

RMP

Small Tributaries

Loading Strategy

by
L. McKee
A. Feng
C. Sommers
R. Looker



SAN FRANCISCO ESTUARY INSTITUTE

4911 Central Avenue, Richmond, CA 94804

p: 510-746-7334 (SFEI), f: 510-746-7300,

www.sfei.org

This report should be cited as:

San Francisco Estuary Institute, (SFEI) 2009. RMP Small Tributaries Loading Strategy. A report prepared by the strategy team (L McKee, A Feng, C Sommers, R Looker) for the Regional Monitoring Program for Water Quality. SFEI Contribution #585. San Francisco Estuary Institute, Oakland, CA. 20pp.

Table of Contents

Introduction.....	1
Management Questions and Priorities	2
Guiding Principles	4
Definitions.....	4
Implementation of the STLS.....	4
Proposed Tasks to Answer the Management Questions	5
Task 1: Guadalupe River Model	5
Task 2: Z4LA Small Tributaries Loading Study	5
Task 3: Develop Multi-Year Watershed Loading Sampling Plan	6
Task 3a: Develop Criteria and Rank Watersheds.....	6
Task 3b: Optimize Sampling Methods for Loadings and Trends	6
Task 3c: Develop Spreadsheet Model for Regional Loadings Estimates	7
Task 4: Pollutants of Concern Monitoring at a Subset of Representative Watersheds	8
Task 4a: Pollutants of Concern Monitoring (Guadalupe River)	8
Task 4b: Pollutants of Concern Monitoring at a Subset of Representative Watersheds – Zone 4 Line A – year 4	9
Task 4c: Pollutants of Concern Monitoring at a Subset of Representative Watersheds – Reconnaissance	9
Task 4d: Pollutants of Concern Monitoring at Representative Land Use sites – Rationale Development and Reconnaissance.....	10
Task 4e: Pollutants of Concern Monitoring at Representative Land Use sites	10
Task 5: Dynamic Modeling in a 2 nd Selected Representative Watershed	11
References	11
Appendix 1: Water Board Priorities for Loads Monitoring	14
Appendix 2 Tools and Methods Applied to-date for Answering Management Questions	18

Introduction

The overarching goal of the RMP, and the intent of the Small Tributaries Loading Strategy (STLS), is to provide information needed to support water quality management decisions. The STLS was developed to ensure that the RMP is providing the information most urgently needed by managers to reduce loads and impacts of pollutants of concern (POC) entering the Bay from small tributaries.

The objective of this document is to present a planning framework for small tributary loads monitoring within the RMP that is consistent with and complemented by monitoring that will be completed in compliance with the Municipal Regional Permit for stormwater agencies (MRP) (SFRWQCB, 2009). MRP provisions relating to POC and sediment loads monitoring are compatible with this *Strategy*. Specifically the MRP states “Pollutants of Concern (POC) monitoring is intended to assess inputs of Pollutants of Concern to the Bay from local tributaries and urban runoff, assess progress toward achieving wasteload allocations (WLAs) for TMDLs and help resolve uncertainties associated with loading estimates for these pollutants.” In particular, the MRP describes “four priority management information needs toward which POC monitoring must be directed:

- 1) identifying which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from pollutants of concern;
- 2) quantifying annual loads or concentrations of pollutants of concern from tributaries to the Bay;
- 3) quantifying the decadal-scale loading or concentration trends of pollutants of concern from small tributaries to the Bay; and
- 4) quantifying the projected impacts of management actions (including control measures) on tributaries and identifying where these management actions should be implemented to have the greatest beneficial impact.”

As shown below, the Strategy questions are completely consistent with the MRP questions. Implementing this *Strategy* will also consistent with the other RMP Strategies (Mercury, Dioxins, Modeling, and PCBs) - linkages are highlighted throughout.

Small tributaries have been identified in the mercury and PCB TMDLs as contributing significant and controllable loads of pollutants to San Francisco Bay. While mercury, methylmercury and PCBs remain the top priority and the focus of the majority of resources, the Sources Pathways and Loadings Workgroup (SPLWG) has ranked PBDEs as a high priority, and pyrethroids, dioxins (see the *RMP Dioxin Strategy*), selenium, OC pesticides, copper, nickel, and PAHs as medium priority for loads information. There are additional analytes listed in the February 2009 draft tentative order of the MRP that will also be considered (Category 1: Cu_D, POC; Category 2: Se_T, Se_D, NO_x, total P and phosphate (PO₄³⁻). In addition, it is recognized this POC list might evolve year-to-year as more information is gained through, for example, the emerging contaminants workgroup (ECWG) of the RMP. For all these POCs there remain uncertainties in:

- the magnitude of total regional loads,
- which watersheds contribute disproportionately to loads and impacts on local and regional scales,
- the relative importance of atmospheric deposition versus local sources contributing to watershed loads,
- how management can reduce loads, and
- trends in loads.

A premise of this *Strategy* is that it is possible to identify small tributaries that exert a disproportionately large influence on loads and impacts (consistent with the PCB and Hg strategies). Older industrial areas in local watersheds are presently hypothesized to be more polluted with PCBs than other parts of the urban landscape, whereas for mercury, a broader distribution is hypothesized that includes industrial and commercial areas with higher imperviousness, and older urban areas. This more even distribution is partly because regionally it is estimated that about one third of the mercury load in urban stormwater is derived from atmospheric deposition. An additional premise of this *Strategy* is that the process of identification of sources and control of Hg and PCBs will also help to control other particle bound POCs. If these premises are correct, it will be possible to focus attention on contaminated tributaries and areas within watersheds and reduce mercury, PCB and other POC loads to the Bay and ultimately reduce beneficial use impacts in a cost-effective manner.

The RMP has already conducted loads monitoring for mercury, PCBs, and other POCs in three tributaries (Sacramento River, Guadalupe River, and Zone 4 Line A, a small tributary in Hayward). This *Strategy* aims to build on existing efforts and increase the amount and cost-effectiveness of information generated to answer key management questions while at the same time coordinating with BASMAA studies in relation to MRP compliance.

Management Questions and Priorities

1) Impairment

Which are the “high-leverage” small tributaries that contribute or potentially contribute most to Bay impairment by pollutants of concern?

An understanding of the POC load contributions of individual watersheds to impairment will be essential to developing cost-effective strategies for reducing loads and monitoring progress in load reductions in the context of sensitive areas on the Bay margin and food web uptake. This question ties closely with the *RMP Mercury and PCB Strategies* which identify the need to determine which processes, sources, and pathways disproportionately contribute to food web accumulation. It is anticipated that a focus on linking loads to impairment will help ensure that load reductions actually lead to reductions in exposure and impacts in target species. Implicitly, to answer this question, information will be needed that links concentrations or loads from watersheds with key biological processes in the near-field habitats on Bay margin. Before that can be done however, we must first make decisions about which watersheds to study using

a ranking derived from the combination of all available information on POC sources, atmospheric deposition, sediment concentrations in stormwater conveyances, and POCs in Bay margin sediment and biota.

2) Loads

What are the loads or concentrations of pollutants of concern from small tributaries to the Bay?

The TMDLs for mercury and PCBs include an allocation for the aggregate loads from urban stormwater runoff. Data collected in compliance of provision C.8.f of the MRP will inform improved measurements of single watershed loads and regional estimates. While load information will be developed for single watersheds, we are emphasizing understanding loading and impairment at the regional scale. This information will be useful for input into models of the Bay process and recovery time (see the *RMP Modeling Strategy*). A combination of field studies and modeling will be needed to answer this question. There are a few key intermediate questions to be answered. For example, what sampling design is needed (how many samples under what kind of field conditions should be taken to generate loads information)? How many categories of watersheds are there in the Bay Area? How many watersheds in each category should be studied? Which categories should be prioritized for collection sooner than others? What sampling design is needed to characterize loads associated within each watershed category? Although Hg and PCBs are the most urgent and data rich POCs to build a framework of investigation from, like all other components of this *Strategy*, it is assumed that there will be benefits for other POCs.

3) Trends

How are loads or concentrations of pollutants of concern from small tributaries changing on a decadal scale?

Understanding long-term trends in loads is essential to tracking progress toward TMDL wasteload allocations. Provision C.8.d and C.8.f of the MRP describe the intent to track trends through water quality sampling in urban stormwater. Answering this question will require the collection of systematic data in fixed locations. Power analysis will be needed to determine the amount of data needed to see a trend of a given magnitude given reasonable expectations of management effort and environmental variability.

4) Support for Management Actions

What are the projected impacts of management actions on loads or concentrations of pollutants of concern from the high-leverage small tributaries and where should management actions be implemented in the region to have the greatest impact?

Answering this question will require conceptual, and ideally quantitative models of the behavior of POCs in the watersheds, along with an adequate foundation of empirical information (see the *RMP Modeling Strategy (Question 4)*). Data will be needed to populate the internal structure of the models (for example concentrations and loads of POCs associated with land use or source categories) as well as for calibration and verification (e.g., single location time continuous flow and concentration data). In addition to model input data, information on anticipated management actions will be

needed: when, where, and what? Another information need for such models is data on the efficacy of the chosen management actions to capture or treat loads (note some of this kind of data may be collected through MRP permit provision c.8.e.ii).

Guiding Principles

- Focus on what should be done, rather than what can be done. Implement control measures where they are most likely to impact Bay water quality impairments.
- Seek opportunities for obtaining information on multiple pollutants in a cost-effective manner (e.g., piggybacking).
- Seek areas where collaboration can be maximized.

Definitions

- Small tributary: Rivers, creeks, and storm drains that enter the Bay downstream of the confluence of the Sacramento and San Joaquin rivers.
- Pollutants of concern (POC): Use SPLWG prioritized list and the list provided in provision C.8.f of the MRP and apply budget disproportionately to higher ranked POCs.

Implementation of the STLS

The largest challenge that is unique to the STLS in contrast to the other RMP strategies is the close coordination with the monitoring components in the MRP. We envisage the need for a consensus between the RMP Steering Committee, the Water Board, and BASMAA on which parts of the STLS will fulfill permit requirements and what kind of reporting will be needed by the STLS team in that regard. This decision will provide the general conceptual framework for partitioning activities between RMP work and BASMAA work under the MRP. Although conceptually there will be a need each year to review that decision and alter it as needed, the success of this *Strategy* and the resulting program of observation and information development will be largely reliant on consistency and predictability for staffing and equipment.

Like any planning document, this *Strategy* will require periodic updating as management needs evolve and questions are answered or new questions are generated. In addition, stakeholders are interested in periodic reports that synthesize the data and information developed as a WHOLE. Lastly, stakeholder meetings will be required periodically to inform interested parties of results and make adjustments to the field components of the strategy.

Proposed Tasks to Answer the Management Questions

Task 1: Guadalupe River Model

Funded in 2008 and 2009 - \$150,000 over two years. Proposed funding 2011 - \$75,000

In 2009 the RMP funded the 2nd year of a two year modeling effort in the data rich Guadalupe River Watershed as a first step towards developing a regional scale model. Guadalupe was chosen because of the abundance of rainfall and runoff data collected by the SCVWD, the abundance of Hg sediment data collected by a number of agencies beginning 1988, and the abundance of suspended sediment and bed load data collected by the USGS. In addition, the RMP/CEP/SCVWD/SCVURPPP has funded SFEI to collect 4 years of Hg, PCB and other POC data during storms. While the model may have local stakeholder uses, the overall intention is to use Guadalupe as a starting point for the development of other watershed models and ultimately a regional scale model. In 2011, the model will be rerun to answer questions like:

- Long term average loads (*Strategy* Question 2)
- Predicting the effects of various BMP scenarios (*Strategy* Question 4)
- Predicting the time to observe trends (Note this would help to refine the sampling plan (Task 3))

Year 1 – Model stormwater flow (Lent and Oram, 2009)

Year 2 – Model suspended sediment, Hg, and PCBs

Year 3 – Model BMPs and loads trends.

Objectives: Improve load estimates for Guadalupe River, develop and calibrate a model for testing BMP scenarios and predicting load trends, and provide tested parameterization of the model to expand the use to other watersheds in the regional context.

Task 2: Z4LA Small Tributaries Loading Study

Funded Water Years 2007, 2008, 2009 - \$400,000 over three years.

Beginning in 2007, the RMP funded a second small tributaries loading study in a small urban watershed in Hayward. The intent of this study was to understand loads of POCs entering the Bay from a small industrialized tributary near the Bay margin. This watershed was chosen because it contrasts with Guadalupe River in size, land use, rainfall variation, soil types, and location on the Bay margin. The study uses an intensive single station design employing 5 minute interval stage, rainfall, and turbidity measurement and storm focused ISCO pump sampling and depth-integrated point sampling. So far this study has been funded for three relatively dry years. Preliminary comparisons to Guadalupe reveal similarity of most POC loads normalized to areas during dry years with the exception of Hg, Cr, and Ni which have greater concentrations and loads in the Guadalupe system most likely due to historic mining.

Objective: Improve regional loads estimates for the class of smaller industrial watersheds near the Bay margin.

Task 3: Develop Multi-Year Watershed Loading Sampling Plan

Funded 2009 - \$10,000

In order to cost effectively and systematically gather data to answer the *Strategy* questions, a multi-year sampling plan is needed to guide both the RMP and MRP data collection efforts. The aim of this task is to provide the rationale and plan for sampling to address the Strategy questions. This document will have strong linkages to provision C.8.d and C.8.f of the MRP. The sampling plan will need to be updated periodically as management needs change.

Three subtasks will contribute to development of the sampling plan. The sampling plan will reflect the present consensus obtained through ongoing discussions between the Water Board and BASMAA with scientific advisory input.

Objective: Write a sampling plan for small tributaries loads that represents consensus and guides RMP and MRP studies over the next 3-5 years.

Task 3a: Develop Criteria and Rank Watersheds

Funded 2009 - \$25,000

The premise of the STLS is that it is possible to identify tributaries where there are controllable sources that exert a disproportionately large influence on loads and impacts. Two key questions in relation to this *Strategy*, and before the Water Board and BASMAA in relation to the MRP, are how many types of watersheds do we have and how many watersheds should be studied to answer the key management questions? A key long-standing recommendation of the SPLWG is to stratify watersheds into broad categories and then to sample one or two watersheds in each category; however due to budget limitations this has never been done. To answer these questions, a list of “representative watersheds” or which in the past have been called “observation watersheds” (Davis et al., 2000) or which in southern California are called “mass emissions sites” (Tiefenthaler et al., 2008) needs to be developed. Data on concentrations in Bay sediment, water, and tissue will be used along with physical parameters such as water depth and circulation patterns to characterize and rank Bay margins. To characterize and rank watersheds, information on PCB and Hg sources and “emission factors” and low and high flow hydrology and loads (McKee and Gilbreath in preparation) will be combined with recent new estimates of watershed specific sediment loads (Lewicki and McKee et al., 2009) to provide hypotheses of sediment concentrations. A weight-of-evidence approach will be used during the ranking process, along with knowledge of opportunities for collaboration, and benefits for multiple pollutants.

Objective: To develop a list of representative watersheds for focused study.

Task 3b: Optimize Sampling Methods for Loadings and Trends

Funded 2009 - \$45,000

Management questions and associated hypotheses that are tested by environmental field data require an appropriate field sampling design that is cost effective and achieves the desired outcomes with appropriate confidence. Over the past eight years the SPLWG has implemented loads studies at Mallard Island, the Guadalupe River, and Zone 4 Line A with the objective of increasing our understanding of the sources and processes of sediment and pollutant transport and calculating accurate and precise loads of particle associated POCs. Given increasing costs, the need to estimate loads at more locations in any given year, and the need to show trends (over 5 or more years) as one tool for evaluating whether the TMDL objectives are being met (see provision C.8.f of the February 2009 draft tentative order of the Municipal Regional Permit (MRP)), there is a clear need to evaluate our sampling design and reformulate it as necessary. Using data collected at the three existing load stations, an analysis will be performed to assess the optimal number of samples and style of sampling coupled with loads calculation techniques for assessing loads and determining trends. Methods similar to those outlined in published works (Leecaster et al., 2002; Ma et al., 2009) will be used. We will also make a cost analysis of each combination so that local managers can assess accuracy versus cost. The simulated sampling techniques will be decided during review of a work plan or, if needed, at a special subcommittee meeting of the SPLWG.

Objective: To determine the optimal sampling design for both loads monitoring and trends detection.

Task 3c: Develop Spreadsheet Model for Regional Loadings Estimates

Proposed funding 2010 - \$35,000, \$10,000 each year thereafter

“Spreadsheet models” provide a useful and inexpensive tool for organizing data to estimate regional scale watershed loads, our second key management question. They are based on the simplifying assumption that unit area runoff for homogeneous sub-catchments has constant concentrations and thus have advantages over models such as HSPF and SWMM that require large calibration data sets which take money and time to collect. Such a model was developed for the Bay Area previously (Davis et al., 2000) however, at that time, there was only local land use specific data on POCs for a drought period late 1980s and early 1990s, and there were no data on Hg and PCBs. In this task, a GIS based “spreadsheet model” will be developed using more recent local data on land use based concentrations and mass emissions collected in the Bay Area (augmented using recent stormwater literature) and updated annually as more and more data becomes available through implementation of this *Strategy*. The model structure will be based on the published work by Ha and Stenstrom (2008) and is more sophisticated than the SIMPLE model used by Davis et al (2000) because it contains calibration steps.

Objective: Develop a calibrated tool to make regional scale loads estimates of current and future POCs that can be updated annually as new information is developed.

Task 4: Pollutants of Concern Monitoring at a Subset of Representative Watersheds

Proposed funding 2011, 2012, 2013, 2014, and 2015 - \$250,000 per year

Provision c.8.f of the revised tentative order of the MRP (February 2009) calls for monitoring to assess inputs of POCs to the Bay from specific local tributaries and urban runoff, to assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and for helping to resolve uncertainties associated with loads estimates for POCs at the regional scale (whole Bay). The objective of this task is to carry out monitoring that achieves these same goals, and addresses *Strategy* questions 1 and 2. An efficient approach to conducting this monitoring will be developed through SPLWG discussions and guided by the multiyear watershed sampling plan (Task 3). With an efficient approach, it should be possible to establish three small tributaries load monitoring stations at a \$250,000 / year level of funding but the cost estimate will necessarily be refined after the completion of Task 3b (above). The locations would be decided through consultation with BASMAA and the Water Board and based partly on Task 3a (Develop criteria and rank watersheds). In year 1, we would install discharge and sediment monitoring equipment at three locations and begin sampling. In year two, the majority of the funds would be applied to collecting field data when all the start up costs would have been expended in the first year. Technical reports would be written in year 3 and year 5 only, to minimize reporting costs.

Objective: Determine loads entering the Bay from representative watersheds and improve regional loads estimates.

Task 4a: Pollutants of Concern Monitoring (Guadalupe River)

Proposed funding 2010 - \$43,000. 2013 - \$65,000 (if selected for ongoing monitoring)

Data collected previously in the Guadalupe River Watershed left a number of unanswered questions and hypotheses. During the first sampling year, a 1:5 year return storm event occurred. From December 16th 2002 mercury concentrations were elevated for the remainder of the WY. The data supported a number of hypotheses about the causes of high concentrations but the watershed was never sampled under similar conditions. Additionally, the original sampling design did not allow an estimate of Hg or PCBs from urban sources alone. In response to remaining unanswered questions and also the need to carry out systematic repeated sampling to assess trends, the RMP has budgeted funding for sampling every three years. Recently, the RMP began modeling Guadalupe using the HPSF numerical model to understand the source, release, and transport of sediment and contaminants to San Francisco Bay. The Guadalupe River was chosen primarily because of existing data richness and secondarily because of imminent management aimed at reaching loads targets imposed by the Hg TMDLs. Despite data richness, the weakest POC data set is land use specific data during flood flow; more of this kind of data will be collected in Task 4e and are necessary for calibrating the land use specific components of loading models and improving model performance for simulating BMPs.

Objectives: To collect land use specific PCB data at two locations, one mostly non-urban and upstream and one mostly urban and downstream to calibrate the land use components of the HSPF model and provide recommendations for similar efforts elsewhere in the Bay Area.

Task 4b: Pollutants of Concern Monitoring at a Subset of Representative Watersheds – Zone 4 Line A – year 4

Proposed funding 2010 - \$150,000

Beginning in 2007, the RMP funded a second small tributaries loading study in a small urban watershed in Hayward. The intent of this study was to understand loads of POCs entering the Bay from a small industrialized tributary near the Bay margin. This watershed was chosen because it contrasts with Guadalupe River in size, land use, rainfall variation, soil types, and location on the Bay margin. The study uses an intensive single station design employing 5 minute interval stage, rainfall, and turbidity measurement and storm focused isco pump sampling and depth-integrated point sampling. So far this study has been funded for three relatively dry years. Preliminary comparisons to Guadalupe reveal similarity of most POC loads normalized to areas during dry years with the exception of Hg, Cr, and Ni which have greater concentrations and loads in the Guadalupe system most likely due to historic mining.

Objective: Improve regional loads estimates for the class of smaller industrial watersheds near the Bay margin.

Task 4c: Pollutants of Concern Monitoring at a Subset of Representative Watersheds – Reconnaissance

Proposed funding 2010 - \$12,000

Conducting loads studies in “observation” watersheds is a long standing recommendation of the SPLWG (see Davis et al., 2001). Recent TMDL reports on PCBs and Hg emphasize the influence of local small tributaries on water quality in the Bay and call for reduced loadings from urban areas. Provision C.8.f of the February 2009 draft tentative order of the Municipal Regional Permit (MRP) describes the need for Permittees to monitor eight watersheds to generate loads information. The watershed ranking study (Task 3a) planned for completion in early 2010, will provide a list of prioritized watersheds for study. Given logistical constraints such as channel form and safety that restrict the practical implementation of a loads monitoring study, a reconnaissance study will be carried out to investigate the potential for safe and successful sampling in the top ranked watersheds in the context of management questions. Note it is possible that some of these locations could overlap with the list of locations developed in Task 4d.

Objective: Document technically feasible and “safe” locations for consideration for future small tributary loads monitoring.

Task 4d: Pollutants of Concern Monitoring at Representative Land Use sites – Rationale Development and Reconnaissance

Proposed funding 2011 - \$30,000

In order to develop models capable of testing and forecasting the effects of best management practices (BMPs) on POC trends (management question 4), data must be collected on land use based concentrations and mass emissions to provide a regional calibration data set. In this task we will refine the rationale for such an effort by reviewing literature and discussing potential modeling questions with local agencies. We will identify land use categories of interest in relation to our POC list. Those presently proposed based on the SoCal experience and discussions at strategy team meetings are a) Agriculture, b) Commercial, c) High density residential, d) Industrial, e) Low density residential, f) Open space, g) Recreational, and h) Transportation. There was also discussion of adding a “land use condition” factor such as age and conditions of roads and drainage systems). A list of potential sampling locations will be developed through a review of locations sampled by BASMAA agencies in 1989-1995 and use GIS and aerial photographs to investigate possible locations in high ranking watersheds (Task 3a) taking into consideration the decisions on land use categories to focus on. Lastly, we will carry out a field reconnaissance to investigate the potential for safe and successful sampling. Note it is possible that some of these locations could overlap with the list of locations developed in Task 4c.

Objective: Provide written documentation of the rationale for land use based sampling and a list of potential sampling locations.

Task 4e: Pollutants of Concern Monitoring at Representative Land Use sites

Proposed funding 2012, 2013, 2014, and 2015 - \$100,000/year

In order to develop models capable of testing and forecasting the effects of best management practices (BMPs) on POC trends (management question 4), data must be collected on land use based concentrations and mass emissions to provide a regional calibration data set. We propose to follow the published methods of Tiefenthaler et al. (2008) after an initial assessment of data needs based on what is learned from the Guadalupe River model (see task above), and assessment of the usefulness of existing local data (BASMAA 1996; Soller et al, 2003/SCVURPPP 1998/99; McKee unpublished; EBMUD, 2009). Note the budget for this task depends on POC list, number of sites, and proximity to other loads monitoring sites. The cost proposal will be revised based on the outcomes of Task 3a, 3b, 4c, and 4d. The proposed budget would cover the following tasks:

- Purchasing and installing sampling equipment.
- Sampling storm events at each land use site following the outcomes of Task 3b above (sampling method (discrete or composite; number of samples per storm; number of storms per site).

Objective: Characterize land use specific concentrations and loads as basic data for model development and calibration.

Task 5: Dynamic Modeling in a 2nd Selected Representative Watershed

Proposed funding 2012 - \$150,000

The *Strategy* calls for developing regional estimates of loads, tracking progress towards loads reductions, and determining the effectiveness of management towards TMDL goals. The completion of the Guadalupe Model (Task 1) will address all these questions but only for one large mercury contaminated watershed. The objective of this task is to address the answers to these key *Strategy* questions in another watershed (likely focusing on one adjacent to a known “high leverage contaminated Bay Margin”). A key outcome will be an assessment of how management might be able to reduce loads in the context of linkage to the processes of uptake on the Bay margin. This task will necessarily need data provided by Task 4a, 4b, and 4c (POC Monitoring at a *Subset of Representative Watersheds* and Task 4d and 4e (*POC Monitoring in Representative Land Use sites*)). At this time, we propose to use the HSPF modeling platform but there now exists modified spreadsheet models (annual average time step) that might be considered (e.g., Ha et al in review).

Objective: Expand our modeling capability to test BMPs and predict trends in other representative watersheds.

References

- BASMAA, 1996. San Francisco Bay Area Stormwater Runoff Monitoring Data Analysis 1988 - 1995. Bay Area Stormwater Management Agencies Association; prepared by URS Greiner Woodward-Clyde.
- Davis, J.A., L. McKee, J. Leatherbarrow, and T. Daum. 2000. Contaminant Loads from Stormwater to Coastal Waters in the San Francisco Bay Region: Comparison to Other Pathways and Recommended Approach for Future Evaluation. San Francisco Estuary Institute, Richmond, CA.
- Ha, S.J., and Stenstrom, M.K., 2008. Predictive modeling of storm-water runoff quantity and quality for a large urban watershed. *Journal of Environmental Engineering*, Sept 2008, 703-11.
- Leecaster, M.K., Schiff, K., and Tiefenthaler, L.L., 2002. Assessment of efficient sampling designs for urban stormwater monitoring. *Water Research* 36, 2556-64.
- Lent, M., Oram, J., and McKee, L., 2009. Guadalupe Watershed Model: Year 1 Report. RMP Technical Report: SFEI Contribution #564. San Francisco Estuary Institute, Oakland, CA.
- Lewicke, M., and McKee, L.J, 2009. Watershed specific and regional scale suspended sediment loads for Bay Area small tributaries. A technical report for the Sources Pathways and Loading Workgroup of the Regional Monitoring Program for Water Quality: SFEI Contribution 566. San Francisco Estuary Institute, Oakland, CA. xx pp + Appendices.
- Ma et al., 2009. Sampling issues in urban runoff monitoring programs: Composite versus grab. *Journal of Environmental Engineering*, Mar 2009, 118-27.

McKee and Gilbreath in preparation. Estimates of flow and contaminant loads entering the Bay under selected rainfall and runoff conditions in relation to the potential for routing to wastewater treatment.

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp.

http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

Soller, J., Stephenson, J., Olivieri, K., Downing, J., and Olivieri, A.W., 2003. Evaluation of first flush pollutant loading and implications for water resources and urban runoff management. Santa Clara Basin Urban Runoff Pollution Prevention Program (SCVURPPP) and Eisenberg Olivieri and Associates INC. (EOA). SCVURPPP Fiscal Year 2002-2003 Annual Report.

Tiefenthaler, L.L., Stein, E., and Schiff, K., 2008. Watershed and land use-based sources of trace metals in urban stormwater. *Environmental Toxicology and Chemistry* 27, 277-87.

Table 1. Study elements, questions and budget allocations small tributaries loadings studies and monitoring proposed for the RMP from 2009 to 2015. Numbers indicate proposed budget allocations in \$1,000s. With the exception on those costs that are marked by an asterisk, all other tasks and costs are subject to funding availability and TRC/SC approval.

Task	Description	Question	2009	2010	2011	2012	2013	2014	2015
1	Guadalupe River Model (2008 and 2009)	3,4	75*						
2	Z4LA Small Tributaries Loading Study (Water Years 2007, 2008, 2009)	1,2	100*						
3	Develop Multi-year Watershed Loading Sampling Plan		80*						
3a	Develop Criteria and Rank Watersheds	1,4	25*						
3b	Optimize Sampling Methods for Loading and Trends	1,2,3,4	45*						
3c	Develop/Update Spreadsheet model for Regional Loadings Estimates	2		35	10	10	10	10	10
4	POC Load Monitoring in Representative Watersheds	1,2,3		235	250	250	250	250	250
4a	Guadalupe			43*					
4b	Zone 4 (Year 4)			150*					
4c	Watersheds to Be Named Later (reconnaissance)			12					
4d	Pollutants of Concern Monitoring at Representative Land Use sites – Rationale Development and Reconnaissance	2,3,4		30					
4e	Pollutants of Concern Monitoring at Representative Land Use sites	2,3,4			100?	100?	100?	100?	100?
5	Dynamic Modeling in a 2 nd Selected Representative Watershed	2,3,4				150			
	Total		255	270	360	510	360	360	360

* Already incorporated into a preexisting proposed budget.

Appendix 1: Water Board Priorities for Loads Monitoring

This table contains Water Board decisions or management questions and SPLWG activities that might be needed to address these decisions/questions. The priorities are the same as those identified in the Sources Pathways and Loading Workgroup 5-year plan and have been developed through a consensus based discussions by the Work Group during 2007 and 2008.

SPLWG Priority	Pollutant	Near-term Decision or Management Question (5 years)	Modeling or Monitoring Needs for 5 years	Long-term Decision or management question (10 years)	Modeling or Monitoring Needs for 10 years	Comments
Top	Mercury, methylmercury	What is the contribution of local tributaries and storm drains to localized problems at the Bay Margins. What is the rate of progress toward TMDL load allocations. MRP requires monitoring of methyl mercury loads from urban runoff.	Local tribs monitoring studies designed to support Bay Margin modeling. Need local trib monitoring and beginning of model development to be able to estimate full watershed loads to assess TMDL progress.	Is the urban runoff (tribs/storm drains) total mercury load from all being reduced consistent with the TMDL load allocations for urban runoff. What is the spatial pattern of such load reductions to guide where more progress is needed.	Need sufficient and representative local tribs monitoring plus development of predictive model to provide refined assessment of loads from all watersheds/storm drains and determine spatial and perhaps temporal patterns?	The overarching issues are: 1) determining progress toward meeting Bay-wide load allocations; 2) determining if there are local impacts from some tribs that would require special attention; and 3) being able to distinguish local tribs/storm drains that contribute disproportionately either to Bay-wide loads or localized impacts at the margins. The modeling and monitoring should be directed at these issues. See narrative sheet as well.
Top	PCBs	What is the contribution of local tributaries and storm drains to localized problems at the Bay Margins. We also need to understand loads to various segments and gain understanding if those segment-specific loads matter to Bay impairment.	Local tribs monitoring studies designed to support Bay Margin strategy. Need local trib monitoring and beginning of model development to be able to assess full watershed loads and loads by Bay segment.	Are loads of PCBs from all watersheds being reduced consistent with the TMDL load allocations for urban runoff.	Need sufficient and representative local tribs monitoring plus development of predictive model to provide refined assessment of loads from all watersheds/storm drains and determine spatial and perhaps temporal patterns?	See mercury comments.

SPLWG Priority	Pollutant	Near-term Decision or Management Question (5 years)	Modeling or Monitoring Needs for 5 years	Long-term Decision or management question (10 years)	Modeling or Monitoring Needs for 10 years	Comments
High	PBDEs	What is the contribution of local tributaries and storm drains to localized problems at the Bay Margins. What are the loads of PBDEs from all stormdrains and local tribs. We will need baseline loads to track future loading trends. We also would like to gain the understanding of loads by Bay segment as for PCBs.	Local tribs monitoring studies designed to support Bay Margin modeling. Need local trib monitoring and beginning of model development to be able to assess full watershed loads.	Need trends in PBDE loads. If TMDL is developed, we would need refined load estimates for TMDL.	May need similar information as for mercury or PCBs if PBDE TMDL is developed. Otherwise, we would need less detailed information but sufficient monitoring and modeling to PBDE loading trend.	Look for "piggy-back" opportunities in course of doing work on PCBs. We are not sure what the form of the TMDL will look like, but we know that we will need to be confirming loading trajectory at the very least.
SPLWG Priority	Pollutant	Near-term Decision or Management Question (5 years)	Modeling or Monitoring Needs for 5 years	Long-term Decision or management question (10 years)	Modeling or Monitoring Needs for 10 years	Comments
Medium	Pyrethroids	Are these compounds being detected and causing toxicity? How widespread is this toxicity? Are these pesticides found in runoff at levels that would impact Bay margins in terms of toxicity?	Need some level of monitoring and trend assessment - coarse assessment and evaluation of Bay Margin load and toxicity.	Are these compounds being detected and causing toxicity?	Need some level of monitoring and trend assessment - coarse assessment.	Potential emerging replacement class of pesticides. Needs: characterize and track possible impacts per implementation plan of Urban Creeks TMDL for pesticide-related toxicity.
Medium	Dioxins	What is the contribution of local tributaries and storm drains to localized problems at the Bay Margins. We may need rough cut loading estimate to Bay. There may be a need to understand role of atmospheric deposition contributions to trib/storm drain loads. We need improved understanding of presence in runoff and spatial distribution and how relevant are small tribs to Bay impairment.	some similarity to above pollutants plus air deposition monitoring/modeling connection.	The long term needs depend heavily on the nature of the TMDL. If there is a TMDL, we would need at least some assessment of loading trends.	Need some level of monitoring and trend assessment - coarse assessment.	Impairment listing for Bay, assumed benefit from PCB actions. Needs: fill gaps in conceptual model/impairment assessment, including sources, loads; also determine benefits from PCB actions? May eventually need refined load estimates for all types of dioxins (dioxin-like PCBs and the furans). Here too - look for piggy-back opportunities on top of PCB studies. For dioxin: is the loading coming from local or global sources? We will need evidence about this question for TMDL.

SPLWG Priority	Pollutant	Near-term Decision or Management Question (5 years)	Modeling or Monitoring Needs for 5 years	Long-term Decision or management question (10 years)	Modeling or Monitoring Needs for 10 years	Comments
Medium	Selenium	We need refined load estimates from local tributaries, probably much more focused on extreme S. Bay at the moment. There could be impairment there and need to understand small trib contribution.	monitoring studies for small tribs in S. Bay to get loading estimates.	Update on local trib load estimates.		North Bay TMDL in development. Needs: refine load estimates from local tributaries. Main focus of monitoring should be S. Bay unless data gaps emerge from N. Bay TMDL development. This is unknown right now.
Medium	DDT, chlordane, dieldrin	What is the contribution of local tributaries and storm drains to localized problems at the Bay Margins. We also need loading baseline to track trends. Can we do anything to assist recovery that appears to be taking place (any areas needing attention?)? Similar strategy to PBDEs.	Find local sources or major small trib pathways.	Are we still recovering? Trends?		Bay TMDL in development. Needs: refined data to clarify impairment assessment and forecasts. Additionally, characterize loads to Bay in vicinity of areas of elevated legacy pesticides contamination to support Bay Margin modeling strategy. Look for piggy-back opportunities on other work (PCBs). Strategy has many similarities to PBDEs because of phase out of uses and presumed decreasing trends. TMDL may seek to use simple linkage (from PCB?) and largely be based on confirming recovery is underway. Information needs center around needing to confirm that this simple linkage is justified and appropriate and to confirm what additional actions, if any, are needed to assist recovery of the Bay.
SPLWG Priority	Pollutant	Near-term Decision or Management Question (5 years)	Modeling or Monitoring Needs for 5 years	Long-term Decision or management question (10 years)	Modeling or Monitoring Needs for 10 years	Comments
Medium	Copper	Monitor local tribs copper load trends. If copper is going up, we would want to know something about spatial pattern. Lower intensity monitoring here is OK. Additional monitoring triggered by increasing Bay trend though.		What is the trend of copper loads from local tribs?	Need some level of monitoring and trend assessment - coarse assessment.	Site-Specific Objectives (SSOs) for all Bay (copper) Need: periodic load confirmations, especially copper, from local tributaries per SSO implementation plan. If Bay levels increase, need more intensive small tribs monitoring perhaps in portion of Bay seeing increase. We may want to look at historical loading data from 90s to see if trend insights possible.

SPLWG Priority	Pollutant	Near-term Decision or Management Question (5 years)	Modeling or Monitoring Needs for 5 years	Long-term Decision or management question (10 years)	Modeling or Monitoring Needs for 10 years	Comments
Medium	PAHs	What is the contribution of local tributaries and storm drains to localized problems at the Bay Margins. See dioxin row - very similar approach.				Impairment listing for some portions of Bay or tributaries. Probably need refined load estimates eventually. There is a possibility that threshold of impairment will be driven downward by NOAA. If so, we will have widespread listings. Strategy is similar to dioxins: distinguish local from global sources and ID local sources. Local sources thought to play a big role for this pollutant, though.
Low	Other trace metals (Ag, As, Cd, Cr, Ni, Pb, Zn)	No specific info needs. Can monitoring these provide insights and understanding of loads of other contaminants.				Some local impairment listings. No urgent data needs at present.
	OP pesticides	Are these compounds being detected and causing toxicity? Low level effort is probably OK here.		Are these compounds being detected and causing toxicity? Confirm trends, assumed decreasing.		Need: ongoing checks of toxicity presence per implementation plan of Urban Creeks TMDL for pesticide-related toxicity
	Nutrients	What are the loads and speciation of those loads (ammonia etc.)from local tributaries in comparison to other sources like POTWs and big rivers? Are these loads causing localized impairments like algal blooms or toxicity? Also, if Bay becomes clearer, might nutrients lead to some eutrophication problems? Finally, how do nutrients impact localized methylation at Bay Margins? Probably good idea to begin building knowledge base with monitoring and modeling.	Monitoring studies to answer the questions posed.	What is the status of the loads from local tribs? Long-range questions are up in the air right now.		We do not know the impairment status for nutrients so there are no imminent regulatory actions. Some loading data may be needed to support development of conceptual model/impairment assessment. There is a possibly linkage to MeHg loads and/or production in receiving waters. They may play an increasingly important role in Bay trophic status if there are long-term Bay changes in terms of clarity from other causes.

Appendix 2 Tools and Methods Applied to-date for Answering Management Questions

This summary was developed to aid discussions in the early meetings of the Small Tributaries Loading Strategy Team

Tools and methods		Previous uses	Spatial and temporal scale	Planned or in progress in the Bay Area	Technical considerations	Stakeholder / implementation concerns
Field monitoring methods	Bed sediment surveys (combining bed sediment concentration with estimates of selected watershed sediment loads)	Used to identify and rank drainage systems with regards to POC concentrations. Combined with estimates of sediment loads to make local and aggregate regional estimates of POC load.	Region wide representing "average conditions"	Yes 1. SFEI prop 13 project, 2. Street sweeping studies, 3. City of Richmond source tracking and solution development	Grain size, there is no reliable relationship between POC in deposited sediment and POCs in water column	Cheap but reliability unknown
	Field based loads studies (combining high resolution flow, surrogate measure (turbidity), manual storm water sampling, lab analysis, regression estimator)	Loads: 1. Sacramento River, 2. Guadalupe River, 3. Zone 4 Line A, 4. pilot in Coyote Creek	Single tributaries. Selected climatic years measured. Other climatic year estimated using long term sediment or climatic data	1. Zone 4 Line A (WY 2009), 2. Sacramento River (WY 2010), 3. Guadalupe River (WY 2010)	Limitations: Only works when there is a relationship between turbidity and POCs; Advantages: High accuracy, multiple uses (loads, water quality exceedences, analysis, modeling, trends, future predictions	Expensive, can't afford to do it everywhere, need to decide where to do it and commit for a number of years. Logistic and cost issues in calibrating Suspended Sediment concentration data, affect site selection.
	Field based loads studies (combining high resolution flow, automated field sampling (ISCO), lab analysis, averaging estimator)	BASMAA load studies for metals and some organics (1989-1991) that also used SWMM modeling to estimate loads (some monitoring continued during 1990's, see SWMM below)	Single tributaries. Selected climatic years measured. Other climatic year estimated using long term sediment or climatic data	Trial planned for Z4LA in WY 2009	If samples are composites will loose information on concentration variation during floods, loads will be less accurate and it will be unknown if each POC load is bias high or low	Cheaper than surrogate method but reliability unknown. If SSC used instead of TSS, logistic and cost issues apply.

Tools and methods		Previous uses	Spatial and temporal scale	Planned or in progress in the Bay Area	Technical considerations	Stakeholder / implementation concerns
Extrapolation methods	Area based extrapolation (load measured in one watershed is scaled up to the Bay Area using an area ratio)	Used in PCB TMDL to estimate regional aggregate stormwater loads based on Guadalupe and Coyote Creek data	Region wide representing "average conditions"		Assumes that Guadalupe is characteristic (has average hydrology and land use of the entire Bay Area)	
	Sediment based extrapolation (load measured in one watershed is scaled up to the Bay Area using a sediment ratio)	Used in the Hg TMDL to estimate regional aggregate stormwater loads based on BASMAA bed sediment data	Region wide representing "average conditions"		Assumes that all sediment is sources from the same places in the landscape regardless of watershed geology, hydrology and land use	Cheap but reliability unknown
Modeling methods	SIMPLE model (An empirical model combining rainfall, land use, land use runoff coefficient and POC concentrations)	Used to estimate stormwater loads to coastal waters in 2000	Region wide representing "average conditions"		Assumes empirical relationships between climate land use and POC generation. No consideration for physical processes	Cheap but reliability unknown
	Hydrologic Simulation Program-Fortran (HSPF). A one dimensional watershed scale grid based conceptual model with routing.	Calibration/validation studies in a few selected watersheds by some BASMAA agencies. Being applied by Brake Pad Partnership for modeling Cu aggregate loads to Bay..	Single tributaries. Selected climatic years measured. Other climatic year estimated using long term sediment or climatic data	Guadalupe (sophisticated level for investigating BMPs), Z4LA (simple for estimating long term hydrology)	Requires a lot of input data some of which many not be available at desired resolutions making calibration challenging. Handles non-urban land use well	Expensive, but can be used for testing management scenarios and predicting future loads. What is the tradeoff between cost and achievable sensitivity in forecasting compared to mass balance models?

Tools and methods		Previous uses	Spatial and temporal scale	Planned or in progress in the Bay Area	Technical considerations	Stakeholder / implementation concerns
Modeling methods	Stormwater Management Model (SWMM). A watershed scale sub-catchment based conceptual model with routing designed for urban areas.	BASMAA (1989-1991) load studies. ACCWP model for Castro Valley Creek watershed was refined for diazinon and copper 1995-2001	Single tributaries. selected climatic years measured. Other climatic year estimated using long term sediment or climatic data		Requires a lot of input data some of which many not be available at desired resolutions making calibration challenging. Handles urban land use well, less flexible for undeveloped (pervious) or mixed watersheds.	Expensive, but can be used for testing management scenarios and predicting future loads
Statistical methods	Power Analysis using a Monte Carlo simulation developed in Matlab. Determine the power to detect user defined trends (e.g. 90% in 20 years) in suspended sediment or contaminant concentration.	Leecaster et al 2002 in Santa Ana R. SoCAL. "Assessment of efficient sampling designs for urban stormwater monitoring"	Single tributaries. Selected climatic years measured.	Yes (perhaps 2008 for suspended sediments in Guadalupe if funding approved)	Many assumptions such as no change in data distributions, no change in source characteristics, no change in dilution effects.	Low cost. Useful to inform the debate on sampling design.
	Lake Core analysis. Uses paleolimnology to identify trends in contaminants in urban and pristine (reference) settings at the multi-decadal scale (50 years)	USGS National Urban Runoff Program studies for understanding national scale trends in environmental quality.	Single tributaries but perhaps regional if atmospheric load is the main source. Decadal (50 years)	Yes 2009 (for multi-contaminants if TRC approves funding)		Decadal time scale - regional in scale if atmospheric load is the main signal. Limited to where there are lakes - not at bottom of watershed