***DRAFT***

# *WORKPLAN FOR DEVELOPMENT OF A CONTAMINANT FATE AND BIOACCUMULATION MODEL FOR SAN FRANCISCO BAY*

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## *Introduction*

The Regional Monitoring Program for Water Quality in San Francisco Estuary (RMP) was established to provide the scientific information needed to support water quality management. The information needs of managers are articulated in the management questions that guide the RMP. One of these management questions is focused on understanding probable future contaminant status and trends. To this end, the RMP has been working to develop the capacity to predict (through quantitative models based on current understanding of ecosystem processes and human activities) probable future scenarios of water quality improvement or impairment by pollutants of concern.

In 2009 the RMP began developing a Modeling Strategy organized around three environmental compartments: open-Bay, Bay margins, and Bay watersheds. The specific information needs related to each compartment are represented by a set of management questions and a brief narrative. This multi-year plan is designed to develop predictive models that will guide the collection and interpretation of data related to contaminant fate in the Bay and its watersheds. In the end, the modeling tools developed will provide a quantitative basis for informed regulatory decision-making.

This document outlines a 5-year work plan for the RMP Modeling Strategy. This work plan provides more detail on the model development tasks planned. The work plan also provides details on the rationale for the selected approach, and how it complements existing modeling activity.

## *Goal of the RMP Modeling Strategy*

The goal of the RMP Modeling Strategy is to develop a capacity to predict the effect of different management alternatives on contaminant loads from watersheds, the recovery of contaminated areas on the Bay margin, and the recovery of the Bay as a whole. This capacity will be gained through the development of conceptual and numeric models of the physical, chemical, and biological processes governing the fate of water, sediment, and contaminants of concern in San Francisco Bay and its associated watersheds. These models will synthesize our understanding of pathways and processes controlling contaminant fate, and uptake into biota. They will also identify critical information needed to refine our understanding of the system.

The overarching goal of the RMP, and the intent of the RMP Modeling Strategy, is to provide the information needed to support water quality management decisions. RMP modeling will allow managers to predict, prioritize, and optimize the impacts of actions aimed at improving water quality, and ultimately, human and wildlife exposure to contaminants. Integration of the modeling strategy with other strategies currently being developed by the RMP (e.g., Hg Strategy, PCB Strategy, Small Tributaries Loading Strategy) will be crucial to the success of the strategies, and will help focus model development.

## *Core (Level 1) RMP Management Questions Addressed*

Q3. What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary?

Q5. What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?

## *Priority Questions of the Modeling Strategy*

1. Bay Margins
   a) What is the contribution of contaminated Bay margins to Bay impairment?
   b) What is the contribution of Bay margin contamination to sport fish, wildlife, and human exposure?
   c) What are the projected impacts of management actions to Bay recovery?

2. Recovery of the Bay
   a) What patterns of water and sediment contamination are forecast for major segments of the Bay under various management scenarios?
   b) What changes in sport fish and wildlife exposure to contaminants are anticipated?

3. Small Tributary Loads: Priority management questions regarding small tributary loading are listed in the Small Tributaries Loading Strategy. Watershed modeling will be needed to address questions 1, 2, and 4 from the Small Tributaries Loading Strategy.

Two models are required to answer questions 1 and 2 of the Modeling Strategy, which focus on within-Bay contamination. The first model is a Bay-scale three-dimensional model of hydrodynamics, sediment, and contaminant transport (i.e., the Bay Grid Model). The second is a model of biotic uptake of contaminants (i.e., a Bay bioaccumulation model) that is able to incorporate the spatial information generated by the Bay Grid Model. The next two sections of this work plan describe each modeling effort in turn.

## *The Bay Grid Model*

*What will it look like?*

The Bay Grid Model will have both the spatial and temporal resolution necessary to answer the management questions posed by RMP stakeholders. Specifically, by utilizing a flexible grid[1], the model will be capable of resolving the fine-scale transport of material

[1] Flexible grid refers to the ability of the model to increase 'accuracy' in dynamically important areas (through grid refinement) and reduce it in other areas where high spatial resolution is not required.

at the Bay margins in the context of the larger transport phenomena of the Ocean-Bay-Delta system.

The Bay model will consist of:

1. The core hydrodynamic model
2. A sediment transport model that includes interaction with the sediment bed
3. A particle tracking model - allows one to track the trajectories of contaminated particles
4. A scalar transport model – allows tracking of the transport of dissolved materials

Watershed models will be developed concurrently with the Bay model. These watershed models will focus on predicting loads of pollutants of concern from local small tributaries. Over time, the watershed models will be integrated with the Bay model, thereby enabling the dynamic prediction of sediment and contaminant transport from source to sink.

*What can be expected of the model?*

The model will be useful in understanding the exchange of material between small tributaries, Bay margins, regions of the Bay proper, the Delta, and the Pacific Ocean. These assessments will be made in a climatological and probabilistic sense. That is, the model will be able to assess the likelihood of a given outcome under a set of representative (or average) climate conditions. Specifically, the model will:

1. Improve understanding of the fate of sediment and contaminants that enter the Bay in the vicinity of a particular Bay margin contaminated site and of sediment and contaminants that are already present at the contaminated site;
2. Project the potential effects of management interventions (e.g., remediation, source control) at a contaminated site or within the watersheds adjacent to a site;
3. Project the trajectory and pace of progress toward cleanup targets (including tissue targets) for a site, region, or segment under various management scenarios;
4. Aid in identifying high-leverage small tributaries and understanding the mechanisms by which they contribute to Bay impairment;
5. Identify and quantify the major input and loss pathways for water, sediment and contaminants (on regional and Bay-wide scales);
6. Aid in the development of climate change adaptation strategies.

Unlike the one box or multibox, the Bay Grid Model has the potential to be effectively applied to evaluate management actions (e.g., dredging, loads reductions) at the scale of individual contaminated margin sites. This is evident by the successful application to evaluate hydromodifications (and sediment changes) at South Bay Salt Ponds. Though model accuracy at these relatively small spatial scales will have to be ascertained as model development proceeds, it can be calibrated and evaluated at local conditions, creating substantial potential for collateral benefits to related projects, such as the developing San Leandro Bay assessment effort. At the same time, the Bay Grid Model can also be scaled up to evaluate entire bay processes, and even quantitatively address broader scale issues such as inputs of larger water volumes associated with sea level rise (global climate change), and how this will effect water and sediment dynamics, and consequent contaminant dynamics. In this capacity, the three dimensional modeling approach applied on a Bay-wide basis will maintain the RMP at the leading edge of environmental modeling geared towards management of Bay resources.

*What will the model limitations be?*
The model will not be a real-time operational model capable of making predictions of exact conditions in space and time. Real-time input data, such as high-resolution two-dimensional winds and waves, and detailed freshwater inputs, are either not available or processing is too time intensive. Therefore, the model is not focused on predicting the exact attributes of a single event (i.e., storms, floods, etc). Rather, the model focuses on predicting the general attributes of a collection of events. Similarly, the model will not be able to reproduce the exact spatial patterns of sedimentation. Rather, the model will be able to identify the areas of the Bay that are most likely to be depositional or erosional under a given set of conditions.

*How will the model be tested and verified?*
Model testing and verification will be performed on an ongoing basis. At each step along the development cycle, model outcomes will be compared to observations and adjustments to model parameters and input data will be made in order to improve the model-data comparison.

The comparison of model outcomes to observations will be made sequentially, including the major model core processes (hydrodynamics, sediment dynamics, and contaminants) in series. The basic premise is that the model must first be able to reproduce the physical movements of water before being able to transport sediments and contaminants. In general, for a given location or set of locations, the models will be tested as follows:

1. The hydrodynamic model will be calibrated and validated first, using existing physical data (temperature, salinity, sea-surface elevation, currents).
2. The sediment model will be calibrated and validated using existing suspended sediment and bed sedimentation data
3. The contaminant model will be calibrated and validated using existing water column and sediment contaminant data

In general, calibration and validation will be performed using different subsets of data. For example, the hydrodynamic model can be fitted to existing data for certain years. It can then be validated by quantitatively comparing model outcome vs. field observations for other years. This model validation activity is an important ongoing process to demonstrate model performance, in light of the fact that its results have the potential to be used in management decision making.

The results of model testing will inform future data needs.

*How will uncertainty be assessed?*
Model uncertainty will be assessed statistically by running a number of model simulations while varying input parameters and assessing the central tendency of all model outcomes (e.g., Monte Carlo simulations). Such analyses will put confidence limits around model predictions.

*What are the data requirements?*
Specific data needs will be dependent upon the desired uses of the model. The following discussion describes some likely data needed to calibrate and validate the various models.

Currently, there are enough existing data to calibrate the hydrodynamic model on the scale of the Bay, the South Bay (including Lower South Bay), and the Guadalupe River-Coyote Creek complex. Existing data sources include the RMP, the South Bay Salt Pond Restoration Project, the Coastal Conservancy, the Army Corps of Engineers, SF Ports, the USGS, local universities, and local consultants.

One caveat regarding hydrodynamic data is that the proposed model will focus on regions of the Bay that have few data: Bay margins. Specifically, there are no data regarding the flux of material in to and out of small local tributaries at the Bay margin. Such data may be necessary to improve model performance in these regions. High-resolution bathymetry may also be required in these regions.

There are significantly fewer data on suspended sediments and bed sedimentation patterns. Still, there are enough of these data to develop a preliminary sediment model. It is anticipated that the sediment model will be able to reasonably reproduce suspended sediment patterns. The challenge will be in reproducing net sedimentation patterns. It is possible that detailed sediment bed studies will be needed in order to improve prediction of sedimentation patterns. These studies might include sediment flume studies to determine the erosivity of bed sediments.

An extensive contaminant data set exists for the Bay. While these data are generally in the deeper regions of the Bay (i.e., not in the Bay margins) they will suffice for a preliminary contaminants model. It is anticipated that, over time, contaminants data in shallow Bay margins will be needed. These data could include surface sediments and cores. It is also likely that improved watershed loads data will be needed to improve model results.

In summary, potential data needs are:
1. high-resolution bathymetry
2. flux measurements at the mouth of local tributaries
3. flux measurements at key Bay constriction points (e.g. Dumbarton Bridge)
4. sediment erosivity studies (flume studies)
5. sediment cores
6. contaminant monitoring in shallow margin areas

7. improved watershed loads estimates (currently being addressed by the RMP SPLWG and the Municipal Regional Permit)

Prioritization of these data needs will be an ongoing adaptive process in which sensitivity of model results to parameter error and uncertainty is evaluated, parameter data quality is assessed, and new information on key parameters is obtained. This process began with the one and multibox models. Both models demonstrated very high sensitivity to sediment depositional and erosional dynamics, resulting in uncertainty in projected Bay response to contaminant source reduction. In response to these findings, the RMP funded sediment coring studies (Item 5 above) through the Contaminant Fate Work Group, to evaluate erosion and deposition patterns in a wide range of sediment conditions. This information will be used to inform the sediment dynamics in the Bay Grid Model. A similar approach, based on sensitivity and uncertainty analysis, and evaluation of current available data, is key to successful integration of monitoring and modeling. The final section of this Work Plan describes potential opportunities to interface with ongoing modeling activities, which will help identify available data.

## *Modeling Biota Contaminant Exposure and Risk*

In order for the development of the Bay Grid Model to benefit Bay contaminant management in general, it must be linked to a quantitative model of contaminant bioaccumulation. Most of the RMP modeling to date has focused on abiotic processes of contaminant fate and distribution. However, collaborating programs (CEP, San Francisco Bay Regional Board, and State Sediment Quality Objectives Program) have supported parameter development and application of a mechanistic model to predict PCB and organochlorine pesticide uptake into the San Francisco Bay food web. This model has been successfully validated for application in San Francisco Bay on a Bay-wide basis. For PCBs, it has also been applied to specific sites to evaluate the potential effect of food web structure and spatial contaminant variability on bioaccumulation. This work plan outlines five specific modeling activities to keep biota modeling moving forward in line with development of the abiotic model:

1. Develop a refined conceptual model of bioaccumulation
2. Develop a spatially explicit version of the mechanistic bioaccumulation model
3. Apply the bioaccumulation model for PBDEs
4. Run coupled fate-bioaccumulation model simulations
5. Perform a spatially explicit risk assessment for wildlife and humans

### *Develop a refined conceptual model of bioaccumulation*

We will develop a conceptual model that evaluates the relative importance of different sources and spatial locations in determining contaminant fate and bioaccumulation to the San Francisco Bay food web. The Gobas food web model has been successfully applied to persistent organic pollutants in the Bay, including a probabilistic treatment of spatial and temporal variation in contaminant food web uptake (Gobas and Arnot 2005).

However there are further opportunities to evaluate spatial and temporal variation in biota uptake of contaminants, in a combined contaminant transport and biota uptake model. A conceptual model development is needed to determine the appropriate management questions and scale of analysis for linking the food web and contaminant fate models.

Potential approaches to biota modeling include: 1. linking separate food-web simulations in different parts of the Estuary, to spatially explicit output of contaminant fate models; 2. incorporating an individual based modeling approach to evaluate variability in expected dietary uptake patterns, based on local fish and wildlife migration patterns; 3. building in temporal variation in uptake patterns based on seasonal differences, age-specific physiology changes, or long-term changes in contaminant bioavailability. The conceptual model development will consider which of these approaches are likely to be feasible and beneficial, based on our current understanding of the key drivers of contaminant uptake in the Bay.

*Develop a spatially explicit version of the mechanistic bioaccumulation model*

A spatially explicit bioaccumulation model is needed to integrate with the Bay Grid Model. Modeling that incorporates spatial and temporal patterns in biota movement will provide greater accuracy and flexibility in evaluating population-level impact of contaminant exposure.

The specific approach to spatial modeling will be determined based on the results of the refined conceptual model development. The most sophisticated option would be a spatially and temporally explicit individual based model. Individual based models are appropriate to track the variable movement, consumption, and consequent exposure of individual animals, based on information on life history and migration patterns (Jaworska et al. 1997). In this approach, the bioaccumulation model equations would be converted from the current steady-state formulation to a time-dependent form. Site specific dietary exposure would depend on local conditions (e.g., contaminant concentrations in sediments and water) predicted by the Bay Grid Model, and the movement and feeding of modeled organisms. Where necessary, this information would be augmented by field data on important local parameters, such as sediment organic carbon. Model runs will be able to generate statistical distributions of exposure of multiple simulated organisms.

The spatially explicit modeling approach requires simulation of the movement, feeding, and consequent contaminant uptake of individual fish and wildlife organisms. Fortunately, researchers on San Francisco Bay biota have developed excellent data on movement behavior of several target fish and wildlife. This includes monitoring data on shorebird and harbor seal movements (Grigg 2003, Ackerman et al. 2007), in addition to studies (funded by the Long Term Management Strategy) on the spatial movement of Pacific herring, striped bass, white and green sturgeon, and Chinook salmon.

Model predicted contaminant concentrations will be validated against independently collected data. In the case of food web models, validation typically entails comparing predicted concentrations in biota to observed concentrations in the region of interest (e.g., Arnot and Gobas 2004). PCBs are excellent contaminants for quantitative validation, because the large number of individual congener results allows quantitative estimates of model error and bias. Multiple pesticides can also be validated. As described in the next section, the model will also be parameterized for PBDEs.

*Run coupled fate-bioaccumulation model simulations to evaluate spatial patterns and management actions*

Once the spatially explicit bioaccumulation model is developed, it will be possible to run simulations integrating both models. The model simulations would evaluate the importance of spatial variation in contaminant sources and fate. Spatial variation in contaminant fate would include estimating water-borne sources, water column concentrations, sediment concentrations, and contaminant partitioning, in multiple locations. Spatial information on dietary uptake, based on dietary studies, could also be incorporated. In this way, the bioaccumulation model could be used to evaluate the potential importance of spatial variation in food web structure and contaminant partitioning for contaminant bioaccumulation among the locations.

For spatial analyses to have the greatest benefit, the Bay Grid Model would be populated with best available current data on PCB sources and distributions throughout the Bay. That model would then be run, while tracking the proportion of PCBs in each model segment that are derived from each of the separate contaminant sources built into the model. Because the Bay Grid Model is a spatially explicit model, contaminant sources would vary based on spatial location. As an example, China Camp in San Pablo Bay would be affected by wastewater discharge from San Raphael, Novato, and the Petaluma River. The model would be run to provide quantification of the contribution of each source to sediments and the water column.

The source-specific contaminant contributions would then be loaded into the food web bioaccumulation model. As with the fate model, the food web model simulations would estimate the proportionate contribution of PCBs from each source to modeled fish and wildlife. Of particular interest here will be the potential differences between sediment and water column as reservoirs of PCBs, and consequent differences in bioaccumulation for benthic vs. pelagic foraging wildlife. Additionally, the potential influence of differences in prey types among locations could be evaluated. This would determine to what extent varying diets in different segments appear to affect bioaccumulation rates.

Once the models have been parameterized to include segment specific information, we would be able to evaluate impact of specific management actions on the different segments. Actions to be evaluated would be developed in coordination with Regional Board staff and the RMP TRC. Potential scenarios to be tested would include: 1. the source curtailments proposed in the relevant TMDL (SFBRWQCB 2004); 2. remediation of in-Bay contamination; and 3. monitored natural recovery.

## *Coordination with Other Efforts*

A number of other ongoing efforts are developing models of the Bay. The USGS is using the Delft modeling software to understand sediment transport through the Golden Gate (D. Hanes, P. Barnard) and sedimentation in South Bay (B. Jaffe et al). UC Berkeley (M. Stacey et al) and Stanford (O. Fringer et al) are developing the SUNTANS model for the Coastal Conservancy with an emphasis on understanding hydrodynamics and sediment transport around the South Bay salt ponds. A number of local consultants (E. Gross, URS, RMI and others) are using proprietary, and in some cases open-source, models on a site- and project- specific basis. Researchers at the USGS are using a series of nested watershed and hydrodynamic models to understand how multiple drivers of environmental change might interact to change ecosystems targeted for restoration by CALFED (the CASCaDE project). The obvious question is "How does the RMP modeling work plan fit with these other projects?"

The RMP modeling work plan was purposefully developed with these projects in mind. It includes strategic relationships with some of the biggest players in Bay modeling: Mark Stacey (UC Berkeley), Ed Gross (consultant), and Craig Jones (Sea Engineering). These researchers are at the cutting edge of Bay modeling and are widely considered the best in the field. In some way or another Mark, Ed, and Craig are involved in nearly all of the modeling efforts listed above and will therefore provide an inherent level of integration with those projects.

*Why not just use one of the existing Bay models?*
Models are typically developed to answer a set of pre-defined questions. As such, the ability of a given model to answer a set of new questions is limited. The RMP is asking some very specific questions. It is therefore difficult to use an existing model to address these specific issues. It is preferable to develop and/or adapt specialized models to answer special questions. In the long run it is likely to be more economical as well (avoids spending money on the wrong models).

*How is the RMP modeling work complementary to existing projects and not redundant?*
Developing models specifically to address RMP management concerns is inherently not redundant. In fact, development of specialized RMP models is complementary to these other projects. These projects will benefit from the specific developments of the RMP models just as the RMP models will benefit from their individual developments. The RMP modeling strategy includes establishment of and/or participation in a Bay Area Modeling Forum where developers of these individual models can come together and share modeling approaches, datasets, etc. (see below).

*Contributions of other programs to the model*
The Coastal Conservancy originally funded the same investigators (M. Stacey et al) to develop a model of South Bay. These funds have been frozen indefinitely due to the state's inability to sell bonds. It is difficult to say with any certainty if and when those funds will be unfrozen. The scope for the Conservancy funds is not too different from the RMP modeling strategy (to improve understanding of hydrodynamics and sediment transport around the South Bay with emphasis on salt ponds). It is anticipated that when

unfrozen the two projects will provide synergy to move things forward at an even faster pace.

At this time there are no financial contributions from other programs to the proposed models. However, it is likely that, as model development progresses, other programs will see that their concerns might be addressed by the RMP models. For example, the Bay Grid Model might prove useful in determining the location of head-of-tide throughout the Bay, a key issue facing climate change adaptation programs. These programs might choose to contribute resources to this modeling effort.

*Mechanisms to ensure RMP priorities are appropriately addressed*
These mechanisms are included in the table accompanying this work plan. Mechanisms include quarterly reviews and annual reports.

*Establishment of a Bay Area Modeling Forum*
Two options exist to promote coordination:

1) The RMP could establish and maintain a Bay Area modeling forum (of technical people organized around the idea of guiding agencies and NGOs in their selection, use, and interpretation of models for describing sediment-water relationships in fluvial and tidal systems). The objectives of the forum would be to improve communication and coordination of local modelers and stakeholders thereby reducing duplication of efforts and improving the overall quality of modeling products. The estimated cost for coordinating a modeling forum is $5,000 per year (assuming five teleconferences and one in-person meeting per year).

2) The RMP could become an active participant in either the California Water and Environmental Modeling Forum or a similar forum being established by the Bay Conservation and Development Commission (BCDC). A similar level of funding ($5,000 per year) would likely be necessary for RMP staff to establish a presence within these forums (e.g., attend meetings, prepare materials, and collaborate with other participants).

At this point it is preferable to engage one of the existing modeling forums (option 2). If after an initial trial period of one year these existing forums do not meet the specific needs of the RMP a new forum can be established.

*Commitment of our collaborators*
Execution of the RMP modeling work plan is highly dependent on our collaborators. The RMP does not have the capacity to develop and maintain the proposed models without their help. RMP scientists have developed relationships with the modeling collaborators over the past five years in hopes that one day this collaborative project would come to fruition. Our collaborators have expressed their intention to participate in this project over the next five years.

*Contingency plan - Should RMP hire a staff modeler or develop subcontracts with independent consultants?*

An alternative approach to maintaining project continuity and establishing a continued RMP presence in Bay assessment would be for the RMP to hire a full-time modeler. This would significantly increase the cost of the work plan, but would result in RMP capacity building. A new modeler on staff should be able to continue model development as long as the RMP maintains a working version of model code and inputs. It is therefore recommended that, wherever possible, the RMP request copies of all model code and input files from its contractors.

## *Detailed Task Descriptions*

**1) Bay Margins Conceptual Model**

**Objectives**
Develop a conceptual model of contaminant transport through Bay margins. Bay margins are the shallow, near shore regions of the Bay that serve as the primary interface between watersheds and open Bay waters. This conceptual model will attempt to charaterize the role margins play in controlling the exchange of contaminants between these two end members.

**Information Gained / Uncertainty Reduced**
Conceptual model report establishes current state of knowledge in regards to water, sediment, and contaminant transport in SF Bay. Report will serve as a guiding document for future model development and as a baseline by which future work can be assessed. Report will help identify information gaps.

**Deliverables:** Draft and final RMP technical reports

**Project Participants:** SFEI staff

**Due Date:** Mar-10

**RMP Contribution:** $40,000

**Total Cost:** $40,000

**2) South Bay Model - hydrodynamics, particle tracking, maybe sediments**

**Objectives**
To develop extensions of the SUNTANS-SF Bay modeling framework to consideration of specific perimeter watersheds. These extensions are motivated by a desire to understand how sediments and contaminant that are sourced in small, local watersheds that drain into South San Francisco Bay are transported and distributed under the influence of tidal, wind and buoyancy forcing. In this first year, we will assess possible locations for the studies, develop the necessary grid and forcing information, and perform preliminary transport studies for passive scalars and Lagrangian particles.

**Information Gained / Uncertainty Reduced**
Model will provide preliminary information on the exchange of material between watersheds, margins, and open bay.

Project will help prioritize margins and watersheds based on data availability and management concerns.

Project will help identify information gaps and will identify the data needs for future RMP modeling efforts.

**Deliverables**
Presentations and/or Reports:

> Q1 - Assessment of data availability; Identification of 3 study areas; Evaluation of time period to model.
>
> Q2 - Acquire and process data; Grid generation at first location.
>
> Q3 - Begin simulations at first location; Grid generation of second location.
>
> Q4 - Begin simulations at second location; Grid generation of third location; Presentation of results.

**Project Participants**: SFEI Staff, Mark Stacey, Ed Gross

**Due Date:** Dec-10

**RMP Contribution:** $100,000

**Total Cost:** $100,000

**3) Biota Conceptual Model**

**Objectives**
Develop a conceptual model of contaminant bioaccumulation with specific linkages to Bay and watershed processes.

**Information Gained / Uncertainty Reduced**
Conceptual model report establishes current state of knowledge in regards to biota modeling. Report will serve as a guiding document for future model development and as baseline by which future work can be assessed.

Report will help identify information gaps.

**Deliverables**
Draft and final RMP technical reports

**Project Participants:** SFEI Staff

**Due Date:** Dec-10

**RMP Contribution:** $40,000

**Total Cost:** $40,000

**4) Field Work To Support South Bay Model**

**Objectives**
Collect empirical data from sites selected for modeling in Task 02. Field work will be conducted in 2011 to be used in modeling in 2012. Possible fieldwork might include suspended sediment monitoring and/or coring and sediment flux work.

**Information Gained / Uncertainty Reduced**
Field work will provide data necessary to improve performance of South Bay Model.

Field work might provide additional benefits. Might provide contaminant concentration data in Bay margins, for example.

Priority will be given to improving model performance.

**Deliverables**
Technical Reports; Data needed for model validation

**Project Participants:** SFEI Staff, Mark Stacey, Ed Gross, Craig Jones

**Due Date:** Dec-11

**RMP Contribution:** $50,000

**Total Cost:** $50,000

**5) Update South Bay Model with Empirical Results**

**Objectives**
Use empirical field data collected during 2011 to update and improve performance of the South Bay model.

**Information Gained / Uncertainty Reduced**
Performance of South Bay Model will be improved through calibration/validation with empirical data collected in 2011.

The uncertainty of the South Bay Model will be characterized (and most likely reduced) through comparison with data collected in 2011.

**Deliverables**
Technical Report; Updated Model

**Project Participants:** SFEI Staff, Mark Stacey, Ed Gross, Craig Jones

**Due Date:** Dec-12

**RMP Contribution:** $50,000

**Total Cost:** $50,000

**6) South Bay Model - Hot spots and tributary model with water, sediment, and contaminants (cursory treatment of biota)**

**Objectives**
Extend South Bay model to include contaminant transport capabilities. Contaminant transport efforts will focus on the more contaminated Bay margin sites identified in the Margins Conceptual Model and monitored during 2011 fieldwork.

**Information Gained / Uncertainty Reduced**
The exchange of material between watersheds, margins, and open bay in the South Bay will be quantified by a calibrated model.

Effects of localized hot spots on Bay water quality will be quantified.

Information needs will be identified.

**Deliverables**
Presentations and/or Reports:

Q1 - TBD
Q2 - TBD
Q3 - TBD
Q4 - TBD

**Project Participants:** SFEI Staff, Mark Stacey, Ed Gross, Craig Jones

**Due Date:** Dec-13

**RMP Contribution:** $100,000

**Total Cost:** $100,000

**7) Full Bay Model - Focus on hydrodynamics and sediment transport**

**Objectives**
Extend spatial extent of South Bay Model to include the entire Bay. Emphasis will be given to hydrodynamics and sediment transport.

**Information Gained / Uncertainty Reduced**
Model will provide ability to improve estimates of overall water and sediment budgets.

Model will help identify spatial erosion and deposition patterns throughout the Bay.

Model will help quantify the exchange of water and sediment between Bay segments.

Model will help quantify the exchange of water and sediment between the Bay and the ocean.

**Deliverables**
Presentations and/or Reports:

Q1 - TBD
Q2 - TBD
Q3 - TBD
Q4 - TBD

**Project Participants:** SFEI Staff, Mark Stacey, Ed Gross, Craig Jones

**Due Date:** Dec-14

**RMP Contribution:** $100,000

**Total Cost:** $100,000

**8) Full Bay Model - Focus on contaminant transport and cursory treatment of biota.**

**Objectives**
Extend capabilities of Full Bay Model to include contaminant transport and possibly biota.

**Information Gained / Uncertainty Reduced**

Model will provide ability to improve estimates of overall contaminant budgets.

Model will help quantify the exchange of contaminants between Bay segments.

Model will help quantify the exchange of contaminants between the Bay and the ocean.

Model will provide preliminary assessment of the spatial variability of contaminant uptake by biota.

**Deliverables**
Presentations and/or Reports:

Q1 - TBD
Q2 - TBD
Q3 - TBD
Q4 - TBD

**Project Participants:** SFEI Staff, Mark Stacey, Ed Gross, Craig Jones

**Due Date:** Dec-15

**RMP Contribution:** $140,000

**Total Cost:** $140,000