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MEMORANDUM

DATE: AUGUST 21, 2009

TO: SARAH LOWE, MEG SEDLAK

FROM: DON L STEVENS, JR.

RE: RMP REDESIGN

Background

(from 3/23/09 memo by Sarah Lowe)
In 2002, a statistically robust sampling design was developed for the Regional Monitoring Program (RMP) by RMP Redesign work group and SFEI staff. The sampling design was a Generalized Random Tessellation Stratified design (GRTS) similar to that employed by USEPA's environmental Monitoring and Assessment Program (EMAP). The sediment design includes repeat sampling of stations built into the sampling plan in order to evaluate temporal trends: some stations are sampled on an annual, five-year, ten-year and 20-year basis (Lowe *et al*. 2005). Prior to 2002, the RMP sampled along the spine of the Estuary sampling during both the wet and dry season between 1993 and 1999. 2000 and 2001 were transitional years, and in 2002 the Program implemented the GRTS design that focused on spatial coverage of the Estuary and long term trends. Several 'historic' stations were maintained in the Program to provide continuity with the original fixed-site design.

Sediment and water sampling was conducted only during the dry season when variation from annual rainfall was least influential. While some contaminants have higher ambient concentrations during the winter with increased runoff, the Redesign work group felt that (although this was an important consideration for environmental managers) the need for increased spatial sampling of the Estuary was more important for the Status and Trends program. The work group recommended that seasonal contaminant issues continue to be addressed, through additional RMP pilot and special studies and through the Sources Pathways and Loading work group.

In 2007/2008 a new redesign review was undertaken by the Technical Review Committee. After a statistical review and consultation with the RMP participants, the RMP decided to add back wet weather sediment sampling into the Status and Trends program and recommended that wet weather sediment sampling be conducting every other year.

The goals of the Status and Trends monitoring effort remain the same: to be able to infer status and trends over time and to characterize the distribution of contamination within and among defined regions of the Estuary. At present, there are five designated regions of the Estuary.

Wet season sediment sampling will focus on characterizing spatial condition; detection of trends is confounded in the wet-season by highly variable seasonal weather patterns. Historically, the program observed that some contaminants and amphipod toxicity test results showed seasonal patterns. The incidence of amphipod toxicity was greater in the wet season in some regions of the Estuary. Among other factors, the RMP is interested in further characterizing and investigating these seasonal patterns.

Proposed Changes to Sediment Sampling

Starting in 2009 (a dry-season sampling year), the RMP will begin alternating annual sediment sampling between the dry and wet season. Wet season sampling will be limited to only four random-design samples per region (with only five regions currently sampled: n = 20). Dry season sampling will continue with eight random-design samples per region (n = 40). Sampling of the historic-design stations will not change and samples will be collected during each sampling event: maintaining one station per region plus the two Rivers stations (n = 7). This document focuses on the random-design stations.

In 2008, Sarah Lowe (SFEI) and Don Stevens evaluated how the proposed changes to the program schedule might affect the spatial and repeat stations based on the original GRTS design implemented in 2002. That design was built on a five-year repeat sampling period to address trends. The evaluation included testing several options for sampling in alternating years starting in either the wet or dry season. These scenarios would not alternate between seasons indefinitely, but would need to cycle through alternating seasons on a five-year cycle in order to maintain the re-visit schedule of sites in the corresponding season. As a result, every five years the sampling schedule would have to sample two consecutive years in a row, which would potentially bias the program to sample more wet (or dry) seasons over time. Results of this evaluation were presented to the RMP oversight committees (TRC and SC) in 2008. The RMP oversight committees and the Program Managers decided to investigate the possibility of updating the sediment sampling effort to an alternating six-year repeat-sampling cycle, which would allow uninterrupted, alternating seasonal sampling.

Don Stevens indicated that it will be relatively straight forward to update the current design to a six--year repeat-sampling effort. In preparation for this effort, Sarah Lowe updated the current sampling design database to include all the information about sampling to date (2008) including all replaced ‘oversample’ sites to be sampled in the future - based on the original design. This updated table of sampling stations was used to develop a six-year repeat-sampling design for the new RMP alternating-season monitoring effort.

Considerations

The original GRTS sample design did not achieve the desired degree of spatial balance. The current redesign effort provides an opportunity to modify the spatial balance. The approach will be to retain the location of sites that have already been visited, and then add new panels and redefine panels that have not yet been visited in order to increase spatial regularity.

Sampling and Design Approach

The 2002 design consisted of an annual panel, five panels on a five-year rotation, ten panels on a 10-year rotation, and twenty additional panels, for a total of 36 panels. As of March of 2009, 20 panels had been visited at least once. In order to address both the spatial balance issues and the wet/dry alternation while maintaining as much continuity as possible, panels that have not yet been visited were redefined and new panels added to implement a rotation based on a six-year

cycle. This permits wet/dry alteration (dry sampling in odd numbered years beginning in 2009; wet samples in even numbered years). This will require a total of 43 panels (1 annual, 6 six year, 12 twelve-year, and 24 twenty-four- year), so seven additional panels will be needed. However, because we want to improve spatial balance, only the 20 panels that have already been visited will be retained, and 23 new panels will be identified. These panels will be selected from the pool of sites from 2002 panels not yet visited and the 2002 over-sample sites.

The new panels were selected to give spatial balance for all points to be sampled in a year. For example, in 2009, panels 1 and 8 are the panels that have been sampled previously, and are scheduled to be sampled. I added two new panels (21 and 22) so that the composite sample had good spatial balance. This was done region by region and year-by-year, in each case creating new panels around those already defined and scheduled to be visited. In contrast, the 2002 panels were defined sequentially using the ordering defined by the GRTS sampling methodology. While that worked on a large scale, it does not work well for two-point panels. The current approach creates spatial balance on a local spatial and temporal basis.

The technique that was used to achieve spatial balance within each year was the same as used in the GRTS methodology. The sites were selected year-by-year, beginning with 2009. The pool of unassigned sites (the sites from the 2002 panels not yet visited plus the 2002 over-sample sites minus sites not previously assigned) plus the sites from existing panels scheduled to be visited in that year were assigned random but proximity preserving spatial addresses, using the process described in Stevens & Olsen (2004). The sites were ordered using the random addresses, and each site was assigned an inclusion probability. Existing sites were assigned a probability of one, so they were certain to be "selected". All other sites were assigned a probability (8 – number of existing sites for that year)/number of sites remaining in the pool. Selection was accomplished using Madow's (1949) method as described in Stevens & Olsen (1999). Thus, the new sites for that year were selected to achieve good spatial balance given the existing sites.

All panels were created with two points each, so that the wet years have 8 points per region (4 panels with 2 points each), even though only 4 points will be sampled. The four points that are to be visited in wet years were selected by choosing one point at random from each panel. These points were identified by having "WET" in the column labeled "Season" in the Excel file containing the sample points.

As noted above, moving to a six year rotation required the definition of some new panels, and we can choose how to insert the new panels into the rotation. Since we have not yet visited all of the ten or twenty year panels from the 2002 design, the new twelve and twenty-four year panels should simple be appended to the existing sequence. The new six year panel could be added in 2009, put off until we have cycled through the existing panels one more time, added in 2010 as a wet year panel, or get into the six year rotation immediately by visiting the panel from six years ago (panel 5). Any of those would work, and there are no long-run implications. These options were discussed with Sarah Lowe, and it was decided to add the new six year panel in 2010.

Oversample Sites

Files containing the sample points and panel assignments for the new design were transmitted to Sarah Lowe on 5/28/2009 and 5/29/2009. The oversample sites from the 2002 design were included in the pool of sites used to construct the new, more-spatially-balanced panels in the current design. The oversample sites for the current design consist of all sites were not assigned to a panel. In the files transmitted to Sarah Lowe, the oversample sites appear following the sites

for Panel 43. These sites appear in the order in which they should be used, that is, the first oversample site to be used for a region should be the 87th site in the table for that region, the second should be the 88th, and so on.

Because of the way in which new panels were constructed, no new analysis issues are involved. The sample is equi-probable within region. Population attribute estimation and variance estimation techniques remain as before.

References

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