



**Final report of the Chesapeake Bay Scientific and Technical
Advisory Committee's workshop:
Evaluating the Design and Implementation of the Chesapeake
Bay Shallow Water Monitoring Program**

November 30-December 1, 2004
Annapolis, Maryland

**Sponsored by
The Scientific and Technical Advisory Committee (STAC)**



STAC Publication 05-003

About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports quarterly to the Implementation Committee and annually to the Executive Council

STAC members come primarily from universities, research institutions, and federal agencies. Members are selected on the basis of their disciplines, perspectives, and information resources needed by the Chesapeake Bay Program.

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Map of Chesapeake Bay shallow waters (≤ 2 meters depth) highlighted in dark blue.

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EXECUTIVE SUMMARY

The Scientific Technical Advisory Committee (STAC) Shallow Water Monitoring workshop endorsed the current 3-year combined spatial and temporal coverage design of the Shallow Water Monitoring Program (SWMP) in order to meet the primary objective of assessing the new water quality criteria for dissolved oxygen, water clarity and chlorophyll. However, existing resources will not provide monitoring information for all Chesapeake Bay shallow water habitats by the Chesapeake 2000 Agreement deadline of 2010, therefore it is recommended that:

- the Tidal Monitoring Assessment Workgroup (TMAW) should develop a more realistic schedule for completing the shallow water monitoring assessments under existing resources;
- the schedule should be based on sound science and not the ease of delisting impaired segments;
- the prioritization schedule should be focused on monitoring tributary/watershed systems as a whole, rather than spreading resources broadly across unconnected Chesapeake Bay Program (CBP) segments.

The Shallow Water Monitoring design should include:

- key long-term sentinel stations that are representative of reference areas;
- better coordination with other long-term monitoring programs;
- small tributaries, which are not part of the current sampling design, should be incorporated.

Insufficient monitoring/modeling integration and research coordination has resulted in a lack of a broader understanding of ecosystem processes. It is therefore recommended that:

- Open planning workshops prior to monitoring implementation as well as data analysis workshops post 3-year assessment periods be implemented to maximize integration with the modeling and research community.

SHALLOW WATER MONITORING DESIGN BACKGROUND

In July 2001, the Chesapeake Bay Program Monitoring and Analysis Subcommittee's Tidal Monitoring and Analysis Workgroup (TMAW) formed a Tidal Monitoring Design Team that undertook the role of redesigning the Chesapeake Bay Tidal Monitoring Network. Over the following 2 years, the Design Team set goals and objectives, reviewed the existing Chesapeake Bay monitoring design, evaluated potential new monitoring strategies and then made recommendations for implementing a network that provided the requisite data and supported the programmatic goals and objectives. The new Tidal Monitoring Network focused on meeting the Water Quality Protection and Restoration goals and objectives of the new Chesapeake 2000 Agreement. It was established that the primary objective of the monitoring network would

provide water quality monitoring information necessary for assessing the new water quality criteria for dissolved oxygen, water clarity and chlorophyll with the goal of removing the Bay and its tidal rivers from the list of impaired waters. Secondary objectives would provide information for defining the nutrient and sediment conditions necessary for protecting living resources (water quality to support crabs, oysters, and fish) and vital habitats (water quality to support submerged aquatic vegetation - SAV). Water quality information would also be made available to support refinement, calibration and validation of the Chesapeake Bay Water Quality Model.

As part of the new Tidal Monitoring Network, an emphasis was placed on designing a shallow water monitoring (SWM) component that is comprehensive in scope and is coordinated with the existing long-term monitoring program to assess the Bay's shallow water habitats required by the development of the new water quality criteria. Sparse water quality data is available in shallow portions of Chesapeake Bay and its tributaries, which presents a major data gap in light of the new Designated Use Areas and Water Quality Criteria (EPA. 2003. Appendix A).

The new SWM design implemented bay-wide in 2003 focused on water quality and habitat measurements made over a 3-year time period consisting of water quality mapping technology and fixed continuous monitors to provide characterization of shallow water habitats that are key to living resources. Water quality mapping was piloted by the Maryland Department of Natural Resources (DNR), the University of Maryland's Chesapeake Biological Laboratory (CBL) and Virginia Institute of Marine Sciences and was extensively tested in Maryland's Magothy River, Severn River, and Tangier Sound from 1999 to 2002. Maryland DNR and CBL implemented continuous monitoring in the Pocomoke River to assess water quality conditions in response to the toxic *Pfiesteria piscicida* outbreak in 1998. The implementation of shallow water monitoring technology is coordinated between States and their partners employing similar equipment and methodology to ensure bay-wide compatibility and comparisons. Detailed information describing these technologies and the 1998 - 2004 results can be found on DNR's Eyes on the Bay web site at <http://www.eyesonthebay.net>.

In September 2003, members of the Design Team presented an overview of the SWM baywide implementation to the Chesapeake Bay Program's Scientific Technical Advisory Committee (STAC) in response to a STAC request for a briefing as a means of initiating an independent review of the plan. Subsequent to the STAC briefing, a number of issues were identified by STAC. These issues were addressed by the Design Team in writing and discussed at the December 2003 STAC meeting. These issues and the Design Team response are included in Appendix 2 under "STAC preliminary comments and questions regarding CBP Shallow Water Monitoring Plan". STAC then requested an opportunity to learn more about the plans for addressing the issues. Members of the Monitoring and Analysis Subcommittee (MASC) developed a proposal for a STAC Workshop to address outstanding SWM issues and submitted the proposal to STAC in March 2004. STAC reviewed the SWM workshop proposal and agreed to fund the SWM workshop.

The SWM workshop steering committee was formed with representatives from Maryland DNR, Virginia Department of Environmental Quality (DEQ), Virginia Institute of Marine Sciences, MASC, EPA Chesapeake Bay Program and STAC. Steering Committee conference calls were

conducted between June and November 2004 to plan the workshop and ensure that the STAC issues raised during the initial SWM presentation in September 2003 were addressed at the workshop and that the appropriate scientific experts were involved in the review process.

WORKSHOP OBJECTIVES AND FORMAT

The Chesapeake Bay Program's STAC sponsored a Shallow Water Monitoring Workshop on November 30 and December 1, 2004 at the Radisson Hotel in Annapolis, MD. There were 48 participants from the Chesapeake Bay scientific community at the workshop, representing academic institutions and federal and State environmental agencies. Detailed presentations on the design process, rationale, methodology, current implementation scheme and analysis techniques were followed by breakout group discussions and plenary discussions.

The objectives of the workshop were two-fold: 1. Review the design of the Chesapeake Bay Shallow Water Monitoring Program established by the SWM Design Team to ensure that the design meets the primary objective for assessing attainment of the new water quality criteria for dissolved oxygen, water clarity and chlorophyll, while optimizing achievable temporal and spatial coverage with limited resources and 2. Solicit input from workshop participants on implementation, data analyses and model integration.

Prior to the workshop, each participant was provided a draft copy of the "Design of Monitoring Network for Chesapeake Bay and Its Tidal Tributaries", the 2004 SWM station location map and an example of current analysis. These can be found on the STAC web site at <http://www.chesapeake.org/stac/SWMWorkshop.html>. The Shallow Water Monitoring Quality Assurance Plans (QAPP) for both Maryland and Virginia were available at the workshop and can be located on the Chesapeake Bay Program web site at <http://www.chesapeakebay.net/amqaw.htm>. These QAPP's provide technical details on shallow water monitoring design, implementation, equipment, maintenance, data processing, data management, data analysis and information dissemination.

The workshop format opened with a plenary session consisting of 6 detailed presentations on the design process, rationale, methodology, current implementation scheme, analysis techniques and preliminary analysis results. The workshop participants were then divided into three breakout sessions covering shallow water monitoring design; implementation issues; and data analysis and interpretation and integration with modeling efforts. Each breakout session had a series of questions that were to be addressed by the group and then presented on the second day. However, during the plenary session in the morning, 3 overarching issues were identified that supplanted the original questions as foci for discussion in the breakout groups, with each group addressing these 3 issues from a different perspective. These overarching issues were 1) segmentation, site selection and timelines; 2) integration with modeling; and 3) data utilization (analysis, interpolation, comparison and presentation). The original questions remained as sub-themes of the more general discussion.

On the second day of the workshop, the breakout group discussion leaders summarized their groups' discussions in a plenary session, followed by a general discussion focused on developing consensus on recommendations for improving design, implementation and data analysis. The

workshop Steering Committee met to review the workshop conclusions and recommendations in the early afternoon, after the other participants had left. The workshop objectives and agenda, attendees list, breakout session questions and overarching issues can be found in Appendix 1. The 6 plenary presentations are available on the STAC web site.

SUMMARY OF DISCUSSION AND RECOMMENDATIONS

The consensus of the SWM Workshop participants was that the existing SWM Program unit design is a good approach for assessing attainment of the new water quality criteria for dissolved oxygen, water clarity and chlorophyll given the limited available resources. The current design at each site consists of temporally intensive continuous monitors integrated with spatially intensive water quality mapping over a 3-year time period, after which the sensor suite is moved to a new site/segment. This provides the minimum necessary information to guide management of nutrient and sediment reduction strategies. There were, however, several suggestions for improving and extending this basic design.

It was clear, however, that existing resources will not provide monitoring information for all Chesapeake Bay shallow water habitats by the Chesapeake 2000 Agreement deadline of 2010. There are two possible actions that might remedy this problem. The first is to extend the assessment timeframe past 2010 for assessment of all Chesapeake Bay shallow water habitats. The second is to identify additional resources to expand the monitoring level of effort to meet the 2010 deadline. The TMAW should develop a more realistic time frame for completing the SWM assessments under the existing resources. The new Chesapeake Bay Financial Authority should be approached for additional SWM funding. The TMAW should also work with the Chesapeake Bay Program Implementation Committee (IC) to prioritize the SWM schedule to ensure that the most important segments can be monitored by 2010, if all segments cannot be completed.

A detailed prioritization schedule must be developed as soon as possible with accompanying timeline to ensure maximization of resources, partnerships and management needs. It was recommended that the prioritization schedule be based on sound science and not the ease of delisting impaired segments; there is much to be learned by evaluating ecosystems in various states of impairment. Also, due to limited resources for implementing nutrient and reduction strategies, it is imperative that systems that are impaired be identified immediately and evaluated for restoration activities. The workshop participants strongly recommended that the prioritization schedule be focused on monitoring tributary/watershed systems as a whole, rather than spreading resources broadly across unconnected CBP segments. This will increase the utility of SWM data for examining cause and effect relationships, which is as important as assessing attainment, and it will facilitate coordination of SWM efforts with other monitoring programs and research efforts. The TMAW should be tasked with developing the prioritization schedule for presentation to the IC in the immediate future.

Although the existing shallow water monitoring design meets the primary objectives set out by the Design Team, there were a number of recommendations for improvement to fully realize the potential of such a comprehensive monitoring effort. These enhancements/recommendations are described below under the headings of the 3 breakout group topics defined for the workshop – design, implementation, and data analysis and modeling integration.

Design: The existing shallow water monitoring design is comprised of temporally intensive and spatially intensive monitoring over a 3-year time period. This design provides adequate information for characterizing a system, but does not provide enough information to assess long-term trends or assess change due to management actions. It is recommended that the SWM design include key long-term sentinel stations that are representative of reference areas. Monitoring of these sentinel stations should be maintained after the initial 3-year assessment is completed. In some cases, these sentinel stations may be coincident with existing long-term stations or through coordination with other programs in which case no additional resources will be required. However, in some cases implementing sentinel stations will require reallocation of available funds for completing 3-year assessments. Potential sentinel sites should be identified with input from the larger Chesapeake Bay scientific community, through an open workshop to be held in the final year of each 3-year assessment.

There are several possibilities for cooperative sentinel stations. The NOAA National Estuarine Research Reserve System currently integrated with the Chesapeake Bay SWM Program provides 4 sentinel areas in Maryland and Virginia. Additional sentinel stations should be explored with the cooperative Chesapeake Bay Observing System (CBOS) as implemented under the Integrated Ocean Observing Systems (IOOS). Representatives from both Maryland DNR and Virginia Institute of Marine Sciences are participating in an on-going effort to integrate the Chesapeake Bay SWM program with open water observing stations in the Chesapeake Bay. This effort has the potential to provide additional sentinel sites in areas of concern.

Implementation: The current SWM design does not provide for assessment of all minor tributaries and embayments. Limited resources and the overall size of the bay make complete shallow water assessments impossible. It is recommended that representative small tributaries within each system be identified to address issues of connectivity and similarity to adjacent water bodies. The TMAW should be tasked with identifying and analyzing potential representative Maryland and Virginia minor tributaries where appropriate.

The current design does not adequately integrate with existing Chesapeake Bay water quality, habitat and living resource monitoring programs established in watersheds and other open and deep water habitats, nor does it directly consider modeling needs although several efforts were made to solicit input from the modelers since 2003. There also are only limited connections to Chesapeake Bay studies carried out by the research community. This lack of monitoring/modeling integration and research coordination has resulted in a lack of a broader understanding of ecosystem processes. Better integrated assessments of phytoplankton, zooplankton, benthic and fish communities in concert with physical and nutrient parameters, across adjacent habitats, will enhance our understanding of these critical system processes and provide scientist and managers with the necessary information to make decisions on ecosystem restoration strategies.

There are two relatively low-cost mechanisms for enhancing integration of monitoring, research, and modeling. First, open planning workshops should be scheduled 1-2 years in advance of SWMP whole tributary monitoring efforts to allow for better study coordination. Advance planning and coordination will allow interested parties to seek external funding and/or adjust

monitoring/modeling plans to take advantage of and enhance SWMP efforts. Second, data analysis and interpretation workshops should be held during the final year of each 3-year tributary monitoring program. This will allow for more effective sharing of data and will promote better understanding of ecosystem behavior.

Data Analysis and Modeling Integration: A Cumulative Frequency Distribution (CFD) analysis approach was suggested by the original SWM Design Workgroup to assess the new water quality criteria. This approach is documented in the CBP Water Quality Criteria Guidance Document (EPA. Pp. 154-176, Appendix H. 2003.), approved by the CBP and the Water Quality Steering Committee, reviewed previously by STAC and was presented at the workshop. Although the CFD approach is a viable analysis tool for criteria assessment, workshop participants recommended that additional analysis methods be evaluated for diagnostic purposes. For example, the CFD approach by itself condenses the detailed information and does not illustrate important temporal and spatial variability. Other approaches that should be explored for diagnostic purposes include spectral and cross-spectral analysis and single parameter and multi-parameter correlative analysis. The TMAW should be tasked with refining the CFD analysis approach, evaluating additional analysis techniques for exploring co-variabilities and causalities in the data.

The CBP must establish a better working relationship with the research community, especially at academic institutions. This is a relatively untapped resource for addressing management questions, evaluating various models and emerging analysis tools and analyzing the wealth of data generated by the Chesapeake Bay Monitoring Program. Chesapeake Bay committees and workgroups need to enhance their communication and interaction with researchers through workshops, grants and internships. The recommended SWMP advance planning workshops and final-year data analysis workshops are an important step in this direction.

Although it is clear that the SWMP should be better integrated with current modeling efforts, there was no clear consensus on how to achieve this within the present CBP structure. Efforts at coordination to date have included information exchange about monitoring plans and additional modeling parameter needs. For example, the Chesapeake Bay Program Modeling Subcommittee (MSC) has requested additional parameters such as water quality color and wave height measurements to enhance understanding of sediment resuspension in shallow water habitats. Funding for these parameters has been secured and monitoring will begin during summer 2005.

One cause of the limited connections between monitoring and modeling in shallow water is that the CBP model currently includes only a very limited representation of shallow water habitats (the shallowest depth in the present model is 5 ft.). Current plans call for development of an explicit shallow water module to begin in 2007. Thus, there are only limited mechanisms for utilizing SWMP data within the present model framework, although the SWMP data will be quite important in the future. In this context, it is very important for modelers (the MSC) to think about future needs and communicate these to the SWMP now, before a new shallow water model component has actually been built and before it is too late to change or modify monitoring plans. Exploration of existing, alternate shallow water models by the research community may be fruitful in the interim. It is also important for the SWMP to consider these modeling needs in their planning. Two workshop recommendations are particularly relevant from this point of

view: that the SWMP should address entire tributary/watershed systems, and that analyzing data to identify cause and effect relationships is important. Prioritizing segments for assessment and establishing a timeline for monitoring will enable the research community to design projects, secure additional funding, and leverage resources to help address these data analysis and modeling needs.

CONCLUSIONS

The STAC Shallow Water Monitoring workshop endorsed the current 3-year combined spatial and temporal coverage design of the SWMP as a practical, efficient way to assess the new water quality criteria for dissolved oxygen, water clarity and chlorophyll in shallow water habitats. The SWMP, through TMAW, needs to develop detailed prioritization schedules and realistic timelines in the near future, recognizing the low likelihood of evaluating all CBP shallow water segments by 2010. The prioritization schedule should be based on sound science and not the ease of delisting impaired segments. This should be accomplished with the input and written approval of the IC. The workshop also endorsed the present practice of focusing on entire tributary/watershed systems rather than unconnected segments. Additional workshop recommendations focused on incorporating longer term sentinel stations within representative systems; opening up the planning and analysis process to the broader monitoring, modeling, and research communities; better coordination with other monitoring efforts and observing systems; and a renewed emphasis on data analysis for identifying causative relationships as well as assessing compliance.

REFERENCES

U.S. Environmental Protection Agency Region III. 2003. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries*. Pp. 154-176, Appendix A, Appendix H.

APPENDIX 1

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WORKSHOP OBJECTIVES AND AGENDA

STAC Workshop Evaluating the Design and Implementation of the Chesapeake Bay Shallow Water Monitoring Program

November 30 – December 1, 2004
Radisson Hotel
Annapolis, MD

Workshop Objectives:

The first objective will be to review the design of the Chesapeake Bay Shallow Water Monitoring Program to ensure that the design meets the objectives established by the Shallow Water Monitoring Design workgroup, while optimizing achievable temporal and spatial coverage with limited resources. The Tidal Design Workgroup met over a 2-year period and evaluated many monitoring strategies and designs, i.e. probabilistic designs, remote sensing, fixed stations. The final Shallow Water Monitoring design incorporates the latest state-of-the-art technologies and provides reliable information for meeting objectives at a reasonable cost. Prior to the STAC workshop, documentation on the tidal monitoring design process will be made available to workshop participants. Discussions will focus on development of criteria to optimize site selection and monitoring duration, and to enhance coordination with living resource and local source monitoring efforts.

The second objective will solicit input from workshop participants and technical experts in the field of monitoring on Shallow Water Monitoring outstanding issues regarding implementation, data analyses and model integration.

Workshop Issues to be Addressed:

- 1 Evaluate the Design of the Shallow Water Monitoring Program
 - a. Site selection criteria – randomized or targeted towards representative habitats
 - b. Monitoring duration – constant or mixed reference and short term stations
 - c. Coordination with living resources monitoring
 - d. Coordination with local source (groundwater, surface water, and shoreline) monitoring
 - e. Coordination with near shore model development needs
- 2 Address several outstanding issues regarding the implementation of the Shallow Water Monitoring component
 - a. integrating spatial and temporal components with the long-term monitoring components
 - b. calibrating spatial mapping for time of day worst case scenarios
 - c. integrating analyses across segments and time frames
 - d. prioritizing monitoring schedules for implementation
 - e. data interpretation and analyses to meet objectives
 - f. spatial interpolation review
 - g. data assimilation into the water quality model

Final Agenda

Tuesday, November 30, 2004

- 9:00-9:30 Registration and Continental Breakfast (provided)
9:30-9:45 Introductions/Workshop Purpose/Format – Bruce Michael/Brian Polkinghorn
- Plenary Presentations
- 9:45-10:05 Shallow Water Monitoring design process – Steve Preston
10:05-10:25 Initial design and implementation – Bruce Michael
10:25-10:45 Timeline, prioritization and outstanding issues – Rick Hoffman
10:45-11:00 Break
11:00-11:20 Preliminary analysis results from Maryland – Mark Trice
11:20-11:40 Virginia monitoring results – Ken Moore
11:40-12:00 Monitoring and modeling integration – Carl Cerco
- 12:00-1:00 Lunch (provided)
- 1:00-2:00 Open discussion to define concerns and solicit additional Shallow Water Monitoring issues – Brian Polkinghorn
2:00-3:00 Break-out sessions into 3 groups:
Shallow Water Monitoring design – Larry Sanford/Mike Williams
Implementation issues – Scott Phillips/Chris Heyer
Data analysis and interpretation, integration with modeling efforts – Kirk Havens/Mark Trice
- 3:00-3:15 Break
3:15-4:30 Continue breakout sessions
4:30 Wrap-up and adjourn - Bruce Michael

Wednesday, December 1, 2004

- 9:00-10:30 20-minute reports with 10-minute discussions from breakout sessions – Larry Sanford, Scott Phillips, Kirk Havens
10:30-10:45 Break
10:45-12:00 Develop consensus on recommendations for improving design, implementation and data analysis issues – Brian Polkinghorn
12:00-1:00 Lunch (provided) and adjourn workshop - Bruce
1:00-4:00 Steering Committee Meeting

WORKSHOP BREAKOUT SESSION QUESTIONS

Shallow Water Monitoring Design

1. Is the Chesapeake Bay Shallow Water Monitoring Program, comprised of continuous monitoring and water quality mapping, the most appropriate and efficient design to assess progress in meeting the new water quality standards for dissolved oxygen, water clarity and chlorophyll?
2. Should other shallow water monitoring designs be given more preference?
3. Coordination with existing monitoring programs – How can we best integrate shallow water monitoring with water quality, habitat and living resources programs to address Chesapeake 2000 commitments?
4. Is the 3-year assessment period adequate to represent water quality conditions?
5. Does the current shallow water monitoring design meet the Chesapeake Bay modeling needs?

Implementation Issues

1. On what bases should shallow water segments be prioritized for assessment?
2. Monitoring requires a large amount of resources – equipment, boats, maintenance, staff, data management, analysis and dissemination. How can we better develop partnerships in order to complete all Chesapeake Bay shallow water monitoring/assessments by 2010?
3. Site selection criteria: How should continuous monitoring sites be selected to ensure optimal benefits? Site location, number of sites per segment, calibration for water quality mapping. Are the current continuous monitoring sites located appropriately for the assessment of shallow water segments?
4. Currently, continuous monitoring employs weekly to biweekly maintenance and calibration and water quality mapping calls for a minimum of 5 calibration sites per cruise. Is this adequate or necessary?

Data Analysis and Interpretation, Integration with Modeling Efforts

1. Interpolation and the cumulative frequency diagrams (CFD) approach are suggested methods for evaluating shallow water monitoring conditions – are there other appropriate methods?
2. How do you integrate spatial, temporal and long-term fixed data into a CFD approach?
3. How do you integrate analyses across Chesapeake Bay segments covering different time frames?
5. Continuous monitoring information is used for calibrating water quality mapping data to the time of day worst-case scenarios – is this appropriate? How do you calibrate using multiple continuous monitoring sites per segment?
6. How can shallow water monitoring data be assimilated into the water quality model?

WORKSHOP OVERARCHING ISSUES

Three overarching issues were identified on the first day of the workshop in response to plenary presentations. The 3 breakout groups in addition to the predisposed questions slated these overarching issues for discussion. The issues were as follows:

- Segmentation, site selection, and timelines
- Integration with modeling
- Data utilization (analysis, interpolation, comparison, presentation)

WORKSHOP BREAKOUT SESSION REPORTS

RECOMMENDATIONS OF THE DESIGN BREAKOUT GROUP

Group members - Larry Sanford (discussion leader), Michael Williams (recorder), Michael Kemp, Ken Moore, Mark Luckenbach, Willy Reay, Ben Longstaff, John Zimmerelli, Doug Wilson, Henry Bush, Bob Paul, Lewis Linker

Objectives

The design breakout group first reiterated and discussed the design objectives of the workshop. The workshop prospectus had stated that “the first objective [of this workshop] will be to review the design of the Chesapeake Bay Shallow Water Monitoring Program (SWMP) to ensure that the design meets the objectives established by the Shallow Water Monitoring Design workgroup, while optimizing achievable temporal and spatial coverage with limited resources.” Specific design issues to be discussed included site selection criteria, monitoring duration, coordination with living resources monitoring, coordination with local source monitoring, and coordination with near shore model development needs.

However, it became apparent during the AM plenary session that the issues were better organized under three headings, to be considered equally by all breakout groups but with different perspectives. Thus, the three major topics considered from a design perspective were: (1) segmentation, site selection, and timelines, (2) integration with modeling, and (3) data utilization (analysis, interpolation, comparison, presentation)

Reiteration of Design Principles

The design group agreed that assessing progress in meeting shallow water quality standards (status and trends) is an important goal for the SWMP, but it should not be the only goal. Assessing cause and effect relationships is also important, and should be considered in the design process. Assessing cause and effect relationships will also be required for model development and testing; as Carl Cerco stated in his presentation, “Observations of states without processes will raise more questions than they answer”. Finally, an understanding of cause and effect relationships is necessary for evaluating the impacts of management actions. The optimal

SWMP design will allow both goals to be addressed without compromising either one, and will result in much greater value for CBP's investment.

The group also affirmed that our ultimate goal is restoring the Chesapeake Bay, not attaining criteria or de-listing segments. From this point of view, choosing sites in order of those most likely to be de-listed first is not appropriate.

Recommendations for segmentation, site selection, and timelines

The design group felt that, to the extent possible, resources should be focused on 1-2 complete tributary systems at a time (the de facto present practice), rather than distributing them broadly across unconnected CBP segments. Supplemental funding requirements and partnering agreements for specific sites may constrain this approach, but SWMP-controlled resources should be dedicated to it. Advantages to the whole tributary system approach include 1) focused, integrated data collection for dynamical understanding and modeling with no loss of criteria assessment power; 2) greater logistical and resource efficiencies possible; and 3) greater potential for collaborative research, model development, and funding. A potential disadvantage is that it will allow less Bay-wide coverage at any one time.

Three years is a reasonable time frame for initial assessment. At the end of the initial assessment period, each system should be reevaluated to determine whether, where, and how longer term measurements can be maintained (could be regular WQMP fixed stations, plus 1-2 continuous stations, ...). This will require significant data analysis (for dynamical behavior as well as statistical behavior) prior to the end of the initial 3 year period. The 3-year reevaluation should involve scientific and local input, most probably in the form of a focused workshop.

Although the goal of assessing all CBP shallow water segments by 2010 should not be dropped, it is more important to evaluate representative segment types than it is to evaluate every segment. Thus, CBP shallow water segments should be stratified (or classified, or blocked together) based on watershed characteristics, potential habitat value (SAV), bottom sediments/benthos characteristics, etc. Other factors influencing segment prioritization include

- Potential for supplemental funding and partnerships
- Significant management actions planned in the monitoring time frame
- Potential for research and/or modeling collaborations
- Potential for collaboration with other monitoring activities

The timeline for assessment of all shallow water segments is resource limited. Thus, partnerships, external funding, etc. should be encouraged. These can be encouraged and facilitated by holding open planning workshops 1-2 years in advance of whole tributary monitoring efforts to encourage collaboration and to allow sufficient time for application for external funding. Additional resource efficiencies may be achieved by not requiring 2 continuous monitors per CBP-defined segment, but instead focusing on key sites from a dynamical perspective. The SWMP should begin exploring remote sensing potential now (especially for Chl and turbidity) for future gains in efficiency and coverage.

Integration with modeling

Processes and mechanistic controls in shallow waters are less well understood than in deeper waters. In order to develop shallow water modeling capabilities we need to address some research/process questions. This may be accomplished most efficiently by encouraging research in association with the monitoring program. Topics needing additional research include:

- Resuspension, deposition, shoreline erosion and associated effects on turbidity
- Waves and over-water winds
- Impact of light on benthic productivity, re-suspension, nutrient cycling/flux, etc., as mediated by benthic algae
- Short-term changes in dissolved oxygen, especially effects on benthic communities and sediment-water fluxes
- Estimates of air/sea exchange for understanding shallow water oxygen dynamics and for improving system metabolism estimates.

The SWMP should work with modelers and researchers to identify and address other high priority information gaps

Data utilization (analysis, interpolation, comparison, presentation)

A crucial aspect of the SWMP data analysis is establishing and exploring links to other data. Links between nearby deep and shallow water environments and between local watersheds and their associated near shore environments, both temporally and spatially, are crucial. Collaboration and coordination with other monitoring efforts is essential, and will be facilitated by the whole system approach recommended here. Comparative data analysis is at least as important as CFD/criteria assessment analysis.

Specific recommendations for data and data analysis needs include:

- Tidal height should be measured at each continuous station. All fixed stations should be referenced to a common datum.
- Local meteorological data is needed, especially over water winds.
- Better sediment/benthos mapping is often needed in the tributaries
- The SWMP should continue and expand access to raw data, and where possible should provide web-based access to supporting data as well.
- The SWMP should be integrated into larger observing system(s), such as CBOS.
- Adequate metadata for external users is needed.
- Spatial and temporal variance estimates are as important as mean values.
- Standardization of outlier flagging is needed. This should allow flagging suspect data w/o deleting it.

RECOMMENDATIONS OF THE DATA ANALYSIS AND INTERPRETATION, INTEGRATION WITH MODELING EFFORTS BREAKOUT GROUP

Group Members – Kirk Havens (discussion leader), Mark Trice (recorder), Denise Breitburg, Claire Buchanon, Dave Jasinski, Gary Shenk, Marcia Olson, Carl Hershner, Steve Preston, Dave Wilcox, Bill Dennison, Kevin Sellner, Julie Baldizar, Jian Shen, Mark Brush, Ricky Bahner

- Timelines are not relevant to management questions and shorten timelines of data analysis (B.D.)
- Three year turnaround adequate for assessment purposes? (C.H.)
- Monitoring/modeling disconnect...we need to measure the specific in a way that will allow us to generalize (i.e., include measurement/research on processes (L.L.)
- Current timeline of completion is inadequate. Are we bound to the current segmentation scheme (K.S.)
- Assess spatial and temporal variability of parameters to place more emphasis on either continuous monitoring or dataflow to streamline monitoring.
- If three-year rotating sample schedule puts the completion at 2027, we need to refocus the design...alternatives using reference station validation, different segmentation schemes, and optimization. Refocus efforts on interpolation to models (C.H.)
- Need to separate out monitoring and modeling to avoid confusion (B.D.)
- Two ideas to replace current approach (C.H.)
- Stratified approach with sentinel sites
- Development of a model to replace interpolator with a model that incorporates hydrodynamics
- Some elements of data variability and environmental processes can be incorporated into the interpolation routine (M.T.)
- Now may be the time to be looking to the next step towards dynamic modeling (several in group).
- Do we need 3500 pts of DATAFLOW/system to characterize for criteria (B.D.)
- Discussion of sample design options....(B.D.) could use a mix of dataflow and probability based monitoring.
- Concern of measurement of instantaneous DO measurement using DATAFLOW (D.B.)
- More funding for analysis of shallow water monitoring data (group)
- Confidence and certainty estimates are being included into criteria assessment (S.P.)
- For criteria, exceedances have different consequences...more dire for D.O. (D.B.)
- Look at biological significance rather than statistical significance...e.g. how often does a certain cell fail over time displayed on a map. Look at smaller spatial scale, pixel by pixel to focus on problem areas (C.H.)
- Map as a better display method and it represents the abundance of data (B.D.)
- Do not monitor best segments first.
- From criteria assessment purposes, if segment fails in first year should we move on to another segment (D.B.).
- We can use fixed station data for prioritizing assessments (MT). And focus on segments that are questionable in terms of assessment/nonassessment. Resources are too scarce to maintain a continuous monitoring to inform adaptive mgmt.
- Stratification of sampling
- What is the plan for incorporating SWM data into the model? (KS) In some way it may be used in calibration.
- Sentinel shallow water segments will be important to determine the ability to predict shallow water quality from mainstem monitoring
- Multiple models for shallow water...need to diversify from the one model approach. Need to develop a dialog with modelers to get SWM data incorporated. What's the best mechanism?

Suggest to CBP that multiple models need to be used; no new workgroup, but empower the groups in existence and communicate the monitoring/assessment needs to modelers better.

Main Consensus

1. Direct resources for expanded data analysis and alternative modeling to support efficient monitoring.
2. Monitoring prioritization should be based on explicit rules for segments whose status is uncertain. (e.g. If the segment fails in the first year, move on)
3. Develop new data analysis products that maintain spatial resolution of criteria assessment.
4. Monitoring effort should be optimized across all approaches.

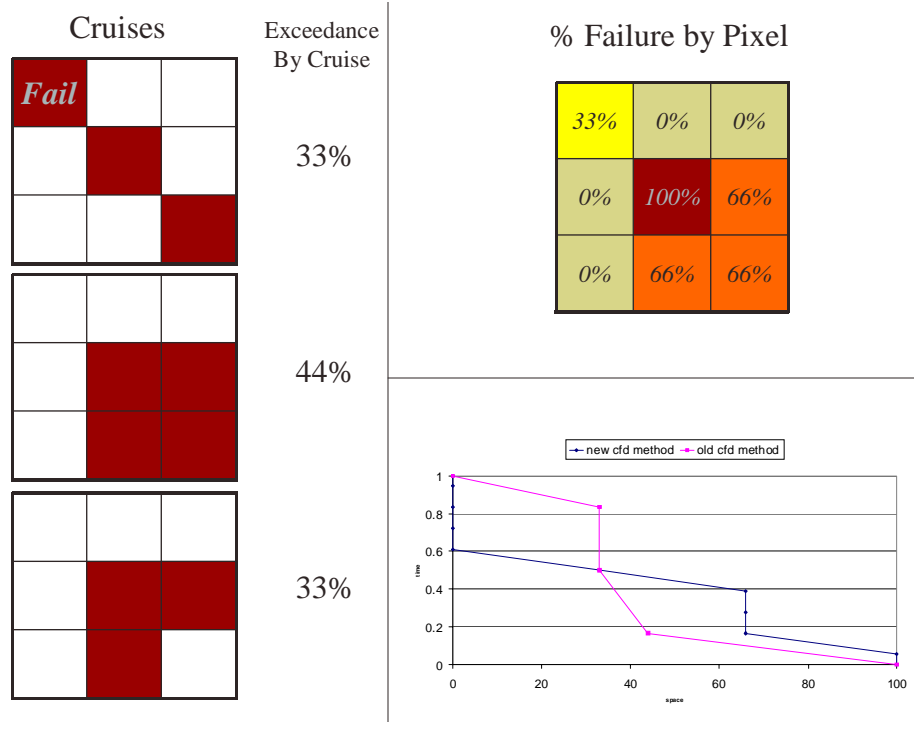
Summary

Currently allocated resources are inadequate for the Bay Program to accomplish a meaningful analysis of segment condition for listing/delisting by 2010. Even within current resources there must be an adequate commitment to ongoing analysis for support of optimization of current monitoring design.

Monitoring prioritization should be based on uncertainty of segment classification. Initial selection should be aimed at “marginal” segments based on available long-term fixed station records. This means avoiding clearly “good” and clearly “bad” segments. Monitoring should be discontinued in a segment if/when the cumulative record indicates nonattainment.

The Chesapeake Bay Program should begin development of models specifically designed to support design and analysis of monitoring. This includes the development of the next iteration of interpolation sophistication and development of data assimilation capabilities in models for real-time simulations.

The data analysis and presentation of monitoring results should be developed to retain the spatial resolution of the original data. Move to map displays of cumulative record. Modify CFD analysis to use pixel-based records. See previous illustration.



RECOMMENDATIONS OF THE IMPLEMENTATION BREAKOUT GROUP

Group Members – Scott Phillips (discussion leader), Chris Heyer (recorder), Rich Batiuk, Carl Cerco, Chuck Gallegos, Carlton Haywood, Rick Hoffman, Bruce Michael, Shih-Nan Chen, Nancy Rybicki, Bob Stankelis, Chris Trumbauer

Segmentation, Site Selection & Timelines

- Issue: Subdividing segments for assessments
 - Need approach for conducting monitoring of large segments.
 - Unless an entire CBP segment/CB trib is assessed within the same three year time period, it will be challenging to piece together a comprehensive assessment for the segment.
- Recommendation: Create a “working group” of field personnel that will sit down with GIS folks to look at the most practical way to subdivide the CBP segments.
 - Based on this information, the partners make a decision and then make it happen.
- Issue: WQ Steering Committee has said, “assess the best segments first.”
 - Do we agree or disagree with this philosophy, and if we disagree what is our recommendation?
 - We did not reach consensus but there were several considerations:
 - By assessing the “best” segments first, the CBP is able to “delist” the segment.

- Investing money in systems that won't pass will only result in having to come back.
- The most useful information and data may be gleaned from "marginal" segments/systems. Therefore, these may provide greater opportunity to learn and adapt our methodologies, protocols and procedures.
- Asses a range of "poor, marginal and best" systems would better our knowledge on causes for impairments
- Help make an informed decision as to which type of systems should be assessed first.
- Need to take partnerships into consideration when planning prioritization for assessment
- Prioritization should try to be based on existing LR data, if we intend to link WQ to LR.
- WQ Steering Committee has said, "assess the best segments first." Cont.
- Recommendations:
 1. Develop criteria to categorize segments and plan an approach:
 2. Categorize segments as "degraded, marginal and best" based on existing long-term monitoring data and comparing to criteria.
 3. Criteria should also consider watershed/land use and predominate sources of nutrients and sediments impacting a segment. This will help provide an understanding factors impacting an areas and type of BMP's needed to improve water quality.
- Evaluate based on the information gathered above to decide where to go next (best vs. worst).
 - Need to get (or develop) further guidance from EPA on criteria to delist a segment if only portions of it do not meet criteria

Integration with Modeling

- Issue: Current segmentation and calibration period of WQ model may not be able to utilize much of shallow-water data
 - Dataflow observations will have to be averaged to correspond to existing segmentation
 - Subdividing model into finer and finer cells may not capture small scale processes.
 - Model calibration is focus to 2000, so 2004 data doesn't really get fully utilized.
 - The present watershed model can't provide loads on the small spatial scales we're interested in (3rd order tributaries).
 - Modelers need guidance to ensure the processes affecting water quality are appropriately represented in the model. (DO, sediment/clarity in shallow waters, wetland/nutrients)
 - Some additional data would be help to calibrate:
 - Desire to collect benthic algae in shallows
 - Desire to collect wind and wave data (Baywide and SW)
 - Grain size analysis and organic carbon at Continuous Monitoring station locations (once a season).
 - Look at historic grain size data where available.

- Recommendations
- Near-term:
 - Looking for opportunities to verify/calibrate what the model is simulating in the SW by doing further comparison with existing data.
 - Further develop relationship between near-shore WQ parameters and channel parameters.
- Longer-term:
 - What additional parameters do we need to look at in SWMP
 - May need to decouple the SW cells from the bigger CB model cells and/or develop additional models
 - GIS model for SWM as a sub routine of the larger model
 - Box model for SWM for fluxes to larger model

Data Utilization-Maintenance and Calibration

- Issue: Is the current level of calibration/validation sample collection (grab samples) is sufficient.
 - Financial restraints dictate how many samples and what samples we can afford to collect and have processed.
 - Have not had time/money to analyze the data we are collecting in order to answer this question, as well as others.
- Recommendation: Prioritize looking at the sufficiency of our current level of calibration/validation sample collection.

Data Utilization

- Issue: Need to develop methods to convert observations to criteria assessment
 - Examples: KD from Turbidity, Chl a from Total Chl, etc.).
- Recommendations:
 - Known entities working on methodologies to come up with calculations should meet and come up with an agreed upon method This would be in the form of an informal working group of some sort.
 - Need to create and disseminate a handbook for using the new Interpolator.
- Issue: Continuous fixed site placement and comparison to DATAFLOW
 - Maryland and Virginia need to continue to work together in a coordinated effort to come to a consensus on methodologies and techniques.
- Issue: Should be a plan for disseminating these data
 - Data needs to be readily available, well documented and metadata on corrections/calculations need to be provided

Developing Partnerships

- Issue: Expansion of SW monitoring will depend on partnerships and more resources
- Recommendations
- Increase work with stakeholders (river keeper groups, watershed groups, watermen associations and other public groups.
 - Partner with watershed groups to form “public monitoring groups” who would physically do the monitoring.

- Pros and Cons associated with this..
 - Work with WWTP operators to monitor for segments near their plants.
- Put together a marketing package and a marketing person to solicit funds.
- Coordinate with CBOS and NOAA efforts.
- Work with the Chesapeake Bay Financing Authority to fund monitoring.

Segmentation, Site Selection & Timelines

- WQ Steering Committee has said, “assess the best segments first.” Cont.
 - Do we agree or disagree with this philosophy, and if we disagree what is our recommendation? Cont.
 - Take a subset of systems to thoroughly understand why it didn’t meet the criteria.
 - Find resources to link 3 year SW assessments to long-term historic fixed station monitoring.
 - Best systems aren’t really that great.
 - Investing money in systems that won’t pass will only result in having to come back.
- Bring to larger group a game plan for how to set up analyses now for bring SW outcomes to long-term historic fixed station network.
- CMON Site Selection Within a System
 - Currently based a bit on convenience (location of existing structures). Really driven by logistics.
 - Is an upriver site and downriver site sufficient?
 - Use DFLOW results to narrow in on an ideal location.
 - Virginia uses “within 6 foot contour” and “even distribution” as a selection criteria.
 - CBL tries to capture as much of the gradient as possible.
 - Maryland and Virginia need to formulize and document the site selection criteria a bit, keeping logistics in mind.
- Need to take partnerships into consideration when planning prioritization.
- SWM was chosen because of the high spatial and temporal resolution in the hopes that it would allow us to pinpoint where the problems are coming from when a system fails.
- Can a portion of a segment be delisted?
 - Working with EPA Region 3 now to determine this.

Integration with Modeling

- What do we need to do to compare SWM data to long-term data to look at gradients from the channel to the shallows?
- How can we best utilized the SWM data in calibration and verification of the bay WQ model?
- Need to deal with wetlands in some rational sense to understand the nutrient fluxes in and out of them.
 - How much wetland interception has greatest impacts on nutrients in the model
- Integration with other monitoring programs (e.g., non-tidal).

APPENDIX 2

Response To STAC Preliminary Comments And Questions Regarding CBP Shallow Water Monitoring Plan

The Scientific and Technical Advisory Committee received an overview presentation on the plans for shallow water monitoring in the Chesapeake Bay and tidal tributaries at its September meeting. STAC had requested the briefing as a means of initiating an independent review of the plan. Subsequent to the initial presentation a number of issues and questions were raised by the membership and are summarized below. The Tidal Monitoring and Analysis Workgroup of the Bay Program's Monitoring and Analysis Subcommittee is being requested to provide additional information on these issues.

1. There was general concern that the planned 3 year rotation of the limited sampling effort among Bay segments would not and could not provide an adequate data base to support evaluation of attainment or TMDL development.
 - *In general, the network design team and TMAW would agree that a longer time frame for criteria assessment would be better. There are multiple reasons why the design was not built around a longer assessment period. First, we are constrained by the conflicting demands of completing a full assessment by 2010 deadline without large new expenditures. To best address those constraints, the assessment period was limited to a maximum of three years. Second, the Water Quality Steering Committee defined the assessment period as being three years based on a compromise between a period that would cover a range of hydrologic conditions and the need to cover all segments by 2010. Third, it is only the shallow water segments that will be assessed on only one three year period. All other segments will be assessed over a longer period based on three-year increments.*
 - *TMAW is now considering the idea of using even shorter assessment periods for shallow water segments in order to cover more within the set time frame (2010). The assessment period would still be defined as three years. However, if it became clear that the segment could not attain its designated use even if it met the criteria at every point of the remaining assessment period, then monitoring would be ended and the resources would be applied elsewhere. This proposal has not been approved to date, but will most likely be presented to the IC as an option.*

There were several preliminary ideas offered for alternative sampling designs that ranged from deployment of fixed monitoring stations combined with spatially distributed sampling, to probability based sampling, to greater reliance on models and data assimilation to generate comprehensive assessments in time and space. These alternatives, and other options seem to merit serious and immediate consideration.

- *TMAW and the tidal monitoring network design team put substantial time and thought into their effort to provide a data collection network that would address all of the monitoring objectives of the Chesapeake Bay Program. All of the options mentioned above were considered and were rejected for one reason or another.*
- *It is not clear what the phrase "deployment of fixed monitoring stations combined with spatially distributed sampling" means. In reality, this is the exact description of the current shallow water monitoring network design.*
- *Probability-based monitoring was considered both as a replacement for the current shallow-water monitoring network design and as a possibly cheaper supplement. It was decided that probability-based monitoring was no less expensive than the current design because it still required the deployment of boats to cover broad spatial ranges. Boat time is the greatest expense and, since the boats would be deployed in either case, it only made sense to spend the time collecting data of greater density using the DATAFLOW system. Furthermore, probability-based monitoring provides a much more limited assessment because all of the data are lumped in space and time*

and there is no spatial or temporal referencing. Thus there would be no potential for evaluating the spatial or temporal pattern of criteria exceedence.

- The CBP has been criticized severely in the past for using models to assess progress toward attainment of its goals. It is somewhat surprising that this idea would be considered to be an option by STAC. It is the contention of TMAW and much of the CBP that attainment of criteria and designated uses should be based on measured data wherever possible. In any case, currently there is almost no data available for model calibration in shallow water areas. One purpose of the current design is to generate the data to develop a greater understanding of how these systems work and that might be used for future modeling efforts. TMAW is currently planning to work with the Modeling Subcommittee to evaluate ways in which data collection in shallow-water areas can best support their efforts.*
2. Within the current design, the protocol for “correcting” sample data to generate a synoptic spatial sample from a data stream spread over several hours was considered suspect. Basing the correction on parameter changes observed at a fixed point inshore from the sampling track was a major concern.
 - This is an obvious limitation in the data collection methodology. This is new technology that is still being refined. It offers great potential to provide a large amount of information at a relatively low cost. TMAW recognizes that correction based on a few inshore fixed continuous monitoring sites may not be optimal. However, it is TMAW’s contention this correction is better than none. Keep in mind that this type of correction should be preformed for any type of broad scale monitoring that is conducted through the period of a day. It is only the availability of the detailed temporal and spatial data that allowed this type of correction to even be considered. Having said the above, TMAW is open to other suggestions on how this might be accomplished.*
 - Keep in mind that the continuous meters provide the only data that can be used to evaluate some criteria components such as the instantaneous minimum dissolved oxygen. There are a number of gaps in our ability to assess all of the criteria components. Those gaps represent a much bigger problem for the overall data needs of the CBP as compared to the technical limitations of the current shallow-water monitoring design.*
 3. The potential of the constant-depth DATAFLOW sampling to miss the natural and often significant depth variation in sample parameters was another major concern.
 - It is recognized that this also is a limitation. Obviously we would like to have data from every point in space and time. The DATAFLOW approach was considered an acceptable compromise. Keep in mind that the DATAFLOW approach was designed to assess criteria in the shallow water and open water designated uses only. It was never intended to assess criteria in the deeper designated uses. Having said the above, if there are specific suggestions on how this might be done better, TMAW would be happy to consider them.*
 4. It is not clear to committee members how the large data sets developed in the DATAFLOW sampling will be used to evaluate attainment (e.g. through assimilation into current or future modeling efforts). Interpolation of “track” data to a comprehensive spatial coverage raises concerns for the accuracy of the interpolation, particularly when combined with a suspect “correction” protocol. The method for extrapolation to temporal coverage is not clear to the committee.
 - Given that STAC provided review comments for the assessment procedures that were approved by the CBP and published in the criteria document it is confusing why this comment has arisen this late in the game. However, the following responses are offered.*
 - The assessment procedures were summarized in the presentation that generated these comments. TMAW would be happy to again review that material for STAC.*
 - The assessment procedures have been completely assimilated into the water-quality model to evaluate management scenarios to establish cap load allocations. That material as well has been published and has been available for many months.*

- *The concern related to accuracy of interpolation is unclear. If there is anything more specific, we could react to it. However, the comment above is very general. The CBP is currently engaged in an effort to improve the spatial interpolator software using the best geostatistical algorithms available. Those algorithms will provide an estimate of error that cannot be provided any other way.*
 - *No matter what monitoring approach is used, there is an implicit or explicit spatial framework that is applied to interpret the data. If there is one fixed-station that is utilized, the data are simply extrapolated to the entire segment to make an assessment of its condition. Under probability-based monitoring the spatial data are lumped in an unbiased manner to again provide one estimate of the condition of that segment. Our approach is simply to view spatial data collection as part of a network and retain its spatial referencing. Each location that is monitored is defined as part of a grid and interpolation is simply a way of extrapolating the measured grid locations to estimate the overall spatial extent of criteria exceedence. This is a much more refined approach as compared to using a fixed station extrapolation approach for criteria assessment. Thus the basis of assertion of poor accuracy is unclear.*
5. The limitations on operation of the DATAFLOW in less than optimal conditions raised questions about the ability to monitor stochastic events or even fairly common events associated with less than great boating days. The logistics and expense of the data collection effort seemed to seriously compromise opportunities to collect information on condition responses that are time-lagged (i.e. delayed after storms or spread over several days).
- *It is unclear where the concerns regarding “limitations on operation of DATAFLOW in less than optimal conditions” came from since no information on this topic were presented to STAC. To date, other than the recent hurricane, there were no occasions where the boats did not go out based on poor weather conditions. In fact many of the cruises were conducted in poor weather (rain and turbulent waters).*
 - *The primary objective of the shallow-water monitoring program is to assess criteria attainment in the shallow-water designated use areas. Event monitoring is not a primary objective and the system might have been designed somewhat differently if it were.*

The committee would appreciate an opportunity to learn more about the plans for addressing these and other limitations that seem inherent in the current sampling design. We would like to investigate the rationales for not pursuing other sampling design options, and we wish to review the plans for analysis and interpretation of the data generated by the current design.

The committee has also expressed a desire to learn more about the ongoing and/or planned operation of the water quality sampling for deeper waters in the Bay, as well as monitoring designs for nontidal waters in the watershed.