have expertise with Delta models, which will facilitate coordination between the Bay and Delta models. A sentence was added to Section 4 to highlight this linkage.
- The workplan should include information on how model development will be coordinated with field data collection and planning. (Lynda Smith comment #7)
    - Response: The modeling and monitoring for nutrients in the Bay are both funded and coordinated by the Nutrient Management Strategy Steering Committee and Nutrient Technical Workgroup.
- Was the SELFE model considered as a hydrodynamic platform for the modeling? (Lynda Smith comment #5)
    - Response: SELFE model was discussed during the Nutrient Management Strategy Model Development Plan process. However, based to the criteria established for that planning process, the group recommended the combination of CASCaDE II for hydrodynamics and the Deltares suite for water quality. The maturity of Deltares' water quality models and the large community of users of these models were major factors in this decision. Going forward, while the Nutrient Modeling Strategy is only able to fund one model, there are many benefits to having more than one model for hydrodynamics and nutrients in the Bay. For example, multiple models will allow for cross validation of observations. Therefore, SFEI will look for close collaboration with the SELFE/CoSINE modeling team throughout this process.

David and Emily,

Thank you for the opportunity to review the draft nutrient reports.

We reviewed the Nutrient Moored Sensor Program report and do not have any comments on the report.

We also reviewed the NMS Detailed Modeling Workplan, and have the following comments and questions. I shared the report with Paul Hutton in MWD's Sacramento office since he has Delta modeling expertise and experience, and these comments include his input.

- Open-Source Community Modeling Platform – The open-source community model concept in the workplan is a positive aspect of the plan, including the requirement for all users to share any refinements or improvements to the model so that the refined model remains open-source. It is also helpful that SFEI is proposing to be the caretaker or hub for the model. Will SFEI be able to employ and maintain adequate expertise to serve in this role? The Modeling Workplan and the modeling deliverables should provide information and status updates on how SFEI will serve in this role.

- It appears that the modeling domain will be as far upstream as Suisun Bay. Since the Modeling Workplan does not envision covering the Delta it will be important to understand how the Delta as a boundary condition is handled in the SF Bay modeling studies. This will be an important issue to address as the modeling work proceeds. I suggest consulting with DWR Delta Modeling staff on this important issue.

- While the Modeling Workplan focuses on the SF Bay Region, it will be important for this modeling effort to coordinate with Delta modeling activities.

- The Modeling Workplan proposes the use of the Deltares suite of models for the nutrient modeling effort, and the document notes that these models are open source. While this sounds positive there are questions that need to be addressed. Will SFEI be fully dependent on Deltares to maintain the code, and if so what resources are required to support this?

Commented [P1]: Comment #1

Commented [P2]: Comment #2

Commented [P3]: Comment #3

Commented [P4]: Comment #4

- The Modeling Workplan states that the current plan is to use a beta version of the CASCaDE II as the hydrodynamic model for SF Bay. Task 1.1 notes the uncertainty in whether or not the model will be ready to use. Task 2.1 in the workplan should be revised to also note this uncertainty. Given the uncertainty about the CASCaDE II model, we have several questions. A reasonable alternative would be for SFEI to consider the SELFE hydrodynamic model, thereby teaming with DWR's staff for continued model maintenance. Was the SELFE model considered by the modeling team, and if not, what are the reasons it was not considered? For the CASCaDE II model, will SFEI be dependent on USGS and other outside entities to maintain this model code, and what level of resources will be required?

Commented [P5]: Comment #5

Commented [P6]: Comment #6

- The SF Bay monitoring and modeling workplans are being developed in parallel. Since the Modeling Workplan does not include any details about where the field data that are needed for the modeling will come from, it raises questions. As these efforts move forward it will be important to connect the two activities in the report deliverables and status updates.

Commented [P7]: Comment #7

Please let me know if you have any questions on these comments.

Thanks,

Lynda

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