PS/SS: Nutrient Studies (Task 1) and Modeling Studies (Tasks 2-3)

Tasks 1.1-1.4 Nutrient Studies
Estimated Cost: $320,000 (2014 funding)
Oversight Group: Nutrient oversight group (to be determined)
Proposed by: David Senn (SFEI), Emily Novick (SFEI), and collaborators

Table 1: Nutrient Studies: Proposed Budget

Subtask	RMP CY2014 1000s $
Task 1.1 Monitoring Program Development	50
Task 1.2 Moored sensor network expansion	215
Task 1.3 Continuation of stormwater monitoring	35
Task 1.4 Program Management	20
TOTAL	320k

Task 2 San Francisco Bay Hydrodynamic and Water Quality Model Development
Estimated Cost: $150,000 (2014 funding); approximately $175K remaining from prior years' funding (2012 and 2013) will also be applied
Oversight Group: Contaminant Fate Work Group and Nutrient oversight group (to be determined)
Proposed by: David Senn (SFEI), Don Yee (SFEI), Jing Wu (SFEI), Emily Novick (SFEI), and collaborators

Table 2: Modeling: Proposed Budget

Subtask	**Budget**
Task 2.1 Draft Model white paper: recommended platform and approach	15k
Task 2.2 Model planning meeting	15k
Task 2.3 Finalize modeling white paper and develop detailed work plan	15k
Task 2.4.1 Develop and refine a Bay-wide hydrodynamic model, building on existing work in the Bay	140k
Task 2.4.2 Develop and test water quality model, and carry out initial modeling experiments	140k
TOTAL	320K

Task 3 Improved quantification of stormwater nutrient loads and uncertainty analysis

Estimated Cost: $50,000 (2014 funding); approximately $30K remaining from prior years' stormwater data analysis funding (2012 and 2013) will also be applied

Oversight Group: Contaminant Fate Work Group and Nutrient oversight group (to be determined)

Proposed by: Jing Wu (SFEI), Emily Novick (SFEI), Lester McKee (SFEI), David Senn (SFEI)

Subtask	**Budget**
Task 3.1 Analyze additional Bay Area stormwater nutrient data, and compare RWSM estimates to other model-derived or empirical load estimates	$10k
Task 3.2 Improved load estimates and uncertainty analysis using a hydrological simulation model, and recommended next steps	$70k
Total	**$80k**

1. Background

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 overenrichment, such as high phytoplankton biomass and low dissolved oxygen. However, recent observations suggest that the Bay's resistance to high nutrient loads is weakening. The combination of high nutrient concentrations and changes in environmental factors that regulate the Bay's response to nutrients has generated concern about whether the Bay is trending toward, or may already be experiencing, nutrient-related impairment.

To address growing concerns about SFB's changing response to nutrient loads, the San Francisco Bay Regional Water Quality Control Board worked collaboratively with stakeholders to develop the San Francisco Bay Nutrient Management Strategy, which calls for a range of activities to develop the scientific foundation that will allow for well-informed management decisions. An initial activity within the Nutrient Strategy was to develop a conceptual model for nutrient load-response in the Bay, and identify critical data and conceptual gaps. That draft report, developed with input from a group of regional scientists and funded by the RMP, was recently completed (Senn et al., 2013) and identified high-priority science questions, most of which fall under one or more of the following broader questions:

1. Do current trends of increasing biomass (in particular in Lower South Bay and South Bay) indicate that conditions are moving along a trajectory toward nutrient-related impairment?
2. Are nutrients causing or contributing to impairment due to changes in phytoplankton community composition?
   2.1. Harmful algal blooms?

2.2. Shifts in assemblage toward a food resource that poorly supports the food web?
3. Is the low dissolved O_2 that is commonly observed in Bay shallow margin habitats (sloughs, wetlands) causing impairment, and is the severity or duration of low DO due in part to elevated nutrients?
4. Under current nutrient loads, could impairment readily develop under plausible future scenarios?
5. How do nutrient loads from different sources contribute to ambient concentrations in different locations in the Bay?
6. If impairment is occurring, or is likely to occur in the future, what load reductions will be effective at mitigating or preventing impairment?

The conceptual model report made two broad recommendations
1. Develop a science plan(s) for SFB's subembayments that targets the highest priority management and science questions
2. Develop and implement an integrated program that combines observation/assessment, prediction of ecosystem response, and process-level studies that combined inform impairment assessment and decisions about how to best manage nutrients
   - 2.1. Develop a regionally-administered and sustainably-funded nutrient monitoring program
   - 2.2. Develop hydrodynamic, nutrient cycling, and ecosystem response models
   - 2.3. Carry out special studies to address key knowledge gaps about mechanisms that regulate ecosystem response, and inform whether or not impairment is occurring

In developing proposals to the RMP and BACWA for funding during CY2014 and FY2013, respectively, we targeted high-priority science questions and recommendations identified in the conceptual model report, which also happened to be well-aligned with the goals and approach laid out in the Nutrient Strategy. Each of the broad recommendations above has a number of more specific sub-recommendations, which are noted in the specific sections of the proposal below. Furthermore, a large number of science and monitoring activities are on-going in San Francisco Bay, funded by various entities (Figure 1), and the proposed set of projects to the RMP and BACWA target current and important gaps in scientific studies and nutrient program development.

The proposals in Tasks 1.1-1.4 focus on nutrient-related special studies, and are targeting 2014 funds provisionally allocated for nutrient work. The proposals described in Tasks 2-3 focus on modeling, driven in the near-term by nutrient issues, and are targeting 2014 funds provisionally allocated for forecasting/modeling.

FY/CY 2014
Amounts in $1000s

		BACWA FY 2013	BACWA FY 2014	RMP	IEP	USGS	SFWCA	SWRCB	TOTAL
Synthesis and Science Plan	Suisun Synthesis I	10							10
Synthesis and Science Plan	Suisun Synthesis II		85						85
Synthesis and Science Plan	Suisun Science Plan		30						30
Synthesis and Science Plan	Lower South Bay Synthesis	40	115						155
Synthesis and Science Plan	Mechanistic special studies				330		500		830
Monitoring Program Development	Ongoing Bay-wide monitoring			170	500	700			1370
Monitoring Program Development	Moored sensor pilot studies		150	215					365
Monitoring Program Development	Comm. comp. pilot study		120						120
Monitoring Program Development	Program Development		75	50				25	150
Monitoring Program Development	Stormwater monitoring			35					
Assessment framework	Assessment framework development							200	200
Assessment framework	Test assessment approaches								0
Model Development	Complete tactical plan			45					45
Model Development	Refine hydrodynamic model			100					100
Model Development	Develop phtyo/nutrient model			80					80
Model Development	Refine and apply phyto/nutrient model			100					100
Model Development	Refining stormwater estimates			50					50
Model Development	Nutrient Modeling in the Delta				180				180
Program mgmt	Science oversight and coordination	20	75	20					115
Program mgmt	Technical review and peer review		25						25
	TOTAL	70	675	865[1]	1010	700	500	225	3965

[1] includes $175k in 2012/2013 funds applied to RMP modeling tasks

Figure 1.1 Estimated nutrient expenditures (1000s $) in CY/FY 2014 in San Francisco Bay across a range of stakeholders and agencies (BACWA fiscal year starts in July). Estimates for BACWA and RMP are proposed projects, pending approval. The majority of work being carried out under the columns for BACWA, RMP, and SWRCB are closely aligned with the Nutrient Strategy, as are "Nutrient Modeling in the Delta", and ~200k in the row "Mechanistic special studies". Note the grey color estimates for USGS, IEP, are SFCWA are highly uncertain.

2. Applicable RMP Management Questions for Nutrient Special Studies and Modeling

1. What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary?
   a. Which sources, pathways, and processes contribute most to impacts?
   b. What are the best opportunities for management intervention for the most important contaminant sources, pathways, and processes?
   c. What are the effects of management actions on loads from the most important sources, pathways, and processes?

2. What are the concentrations and masses of contaminants in the Estuary and its segments?
   a. Do spatial patterns and long-term trends indicate particular regions of concern?

3. Proposed Work

<u>Task 1 Nutrient Studies</u>
Proposed by: David Senn (SFEI), Emily Novick (SFEI), and collaborators

Task 1.1 Monitoring Program Development

The conceptual model report pointed to the need to develop the scientific framework for a monitoring program, along with the institutional agreements and funding plan to support the transition of monitoring away from primarily a federally funded program (in anticipation of budget cuts to the USGS) toward a regionally-administered and sustainably funded program. Task 1.1-1.3 will focus primarily on the science program development, but also allow SFEI staff to play a coordinating role to bring key partners to the table and assist in the institutional and funding planning. Additional matching funds for this task are being sought from BACWA, and activities will be shared across those two proposals.

Task 1.1.1 Convene monitoring program working group and advisory team
A monitoring program working group will be established to guide development of the monitoring program. This group will consist of regulators, stakeholders, and technical experts. Regulator and stakeholder input will play an essential role in monitoring program development, in particular for identifying monitoring program goals, prioritizing program components to meet those goals, and establishing institutional and funding agreements. A monitoring program technical advisory team will also be established to provide guidance to SFEI staff, technical collaborators, and stakeholders on program development. The technical advisory team will consist of regional and national experts that have experience establishing and maintaining monitoring programs. The technical advisory team will meet 2 times in 2014, with electronic exchanges between meetings. The monitoring program working group may meet more frequently (up to quarterly), as needed.

Task 1.1.2 Draft and implement a program development plan
A major outcome of the meetings with the monitoring program working group and technical advisory team will be a draft monitoring program development plan. This plan will:

- Clearly articulate monitoring program goals
- Lay out an approach for identifying and evaluating different program structures (e.g., specific parameters, spatial and temporal frequency of data collection; balance between ship-based and moored-sensor approaches)
- Identify specific data analysis activities that will be carried out in Task 1.3
- Recommend pilot studies to test monitoring approaches
- Present goals and an approach for pursuing institutional agreements, exploring funding options, and identifying budgetary constraints.

A draft of this report will be developed at the end Q1 2014, following the first team meeting in 2014. This report will be updated periodically over the course of the year. The report will prioritize work elements for year 1 and beyond. Status updates on work elements will be presented to the working group at meetings, and a year-end progress report will be prepared.

Task 1.1.3 Data analysis to inform future monitoring program structure
The long-term science and monitoring efforts in the Bay/Delta provide a nearly 40-year record of water quality and ecological indicators. This data set provides a tremendous historical record that can be quantitatively probed to inform monitoring program design, and help identify which parameters to measure; the spatial and temporal density of sampling required; and the balance between ship-based and moored sensor applications. Analysis and synthesis of existing data was also recommended in the conceptual model report.

With guidance from the technical advisory team and the monitoring program working group team, the program development plan will identify and prioritize data analysis and numerical simulation tasks. Results of these tasks will be reported back to the technical advisory team and monitoring program working group in the form of periodic update presentations and sections to be included in the end of year progress report.

Budget for Task 1.1

Personnel: Coordinating advisory team, data analysis, status updates, and annual progress report	$42,000[1]
Advisory team compensation	$8,000
TOTAL	$50,000

[1]Additional $75,000 in personnel support from BACWA being proposed for this task.

Schedule & Deliverables

1.1.1 Minutes and presentations from 2 or more monitoring program working group and advisory team meetings	Jan – Dec 2014
1.1.2 Draft program development plan	Mar 2014
1.1.3 Annual progress report	Dec 2014

Task 1.2 Moored sensor program development

The conceptual model report recommended developing a moored sensor sub-program that complements the ship-based monitoring program by providing high temporal resolution data for a range of parameters (chl-a, DO, nutrients, turbidity) to, for example, i) identify the onset of events (e.g., large blooms); ii) improve understanding about the processes that influence phytoplankton blooms in order to predict future responses; iii) assess oxygen budgets; and iii) quantify nutrient fate. High temporal resolution data will also be essential for accurately calibrating water quality models. Continuous monitoring with moored sensor systems is feasible for a wide range of water quality parameters. Techniques for some parameters are becoming increasingly well-established and reliable (e.g., salinity, T, turbidity, chl-a, DO, and more recently nitrate), while others are advancing (e.g., phosphate, ammonium, phytoplankton composition using *in situ* flow cytometry and digital imaging). Moored sensor systems can telemeter data, allowing for near real-time assessment of conditions, which can be used to trigger field sampling or to identify sensor failure or drift.

Compared to Suisun Bay and the Delta, where there are an abundance of moored sensor stations maintained by DWR/IEP, the moored sensor infrastructure is quite limited in San Pablo Bay, Central Bay, and especially Lower South Bay and South Bay. This is particularly true for parameters like chl-a, nutrients, and DO.

The RMP funded a pilot project in 2013 to deploy moored sensors at Dumbarton Bridge. Work is proceeding well on that project and the planned deployment date is June 27.

This task proposes to fund the expansion of the moored sensor network in Lower South Bay and South Bay. RMP funding would be directed toward:

- purchasing equipment for two additional stations for measuring chl-a, pH, DO, turbidity, fluorescent dissolved organic matter, depth, and nitrate (these stations would be in addition to the current Dumbarton Bridge station)
- field logistics (e.g., ship time) for sensor deployment and maintenance, intensive *in situ* calibration studies, and pilot field deployments to inform final site selsction; and
- data management.

This proposal to the RMP is being augmented by a proposal to BACWA ($150k). The BACWA funding would be directed toward funding moored sensor program development, which will include:

- analysis of existing monitoring data to help optimize placement of moored sensors;
- design and implementation of field experiments for intensive *in situ* calibration and testing of sensor accuracy and precision (e.g., identifying and developing approaches for correcting for interferences); and pilot field deployments to inform final site selection
- analysis and interpretation of data from field experiments
- based on the above work, recommendation of specific program expansion sites in Lower South Bay and South Bay;
- development of beta software for automated data assimilation, initial QA/QC, graphics/visualization, and upload to website for near real-time data viewing on a web-based platform.
- To the extent possible, data from moored sensors in Suisun Bay and the Delta will also be retrieved in near real-time and uploaded to the beta web platform.

Although the Suisun and Delta sites use similar sensors as those we will use in Lower South Bay and South Bay, there will be differences in the maintenance, calibration, and QA/QC between programs. This is likely to be a non-trivial caveat, and in the long run would need to be addressed by developing common maintenance, calibration, and QA/QC procedures. The near-term goal of the final bullet above is more proof-of-concept, aimed at highlighting the feasibility and advantages of coordination, to develop momentum along the path of establishing institutional agreements with IEP/DWR on monitoring. IEP/DWR spend ~$1.5 mill/yr maintaining the Suisun and Delta sensor network. Implementing a Bay-wide maintenance, calibration, and QA/QC program would cost far less.

Budget for Task 1.2

Additional moored sensor equipment (for 2 new stations) + annual sensor repair/maintenance costs	$125,000
Field deployment equipment/infrastructure/boat costs	$40,000
Discrete sample analysis	$15,000
Personnel – routine servicing, data management	$35,000
TOTAL	$215,000

Schedule & Deliverables for Task 1.2

Since the majority of RMP funding is being directed toward equipment and logistics, the table below includes a combination of RMP and BACWA deliverables. Note: BACWA operates on a July-June fiscal calendar.

1.2.1. Summary of data analysis and field experiment results, and recommended locations for new sites in South Bay and Lower South Bay (Note: dates may shift depending on BACWA project start)	Draft Apr 2014 Final Jun 2014
1.2.2. Beta website presenting near real-time data for up to three RMP-funded sites in LSB and South Bay, and, if possible, DWR/IEP sites in Suisun Bay and the Delta	Jun 2014

Task 1.3 Stormwater monitoring

For this task we request continued funding to support the collection and analysis of stormwater samples for additional nutrient analytes (NH_4^+, total Kjeldahl nitrogen (TKN), and NO_2^-) at the six watersheds being sampled during WY2014 as part of the Small Tributary Loadings Strategy (STLS) and the Pollutants of Concern study. Although nutrients are not the main focus of the STLS and POC, three nutrient analytes (NO_3^-, total phosphorous, dissolved orthophosphate) are among the current list of analytes because they are required as part of the Municipal Regional Stormwater Permit. However, other important nutrient analytes are not funded because the permit does not require them.

Task 3 requests funding to support the collection and measurement of samples for NH_4^+, TKN, and NO_2^-, as well as data management costs (6 sites, 4 storms/site, 4 samples/storm, plus appropriate QA/QC samples). The combined suite of nutrient analytes matches the type of information being collected in the USGS monthly Bay surveys, and data being collected for POTW effluent characterization. Adding these three analytes, when teams are already mobilizing for the other contaminant sampling, is a wise investment that leverages current funds being invested in this effort. That said, our intent is to have no adverse impact on the overall STLS/POC sampling program, and we are proposing that external contractors be compensated ($2000 per site). In most cases, the additional analytes will be measured in samples already being collected for other purposes, so there will be little additional work on the part of field crews, and they will not be responsible for data management. We will work with STLS and POC partners to secure the necessary permissions/agreements.

A short report will also be prepared summarizing results.

Budget for Task 1.3

Sample analysis	$17,000
Compensation for extra sampling effort	$8,000
Personnel – coordination of field effort, data management, brief summary of results	$10,000
TOTAL	$35,000

Schedule & Deliverables for Task 1.3

1.3.1 Database of additional analytes	Summer 2014
1.3.2 Brief technical report summarizing results	December 2014

Task 1.4 Science coordination and program management

Proposed funding in this task will be used to support SFEI staff's activities in the area of overall science coordination and program management. As noted in Figure 1, there are a large number of stakeholders and programs involved in nutrient-related work in San Francisco Bay. RMP nutrient-related activities need to be coordinated with these other efforts to achieve maximum benefit. Additional funding is being sought from BACWA to further support science coordination and program management. Funding to support and oversee a peer review process for key documents is also being requested from BACWA.

Budget for Task 1.4

Personnel – science coordination	$20,000[1]
TOTAL	$20,000

[1]Additional $120,000 in personnel support from BACWA for this task

<u>Task 2 San Francisco Bay Hydrodynamic and Water Quality Model Development</u>

Proposed by: David Senn (SFEI), Don Yee (SFEI), Emily Novick (SFEI), and collaborators

The Nutrient Strategy calls for the development of models to quantitatively characterize the Bay's response to current nutrient loads; explore ecosystem response under future environmental conditions and identify scenarios under which impairment may occur; and test the effectiveness of load reduction scenarios and other scenarios that mitigate or prevent impairment. Moreover, the recent conceptual model report prepared for the RMP by a team of regional experts recommended development of integrated models of hydrodynamic and water quality to inform nutrient management decisions. That report also identified a set of high priority science questions, many of which will need to be addressed in part through modeling (see Tables 11.3-11.5; Senn et al., 2013).

The primary goal of this proposed work is to launch the development and refinement of a set of integrated Bay-wide hydrodynamic, nutrient cycling, and ecosystem response models to inform nutrient management decisions. The primary objective of this effort is to develop models that can be applied to inform nutrient management decisions in the Bay. Beyond nutrients, there is the desire to adopt a platform that has sufficient flexibility that it can also be adapted to explore management issues related to other contaminants (e.g. emerging or legacy aqueous or particle-reactive contaminants).

Past funding, and funding requested this year, will support this initial, but critical, phase of model development. In subsequent years, funding will be sought from a broad set of stakeholders and funding programs to support continued model refinement and simulation of scenarios.

The proposed work will utilize previously allocated modeling funding (175K remaining) plus additional funds requested in 2014 (150K) to develop a modeling approach and work plan, and implement that work plan. The previously allocated funding is expected to easily cover all remaining costs related to planning, with ~270k in combined funding remaining for actual model development, refinement, and application.

Task 2.1 Complete report for recommendations for modeling platform and approach

Work began in the second half of 2012 and the first half of 2013 on developing a set of criteria for model selection, recommendations for a model platform, and a recommended approach to model development. SFEI staff worked with RMP stakeholders to define relevant management questions, and held meetings with regional and national modeling experts to solicit input on appropriate model platforms for addressing these management questions. Table 3 presents a set of management and science questions that were developed to inform model selection and the initial approach to model development. An outline of the report was developed and served as the basis for a meeting with a modeling advisory team held in March 2013. The group consisted of experts in the areas of hydrodynamic modeling (E Gross, RMA; O Fringer, Stanford; L Erikson, USGS; C Jones, Sea Eng'g) and phytoplankton modeling (L Lucas, USGS), and water quality modeling (J Fitzpatrick, HDR-Hydroqual). There was broad consensus among the group about model selection criteria, model platforms that meet those criteria, and about general approach for model development and refinement. The recommendations that evolved from the recent RMP-funded nutrient conceptual model report will be incorporated into the draft approach identified in the modeling report.

A draft report will be completed in Summer 2013 (August). That report will be circulated to RMP stakeholders and the modeling advisory team

Task 2.2 Model planning meeting

A focused meeting or workshop will be held in September 2013 to solicit additional input on the modeling plan. Meeting participants will include the core modeling advisory team, additional technical experts, and stakeholders. Main meeting goals will include:

- vet the selected model platform and draft approach with a broader group of experts and stakeholders; and
- solicit expert input on the specific approach for model development, which will be incorporated into the detailed work plan.

Task 2.3 Finalize modeling report and develop detailed work plan

Based on input from the modeling plan meeting, the modeling report will be finalized, and a detailed work plan will be developed that identifies the recommended path forward for model development, refinement, and application. The report and work plan will be will be submitted in October 2013 to the RMP TRC and SC for review and approval. The work plan will lay out an overall long-term plan for model development and application, with near-term (subsequent 2-3 years) goals, approach, and milestones described in substantial detail.

Task 2.4 Model development and refinement, and initial application

Once the recommended modeling approach and work plan have been approved, work on model development will begin. The exact details of model development will depend on the final recommended approach. That said, we anticipate that work will proceed simultaneously along two parallel fronts (Task 2.4.1 and 2.4.2) during the 1-1.5 years, and then iteratively along three fronts (4.1, 4.2, 4.3) in year 2 and beyond (Figure 2):

Task 2.4.1 Develop and refine a Bay-wide hydrodynamic model, building on existing work in the Bay

2.4.1.a An initial grid will be adopted and refined, and model calibration and validation will proceed to obtain an acceptable full-Bay hydrodynamic model. This initial grid and model output will be handed off to Task 4.2.b

2.4.1.b The initial hydrodynamic grid and model will be refined to achieve necessary model skill

Task 2.4.2 Develop and test water quality model, and carry out initial modeling experiments

2.4.2.a Use existing water quality model that has been successfully applied in other estuaries, and refine parameterizations and features as necessary.

2.4.2.b Use initial hydrodynamic output from 4.1.a, aggregate the grid, and carry out subembayment-scale modeling 'experiments' for sensitivity analysis, uncertainty analysis, hypothesis testing and data synthesis, and to identify high priority data collection or process-level studies

Task 2.4.3 Refine hydrodynamic inputs to water quality model, building toward more highly-spatially-resolved integrated models, and apply these models
This task embodies the ultimate goal of the modeling work. We will not reach this point within the first 1-1.5 years and with the proposed, but work will be building toward this. Additional funding will be sought (from other partners, and potentially the RMP) for continued model development in FY/CY2015.

Table 3 Draft science/management questions developed to inform model selection and early stages of model development

Modeling-related Science/Management Questions	*Notes*
1. What are the relative magnitudes/contributions of factors controlling ecosystem response to nutrients?	*Response*: Early focus: phytoplankton biomass, DO; Potential future focus:, phytoplankton community composition, HABs *Regulating factors to evaluate*: light attenuation, clam grazing, NH4-inhibition, nutrient abundance
2. To what extent can observed changes in ecosystem response over the past ~25 years be explained by actual or hypothesized changes in regulating factors?	Being able to predict observed changes, using known changes in regulating factors, or changes in factors within realistic ranges, will provide needed confidence in model to explore plausibility of future impairment scenarios
3. What are the contributions of anthropogenic nutrient loads to low DO in shallow poorly-exchanging margin habitats? (e.g., low DO in LSB sloughs)	
4. What is the natural capacity to assimilate or process nutrients at the subembayment (or finer) scale?	Pelagic and benthic nitrification, denitrification, assimilation, flushing
5. Under what future conditions would impairment be expected? What magnitude(s) of changes in drivers could lead to a tipping point, and are those changes plausible/probable?	*Causes:* prolonged stratification, loss of clams, increased water clarity *Effects:* Large blooms, low dissolved O_2, acute nuisance blooms, HABs, shifts in species composition
6. Once hydrodynamics and (mixing, dilution, transformation) are taken into account, what spatial scales are relevant in terms of regulation/permitting?	- Explore the potential effectiveness of various control measure scenarios - Identify and evaluate the environmental-effectiveness of "nutrient trading"? In which areas of the Bay, during what times of year, can load trading be an effective management option?
7. If there are current or future impairments, what magnitude of effect would different control measures have on mitigating or preventing those problems at the subembayment (or finer) scale?	e.g., load reductions, wetlands, shellfish beds

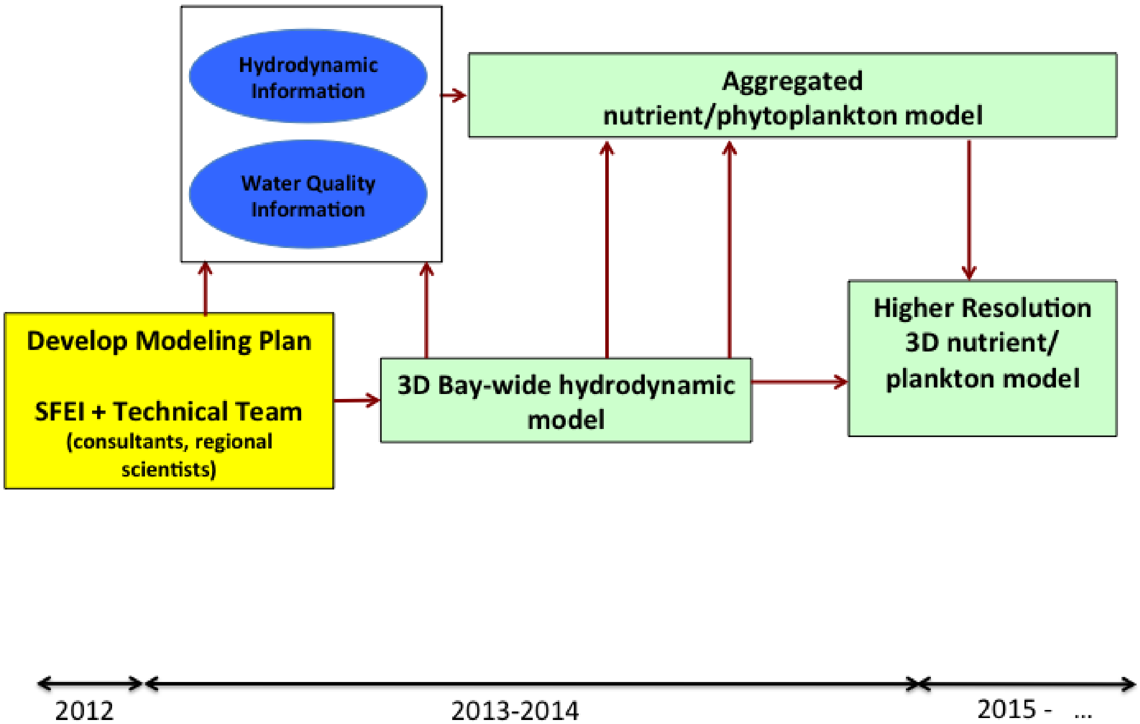

Figure 2: Timeline for hydrodynamic and water quality model development

Budget for Task 2.1-2.4

Funds for 2012 and 2013 (~175k) will be used to complete previously approved tasks detailed in the 2013 Detailed Work Plan. A number of these tasks are currently underway (Items 1-4) and are expected to be completed within 2013, and model development (Item 5) will begin upon the completion of the modeling work plan. New 2014 funds (~150k), and the remainder of 2012-2013 funds, will be directed toward model development (Item 5). The costs presented below are approximate and will be revised when the detailed work plan is developed

Subtask	**Budget**
Task 2.1 Draft Model white paper: recommended platform and approach	15k
Task 2.2 Model planning meeting	15k
Task 2.3 Finalize modeling white paper and develop detailed work plan	15k
Task 2.4.1 Develop and refine a Bay-wide hydrodynamic model, building on existing work in the Bay	140k
Task 2.4.2 Develop and test water quality model, and carry out initial modeling experiments	140k

Schedule & Deliverables for Task 2.1-2.4

Deliverable	**Date**
2.1 Draft Model white paper: recommended platform and approach	Aug 2013
2.2 Workshop, and presentations and meeting minutes from workshop	Sept 2013
2.3 Final model white paper and modeling work plan	Oct 2013
2.4 Progress reports on model development (6, 12, 18 months from Jun 2013)	Dec 2013 - Dec 2014

Task 3 Improved quantification of stormwater nutrient loads and uncertainty analysis

Proposed by: Jing Wu (SFEI), Emily Novick (SFEI), Lester McKee (SFEI), David Senn (SFEI)

Quantifying external nutrient loads to San Francisco Bay was identified as a high priority by the Nutrient Management Strategy for San Francisco Bay. Initial estimates developed for the RMP-funded loading study (Novick and Senn 2013) suggest that stormwater loads have the potential to be substantial nutrient sources during the wet season in certain Bay segments. However, these initial estimates, made with the Regional Watershed Spreadsheet Model (RWSM), are highly uncertain, because 1) land-use specific nutrient concentrations used for agriculture may not be accurate for the type of agriculture in these regions (vineyards, not crops or livestock); and 2) the model was not necessarily developed for nutrients, and while it has been calibrated/validated for hydrology, a nutrient calibration is not possible due to sparse data. As a result, there is a need to further explore these estimates, and, to the extent possible, refine them. Furthermore, a plan is needed for better constraining stormwater nutrient load estimates to the northern estuary, and potentially to other subembayments.

We propose to apply $30k in current RMP funds, originally allocated to stormwater nutrient data analysis, combined with additional requested funding in 2014 ($50k), to

- better constrain stormwater nutrient load estimates from watersheds draining to San Pablo and Suisun Bays using hydrologic simulation models;
- quantify uncertainty in load estimates and identify necessary data collection to better constrain load estimates (based on sensitivity analysis); and
- recommend next steps for future stormwater nutrient load work.

Task 3.1 and initial steps in Task 3.2 (will be carried out with the already-allocated funds. The success of Task 3.2, and the meaningfulness of any model output, hinge on the quality of existing and readily available hydrologic models for the watersheds of interest. With the current budget it is unlikely we can build and calibrate/validate a hydrological model from scratch, and then apply it for the purposes of exploring nutrient loads. For that reason, we will consider the likelihood of a successful outcome before investing heavily in Task 3.2, and will report back to the TRC and SC about any recommended changes in plan.

Task 3.1 Analyze additional Bay Area stormwater nutrient data, and compare RWSM estimates to other model-derived or empirical load estimates

Newly available stormwater nutrient data from WY2012 and 2013, collected through the RMP, will be analyzed to better constrain nutrient concentrations in runoff. Nutrient data available from other Bay Area monitoring efforts will also be analyzed (e.g., nutrient data from recent San Francisco Bay Regional Water Quality Control Board sampling efforts in the Napa River watershed). The RWSM results will also be compared to other nutrient load estimates in Bay Area watersheds to determine whether the RWSM estimates are similar to or differ considerably from other estimates. An initial search found that some limited hydrological and nutrient load modeling work has been done for the Napa River (Kella et al. 2004). In addition, McKee and Krottje (2005) developed empirical estimates for nutrient loads at several locations in Napa and Sonoma watersheds. While the Napa load estimates from those studies are also highly uncertain, it is worth noting that their nitrogen loads are quite similar in magnitude to nitrogen loads determined for Napa River by the RWSM (within 15%). Loads from other watersheds will also be explored.

Task 3.2 Improved load estimates and uncertainty analysis using a hydrological simulation model, and recommended next steps
In this task we will use a hydrologic simulation model to better constrain nutrient loads in one or more watersheds draining to San Francisco Bay. The modeling effort will likely initially be focused on Napa River or Sonoma Creek, both because of the relatively high nutrient yields determined by the RWSM (Novick and Senn 2013) and since calibrated hydrologic models exist for these watersheds or some of their subcatchments. A range of potential model platforms will be considered. For example, for the Napa River watershed HSPF, SWAT, and WARMF models already exist. The applicability of the USGS SPARROW model will also be considered.

The watershed(s) analyzed and the model platform used will depend on data availability and whether calibrated/validated hydrological (and, if possible, nutrient) models are available. Data availability, especially with respect to nutrient data, will no doubt hamper our efforts. However, with a reasonably-sophisticated model platform - in particular if there is an existing model in which hydrology is already well-calibrated - we can both better constrain loads by using more realistic parameterizations, and can quantitatively explore the uncertainty of load estimates. The availability of suitable nutrient data to help calibrate a nutrient module (e.g., Napa) will be considered in watershed selection.

The uncertainty in nutrient load estimation will be examined to construct a range for estimated loads. Sensitivity analysis will first be conducted to identify model parameters/input data to which load estimates are most sensitive, and then a Monte Carlo-type simulation will be applied to quantify the uncertainty contributed by each identified source or variations in parameters. A distribution of load estimates will be derived from the Monte Carlo Simulation. The uncertainty analysis will likely be carried out on a small-scale watershed due to the high demand on model run-time.

Based on the results from data analysis in Task 3.1 and simulations and uncertainty analysis in Task 3.2, we will recommend a series of next steps to further evaluate the potential importance of stormwater nutrient loads.

Proposed budget for Task 3
For this task, $30,000 of current stormwater-related data-analysis funding (2012-2013) will be combined with $50,000 in 2014 forecasting/modeling funding.

Subtask	**Budget**
Task 3.1 Analyze additional Bay Area stormwater nutrient data, and compare RWSM estimates to other model-derived or empirical load estimates	$10k
Task 3.2 Improved load estimates and uncertainty analysis using a hydrological simulation model, and recommended next steps	$70k
Total	**$80k**

Schedule & Deliverables for Task 3.1 and 3.2

Deliverable	**Date**
3.1 Progress update on data analysis, any initial simulation modeling efforts, and recommended approach	Dec 2013
3.2 Technical report on Data comparison, improved modeling, uncertainty quantification, and recommended next steps	Dec 2014