Small Tributaries Loading Strategy Multi-Year Plan

Contents

Acknowledgments

This document was developed collaboratively by the Small Tributaries Loading Strategy Local Team of the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP):

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BASMAA and ACCWP provided funding for preparation of the draft text and Appendix A incorporating information from many working products by RMP and BASMAA. [SFEI staff are responsible for preparation of Appendices B, C, D, E and G – if not credited in those respective appendices];

Additional technical advice to the STLS Work Group was provided in early meetings by Mike Stenstrom (UCLA) and Eric Stein (SCCWRP), who also participated in reviews by the RMP Sources Pathways and Loadings Workgroup.

Members of the BASMAA Monitoring and Pollutants of Concern Committee and stormwater program staff also participated in development and review of the Multi-Year Plan, especially Jamison Crosby (Contra Costa Clean Water Program) and Jon Konnan (San Mateo Countywide Water Pollution Prevention Program).

Introduction

The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) was established to provide the scientific information needed to support water quality management. In the 21st century, the RMP's activities are shifting to provide more direct support for answering specific Management Questions through multi-year Strategies consisting of coordinated activities centered on particular pollutants or processes. The Small Tributaries Loading Strategy (STLS, SFEI 2009) presented an initial outline of potential activities to address four key Management Questions regarding local watershed contributions of Pollutants of Concern to San Francisco Bay. The objective of this Multi-Year Plan (MYP) is to provide a more comprehensive description of the suite of activities to be included in the STLS over the next 5-10 years. It provides a detailed rationale for the methods and locations of proposed activities, including watershed monitoring of local tributaries.

Some of these activities will be conducted by stormwater programs to fulfill the requirements of the Municipal Regional Stormwater Permit (MRP, SFRWQCB 2009) for Pollutants of Concern (POC) loads monitoring[1]; this MYP supports development of an improved alternative monitoring approach for addressing these MRP needs that will be integrated with the RMP-funded activities.

The MYP includes continuing development of the Regional Watershed Spreadsheet Model as a tool for estimating regional loads. It also clarifies the linkage between the STLS and the RMP's developing Modeling Strategy for pollutant fate and transport in the Bay as a whole and also in the Bay margins which are a vital link between the local watersheds and the Bay.

The first version of the MYP (Version 2011) was prepared in September 2011. The updated Version 2012A incorporated additional information and STLS activities through mid-January 2012, including:

- Progress on the Regional Watershed Spreadsheet Model including preliminary explorations and recommendations for developing Event Mean Concentrations to parameterize the model for priority POCs.
- Setup of 4 watershed monitoring sites, preparation of draft QAPP and Field Manual, and coordination among field crews.
- Coordination of laboratory contracting and management and QA/QC of watershed monitoring data

Version 2012 B incorporates additional information and STLS activities through June 2012, including:

[1] Described in Provisions C.8.e and its sub-provisions i, iii, iv and v. Sub-provisions vi and vii are also related to the same objectives, see Appendix A.

- Review of lessons learned from the first year of watershed monitoring
- Selection of two additional watershed monitoring sites in addition to the four previously selected.

Version 2012A involves no updates to the Appendices provided with MYP Version 2011[2]. Updated or new versions of some Appendices will be provided in the future.

Background

Based on data collected by the RMP and others, the San Francisco Regional Water Quality Control Board (Water Board) has determined that San Francisco Bay is impaired or potentially impaired by a number of POCs. For some of these, the Water Board has adopted water quality attainment strategies including Total Maximum Daily Loads (TMDLs) for mercury and PCBs (SFRWRCB 2006, 2008) due to their persistence in the environment and accumulation in aquatic food webs that pose threats to wildlife and human consumers of fish from the Bay.

Each TMDL identifies sources and pathways contributing to the impairment or detrimental effects associated with the subject pollutant, as illustrated for PCBs (Figure 1). The sizes of the arrows on the figure illustrate, conceptually, the importance of each source, pathway or process. For PCBs, urban runoff, deposition of associated sediment, and transfer from sediment up through the food chain are the important pathways and processes. For each source, the TMDL estimates current annual loads and identifies reductions in those loads that would be required to eventually eliminate the impairment. Each TMDL is adopted along with an implementation plan consisting of management actions to be taken by various discharger groups in order to achieve these load reductions.

Urban runoff from local watersheds is a significant pathway for many pollutants of concern into the Bay, and the MRP contains several provisions requiring management actions and studies to address mercury and PCB its (see Appendix A for details). The MRP's monitoring provisions also include other pollutants for which storm water data are needed. The MRP also encourages coordination of storm water program activities with the RMP are other regional collaborative groups.

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[2] On behalf of MRP Permittees, the Bay Area Stormwater Management Agencies Association (BASMAA) provided MYP Version 2011 and available Appendices A, C, D, E and F to the San Francisco Regional Water Quality Control Board as attachments to a Monitoring Status Report (Part B of a composite document that also included a Regional Pollutants of Concern Report for required annual reporting); these documents are available on the Internet at http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/MRP/2011_AR/BASMAA/index.shtml
In March 2012, MYP version 2012 A was attached to another semiannual Monitoring Status Report, but without any revisions to the appendix list.

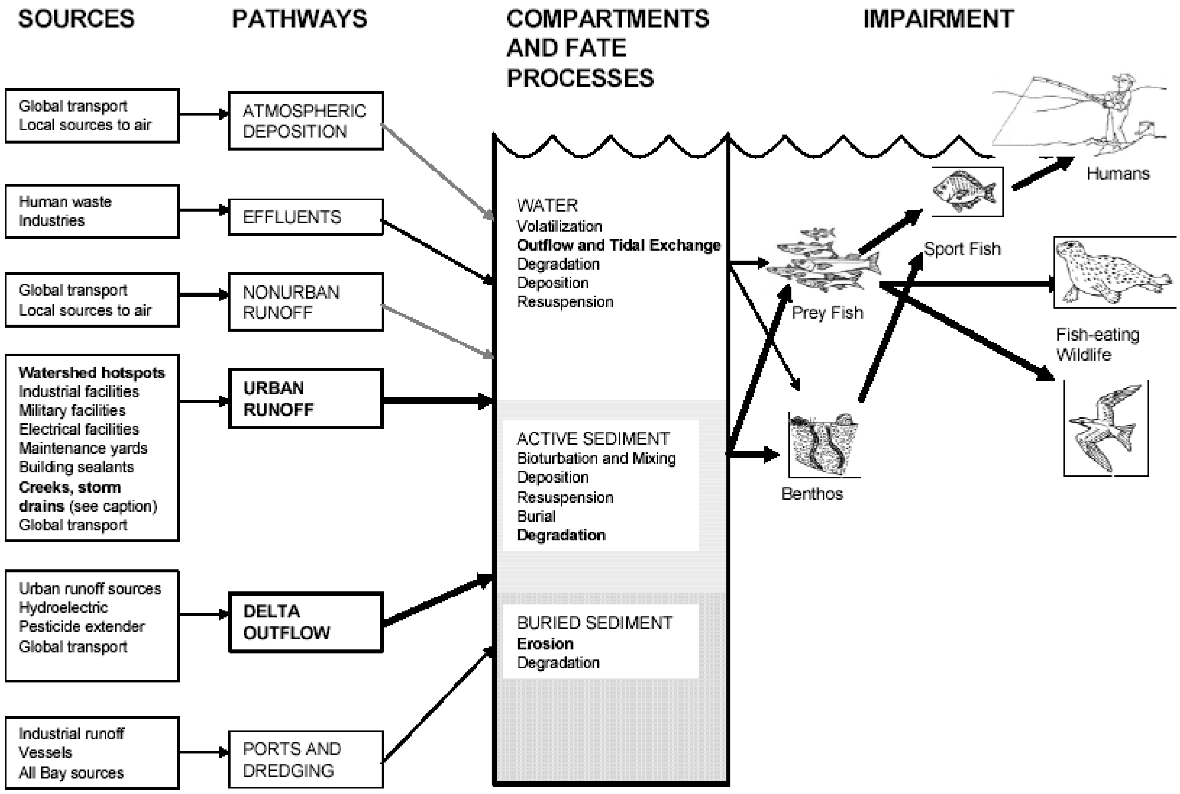

Figure 1. Conceptual Model of PCBs in San Francisco Bay (from Davis et. al 2006)

The STLS MYP is a major component of the RMP Multi-Year Plan, which integrates the efforts of many workgroups and strategy teams to develop five-year plans addressing the highest priority management information needs identified by the RMP stakeholders. The intent of the Multi-Year Plan is to anticipate regulatory or management decisions and policies that are on the horizon, so that the specific scientific knowledge needed to inform the decisions will be available at the required times.

The RMP's Multi-Year Planning Process, initiated as the "Master Planning Process" in 2010[3], articulates several "strategies" which coordinate studies across the pre-existing process-oriented work groups (see Appendix A). The STLS is a major strategy with linkages to other strategies for mercury, PCBs and forecasting/ modeling. The Water Board has given a high priority to refining and tracking load estimates of PCBs and mercury to assess progress towards the reductions in the TMDLs. Initial estimates of stormwater contributions to annual loads of mercury and PCBs to the Bay were based on limited data and one of the RMP's goals has been to improve both data collection and the conceptual framework for developing load estimates. Understanding trends from individual watersheds will also be important, whether in response to general demographic

[3] RMP activities are planned on a calendar year basis, while BASMAA and most of its member agencies operate on a Fiscal Year that begins on July 1.

and climatic changes or targeted management actions to reduce local discharges of PCBs and mercury.

Depending on the state of existing knowledge and potential impairment status, loading information needs may be a somewhat lower priority for other POCs such as copper (for which the highest priority information gaps are about effects and not loading) or legacy organochlorine pesticides (for which the monitoring objective may be tracking a long-term "recovery" curve of diminishing concentrations in the Bay). A third group of POCs are present in the Bay at concentrations that cause concern; since existing data are insufficient to assess the amount of contribution from stormwater conveyance, initial STLS work will contribute to a general characterization of spatial occurrence and ranges of concentrations. This differential prioritization is reflected in the MRP's partitioning of required stormwater monitoring parameters into two groups with different levels of minimum sampling frequency:

- Category 1 (minimum 4 events per year): Total and Dissolved Copper; Total Mercury; Methyl Mercury; Total PCBs; Suspended Sediments (SSC); Total Organic Carbon; Water Column Toxicity; Nitrate as N; Hardness.
- Category 2 (minimum 2 events in alternate years): Total and Dissolved Selenium; Total PBDEs (Polybrominated Diphenyl Ethers); Total PAHs (Poly-Aromatic Hydrocarbons); Chlordane; DDTs (Dichloro-Diphenyl-Trichloroethane); Dieldrin; (Nitrate as N –duplicate?); Pyrethroids - bifenthrin, cyfluthrin, beta-cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, permethrin, and tralomethrin; Carbaryl and fipronil; Total and Dissolved Phosphorus.

The RMP Sources Pathways and Loadings Work Group (SPLWG) was initiated in 1999 to address pollutant loading to the Bay. It has overseen monitoring studies of high-priority POCs in small tributaries at the Guadalupe River (McKee et al., 2004; 2005; 2006) and at Zone 4 Line A (a small flood control channel in Hayward) (McKee et al., 2009; Gilbreath et al., in review) as well as at Mallard Island (Leatherbarrow et al., 2005; McKee et al., 2006; David et al., 2009, David et al., in review) where the Sacramento River enters the region.

Development of the draft MRP led to an RMP initiative in 2007 to develop the STLS as a framework for coordinating stormwater requirements and RMP activities. In recognition of those discussions already initiated prior to its adoption, the MRP allows Permittees to pursue an alternative approach to answer the same information needs underlying the STLS. The STLS Work Group, a subgroup of SPLWG, includes representatives from BASMAA and Water Board staff to ensure close coordination, as well as SFEI staff and technical advisors recruited through the RMP. A series of meetings during 2008 and 2009 and associated meeting support materials led to the finalization of the draft Strategy (SFEI, 2009). In 2009 and 2010 SFEI provided further planning support through the completion of several data synthesis reports (Greenfield et al., 2010; Melwani et al., 2010). An initial draft MYP presented the STLS Work Group's recommended approach for implementing the STLS, was reviewed by the SPLWG at its May 2011 meeting, followed by brief review of the completed Version 2011 at its meeting on October 25, 2011; at this meeting the SPLWG agreed to a communications strategy for informing the SPLWG of further MYP updates produced by the STLS Work Group.

This 2012 B version reviewed the status of planning and implementation for coordinated watershed monitoring beginning October 1, 2011[4]. This 2012 B version updates the status of the first season of monitoring and selection of two additional watershed monitoring sites to be phased in beginning October 2012. Further details and documentation of watershed monitoring and other work plan activities for later years will be added in future MYP versions in 2013 (see Adaptive Updates below).

Management Questions and Strategy Elements

The stakeholder process established the following Management Questions for the STLS:

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

STLS technical activities are grouped into three Elements, listed with their sub-elements in Table 1. Figure 2 shows the main linkages between Management Questions and individual Elements; some Elements also support each other, as suggested by the dotted lines and described in the following MYP sections. Other activities outside the scope of the STLS also have bearing on these Management Questions; see Appendix A for background and context of regional projects to evaluate the potential effectiveness of management actions to reduce PCB and mercury loads to the Bay.

[4] The Water Year designation used by USGS begins on October 1, which is the nominal start of the wet weather monitoring season. Stormwater monitoring beginning in October is customarily budgeted by the RMP with funds for the following calendar year and by BASMAA with funds for the FY beginning the previous July.

Table 1. Small Tributaries Loading Strategy Elements and projected implementation roles.

Element	RMP	Stormwater Programs
1. Watershed and associated Bay Modeling		
A. Regional Watershed Spreadsheet Model	X	
B. Coordination with Bay Margins Modeling	X	
C. HSPF dynamic modeling (potential)	(X)	
2. Source Area Runoff Monitoring and EMC Development	X	
3. Small Tributaries Monitoring		
A. Monitor Representative Small Tributaries	X	X
B. Monitor Downstream of Management Actions		X

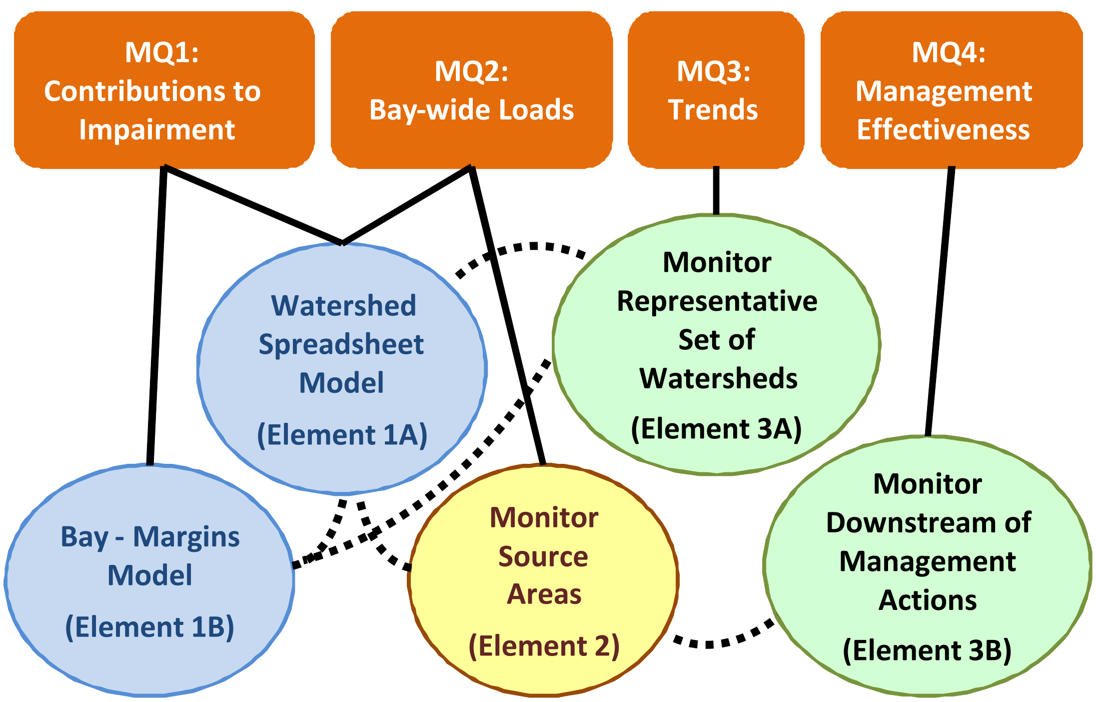

Figure 2: Primary relationships between Small Tributaries Loading Strategy management questions and Elements.

The first element, Modeling, includes a watershed spreadsheet model specifically designed to estimate Bay-wide loads of POCs (Management Question 2) which will also clarify the relative contribution of small tributary loads to the overall Bay impairment for each pollutant (Management Question 1). The spreadsheet model will provide estimates of relative load contributions from individual watersheds around the Bay and will help to identify high-leverage watersheds or more likely clusters of watersheds that may be having a greater local impact to sensitive reaches of the Bay margin[5]. However, the model is of limited use for this question without comparable understanding of the spatial variation within the Bay and local contributions from non runoff sources; these will be provided through a Bay margins model being developed by the RMP as part of a separate Forecasting or Modeling Strategy. In the future, dynamic modeling of one or more individual watersheds may be useful to deepen the understanding of underlying mechanistic behavior not captured by the spreadsheet model. The finer temporal scale of dynamic models may also be helpful in linking the tributary loads to the time scales of biological processes represented in the Bay margins model.

The second element, Monitor Source Areas, is intended to provide Event Mean Concentrations (EMCs) of targeted POCs to parameterize the watershed loadings spreadsheet model. Such monitoring would require catchments that are relatively homogenous in terms of land use or other source area characteristics, which would differ from the watersheds selected for Element 3. The STLS is exploring a number of desktop approaches to estimate EMCs for initial work on the Regional Watershed Spreadsheet Model. Understanding that is gained through this element about the range of EMCs and the factors that affect them can also inform the approach to monitoring downstream of management actions. Element 3, Watershed Monitoring, has two sub elements to address Management Questions 3 and 4.

Strategy Elements

Load Estimation and Modeling

The Regional Watershed Spreadsheet Model (RWSM) will be the primary tool for estimation of overall loads to the Bay. Spreadsheet runoff models are based on the simplifying assumption that unit area runoff for each homogenous subcatchment can be represented by a constant concentration for each POC. Given the large number of small tributaries, initial STLS Work Group discussions indicated this is more suitable as a

[5] Another group of spreadsheet models is being used by the stormwater programs to address Management Question 4 by providing quantitative scenarios of PCB and mercury load reductions from implementation of source control measures in local watersheds. Monitoring data from pilot projects begun in 2010 to refine and test these "desktop evaluation" models is also likely to provide useful input for running scenarios on the RWSM. See Appendix A.

framework for regional load estimation than simulation models such as HSPF and SWMM that require large and detailed calibration datasets. The RWSM is structured similarly to Ha and Stenstrom (2008), using GIS-derived data for land use, imperviousness, average soil type/slope and annual precipitation. It uses recent local data on land use based concentrations collected in the Bay Area and augmented using data and information extracted from recent stormwater literature. These runoff concentration coefficients can be updated periodically as new data become available through the monitoring elements of the STLS or related compatible efforts.

RWSM Development

This section summarizes the details and development of the RWSM which are described in draft reports under review by the SPLWG, which will be provided as Appendix B in the 2012B version of the MYP. The model's spatial extent covers the entire region overseen by the Region 2 Water Board boundary (corresponding closely to the Calwater outline in Figure 3). Within this region, the spatial resolution of individual watershed areas is provided by several data sources:

- Watershed boundaries for Central and South Bay. The urban portions of this dataset are based on compilations by the Oakland Museum of California (OMC) Creek and Watershed Mapping Project (a long term collaboration between William Lettis and Associates, OMC, and SFEI funded by cities and counties http://www.sfei.org/content/gis-data). Begun in 1993, and largely completed in 2008 through a state bond-funded Proposition 13 grant awarded to SFEI, this dataset incorporates further corrections by stormwater managers and is provides a fairly accurate depiction of urbanized catchments, although many of the smaller catchments have been arbitrarily aggregated and the dataset is not fully conformant to data standards of the National Hydrography Dataset.
- Contra Costa Flood Control District's watershed boundaries to fill in the eastern portion of Contra Costa County (Water Atlas cite)
- Provisionally, Calwater Hydrologic Areas are used to fill in remaining portions of the North Bay, Contra Costa, SF & coastal peninsula. Later versions of the RWSM could use increased spatial resolution provided by NHD or other sources if needed.

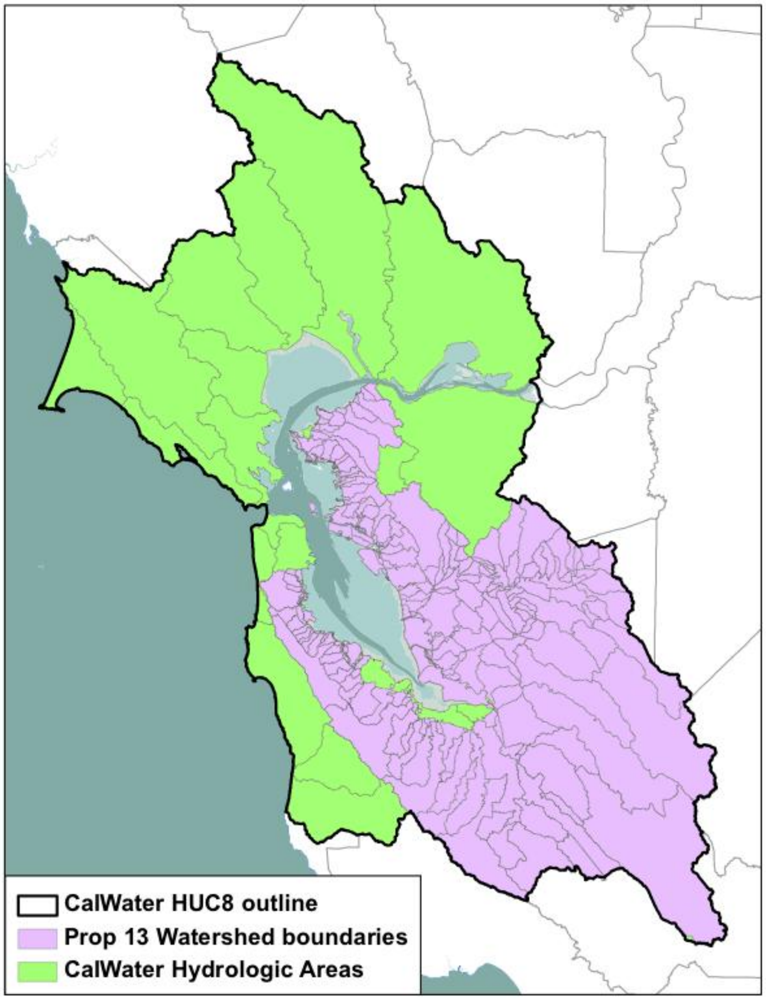

Figure 3: Spatial extent of RWSM and detailed watershed boundaries[6]

The outcomes of the first year included the development of two parallel hydrological models, one using land use based runoff coefficients and the other using imperviousness based runoff coefficients. The model outcomes were compared to empirical observations in 18 calibration watersheds. Preliminary loads of suspended sediment were also generated but the loads generated were quite different from the empirical observations (of which there are many).

An available land use dataset for the Bay Area (ABAG, 2005) is based on a combination of remote sensing and local assessor's parcel information. The first construction of the RWSM used the land use categories of Ha and Stenstrom (2008), with Event Mean

[6] Watershed boundaries based on the Oakland Museum of California Guide to San Francisco Bay Area Creeks (http://museumca.org/creeks/GIS/index.html) and compiled and improved through a Proposition 13 grant awarded to SFEI (http://www.sfei.org/content/gis-data).

Concentrations (EMCs) in initial runs taken from literature. Other categories could be substituted following further analyses from Element 2 studies to develop a framework for specific loads based on land use or other source area characteristics such as age or condition of development.

Work for the RWSM in 2011 included preparation of the Year 1 report (Lent and McKee 2011, in review) and follow-up on several of its recommendations to refine the hydrology model by:

- Adding several calibration watersheds to ensure watershed characteristics that span a wider range of imperviousness. Since the original calibration data set used in the RWSM year 1 model lacked representation at the high end of the imperviousness range, three high imperviousness catchments were added to the calibration data set. All three of these catchments drain to pump stations and required conversion of pump logs to estimated flow; these records were only available for short periods.
- Removing gage records for some watersheds and time periods with pre-development land use / impervious characteristics differing significantly from present conditions
- Refining land use categories with the updated ABAG 2005 dataset used as base. This improved the consistency of the spatial dataset among counties, particularly in the treatment of transportation land uses which are highly impervious.

The Year 2 progress report (Lent et al 2012) describes these model refinements and is attached as part of Appendix B, The year 2 tasks served to correct or reduce errors and biases in the hydrological model that were noted in the year 1 report. The hydrologic model will need to be re-visited, in the context of further model development such as calibrating the sediment model or the contaminant models, which are the recommended focus of RWSM work in year 3 (See Appendix B).

Each pollutant has a unique set of properties that determines its uses, the resulting products and environmental attributes such as in-use spatial distribution, potential for reuse, and mechanisms of inadvertent environmental pollution. A series of “contaminant profile” fact sheets will summarize these properties and frame conceptual models of source areas and other information needed to build each POC specific model using the RWSM. The initial version of the RWSM focuses on load estimates for sediment, mercury and PCBs. The year 1 report presents the available information and proposed modeling approaches for the highest priority POCs, along with discussion of data gaps:

- There is little direct EMC information about PCBs, so the sediment surrogate will initially be used to understand the potential range of loadings. Refining the spatial characterization of the particular types of land uses and source areas for PCBs is a high priority.
- The sediment model does not have the same structure as other POCs and will be represented as a hybrid of available USGS datasets for larger mixed-use

watersheds and a more land use oriented source area model for highly urbanized watersheds which are generally smaller.
- Mercury will follow a similar conceptual model to the sediment model.

Copper is also being included in the first round of RWSM development because extensive data are available both from the Bay Area and in the world literature, and also because as a primarily dissolved constituent it serves to define the limitations of the hydrologic model alone and helps to set up realistic definitions for success for the other more difficult contaminants.

In March 2012 the STLS Work Group reviewed a draft multi-year planning matrix for RWSM-related activities, which is included in the Year 3 and RWSM multi-year work plan in Appendix B.. The planning matrix includes all tasks and POCs that are of interest to the STLS, BASMAA and other RMP strategies, which are potential funding sources for specific tasks. The draft matrix projects construction of a version 2 model for each of the above POCs in 2012. Contaminant profiles will also be drafted for the next tier of POCs to be examined, which were selected based on MRP priorities with the concurrence of Water Board staff.as described in the next section. Work plan details will be updated as findings of further model testing and calibration are incorporated in future versions of Appendix B. These updates will also describe recommendations for further testing and verification, for example selection of monitoring locations that would be supportive for improving model weaknesses; EMC-related data needs and proposed future activities will be detailed in Appendix G for future versions of the MYP.

RWSM Uses

In 2011 and 2012 the RWSM framework contributed to the watershed monitoring design and influenced the selection of the fifth and sixth watershed monitoring sites. When coupled with monitoring data in the near future, it will provide improved estimates of current loading. Other near-term functions will be as a tool to help stormwater programs address two related MRP requirements:

- Provision C.8.e(vi) requires developing a design for a robust sediment delivery estimate/sediment budget in local tributaries and urban drainages. RWSM model coefficients will also be developed for sediment, which will provide an alternative perspective to regional load estimates previously developed by Lewicki and McKee (2009).
- Provision C.14.a(v) requires developing information required to compute loads to San Francisco Bay of PBDEs, legacy pesticides, and selenium from urban runoff conveyance systems throughout the Bay. The RWSM will provide the framework for initial load characterization with available data from RMP and STLS monitoring, and to develop recommendations for additional studies as needed to improve these initial estimates.

Water Board staff have indicated that the RWSM is an appropriate tool for addressing these provisions, and BASMAA has approved regional project budgets to support work on sediment, PBDEs and the legacy pesticides chlordane, dieldrin and DDTs[7]. These budgets are incorporated in the workplan Table 11 and will be integrated with the RWSM multi-year planning matrix that is presented in Appendix B. In particular the sediment modeling work in 2012 will address both the MRP requirements and also may improve the calibration of the hydrological model to support development of the PCB and mercury models.

A related model that was discussed in the STLS but is not part of the STLS workplan is a desktop model for evaluating the effectiveness of management options to reduce loads of POCs from local watersheds (see description of Proposition 13 products in Appendix A). As storm water programs collect monitoring data from sites of pilot management projects, these can be used in conjunction with existing EMC information to run scenarios for wider application of various management strategies and predict regional load reductions using the RWSM. Other medium and long term uses will be determined by the STLS Work Group, which will provide ongoing stakeholder discussion forums to update priorities as described in Adaptive Updates below.

Coordination with Bay Modeling and Other Modeling Efforts

The RMP is also developing a Bay Margins Conceptual Model as part of a separate Bay Modeling Strategy overseen by the Contaminant Fate Work Group (CFWG). The initial draft (Jones et al., 2011) recommends development of a full-Bay 3-D model that could identify high-leverage watersheds whose POC loadings contribute disproportionately to Bay impacts. Until the RMP Modeling Strategy is developed to a point that offers practical guidance on characterizing the relationship of specific tributaries or groups of tributary POC sources to contaminant fate in local portions of the Bay margin, working versions of the RWSM will not apply special weighting or other spatial considerations when estimating individual tributary inputs.

Dynamic Watershed Modeling (Potential)

The SPLWG supported development of a dynamic watershed model for the Guadalupe River Watershed as a pilot effort with funds from 2008 and 2009. This watershed is the subject of a separate TMDL for legacy mercury from the historic New Almaden Mining district. An abundance of local water, sediment, and contaminant data made this watershed a logical place for an initial exercise in mechanistic modeling using Hydrologic Simulation Model-Fortran (HSPF). The basic proof-of-concept Guadalupe watershed model for hydrology was completed (Lent et al., 2009). The final report is presently being completed (Lent et al, in review)

Further dynamic modeling work for the Guadalupe River watershed, or initiation of modeling for other watersheds, may be recommended in the future depending on specific information needs of the STLS or Bay Modeling Strategy. STLS need for detailed watershed modeling would be identified through the Adaptive Update process.

[7] Lent and McKee (2011) also includes a contaminant profile for selenium.

Watershed Monitoring

This MYP element outlines a cost-effective and flexible approach to watershed monitoring that can be implemented in the context of both the RMP Multi-Year Plan and MRP permit requirements. As part of STLS development, the RMP conducted several related projects in 2010 through 2011 to evaluate potential design considerations:

- Desktop methods optimization study
- Preliminary watershed classification
- Watershed characterization sampling study

Results of these studies were evaluated along with several other considerations, including analytical sensitivity and cost, to develop several alternative scenarios for implementation of the MYP watershed monitoring element.

Table 2 shows the six STLS watershed monitoring stations and their phasing for start-up during the first two years of sampling, beginning in Water Year (WY) 2011-12. The assignment of responsibilities for operation of the stations were based onfunding sources and availability of staffing by SFEI and BASMAA consultants. The rest of this section summarizes various aspects of the watershed monitoring and the discussions that informed the decisions made by the STLS Work Group.

In 2011, frequent STLS meetings and communications focused on decisions regarding site selection and procedures for setup and operation of the first four (Phase 1) watershed monitoring stations. In the WY 2011-12 wet season SFEI operated two stations for the RMP and one station (Guadalupe River) under contract to the Santa Clara Valley Urban Runoff Pollution Prevention Program, while the fourth site is operated by contractors for the Contra Costa Clean Water Program. The STLS work group continued to coordinate details of setup and monitoring through the first part of 2012.

BASMAA has supported preparation of a draft Quality Assurance Project Plan (QAPP) and BASMAA and RMP funds were used to develop a Field Manual to document standard procedures for field sampling and Quality Assurance. These documents will address the MRP requirement for protocols and data quality comparable to the Surface Water Ambient Monitoring Program. The QAPP and Field Manual will be finalized and incorporated in the MYP later in 2012, to include the lessons of the first field season.

Table 2. Watershed Monitoring Stations for the STLS

Station Name (County)	Funding source WY 2011-12	Funding source WY 2012-13
Phase 1		
Lower Marsh Creek (Contra Costa County)	CCCWP in-kind	CCCWP in-kind
San Leandro Creek (Alameda County)	ACCWP in-kind (setup) RMP (operation & maintenance)	ACCWP in kind
Guadalupe River - (Santa Clara County)	SCVURPPP in-kind (SFEI contract)	SCVURPPP in-kind
Sunnyvale East Channel (Santa Clara County)	RMP	RMP
Additional Phase 2		
North Richmond Pump Station (Contra Costa County)	N/A	RMP
Pulgas Creek Pump Station [c] (San Mateo County)	N/A	SMCWPPP in-kind

Monitoring Methods

A standard approach for stormwater monitoring is composite sampling in which multiple discrete samples from one storm event are combined into one sample for analysis. This concept is the basis for basic requirements in 40CFR121.21(7)(g)(ii), referenced in the MRP as the default procedure to be used. A common practice for collecting stormwater samples is to use automated samplers with onset of the storm event sampling triggered by increase in flow (as indicated by a change in stage height of the monitored channel or conveyance) with subsequent discrete aliquots sampled at pre-programmed intervals that may represent equal increments of elapsed time or of discharge volume.

The SPLWG oversaw RMP load studies on the Guadalupe River in water years (WYs) 2003-06, 2010, and at Zone 4 Line A (Z4LA) in WYs 2007-10, collecting multiple discrete depth integrated point samples (loosely referred to as grab samples for STLS purposes) during many storm and base flow events. These studies were based on the use of continuous turbidity monitoring as a more sensitive way to identify the onset of storm discharge, as well as for characterizing the within-storm variations in transport of sediments and POCs associated with fine sediments. The turbidity record was used as a surrogate for continuous estimation of finer fractions of SSC and the associated POCs to generate highly accurate and precise load estimates at 5-15 minute intervals which could then be summed to any other desired time interval (e.g. event, day, month or season).

Using the Guadalupe and Z4LA datasets, an optimization study was conducted to recommend sampling methods and style of sampling that would be useful for assessing loads and determining trends. Using methods similar to those outlined in Leecaster et al (2002) and Ackerman et al. (2011), a series of analyses were performed to assess the optimal number of samples and style of sampling for SSC, PCBs and mercury within storms as well as approaches for choosing which storm events to sample. Detailed methods and results are presented in Appendix C. Results differed somewhat for Guadalupe vs. Z4LA and for PCBs vs. mercury, but preliminary review of tested scenarios suggested the following:

- Turbidity triggering was slightly better than flow for defining the start of the storm, but no particular trigger strategy for within-storm sampling was identified that was consistently more accurate for characterizing the POC loads of a particular event.
- To use regression on the turbidity surrogate records for estimating annual loads, at least 10 but ideally 16 samples per year should be collected at each site; however focusing this number of samples on just a few randomly selected storms would likely cause spurious loads estimates of poor accuracy and precision.
- Strategies for selecting a more representative set of storms to sample (e.g. first flush + a larger storm + several random, first flush + several random, vs. all random) were evaluated. From the analysis it appears that scenarios that include first flush and one of the largest storms of the year provide more robust loads estimates than random sampling alone.
- Power for detecting trends appeared to be possible with just 10 samples collected per year, based on a preliminary scenario in which the samples were randomly selected and did not confirm to any of the tested sampling designs

While the optimization assessment focused on PCBs and mercury, the findings should be generally applicable to other sediment-associated pollutants and probably more than adequate for dissolved constituents since dissolved concentrations generally vary much less with flow. They may not be as relevant for methylmercury since the intent of the permit is to investigate a representative set of drainages and obtain seasonal information and to assess the magnitude and spatial/temporal patterns of methylmercury concentrations. It may also not be particularly good for water toxicity since toxicity response is a function of both concentration and cumulative duration of exposure.

Taking into consideration recent automated sampling experiences at other Bay Area sites, the final sampling design for WY 2011-12 was modified to include manual grabs for mercury and methylmercury, and both discrete and composite samples using autosamplers as shown in Table 10. Discrete samples collected with a D94 or DH84 FISP sampler are depth-integrated. Samples collected using ISCOs are considered mid depth relative to flow, and samples collected using hand dipping methods (Marsh Creek only) will be reported as collected 25 cm below water surface. This hybrid approach was estimated to be roughly equivalent or slightly lower in cost than using autosamplers for all samples; other advantages include reducing the likelihood of false starts and more flexibility in sampler configuration.

The STLS Work Group decided all sites will use a new high-range model of turbidity probe based on turbidities observed during the WY 2010-11 characterization study. However delays in delivery of the probes caused a delay in completing the site set-up. At Guadalupe River, logistical problems prevented completion of composite sampler installation prior to the WY 2011-12 sampling season so monitoring during WY 2011-12 is being conducted using manual grabs (a D95 FISP) water quality sampler and 4-wheel boom-truck assembly.

Categories of watersheds

From its early days, the SPLWG has recommended stratifying the numerous watersheds of Bay Area small tributaries into general categories to provide a rationale for systematic sampling of a subset of watersheds in selected categories (Davis et al., 2000). These categories are needed to answer two key questions for the design of the STLS MYP watershed monitoring:

1. How many types of watersheds occur in the region and,
2. How many watersheds should be studied to answer key management questions, and how should they be distributed among the identified types?

To address the first question, SFEI conducted a preliminary characterization study using ordination and cluster analysis, exploratory statistical techniques designed to visualize patterns on complex multivariate data sets (see background in Appendix C preliminary discussion "Categorization of watersheds for potential stormwater monitoring in San Francisco Bay"). The study aimed for an initial classification of Bay Area small tributary watersheds into a small number (<10) of classes, relevant for loads monitoring and Bay margin impacts. Statistics were generated for 18 attributes on each of the watersheds to form the basis for analyses. Table 3 summarizes a scheme consisting of eight clusters or classes which appeared robust and meaningful for the STLS purposes.

The descriptions in Table 3 include those attributes that seemed most influential in discriminating among the clusters (all attributes were assigned equal weight in the analyses). Clusters 1, 2, and 3 are similar to each other in all having relatively high residential, commercial, and industrial land cover and consequently, high surface imperviousness. Combined, these clusters include 119 watersheds, and could therefore be described as typical watersheds for the study area. These clusters generally include densely populated, low-lying areas that drain into South Bay and Central Bay
In the remaining groupings, Cluster 6 watersheds are distinguished by their large size while the rest seem to fall into smaller, more specialized clusters.

Table 3. Description of eight preliminary watershed clusters generated using Bray-Curtis distance with Ward's linkage method.

Cluster No.	Number of watersheds	Description
1	41	High commercial and residential land cover and imperviousness. High historic industry and railroads. No PG&E facilities. Moderate area.
2	43	High commercial and residential land cover and imperviousness. High historic industry and railroads. One to four PG&E facilities. Large area.
3	35	High commercial and residential land cover and imperviousness. Low historic industry or railroads. Smaller area.
4	11	Small, sparsely populated, predominantly industrial, highest historic industrial and imperviousness. Located around San Francisco Airport and Brisbane.
5	11	Sparsely populated, low development, high open land cover, no railroads, "green space." Located adjacent to Bay or in undeveloped uplands.
6	22	Largest watersheds, with moderate population density, high open land cover, and low imperviousness.
7	17	High agricultural land cover, lower rainfall, draining to Carquinez Strait and Suisun Bay.
8	5	Small, sparsely populated, predominantly open, containing historic railroad, and draining to Carquinez Strait.

After reviewing the preliminary watershed classification the STLS agreed that further information was needed to select watersheds for future STLS monitoring. RMP resources for WY 2010-11 monitoring were redirected to a characterization study consisting of storm water grab samples from 16 of the candidate watersheds for which there were little or no existing PCB or mercury concentration data[8].

Table 4 shows the watersheds selected for the characterization study, along with a summary of some of their key attributes. Criteria for the composition of the sampling list included the following:

[8] This redirection is allowed by MRP Provision C.8.a, which indicates that initiation of the required POC loads monitoring can be deferred to October 2011 if the stormwater Permittees are participating in a regional collaborative process to plan and conduct the monitoring.

- Multiple representatives of the most common small to medium sized watershed classes 1-3, distributed throughout the four counties (Contra Costa, Alameda, Santa Clara, and San Mateo) where loads monitoring is required by the MRP.
- A few representatives of the medium to large watershed classes.
- Smaller catchments, generally heavily urban with industrial land uses, where stormwater programs are planning enhanced management actions to reduce PCB and mercury discharges.
- Other watersheds with distinctive histories of mercury or PCB occurrence, or related management concerns.

Figure 3 shows the general locations of the study watersheds and the drainage areas above the initially selected monitoring locations. Some of the monitoring station locations were adjusted after field reconnaissance. Table 5 lists watersheds considered but not selected for the study, and also watersheds excluded from the study because of the availability of significant amounts of previously collected PCB and mercury data. Appendix E provides details of the study design, methods and preliminary results, which will be updated with a more complete analysis later in 2012.

In June 2011 the STLS Work Group reviewed the results of the WY 2011-12 sampling. Analytes measured at each sampling site varied depending on budget and Water Board management questions (Table 6). Between 4-7 PCB, total mercury, SSC and organic carbon samples were collected at each site. PBDE and PAHs were collected at a subset of sites chosen based on logistics (essentially randomly from a water quality perspective). Selenium data were only measured at Contra Costa sampling locations.

Table 4. Watersheds sampled during reconnaissance characterization study of Water Year 2011.

Watershed/ station	Area (km^2)	Prelim, Cluster No.	Percent Impervious	Percent Old Industrial	Reconnaissance Feasibility/ Safety	PCB-Hg attributes
Ettie Street Pump Station	4.0	1*	73.4**	28.60**	Good/Good	PCB P13 Cluster, CW4CB pilot watershed
Pulgas Creek	7.1	2	28.2		Good/Good	CW4CB pilot watershed
Sunnyvale East Channel	18.0	2	59.7	3.47	Good/Good	PCB P13 Cluster
Santa Fe Channel	2.64	2	70.3	3.6	Poor-Medium/ Good	Confirm proposed station vs. locations of CW4CB pilot watersheds
Lower San Leandro Creek	8.9	2	37.5	2.96	Good/Good	PCB spill into creek in 1995
Stevens Creek	73.7	6	15.8	0.24	Good/Good	Within airshed of Lehigh-Hanson Cement Manufacturer
Zone 5 Line M	8.1	*	33.5	3.15	Good/Good	Hg P13 Cluster
Lower Marsh Creek	97.5	?	14.7		Good/Good	Drains historic Hg mine
San Lorenzo Creek	124.8	6	13.2	0.50	Medium/Good	
Walnut Creek	318.7	7	16.6	0.72	Good/Good	
Lower Penitencia Creek	12.0	*	67.1	7.14	Good/Good	
Belmont Creek	7.2	2	27.4	0.00	Medium/Good	
Borel Creek	3.2	2	31.4	1.57	Medium/Good	
Calabazas Creek	52.9	1	45.6	0.44	Good/Good	
Glen Echo Creek	5.4	3	39.3	0.80	Good/Good	Hg P13 Cluster
San Tomas Creek	114.1	1	34.4	0.35	Good/Good	

***** Catchment does not correspond to a polygon used in cluster analyses
****** Estimated for larger polygon used in cluster analyses

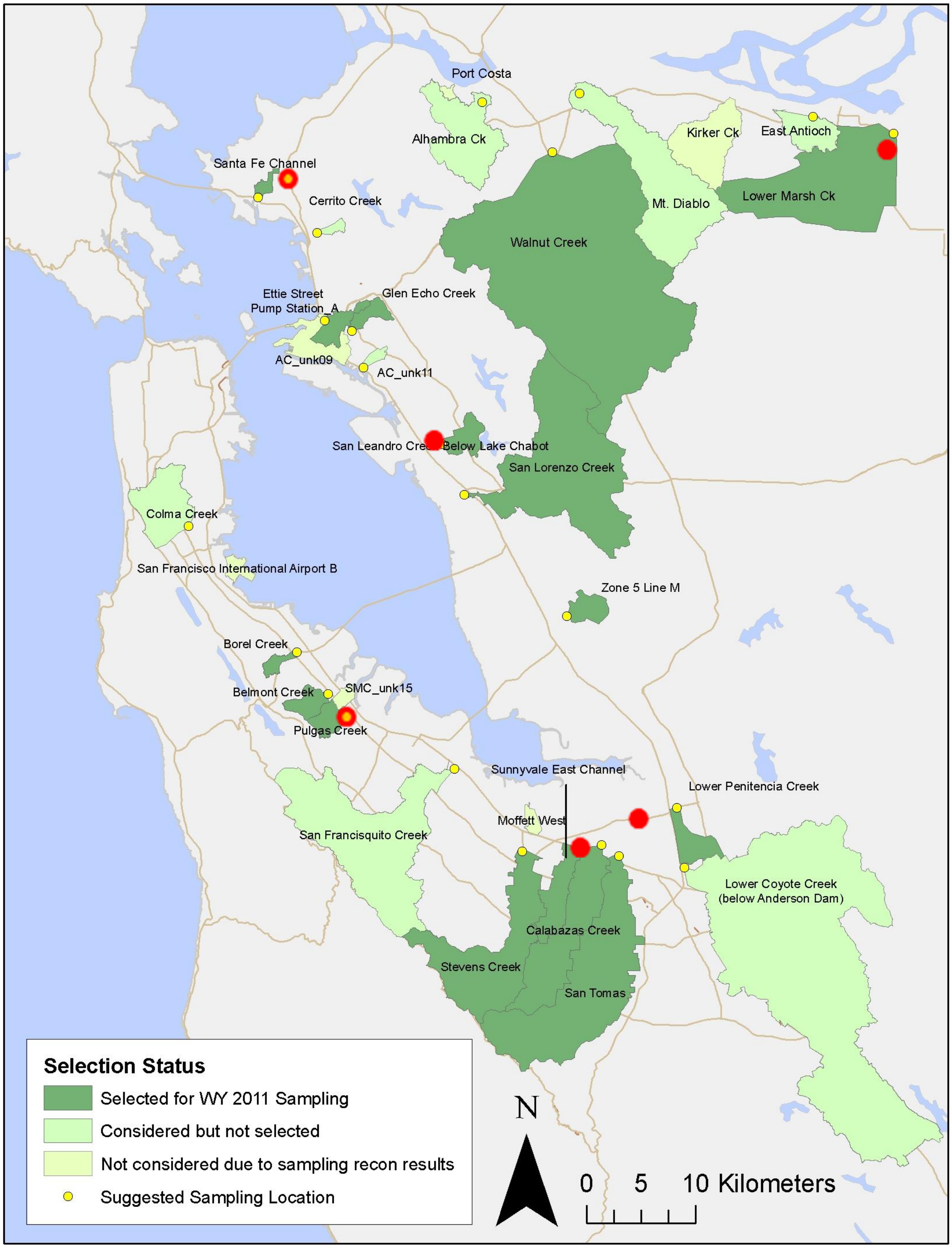

Figure 4. Watersheds sampled in Water Year 2010-11 reconnaissance characterization study. Red circles indicate approximate locations of six watershed monitoring stations for WY 2012-13.

Table 5. Potential candidate watersheds, not selected for reconnaissance characterization sampling during WY 2010-11.

County	Watershed	Area (km^2)	Prelim, Cluster No.	Percent Impervious	Percent Old Industrial	PCB-Hg attributes
San Mateo	Colma Creek	28.0	2	37.5	2.18	PCB P13 Cluster, CW4CB pilot watershed
Contra Costa	Alhambra Creek	41.0	6	6.0	0.01	
Alameda & Contra Costa	Cerrito Creek	1.9	2	35.8		
Contra Costa	East Antioch	14.4	7	41.4	1.31	
Contra Costa	Mt Diablo Creek	80.2	6	10.5		
Alameda	Oakland, East of Lake Merritt	2.1	2	67.3	6.18	PCB P13 Cluster
Alameda	Zone 4 Line A	8.78*	1	67.6	10.1	
Santa Clara	Lower Coyote Creek (below Anderson Dam)	318.6	6	21.1	0.38	PCB P13 Cluster
Santa Clara	Guadalupe River	226	6	32.5	2.7	Hg TMDL
San Mateo & Santa Clara	San Francisquito	111.8	6	7.3	0.27	

Table 6. Summary of analytes collected during the water year 2010-11 reconnaissance characterization study.

Analyte	MRP Category	Number of Samples
PCB	Category 1	91
Total Mercury	Category 1	91
SSC	Category 1	91
Total Organic Carbon	Category 1	91
PBDE	Category 2	22
PAH	Category 2	22
Total Selenium	Category 2	30
Dissolved Selenium	Category 2	30

Table 7 shows that while maximum concentrations of total mercury varied from 19-1740 ng/L (about 100x) between sites in relation to suspended sediment concentration and watershed characteristics, maximum PCB concentrations varied from 1,851 - 467,696 pg/L a variation of about 250x. Methylmercury did not relate directly to maximum total mercury observed at each site. Normalizing mercury and PCB data to SSC and turbidity respectively (see Appendix E for discussion) resulted in a different pattern and rankings of the sampled watersheds, as shown in Table 8.

Table 7. Maximum concentrations of mercury and PCBs for the Water Year 2010-11 reconnaissance characterization study.

Watershed	Max HgT (ng/L)	Max. PCBs (pg/L)
Belmont Creek	59	4,909
Borel Creek	74	8,671
Calabazas Creek	89	24,765
Ettie Street Pump Station	73	68,996
Glen Echo Creek	179	85,815
Lower Marsh Creek	200	4,136
Lower Penetencia Creek	19	1,851
Pulgas Creek Pump Station - North	27	84,490
Pulgas Creek Pump Station - South	28	53,894
San Leandro Creek	477	31,336
San Lorenzo Creek	77	20,421
San Pedro Storm Drain	499	No data
San Tomas Creek	129	4,372
Santa Fe Channel	217	467,696
Stevens Creek	121	22,554
Sunnyvale East Channel	151	67,462
Walnut Creek	181	24,396
Zone 5 Line M	1740	25,091

Table 8. Summary of PCB and Hg results in relation to suspended sediment or turbidity and organized by PCB/turbidity ratio.

Site	PCB/Turb Avg Ratio (pg/NTU)	HgT/SSC Avg Ratio (ng/mg)	PCB Rank	Hg Rank	Rank Sum	Feasibility Constraint?
Santa Fe	2882	0.68	1	4	5	Tidal
Ettie St	1097	0.78	2	3	5	Access time restricted
Pulgas North	822	0.47	3	5	8	Extremely flashy
Pulgas South	639	0.83	4	1	5	Extremely flashy
Glen Echo	443	0.38	5	7	12	Underground downstream
Sunnyvale Channel	369	0.34	6	8	14	Bridge narrow
San Leandro	98	0.8	7	2	9	
Z5LM	84	0.41	8	6	14	SSC > 1800 mg/L
San Lorenzo	74	0.28	9	9	18	
Stevens	33	0.26	10	11	21	
Calabazas	29	0.16	11	16	27	
Walnut	21	0.19	12	17	29	SSC > 1800 mg/L, 12-24 hour hydrograph – sample preservation
San Tomas	21	0.27	13	10	23	
Lower Penetencia	20	0.16	14	15	29	
Borel	17	0.17	15	14	29	
Belmont	15	0.24	16	12	28	
Lower Marsh	4	0.23	17	13	30	SSC > 1800 mg/L, Remote, access by Hwy 4, sample preservation

For the most part, sampling logistics at these sites were taken into account as part of the decisions made prior to the reconnaissance study. However, there were some additional lessons learned during the reconnaissance study about feasibility and potential sampling constraints that are worth noting in Table 8. The tidal nature of the Santa Fe channel, although it was sampled during low tide, will challenge the measurement of discharge if loads at this site are desired in the future; acoustic Doppler technology at a greater cost would be needed. Three locations (Zone 5 Line M, Walnut and Lower Marsh) had observed turbidities that exceed the use of the DTS12 turbidity sensors employed previously at Guadalupe and Zone 4 Line A; sensor technology that ranges to 4000 NTU is available but with some loss of sensitivity at the lower end of the range (<50 NTU). The narrow sampling platform at Sunnyvale East Channel adds challenges for manual sampling equipment and safety due to lack of space. Sampling locations at the base of large watersheds such as Walnut Creek and Guadalupe River, with storm hydrographs that can span a day or more, may add sample preservation challenges if ice melts before samples can be retrieved following storm events. Lower Marsh Creek is a challenging location due to travel time to the site and the same kinds of preservation challenges.

Criteria for watershed selection

In June 2011 the STLS WG reviewed characteristics of the candidate watersheds that it considered as priorities for the watershed monitoring:

- **Representative** for purposes of long-term trends monitoring. Watersheds selected have a station near the bottom of the watershed, and include a range of sizes and land uses, ranging from already urban to those expected to undergo significant additional urbanization over the next 20 -30 years.
- Containing **Management** opportunities for TMDL load reductions, especially of PCBs and mercury, that are likely to be explored through pilot projects or other targeted stormwater program activities during the next 5-10 years (see Appendix A). Since the first round of pilot management activities will be limited to a few local catchments, the STLS Work Group decided to focus the watershed selection for Phase 1 (WY 2011-12) on representative sites and defer potential selection of these watersheds until later in 2011, to plan for Phase 2.
- Named as a monitoring location for specific NPDES **Permit** requirements affecting Bay Area stormwater programs. This includes Lower Marsh Creek which is named in a parallel C.8.e provision in the municipal stormwater permit for eastern Contra Costa County. The Guadalupe River site previously monitored by the RMP is one of the 8 stations identified as default locations for POC Loads Monitoring in the MRP, and continued monitoring at this site is also required by a permit supporting the implementation of the mercury TMDL for that watershed.[9]
- **Feasibility** of monitoring for the desired Management Question. For example, many catchments with planned or potential management activities are heavily culverted and located in low-lying Bayside areas, so that monitoring stations downstream of the management areas are often subject to tidal inflow or inaccessible due to private property boundaries.

The four stations selected for Phase 1 start-up were:

- Lower Marsh Creek (Contra Costa County) operated with funding from Contra Costa Clean Water Program on behalf of BASMAA.
- Lower San Leandro Creek (Alameda County) operated in Year 1 by SFEI for RMP
- Sunnyvale East Channel (Santa Clara County) operated by SFEI for RMP
- Guadalupe River (Santa Clara County) operated with funding from Santa Clara Valley Urban Runoff Pollution Prevention Program on behalf of BASMAA.

[9] Both of these permits specify additional monitoring requirements which are not included in the scope of this STLS MYP, i.e. additional parameters for Lower Marsh Creek and additional sites and periodic intensified monitoring in the Guadalupe River watershed.

In March 2012 the STLS Work Group discussed criteria for selecting two additional stations to be initiated in 2012 for Phase 2

Analytes and Data Quality Objectives

Where applicable, the MRP specifies that default standards for monitoring data quality be consistent with the latest version of the Quality Assurance Program Plan (QAPrP; SWAMP 2008) adopted by the Surface Water Ambient Monitoring Program (SWAMP). The QAPrP adopts a performance-based approach with target Reporting Limits (RL) for a large list of analytes in water and sediment.

The RMP has not specified target Reporting Limits for most analytes; for the SPLWG monitoring studies SFEI has utilized laboratory services that provide much lower method detection limits (MDL) for some analytes than those that would be associated with the SWAMP Target RLs.

Table 9 summarizes the results of a review of detection frequency at Zone 4 Line A, indicating that the RMP laboratories have obtained much higher frequencies of detection with much lower detection levels for the organic compounds (see Appendix F).

MDLs are variable depending on the concentrations of the target analyte and similar compounds as well as potential interference from other constituents in the sampling matrix. While quality assurance considerations should be used in interpreting data near the MDL, accurate quantitative results at low range are important for developing load estimates.

For WY 2011-12, analyses were performed by the laboratories listed in Table 10[10]. Laboratory contracting and Quality Assurance procedures for laboratory data are being performed by SFEI for all four stations, through funding provided by the RMP and BASMAA.

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[10] The STLS MYP does not include other analytes for which occasional sampling at some or all of the STLS watershed monitoring stations may occur, such as monitoring required by the municipal stormwater permit for eastern Contra Costa County issued by the Central Valley Regional Water Quality Control Board, or sampling for special studies initiated through other RMP strategy workgroups (e.g. nutrients and dioxins) that take advantage of the existing infrastructure for STLS monitoring stations while covering all incremental costs for sampling those analytes.

Table 9. Comparison of detection rates for selected analytes using SWAMP Reporting Limits vs. RMP-contracted lab results for storm water samples at Zone 4 Line A; see Appendix F for additional notes.

Analyte	SWAMP Target RL	Z4LA data, fraction > SWAMP RL	MDL range	Z4LA % detection	Sample Volume, Liters
Category 1					
Copper (Total)	0.01 µg/L	45/45		100%	0.12
Copper (Dissolved)	0.01 µg/L	11/11		100%	
Mercury (Total)	0.0002 µg/L	112/112		100%	0.25
Methylmercury	0.00005 µg/L	55/56		99%	0.25
PCB congeners	0.02 µg/L	20/77		(98%)	2.5
SSC	0.5 mg/L	392/392		99%	0.25
TOC	0.6 mg/L	40/40		100%	.25
Nitrate as N	0.01 mg/L	10/12		(NA)	(0.15)
Hardness (as CaCO3)	1 mg/L	NA		NA	NA
Category 2					
Selenium (Total) [e]	0.30 µg/L	15/30		36%	0.5
Selenium (Dissolved)	0.30 µg/L	0/5		66%	
PBDEs	NL - assume 0.02 µg/L	18/36		(75%)	2.5
PAHs [g]	10 µg/L	3/21		(99%)	2.5
DDTs	0.002 µg/L [h]	14/20		(100%)	
Chlordane [i]	0.002 µg/L	13/20		(100%)	
Dieldrin [i]	0.002 µg/L	3/20		(100%)	
Pyrethroids [j]	NL	NA		NA?	4
• Bifenthrin		--	NA		
• Delta/Trihalomethrin		--	NA		
• Permethrin, total		--	NA		
Carbaryl	NL	NA	NA	NA	NA
Fipronil	NL	NA	NA	NA	NA
Phosphorus (Total)	NL	NA	NA	NA	(with N)
Phosphorus (Diss.)	NL	NA	NA	NA	(0.17)

Watershed Monitoring Approach

The MRP requires POC loads monitoring effort that is equivalent to conventional flow weighted composite sampling at eight sites, with an annual average of four events sampled for Category 1 analytes and one event for Category 2. The MRP allows phased implementation: Phase 1 monitoring of at least four stations, or roughly half of the effort, must be initiated by October 2011 and Phase 2 monitoring of the remaining stations must start by October 2012.

After discussion of assumptions for the MRP default plan compared with alternative scenarios incorporating the recommendations for sampling frequency and laboratory data quality described above, the STLS work group agreed to pursue a watershed monitoring plan that would be roughly consistent with the MRP cost benchmark and include:

- A total of six watershed monitoring stations, with four to be deployed in Phase 1 (WY 2011-12) and an additional two stations in Phase 2 (WY 2012-13), subject to review after the first year to evaluate whether resources should be reallocated between watershed monitoring and EMC development elements.
- Continuous turbidity monitoring (not included in the MRP) at all stations to enable turbidity surrogate regression estimation of seasonal loads of particulate associated POCs and allow for the future inclusion of other analytes and the back calculation of loads using turbidity records.
- For best load estimation of mercury, PCBs and sediment at least 16 samples should be collected in a season; for planning purposes, this would be a minimum of 4 events with an average of 4 samples per event. Sampled events should target a first flush event and at least one of the larger storms of the year.
- Sample analyses for all stations would be performed by specific laboratories recommended on the basis of previous performance and reliability in achieving low MDLs for each parameter.

In March 2011 Water Board staff indicated that this STLS program with annual cost similar to the MRP benchmark of $800,000-$1,000,000[11] would meet the MRP requirement for an alternative monitoring approach that addresses the priority Management Questions, with the assumption that at least 2/3 of this cost would be supported by the storm water programs (see work plan below). At the SPLWG meeting on October 25, 2011, Water Board staff confirmed that the mobilization then in progress for Phase 1 watershed monitoring stations was in compliance with the MRP.

In July 2011 the STLS Work Group determined that all monitoring stations should use the same sampling methods for each parameter, and began developing a plan using automated sampling equipment (Model 6712 full size by Teledyne ISCO, hereafter "ISCO") for all parameters except methyl mercury. After further evaluation this was changed to a hybrid of several sampling methods as described above. Modifications were also made to the sampling plan to permit efficient use of ISCOs for composite sampling and to reflect evolving regulatory priorities for data on particular analytes. The revised STLS Work Group consensus plan for sampler configuration is shown in Table 10.

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[11] Benchmark cost for default MRP monitoring (including ongoing project administration but excluding data management and reporting and contingency for false starts) was established as a range to express variation in labor costs among the participating agencies. Benchmark calculations distributed one-time start-up costs over 3 years of operation, although this assumption has limited value for actual project planning. No site-specific cost variations were assumed other than stage-discharge monitoring and calibration for sites not served by an existing USGS gauging station.

Annual number of samples per site is equal to or greater than the average annual frequency specified in the MRP for all analytes except organochlorine pesticides, for which recent data have suggested a reduced regulatory priority. Due a very dry WY 2011-12 rainy season, fewer than the planned number of storm events were sampled at 3 of the first 4 stations. With concurrence of Water Board staff, The STLS Work Group agreed that additional samples would be added to WY 2012-13 sampling plans so that over a 3- year period, a total of 12 representative storm events will be sampled at each site..

In June 2012 the STLS Work Group also discussed potential improvements to monitoring procedures for WY 2012-13 including:

- Collecting composite samples on a time-interval rather than flow-weighted basis.
- Re-evaluating guidelines for number of composite aliquots per storm event to balance needs for storm representation against variability in pumping capabilities of the auto samplers.
- Changing contract laboratories for Some analytes (pyrethroid as, SSC, TOC) to improve turnaround times, quality control and costs.

Updated methods will be finalized in late summer 2012 and incorporated in the Quality Assurance Project Plan and Field Manual as described below.

Table 10. Sample type and target frequency of STLS sampling by analyte.

MRP Category	Parameter	No. of Storms / year	No. of Samples/ storm	Frequency change from MRP	Sample Type	Recommended Lab*
1	PCBs (40 congener)	4	4	400%	Discrete	AXYS
1	Total Mercury	4	4	400%	Grab	MLML
1	Total methyl mercury	2[12]	4	400%	Grab	MLML
1	Dissolved Cu	4	1	0%	Composite	BRL
1	Total Cu	4	1	0%	Composite	BRL
1	Hardness	4	1	0%	Composite	BRL
1	SSC (GMA)	4	8	800%	Discrete	EBMUD
1	Nitrate as N and Total Phosphorous	4	4	400%	Discrete	EBMUD
2	Dissolved phosphorus	4	4	400%	Discrete	EBMUD
1	Total Organic Carbon	4	2.5	250%	Discrete	Delta
1	Toxicity – water column (3 species + *Hyalella azteca*)	4	1	0%	Composite	PER
2	Pyrethroids	4	4	1600%	Composite	AXYS
2	Carbaryl	4	4	1600%	Composite	DFG – WPCL
2	Fipronil	4	4	1600%	Discrete	DFG – WPCL
2	Chlordane, DDTs, Dieldrin	0	0	-100%	N/A	N/A
2	Dissolved Se (collect with Dissolved Cu)	4	1	400%	Composite	BRL
2	Total Se (collect with Total Cu)	4	1	400%	Composite	BRL
2	PBDE	2	1	200%	Discrete	AXYS
2	PAH	2	1	200%	Discrete	AXYS

* Laboratory abbreviations: AXYS - AXYS Analytical Services; MLML - Moss Landing Marine Laboratory; BRL – Brooks Rand Labs; EBMUD - East Bay Municipal Utility District; Delta – Delta Environmental Laboratories; PER – Pacific EcoRisk; DFG – WPCL – California Department of Fish and Game Water Pollution Control Laboratory.

[12] Two additional dry weather methyl mercury grab sampling events, required by the MRP, will occur during station set-up in September and shutdown in April or May.

Watershed Monitoring Plan

This section contains recommendations in two categories. The core plan is the minimum recommendation to meet the requirements for an alternative equivalent approach to the POC Loads Monitoring in the MRP. Additional plan options may be considered subject to the availability of additional resources, either for the current participants or by leveraging resources of additional programs or partners in the future.

The core plan comprises 6 sites as shown in Table 2, using the sampling frequencies and methods in Table 10.

In January 2012, STLS Work Group members noted that initiating field sampling for EMC development may be premature since we are still in the discovery phase of final model structures for the initial group of POCs, and evaluating GIS data quality in relation to pollutant specific land use/ source areas and the usefulness of existing data sets for back-calculation of EMCs.

The Quality Assurance Project Plan and Field Manual with Standard Operation Procedures will document details of equipment and methods, to be summarized in a 2012B revision of Appendix F. The first year of monitoring in WY 2011-12 involved some method variations that are being resolved along with recommendations for additional quality assurance/quality control procedures. .

Should additional resources become available, plan options could include:

- Accelerating Core Plan activities on an earlier schedule.
- Adding other analytes where compatible with the STLS autosampler configuration and grab sampling logistics described in the Field Manual and summarized in Table 10. MYP updates would not necessarily include short-term examples such as the RMP nutrient and dioxins strategies' separately funded studies involving supplemental nutrient and dioxins sampling and analysis at the two STLS sites operated by the RMP.

The STLS Work Group will not produce a detailed written interpretive report of WY 2011-12 results, but will provide a limited summary of the monitoring activities for purposes of the RMP and MRP. SFEI will present a preliminary review of the first year's data for discussion at STLS and SPLWG meetings to be scheduled in the second half of 2012. An integrative 2-year report will be prepared in late 2013, and will be incorporated in BASMAA's Integrated Monitoring Report for MRP reporting requirements.

Source Area Runoff Monitoring

The RWSM literature review identified several gaps in available information about EMCs. As an alternative to starting reconnaissance for source area monitoring sites, SFEI began exploratory work with an approach suggested at the May 2011 SPLWG meeting that uses available data from sediment samples collected in storm drain conveyances to back-calculate EMCs for the input side of the RWSM. Initial results of this exploration were unfruitful, but several refinements are being pursued as described in Appendix B and further results and potential implications for source area runoff monitoring will be provided in a 2013 version of the MYP Appendix G.

Adaptive Updates

This MYP is a working document and will require revisions as new information and data are reviewed for POCs on the existing priority list, or new pollutants are identified as regional priorities. Updated working versions of the MYP will be incorporated in BASMAA Monitoring Status Reports or Urban Creeks Monitoring Reports related to MRP requirements. The next future revision in version 2013A will cover the period through December 2012 and may incorporate:added or updated materials listed below:

- Updated Appendix F with details of watershed monitoring sampling procedures, & QA, with reference to QAPP, field Manual, and field training materials; also documentation of procedures for coordinating management, QA/QC of watershed monitoring data
- Review priorities for watershed monitoring data vs. EMC studies, document potential scenarios for future allocations of STLS effort
- Draft planning timeline for future data reviews (e.g. trends analyses, integration with spreadsheet modeling)
- Preliminary review of first year watershed monitoring data and experience, recommended changes to MYP watershed monitoring design, if applicable
- Updates on potential coordination with RMP Modeling Strategy, as applicable
- Update on Regional Watershed Spreadsheet Model development, study designs for preliminary load estimates for selected POCs and sediment,
- Updates to work plan and descriptions of future planned studies
- Update on preliminary EMC explorations and recommendations for EMC development studies
- Approach for preparing integrated monitoring report (draft in September 2013)
- Coordination with RMP monitoring strategy, as applicable
- Updates to work plan and descriptions of future studies
- Timeframe for next MYP version(s) and adaptive updates

As the primary stakeholder forum, the STLS Work Group will track these various needs and set priorities for further MYP updates. The SPLWG will review these updates, at least annually but ideally several times per year, to track progress according to the RMP Multi-Year Plan, or at milestones such as the following:

- Trends power analysis, after accumulation of appropriate minimum number of samples. Revisions of the MYP in 2012 will develop a provisions timeframe for trends analyses over the next 3-5 years.
- Bay Modeling milestones as they become established through Modeling Strategy

Workplan and Detailed RMP Task Descriptions

This section outlines the 5-year STLS workplan for both the RMP and stormwater programs acting collaboratively through the Bay Area Stormwater Management Agencies Association (BASMAA) (see Table 11), and presents capsule summaries of RMP workplan tasks for the same time period as guided by the RMP Multi-Year Plan which has committed $400,000 annually during 2012-2014[13]. The budgets and scopes shown below are as of spring 2011 and will be updated in version 2013A after the RMP develops its proposed budget for 2013. Detailed task scopes for future years will be prepared as part of the annual planning process with STLS and SPLWG oversight.

1A) Regional Watershed Spreadsheet Model Development and Support.

Objective: Develop and use GIS-based spreadsheet model for regional load estimation.

Deliverables: Load estimates for priority pollutants of concern and sediment; see 2012 study proposal for more details on near-term activities.

Milestones and Linkages to other Projects: [to be included in future Appendix B]

Project Participants: RMP

Due Date: [to be included in future Appendix B]

RMP Contributions and Years: 2011 approved $20,000; 2012 approved $20,000; 2013 approved $25,000; 2014-2015 TBD (Phase II).

BASMAA funding for sediment load estimation (Phase I, estimated) 2012: $28,000; 2013: $15,000/TBD; PBDE, chlordane, dieldrin, DDT (Phase II) 2012 $35,000; 2013-14 TBD.

Total Cost: TBD,

[13] RMP Master Planning Workshop, February 7. 2011

Table 11. Draft five-year STLS workplan. Numbers indicate budget allocations or planning projections in $1000s. Stormwater programs budgets interpolated from BASMAA Fiscal Year budgets (regional reporting budgets not shown). Budget numbers shown in parentheses for later years are projected, subject to annual authorization processes of the RMP and BASMAA.

Task ID	Funding Agency	Task Description	2011	2012	2013	2014	2015
1		**Watershed and Associated Bay Modeling**					
1A		Regional Watershed Spreadsheet Model					
1A.1	RMP	Phase I – Water, Sediment, PCBs and Mercury	20	20	25		
1A.1	BASMAA	Phase I – Sediment		28	15	TBD	
1A. 2	RMP	Phase II – Other Pollutants of Concern				TBD	
1A.2	BASMAA	Phase II– PBDE, DDT, chlordane, dieldrin		35	TBD	TBD	
1A.3	RMP	Phase III – Periodic Updates				TBD	TBD
1B	RMP	Coordination with Bay Margins Modeling				TBD	
1C	TBD	HSPF dynamic modeling					TBD
2	RMP	**Source Area Monitoring / EMC Development**	20	80	80	TBD	TBD
3		**Small Tributaries Monitoring**					
3.1	BASMAA	Multi-Year Plan Development	15				
3.2	BASMAA	Standard Operating and Quality Assurance Procedures	55				
3A	RMP	Monitor Two Representative Small Tributaries	300	328	343	300	TBD
3AB.1	BASMAA	Monitor Two to Four Representative Small Tributaries or Sites Downstream of Management Actions	255	510	(480)	(480)	TBD
3AB.2	BASMAA	Lab analyses, Quality Assurance, Data Management	183	316	(320)	(320)	TBD
4	RMP	**Reporting, Stakeholder Administration and Adaptive Updates**	41		20	TBD	
	BASMAA	**Data Analysis, Communications, Administration**	45	84	(85 est)	TBD	TBD
RMP Total			381	428	468	TBD	TBD
BASMAA Total		**Task 1**		63	15	TBD	
		Tasks 2-4	558	910	(885)	TBD	TBD
Total			934	1,401	(1368)	TBD	TBD

1B) Coordinate STLS with Bay Margins Modeling.

Objective: Identification of high-leverage watersheds contributing to POC impairment in S.F. Bay.

Deliverables: Timely coordination and exchange of information between STLS and Bay Margins modeling Work Groups.

Milestones and Linkages to other Projects: Depends on Modeling Strategy

Project Participants: RMP

Due Date: Depends on Modeling Strategy

RMP Contributions and Years: 2013-2015 TBD?

Total Cost: TBD

2) Land Use/Source Area Specific EMC Development and Monitoring.

Objective: Calibrate RWSM loading estimates to Bay Area specific conditions and POCs.

Deliverables: Refined EMCs or other modeling coefficients for RWSM; see 2012 study proposal for more details on near-term activities.

Milestones and Linkages to other Projects: Coordinate with 1A, RWSM Development.

Project Participants: RMP

Due Date: TBD

RMP Contributions and Years: 2011 approved $20,000; 2012 approved $80,000; 2013 approved $80,000; 2014-2015 TBD.

Total Cost: TBD

3.1) Development of STLS Multi-Year Plan

Objective: Develop alternative monitoring approach to POC Loads Monitoring that meets objectives of STLS and MRP; facilitate consistent implementation

Deliverables: Consensus STLS MYP document for timely implementation of required stormwater monitoring.

Milestones and Linkages to other Projects: To be coordinated with RMP 3A and MRP reporting requirements (initial Phase 1 results in late.2012)

Project Participants: BASMAA

Due Date: Selection of monitoring methods and Phase 1 sites by July 2011; sites for Phase 2 monitoring by January 2012

RMP Contributions and Years: (review using 2010 available funds).
BASMAA funding 2011: $15,000

Total Cost: BASMAA $15,000 one-time

3.2) Stormwater Programs - Monitoring, Standard Operating and Quality Assurance Procedures.

Objectives: Ensure that alternative monitoring methods in STLS meet MRP requirements for SWAMP comparability and reporting formats; provide documentation and facilitate consistent implementation

Deliverables: Quality Assurance Project Plan, Standard Operating Procedures

Milestones and Linkages to other Projects: To be coordinated with RMP 3A and MRP reporting requirements (initial Phase 1 results in late.2012)

Project Participants: BASMAA

Due Date: July 2012

RMP Contributions and Years: RMP N/A;
BASMAA funding 2011: $55,000

Total Cost: BASMAA $55,000 one-time
:

3A) Monitor Representative Small Tributaries.

Objective: Collect POC stormwater data to be used for tracking long-term trends in loading to S.F. Bay

Deliverables: small tributaries monitoring data

Milestones and Linkages to other Projects:

Project Participants: RMP, BASMAA

Due Date: Exploratory watershed characterization results by June 2011; Phase 1 monitoring begins October 2011; Phase 2 monitoring begins October 2012[14]

RMP Contributions and Years: 2011 approved $300,000; 2012 approved $328,000; 2013 approved $343,000; 2014 [$300,000/year projected in Multi-Year Plan].
BASMAA funding $2011: 255,000, TBD 2013-2015 (see 3A/B.1 below for 2012-2015)

Total Cost: RMP: [$300,000/year projected in RMP Multi-Year Plan?]

3A/B.1) Monitor Sites Downstream of Management Actions.

Objectives: Collect POC stormwater data to be used for tracking potential load reductions downstream of Management Actions.

Deliverables: Monitoring data.

Milestones and Linkages to other Projects:

Project Participants: BASMAA

Due Date: Phase 2 monitoring begins October 2012

RMP Contributions and Years: N/A.
BASMAA funding up to $510,000 for all monitoring including 3A and setup in 2012; estimated $480,000 in 2013; TBD 2014-2015

Total Cost: TBD.

[14] , RMP budgets include all project management, laboratory analyses and data management and Quality Assurance, while BASMAA scopes and budgets for those are shown separately under Task 3A/B.2 and a portion of Task 4.2)

3A/B.2) Stormwater Programs ongoing Quality Assurance and Data Management.

Objective: implement and document QA procedures and reporting for SWAMP comparability.

Deliverables: QA review and data management.

Milestones and Linkages to other Projects: To be coordinated with Task 3A/B.1 and MRP reporting requirements.

Project Participants: BASMAA

Due Date: Ongoing Quality Assurance and Data Management; BASMAA funding

RMP Contributions and Years: N/A;
BASMAA funding 2011: $183,000, 2012: $316,000, 2013: $320,000 estimated; 2014-2015 TBD

Total Cost: TBD,

- Phase 1 setup, station operation and laboratory analyses:
- Quality Assurance and Information Management on laboratory results, consistent with those for RMP-operated stations.:

4) Reporting, Stakeholder Administration and Adaptive Updates.

Objectives: Report results at agreed-upon intervals; support future STLS decision-making through facilitation of stakeholder processes and timely updates to STLS MYP.

Deliverables

Milestones and Linkages to other Projects

Project Participants: BASMAA (initial MYP draft); RMP (ongoing)

Due Date: WY 2011-12 Watershed Monitoring Plan complete by July 2011; other due dates TBD.

RMP Contributions and Years: 2011 special allocation approved: $41,000; 2012: $0; 2013 approved $20,000. [$50,000 projected for reporting in Multi-Year Plan]; 2014-2015 TBD.
BASMAA funding 2011: $45,000; 2012: $84,000 budgeted; 2013 $85,000 estimated; 2014-2015 TBD..

Total Cost: TBD

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