State of Maryland's Comprehensive Water Monitoring Strategy

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EXECUTIVE SUMMARY

This plan updates Maryland's 2004 Comprehensive Water Quality Monitoring Strategy, which was developed in accordance with EPA's 2003 guidance entitled, "Elements of a Water Monitoring and Assessment Program."[1] EPA's guidance calls for states to address ten basic monitoring strategy elements by 2014. This 2009 mid-course revision of Maryland's 10-year plan supports Maryland's intent to address the ten basic elements. This Strategy describes existing programs and documents plans for refinements over the coming years.

Maryland's water quality monitoring programs are designed to support assessment of all State waters relative to Maryland's Water Quality Standards[2] and addresses specific resource management and regulatory responsibilities under the federal Clean Water Act. This Strategy identifies the programs, processes and procedures that have been institutionalized to ensure State monitoring activities continue to meet defined programmatic goals and management objectives. It is comprehensive in addressing monitoring for all water body types, including rivers and streams, lakes, tidal waters, ground water and wetlands. The Strategy also discusses current data management and quality assurance/quality control procedures that ensure data integrity and guarantee that data are of sufficient quality and quantity to meet their intended use.

This Strategy was updated during 2008-2009 through a multi-agency process led by the Maryland Department of Environment (MDE). This process led to several broad shifts in the State Strategy:

- **Supporting Implementation:** Maryland is undergoing a strategic shift in monitoring emphasis from supporting TMDL development to supporting TMDL implementation. This will be reflected in more assessments to identify sources of pollutants and biological stressors, to more effectively target implementation and to support evaluation of implementation policies, programs and practices.

- **Documenting Incremental Water Quality Improvements:** It is difficult to observe incremental improvements in large waterbodies. In view of this, and the need to show near-term progress, greater emphasis will be placed on demonstration monitoring initiatives at more refined geographic scales. This strategic shift compliments the greater emphasis being placed on evaluating the progress of TMDL implementation.

- **Monitoring Design and Data Analysis:** A greater emphasis will be placed on quantitative monitoring design to improve the efficiency of field operations and to support more effective data analyses.

- **Protection of High Quality Waters:** The Strategy reflects a greater emphasis on the protection of high quality (Tier II) waters pursuant to implementing the antidegradation policy of Maryland's water quality standards.

[1] EPA 841-B-03-003.

[2] Code of Maryland Regulations Title 26, Subtitle 08

This document identifies plans for refining Maryland's monitoring strategy over the coming years. To that end several near-term initiatives are outlined in Section 8, "Program Evaluation," and Section 9, "General Support and Infrastructure." These near-term initiatives are highlighted below:

- **Monitoring Design Refinements:** Consistent with the strategic shifts outlined above, as well as other needs, the following monitoring design work is being conducted:

    - **Bacteria:** An efficient means of evaluating bacteria in areas other than beaches and shellfish harvesting areas is under development.
    - **Flow Gaging:** The network of long-term and temporary gaging stations is being refined via a multi-stakeholder process.
    - **Watershed Monitoring Cycling Strategy:** The design of the watershed monitoring cycling is undergoing refinement. Maryland's watershed cycling strategy was initially designed to support TMDL development. Now, as more emphasis is placed on TMDL implementation, the monitoring needs are shifting. In principle, Maryland continues to have a need for a cycling strategy. In particular, Maryland's resources are too limited to monitor the entire State in a single year. Periodically revisiting areas of the State to evaluate implementation progress is also a motivating principle.
    - **Chesapeake Bay Monitoring:** The EPA Chesapeake Bay Program is leading an initiative to refine the tidal and nontidal monitoring designs.

- **Water Quality Data Exchange and Management:** MDE will continue to lead the Water Quality Exchange (WQX) project to establish a system for storing and transferring water quality data among MDE, the Maryland Department of Natural Resources (DNR), the EPA Chesapeake Bay Program and the EPA Center for Data Exchange.

- **Program Evaluation and Resource Restructuring:** Budget analyses will be conducted in concert with program evaluations to implement the strategic shifts and initiatives outlined above.

1.0 Monitoring Program Strategy and Objectives

The State of Maryland has a comprehensive water monitoring strategy that provides for assessment of all State waters relative to Maryland's Water Quality Standards. It also addresses other specific resource management and regulatory responsibilities under the federal Clean Water Act. This strategy serves to both a) describe existing programs and b) document plans for refinements over the coming years, both near-term and long-term.

Section 1.1, "Management Objectives," describes the broad desired outcomes that motivate the State monitoring programs. This section also describes several broad shifts in Maryland's monitoring strategy. It also summarizes refinements that are underway or pending, which will support the broad strategic shifts. Some of these refinements are elaborated on further in Section 8, "Programmatic Evaluation," and Section 9, "General Support and Infrastructure."

Section 1.2, "Programmatic Goals," describes the key existing programs, responsible state agencies and funding sources that support the management objectives. This section also gives an overview of how the programs relate on a strategic level. A matrix is presented that shows how various monitoring programs support the assessment of attainment of designated uses and other key monitoring functions. A flowchart is presented that shows an even broader perspective of how the monitoring strategy supports key aspects of the Clean Water Act.

Section 1.3 "Monitoring Designs" outlines Maryland's current designs and discusses future refinements. One shift in Maryland's Strategy involves placing greater emphasis on enhancing statistically based monitoring designs. This shift is motivated in two ways. First, it more rigorously supports TMDL implementation management needs. Second, it recognizes that greater efficiency and effectiveness can likely be achieved by ensuring that monitoring is designed with data analyses in mind.

1.1 Management Objectives

There are four management objectives associated with the various monitoring programs in Maryland. They are listed below in order of priority;

(1) Protecting public health from environmental contaminants,
(2) Protecting the health and stability of aquatic communities,
(3) Managing aquatic resources, and
(4) Determining if water quality/habitat/resources are improving or degrading.

1.1.1 Protecting public health

Key monitoring programs for protecting public health require monitoring for bacteria, toxic contaminants and harmful algal blooms. Bacterial monitoring provides information to protect drinking water supplies, recreational uses, especially at beaches, and to classify and protect shellfish harvesting areas. Bacterial contamination is widespread and difficult to assess.

New technologies such as bacterial source tracking (BST) are used to help locate sources and better characterize threats to human health.

For persistent bio-accumulative compounds, the problem is chronic, and fish tissue monitoring provides the data needed for risk assessment and public education so that consumers can make informed decisions about eating recreationally caught fish. However, there are also concerns about inorganic contaminants, metals and other substances being carried to drinking water through nonpoint source runoff. These substances are particularly problematic because they are not readily removed by water treatment. Where groundwater provides drinking water supplies, additional concerns regarding nitrates and radioactive compounds arise.

The State receives funding from the U.S. Centers for Disease Control and Prevention (CDCP) to participate in a multi-agency State Harmful Algae Bloom Surveillance Program (HABSP). This program is collectively comprised of the State Departments of Health and Mental Hygiene, Natural Resources (DNR), Environment (MDE), and the CDCP. It supports MDE initiatives to protect public health and the environment by enhancing timely diagnosis of harmful algae bloom (HAB) toxins in shellfish waters, bathing beaches, drinking water reservoirs, and as evidence for causes of certain types of fish kills.

In 2009, MDE began using Enzyme-linked Immunosorbent Assay (ELISA) equipment to test for the presence of Microcystin toxin (a specific HAB toxin) in state waters. This toxin is a public health concern for drinking water and bathing beaches. ELISA tests provide fast accurate results for timely management decisions.

Although there are emerging issues including the presence of endocrine disruptors, pharmaceuticals and personal care products, antibiotics and other biologically active compounds that have been increasingly identified in our waters, the impact of those substances with respect to which substances and levels are of concern, has not yet been determined.

1.1.2 Protecting the health and stability of aquatic communities

Attaining and maintaining balanced aquatic communities are clear management goals of the Clean Water Act (see Appendix A, Biological Assessment of Water Quality). Monitoring for the protection of aquatic life (aquatic plants and animals) and terrestrial wildlife includes dissolved nutrients, suspended and bed load sediments, dissolved oxygen, pH and Biochemical Oxygen Demand and essentially the same list of toxic substances that are monitored for public health, except for bacteria. Interpretation of biological monitoring results may be confounded by the complexity and interactions of the life history, the hydrologic environment, habitat and natural and anthropogenic stressors making it difficult to identify any specific stressor (s) that may be responsible for lack of attainment. Interpretation and achievement of management goals may be further complicated by natural variation in temperature and rainfall, and by variations in habitat.

1.1.3 Managing Aquatic Resources

Management of Maryland's diverse aquatic resources involves a delicate balance between managing resource allocation (exploitation), maintaining long-term ecological quality (water quality), socio-economic constraints and resource sustainability. Due to interrelationships between resource management and a healthy ecosystem, various anthropogenic and natural stressors may ultimately affect the outcome. As a result, monitoring to support specific aquatic resource management needs (e.g., fisheries harvest) may mutually support, or be supported by, other state monitoring objectives. For instance poor water quality may affect fisheries stock, and conversely, over/under harvest of fisheries may ultimately affect ecosystem balance, which may in turn affect water quality. Better coordination with resource management agencies is a priority.

1.1.4 Determining if water quality/habitat/resources are improving or degrading

The State has a strong interest in evaluating whether environmental protection and restoration policies are effective so that programs may be refined if necessary.

Water pollution management occurs at various scales. Due to the complexity of pollution sources and natural variability, it is challenging to observe the effects of management programs for large water bodies. Alternatively, although it is easier to observe management responses for smaller water bodies, the vast number of smaller water bodies greatly outstrips the State's monitoring resources.

Maryland's 2009 Monitoring Strategy signals an intent to shift resources in a way that enhances monitoring of smaller water bodies without compromising the State's historic network of long-term trend monitoring stations. The following broad shifts in Maryland's Strategy support this broad objective in addition to meeting each of the narrow goals:

- **Supporting Implementation:** Maryland is strategically shifting a portion of monitoring resources, previously assigned to TMDL development, to TMDL implementation. This change promotes a more balanced program of TMDL development and TMDL implementation. This will be reflected in more monitoring to identify sources of pollutants and biological stressors, to target implementation and to evaluate implementation policies, programs and practices.

  Synoptic Surveys: Some monitoring methods can serve dual purposes of pollution source assessment and restoration evaluation. One such method applied to non-tidal streams is the synoptic survey in which numerous samples are collected throughout a watershed over a period of one or two days. These surveys offer the possibility of both identifying localized pollution hot spots for targeting implementation and establishing a baseline against which implementation evaluation can be compared. See Section 1.3.3 under "Monitoring Design" for more discussion.

  Biological Integrity of Non-tidal Streams: As part of a TMDL implementation strategy, a small number of watersheds with high recovery potential are being targeted for restoration. The biological monitoring data used originally to determine stream impairment are also being used for targeting implementation. Additional monitoring in the targeted watersheds will likely be necessary to identify specific restoration project opportunities, refine source assessments and document restoration benefits using pre and post monitoring.

Bacteria (Tidal and Non-tidal): As part of a TMDL implementation strategy, a small number of watersheds with high recovery potential are being targeted for restoration. This is being done for tidal shellfish harvesting areas and non-tidal streams. Analysis of existing data is being used for targeting purposes. Additional monitoring in the targeted watersheds will likely be necessary to identify specific restoration project opportunities, refine source assessments and document restoration benefits using pre and post monitoring. MDE is also contemplating research to improve our understanding of bacteria transport and fate. Initially, this research will focus on data analyses; however, it could lead to recommendations for additional monitoring.

Acid Mine Drainage: Maryland's Bureau of Mines, Acid Mine Drainage Section, supported in part by State 319 Nonpoint Source Program grants, is conducting a series of restoration projects. Monitoring information is used to identify specific sources and to support the implementation design. Additional monitoring will be conducted to evaluate the effectiveness of the implementation.

- **Demonstrating Incremental Water Quality Improvements:** It is difficult to observe incremental improvements in large waterbodies. In view of this, and institutional pressure to show progress, greater emphasis will be placed on demonstration monitoring initiatives at more refined geographic scales. This strategic shift compliments the greater emphasis on evaluation in support of TMDL implementation.

  Because improvements in water quality are only likely to be observable in areas where significant restoration resources have been invested, evaluation monitoring resources will be limited to those areas. This monitoring is intended to address systems of implementation practices rather than the evaluation of individual practice performance. The lessons learned from such projects can be transferred to other areas. Several examples are noteworthy:

  - Maryland's Nonpoint Source Grant Programs (319 and Coastal Zone Management) leverage local implementation resources. In addition to nutrients, these targeted implementation efforts address acid mine drainage in Western Maryland, tidal and non-tidal bacteria, and biological integrity of non-tidal streams. The 319 Program is striving to foster measurable incremental improvements to support documentation of local scale "success stories."

  - The Corsica River Restoration Initiative involves a long-term, intensive investment of State and local implementation and monitoring resources. This demonstration project addresses multiple types of impairments, restoration and monitoring techniques. It also serves as a social sciences laboratory in which methods of affecting behavior changes can be tested.

  - The Chesapeake and Coastal Bays 2010 Trust Fund, established by Maryland's General Assembly, is intended to focus funding to areas of greatest nutrient contribution to these bays. A multi-agency effort to evaluate the local-scale results of this restoration is part of Maryland's Strategy.

- Marylands' Municipal Separate Storm Sewer System (MS4) permits are being enhanced the improve accounting of stormwater retrofitting activities. An associated enhancement of monitoring by local governments will support the State's emphasis on evaluating local scale water quality improvements.

More generally, the State is interested in evaluating water quality *changes*, including degradation. Recent consideration has been given to shifting some of the Trend/Core stations to different places where long term trend assessments might be of more concern. However, given the unique value of long historical records, no decision has been made in the context of revising this Strategy. This issue may be considered in the future. In the interim, monitoring is being enhanced to ensure the protection of high quality waters, which is discussed below.

- **Monitoring Design and Data Analysis:** Detecting changes in highly variable natural systems can be strengthened by proper monitoring design that explicitly considers data analysis design simultaneously. A greater emphasis will be placed on monitoring designs and data analyses over the next several years. This will be supported by hiring a person in MDE with the skills and job duty to focus on this subject. Several noteworthy examples of this need are elaborated upon in Section 1.3.3 under "Monitoring Design."

  In October 2003, the State made its first upload to EPA's STORET database using a traditional "file transfer protocol (FTP) method. Since that time, Maryland has continued to annually upload data to STORET. Thanks to an EPA Water Quality Exchange (WQX) grant, in 2005 MDE started to develop a new data submission process using XML Web Services for transmitting data to EPA using the National Environmental Information Exchange Network (NEIEN). The development is now complete and MDE has begun incorporating Beaches data since 2008. The data submission expanded to other sampling projects beginning in June 2009.

  STORET WQX will continue to be a high priority effort in Maryland in coming years, and is actively taking steps to include data from the Department of Natural Resources. Although some institutional and staffing obstacles still remain, the State is working to centralize environmental monitoring data in STORET WQX with the goal of relying increasingly on this system to conduct water body assessments and develop the State's Clean Water Act Section 303(d) and 305(b) Integrated Report.

- **Protection of High Quality Waters:** Maryland's Strategy reflects a greater emphasis on the protection of high quality (Tier II) waters pursuant to implementing the antidegradation policy of Maryland's water quality standards.

  Resources from Maryland's 319 Nonpoint Source Program have been dedicated to monitor high quality waters that are at risk of degradation. In particular, beginning in 2009 funding has been provided to the Maryland Department of Natural Resources to conduct targeted assessments of biological integrity for Tier II waters protected by the anti-degradation policy of Maryland's water quality standards. The location of monitoring corresponds to areas coming under development pressure and is intended to support implementation of the State's anti-degradation policy.

1.2 Programmatic Goals

Programmatic goals are intended to support management objectives, but are generally narrower and more precisely tailored to the defined activities needed to meet specific program initiatives. Each program addresses a specific environmental concern generated from statutory, regulatory or policy mandates, and agency goals.

The key programmatic functions, responsible agencies and primary funding sources are summarized in Table 1.

Table 1: Major programmatic monitoring functions

Program Function	Responsible Agencies	Primary Funding Sources
Clean Water Act section 305(b) and section 303(d) Statewide water quality assessments and impaired waters management listing (integrated report)	MDE and DNR	State general funds, Federal S. 106 grant
Water Quality Standards[1] development	MDE and DNR	Federal S.106 grant, State funds
TMDL development	MDE	Federal S. 106 grants, State funds
TMDL implementation	MDE and DNR	Federal S. 319 grant, State and local funds
Water quality characterization/trends/criteria assessment (Core/Trend stations, Chesapeake Bay and tidal tributary stations)	DNR	Federal S. 106, S. 117 grants, State general funds
Ambient condition (aquatic life use) monitoring (Maryland Biological Stream Survey, Chesapeake Bay Benthic, Plankton, Aquatic vegetation, HAB monitoring)	DNR/MDE	Federal S. 106, S. 117 grants, Environmental Trust Funds
Public health protection at beaches	Local health departments (MDE oversight and guidance)	Local funds supplemented by funds from federal (National Beaches) grant
Tissue contaminants for fish and shellfish[2]	MDE	Federal S. 106 and State matching funds
Wetlands condition	MDE and DNR	State and federal funds
Drinking water supplies	MDE	State general funds and federal DWSRF
Classification of shellfish waters	MDE	Federal 106 grant, State general funds

Groundwater-quality/quantity	MDE/DNR	Safe Drinking Water Act Funds
Aquatic resource management-fisheries, wildlife, State lands	DNR	Federal (US FWS), State funds
EPA's National Aquatic Resources Survey-lakes, streams, wetlands	MDE/DNR	Federal Funds (EPA)
Watershed restoration (e.g., Corsica River)- urban/agricultural nonpoint source, point source, receiving water quality, aquatic resources status and restoration and implementation management	DNR/MDE	Federal (USGS), EPA, State Funds, State 2010 Trust Fund

[1]The existing data from the Chesapeake Bay monitoring program contributed significantly to the development of Chesapeake Bay standards; a separate grant has been received for development of nutrient criteria in rivers and streams.

[2] Environmental Trust Funds (mandated electricity use surcharge) has provided funding support for assessing mercury contamination in fish in impoundments.

The previous table provides a concise summary of Maryland's primary monitoring programs. However, to gain a sense of how Maryland's monitoring programs function strategically, we created a matrix shown in Table 2.

Table 2: Strategic Overview of Maryland's Monitoring Programs

Designated Uses & Anti-Degradation					Other Key Monitoring Functions					
A Aquatic Life	**B Drinking Water**	**C Water Contact**	**D Fishing**	**E Antideg. and Protection**	**F Long-term Trends**	**G Implementation Effectiveness**	**H Source ID & TMDL Develop**	**I Compliance**	**J Reactive**	**K Water Quality Standard R & D**
Non-tidal Rivers & Streams										
• MBSS • Core/ Trend • Invasive species • Volunteer	• Local Delegation	• Under Developmnt	• Fish Tissue • DNR Fisheries	• MBSS	• Core/ Trend • MBSS	• 319 NPS • MBSS • Synoptic Surveys • Local Programs • 2010 TFE	• MBSS • TMDL • Synoptic Surveys • Corbicula Surveys	• NPDES • MS4 • Bureau of Mines	• Fish Kill • Emergency Response • HAB Monitoring	• MBSS • Nutrient Criteria • Temp.
Lakes and Reservoirs										
• Nat'l Lake Survey	• Reservoir Source Water Assessment	• Beaches Program	• Fish Tissue	• N/A	• Nat'l Lake Survey	• 319 NPS • Local Delegation • MS4 Permits	• TMDL • 319 NPS	• NPDES • MS4	• Fish Kill • Emergency Response • HAB Monitoring	• Nat'l Lake Survey
Chesapeake and Coastal Bays										
• Ches. Bay Program • DNR Bay Mon.	• N/A	• HAB Mon. • Beaches Program	• Shellfish • Fish Tissue • DNR Fisheries	• Ches. Bay Program • DNR Bay Monitoring	• Ches. Bay Program DNR Bay Monitoring	• Ches. Bay Program • Shellfish • BST • 2010 TFE	• TMDL • 319 NPS	• NPDES • WQC & Wetland License	• HAB Monitoring • Fish Kill	• Complete for Ches. Bay
Groundwater										
• N/A	• Source Water Assessment • Wellhead Protection	• N/A	• N/A	• Wellhead Protection	• Wellhead Protection	• N/A	• 319 NPS	• Source Water Assessment	• Emergency Response • Oil Control Program	• Fed. Delegation
Wetlands										
• Under Developm ent	• N/A	• N/A	• N/A	• Wetlands of Special State Concern	• FED. DEL. – Under Development	• 319 NPS	• Local	• Wetland Permit & mitigation	• N/A	• Under Developmnt
Ocean										
• N/A	• N/A	• Beaches Program	• DNR Fisheries • HAB • Fish Tissue	• N/A	• Beaches Program	• N/A	• NA	• NPDES • WQC & Wetlands License	• Fish Kill • HAB Monitoring	• Fed. Del. - National Coastal Survey

This matrix helps ensure that the State Strategy, like a two-dimensional checklist, covers the many complex-monitoring needs. It is organized to highlight designated uses (left half of table) by water body type (rows). It also highlights other key broad functional monitoring areas (right half of table).

The left side shows the programs that are the primary source of information for assessing the waters of the State in support of the integrated 305(b) and 303(d) reports. In addition to the designated uses of aquatic life, drinking water, water contact, and fishing, the table identifies monitoring that supports implementation of the anti-degradation policy for protecting high quality waters.

The right side of Table 2 identifies long-term trend monitoring, implementation effectiveness monitoring (short-term progress), source identification and other monitoring to support TMDL implementation. It should be noted that source identification monitoring also supports TMDL implementation, so there is some overlap of these categories. In addition to compliance monitoring, we've identified "reactive" monitoring, which addresses monitoring in response to uncertain events like algae blooms, fish kills, spills and special investigations. Finally, we've identified research and development monitoring to support the refinement of Maryland's water quality standards.

In sum, Table 2 provides a snap-shot of how Maryland's monitoring operates at a strategic level. This table is the basis for the organization of Chapter 3, in which each program is described in detail.

A third way of looking at the programs is in relation to a flow chart that depicts their relationship in terms of Maryland's Strategy for supporting the key elements of the federal Clean Water Act (Figure 1).

The flowchart depicted in Figure 1 below graphically illustrates the critical components and programmatic relationships that define the State's Water Monitoring Strategy, pursuant to the federal Clean Water Act. The succeeding sections of this document (Sections 2.0 through 9.0) describe each of these components in greater detail.

The foundation of Maryland's Water Monitoring Strategy are the State's Water Quality Standards (WQS – square #1 in the flowchart, see section 6.1.1 for details). Maryland's Water Quality Standards (WQS – COMAR 26.08.02) set the minimum thresholds for acceptable water quality that the State is required to enforce. As a result of these standards, Maryland developed a State Water Monitoring Strategy to provide data for making regulatory and resource management decisions necessary to protect human health and aquatic life uses.

The State programs that form the cornerstone of Maryland's Water Monitoring Strategy are identified by the #2 squares in the flowchart (see Section 3.0). All of these programs have independent programmatic evaluation processes designed to determine adherence to project-specific goals and objectives. However, the goals and objectives for each project or program also feed back into the goals and objectives of Maryland's larger Strategy (see section 9.0). The TMDL monitoring program is unique in that it is required only if a water body has been listed as impaired on Maryland's 303(d) List. Local and volunteer water monitoring programs are identified in the flowchart as well. Maryland recognizes the importance of using these data for water body assessments and feels strongly that local and volunteer programs should be fully considered in development of the State's Strategy. A monitoring programs and goals document compiled by the Maryland Water Monitoring Council in 2005 is included in Appendix B. Maryland is using this document as a starting point for better integration of State and local water monitoring programs.

All water monitoring data collected by State agencies must meet quality assurance plan requirements prior to entry into a digital medium (see sections 4.0 and 5.0, respectively). The #3 "Data Management and Quality" hexagon represents this critical component of the State's strategy. The Maryland Department of the Environment (MDE) currently uses STORET (WQX) (http://www.epa.gov/storet) for ambient water quality monitoring data while the Department of Natural Resources (DNR) uses the Chesapeake Information Management System (http://www.chesapeakebay.net/cims). All CIMS data is periodically copied to the MDE WQX system in an attempt to centralize as much state monitoring data as possible.

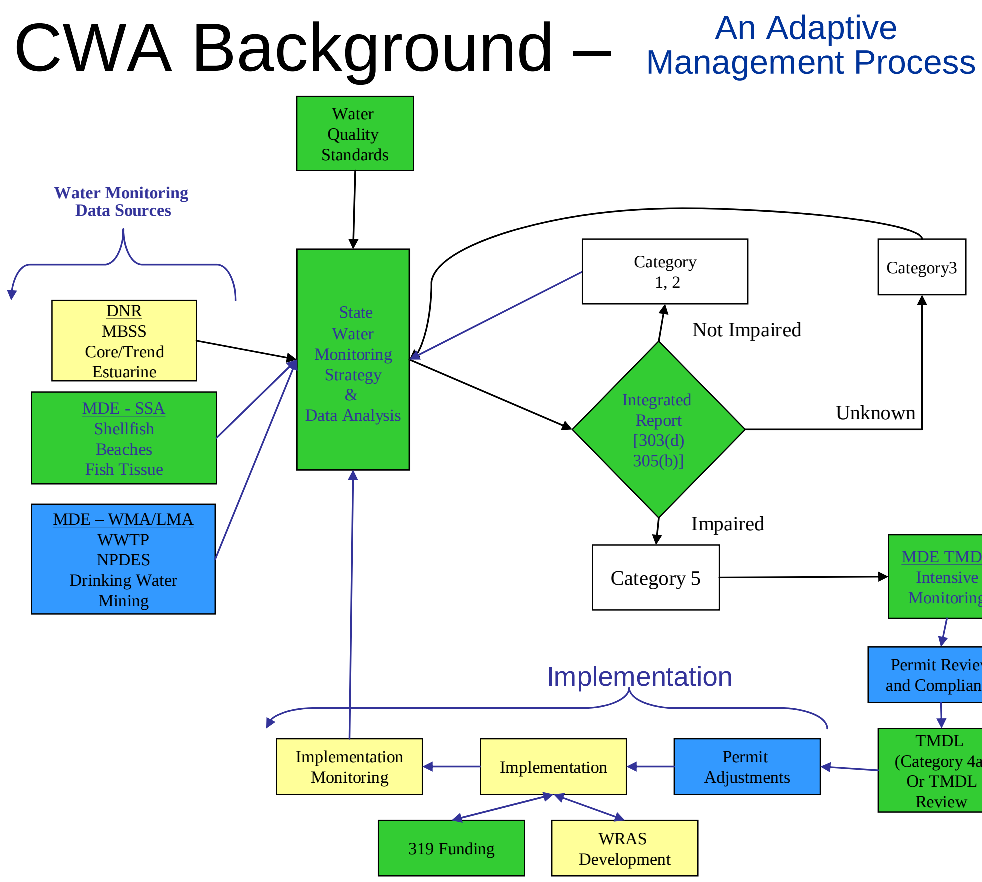
Once these data have been quality assured and are electronically available, the State uses publicly reviewed Listing Methodologies to interpret and analyze these environmental data for water body attainment decisions (see section 6.0 and Appendix A). For permitted facilities, MDE uses a 5-year watershed cycling approach to review environmental permits and ensure compliance with permit limits. This process is represented by the #4 "Data Analysis" square in the middle of the flowchart.

Subsequent to data analysis and application of the State's Listing Methodologies, a water body impairment determination is made. All impaired water bodies are identified in the State's 305(b) Report and trigger a Category 5 303(d) Listing (e.g., they require a TMDL). All water bodies that are either unimpaired or indeterminate fall into different 303(d) Listing categories (Categories 1, 2, 3 or 6) that do not require a TMDL. These various components of the 303(d) List and 305(b) Report are represented by the #5 boxes and diamond. Additional data will be collected to reassess unimpaired or indeterminate waters to evaluate whether they are meeting Water Quality Standards (WQS) or whether the data support listing them as impaired.

For impaired waters, the State: (1) conducts monitoring for TMDL development (#2 square at bottom right); (2) conducts permit reviews and determines compliance with permit conditions (#6 square at bottom right); (3) develops TMDLs (#4 square on the bottom right); and, (4) future TMDL implementation phase (#7 rectangles).

Implementation monitoring data then goes back into the data management, analysis, and 305(b)/303(d) phase to see if implementation has resulted in attainment of WQS. This management process is labeled as adaptive management because it creates a constant feedback loop where implementation planning, restoration projects, and best management practices are related back to the TMDL and permitting process to determine if the proposed TMDL reductions are achievable. If not, one or more components may need to be further adjusted to meet water quality standards.

Figure 1: Flowchart Depicting Maryland's Comprehensive Water Monitoring Strategy



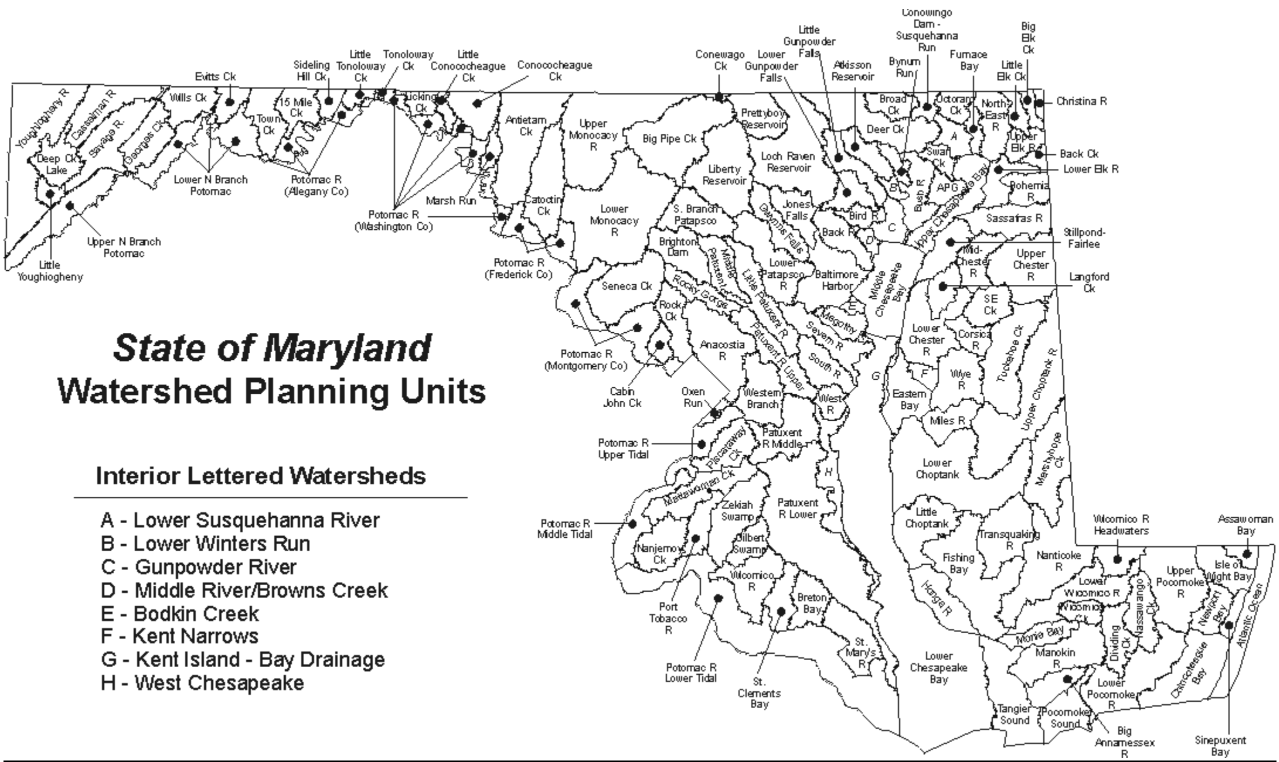
1.3 Monitoring Design

Maryland employs multiple sampling designs to address different programmatic needs. As the regulatory agency in the State, the Maryland Department of the Environment (MDE) generally uses targeted monitoring and fixed stations to evaluate point source discharges associated with permitted facilities, develop water body specific TMDLs, and to protect public health. The Department of Natural Resources (DNR) is responsible for conducting statewide assessments on the condition of Maryland's living resources. Accordingly, DNR uses both fixed-station as well as probabilistic, stratified random design to statistically sample the entire State at regular intervals. Close coordination between DNR's assessment programs and MDE's regulatory programs ensures that water quality concerns across the State are effectively identified, prioritized and addressed. These programs address both public health and aquatic life needs.

1.3.1 Watershed Size and Segmentation

Two watershed scales are most often used to interpret water quality conditions in Maryland – the 8-digit (Figure 2) watershed scale, which is roughly 75 square miles in size, and the 12-digit watershed scale (Figure 3), which is approximately 11 square miles in size. A different segmentation schema is usually used to assess water quality conditions in Chesapeake Bay and its tidal tributaries. In Maryland, there are 65 Bay segments (Figure 4); many of which share 8-digit watershed boundaries, but other areas are defined by smaller segments (range <0.1 to 355 square miles; average area of almost 38 square miles).

Figure 2: Names of the 8-digit basins (averaging 90 square miles each)



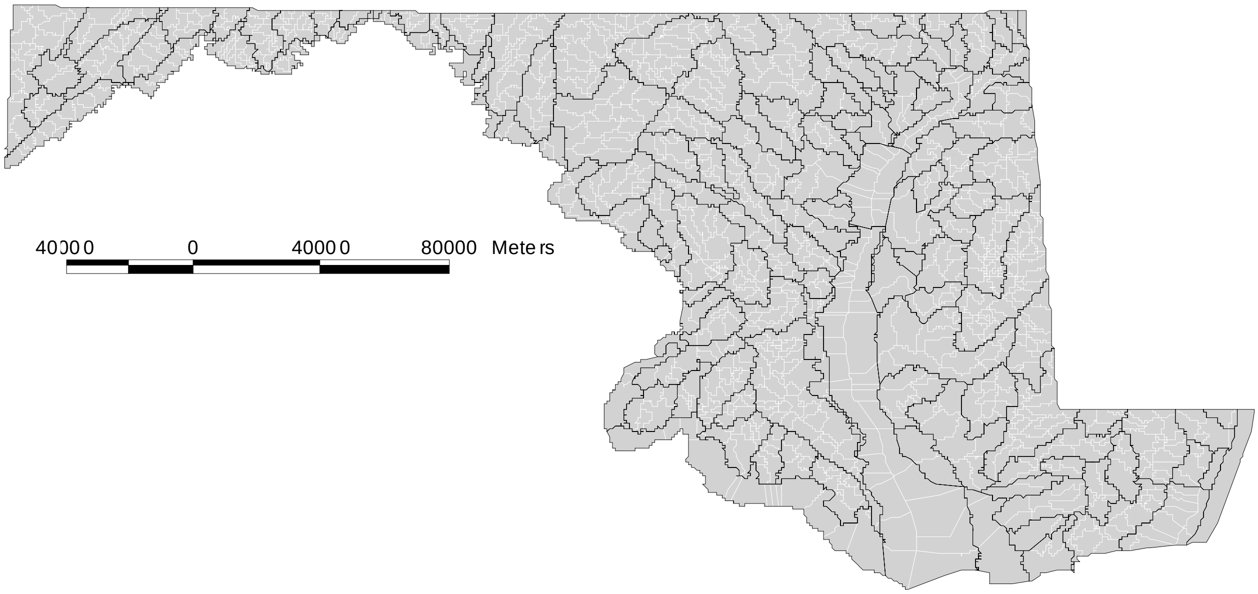


Figure 3: Maryland 12-Digit subwatersheds (averaging 11 square miles each) with surrounding 8-digit basins in black

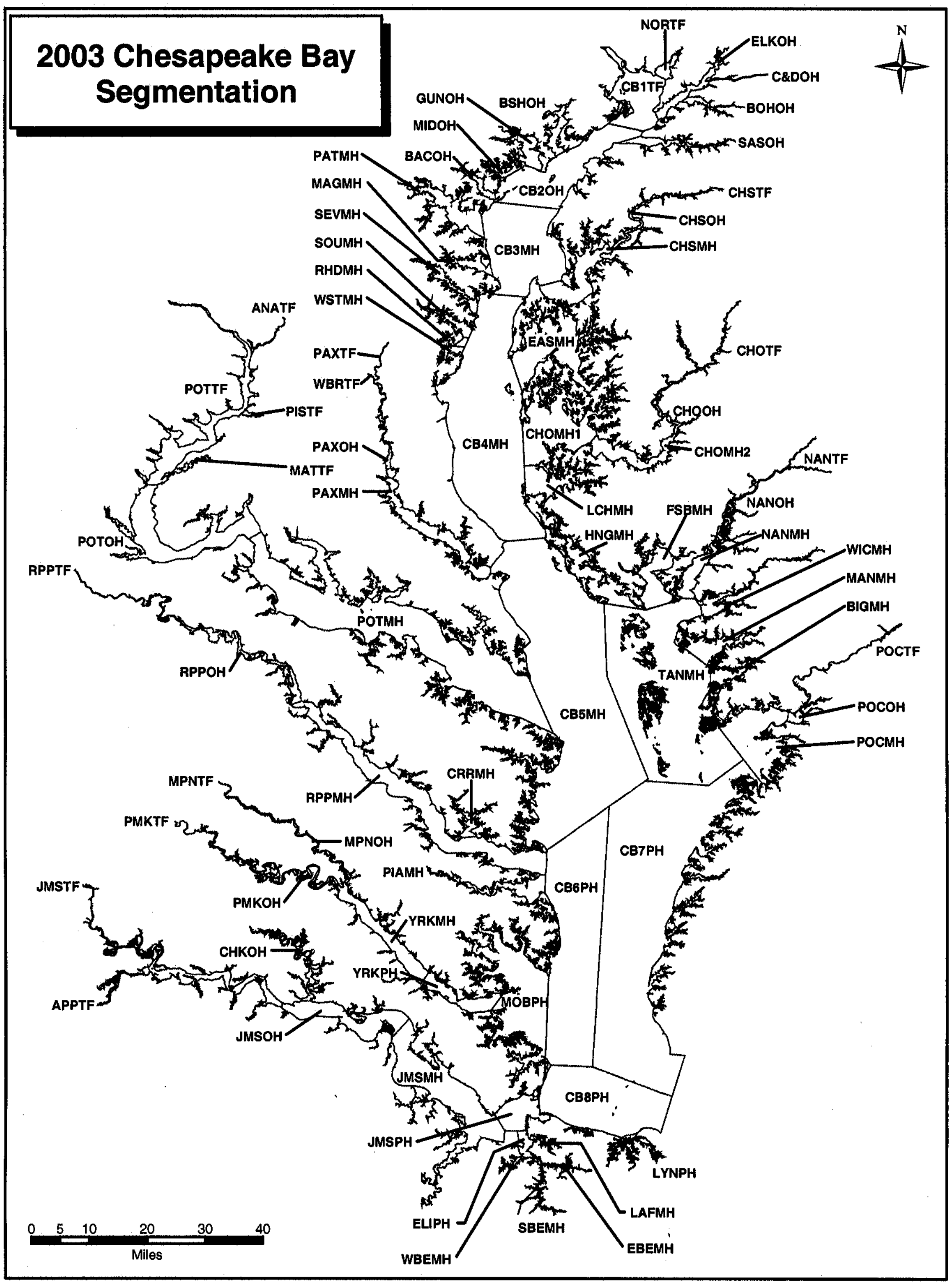


Figure 4: Chesapeake Bay Segmentation Scheme

1.3.2 Application of probabilistic monitoring design

Probabilistic monitoring using biological assessment tools (Maryland Biological Stream Survey – MBSS, and Chesapeake Bay Benthic Monitoring - CBBM) provides for the integrated and comprehensive assessment of most State waters. Biological communities are sensitive to multiple environmental stressors over relatively long timeframes, which, coupled with a probability based site selection, provides for an efficient means of Statewide water quality assessment. Biological assessments effectively address the potential for both cumulative impacts as well as provide a screening mechanism for identifying emerging pollutants.

Bioassessment methods are well documented and their application to 305(b) reporting and 303(d) listing is published in the Integrated 305(b)/303(d) report. MBSS monitoring of fish and benthic macroinvertebrate communities is conducted on a five-year cycle and reassessed at the end of each cycle. Common nutrient and physical parameters as well as stream habitat data are collected in conjunction with biological monitoring and MDE watershed cycling strategy. The CBBM, which includes fixed as well as probabilistic stations, randomly selects new sites on an annual basis and across multiple habitats (six different salinity strata, and two sediment types).

1.3.3 Application of fixed station monitoring and Watershed Cycling

1.3.3.1 Environmental Health and Aquatic Life Use Support

Fixed station monitoring serves several purposes. Maryland assesses the entire state using physical/chemical monitoring on a five-year cycle. These data are used to evaluate the effectiveness of permits, are integrated with biological assessments for 305(b) and 303(d) purposes, and aid in the development of TMDLs. Chesapeake Bay monitoring has been redesigned to accommodate the new water quality standards and assessment methods published as regional guidance.

1.3.3.1.1 Wetlands Updates

MDE received a grant from EPA in 2004 to develop a State Wetland Monitoring Strategy (see section 3.4). The objectives for Maryland's wetland monitoring and assessment program include:

1) Meet 305(b) reporting requirements;
2) Improve existing wetland and waterway regulatory programs;
3) Provide additional information for targeting wetland/waterway restoration and protection efforts;
4) Comply with TMDL requirements, if applicable;
5) Develop use designations and water quality standards for wetlands;
6) Assist in evaluating the effectiveness of compensatory mitigation;
7) Improve our ability to comprehensively assess landscape and watershed function;
8) Develop the capability to study and assess the status of wetland condition over time; and
9) Make wetland condition and functional value information available for use in federal, State, local and citizen group-driven natural resource conservation and restoration efforts (examples include Tributary Strategies, Watershed Restoration Action Strategies, TMDL implementation plans, Green Infrastructure Assessment/GreenPrint Program, Strategic Forest Lands Assessment, etc.).

In recent developments, an MOU with Virginia Tech has been secured to prepare background information for the project. In addition, a contract with the Association of State Wetland Managers will provide moderator services and additional discussion papers. The first workgroup meeting is tentatively scheduled for the week of September 14, or September 21, 2009.

1.3.3.1.2 Monitoring for Modeling Needs

Fixed stations provide the data necessary to calibrate watershed models for TMDL development and provide data for load duration models. This monitoring design necessarily accommodates the location of gaging stations and model segmentation. In addition, this monitoring serves to refine and calibrate the new Chesapeake Bay water quality model.

1.3.3.1.3 Monitoring for Water Quality Characterization and Trends Assessment

The CORE/Trend water quality program is composed of a network of fixed stations located in most of the State's larger, non-tidal streams and rivers (Strahler 4th order and larger). The data are used to assess water quality status and also examine long-term trends. Monitoring at the Core stations is funded by US Environmental Protection Agency through a Clean Water Act Section 106 grant.

1.3.3.2 Public Health and Recreational Uses

1.3.3.2.1 Shellfish

Bacterial monitoring in estuarine waters is conducted consistent with the requirements of the U.S. Food and Drug Administration (USFDA)/ National Shellfish Sanitation Program (NSSP) to protect public health related to shellfish harvest and consumption. Fixed stations are used, but visits are randomly assigned consistent with the relevant guidance. Fecal coliform bacteria continue to be the indicator required by USFDA. NSSP monitoring also includes shoreline surveys to look for sources of bacteria.

1.3.3.2.2 Harmful Algae Bloom Surveillance (HAB)

The state departments of Environment (MDE), Health and Mental Hygiene (DHMH), Natural Resources (DNR), and the other investigators collaborate to manage a State-wide Harmful Algae Bloom (HAB) surveillance program. The program includes a plan for field response, laboratory analysis, and management actions as appropriate to protect public health and the environment. The cooperating agencies coordinate with the MDE Shellfish Sanitation Program, local health departments, and the Center for Disease Control and Prevention (CDCP) to assure that swimming and recreational waters are monitored, and that shellfish waters are free of bioaccumulating algae toxins.

1.3.3.2.3 Monitoring at Beaches

Maryland's Beaches Program complies with the requirements of the Federal BEACH Act of 2000. Beaches monitoring is conducted by local governments and is consistent with current EPA guidance. The results are reported to MDE and EPA for posting on the Internet for public notification.

1.3.3.2.4 Fish and Shellfish Tissue Monitoring

MDE monitors fish tissue on a five-year watershed cycle to analyze general trends in bioaccumulation throughout the state. Each year additional monitoring efforts are devoted to special projects, which include TMDL development and intensive studies to address localized public health concerns. Individual and composite fillet samples from target species are analyzed for a broad suite of metals and organic contaminants, and tissue levels are assessed following EPA's risk-based guidance. In addition to finfish, the crabmeat and hepatopancreas from the blue crab are also analyzed for contaminants. Finally, Maryland shellfish stocks are sampled for toxics at regular intervals in accordance with NSSP requirements.

When appropriate, fish consumption advisories and updates are released as new data indicates increased (or decreased) risk to consumers. Education and outreach, especially for sensitive populations, is conducted. These efforts are coordinated with the State Children's Environmental Health Advisory Committee to address children's issues related to contaminated fish. Periodic surveys of recreational fishermen's consumption behaviors help to guide the program for the long term.

1.3.3.2.5 Drinking water (both surface and ground water sources)

The Maryland Department of the Environment Water Supply Program's (WSP) goal is to ensure that the water quality and quantity at all public water systems meet the needs of the public and that the drinking water is in compliance with federal and State regulations. Monitoring activities are undertaken on a routine basis to ensure that public drinking water systems provide safe water to their consumers; this monitoring is accomplished through testing performed by State and private laboratories and at water treatment plants. Water suppliers using surface water conduct daily and more frequent tests for water quality information needed to optimize water treatment.

In 2003, water systems were required to sample for up to 83 different contaminants on a routine basis, depending on the population served and source type of the water system. Following recent changes to the regulations, over 90 contaminants are regulated for public drinking water systems. Approximately 3700 water systems are routinely monitored according to the Safe Drinking Water Act requirements. MDE uses information concerning the vulnerability of a source to determine the frequency of monitoring for various chemical contaminants. This enables the state and water systems to maximize the efficiency of limited resources and target monitoring where needed most.

MDE conducts source water assessments that identify potential sources of contaminants and the susceptibility of water sources to contaminants regulated by the Safe Drinking Water Act. These assessments rely on data from water suppliers, ambient monitoring from other programs and testing of the water system by the State. Information from the assessments helps determine the frequency and necessity of monitoring for various contaminants. Local governments and water suppliers use the assessments as the basis for plans to protect their water sources before contamination occurs. Other important WSP activities include regular on-site inspections of water systems to identify any sanitary defects in the systems and a permitting process that helps systems obtain the best possible source of water. Special monitoring is conducted for permitting of new sources and in response to emergencies, spills or other events.

1.3.3.2.6 Special Studies

Maryland performs special studies as needed to assist with permit compliance and enforcement efforts, stressor identification, harmful algae blooms, fish kills, and source water and dredging assessments, to name a few. Targeted MBSS style biological sampling has been used to confirm the impacts of unpredictable, sporadic discharges of pollutants to surface waters. Also, the State is currently developing a methodology for using watershed surveys (both stream corridor and upland), rigorous land-use analysis, and fixed-station biological sampling to both delineate and characterize the causes of 303(d) listed biological impairments in non-tidal waters (watershed cycling strategy). MDE and DNR are working together, with planned future input and assistance from local governments and communities, on ways to expedite TMDL implementation in impaired watersheds by using tools such as watershed management plans, best management practices, targeted restoration or mitigation projects and other alternative approaches to TMDLs that result in more rapid project implementation and ecosystem response. For instance, over the last five years bioaccumulation studies (using caged clams *Corbicula fluminea*) have been successfully deployed in PCB impaired watersheds to help identify sources of contamination in support of future remediation plans. Furthermore, Maryland has conducted several special studies to investigate the environmental impacts of dredging and sources of pollution in drinking water. Both MDE and DNR have emergency response capabilities that allow the State to respond to episodic events like fish kills and harmful algae blooms as well as implement rapid sampling to identify causal agents.

1.3.4 Monitoring Design Enhancements

As briefly mentioned in Section 1.1 "Management Objectives," a greater emphasis is being placed on quantitative monitoring design to support more effective data analyses. Particular areas of attention are discussed below.

- **Bacteria:** Maryland's bacteria monitoring consists of four programs associated with management of shellfish harvesting areas, beaches, drinking water supplies and the remaining non-tidal ambient conditions. Over the past few years, the later program was temporarily altered to generate intensive data to support non-tidal bacteria TMDL development.

  Recently, it has been recognized that 1) areas of elevated bacteria levels have been identified for the entire State and have been documented on Maryland's 303(d) list, and 2) elevated bacteria levels are very unlikely to decline unless remedial actions are taken. It is further recognized that monitoring impaired areas that have *not* undergone remedial actions is a wasteful use of limited monitoring resources, because the results are predicted to remain elevated. With these insights in mind, Maryland is currently reconsidering the design for this subset of bacteria monitoring.

- **Flow Gaging:** Stream flow information is critical to interpreting monitoring data, which supports a variety of water resource management needs, including water supply appropriations. Representatives from Maryland DNR, MDE and USGS met in February 2009 to discuss the status of the Maryland gage station network and to consider strategies for improvement since the last major evaluation in 2000 (Cleaves and Doheny, 2000).

Currently there are approximately 140 USGS gages in service throughout the state, Eighty-six are active core sites. One hundred twenty-nine provide both stage and discharge data. Eighty-six of these gages coincide with long-term core monitoring stations. Several of these are important to help measure the impact of climate change or manage drinking water withdrawal. Twenty gages are used to monitor drought conditions. All of the gages are used to calibrate loading models for TMDL's.

In 2000, Cleaves and Doheny proposed that a total of sixty new gage sites would be necessary to accomplish all the resource management needs in the state. Only ten additional sites have been established since the 2000 report. USGS anticipates that a few additional gages may be lost in the Potomac River drainage unless new partners can be established. As of 2009, eight sites currently at risk of being lost due to cutbacks in the U.S. Army Corps of Engineers budget may be supplemented by the USGS National Stream flow Information Program http://water.usgs.gov/nsip/.

State agencies currently fund several gage sites, which include; MDE (8 gages), DNR (24 of which 16 are supported by the MD Geological Survey). 2010 Bay trust funds will likely support seven to ten new localized sites next year. State MS4 regulatory storm water permits require upkeep of existing sites, or starting new sites as necessary, to meet permit requirements. Of note, there are a significant number of flow/stream level gages in the State, which are operated by local agencies or their consultants (e.g., Baltimore City, MD Department of Transportation) doing special projects at the local level, that could potentially be better coordinated with State and federal initiatives in the future. For instance, the MDE Water Management Administration recently applied federal base realignment funds (BRAC) to support several new stream and rain gage sites in the Coastal Plain and Piedmont regions.

- **Watershed Monitoring Cycling Strategy:** Maryland's watershed cycling strategy was initially designed to support TMDL development. It was only partially successful in that regard, in part because data needs often demanded monitoring to be conducted outside of the cycling scheme.

  Now, as the emphasis shifts from TMDL development needs to TMDL implementation, the monitoring needs are shifting. In principle, Maryland continues to have a need for a cycling strategy. In particular, Maryland's resources are too limited to monitor the entire State in a single year. Periodically revisiting areas of the State to evaluate implementation progress is also a motivating principle.

  However, the monitoring designs that supported model calibration and other TMDL development needs differ from the needs of more refined source assessments and evaluation of progress associated with TMDL implementation. In light of this, Maryland is presently revising the watershed cycling strategy.

  As noted above, fish tissue monitoring is conducted on a five-year cycle.

  Another need that is being contemplated in this context includes assessing non-tidal bacteria that isn't addressed by water supply or beaches programs. Monitoring of small tidal tributaries for which TMDLs have been developed is also being considered in coordination with Bay Program monitoring. The value of monitoring Maryland's 12-digit non-tidal watershed outlets is being reevaluated as part of this process. Monitoring to support stressor identification associated with the degradation of non-tidal streams is also being considered in the context of the watershed cycling strategy.

The utility of the synoptic survey design is also being assessed in this context. This is a survey in which numerous samples are collected throughout a watershed over a period of one or two days. Conceptually, these surveys offer the possibility of identifying localized pollution hot spots for targeting implementation and establishing a baseline against which implementation evaluation can be compared. Several design questions are under consideration. Are individual samples robust enough to identify hot spots (areas of high pollutant source contribution)? This question assumes the spatial stability of sources. If sources vary by season, is it necessary to conduct multiple surveys for account for seasonality of pollutant sources? Can single samples, collected at five-year intervals be used to judge progress?

Chesapeake Bay Monitoring: In 2009, the EPA Bay Program began an analysis of monitoring needs in the Chesapeake Bay watershed. One key consideration is to shift resources from monitoring shallow tidal waters and algae to monitoring non-tidal rivers. They are considering several strategic elements, which include targeting strategies, demonstrating progress through use of adaptive management and establishing "Reasonable Assurance" that abatement programs are functioning as designed. The Chesapeake Action Plan (CAP) is a management program being developed by the EPA Bay Program to track, target and evaluate goals of the bay TMDL http://cap.chesapeakebay.net/. One motivation is a desire to enhance the pollution source assessment in support of refining TMDL allocations and supporting implementation. Another motivation is the recognition that, in the near term, both actions and water quality responses are more likely to be detected in the smaller rivers than in the Bay itself.

This program should have the capacity to analyze who's doing what, where they are doing it, the amount of effort involved, etc. The goal of CAP is to look for areas that can be effectively integrated for management action. The concept is currently under review by the Science and Technical Advisory Committee (STAC) workgroup. This effort is in preparation of the Chesapeake Bay TMDL, which includes 303(d) delisting and success monitoring as one of the primary goals. The Departments of Natural Resources and Environment are working closely with the Chesapeake Bay Program on this monitoring design issue.

1.3.5 Sampling Frequency and Timeline

Sampling frequencies and timelines are developed as an integral part of the monitoring design and are determined by the goals of the monitoring project, available resources, temporal scale of the parameters being monitored, and programmatic guidance. For example, the National Shellfish Sanitation Program requires approximately 30 samples taken over three years to appropriately classify an area for harvest. The Shellfish Monitoring Program therefore monitors approximately twice per month over three years providing up to 36 samples, but also allowing for additional samples assuming that some trips may be cancelled due to inclement weather.

As another example, surface water monitoring is on a five-year cycle and is meant to coincide with permit cycles, while Beaches monitoring follows the Beaches Guidance and responds to the need for frequent monitoring before and during the recreational bathing period, but with few samples during winter in a temperate location like Maryland.

Although each monitoring program has specific goals, objectives and timing constraints to which it adheres, it is also periodically reviewed in the broader State Strategy context. During each 5 year Strategy evaluation cycle, each monitoring project or program is evaluated to determine how it fits into the goals for the State's overall strategy and whether there is some program redundancy or efficiency gains that could be realized through program consolidation, elimination or through combined sampling efforts.

2.0 Water Quality Standards and Core Indicators

As mentioned in the previous section, Maryland's Water Quality Standards (WQS) define the State's water quality goals and provide the foundation for water pollution control efforts. Maryland classifies all surface waters based upon a set of defined ("designated") uses that may not be currently supported, but that should be attainable.
http://www.dsd.state.md.us/comar/getfile.aspx?file=26.08.02.02.htm

The State's basic water use designation (Use I) includes "water contact recreation" (e.g., swimming, wading), "fishing, protection of aquatic life and wildlife, and agricultural and industrial water supply" (COMAR §26.08.02.02). Use I waters are equivalent to the national goal "for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water" - a goal often referred to as "fishable and swimmable".

Waters that support more specific resource uses (Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting, trout, drinking water) have designated uses to protect these resources/uses which are supported by the appropriate criteria.
http://www.dsd.state.md.us/comar/getfile.aspx?file=26.08.02.03-3.htm

The State of Maryland has defined the following Uses:

- **Use I:** Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life
- **Use I-P:** Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply
- **Use II:** Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (Figure 4)
  - Shellfish Harvesting Subcategory
  - Seasonal Migratory Fish Spawning and Nursery Subcategory (Chesapeake Bay watershed only)
  - Seasonal Shallow-Water Submerged Aquatic Vegetation Subcategory (Chesapeake Bay watershed only)
  - Open-Water Fish and Shellfish Subcategory (Chesapeake Bay watershed only)
  - Seasonal Deep-Water Fish and Shellfish Subcategory (Chesapeake Bay watershed only)
  - Seasonal Deep-Channel Refuge Use (Chesapeake Bay watershed only)

http://www.dsd.state.md.us/comar/getfile.aspx?file=26.08.02.02-1.htm

- **Use II-P:** Tidal Fresh Water– includes applicable Use II and Public Water Supply
- **Use III:** Nontidal Cold Water
- **Use III-P:** Nontidal Cold Water and Public Water Supply
- **Use IV:** Recreational Trout Waters
- **Use IV-P:** Recreational Trout Waters and Public Water Supply

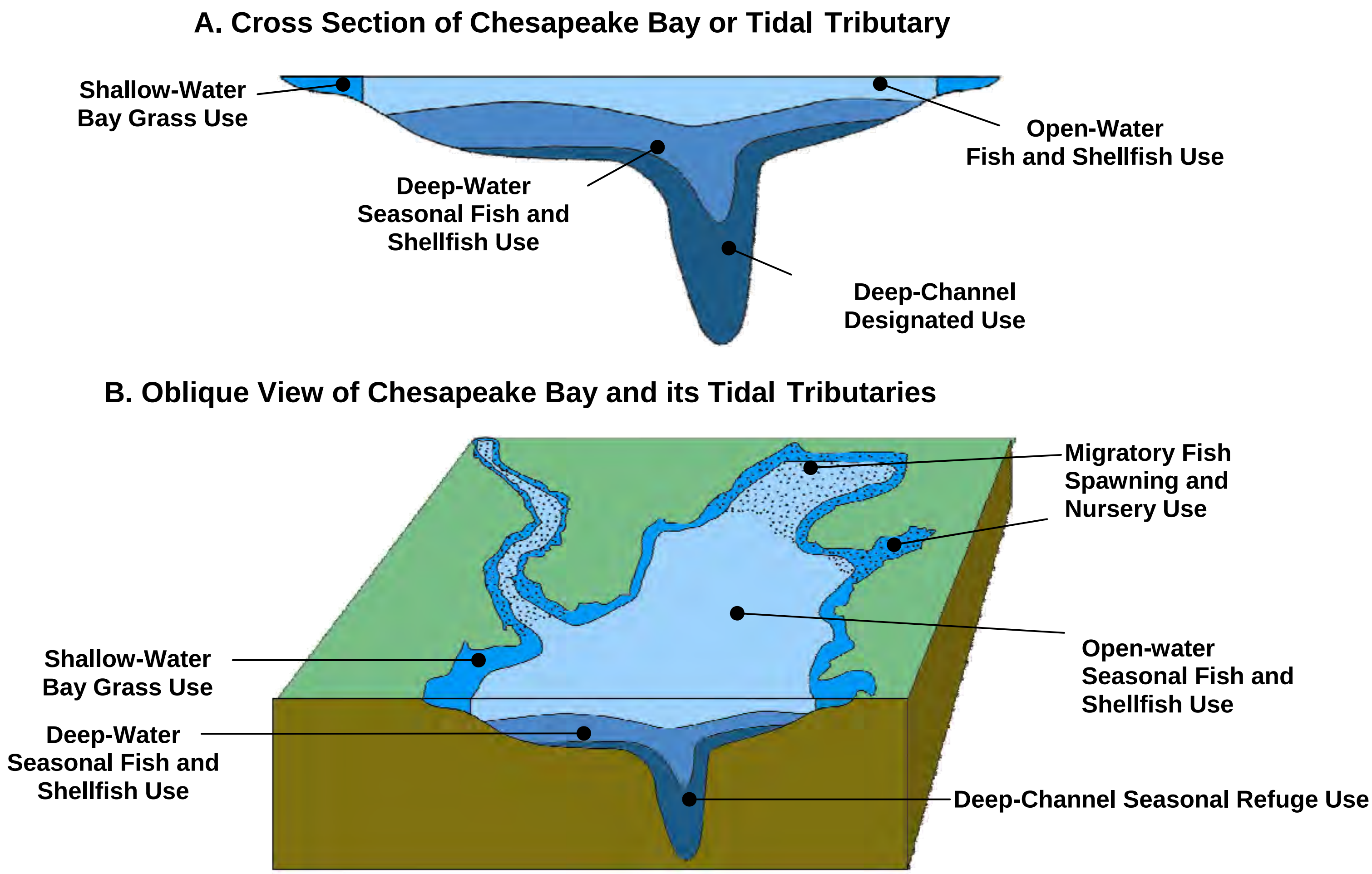


Figure 5: (Use II) Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting

2.1 Anti-degradation

Maryland's anti-degradation policy, defined in COMAR §26.08.02.04, assures that water quality conditions support designated uses. Where existing water quality conditions are better than the standards, this policy requires that the higher water quality be maintained. Implementation procedures for the anti-degradation policy were recently promulgated. http://www.mde.state.md.us/ResearchCenter/Data/waterQualityStandards/Antidegradation/index.asp

2.2 General Water Quality Indicators

Specific environmental indicators are used to measure whether or not WQS are being achieved. An environmental indicator is a measurable feature that singly or in combination provides valid evidence for assessing environmental and ecosystem quality or reliable evidence of trends in quality. Environmental indicators need to be measured using available technology that is scientifically valid for assessing or documenting ecosystem quality. To make sound resource management and regulatory decisions, the State's monitoring program must include a comprehensive suite of indicators covering all aspects of ground and surface water quality. Parameters measured as part of a monitoring program can be physical, chemical or biological in nature. Physical characteristics of water quality include temperature, dissolved oxygen and suspended solids. Chemical parameters are a measure of substances, such as nutrients and toxic chemicals, which are dissolved in the water or in particulate form. Biological parameters refer to aspects of the living environment, from microscopic algae (periphyton) and macroinvertebrates to macrophytes and fish assemblages.

Measuring a combination of water quality parameters allows for a comprehensive representation of the state of a water resource. If only physical or chemical parameters are measured, it may be difficult to gauge the impact of those stressors on the biota. Similarly, measuring biological parameters allows the Department to assess the level of stress on an ecosystem, but not necessarily the cause(s) of the stress. The combined data can be used to generate information essential for those managing and protecting natural resources, and allowing managers to determine trends in water quality over time as well as the impact of management initiatives.

2.2.1 Indicator Categories

Resource limitations require the State to use a tiered monitoring design that includes a core set of baseline indicators selected to represent each applicable designated use, plus supplemental indicators selected according to site-specific or project-specific decision criteria. The tiered approach enables efficient use of resources in making water quality management decisions. These decisions include assessment of designated use attainment, identifying needed changes to water quality standards, describing causes and sources of impairments, and developing water quality-based source controls.

Core indicators are considered most important for measuring water quality for designated uses. These indicators (e.g., water quality parameters) should consist of the physical/habitat, chemical/toxicological, and biological/ecological endpoints as appropriate, that reflect designated uses, and that can be used routinely to assess attainment with applicable water quality standards throughout the State. Designated uses include aquatic life, recreation, public water supply, and fish and shellfish consumption. A set of core indicators is monitored to provide Statewide or basin/watershed level information on the fundamental attributes of the aquatic environment and to assess water quality standards attainment/impairment status. Currently chemical, biological and physical indicators are emphasized for this purpose.

The core indicators are supplemented with additional indicators based on the characteristics of the watershed, designated uses, and potential stressors (point and non-point sources) influencing the water body. For example, when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core indicators indicate impairment, or to support a special study such as screening for potential pollutants of concern at a Statewide, watershed, or water body scale. These supplemental indicators may include each water quality criteria in the State's water quality standards, any pollutants controlled by the National Pollutant Discharge Elimination System (NPDES), and any other constituents or indicators of concern.

2.3 Core Indicators

2.3.1 Water Quality

Physiochemical water quality characteristics affect the ability of organisms to persist in a given aquatic habitat. Water quality data are collected to determine the acid-base status, trophic condition (nutrient enrichment), and chemical stressors. Physical parameters include light penetration (e.g., water clarity [Secchi depth] turbidity, and suspended solids), temperature and ionic strength (e.g., conductivity). Chemical parameters include the concentrations of dissolved gases, major cations, anions, and nutrients (i.e., nitrogen, phosphorus). These indicators are compared to the water quality criteria specific to each designated use.

2.3.2 Aquatic Macroinvertebrate Assemblages

Aquatic macroinvertebrates play important functional roles in aquatic ecosystems and are used to help determine compliance with the aquatic life use support standard as identified in Section 26.08.02.02-B1-d (go to: http://www.dsd.state.md.us/comar/26/26.08.02.02.htm). Aquatic macroinvertebrates represent a fundamental link in the food web between organic matter resources (e.g., leaf litter, periphyton, detritus) and fishes. In lotic systems within specific biogeographical regions, aquatic macroinvertebrate assemblages respond in predictable ways to changes in stream environmental variables. Because many aquatic macroinvertebrates have limited migration patterns or a sessile mode of life, they are particularly well suited for assessing site-specific effects.

2.3.3 Fish and Aquatic Vertebrate Assemblage

The fish and other aquatic vertebrates can indicate water and habitat quality and are used as another measure to evaluate compliance with Maryland's aquatic life use standard. Extensive life history information is available for many species, and because many are high order consumers, they often reflect the responses of the entire trophic structure to environmental stress. Also, fish provide a more publicly understandable indicator of environmental degradation. Fish generally have long life histories and integrate pollution effects over longer time periods and large spatial scales.

2.3.4 Physical Habitat Structure

Physical habitat structure includes all of those structural attributes that influence or sustain organisms within the aquatic ecosystems. Habitat assessments generally provide a critical understanding of a stream's ecology. Some common physical habitat attributes are stream size, channel gradient, channel substrate size and type, habitat complexity and cover, riffle/pool ration, riparian vegetation cover and presence of large woody debris. Understanding the physical habitat of an area allows for better assessments of the stream ecosystem and human caused effects. Physical habitat conditions assessment and documentation also allow the State to determine if aquatic life use impairments are the result of pollutants or more related to degraded aquatic habitat.

2.3.5 Submerged Aquatic Vegetation (SAV)

SAV plays a number of important ecological roles in tidally influenced systems like the Chesapeake Bay. In addition to providing food and habitat for waterfowl and aquatic living resources, the grasses serve as a nursery habitat and refuge for many species of fish and

invertebrates. SAV also has important water quality functions, from producing oxygen through photosynthetic processes to sediment removal from the water column, and reducing shoreline erosion by slowing wave action. Finally, SAV removes excess nutrients such as nitrogen and phosphorus, thus reducing the potential for nuisance algae in the surrounding waters. The new water quality criteria for Chesapeake Bay have light attenuation requirements for shallow water that designate critical SAV zones and habitat.
http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/wqstandards/index.asp

2.3.6 Bacteria

Pathogen indicator species such as *Escherichia coli* and *Enterococcus* spp. are used to determine the human health risk associated with recreational water contact. Regular bacteria monitoring allows us to detect fecal pollution from human or animal waste in surface waters, and thus to evaluate and minimize the risk of human exposure to harmful pathogens. It is impossible to monitor all potential pathogens in water, but by watching for certain indicator organisms, we are able to assess health risk. In the past, fecal coliform was used for both shellfish and recreational waters, and Enterococcus or *E. coli* was used for swimming beaches. These standards were changed, following EPA guidance, and now Enterococcus/E. coli are used for all recreational waters.

The State continues to monitor fecal coliform levels as a requirement of the National Shellfish Sanitation Program (NSSP). The Department of the Environment is responsible for classifying and managing Maryland’s shellfish harvesting areas. The goal of shellfish harvesting area classification and management is to provide maximum utilization of shellfish resources and to reduce the risk of shellfish-borne illness.
http://www.mde.maryland.gov/Programs/WaterPrograms/TMDL/home/tmdl_bacteria_monitoring.asp

2.3.7 Fish/Shellfish Tissue Monitoring

The Department of the Environment recognizes that many chemical pollutants discharged into state waters by point and non-point sources may impair public uses and/or aquatic life. Several chemical pollutants tend to accumulate and persist in aquatic sediments and in the tissue of aquatic organisms (including various edible species of fish and shellfish) at potentially toxic concentrations. In addition, chemical pollutants that bioaccumulate tend to magnify in concentration as they pass through aquatic food chains and may cause detrimental effects to consumers, including humans. Maryland routinely monitors fish and shellfish tissues to evaluate the fishability of State waters as mandated in COMAR section 26.08.02.03-1A-2c (go to: http://www.dsd.state.md.us/comar/26/26.08.02.03%2D1.htm).

2.4 Supplemental Indicators

2.4.1 Ambient Toxicity

Ambient water and sediment quality test results may be useful as water body-specific indicators to identify trends in the occurrence of toxicity. Deterministic stations may be strategically placed to identify toxicity from known or suspected sources and probabilistic stations may be used to assess conditions across broad geographic areas (e.g., MAIA Chesapeake Bay

Study). Toxicity tests do not provide a direct measure of ecological health; therefore, test results are more useful for identifying water quality problems or for use as a screening mechanism rather than for use as environmental indicators. The State monitors both tidal and non-tidal waters to determine compliance with numeric chemical criteria set forth in COMAR 26.08.02.03-2-G1 (go to: http://www.dsd.state.md.us/comar/26/26.08.02.03%2D2.htm)

2.4.2 Organism Health

Exposure to environmental stressors can result in biochemical, physiological and histological (tissue) alterations in living organisms. The presence of these alterations may serve as "biomarkers," signaling exposure to stressors or adverse effects, which can range from molecular, cellular and tissue damage to genetic alterations. In the aquatic environment, such stressors include physical parameters such as temperature, pH or salinity, as well as toxic concentrations of chemical pollutants or any combination of stressors. Organism health metrics are recorded during fish kill incidents and during Maryland Biological Stream Survey fish sampling, and have played important roles in previous investigations such as the Atlantic menhaden *Brevoortia tyrannus* lesion outbreak in the late 90's. Maryland uses organism health as another indicator of aquatic life use support.

2.4.3 Chemicals of Concern

The Department monitors priority pollutants in water body segments where land use(s) indicate a current or historic potential for chemical releases. Chemical water quality monitoring may be done to determine loads or concentrations or both. Chemical pollutant monitoring is used as a screening tool in Maryland's watershed cycling strategy, while intensive monitoring of water column and/or sediments occurs as part of the assessment required by the TMDL program. Maryland uses this information to determine compliance with numeric water quality criteria for chemicals (see Section 2.4.1).

2.4.4 Periphyton

Periphyton is a complex mixture of algae, cyanobacteria, protozoa and detritus associated with channel substrates. Periphyton can also exist as epiphytic or floating assemblages. They may be useful indicators of environmental condition because they respond rapidly and are sensitive to a number of anthropogenic disturbances, including habitat degradation, contamination by nutrients, metals, herbicides, hydrocarbons, and acidification. The Maryland Biological Stream Survey (MBSS) recently added periphyton to their monitoring repertoire. In the future, this data may be used to help support management actions specific to water pollution abatement initiatives in the state.

2.4.5 Aesthetics

MDE field crews include general documentation of the aesthetic conditions at a sampling site. The aesthetic indicators used in Maryland include water clarity, odor, water color, visible debris, and signs of obvious pollution. For drinking water, indicators include color, taste, and odor. Maryland considers changes in water body aesthetics as an indication of water's suitability for contact recreation.

2.4.6 Species of Interest

Documenting the status of rare, threatened or endangered aquatic species (e.g., Maryland darter survey) and associated environmental conditions can help define impacts of long-term natural or man-made changes on habitat fringe that is critical to these species, whether there are issues involve climate change, environmental degradation or changes in habitat that affect food sources, competition or predation. Also, identifying the habitat potential for or the presence of invasive, non-native species that can alter water quality, habitat and trophic levels (e.g., zebra mussel potential in State lakes; northern snakehead and rusty crayfish introduction; invasive benthic diatoms (*Didymosphenia geminate*) in critical trout habitat; water chestnut growth) can require efforts to remove or reduce these populations, change public uses/practices to limit the spread of these species (disinfecting boats, fishing gear or implementing more restrictive use regulations).

3.0 Monitoring Programs, Goals and Objectives

Assessment monitoring programs are organized below according to designated uses and other key monitoring functions, (Table 3) which are consistent with management goals: e.g., water contact recreation, drinking water supply, fish and shellfish monitoring for protection of public health, etc. Protection of aquatic life includes protecting warm water aquatic life and wildlife (Use I), natural trout (coldwater) fishery (Use III), and the recreational trout fishery (Use IV). Tidal or estuarine uses for protection of aquatic life can include (for Chesapeake Bay waters): open water, deep water, deep channel, shallow water (SAV) and, migratory spawning and nursery areas (Chapter 2).

Assessment includes routine monitoring to establish either the concentration of various pollutants in the water or more directly measure aquatic life use support through biological monitoring. By comparison, water quality standards provide measures needed to determine attainment of designated uses. In addition, assessment monitoring determines trends in water quality.

Table 3: Monitoring Programs organized by Designated Use and other key functions

Designated Uses & Anti-Degradation					Other Key Monitoring Functions					
A Aquatic Life	**B Drinking Water**	**C Water Contact**	**D Fishing**	**E Antideg. and Protection**	**F Long-term Trends**	**G Implementation Effectiveness**	**H Source ID & TMDL Develop**	**I Compliance**	**J Reactive**	**K Water Quality Standard R & D**
Non-tidal Rivers & Streams										
• MBSS • Core/ Trend • Invasive species • Volunteer	• Local Delegation	• Under Developmnt	• Fish Tissue • DNR Fisheries	• MBSS	• Core/ Trend • MBSS	• 319 NPS • MBSS • Synoptic Surveys • Local Programs • 2010 TFE	• MBSS • TMDL • Synoptic Surveys • Corbicula Surveys	• NPDES • MS4 • Bureau of Mines	• Fish Kill • Emergency Response • HAB Monitoring	• MBSS • Nutrient Criteria • Temp.
Lakes and Reservoirs										
• Nat'l Lake Survey	• Reservoir Source Water Assessment	• Beaches Program	• Fish Tissue	• N/A	• Nat'l Lake Survey	• 319 NPS • Local Delegation • MS4 Permits	• TMDL • 319 NPS	• NPDES • MS4	• Fish Kill • Emergency Response • HAB Monitoring	• Nat'l Lake Survey
Chesapeake and Coastal Bays										
• Ches. Bay Program • DNR Bay Mon.	• N/A	• HAB Mon. • Beaches Program	• Shellfish • Fish Tissue • DNR Fisheries	• Ches. Bay Program • DNR Bay Monitoring	• Ches. Bay Program DNR Bay Monitoring	• Ches. Bay Program • Shellfish • BST • 2010 TFE	• TMDL • 319 NPS	• NPDES • WQC & Wetland License	• HAB Monitoring • Fish Kill	• Complete for Ches. Bay
Groundwater										
• N/A	• Source Water Assessment • Wellhead Protection	• N/A	• N/A	• Wellhead Protection	• Wellhead Protection	• N/A	• 319 NPS	• Source Water Assessment	• Emergency Response • Oil Control Program	• Fed. Delegation
Wetlands										
• Under Development	• N/A	• N/A	• N/A	• Wetlands of Special State Concern	• FED. DEL. – Under Development	• 319 NPS	• Local	• Wetland Permit & mitigation	• N/A	• Under Developmnt.
Ocean										
• N/A	• N/A	• Beaches Program	• DNR Fisheries • HAB • Fish Tissue	• N/A	• Beaches Program	• N/A	• NA	• NPDES • WQC & Wetlands License	• Fish Kill • HAB Monitoring	• Fed. Del. - National Coastal Survey

3.1 Designated Uses & Anti-Degradation:

Designated use establishes a water quality goal for each water body type. Monitoring data is analyzed to interpret whether or not state water quality standards are being attained.

3.1.1 (A) Assessment Monitoring for Protection of aquatic life (survival, propagation):

Assessment includes routine monitoring to establish either the concentration of various pollutants in the water or more directly measure aquatic life use support through biological monitoring.

3.1.1.1 Non-tidal Streams and Rivers

Maryland has thousands of miles of freshwater streams and rivers (Figure 6---map showing stream network). These waterways drain the landscape and transport ground water along with nutrients, sediment and contaminants to Delaware Bay, Atlantic Ocean, Chesapeake Bay, and the Gulf of Mexico via the Ohio and Mississippi rivers. Free-flowing and non-tidal streams and rivers are found throughout the State, except in some low-lying Coastal Plain areas and on barrier islands.

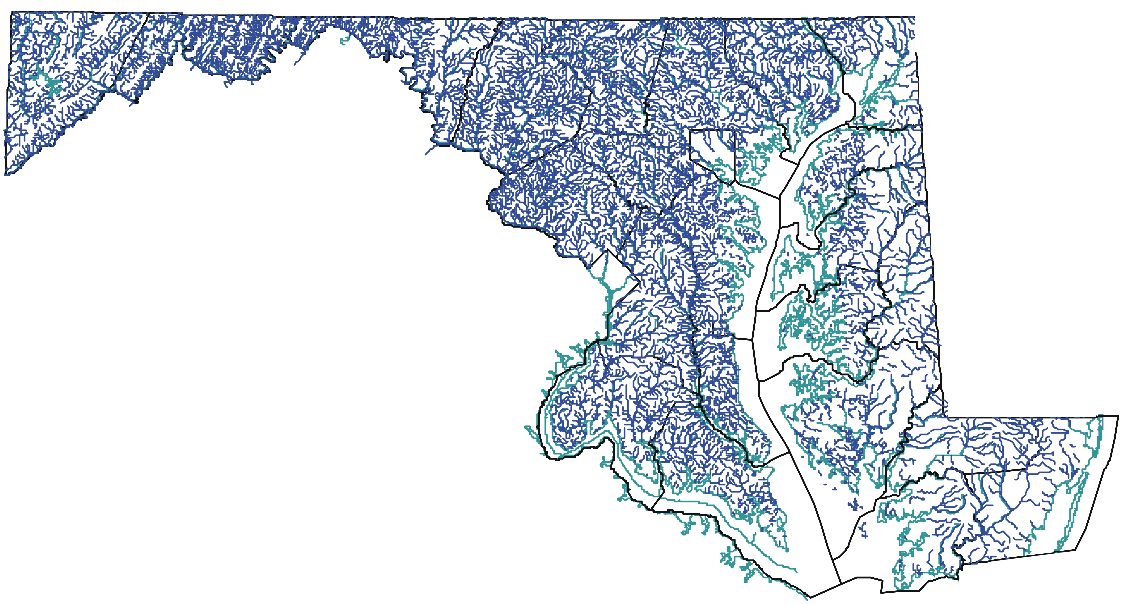


Figure 6: Stream drainage network in Maryland (overlain on county boundaries)

Using a 1:100,000 scale USGS map, we currently identify 9,941 miles of streams and rivers in Maryland. An unknown number of miles of small 1st order perennial streams, in addition to ephemeral and intermittent streams, are not captured on a 1:100,000 scale map. Stream patterns are dendritic, so most mileage is in the smallest streams (Table 4). The widely used Strahler classification scheme (Strahler 1957) identifies 1st order streams as the smallest, most upstream, and permanently flowing (perennial) reaches. The convergence of two streams of order *n* yields a stream of order *n* +1 (i.e., the merger of two 1st order streams creates a 2nd order stream, the merger of two 2nd order streams creates a 3rd order stream, and so on; the merger of a 1st order stream with a 2nd order stream creates another 2nd order stream). This classification scheme is usually a surrogate of catchment area and also provides a convenient way to compare streams of similar size (Allan 1995).

Various modifications to streams and their corridors occur across the State. Ditching is a common practice in parts of the Eastern Shore to drain low-lying lands and make them tillable. In many agricultural areas, stream channels are often re-routed to increase usable land area. Streams are sources of irrigation water and are also used as natural watering troughs for livestock.

Table 4: Extent of stream miles by reach order in Maryland

Reach Order	Stream Miles	Percent of Total
1	6,480.08	65.2 %
2	1,561.4	15.7 %
3	739.7	7.4 %
4	412.6	4.2 %
5+	747.0	7.5%
TOTAL	**9,940.7**	

(Source: ArcView analysis - 1:100,000 scale stream trace)

Stream systems have also been extensively modified in urban and rapidly developing suburban areas to more quickly carry storm water flows away from buildings and roadways. Increases in impervious land area associated with development have disrupted the hydrologic cycle and caused extensive bank erosion, channel down-cutting, and increased sediment transport. In older urban areas, like Baltimore City, many miles of streams are buried and now flow in underground pipes.

Highway and bridge construction can modify streams within the rights-of-way, although adverse impacts can also occur upstream and downstream from the construction sites. Poorly designed culverts block fish migrations and accelerate bank and channel erosion.

In western Maryland, many miles of streams have been rendered nearly or completely lifeless by the impacts of acid mine drainage (AMD). Acid deposition impacts on streams tend to be less acute than AMD-related impacts, but are more widespread across the State.

Short-term Monitoring Goals and Objectives for Non-tidal Streams and Rivers

Maryland’s monitoring goals for non-tidal streams and rivers are basically three- fold: (a) to conduct probability-based and fixed station sampling programs in 1st through 4th order, wadeable streams and fixed station sampling programs in larger streams and rivers; (b) to assess the current status of these flowing waters; and (c) to document temporal trends in water and habitat quality. Probability-based sampling ensures that all wadeable streams have a known probability (greater than zero) of being sampled. Estimates of current chemical, physical, and biological stream characteristics (status) can be calculated with known levels of precision. Fixed station sampling provides the best information for tracking changes (trends) in water and habitat quality over time, for tracking water quality permit compliance, for monitoring fish and shellfish populations to ensure that they are safe for human consumption, for developing/evaluating TMDLs, but also for providing information on current status.

Specific objectives and programmatic issues/needs for non-tidal stream and river monitoring programs are given below.

3.1.1.2 US EPA Chesapeake Bay Program - Enhanced Non-tidal Monitoring Network

Agency: DNR Resource Assessment Service

Contact: Sherm Garrison (410-260-8624); mailto:sgarrison@dnr.state.md.us

Watersheds: Selected nontidal, free-flowing streams and rivers in Maryland:

1) near the outfall of Chesapeake Bay Tributary Strategy watersheds (including: Choptank, Patuxent, Potomac, (Washington Metropolitan, Middle, Upper, and North Branch sub-basins), Upper Eastern Shore and Upper Western Shore
2) downstream of watershed restoration projects (e.g., Corsica River, select 2010 Trust Fund or Chesapeake Bay Program projects),

Media: water column, nutrients, sediment, streamflow

Goals: The goals of this program are to:

1) collect and analyze water quality samples from selected, gaged non-tidal stream sites in the Chesapeake Bay watershed monthly and during targeted storm flows throughout the year, and
2) use field sampling and analytical procedures that are consistent with methods in other Bay watershed states (DE, NY, PA, VA, WV) so that nutrient and sediment data results from all 85 sites in the Bay watershed can be combined to define annual nutrient and sediment loadings from these watersheds, help determine the effectiveness of management actions and assess progress towards reaching Maryland's 2-year nutrient and sediment reduction milestones for the Chesapeake Bay.
3) Meet EPA and Chesapeake Bay Program strategic goals (Improve Aquatic Health of the Chesapeake Bay) and Chesapeake 2000 (C2K)goal to "Achieve and maintain the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health".

Program description: Of the 59 non-tidal water-quality monitoring sites in Maryland; 13 are operated as part of the Chesapeake Bay Nontidal Network (NTN) and include both monthly samples collection, and targeted storm samples collection for nutrients and sediment.

This program was initiated in 2005 with nine sampling sites and, with additional funding over the years, has added four monitoring sites in the State. Paired stream flow gages are operated by the US Geological Survey (USGS) with operation/maintenance costs provided by various sources (State - DNR and DNR-Geological Survey, State Highway Administration; federal - US Army Corps of Engineers, USGS; local - City of Aberdeen, Baltimore City, Frederick County, Washington Suburban Sanitary Commission; others - Univ MD-Baltimore Co.). Water quality samples are analyzed by the MD Department of Heal;th and Mental Hygiene Laboratories Administration, in Baltimore and sediment samples are analyzed by the USGS Sediment Laboratory in Louisville, KY. Results are submitted to the USGS-Pennsylvania office which reviews these data, as well as data submitted by other Bay watershed states and will estimate nutrient and sediment loadings once there is at least five years of supporting data. Nutrient and sediment load results are provided to the Bay Program and States, for reporting and dissemination.

At each site, monthly samples are collected and well as at least 8 storm samples on an annual basis. Storm event sampling is emphasized because a major fraction of runoff and associated nutrients and suspended sediment loads are carried by storms. Water-quality data for these 13 stations are collected in accordance with “Sampling Procedures and Protocols for the Chesapeake Bay Non-tidal Water Quality Network” (revised April 13, 2005). Field sampling is performed by MD DNR using equal width interval depth integrated composite sampling. Composite samples are sent to USGS Kentucky District Sediment Laboratory for particle size analysis (sand/fine) and sediment concentration. Concentrations of: Particulate Phosphorus, Total Dissolved Phosphorus, Phosphorus, Orthophosphate (Filtered), Particulate Nitrogen, Total Dissolved Nitrogen, Nitrogen, Nitrite (Filtered), Nitrogen, Nitrate plus Nitrite (Filtered), Nitrogen, Ammonium (Filtered), Particulate Carbon, Dissolved Organic Carbon, and Total Suspended Solids will be analyzed at the DHMH Laboratory, Baltimore MD. Total nutrient and sediment concentrations are used along with streamflow data to calculate loads and trends.

These data are annually transferred to USGS-Pennsylvania which compiles data from different agencies, reformats and reviews data quality. These data are supplemented with daily flow files are obtained from USGS databases and other water quality data are obtained annually from USGS and state agency databases.

Loads are estimated using a 7-parameter regression model which also estimates a flow-adjusted trend. Where possible, loads and trends are estimated for: total nitrogen, ammonia nitrogen, Total Kjeldahl nitrogen, nitrate and nitrite, total phosphorus, dissolved phosphorus, dissolved inorganic phosphorus, and total suspended solids or sediment. Trends are estimated for:
a) *Annual and Seasonal Mean Flow* which indicate the natural changes in hydrology;
b) *Annual Load* which helps explain water quality and living resource changes in the tidal estuaries and in comparing and identifying changes in contributions among basins;
c) *Flow-adjusted Concentration (FAC)* which removes flow-related variability and allows for examination of changes in water quality resulting from human activities;
d) *Flow-weighted Concentration (FWC)* which represents a truer monthly concentration (both over the time and flow) than is represented by the one point in time andprovides a more accurate estimate

of the monthly concentration and trends that may correlate better with trends in estuarine concentrations; and
e). *Observed Concentration* which can be useful in comparing to trends in non-tidal areas to those in the tidal estuaries.

This information, together with the streamflow collected through NTN, provides Federal and State managers with documented data and results for a variety of purposes, including progress toward meeting nutrient and sediment reductions in the tributaries. All trend and load data are released to the public, and in prepared summary reports and served via a project website.

Data management:
DNR manages the field and laboratory data (nutrient and sediment data) on its Access-based water quality files. Annually, data collected in the nontidal network are forwarded to the USGS-Pennsylvania office which merges these data with that collected by other State partners and River Input programs. These data are reviewed and a comprehensive copy of the data are forwarded to the EPA Chesapeake Bay Program which adds these data to the Chesapeake Bay Information Management System (CIMS). USGS assess available data for trends in nutrients and sediment, providing results to the States and Bay Program office..

Programmatic issues:
Maryland and other Bay signatory partner States and agencies have been fully and actively involved throughout the Chesapeake Bay Program's management, workgroups, and water quality and living resource-related committees since its inception in 1985. DNR is also an active participant in the Nontidal Workgroup, the consortium of six state natural resource agencies, two river basin commissions, USGS and EPA that has provided coordinated nontidal monitoring since 1985 and since expanded in 2004.

With reorganization of the Chesapeake Bay Program beginning in 2008 with new program goals and a 2009 Presidential Executive Order providing additional direction and legal weight, existing water monitoring activities have been reviewed and are being re-cast. All monitoring activities will be redefined in fall 2009 and proposals for monitoring water quality and living resources to meet Bay restoration goals will be reviewed and will be implemented beginning in 2010. A Monitoring Realignment Action Team Optimization Report describes the following objectives for an enhanced non-tidal network program that are supportive of Bay Program management and communication priorities:
a) Measure and assess the status and trends of nutrient and sediment concentrations and loads in major tributaries and sub watersheds, selected tributary strategy basins;
b) Provide data suitable for the assessment of factors affecting nutrient and sediment status and trends from major pollutant source sectors;
c) Measure and assess the effects of targeted management and land-use change;
d) Improve calibration and verification of partners' watershed models; and
e) Support spatial and topical prioritization of restoration and preservation.

Under the revised Bay Program management structure, a Technical Services Subcommittee will define, guide and review assessments of conditions in the Bay and its watershed under of a Management Board The Nontidal Workgroup coordinates monitoring activities with other monitoring and assessment workgroups though the Technical Services Subcommittee.

In response to an RFP for projects funded under Clean Water Act S. 117(d), DNR has submitted proposals for non-tidal network monitoring and data analysis. While the non-tidal network proposal is developed as a stand-alone offering, it is a part of a larger, cooperative effort by other Bay states and USGS which have: the qualifications and experience to maintain a consistent and information-rich database, expertise in the operation of the network and subsequent analysis of the data, and a diverse communication network to report on findings.

Maryland's proposal for an Enhanced Non-tidal Network monitoring plan for 2010-2016 would maintain, expand and enhance the established, coordinated monitoring program at non-tidal network sites, document changes in nutrient and sediment loads in response to climate, biology and management effects and provide information to help Bay managers better determine the effectiveness of management actions and assess progress towards reaching the State's two-year milestones for nutrient and sediment reduction goals as required by the 2009 Chesapeake Bay Agreement.

The need to enhance non-tidal monitoring to assess relative success of applied watershed management actions needs to be coordinated across the Bay watershed with other partners to ensure that any new monitoring sites maximize network efficiency, avoid redundancy, and complement overall study design. Based on an initial geospatial network analysis the following are the priorities for network improvements in Maryland:
(1) Establish sentinel sites to better evaluate management effectiveness of BMP implementation,
(2) Establish sites small urban and agricultural watersheds, and
(3) Establish a site in an important gap in the southern eastern shore of Maryland.

Based on this initial analysis, the following list of potential network improvements are proposed; the final network improvements will be determined through discussions with the other NTN Partners, the CBP, and on the basis of the network analysis. Maryland intends to

In addition to continuing the enhanced sampling of non-tidal water quality as described above, the DNR's proposal would try to identify sites that fulfill multiple monitoring objectives. The draft proposal add four sites to the existing enhanced non-tidal monitoring network to monitor and are based on targeted locations of the 2010 Chesapeake and Atlantic Coastal Bays Trust Fund targeting program and Bay Program needs. Suggested sites include:
1) Morgan Creek, a small agricultural watershed on the upper Eastern Shore of MD that has been targeted for BMP implementation and other actions through the 2010 Trust Fund (2010TF);
2) Little Patuxent River at Savage, a target for 2010TF restoration which drains a significantly urbanizing area of central MD;
3) Wheel Creek, a very small watershed in Harford Co., MD that is under heavy development pressures due to the additional personnel being assigned to a nearby US Army site; and
4) Nassawago Creek at Snow Hill, identified as a candidate to fill an important gap in nutrient and sediment loading in ditched/well-drained agricultural lands in the Coastal Plain.

All four proposed sites currently have stream flow gages operated by USGS, thus requiring the addition of routine and storm-event monitoring. Data will be collected during years 1-6; however, nutrient and sediment loads will only be analyzed and reported at the end of the project as at least five years of data are required to define the model parameters needed to calculate loads.

3.1.1.3 Maryland Biological Stream Survey (MBSS)

Agency: DNR Resource Assessment Service

Contact: Ron Klauda (410-260-8615); mailto:rklauda@dnr.state.md.us

Watersheds: Statewide (all 18 basins except mainstem Chesapeake Bay, 134 of 138 watersheds, wadeable 1st through 4th order streams)

Media: Biological assemblages (fish, invertebrates, amphibians, reptiles, mollusks, plants), water chemistry, in-stream and riparian habitats

Goals: The goals of the Maryland Biological Stream Survey Program are:
1) Assess the current status of the biota in non-tidal streams;
2) Quantify the extent to which acid deposition is affecting stream biota;
3) Examine which other water chemistry, physical habitat, and/or land use factors may be affecting stream biota;
4) Provide a statewide inventory of stream biota;
5) Establish a bench mark for documenting trends;
6) Map locations of high quality streams for protection; and
7) Target local-scale assessments and mitigation measures needed to restore degraded streams.

Program Description: The Survey's focus is on wadeable (1st, 2nd, 3rd, and 4th order) non-tidal streams in all of the State's 18 major basins (except for the mainstem Chesapeake Bay) and in 134 of 138, 8-digit watershed segments grouped into 84 primary sampling units. Data are collected from about 240 stream segments of fixed length (75 m) each year and analyzed to assess current conditions, identify local degradation issues, and target restoration actions. The locations of about 80 of these segments are randomly selected each year. The rest are targeted sites selected for special purposes (e.g., high quality sentinel sites used to evaluate natural variations in stream conditions). Statewide sampling is conducted over a three-year or five-year schedule (Round One, 1995-1997) Round Two, 2000-2004 and Round Three 2005-2009), so a portion of the State's eligible streams is sampled nearly every year.

The Survey uses a probability-based sampling design as a cost-effective way to assess the status of stream resources Statewide. By randomly selecting sites, the Survey can make quantitative inferences about the characteristics of the 10,000 or so miles of wadeable, non-tidal streams in Maryland. The US Environmental Protection Agency (EPA) is encouraging the use of probability-based sampling designs to assess status and trends in surface water quality (EPA 1993). The Survey's random sampling design is stratified by year, region (western, central, eastern), watershed, and stream order. Fish and benthic macroinvertebrate assemblages are the major indicators of stream health; however, observations on the presence/absence of amphibians, reptiles, mollusks, and crayfishes are also recorded. Several regionally-specific, fish and benthic IBIs were developed by DNR for Maryland's wadeable, non-tidal streams. A suite of chemical parameters (emphasis on acid-base chemistry and nutrients) and a continuous record of water temperature are measured at each site. An array of quantitative and qualitative physical habitat parameters (in-stream and riparian zone) is also measured. A regionally-specific, multimetric physical habitat indicator was developed by DNR from Survey data. Each sampled site is geo-referenced in the field so later analyses can determine the drainage area and land cover/land use in each site's catchment using GIS.

Field sampling and benthic macroinvertebrate sample processing manuals of the Survey document methods (Boward and Friedman 2000, Kazyak 2001, Stranko et al. 2007). For additional monitoring program information, see: *www.dnr.state.md.us/streams/mbss/index.html* .

The following elements can be found within the MBSS Field Sampling Manual (online at: *www.dnr.state.md.us/streams/pubs/ea-07-01b_fieldRevMay2007.pdf* and the MBSS 2000 QA Report (online at: www.dnr.state.md.us/streams/pubs/ea01-10_qaqc.pdf):

- An approved study plan
- Quality Assurance Project Plan
- Standard Operating Procedures

Funding support for the MBSS program comes from many different sources that can vary from year to year. For the 2009 calendar year, support comes from the following sources:

- State of Maryland General Funds, Environmental Trust Fund, 2010 Trust Fund
- Coastal Zone Management grant via US Department of Commerce National Oceanic and Atmospheric Administration (NOAA)
- State Wildlife Grant from the US Department of the Interion, Fish and Wildlife Service via the DNR Natural Heritage Program
- MD Department of the Environment, Federal Clean Water Act S.319 and S.106 grants
- EPA grant to the University of Maryland
- Corsica River Restoration Project supporting sources, and

Brief History of the Program - The Maryland Biological Stream Survey was initiated with a 1993 pilot study in two small watersheds. A demonstration project followed in 1994 to test broader implementation of protocols (in 6 digit basins). The first complete assessment of Maryland's streams was completed during 1995-1997 (Round One). A symposium to release results from this first assessment was conducted in 1999. The Round Two MBSS was conducted from 2000-2004, with a symposium in 2005. Round three will be completed at the end of 2009.

Products: Over the years, the results of the MBSS sampling rounds have been highly useful in answering many important management questions regarding stream protection and restoration. Examples include supporting biocriteria development and implementation, the identification of priority protection areas, support of Watershed Restoration Action Strategies, and finding new records for imperiled aquatic species. To date there have been more than 100 peer reviewed journal articles published from MBSS data and more than 50 reports have been developed and are available on the Maryland DNR web site (online at: www.dnr.state.md.us/streams/mbss/) as well as fact sheets, posters, and other media describing MBSS results.

Data Management: Survey crews use standardized, pre-printed data sheets developed for the Survey to ensure that all data collected at each sampled stream site are recorded and only standard units of measure are used. The field crew leader and a second reviewer check all data sheets for completeness and legibility before they leave the sampling site. The original data sheets are submitted to the Data Management Officer who requests a review by the Quality Control Officer. Copies of all data sheets are retained by the field crew leader. Data entry is completed using entry screens designed in Microsoft Access. Except for water sample analyses conducted at the University of Maryland's Appalachian Laboratory and identifications of benthic macroinvertebrates completed in DNR's Annapolis Field Office laboratory, all Survey data are independently entered into two data bases and then compared using a computer program, another quality-control procedure. Differences between the two databases are resolved using original data sheets and/or through discussions with field crew leaders. For each round of Statewide sampling, a report is prepared that documents the quality assurance/quality control activities associated with the Survey (e.g., Mercurio,et al. 2004).

Programmatic Issues/Needs: The third Statewide round of the Survey will be completed in 2009. A quality control report is completed at the end of each sampling round (3-5 years). Prior to beginning another multi-year sampling program, the sampling design, methods, and indicators will be examined to determine if changes or refinements are needed to more effectively and efficiently achieve Survey goals. Changes will be made only if they do not diminish data comparability with previous rounds. We also critically review each aspect of the parameters being measured and results obtained to determine if changes should be made. For example, some parameters that turn out to be less useful than anticipated have been eliminated from the collection process based on this review.

For example, possible changes to the Survey for Round four (ca 2010-2015) include:

(a**)** Increase the monitoring effort being used to assess the effectiveness of restoration efforts and BMPs**,**

(b) Addition of more quantitative measures of sediment flux,

(c) Incorporation of data from the volunteer-based Stream Waders program with Survey data to better assess stream conditions at the smaller 12-digit watershed scale,

(d) Selection of the best combination of random and targeted location sampling designs to allow monitoring of both status and trends, and

(e) Expansion of the current Survey into tidal fresh and brackish streams.

An important need for the Survey is a long-term, consistent funding base. To complete rounds one, two, and three, DNR had to secure and pool a multitude of funding sources (from short-term, usually one-time grants and cooperative agreements with EPA, US Department of Interior's National Park Service, NOAA and others) to supplement support from the State's Environmental Trust Fund. Without a consistent, long-term funding base, DNR may not be able to continue finding and pooling enough short-term, one-time source of funds to keep the Survey going long enough to conduct meaningful trends analyses.

MBSS staff are uniquely suited to collect certain biological parameters with sufficient data quality, providing the taxonomic and ecological expertise to collect, analyze and report on findings at different scales (site-specific, watershed, county, ecoregion, Statewide). In addition to monitoring over 3,000 sites, the MBSS program has been compiling data from many sources (counties, other state agencies, universities, museums) to supplement the data we collect. This information is being compiled in a GIS database which will be available to various users. Additionally, DNR staff assigned to the MBSS provides training for other groups conducting stream sampling in Maryland to improve data and assessment comparability.

There are no monitoring sites/strata/seasons in which monitoring results are duplicative or where sampling could be eliminated without affecting program goals. Although statewide and watershed estimates were generated using the probability-based MBSS surveys, actual MBSS monitoring has only occurred in a small proportion of the state's total stream miles (less than 3 percent). Many important management questions require finer scale sampling in certain areas, such as priority protection watersheds and streams where restoration projects have been conducted. The MBSS has evolved its monitoring strategy to address many of these questions. Both probability-based sampling and targeted sampling will be necessary to address as many needs as possible with an efficient use of limited funding.

There under-sampled areas of the State that need to be monitored, but the MBSS strategy has evolved and, if resources are available, efforts will continue to evolve to address these needs.

Inter-round reviews address whether there are other cost-effective monitoring/analysis methods that could be implemented and changes are made when the benefits outweigh changes, especially in terms of being able to compare past results to assess trends. While MBSS methods will be reviewed again following the present round (2010), it is believed that, at present, the parameters currently being measured are the most useful measures needed to address the programs objectives.

This monitoring program is the only monitoring program focused on non-tidal streams in Maryland that is capable of defining conditions in all streams Statewide. It is a program that provides significant new information at all stations each year at a very cost effective effort which has been proven invaluable in protecting Maryland's stream resources and has been used to provide the information to citizens and public officials that could be used to support activities to protect and restore Maryland's streams as:

- Identifying that half of Maryland's streams and watersheds are in poor biological conditions
- Identifying specific watersheds and streams with high biological integrity and biodiversity have been identified
- Identifying the impact that very small amounts of urban development have on Maryland stream animals (e.g. native trout disappear from streams with around 5% pavement in a watershed, even when forested buffers are fully maintained).
- Identifying the wide establishment of invasive, non-native crayfishes in streams throughout central Maryland and the detrimental impact these species have had on native species and other aquatic communities.
- Rediscovering at least three species of aquatic animals that have not been seen for over 20 years in the State.

In addition to answering these and many other management questions, MBSS results are used by a large number of federal, State agencies, scientists and private consultants to conduct watershed assessments, environmental review, environmental impact statements, assess trends, and answer broad ecological research questions. Under the current program, changes to the sampling program (e.g., prioritizing sample areas or reducing sampling effort – by changing sampling sites, strata or seasons) would adversely affect the program's current goals and would adversely affect the program's ability to define status and trends at the current level of likely error.

3.1.1.4 CORE/TREND Monitoring Program

Agency: DNR Resource Assessment Service

Contact: Tony Prochaska (410-260-8616); tprochaska@dnr.state.md.us

Watersheds: Statewide (14 of 20 basins - Choptank, Chester, Chesapeake Bay, Susquehanna, Gunpowder, Patapsco, Patuxent, Potomac River (all 5 basins), Monocacy River; and Youghiogheny River; 39 of 138 watershed segments)

Media: Water chemistry and macroinvertebrate assemblage

Goals: The general goals of this program are to:

1) Assess status and trends in water quality and benthic macroinvertebrate assemblage for Section 305(b) and Integrated Reports and for Tributaries Strategy teams; and
2) estimate nutrient and sediment loadings. Sample areas where future development may influence water quality/habitat condition and provide data needed for the development, implementation, and evaluation of TMDL's.

Program Description: This ambient water quality program is a network of fixed stations located in most of the State's larger, non-tidal streams and rivers (Strahler 4^{th} order and larger). The data collected in the Core/Trends network are used to assess water quality status and also examine long-term trends. Monitoring at the Core stations (Figure 7) is funded by US Environmental Protection Agency through a Clean Water Act Section 106 grant.

Many of the stations in this network have been sampled since the early 1970's. One to three stations in 39 of the 138, 8-digit watershed segments (54 stations total) are sampled monthly for water chemistry. Benthic macroinvertebrate assemblages are sampled annually at a subset of water chemistry stations using Surber and Hester-Dendy multiplate samplers. Thirty-two of the monitoring stations are located near a USGS stream gage.

The distribution of monitoring stations is focused on the Potomac River and central Maryland watersheds, but is sparse on the eastern and western shores of Chesapeake Bay, as well as in the Southern Coastal Plain. This pattern reflects the focus on point-source discharge concerns when the network was established in the early 1970's. Physico-chemical parameters (temperature, dissolved oxygen, pH, conductivity, alkalinity, turbidity, total suspended solids, total organic carbon, chlorophyll, sulfate, nitrogen and phosphorous species) are sampled from near the surface by MANTA staff and analyzed in the State Department of Health and Mental Hygiene's laboratory. Benthic macroinvertebrate samples are collected and processed by MANTA.

Data Management: Water chemistry samples collected by DNR's Monitoring and Non-Tidal Assessment (MANTA) Division staff are delivered to the MD Department of Health and Mental Hygiene (DHMH) laboratory in Baltimore for analysis. Raw data sheets are forwarded by DHMH to DNR/RAS's Tidewater Ecosystem Assessment Division (TEA) for data entry. TEA staff posts the water chemistry data files (in SAS format) on DNR's server. Data from this program are analyzed and interpreted by MANTA staff. The water chemistry data files are also sent by DNR to the Chesapeake Bay Program for posting on their web site (www.chesapeakebay.net) to facilitate downloading by the general public.

Benthic macroinvertebrate samples are collected and processed at laboratory in MANTA's Annapolis Field Office. This group also handles data entry and data file maintenance. The benthic macroinvertebrate data files and are analyzed and interpreted by MANTA staff.

Documentation: Station locations, sample collection procedures, parameter analyses, and detection limits are described in a document titled "Section 106 Ambient Water Quality Monitoring (CORE/Trend Monitoring) Quality Assurance/Quality Control Plan (DRAFT)" (MD DNR, 2009).

Programmatic Issues/Strategic Review: For a less point-source centric effort, this program should be expanded to include larger non-tidal streams and rivers on the Eastern Shore and in southern Maryland that are not currently being sampled. Expanding the network of fixed stations into these areas will aid in the statewide assessment of Maryland's larger streams and rivers not sampled by the Maryland Biological Stream Survey. Recent discussions by a multi-jurisdictional workgroup within the Chesapeake Bay Program should address this need, but the effort would be supported by the Bay Program and approved by the regional monitoring coordinator for EPA. It should be noted that shifting CORE monitoring resources to underserved areas or even deleting some sites would not conserve funding as costly field efforts (principally manpower and travel) would remain for other sites. It is likely that additional monitoring resources would be required to expand the existing network.

It should be noted that discussions in early 2009 by Chesapeake Bay Program planners suggesting a reduction in Chesapeake Bay tidal monitoring efforts - reducing the sampling season or sampling intensity. Seven of the eight tidal CORE monitoring sites are now being sampled as part of the Chesapeake Bay network and reductions in Bay Program monitoring would likely affect the monthly sampling frequency that the CORE program uses. It is likely that CORE monitoring efforts would have to be expanded to replace tidal samples - increasing costs (effort requires boat use / equipment / staff, even if the data are not required by the EPA Bay Program. As part of the EPA's National Basic Water Monitoring Program effort, changes to the State's CORE monitoring effort needs EPA region approval and likely modification to the supporting grant (Clean Water Act S.106).

MANTA and Versar staff are currently working to determine how data collected by the Core/Trend program can be seamlessly integrated with the data being collected by the probability-based MBSS, and thereby produce more comprehensive watershed and state assessments of water quality and habitat conditions.

Figure 7: Map showing Maryland's CORE/TREND Monitoring Stations

3.1.1.5 Aquatic Invasive Species Monitoring Program

Agency: DNR Resource Assessment Service

Contact: Ronald Klauda (410-260-8615); mailto:rklauda@dnr.state.md.us

Watersheds: Statewide- all areas with freshwater, wadable streams (20 sub-basins; 138 8-digit watersheds)

Media: Biological assemblages (fishes, mussels, crayfishes, algae, riparian plants), water chemistry, physical habitat assessment

Goals: The goals of the Aquatic Invasive Species Monitoring Program are:

1) To assess the current distribution and abundance of invasive species in Maryland freshwater streams and rivers;
2) To establish a benchmark for assessing trends; determine the potential for population control or eradication; and
3) To determine the potential for population control or eradication.

Program Description:
This program currently incorporates statewide and targeted sampling components. Invasive aquatic species have been monitored as part of the Maryland Biological Stream Survey, a probabilistic statewide stream monitoring survey, conducted by DNR's Monitoring and Non-tidal Assessment Division (MANTA), since 1994. Data on the presence and abundance of invasive fishes, mussels, crayfishes, and riparian plants are collected at each of 250-300 sites sampled annually. MANTA also conducts a targeted survey for the rusty crayfish in the Monocacy River watershed to track the

spread of this new, non-native invasive species and its subsequent impact on the native crayfish community. MANTA field crews sample 50 sites annually as part of this monitoring effort. In 2008, following the discovery of the invasive Didymo alga in the Gunpowder Falls watershed, MANTA initiated monthly monitoring of the Gunpowder River at 11 fixed locations to document the extent of Didymo in the watershed and track changes over time.

Invasive species monitoring has been conducted since 1994 in the MBSS Program. Targeted monitoring for the invasive rusty crayfish began in 2007, following its discovery in the upper portion of the Monocacy River watershed. Targeted monitoring for Didymo began in 2008, following its confirmation in the Gunpowder Falls in April.

MANTA has received strong support from DNR Fisheries Service and the DNR Wildlife and Heritage Service. Local county governments, colleges, and universities have also provided support for targeted monitoring efforts. DNR's invasive species monitoring and education programs have been coordinated since 2007 by an Invasive Species Matrix Team.

Data management:
All data are managed by DNR using Access.

Programmatic issues:

1) Although non-tidal streams are adequately addressed, other aquatic habitats (e.g., wetlands, lakes, reservoirs, non-tidal rivers) are not currently monitored adequately for invasive aquatic species. DNR does not currently have the staff or resources to initiate and sustain monitoring efforts for invasives in all aquatic habitats.

2) It would be beneficial to combine invasive species presence and abundance data collected by other state agencies, county monitoring groups, and local watershed organizations and build an integrated, GIS-based web site to store and display this information.

3) DNR is exploring a new, genetics-based method for use in rapid detection of Didymo cells. Its accuracy and cost-effectiveness will be evaluated.

4) Probabilistic sampling by MBSS has provided information on species already widely established and detected previously unknown populations of invasive species recently introduced in Maryland. Targeted monitoring efforts for rusty crayfish and Didymo will provide important information on the ability of these species to disperse and their effects on native aquatic communities. The monitoring results are also essential to sustain DNR's public educations/outreach activities and help the agency promulgate regulations designed to prevent the introduction and spread of invasive species.

3.1.1.6 Volunteer monitoring support - Stream Waders

Agency: DNR Resource Assessment Service

Contact: Dan Boward (410-260-8605); mailto:dboward@dnr.state.md.us

Watersheds: Statewide – all areas with freshwater, wadeable streams (20 sub-basins; 138 8-digit watersheds)

Media: Benthic macroinvertebrates; basic physical information

Goals: The goals of the Stream Waders Program are:

1) To increase the density of sampling sites for use in stream quality assessments;

2) Educate the local community about the relationship between land use and stream quality;

3) Provide quality assured information on stream quality to state,local, and federal agencies, environmental organizations, and others; and

4) Improve stream stewardship ethics and encourage local action to improve watershed management.

Program Description: Since 2000, the MD Department of Natural Resources' (DNR) Monitoring and Non-tidal Assessment Division (MANTA) has operated a Statewide volunteer stream monitoring program, Maryland Stream Waders. The Program is the volunteer "arm" of the Maryland Biological Stream Survey (MBSS). Volunteers collect macroinvertebrate samples in the spring which are then identified by DNR professional taxonomists. Stream Waders data are used to support the MBSS by "filling the gaps." Stream Waders is nearly seamless with the MBSS because in both programs:

1) samples are collected during the same index period,
2) the same equipment (D nets) and field protocols are used,
3) the same watersheds are sampled, and
4) the same experienced DNR taxonomists identify the organisms using the same sub-sampling procedures and identification keys.

Samples are collected primarily to supplement the findings (at various scales) of the MBSS to be used in watershed assessments, identifying areas in need of preservation or restoration, etc. Application and annual review of this effort has resulted in a program that does meet its goals.

Stream Waders protocols are outlined in an easy-to-read manual, available online at: *www.dnr.state.md.us/streams/pubs/sw2003_man.pdf*. Volunteers are asked to sample up to three sites within each Maryland 12-digit subwatershed in a targeted 8-digit watershed. The Maryland stream Benthic Index of Biotic Integrity is a reliable indicator of overall stream quality. Three samples per subwatershed is appropriate, given limits to MANTA staff capabilities for conducting volunteer training sessions and processing benthic macroinvertebrates. The monitoring frequency is adequate but the rotating basin design and changes in volunteers or in site dynamics often does not allow for trend assessments. MANTA staff have considered adding a "fixed station" component to the Program to enhance our ability to evaluate trends in certain watersheds. While more field observations (e.g., vernal pools, physical habitat) could be collected at each site, there are insufficient resources available to modify the Program to accommodate additional data collection at this time. Also, given the unpredictability associated with ambient stream monitoring, changes to the program are evaluated continuously.

Program details: Annually, the Maryland Stream Waders Program records site location and stream characteristic (depth, width) information along with a sample of benthic macroinvertebrates from between 300 and 700 sites. Samples from free-flowing streams are typically collected from the same 8-digit watersheds scheduled for sampling by the MBSS. However, Stream Waders effort is stratified by 12-digit subwatershed. Volunteers choose their own sample sites depending on local interest, landowner permission, safety, etc. These sites often are chosen according to their proximity to roads, so sampling site selection is a mixture of fixed and random sites. MANTA's benthic macroinvertebrate laboratory subsamples and identifies Stream Waders samples, which are collected with a D-net. The Program could be enhanced by the addition of a fixed station network and more samples could be collected in each watershed, however, the MANTA benthic lab staff would need to be increased. Details about the methods are available online at: *http://www.dnr.state.md.us/streams/pubs/sw2003_man.pdf* .

Initiated in 2000, the Program has remained relatively unchanged since its inception. Training sessions and samples collected during all years. The Stream Waders program is supported by a mixture of General and Special funds. Training and analysis support is provided by Maryland Biological Stream Survey staff. Stream Waders has partnered with some local government agencies. Publications produced by the Stream Waders program include sampling manuals, annual reports (2000 to 2003) and various other publications - all available online at: *www.dnr.state.md.us/streams/mbss/waders_pubs.html* .

Data management: All data are managed in Microsoft Access (entry and storage). Searchable online data available via the Chesapeake Bay Program's server (Cold Fusion). ESRI products used for QC on geo-referenced data. Summary results are posted on the Internet at: *http://www.dnr.state.md.us/streams/mbss/w_new.html* .

Programmatic issues: The Stream Waders program is reviewed annually and managed to allow for annual training/participation opportunities Statewide while addressing data gaps. The program's simplicity results in no duplication of monitoring sites/strata/seasons or where the level of sampling affects program goals. The resulting rich level of data could be better used to meet goals of multiple programs (e.g., MD Department of the Environment, local governments and watershed organizations).

Data on stream width and depth are thought to be a valuable observation, but current analysis approaches have not used with these data. This volunteer effort could be expanded to include training to assess vernal pools and physical habitat conditions, but the existing data management system would have to be updated to accommodate new variables. Finally, some areas are undersampled due to landowner restrictions, permit requirements or inaccessibility and integration with other, more quantitative monitoring efforts needs additional work

Given the involvement and education opportunities offered to Stream Waders volunteers, this effort is well worth the cost.

3.1.1.7 US EPA - National Streams and Rivers Assessment

Agency: DNR Resource Assessment Service

Contact: Paul Kazyak (410-260-88607); mailto: pkazyak@dnr.state.md.us

Watersheds: All nontidal, free-flowing streams and rivers in Maryland.

Media: Water column, sediment, streamside habitat, aquatic plants, fish, invertebrates, bacteria

Goals: The goals of this program are to:

1) Provide statistically valid regional and national estimates of the water quality, aquatic resource and habitat condition of wadeable streams and larger rivers in the United States and

2) Use consistent sampling and analytical procedures so that results can be compared across the country

Data management:
EPA indirectly manages the physical, chemical, biological and habitat databases through contractors. Once the data are reviewed and proven they data will be submitted to WQX - EPA's environmental data exchange framework.

Programmatic issues:
This National Streams and Rivers Assessment program is one of five national waterbody assessment efforts (lakes, streams, rivers, tidal waters, wetlands) that EPA plans to initiate between 2007 and 2011. If funding can be continued, this effort would become cyclic and would eventually provide sufficient data to define trends.

3.1.1.8 Tidal (Coastal Bays and Chesapeake Bay Designated Uses)

Tidally influenced rivers, tributaries, and embayments of Chesapeake Bay, and the coastal lagoons behind the Atlantic barrier islands, account for an estimated 2,522.4 square miles or 20 percent of the State's total surface area (Figure 8). Modifications to estuarine waters include dredging for navigation purposes (channels, canals, anchorage areas), dredging for oyster shell and oyster bar shoreline erosion, stabilization projects (bulkheads, jetties) and shore structures (piers, wharves).

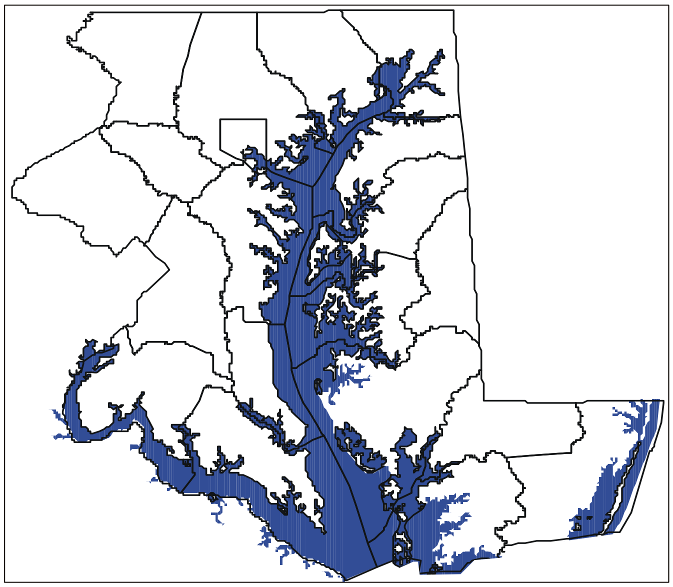


Figure 8: Estuarine waters (shaded) in Maryland

3.1.1.9 Chesapeake Bay Monitoring Program

Agency: DNR Resource Assessment Service

Contact: Tom Parham (410-260-8633); mailto:tparham@dnr.state.md.us

Watersheds: Chesapeake Bay (all Maryland counties and Baltimore City)

Media: water column, aquatic resources

Goals: The general goals of Maryland’s Chesapeake Bay Monitoring Programs are to:

1) Monitor the physical, chemical and biological components that are indicators of water quality status and trends in the Chesapeake Bay and its tidal tributaries,
2) Reduce the impacts of excess nutrients on the Bay that will result in improvements in dissolved oxygen levels and in the habitat for submerged aquatic vegetation (SAV),
3) To assist in the development and implementation of management policies to protect and restore the economic and recreational value of Chesapeake Bay, and

4) To measure progress towards meeting the ultimate goal of protecting and restoring Chesapeake Bay.

Program Description: Since 1985, this multidisciplinary monitoring program was defined by component programs that measured:

- The physical/chemical environment (including nutrient levels),
- Point and non-point source pollutant loadings,
- Biological indicators of water quality (phytoplankton and benthos), and
- Rates of important ecosystem processes (photosynthesis, metabolism, and nutrient limitation).

These programs included:
Mainstem/Tributary Monitoring - water chemistry samples are collected 14 times a year (monthly from September through March and in June and twice each month in April, May, July and August) at 22 stations located in Maryland’s Chesapeake Bay mainstem and 12 to 20 times a year at 55 stations sampled in the tidal tributaries.

This effort incorporated more intensive tributary monitoring programs in the tidal portions of the lower Patuxent and Potomac River tributaries with sub-goals that included:

1) Characterization of the health of these estuaries;
2) Information that will assist in anticipating water quality responses to implementation of proposed management actions; and
3) Developing monitoring datasets from these principal Chesapeake Bay tributaries that would be used to better evaluate water quality in other Bay tributaries with few stations.

The intensive estuarine monitoring effort in the tidal Potomac River was initiated as part of a coordinated interstate monitoring effort focused around and downstream of the metropolitan Washington area. Originally coordinated by the Interstate Commission on the Potomac River Basin and the Metropolitan Washington Council of Governments (MWCOG), the program was focused on development of an area model to assess wastewater loadings. Monitoring activities continue to be coordinated through MWCOG.

Intensive sampling in the tidal portion of the Patuxent River began in 1983 as an effort to characterize the estuary’s health and document its response to the State’s nutrient control strategy in the basin, especially in terms wastewater discharges in the upper watershed. Like the Chesapeake Bay Program, samples for analysis of physical and chemical parameters and chlorophyll, are collected here from 13 stations throughout the year.

Analysis of water samples is addressed by the University of Maryland’s Chesapeake Biological Laboratory. A map of all Chesapeake Bay monitoring stations is available at *http://www.eyesonthebay.net*.

2) *River Input* - quantifies the amount of nutrients and sediment entering the Chesapeake Bay from four Maryland tributaries that represent the range of different sources of runoff contribution to the Bay (Susquehanna, Potomac, Patuxent and Choptank Rivers). In cooperation with the US Geological Survey, each river site is monitored for flow, sediment and nutrient concentrations during both storm and non-storm events in each season. This information provides a measure of the success of management actions in the Bay’s watersheds on reducing nutrients and sediment loading to the Bay. Analysis of water samples is addressed by the University of Maryland’s Chesapeake Biological

Laboratory. A map of the monitoring stations is available at
http://va.water.usgs.gov/chesbay/RIMP/map.html.

3) *Nutrient Limitation* - determines the specific factors, primarily nutrients, that limit algal growth at various times in Chesapeake Bay and its tributaries by measuring phytoplankton growth rates under ambient nutrient conditions and under various combinations of nitrogen and phosphorus addition. This information is used to determine locations nitrogen or phosphorus or both nutrients are limiting algal growth to target future nutrient reduction efforts and to interpret monitoring data used to track the restoration. Water samples are collected from locations in the Patuxent, Potomac and Choptank Rivers and in the mainstem Chesapeake Bay.
These samples are tested using a bioassay to determine if a sample is:

- Nitrogen limited (excess phosphorus),
- Phosphorus limited (excess nitrogen), or
- Nutrient Saturated (excess phosphorus and nitrogen or inadequate light)

In addition, data from this component has been used to develop a predictive model that uses routinely measured water quality components (total nitrogen, total phosphorus, dissolved inorganic nitrogen, dissolved inorganic phosphorus, salinity and water temperature) to estimate the nutrient limitation status for locations where bioassay samples are not collected. This model has been applied to determine annual patterns of nutrient limitation for all DNR monitoring sites. Analysis of water samples is addressed by the University of Maryland's Horn Point Environmental Laboratory.

4) *Benthic monitoring program* - consists of two primary elements:
(1) A fixed site sampling effort of samples from 27 sites to identify temporal trends in benthic condition - most of which have been sampled since 1984. These are all sampled in both spring and summer to see if management actions designed to improve water quality are resulting in healthier benthic communities
(2) A probability-based sampling program (150 randomly-selected sites sampled in the summer in 6 major salinity regions and two sediment types in the Chesapeake Bay mainstem and tributaries in Maryland) designed to estimate the area of the Bay where benthic communities meet the Chesapeake Bay Program's Benthic Community Restoration Goals (a summer-only goal). Probability sites are allocated according to a stratified random sampling scheme designed to produce an annual estimate with known precision of the tidal area meeting the restoration goals for the Maryland Bay. Regions of the Maryland mainstem deeper than 12 m are not included in the sampling strata because these areas are subject to summer anoxia and have consistently been found to be azoic. Except for these excluded areas, every point of the Maryland Bay tidal bottom deeper than 1 m mean lower low water (MLLW) has a chance of being sampled.

For general information and results of the benthic monitoring program, see (*http://www.baybenthos.versar.com/*). For detailed information about this program, see the program QA Project Plan (*http://www.esm.versar.com/vcb/benthos/docs/LTB_QAPP09.pdf*). Through 2011, sampling and laboratory activities are performed under contract by Versar, Inc.. See the p, monitoring site figures, etc.

5) *Phytoplankton monitoring program* had annually evaluated Chesapeake Bay and tributary phytoplankton productivity and biomass at 12 Bay mainstem and tidal tributary stations 14 times per year. Because of budget shortfalls, State funding for support of the phytoplankton program will end October 2009. The end of this program likely will be reflected by the a loss of information about

biological responses to management reductions of nutrients flowing to the Bay and that there likely will be fewer reports of potentially “harmful” algal blooms, their extent and opportunities to collect samples of algae and possible toxins.

Data management:
DNR manages the field and laboratory data (nutrient and sediment data) on its Access-based water quality database. On a monthly basis, these data are forwarded to the EPA Chesapeake Bay Program which reviews these data and adds them to the Chesapeake Bay Information Management System (CIMS). DNR is working with the MD Department of the Environment to provide these data to EPA’s WQX (Water Quality Exchange) system in the near future.

Programmatic issues:
The end of the phytoplankton monitoring component marks the likely beginning of an evolution in water monitoring activities in the Chesapeake Bay watershed that may be partially a result of severe economic restrictions (e.g., continuing State budget shortfalls are expected through 2010) or changes in federal direction/support as the Chesapeake Bay Program is reorganized and monitoring priorities are changed.

Following critical reports from the US Government Accounting Office (2005) and the Congress that the Chesapeake Bay Program needed to:

1. Develop an overall, coordinated implementation strategy that unifies the program's various planning documents, and
2. Establish a means to better target its limited resources to ensure that the most effective and realistic work plans are developed and implemented,

the Bay Program developed a strategic plan that would change the existing organization from one that provided a supporting/coordination role to an organization that was more management oriented (see: *http://www.chesapeakebay.net/committeeactivities.aspx?menuitem=14890*)

With this framework, the revised program goals and objectives would be to

- Target limited resources,
- Enhance accountability,
- Implement a protection/restoration strategy (e.g., Chesapeake 2000 Action Plan),
- Align resources with Bay Program priorities,
- Enhance implementation, and
- Implement an adaptive management approach.

Chesapeake Bay Program reorganization
In a reorganized Bay Program structure, the Executive Council would work through a Management Board which would direct Goal Implementation Teams that would each address primary goals of the Chesapeake Action Plan (protect and restore fisheries, aquatic habitats and water quality; maintain healthy watersheds; foster Bay stewardship, and enhance partnerships, leadership and Bay management

These teams and their workgroups are supported by a centralized Technical Services and Support Unit which provides on-going technical and policy assessment (within an adaptive management framework) to support Goal Teams and other technical needs of the Bay Program (assessment, data management, modeling, monitoring, analysis, Internet communication, decision support tools indicators, habitat and restoration and integrated assessments. To support these needs monitoring workgroups need to modify existing monitoring networks to support integrated assessments (e.g., defining linkages between non-tidal and tidal systems by directing more efforts into watershed areas where management/restoration activities are directed, develop decision support tools for management (e.g., targeting watersheds for restoration).

A draft schedule for adapting existing monitoring networks to new Bay Program priorities with shifts in resources was proposed to begin in 2008 with recommendations implemented by early 2009, including a shuffling of available resources. A review of monitoring programs by the Scientific and Technical Advisory Committee and senior Bay Program managers in early 2009 found that the continuing operation of monitoring networks was unacceptable as these monitoring efforts needed to:

1. Focus on assessing Bay criteria and delist pollutant-impaired Bay segments, and
2. Expand the watershed network to assess the effectiveness of management actions to reduce nutrient and sediment loads in the watershed.

Draft options for ‘realigning’ Bay monitoring resources defined various options for shifting monitoring efforts via program maintenance (SAV, Benthic Community monitoring), canceling monitoring efforts (Shallow Water, Phytoplankton, Ecosystem Processes and River Input programs), reducing Mainstem/Tributary monitoring efforts and expanding the Watershed NonTidal network - a proposed reallocation of $0.9 to $1.4 million from tidal monitoring efforts to watershed monitoring (of a total of $4.3 million in monitoring resources (combined State, federal and other funding).

Proposed implementation of a refocused Bay monitoring effort was delayed to allow analysis by Technical Support Services and workgroups (Monitoring Realignment Action Team or M-RAT) of monitoring networks – redundancy, site distribution and sampling frequency. Reports of these workgroups were provided to a Synthesis Team which will provide a report on recommended changes for the Management Board in Fall, 2009 with implementation proposed in January 2010.

With the summer 2009 loss of State funding for supporting the Phytoplankton monitoring program, there is an immediate loss in option flexibility, which is further threatened by the current, poor economic climate affecting budgets of all Bay partner States. It is possible that further reductions in State monitoring funds may occur over the next 12-18 months. Current options for shifting funding resources in Maryland include reductions in the number of tidal monitoring trips with an increase in nontidal sites monitored in the State. Proposals to increase sampling interval (e.g., increase benthic sampling from annual to every other year or every third year affects public reporting. Efforts to increase Watershed monitoring need to be tempered by the 5-6 year delay that is required to define watershed loads and the loss of information from limiting tidal water monitoring. Until the Management Board makes its decisions, any further discussion is conjecture.

Chesapeake Bay Protection and Restoration Executive Order

On May 12, 2009, President Barack Obama signed an Executive Order that recognizes the Chesapeake Bay as a national treasure and calls on the federal government to lead a renewed effort to restore and protect the nation’s largest estuary and its watershed. This Chesapeake Bay Protection and Restoration Executive Order established a Federal Leadership Committee that will oversee the development and coordination of reporting, data management and other activities by agencies involved in Bay restoration. The committee will be chaired by the Administrator of the

Environmental Protection Agency and include senior representatives from the departments of Agriculture, Commerce, Defense, Homeland Security, Interior, Transportation and others.

- The Executive Order requires that these agencies prepare and submit by September 9, 2009 draft reports and recommendations on how to protect and restore Chesapeake Bay
- By November 12, 2009 the Federal Leadership Committee will integrate these reports into a coordinated strategy for restoration and protection of the Chesapeake Bay. This draft strategy will be available for public comment.
- Complete a final strategy by May 12, 2010
- Beginning in 2010, the Federal Leadership Committee will publish an annual Chesapeake Bay Action Plan that describes how federal funding will be allocated toward Bay restoration in the upcoming year, and
- An independent evaluator will also periodically report on progress toward meeting the goals of the Executive Order

Progress (September 2009)
In response to the President's Executive Order, Federal agencies released several draft reports on protecting and restoring the Chesapeake Bay, including a report (202(f)) by the Department of Commerce and Department of the Interior that would strengthen scientific support for decision making to restore the Chesapeake Bay and its watershed, including expanded environmental research and monitoring and observing systems. When a draft strategy and revised reports are released on November 9, the formal public comment period will begin on this and six other documents addressing: water quality, targeting resources, federal stormwater management, climate change, access and landscapes, habitat and living resources. For reports, summaries and more information, see the Chesapeake Bay Restoration Executive Order website (*http://executiveorder.chesapeakebay.net*).

3.1.1.10 Coastal Bays Monitoring Program

Agency: DNR Resource Assessment Service

Contact: Cathy Wazniak (410-260-8638); mailto:cwazniak@dnr.state.md.us / Matt Hall (410-260-8632); mailto:mhall@dnr.state.md.us

Watersheds: Atlantic Ocean coastal bays (Worcester Co.)

Media: water column, aquatic resources

Goals: The Maryland Coastal Bays Comprehensive Monitoring Program is designed to:

1) To measure the effectiveness of implementing the management actions identified in the Comprehensive Conservation Management Plan (CCMP),
2) To provide information that can be used to redirect and refocus the CCMP over time,
3) To provide information that will assist in anticipating water quality responses to implementation of proposed management actions, and

4) To bring the monitoring and evaluation of Coastal Bays up to par with efforts in the Chesapeake Bay.

Program Description: Eutrophication and its impacts to living resources was identified in the Maryland Coastal Bays Program (1998) characterization report as the most pressing environmental issue facing these waters. As a result, the Scientific and Technical Advisory Committee (STAC) recommended that the initial focus of the monitoring plan be on nutrient and sediment inputs to the Coastal Bays and their impacts on living resources (Maryland Coastal Bays Program, 1999). Five general categories of monitoring activities were identified:

1) Tracking management actions;
2) Nutrient and sediment inputs from the watershed and airshed;
3) Ambient water quality;
4) Eutrophication impacts to habitat; and,
5) Eutrophication impacts to living resources.

Structure: Actions in the monitoring plan have been organized into three levels: Landscape Monitoring (Level I), Stressor Monitoring (Level II), and Response Monitoring (Level III). The lower the level, the more directly the monitoring is related to management actions. Inherent within all three levels is monitoring for both baseline water quality conditions and long-term trends. The resulting Comprehensive Environmental Monitoring Program was developed by DNR with extensive input from local, State, and federal agencies operating in Maryland's Coastal Bays, reviewed for technical merit and approved by the STAC.

Baseline monitoring determines the current status of important indicators of environmental health to measure change and to determine if management actions have an impact. DNR has been monitoring 24 fixed-station sites since 1999 and an additional 18 sites since 2001 using a suite of water quality indicators, including water column chlorophyll, dissolved oxygen, and nutrients (monitoring map at *http://www.dnr.state.md.us/coastalbays/water_quality/index.html*).

The National Park Service at Assateague Island (ASIS) has been monitoring 18 fixed-station sites in the southern Coastal Bays since 1987. These programs are providing critical baseline data. In addition, DNR has installed continuous water quality monitors in Bishopville Prong and Turville Creek. These monitors provide nearly instantaneous data on water quality conditions and aid in tracking events such as harmful algae blooms. Comprehensive analysis of the water quality data provided by these programs, as well as related management activities, was presented in a *State of the Coastal Bays* report released in 2004. The analysis was updated and greatly expanded in the 2009 book, "Shifting Sands" published by the University of Maryland Center for Environmental Science.

Landscape monitoring (Level I) tracks activities going on in the watershed (e.g., nutrient and chemical application rates, implementation of best management practices and land cover). This can often be directly related to implementation of management actions and may not need intense field monitoring. This monitoring process may need to be reviewed, depending on the outcome of the final management plan and its goals, to evaluate the adequacy of current programs to track important aspects of landscape conditions and activities.

Stressor monitoring (Level II) determines the amount of pollutants (nutrient, sediment or chemical contaminants) entering the bays or extent of habitat alteration or loss occurring in the watershed. While it may be very difficult to do in a comprehensive fashion, the STAC decided to initiate some of the high priority monitoring elements in this category related to nutrient inputs. DNR and ASIS currently monitor nutrient levels in the Coastal Bays. The abundance of SAV habitat is also closely monitored, and an SAV restoration goal has been established. Ambient sediment toxicity was tested in 2000 (under the Coastal 2000 initiative), and Maryland Geological Survey completed a review of sediment toxicity.

Response monitoring (Level III) uses indicators to show how the system is responding to management actions (changes in stressors) over time. This monitoring information is very important to the public (e.g., - Is the water degraded? What is the condition of the fish?). Now that many management actions presented in the original CCMP are underway and monitoring infrastructure is in place, response monitoring can be undertaken.

Programmatic Issues/Needs:

1) Harmful algal blooms pose a threat to the Coastal Bays. Beginning in 1998, several HAB species have been identified in Coastal Bay waterways. Although the presence of these organisms has not yet affected human health risks or impaired uses, their presence emphasizes the need to control nutrient inputs to these lagoons.
2) Submerged aquatic vegetation (SAV) abundance should continue to be monitored using aerial photography. SAV habitat criteria need to be established specifically for the Coastal Bays. Seasonal, intensive macroalgae surveys were conducted to characterize the taxa found in the Coastal Bays as well as determining spatial and temporal coverage and estimates of biomass. This program should be reinstated I order to better understand the relationships between macroalgae, SAV, habitat and water quality.
3) System-wide benthic monitoring began in 2000 as part of the EPA National Coastal Assessment (NCA), but is not a long-term part of the management plan. The spatial and temporal variability due to physical and biological factors can confound attempts at detecting anthropogenic disturbances in the molluscan community over time. Indicator development and analysis of benthic/fish data as it relates to eutrophication needs more study.

3.1.1.11 US EPA - National Estuary Assessment

Agency: DNR Resource Assessment Service

Contact: Cathy Wazniak (410-260-8638); mailto:cwazniak@dnr.state.md.us

Watersheds: All tidal waters in Maryland, excluding Atlantic Ocean.

Media: water column, sediment, shoreline habitat, aquatic plants, fish, invertebrates, bacteria

Goals: The goals of this program are to:

1) Provide statistically valid regional and national estimates of the water quality, aquatic resource and habitat condition of estuarine waters in the United States and

2) Use consistent sampling and analytical procedures so that results can be compared across the country

3.1.1.12 Chesapeake Bay Programs – Submerged Aquatic Vegetation

Agency: DNR Resource Assessment Service

Contact: Lee Karrh (410-260-8650); mailto:lkarrh@dnr.state.md.us

Watersheds: Tidal tributaries and Mainstem Chesapeake Bay

Media: water column chemistry, submerged plants

Goals: The goals of the Submerged Aquatic Vegetation (SAV) monitoring program are:

1) To assess areas designated for bay grass use in terms of Chesapeake Bay shallow water quality criteria, and
2) To annually assesses segment-specific bay grass populations in Chesapeake and Coastal Bays and corresponding water quality data to identify specific reasons for lack of bay grass in those segments.

Program Description: Bay grasses (technically known as Submerged Aquatic Vegetation or SAV) are an important part of the Chesapeake Bay ecosystem. Fifteen varieties of bay grasses are commonly found in the Chesapeake Bay and surrounding rivers. Not only do bay grasses improve water quality, they also provide food and shelter for waterfowl, fish, and shellfish. Because of their importance, the restoration of bay grasses in the Chesapeake and Coastal bays is a priority for Maryland as well as the other Bay partners (see *www.vims.edu/bio/sav*).

Adopted in December 2003, the enhanced bay-wide bay grass restoration goal calls for the protection and restoration of 185,000 acres to be met in 2010. The monitoring efforts at VIMS are of sufficient temporal and spatial resolution to meet management objectives. The monitoring program has been thoroughly vetted at multiple levels (local, State and Federal), and is of adequate scale and scope to meet management objectives.

The new strategy commits Maryland and other Bay Partners to four major initiatives.

1) Meet Chesapeake Bay Program water quality criteria in areas designated for bay grass use
2) Provide existing bay grass beds greater protection
3) Enhance bay grass research, citizen involvement and education, and
4) Accelerate bay grass restoration by planting 1,000 acres of new bay grass beds by December 2008

Some of the monitoring efforts are directed by specific management questions

- **Technical Assessments**
  - Annual assessment of segment-specific bay grass populations in Chesapeake and Coastal bays – under contract to Virginia Institute of Marine Science

- Specific technical assessments (ex. historic bay grass distribution, role of personal watercraft/recreational boats in damaging bay grass beds, etc) to direct management actions to protect existing bay grass beds

- **Large-scale Bay Grass Restoration Projects:**
  - Evaluation of water quality and habitat (Geographic Information System data project involving water quality and habitat data layers) to determine potential for future large-scale projects in some grass-barren areas. MD-DNR is committed to achieving or exceeding the Bay Program's goal of planting 1,000 acres of bay grass by 2008. This represents bay grass restoration on a scale never before attempted, and will require the development and implementation of numerous new technologies.

- **Education and Outreach:**
  - SAV Resource Center website offers technical support, issues permits, and tracks progress for groups or individuals interested in undertaking bay grass restoration projects.
  - The Bay Grasses in Classes (BGIC) program is a hands-on, interactive education project that enables students to play a direct role in Chesapeake Bay restoration.

Program Details: Aerial photography is collected from 181 flight lines annually for the entire Chesapeake and Coastal Bays. Photography is acquired by AirPhotographics in Martinsburg, WV. The flight lines are chosen to capture images from all tidal areas with water depths less than 2 meters. The resulting photos are digitized and signatures of bay grasses are delineated for both total cover as well as density by Virginia Institute of Marine Science in Gloucester Point. As the monitoring is population-wide, no subsampling is necessary.

The aerial survey began in limited areas in 1978, going Chesapeake Bay wide in 1984, and expanded to the Coastal Bays in 1986. VIMS has performed the GIS analysis for the entire time series. These data are used by multiple units within DNR, MDE, local jurisdictions, EPA, USFWS, NOAA, USGS and other federal agencies. Annual reports are produced by VIMS and GIS coverage information is transferred to Chesapeake Bay Program.

Data management: Data held by both EPA-CBP and VIMS. Reports and GIS data are available online at: *www.vims.edu/bio/sav*

Programmatic issues:

- No immediate needs to revise monitoring. However, VIMS has begun evaluating using color and multi-spectral images and advanced delineation techniques.

- There are some modifications that could be made to reduce program costs, such as biennial sampling, or alternating segments sampled. However; this would complicate water clarity criteria assessment and would compromise the utility of the existing dataset for trend analysis!

3.1.1.13 Intensive Monitoring

Agency: DNR Resource Assessment Service

Contact: Mark Trice (410-260-8649); mtrice@dnr.state.md.us

Watersheds: Chesapeake Bay embayments/tributaries (Anne Arundel, Baltimore, Calvert, Cecil, Charles, Dorchester, Harford, Kent, Prince George's, Queen Anne's, St. Mary's, Somerset, Talbot, Wicomico); Atlantic Coastal Bays (Worcester Co.)

Media: water column chemistry, phytoplankton, aquatic resources, sediments

Goals: The general goals of the Intensive Monitoring Program are:

1) To better assess important intensive temporal and spatially intensive water quality and habitat conditions in dynamic environments;
2) Identify links between water quality, harmful algal blooms, and fish kills;
3) Analyze shallow water habitat for Submerged Aquatic Vegetation requirements and nursery areas for juvenile fishes; and
4) Assessment of proposed Chesapeake Bay water quality criteria (dissolved oxygen, water clarity and chlorophyll a) that support habitat and aquatic resource needs focused in the Chesapeake Bay 2000 Agreement.
5) Provide data for site identification and evaluation of program success for various living resources restoration projects

Program Description:

One important focus of the Intensive Monitoring Program is the implementation of new monitoring technologies and continuous monitoring to better assess temporally and spatially variable water quality conditions. As part of the US Environmental Protection Agency's Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program the Maryland Department of Natural Resources (DNR) established four EMPACT stations on Maryland's Eastern Shore that have been monitored since the late 1990's with the purpose of providing timely and relevant information regarding harmful algal blooms (focusing on *Pfiesteria piscicida*) and water quality. Physicochemical parameters (water temperature, specific conductance, salinity, and dissolved oxygen concentration) are automatically recorded every 15 minutes with continuously recording meters deployed to monitor both surface and bottom conditions between May and October at these stations. Results are posted online at: *www.eyesonthebay.net* .

A near-real-time water quality monitor was installed at Fort McHenry in Baltimore Harbor. These data are provided to the National Aquarium in Baltimore, which established a kiosk and an educational display describing what visitors see on-line. These projects were designed to allow people to learn more about Maryland's waterways and keep up to date with water quality conditions, impacts such as storm events and harmful algal blooms. Although EPA's EMPACT funding ended in 2002, this monitoring effort continues with funding from NOAA and other partners, which is actively sought to continue and expand this continuous monitoring network to other key tidal tributaries around the Bay.

An other important focus of the Intensive Monitoring Program is Water Quality Mapping, which involves the collection and analysis of geographically referenced, continuous surface water temperature, salinity, dissolved oxygen, chlorophyll, and turbidity data aboard a small moving vessel. These data aid in the assessment of Chesapeake 2000 Agreement's focus on water quality criteria and shallow water habitats that are vital for submerged aquatic vegetation, fish, and shellfish. In conjunction with continuous monitoring and fixed long-term monitoring station data, these spatially-intensive monitoring data can provide a comprehensive spatial and temporal portrait of water quality conditions. Results are posted as water quality maps on the Department's Internet site along with additional information about the project at *http://mddnr.chesapeakebay.net/sim/*.

Each Maryland Chesapeake Bay Segment is scheduled to be assessed for at least three consecutive years with a combination of two or more continuous monitors and monthly water quality mapping cruises from April through October. Continuous monitors are generally located to capture the range of upstream and downstream conditions and provide for a continual data record. Monthly water quality mapping cruise tracks follow paths that capture inshore and open water. Each program collects calibration samples (bi-weekly for continuous monitoring and at 5-8 stations monthly for water quality mapping) for parameters such as extractive chlorophyll, light attenuation, total suspended solids, nutrients, and water column physicochemical profile data. As of the end of 2008, intensive sampling has been completed in **xx** segments and is partially completed (1-2 years of data) in **xx** segments. At the end of 2008, the tidal Potomac River assessment has been completed with monitoring resources scheduled to be transferred to the Tangier Sound/tributaries. Following that, main stem Chesapeake segments will be assessed, and all segments will be assessed by 2014. A map of the current year's monitoring stations and water quality mapping segments, along with archived data and maps from past years can be found online at *http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm* . QAPPs for each program are also available at the website.

Data Management: Data are processed for data quality in a manner similar to the Chesapeake Bay Program data, except that data from real-time sources are posted automatically to the Eyes on the Bay website. Programming for analysis of the data and posting on the Internet is accomplished in-house. There are electronic and overall evaluation/review of the data, which are stored in an Access database. Data are reviewed and are annually (or more often) submitted to the EPA Chesapeake Bay Program.

Programmatic Issues/Needs: Rotating continuous monitors in the State's principal Chesapeake Bay tributaries on a three-year schedule provides an opportunity to assess new shallow water Bay criteria that were established throughout the State's tidal tributaries.

The program works to build partnerships with many different organizations and levels of government to fund the program and collect and disseminate data. Current examples of partners include Harford and Anne Arundel County governments, the EPA/NOAA Chesapeake Bay Program, NERRS, State of Virginia, University of Maryland, Virginia Institute of Marine Sciences, and St. Mary's College of MD.

In addition to criteria assessment, data from the intensive monitoring program can be used to help identify restoration sites for artificial fishing reefs and oyster reef initiatives that are now in the planning phase. We will continue to provide data that serves as input for SAV restoration site identification. This monitoring effort can also help with fisheries habitat identification.

Having a three-year rotating assessment cycle allows for the capture of data that may occur during drought, average and/or flood years. There is a need to maintain sentinel sites in the Bay to observe data over the entire statewide assessment cycle (2003-2014) Maintaining sentinel sites is difficult due to funding limitations - the longest term sites having been where there has been additional external support from organizations such as The US Department of Commerce/National Oceanic and

Atmospheric Administration's National Estuarine Research Reserve System (NERRS) research sites (Monie and Jug Bays, and Otter Point Creek.

3.1.1.14 Lakes

All of the principal lakes in Maryland are man-made reservoirs created by impounding water behind a dammed stream or river. There are numerous, small natural lakes created by beaver dams, as coastal impoundments created by natural shoreline drift, and as natural, water-filled depressions. Based on connecting River Reach traces (1:100,000 scale), the US Environmental Protection Agency identified 947 lakes in Maryland, however, these include many stormwater and waste treatment lagoons and impoundments surrounded by private lands or on federal property - these are often inaccessible to the public. For implementation of Clean Water Act Section 314, the State identified 58 'significant, publicly-owned lakes' as water bodies having public access, a surface area of five acres or greater, providing public benefit, and available for other public uses (e.g., public water supply, fishing). 'Run-of-the-river' lakes, formed behind relatively low dams on rivers, are not included in this profile.

Maryland's significant, publicly-owned lakes are found in all physiographic provinces and in all counties except Calvert, Dorchester and Talbot Counties (Figure 9*)*. These lakes range in size from 5 to 4,500 acres and account for a total surface area of 21,010 acres. Most lakes are small (the 45 smallest lakes account for 10 percent of the total lake area; the 4 largest lakes account for more than half of the State's total lake acreage).

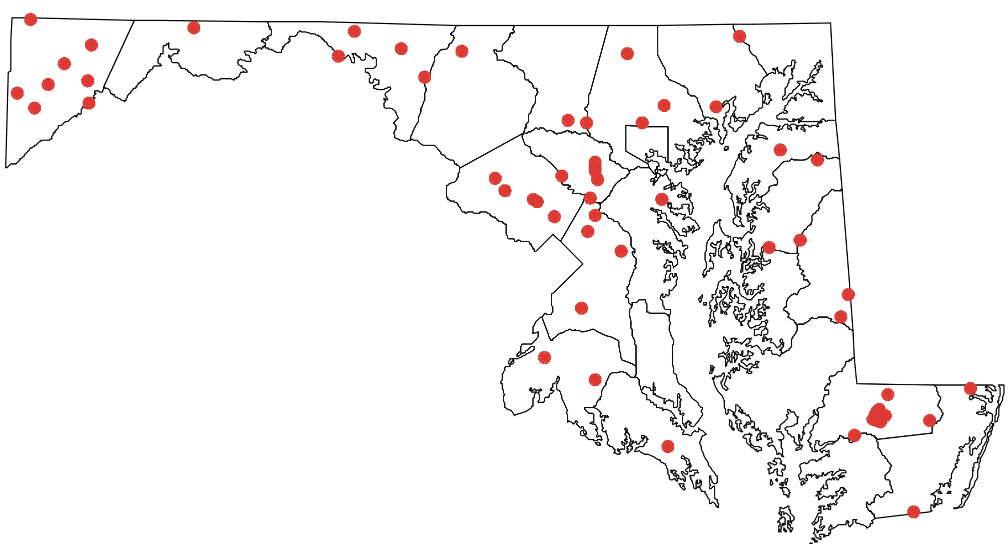


Figure 9: Significant, publicly owned lakes in Maryland

3.1.1.14.1 Short-Term Lakes Monitoring Strategy and Objectives

Maryland's current monitoring strategy for lakes is seven-fold:

1. Continue targeted monitoring of lakes listed on the State's 303(d) in order to achieve Water Quality Standards for those water bodies;
2. Continue cycling throughout the State's recreational lakes to monitor for contaminants in fish tissue;
3. Continue to respond to citizen complaints and investigate fish kill/algal bloom events in lakes when notified;
4. Support existing and proposed local agency and volunteer monitoring efforts in lakes that can support State agency needs;
5. Support projects funded by Clean Water Act Section 319 set-aside (Nonpoint Source Program) funding for lake assessment/restoration activities defined as replacement fund source for Section 314 (Clean Lakes Program) projects; and
6. Support lake/watershed management activities to protect and restore water quality, aquatic habitat and aquatic resources in publicly-owned lakes.
7. Support EPA national lake survey efforts to assess the quality of the nation's lake waterbodies.

3.1.1.15 Current Status of Lakes Monitoring in Maryland

3.1.1.15.1 Local Agency/Volunteer Lake Monitoring support

Agency: DNR Resource Assessment Service

Contact: Sherm Garrison (410-260-8624); sgarrison@dnr.state.md.us

Watersheds: All with significant, publicly owned lakes and local interest in monitoring water quality in these water bodies

Media: water column chemistry, phytoplankton, aquatic resources, sediments

Goals: The general goal of this effort is to assess status of lake conditions (trophic status) and aquatic habitat and resources

Program Description:
The Department of Natural Resources, local and quasi-governmental agencies and federal agencies own and manage most reservoirs in Maryland, principally for uses including fish and wildlife habitat, recreational purposes (fishing, bathing, boating), water supply, water quality or flood control. There are several reservoirs owned by residential community organizations for private recreational purposes or businesses which partially managed several reservoirs for hydropower generation.

Larger impoundments drain larger watershed areas and may experience different levels of eutrophication which can affect use. Several of these agencies have established water monitoring programs collecting physical and chemical water quality information to determine ambient conditions or trends and /or are used to implement reservoir management strategies focused on the quality of water withdrawals (water supply needs) or downstream releases (improving water quality, meeting minimum downstream flow or increasing storage capacity needs).

While there is no State review of these monitoring programs, some programs use defined QA Project Plans and Standard Operating Procedures. While DNR cannot prescribe certain field, laboratory or analytical methods to be used, database software or format, all water quality datasets should meet minimum data elements defined by the Maryland Water Monitoring Council (MWMC). In a few instances, some agencies have supported volunteer/citizen monitors to collect data. Lake water quality data and/or summary reports may be published for intra-agency or public consumption or the data may be available upon request. Digital data and reports received by DNR are subject to storage/disposal action through the State's records retention policies.

Data Management: Review of these data is managed internally and is the responsibility of the originating agency.

Programmatic Issues/Needs:

1) A Statewide assessment of trophic conditions in lakes was last done in 1991-1993. Although trophic conditions are believed to change only gradually with time, a Statewide reassessment is long overdue. New, publicly owned lakes have been created and basic water quality information is needed or needs updating. Proposals for funding a Statewide trophic lake assessment project within the State's Section 319 (Nonpoint Source) Program thus far have had low priority.

2) Expansion of the Maryland Water Monitoring Council's Monitoring Roundtable to include data from other water bodies (lakes) will provide opportunities for sharing information and cooperation on lake monitoring activities.

3) The lack of consistent QC documentation limits confidence in available results

3.1.1.15.2 US EPA - National Lakes Assessment

Agency: DNR Resource Assessment Service

Contact: Ron Klauda (410-260-8615); mailto:rklauda@dnr.state.md.us

Watersheds: All natural or man-made lakes, ponds, and reservoirs identified on the National River Reach file (not including waste lagoons, process ponds or tidally-influenced coastal ponds were eligible for selection. Four lakes selected at random by EPA, were reviewed by DNR and approved for sampling (Johnson Pond, Lake Kittamaqundi, Lake Habeeb, Lake Louise). Two lakes (Piney Run Reservoir, Savage River Reservoir) were sampled by EPA Regional biologists as reference lakes.

Media: water column, sediment, littoral habitat, aquatic plants, fish, invertebrates, bacteria

Goals: The goals of this program are to:

1) Provide statistically valid regional and national estimates of the water quality, aquatic resource and habitat condition of lakes in the United States and
2) Use consistent sampling and analytical procedures so that results can be compared across the country

Program Description:
This National Lake Assessment program is one of five national waterbody assessment efforts (lakes, streams, rivers, tidal waters, wetlands) that EPA plans to initiate between 2007 and 2011. If funding can be continued, this effort would become cyclic and would eventually provide sufficient data to define trends.

The sampling design uses a probability-based sampling design to represent the condition of all lakes in similar regions sharing similar ecological characteristics. Consistent sampling and analytical procedures ensure that the results can be compared across the country.

DNR field staff attended a regional training program and sampling trips were scheduled in late summer 2007. In each lake, one mid-lake site was selected for most sample collections. For nearshore habitat surveys, 10 transects were defined in each lake. In the field, samples were collected, field processed if necessary, labeled and shipped by courier to an EPA- designated laboratory along with completed field sheets.

Data Management:
This National Lake Assessment program is one of five national waterbody assessment efforts (lakes, streams, rivers, tidal waters, wetlands) that EPA plans to initiate between 2007 and 2011. If funding can be continued, this effort would become cyclic and would eventually provide sufficient data to define trends. Results of this effort have been posted

Programmatic Issues/Needs:
This National Lake Assessment program is one of five national waterbody assessment efforts (lakes, streams, large rivers, coastal waters, wetlands) that EPA plans to initiate between 2007 and 2011. If funding can be continued, this effort would become cyclic and would eventually provide sufficient data to assess long-term changes.

Specific issues about this program include:

1) State-specific results are limited to six lakes in Maryland. If at least 40 lakes are sampled using this process in a State, EPA would assess a similar statistical summary of lake conditions for the State, though finding a source of funding to add 36 more lakes is problematic.
2) Compilation, review, analysis and reporting took an inordinate amount of time - hopefully this was a result of being the initial water - interim results were provided some 18 months after data and samples were submitted to EPA.

3.1.1.15.3 Monitoring Program Development Activities

Maryland has developed a draft proposal to update the 1993-1995 Statewide Trophic Lake Assessment for use in 305(b) and 314 reporting and 303(d) listing. Secchi depth, total phosphorus and chlorophyll a data collected would be used to update this information. New, publicly owned lakes and other lakes not previously examined might be included. An expanded database would be used to develop a Maryland-specific trophic condition index. Updated trophic conditions will be reported in the State's Integrated 305b/303d report that, with other water quality and physicochemical data collected, will help evaluate use support. Inclusion of this information in this report meets the 314 reporting requirements for future funding. Samples collected across seasons and in different lake zones would provide information about spatial and temporal variability in trophic classification. The trophic assessment data collected with concurrent satellite imagery data eventually would be used to develop a satellite-based trophic assessment process for future updates.

3.1.1.15.4 Long-Term Lake Goals and Objectives

Congressional recession of Clean Lakes funds in 1995 ended activities in Maryland's developing Statewide Lake Management Program. In November 2000, the Estuaries and Clean Water Act of 2000 (P.L. 106-457) authorized funding for Clean Lakes through FY2005, however, the Administration has never requested and Congress has not appropriated funds for this effort. Because demand far exceeds available funds, lake project proposals submitted for lake management suggested in the §319 (Nonpoint Source) program have never been identified as "high priority" projects or funded. Reauthorization of the Clean Lakes Program funding beyond FY2005 and Administration support for fund appropriation is critical for restarting Maryland's Lake monitoring efforts.

If Maryland were to receive funding to reestablish a Statewide Lake Water Quality Assessment Program and analyze data on trophic condition, the State will update its listing methodologies to incorporate the latest data, analytical and statistical techniques. The listing methodology will then be open to public review and comment prior to application for 303(d) listing purposes. Development of a lake index of biotic integrity is another useful assessment tool that may be worthy of pursuing in future years.

3.1.2 (B) Drinking Water Supply:

Surface water sources such as rivers, streams, and reservoirs serve approximately two-thirds of the State's 5.1 million citizens. The remaining one-third of the State's population obtains water from underground sources. Both surface and ground water sources are monitored to assure that all Marylanders have a safe and adequate supply of drinking water.

3.1.2.1 Drinking water protection program

Agency: MDE Water Management Administration

Contact: Bill Beatty - compliance (443-482-2700); wbeatty@mde.state.md.us
John Grace - source water protection (410-631-3713); jgrace@mde.state.md.us

Watersheds: Surface water intakes/utilities in streams classified as potable water supply

Media: water column

Goals: To protect the physical, chemical and biological integrity of the ground water resource in order to protect human health and the environment, to ensure that in the future an adequate supply of the resource is available, and to manage that resource for the greatest beneficial use of the citizens.

Program Description:
MDE's Water Management Administration oversees the surface water intake monitoring results from utilities, monitors basic water quality, documents chemical quality conditions at water intakes, and provides a basis for monitoring future trends. These sites are tested for major dissolved ions, bacterial indicators, selected trace elements, selected volatile organic compounds, several classes of pesticides, and selected radionuclides - (***see Ground water - Source Water Protection Program***).

Finished Water Protection Program **-** Maryland's public drinking water monitoring program meets all Federal mandates of the Safe Drinking Water Act. This program monitors 1,024 municipal drinking water supplies for maximum contaminant levels established by the US Environmental Protection Agency. Self-monitoring is required of all public supplies as specified in federal regulations. Compliance monitoring is conducted by the Water Management Administration for specific constituents including bacteriological, chemistry, THMs (trihalomethanes), VOCs (volatile organic carbons), pesticides, radiation, radon, metals, and nutrients (nitrates and nitrites). Monitoring efforts also include responses to consumer complaints and emergencies where protection of public health is a primary concern.

3.1.2.2 Drinking Water Supply, Groundwater

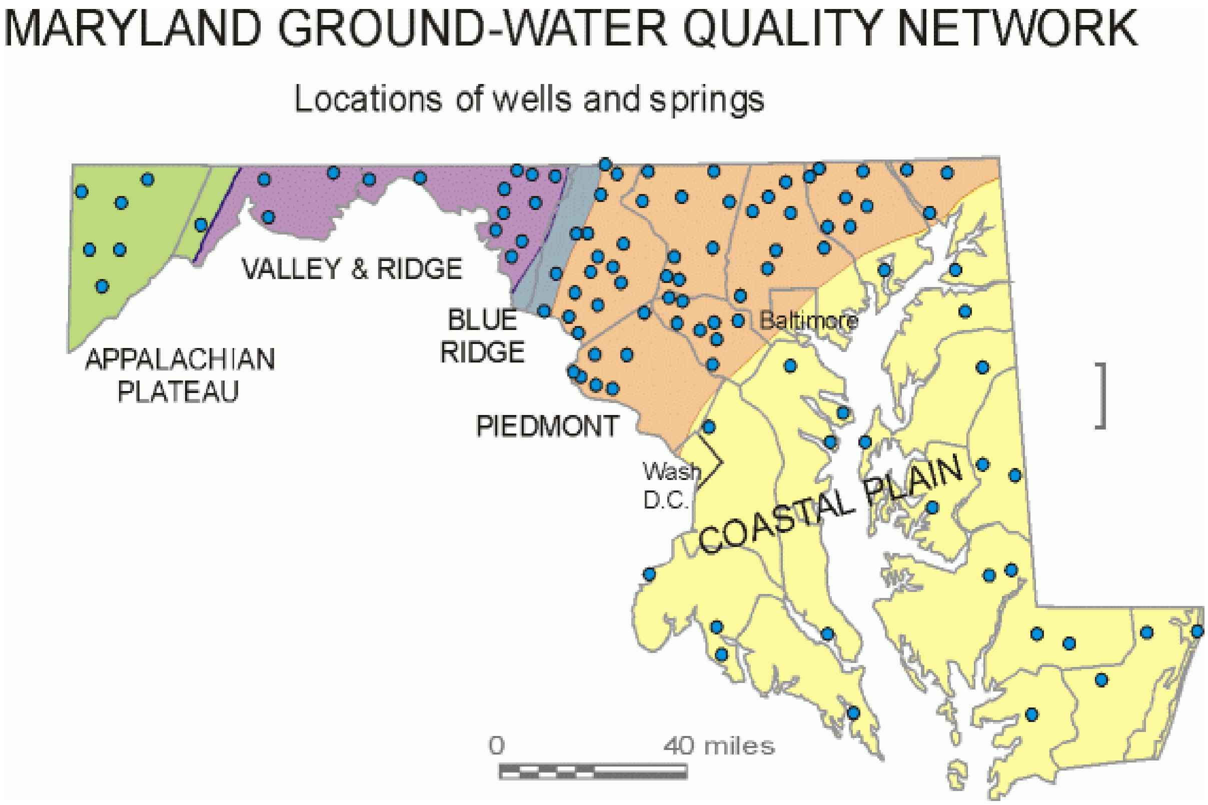


Figure 10: Maryland's Groundwater Quality Monitoring Network

Ground water is an abundant natural resource that serves as a significant source of drinking water in Maryland. Ground water levels in unconfined aquifers undergo seasonal fluctuation and are principally recharged by precipitation during the fall and winter months, while ground water levels in confined aquifers are not as responsive to short-term variability in climate or precipitation. About 31 percent of the State's population use ground water as a drinking water supply. In Southern Maryland and the Eastern Shore, ground water meets practically all of the water supply needs. About half of the Marylanders acquire drinking water from a well that they own, while the other half obtain drinking water from public water supplies that use ground water. Ground water contributes to base flow water in the State's rivers, streams, tidal tributaries and the Chesapeake and Coastal Bays. Other major uses of ground water include agriculture and industry.

Geologic conditions vary widely across Maryland and produce significant variations in the quantity and quality of ground water. Aquifers in Maryland fall into two major types- unconsolidated sedimentary rock aquifers of the Coastal Plain Physiographic Province found east of the Fall Line, and hard rock (consolidated sedimentary and crystalline rock aquifers found in the western part of the State (Figure 11). The Coastal Plain aquifers, composed primarily of sand and gravel with layers of silt and clay, are productive, and generally of good quality. The hard rock aquifers typically have a lower yield than unconsolidated sedimentary aquifers of the Coastal Plain.

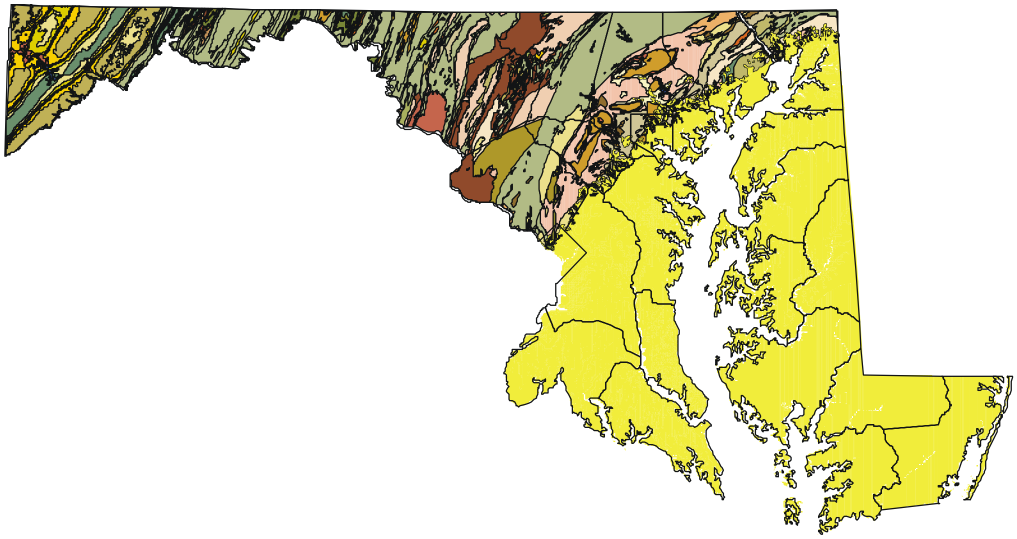


Figure 11: Coastal Plain aquifers and upland geological formations in Maryland

Short-Term (2 to 5 years) Ground Water Monitoring Strategy and Objectives

The State of Maryland is committed to protect the physical, chemical and biological integrity of the ground water resource, in order to protect human health and the environment, to ensure that in the future an adequate supply of the resource is available, and in all situations, to manage that resource for the greatest beneficial use of the citizens of the State. To this end, the State will continue to: monitor ambient groundwater conditions on a five year rotation; work with counties to develop special studies on pollutants of concern; monitor public water systems (for both quantity and quality) that serve communities of 25 people or greater for more than 60 days a year; and, monitor ground water in areas of known pollution sources to protect public health and the environment. Also, the State will continue to monitor wells serving 25 people or greater in non-transient, non-community areas (schools, work places, etc.) for both acute and chronic levels of contaminants.

3.1.2.2.1 Drinking Water Quality

A significant amount of sampling occurs at public water systems to determine if the water being supplied is in compliance with State and Federal drinking water standards. Sampling requirements depend on system type, system size, source type, system vulnerability and contaminant. Community ground water systems are subject to monitoring requirements for over 80 contaminants that have health-based standards or maximum contaminant levels. Forty-two other unregulated contaminants are also tested at these systems. Water supply systems often use ground water with little additional treatment. The most common treatment objectives to improve ground water quality, in descending order, are: pH adjustment, iron removal, corrosion control, inorganics removal, softening, particulate removal, organics removal, manganese removal, and radionuclide removal.

3.1.2.2.2 Cadmium in Ground Water in the Aquia aquifer in central Anne Arundel County, Maryland

In 2003, cadmium concentrations in several domestic water-supply wells in the Aquia aquifer in central Anne Arundel County exceeded the USEPA's Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L). The Department of Natural Resources-Maryland Geological Survey (DNR-MGS) analyzed additional water and core-sediment samples in 2005 to better define the distribution and hydrogeologic and geochemical relations of cadmium in the area. The study indicated that the elevated cadmium concentrations are found only within the weathered upper part of the Aquia Formation, and ground water in this zone appears to have a different chemical signature than ground water in the unweathered lower part of the Aquia Formation. Cadmium concentrations increased with decreasing pH and increasing chloride concentrations. Cadmium concentrations in core-sediment samples were not consistently higher in the weathered zone than in the unweathered zone. The study did not determine whether the cadmium was from natural or human sources. A preliminary map was developed showing the depth to the base of the weathered zone that can be used to guide depth specifications for new wells. The County requires wells in the area that have a pH less than 6 to be tested for cadmium. Less than 2 percent of the new wells sampled have exceeded 5 micrograms per liter cadmium.

3.1.2.2.3 Arsenic in Ground Water in the Major Aquifers of the Maryland Coastal Plain

The Department of Natural Resources-Maryland Geological Survey (DNR-MGS) continued its investigation of arsenic in ground water in the major aquifers of the Coastal Plain, in cooperation with the Maryland Department of the Environment. In addition to the approximately 300 samples collected in the initial phase of this project, about 3,200 arsenic analyses were obtained from county health departments for domestic wells, and 200 arsenic analyses were obtained from MDE for public-supply wells. These additional data were used to refine arsenic distribution patterns in the Aquia and Piney Point aquifers. Bands of elevated arsenic concentrations were delineated in each of these aquifers that run roughly northeast-southwest, and appear to be associated with the chemical evolution of ground-water geochemistry. An additional area of arsenic exceedances was identified in the shallow portion of the Aquia aquifer in the Mayo area of Anne Arundel County. This area is localized (about two miles by one mile), and appears to be distinct, both laterally and chemically, from the main band of elevated arsenic in the Aquia aquifer.

3.1.2.2.4 Ground Water Virus Study

A second of two studies was completed by the U.S. Geological Survey (USGS) for MDE in 2002, concerning the occurrence and distribution of viral contamination in selected public supply wells. Both studies selected public supply wells using less than 10,000 gallons per day.

One study ranked over 270 wells in Worcester and Wicomico counties based on depth and surrounding land use. Twenty-seven wells, which were ranked highest for potential for viral contamination and where permission was secured from the property owner, were sampled. Each site was sampled for basic water quality parameters (nutrients, major cations and anions, pH, temperature and conductance), RNA and DNA viral fragments, bacteria, culturable viruses and coliphages. For additional information, please go to http://md.water.usgs.gov/publications/wrir-01-4147/.

The second study randomly selected 91 wells from all public systems pumping less than 10,000 gallon/day in Baltimore and Harford counties. The wells were sampled for the same suite of indicators, viruses and water chemistry parameters as identified above.

3.1.2.2.5 Radium in Coastal Plain Ground Water

As a continuation of a study of radium occurrence in ground water, a project was undertaken for MDE by the MGS to examine the aquifer materials as related to the radium measured in the ground water in aquifers in Anne Arundel County. A report describing a study of the geochemistry of aquifer materials from two core holes in northeastern Anne Arundel County was prepared by MGS for distribution in June 2003. The study was undertaken because ground-water samples from shallow wells in the Magothy and Patapsco Formations often contain measurable concentrations of radium (even though concentrations of radon, a decay product of radium, tend to be low), whereas samples from shallow wells in the Aquia Formation generally have low radium concentrations but, in some cases, relatively high radon concentrations. For additional program details, go to http://www.mgs.md.gov/hydro/aagisindex.html.

3.1.2.2.6 Arsenic in Ground Water in the Major Aquifers of the Maryland Coastal Plain

In accordance with the funding and agreement with MDE the MGS continued its investigation of arsenic in ground water in the major aquifers of the Coastal Plain. About 25 percent of samples from the Aquia aquifer and 10 percent of samples from the Piney Point aquifer exceeded USEPA's newly established drinking-water standard of 10 micrograms per liter (µg/L); most of the exceedances were from Queen Anne's, Talbot, Dorchester, and St. Mary's Counties. Arsenic was detected only sporadically in wells from other aquifers. Following the initial phase of the study, about 60 wells were resampled and analyzed for major ions, nutrients, and arsenic species. Most arsenic was present as arsenite (the reduced form), which tends to be more mobile in ground water than arsenate (the oxidized form). Additional samples were collected from the Aquia aquifer in the Kent Island area to gather information on local variability in arsenic concentrations (both vertically and laterally). Data analysis is continuing. For more program details, see http://www.mgs.md.gov/hydro/arsenic/index.html.

3.1.2.2.7 MTBE

A multi-phased approach has been initiated by MDE to determine the extent of MTBE's impact to ground water in Maryland. Emergency legislation passed during the 2000 legislative session created a 16-member Task Force in which MDE participated, to investigate and assess the environmental impact of MTBE to Maryland's waters. The Task Force reported its findings in December 2001. The Oil Control Program also began an initiative to identify existing and potential pathways of migration of petroleum from active USTs to ground water and to assess the threat of past releases of petroleum that were cleaned up prior to analysis for MTBE. For more details, please go to http://www.mde.state.md.us/programs/landprograms/oil_control/mtbe_update/index.asp.

3.1.2.2.8 Pesticides

In July 2002, MGS and MDA (Pesticide Regulation Section) began a project in which 20 wells in central and southern Maryland were analyzed for approximately 60 pesticides, nitrogen isotopes, and other constituents. The objectives of this study were to determine the types and concentrations of pesticides that are present in ground water in central and southern Maryland, and to evaluate the relationship between nitrate concentrations, $^{15}N/^{14}N$ isotope ratios, pesticide detections, and other data in order to identify sources of nitrate (i.e., agricultural, residential, or natural sources). Data indicated that deethyl atrazine (a breakdown product of atrazine and other triazine herbicides), atrazine, and metolachlor were the most frequently detected pesticide residues. All pesticide detections were less than 1 µg/L, and none of the detections exceeded drinking-water standards (although not all the pesticides detected have drinking-water standards established). Nitrogen-isotope data in conjunction with other water-quality data suggest a variety of sources for nitrate in samples having above-background levels of nitrate.

3.1.2.3 Long-Term (5 to 10 years) Ground Water Monitoring Goals and Objectives

Maryland delegates local jurisdictions (all but three) with the responsibility for permitting well construction for public systems only. Some water quality data (nitrates and bacteria) are collected in the permitting process. However, many counties do not store these data in an electronic medium. The State would like to have these data available for decision-making and plans to assist the local jurisdictions in this effort.

3.1.2.3.1 Source Water Assessments

Maryland is enhancing previous wellhead protection activities by committing to developing source water assessments for all community ground water. All source water assessments have recommendations for protection of the water supply and water suppliers are strongly encouraged to develop and implement protection measures. Maryland's Source Water Assessment Program (SWAP) is described in detail on its web site at: http*://www.mde.state.md.us*. The SWAP was approved by EPA in November 1999.

One priority for the WSP is to ensure the safety of new public water supplies by reviewing and evaluating proposals for the siting of new wells. To ensure that wells are sited in the safest locations, staff review Departmental databases to identify existing or potential contamination sources, and use site investigations to verify this information and evaluate any additional factors that might influence the safety of the water supply. In FY 2003 the program reviewed proposals for the siting of approximately 50 new public water supply wells (see http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/sourcewaterassessment/index.asp).

3.1.2.3.2 Water Quantity

MDE's Water Supply Program has the responsibility of controlling the impacts of ground water withdrawal through the water appropriation and use permit process. With few exceptions, all ground water uses must be authorized through MDE's permitting process. Exempt from the requirement for a water appropriation permit are uses for temporary construction dewatering (up to 30 days and 10,000 gallons per day), creation of small subdivisions (10 lots or fewer), individual domestic use, agricultural use under 10,000 gallons per day, and extinguishing a fire.

Each permit application is evaluated for the reasonableness of the amount of water planned for a particular use and the impact of that use on the resource and other users of the resource. Aquifer testing, fracture trace analysis, water level monitoring, the development of a water balance and other investigation techniques are part of the evaluation. Through the permit review process, the Water Supply Program attempts to avoid impacts to other water users and assures that ground water withdrawals do not exceed the sustained yield of the State's aquifers.

In addition, MDE has delineated some areas for special management considerations. An example is Kent Island where, to prevent further degradation of the Aquia aquifer from salt-water intrusion, new appropriations are directed to deeper aquifers. Ground water modeling is also used to project the impacts of comprehensive land use plans and direct future development.

Agricultural water use has been growing steadily in recent years, particularly for irrigation on Maryland's Eastern Shore. In general, MDE directs large irrigators to use the water table aquifer, reserving the more protected confined aquifers for individual potable and municipal uses. In some areas, however, the water table aquifer produces low yields, or is nonexistent, compelling an increasing number of farmers to seek water appropriation permits for confined aquifers.

The Maryland Geological Survey has and continues to conduct special studies to evaluate water supply, including: a four-year study begun in 1991 of the hydrogeologic characteristics and water supply potential of the Patapsco aquifer system in southern Maryland; a study of the water-supply potential and natural water quality of the Aquia and Magothy aquifers in southern Anne Arundel County; as well as a study to determine optimum pumping scenarios for wells in the Waldorf system pumping from the lower Patapsco aquifer.

3.1.2.4 Ground Water Monitoring Programs

3.1.2.4.1 Ground-Water Level Monitoring Network

Agency: U.S. Geological Survey, Maryland Geological Survey

Contact: Jim Gerhart (443-498-5501), David Bolton (410-554-5561)

Watersheds: All aquifers in Maryland.

Media: Ground water

Goal: Ground-water levels in observation wells are measured throughout all of Maryland's physiographic provinces and major aquifers. Ground-water level data are critical to water-resources management goals as indicators of climatic variations, including droughts, and as indicators of the impact of ground-water withdrawals on the State's ground-water resources. Ground-water level data also are important indicators of streamflow conditions, as ground water provides more than half of the flow in Maryland's streams.

Program Description:
The overall observation-well network in Maryland currently includes about 650 wells (Figure 12). The overall network includes numerous sub-networks: (1) A statewide climate-variability sub-network; (2) sub-networks in 7 major confined aquifers; and (3) several project-based sub-networks.

The climate-variability sub-network tracks the effect of climatic variations on shallow ground-water resources, and currently has about 30 wells. The sub-networks in the 7 confined aquifers monitor the impact of pumping on deep ground-water resources, and currently have about 110 wells. Project sub-networks address specific ground-water resource issues in specific areas. The largest project sub-network is the Southern Maryland project sub-network, which has about 250 wells.
The observation wells in the climate-variability sub-network are measured either continuously with automatic recorders or monthly by manual measurements. Most of the wells in the 7 sub-networks in confined aquifers are measured 1-2 times per year, with a small number measured continuously. Project sub-network wells are measured at various frequencies dictated by project needs. The wells in the Southern Maryland project sub-network are measured 1-2 times per year. About 30 wells in the overall network provide near-real-time ground-water levels.

Expansion of the Stream-Gage Network:
The Maryland Water Monitoring Council convened a workshop in 2002 for stakeholders of the ground-water level network, and a summary report is being prepared by the Maryland Geological Survey for publication in 2009. The report describes the current climate-variability and confined-aquifer sub-networks, and makes recommendations for how the sub-networks should be expanded to provide the additional data that all stakeholders need. The 2008 report of the Advisory Committee on the Management and Protection of the State's Water Resources adopted the recommendations of the MGS report, which include the addition of about 50 observation wells to the climate-variability sub-network and about 50 observation wells to the confined-aquifer sub-networks. As a result of the Advisory Committee report, discussions are underway to prioritize the needed additional wells and to identify funding sources.

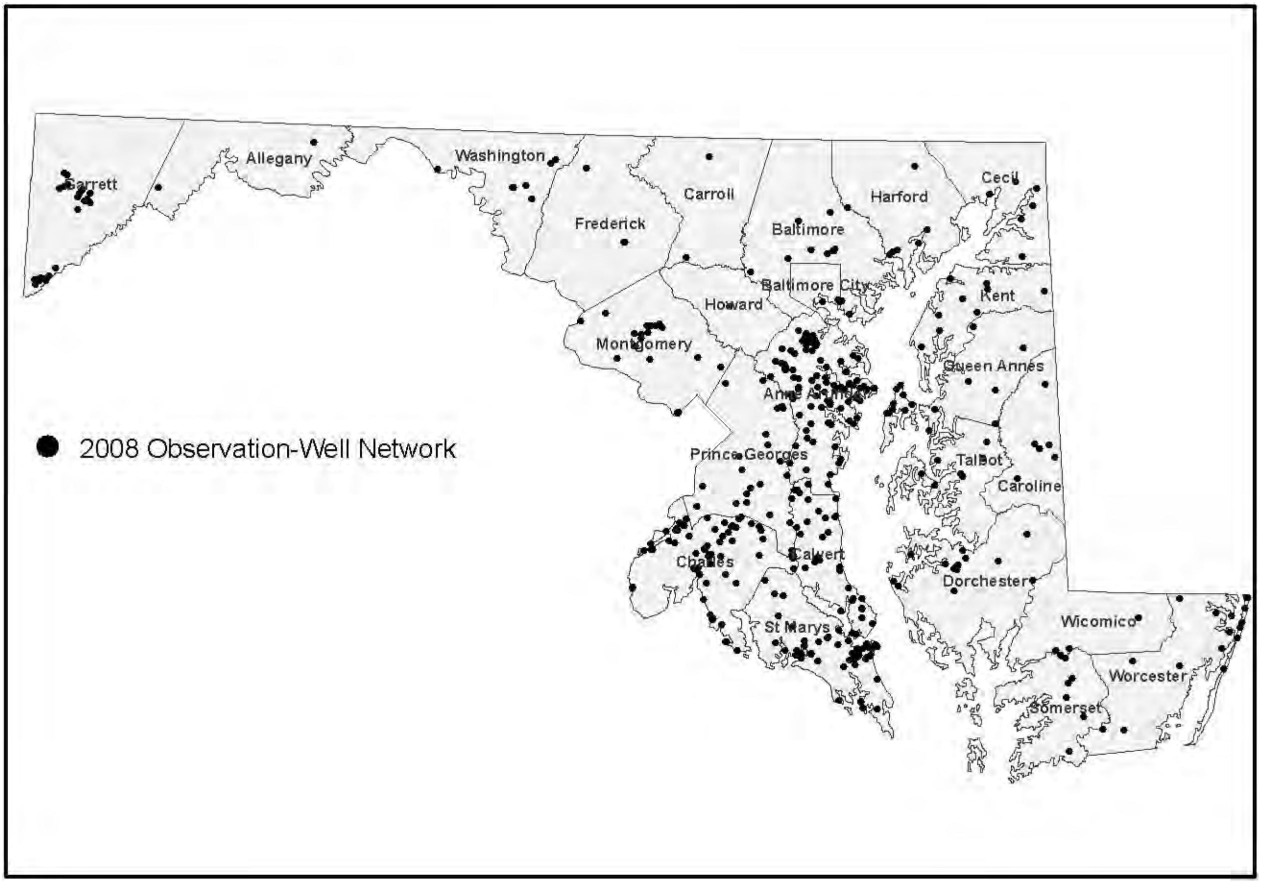


Figure 12: Ground Water Monitoring Wells

3.1.2.4.2 Maryland Ground Water Quality Network

Agency: Maryland Geological Survey (MGS)

Contact: David Bolton (410-554-5561); dbolton@dnr.state.md.us

Watersheds: Ground water throughout Maryland

Media: Ground water throughout Maryland

Goals: Collect samples from a statewide network of wells and springs in order to 1) document ambient groundwater quality conditions in aquifers, and 2) collect long-term groundwater-quality data from wells and springs throughout Maryland.

Program description:
MGS resamples approximately 100 network wells and springs approximately every 5 years and analyzes the data for long-term changes in groundwater quality. Additional wells are sampled to provide more detailed data on areas or water-quality constituents of interest. Most sites are in unconfined aquifers, but samples are sometimes collected from confined-aquifer wells to fill in data

gaps. For additional monitoring program information, please go to http://www.mgs.md.gov/hydro/qwindex.html.

3.1.2.4.3 Assessment of the Water Resources of the Fractured-Rock Area of Maryland

Agencies: DNR Maryland Geological Survey (MGS)
U.S. Geological Survey (USGS)

Contact: MGS: David Bolton (410-554-5561); dbolton@dnr.state.md.us
USGS: Matthew Pajerowski (443-498-5506); mgpajero@usgs.gov

Watersheds: Ground water system in central and western Maryland

Media: ground water

Goals: Conduct a comprehensive assessment of the fractured-rock resources of Maryland; develop a set of tools that can be used to more effectively manage the water resources in the fractured-rock area of Maryland (Figure 13).

Program description:
This Assessment was one of the recommendations of the 2004 report by the *Advisory Committee on the Management and Protection of the State's Water Resources*. It is a multi-year, multi-agency assessment that is beginning in 2009. The assessment will include the area of Maryland that is west of Interstate 95, which includes the Piedmont, Blue Ridge, Ridge & Valley, and Appalachian Plateau provinces. The goals of the assessment are to: 1) develop a comprehensive database of surface-water and ground-water information; 2) develop a statistically-based software tool to estimate water availability; 3) determine streamflow requirements for aquatic organisms in streams in different settings; 4) determine factors affecting ground-water availability in different hydrogeologic settings; and 5) establish research watersheds to assess watershed processes in different settings. The assessment is planned to take place over five years.

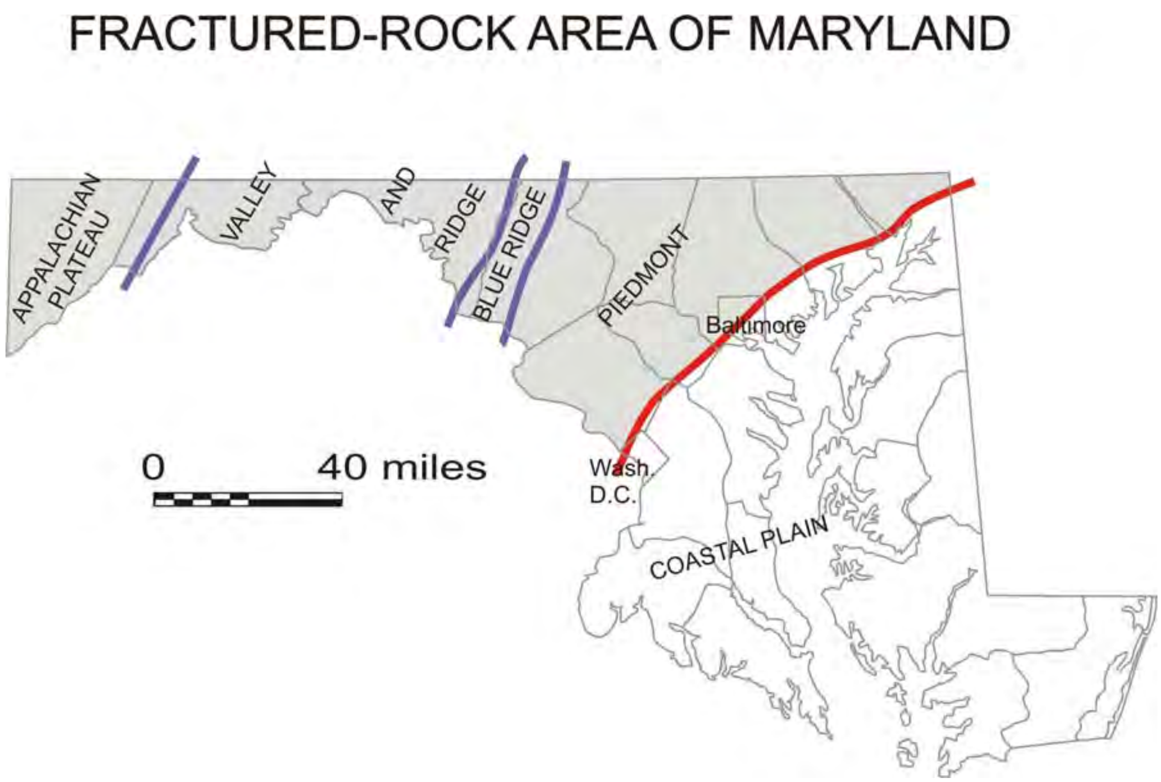


Figure 13: Fractured-Rock Area of Maryland

3.1.2.4.4 Comprehensive Assessment of Maryland Coastal Plain Aquifer System

Agencies: DNR Maryland Geological Survey (MGS)
U.S. Geological Survey (USGS)

Contact: MGS: David Bolton (410-554-5561); dbolton@dnr.state.md.us
USGS: Robert Shedlock (443-498-5503); rjshedlo@usgs.gov

Watersheds: Ground water system in Southern Maryland and the Eastern Shore

Media: ground water

Goals: Conduct a comprehensive assessment of the ground-water resources of the Maryland Coastal Plain

Program description:
This Assessment was one of the recommendations of the 2004 report by the *Advisory Committee on the Management and Protection of the State's Water Resources*. It is a multi-year, multi-agency assessment that was begun in 2006. The goals of the assessment are to: 1) document the geologic and hydrologic characteristics of the aquifer system in the Maryland Coastal Plain and appropriate areas of Delaware and Virginia; 2) conduct detailed studies of the regional ground-water flow system; 3) document water-quality patterns in all aquifers; 4) enhance ground-water-level, stream-flow, and water-quality monitoring networks in the Coastal Plain; and 5) develop better tools to improve the sound management of the ground-water resources in the Maryland Coastal Plain.

The assessment is being conducted in three phases. In the first phase, which began in 2006, the hydrogeologic framework is being refined, data gaps are being identified, and an Aquifer Information System is being developed that will allow all appropriate water data to be accessed by water-management personnel. In the second phase, a regional ground-water flow model will be developed, field studies will be carried out to fill in information gaps, and the water-monitoring networks will be enhanced. The third phase will focus on developing and using management tools to optimize water use.

3.1.2.4.5 Brackish-water intrusion monitoring, Kent Island

Agency: Maryland Geological Survey, in cooperation with Queen Anne's County, MD.

Contact: David Bolton (410-554-5561); dbolton@dnr.state.md.us

Watersheds: Chesapeake Bay, Maryland

Media: Ground Water

Goals: Determine trends in chloride concentrations in the Aquia aquifer associated with brackish-water intrusion from Chesapeake Bay.

Program Description:
Brackish water from the Chesapeake Bay is present in the Aquia aquifer within about a quarter mile of the entire bay shore of Kent Island. Water with elevated chloride concentrations (10 to 1,000 mg/L) is present in the upper part of the Aquia aquifer along the western shore of Kent Island.

The Maryland Geological Survey has collected water samples from a network of domestic and observation wells on Kent Island since 1984 to determine long-term trends in chloride concentration of the Aquia aquifer. Approximately 35 wells are sampled annually for chloride, specific conductance, and pH. Water levels are also measured in the observation wells.
The monitoring data indicate that, in general, chloride concentrations are elevated and increasing in the upper Aquia aquifer in the central part of the bay shore on Kent Island. North and south of that central area along the bay shore, chloride concentrations are elevated but do not show a general trend. The lower Aquia aquifer is brackish along the entire bay shore. Inland from the bay shore (about ¼ mile) the entire section of the Aquia is fresh, and does not show evidence of an increasing trend. Trends in chloride concentrations may indicate slight landward movement of the brackish-water interface, but variations mask the trends on parts of Kent Island.

3.1.2.4.6 Salt-water Intrusion Monitoring Investigations, Ocean City

Agency: U.S. Geological Survey, in cooperation with Maryland Geological Survey and the Town of Ocean City, MD.

Contact: Holly Weyers (302-734-2506, x 224); hsweyers@usgs.gov
Watersheds: Coastal Worcester County, Maryland

Media: Ground Water

Goals: Detect warning signs of salt-water intrusion into the confined aquifers in the Ocean City area.

Program Description:
The USGS has been monitoring trends in ground-water quality and ground-water levels in confined aquifers in Coastal Worcester County since 1985. These aquifers include the Manokin, which is the deepest fresh-water aquifer in the area, and the overlying Ocean City and Pocomoke aquifers.
Five wells are instrumented with continuous water-level recorders. Water levels are measured monthly in 23 wells. Approximately 11 wells are pumped shortly after Labor Day each year and samples are analyzed for chloride concentrations. Water samples are collected from operating production wells and analyzed weekly by the Worcester County Health Department at Ocean City.
The primary area of concern for increased chloride concentrations in the confined aquifer is at the 44th Street Water Plant, where chloride concentrations in the Ocean City aquifer have gradually increased from about 70 milligrams per liter (mg/L) in the mid 1970's, to about 230 mg/L in 2008. This increase has been studied, and was found to be caused by movement of water upward from the deeper Manokin aquifer, through a nearly absent confining layer, upwards toward the production wells in the Ocean City aquifer at 44th St. An upward gradient is created when the production wells in the Ocean City aquifer are being pumped. The source of the higher chloride concentrations in the Manokin aquifer appears to be water with higher dissolved mineral content and likely older than the water in the surrounding area in the Manokin aquifer, and not from salt-water intrusion coming from downdip and under the ocean.
Reports with graphs showing water levels, chloride concentrations in production wells, and pumpage from each of Ocean City's water plants since 1974 are prepared and delivered annually to MDE and the Town of Ocean City.

3.1.2.4.7 Salt-water Intrusion Monitoring, Anne Arundel County

Agency: Maryland Geological Survey, in cooperation with Anne Arundel County Department of Health

Contact: David Andreasen (410.260.8814); dandreasen@dnr.state.md.us
Watersheds: Anne Arundel County, Maryland

Media: Ground Water

Goals: Determine if the brackish-water/freshwater interface in the Aquia, Monmouth, and Magothy aquifers on Annapolis Neck, Mayo Peninsula, and Broadneck is migrating landward.

Program Description:
Changes in the position of the brackish-water/freshwater interface are determined by comparing borehole geophysical logs (resistivity) and chemical analyses (chloride and specific conductance) to earlier testing of test wells on Broadneck, Annapolis Neck, and the Mayo Peninsula. Knowledge of the position of the interface is critical to insuring the continued supply of fresh ground water to the many domestic wells present on the three peninsulas. Periodic assessments provide guidance to water-supply planners, sanitary engineers, and well drillers in effectively developing the water supply.

3.1.2.4.8 Water Supply Program

Agency: MDE Water Management Administration

Contact: John Grace - source water protection (410-537-3714); jgrace@mde.state.md.us

Watersheds: Ground water supply wells

Media: ground water

Goals: To ensure safe and adequate public drinking water in Maryland. .

Program Description:
The Water Supply Program (WSP) is responsible for ensuring safe and adequate public drinking water in Maryland. Statewide about 800,000 residents, served by about 460 community ground water systems, use over 80 million gallons of water per day. Additionally there are about 3,300 Maryland facilities relying on ground water, which are defined by the Safe Drinking Water Act as non-community public water systems. These small facilities include schools, day care centers, places of work, restaurants, churches, community centers and campgrounds that have their own source of water. For additional program details, please visit http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/home/index.asp

3.1.3 (C) Water Contact Recreational Uses:

Water contact recreational uses are monitored for compliance with Maryland water quality criteria to protect public health and aquatic resources.

3.1.3.1 Beaches Monitoring

Agency: MDE

Contact: Kathy Brohawn Kbrohawn@mde.state.md.us
Heather Morehead hmorehead@mde.state.md.us

Watersheds: Tidal tributaries and Mainstem Chesapeake Bay

Media: water column

Goals: To protect public health from water-born pathogens associated with swimming beaches.

Program Description:
Non-tidal Beaches. Non-tidal beaches include stream areas like Cunningham Falls State Park and various quarries such as Oregon Ridge. Local health departments are responsible for monitoring and maintaining the facilities required for permitted beaches. MDE tries to communicate and apply lessons learned with regard to monitoring program design from the coastal program.

Tidal (or coastal) waters. Coastal beaches that are typically our most used beaches are the most intensely monitored beaches. Local health departments are responsible for the monitoring and MDE provides both technical and resource assistance through the BEACHES Act funding (typically about $250,000 per year in total).

3.1.3.2 Harmful Algal Bloom Response

Agency: MDE Field Evaluation Division

Contact: Chris Luckett (443-482-2731); cluckett@mde.state.md.us
Charles Poukish (410-537-4434 or 410-482-2732; cpoukish@mde.state.md.us)

Watersheds: All - wherever algae and aquatic odor complaints occur

Media: water column, aquatic resources

Goals: (1) Respond to public complaints of discolored water in order to identify and document nuisance algae blooms or other phenomena that may be misinterpreted as gross pollution in waters of the state and

(2) Determine algae community composition in response to algae driven low dissolved oxygen induced fish kills in waters of the State, and

(3) Document pollution induced algae blooms and characterize for regulatory response.

Program Description:
The Department of Environment manages a program to investigate discolored water, analyze composition, and initiate emergency containment and recovery initiatives if a pollutant is detected. This response program responds directly to public and local government complaints. Because nuisance algae blooms are typically responsible for discoloring water, this program maintains the capability to identify common algae organisms. The program typically responds to non-toxic mahogany tide bloom organisms including *Prorocentrum minimum*, *Gymnodinium uncatenum*, and *Katodinium rotundatum*, and often initiates state wide response if a toxic species such as *Mirocystis* or *Karlodinium veneficum* is suspected or confirmed. Harmful Algae Blooms (HAB) are quickly forwarded to the DNR Harmful Algal Bloom monitoring program

for dissemination of data to the general public and to coordinate follow-up monitoring. HAB's are responsible for fish kills by both passive and direct association. The program is expanded to support adherence to recreational contact guidance established by the World Health Organization. Algal samples from recognized beaches can be analyzed for algal toxins using ELISA testing. Those results will be used to assist decision-making regarding public advisories. Most of the typical non toxic mahogany tide organisms are responsible for massive low dissolved oxygen-induced fish kills and may be indicative of habitual nutrient or gross organic pollution requiring immediate regulatory response and follow-up. This program enhances the fish kill response program as part of the Clean Water Act Section 106 grant initiative.

3.1.4 (D) Fishing:

State fisheries stocks, including finfish, crabs and shellfish, are routinely monitored to protect public health from potential food chain contaminants.

3.1.4.1 Shellfish stock-Shellfish harvesting area monitoring

Agency: MDE

Contact: Ms. Kathy Brohawn (410-537-3608); kbrohawn@mde.state.md.us

Watersheds: Chesapeake Bay and tidal tributaries (adjoining counties), Atlantic Ocean coastal bays (Worcester Co.) Boundaries are defined in COMAR 26.08.02.08 Use Designations, Use II Shellfish Harvesting Waters.

Media: water column

Goals: The goals of this program are to ensure that commercially harvested shellfish (oysters, clams) harvested from State waters are safe for human consumption, to provide information on potential sources and trends in water pollution levels, and to protect shellfish harvesting water quality.

Program Description:
The program fulfills MDE's responsibilities under the National Shellfish Sanitation Program to classify waters that are safe for shellfish harvesting to protect human health. Shellfish have the potential to accumulate human pathogens, heavy metals or organic chemicals in their tissues even when these materials cannot be measured in the water column. Bacteria monitoring in the water column is conducted to establish the suitability for harvesting to occur. Monitoring contaminant levels is also conducted in oyster and clam tissues to determine whether the specific contaminant levels in these species are within safe limits for human consumption. Go to http://www.mde.state.md.us/CitizensInfoCenter/Health/shellfish/index.asp for locations of shellfish harvesting waters in Maryland.

Shellfish harvest:
The principle goal is to fully implement the requirements of the National Shellfish Sanitation Program (NSSP), which are designed to minimize the risk of contaminated shellfish reaching markets and/or being consumed. MDE's responsibilities under the NSSP are to classify shellfish

harvesting waters. The key elements of shellfish water classification under the program include a sanitary survey which involves: a shoreline or pollution source survey, statistical analysis of bacteria monitoring data, evaluation of the effect of any meteorological, hydrodynamic, and geographic characteristics of the shellfish harvesting waters, evaluating performance of any waste water treatment facilities that discharge to shellfish harvesting waters, and protecting shellfish waters through regulation. Below is a description of the water monitoring component only.

3.1.4.2 Fish Tissue Monitoring Program

Agency: MDE Technical and Regulatory Services Administration

Contact: Charles Poukish cpoukish@mde.state.md.us
John Backus Jbackus@mde.state.md.us

Watersheds: Selected commercial/recreational harvesting areas in non-tidal and tidal tributaries and lakes - 10 sites each year

Media: water column, aquatic resources (fish, shellfish and crabs)

Goals: The goals of this program are to ensure that aquatic resources harvested from State waters are safe for human consumption, and to provide information on potential sources and trends in water pollution levels.

Program Description:
Fish and shellfish have the potential to accumulate heavy metals or organic chemicals in their tissues even when these materials cannot be measured in the water column. This makes these aquatic animals good indicators of environmental pollution in a body of water. Monitoring contaminant levels in tissues also allow the determination of potential human health effects. Go to http://www.mde.state.md.us/CitizensInfoCenter/Health/fish_advisories/index.asp for more monitoring program details.

The evaluation of the data in determining potential health effects considers:

- Persistence and fate of chemical contaminants in waters and sediments;
- Types of aquatic animals present in the water body;
- Fat content, feeding, and migration habits of those aquatic animals;
- Ability of each contaminant to accumulate in tissues of aquatic animals and humans;
- Human and animal health effects information for each contaminant;
- Preparation, cooking, and fish consumption behaviors of fishers/crabbers;
- Likelihood that sensitive populations eat these animals.

MDE has monitored chemical contaminant levels in Maryland's fish and shellfish since the 1960s. Fish monitoring focuses on species that are either predators (bass, perch, and sunfish) or bottom feeders (catfish, carp, and suckers). Within these categories, efforts are focused on those species with a relatively high fat content, however, game fish are preferred targets. Consistency in species throughout the State allows for the assessment of regional trends. Sampling is generally conducted from the end of summer through early fall to avoid biological extremes that can be linked to spring spawning. The goal is to composite five fish in each species sample. Where quantities and weights allow, fish fillets and whole fish samples are collected to provide for both human health and environmental evaluations. Standard procedures for collecting, handling, preserving and analysis have been established to maximize data integrity.

Historical sampling strategies have included annual and biennial collections at approximately 30 sites for general trend assessments. A triennial sampling strategy has been utilized since 1990, with 1/3 of the State sampled each year. Sampling is conducted in localized areas where special needs have been identified.

MDE also has been monitoring chemical contaminant levels in shellfish (oysters, clams) and crabs from the Bay and its tributaries. Because of low levels of contaminants and negligible yearly changes in those levels, this Bay-wide monitoring effort occurs every three years. If necessary, small intensive surveys are performed during off years. Sampling in the estuarine program from the beginning of summer to late fall prior to harvesting.

Fishing (Use I): Fish consumption advisories: Develop and distribute fish consumption advisories to educate the public so they can make informed decisions about eating recreationally caught fish. Monitoring occurs annually and is funded in the amount of approximately $200,000 per year.

3.1.5 (E) Anti-degradation and Protection

Various state waters are routinely monitored to help protect water quality for future generations.

3.1.5.1 Water Quality Protection (Tier II)

Agency: MDE

Contact: Matthew Rowe mrowe@mde.state.md.us
John Backus jbackus@mde.state.md.us

Watersheds:
2007 – Northeast River, Wicomico River, Zekiah Swamp, Nanjemoy, Middle Patuxent River, Upper Chester, Upper Choptank and South Branch Patapsco River
2008 – Liberty Reservoir, Deer Creek, Zekiah Swamp, Youghiogheny River, Lower Patuxent, Mattawoman Creek, Little Youghiogheny, South Branch Patapsco, Nanjemoy Creek, Langford Creek,

Media: fish/benthos and water

Goals: To identify additional Tier II sites and to start collecting baseline water quality data in previously identified Tier II waters.

Program Description:
Identifies (using GIS and other tools) existing water segments that have the greatest chance of being identified as Tier II or high quality waters (i.e., both fish and benthic community score equal to 4 or

greater). Fish and benthic samples are then collected in these segments and analyzed using MBSS protocols.

3.1.5.2 Wellhead Protection

The Wellhead Protection Program (WHPP) is a preventive program designed to protect public water supply wells from contamination by establishing a wellhead protection area (WHPA) around each well. Existing and potential contamination sources are identified and plans for management are developed. EPA approved Maryland's Wellhead Protection Program in June of 1991. The program coordinates wellhead protection activities among State agencies, public water suppliers, local governments, and the public. The WSP assists local governments in delineating WHPAs, and in developing management programs to protect water supplies within the wellhead protection areas (see http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/wellheadprotection/index.asp)

3.2 Other Key Monitoring Functions:

These critical monitoring functions are not specifically designed to support designated use or anti-degradation policy. They include; monitoring for long-term water quality trends, TMDL implementation effectiveness, documentation of pollution sources for TMDL development, compliance monitoring, reactive monitoring in response to episodic environmental events, and monitoring for water quality standards research and development.

3.2.1 (F) Long-term Trends:

Several monitoring programs, including MBSS, Chesapeake Bay Monitoring and the Core Monitoring Network serve a duel management role because they augment both designated use and long-term trend analysis (see section 3.1). The monitoring programs listed below are uniquely designed to support long-term trend analysis.

3.2.1.1 Stream-Gage Network

Agency: U.S. Geological Survey

Contact: Jim Gerhart (443-498-5501)

Watersheds: Selected perennial non-tidal streams statewide

Media: Water column

Goal: Stream gages are operated throughout Maryland to meet numerous water-resources management goals of Federal, State, and local agencies. Streamflow data are crucial to water-resources management goals in many ways, including allocation of water resources, evaluation of drought conditions, watershed management and planning, and discerning long-term climatic variations.

Program Description:
The stream-gage network in Maryland currently includes 130 gages where streamflow is continuously monitored and served on the web on a near-real-time basis (Figure 14). The gages are funded by more than 20 Federal, State, and local agencies. Drainage areas range from less than 1 to 27,100 square miles, and include all of Maryland's diverse physiographic provinces. Many of the gages have been operated for more than 50 years.

Expansion of the Stream-Gage Network: Based on recommendations of the Maryland Water Monitoring Council in 2000, it is recommended that Maryland's stream-gage network be expanded to include 157 gages. The 2008 report of the Advisory Committee on the Management and Protection of the State's Water Resources supports that recommendation. Discussions are underway to develop a plan and identify funding sources to expand the network.

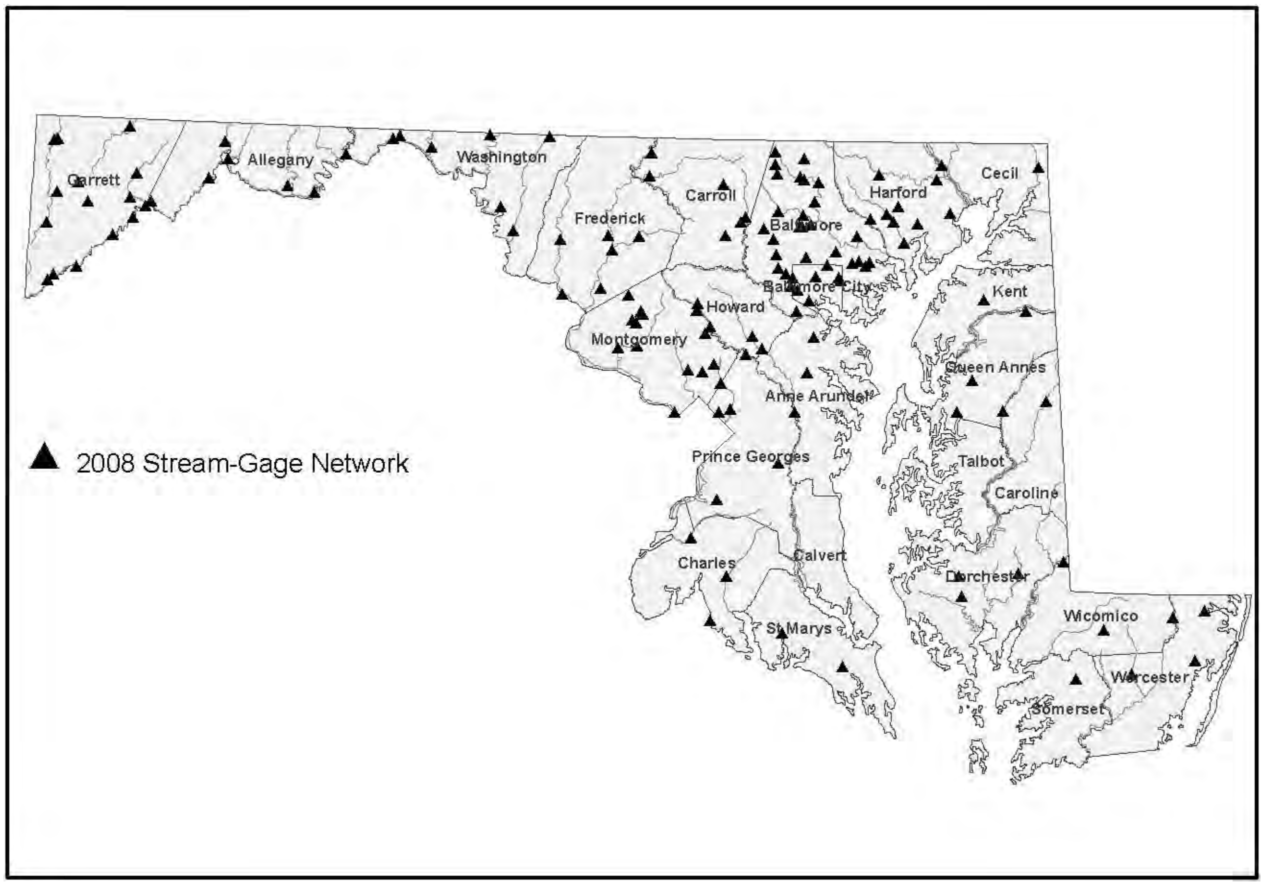


Figure 14: Steam-Gage Network

3.2.1.2 Wetlands

There are a total of approximately 757,000 acres of wetlands in Maryland; roughly 342,626 acres are nontidal wetlands and 261,309 acres are tidal wetlands. The remaining wetland areas are non-tidal shoreline areas adjoining river and lakes (Tiner and Burke 1995). Wetland areas occur in all physiographic regions of the State and in all counties. In Maryland, most wetland areas have been lost due to filling, drainage, agriculture, urbanization, transportation, and other commercial uses.

3.2.1.2.1 Short-Term Wetlands Monitoring Strategy and Objectives

The objective is to build on current monitoring efforts and research in order to implement a statewide wetlands assessment program.

3.2.1.2.2 Current Status of Wetlands Monitoring in Maryland

The US Environmental Protection Agency has developed national guidance for a comprehensive wetland monitoring and assessment program.

3.2.1.2.3 Monitoring Program Development Activities

Maryland's wetland management activities are diverse and spread among numerous State agencies, and in different programs within those agencies. Due to the extent of information and diverse management efforts, the development of a detailed, multi-agency strategy will likely be a complicated process. The number of potential information sources, their suitability, limitations, format, and location, is extensive. Numerous pilot efforts have been undertaken by MDE and DNR, as well as by other States. MDE has an interagency agreement with Virginia Polytechnic Institute and State University to evaluate various wetland assessment and monitoring methods. The report will be finished by the end of 2009.

This project seeks consensus from a variety of stakeholders in wetland management. Consensus will be sought through discussions and exchanges of written materials between stakeholders. The first meetings were held with representatives from State agencies only. After some a basic consensus is reached, the work group will expand to include representatives from federal and local agencies, academic institutions, and other advisory groups. Meetings were held on August 29, 2006; September 19, 2006; and October 19, 2006. The Association of State Wetland Managers will be providing background reports and moderator services to MDE for meetings with a broader stakeholder work group. The first meeting is expected to be held in June 2009.

Agencies agreed that both wetland condition and function should be assessed. A draft wetland classification system, that allows sorting by hydrogeomorphic (HGM) wetland types and a Department of Natural Resources (DNR) community classification.

A three-tiered approach has been proposed to assess the overall condition of wetlands in an entire watershed using a statistical sampling procedure. The Three tiers are:

1. Landscape level (GIS based) analysis of wetland condition by HGM class. Requires trained personnel, software, current databases and adequate computing power but can do large areas in a short period of time.
2. Rapid on-site assessment method (RAM) for a selected sample of wetlands within the watershed population of wetlands of that class.
3. Intensive field sampling of a relatively small number of sites. The results will be used for calibration of landscape level and rapid assessments.

This tiered approach is mutually interdependent. The intensive measurements validate the results of the RAM, the on-site RAM validates the landscape level analysis. The intensive sampling yields indices that are scaled to reference conditions. Without on-site verification, of at least a random sample of locations, a landscape level GIS exercise is meaningless.

Maryland has been a member of the Mid-Atlantic Wetland Work Group (MAWWG), an organization of federal and State agencies and academic institutions that exchanges information on various aspects of wetland monitoring. MAWWG has held semi-annual meetings since 2002.

In 2007, MDE completed an EPA-funded project to evaluate effectiveness of the State's compensatory wetland mitigation efforts. Most sites evaluated were found to meet the wetland definition and contained features associated with wetland functions. This is the first effort to monitor wetlands for anything other than wetland parameters, and it will evolve over time. MDE's progress and future developments of the scoring system will be included in the monitoring strategy. The report is available from MDE. MDE continues to monitor mitigation sites for wetland characteristics and function.

Progress reports on strategy development through 2008 are available from MDE. Further information and links on Maryland's wetland monitoring efforts is available on MDE's web page at:

www.mde.state.md.us/Programs/WaterPrograms/Wetlands_Waterways/about_wetlands/monitoring.asp

3.2.1.2.4 Future Goals and Objectives

MDE will form a broader stakeholder group in 2009 to assist in strategy development. The strategy is scheduled for completion in 2010. In addition, as a grant deliverable to EPA, MDE will prepare draft designated uses for wetlands and identify potential reference sites.

3.2.2 (G) Implementation Effectiveness:

TMDL implementation monitoring is designed to demonstrate the success of pollution remediation efforts.

3.2.2.1 Bacterial Source Tracking- Public Health

Agency: MDE

Contact: William Beatty wbeatty@mde.state.md.us

Watersheds: all

Media: water column

Goals: protect public

Program description:
Bacterial source tracking meets two management objectives. The first is to establish source contributions for the purpose of developing a TMDL. The second is to direct management attention to those sources that pose the highest risk, can most effectively reduce overall bacterial concentrations, or that can be most effectively mitigated.

3.2.2.2 Shoreline surveys-Public Health

Agency: MDE

Contact: William Beatty wbeatty@mde.state.md.us

Watersheds: Chesapeake Bay, Tidal Tributaries, Coastal Bays, and Atlantic Ocean.

Media: On-site Waste Disposal Systems

Goals: To comply with the mandates of the National Shellfish Sanitation Program by conducting Sanitary Surveys of all shellfish harvesting waters through the use of the Shoreline Survey Program. This mechanism provides data that allows the Shellfish Certification Division to properly classifying the waters for shellfish harvesting by commercial and recreational watermen**.** To protect public health and to maintain Maryland's certification as a nationally approved shellfish exporting state.

Program Description:
Both the shellfish and beaches programs require shoreline surveys. The surveys evaluate the entire watershed at a detailed level, including visiting homes to evaluate septic system functioning, to determine possible sources of coliform bacteria. The management objective is to identify such sources so they can be corrected.

3.2.3 (H) Source ID and TMDL Development:

The following monitoring programs are designed to help identify specific pollution sources for TMDL development.

3.2.3.1 Biological Stressor identification

Agency: MDE

Contact: Lee Currey lcurrey@mde.state.md.us

Watersheds: Maryland 8-digit

Media: Biological/Habitat/Chemical Monitoring

Goals: Stressor Identification for biologically impaired watersheds

Program Description:
The management objective for stressor identification is to determine the impairing substance(s) for each biological impairment so that a TMDL can be developed, the impairment can be attributed to an impairing substance for which a TMDL has been developed but not yet implemented, or it can be determined that a TMDL is not required.

Use I, All nontidal uses are monitored for the presence of contaminants from nonpoint source runoff. Some monitoring is provided through the stormwater program. Point source toxic discharges are addressed through discharge permits, DMRs, and WET testing.

3.2.3.2 Watershed Cycling Strategy

Agency: MDE Science Services Administration

Contact: Lee Currey lcurrey@mde.state.md.us

Watersheds: Statewide - focus on impaired watersheds on State's 303(d) list and NPDES modeling needs.

Media: water column

Goals:
(1) Provide the detailed spatial data needed for modeling and development of total maximum daily loads (TMDLs) necessary to achieve water quality standards, and
(2) Provide detailed data for determining permit limits for all facilities in a given watershed that are operating under National Pollutant Discharge Elimination System (NPDES) permit.

Program Description:
The Clean Water Act requires that impaired watersheds be evaluated and monitored in a comprehensive manner so to identify all point and nonpoint sources of pollutants, and to allocate the pollutant loads among the various sources. This process is designed to produce the information necessary to allow managers to estimate the pollutant loads and develop total maximum daily load (TMDL) estimates so that impairments to the designated uses of the water can be corrected. When impairments or potential impairments are demonstrated by CORE/Trend water monitoring data, Maryland Biological Stream Survey data, Chesapeake Bay Monitoring Program and/or other data, the intensive watershed monitoring and evaluations conducted under this program will confirm the extent of the impairment. These data are then used to calibrate the models necessary to develop and define the TMDL and permits needed to correct the impairment.

Maryland has instituted a five year watershed cycling strategy designed to focus monitoring at a large number of sites in a portion of the State each year. One fifth of the state is monitored intensively each year in order to cover the entire State in a five-year rotation. Referred to as the "Watershed Cycling Strategy", the effort integrates monitoring for TMDL development, evaluation of progress towards TMDL goals, and permit development of each of the five regions of the state on a five-year rotation (MD Dept. of the Environment, 1999c). Maryland anticipates that each step will take approximately one year to complete in each region. The watershed cycling strategy establishes a natural evaluation framework as the cycle is repeated.

Implementation of the steps will be staggered through each of the watersheds and resources for each step focused in one region each year starting with the Lower Eastern Shore in 1998.

This monitoring program tracks the hydrologic year, sometimes termed the "water year", which begins on October 1st. This full-year monitoring allows for the collection of information on representative hydrologic flow regimes. Critical 7-day, 10-year low flow conditions and those associated with flooding are obtained from flow records maintained by the US Geological Services gauging station network. The monitoring design is to collect water quality samples from key points located throughout the water body of interest, during three low flow and three high flow periods during the annual cycle. Parameter coverage is determined each year based on the impairment being investigated. Monitoring activities include measurements of streambed geometry and/or tidal bathymetric profiles that are necessary mathematical model inputs.

Maryland's cycling strategy has been successful in that all monitoring throughout the five larger watersheds has been completed for eutrophication. A major portion of the toxic monitoring has also been completed.

3.2.4 (I) Compliance:

Monitoring is performed to comply with National Pollution Discharge Elimination System (NPDES) and other regulatory requirements.

3.2.4.1 Hart/Miller Island Dredge Impact Assessment

Agency: MDE Science Services Administration

Contact: Charles Poukish cpoukish@mde.state.md.us

Watersheds: Upper Bay

Media: Benthic Macro-invertebrates

Goal: To assess water quality impact from Hart/Miller Island dredge disposal site.

Program Description:
Twice a year, in the spring and fall, twenty-two long-term monitoring sites are sampled, identified and evaluated for benthic macroinvertebrate health. These efforts support MDE permitting and dredge site operation.

3.2.4.2 NPDES point source permit monitoring

Agency: MDE Science Services Administration

Contact: William Beatty WBeatty@MDE.State.md.us

Watersheds: Statewide - water bodies with permitted wastewater discharges

Media: water column

Goal: The goal of this monitoring effort is to provide facility-specific water quality data essential for determining pollutant sources and pollutant loads in the vicinity of the discharge in order to support the development of facility specific permits.

Program Description:
MDE conducts between four and 8 localized intensive water quality studies annually addressing specific permitting concerns. These studies are conducted to evaluate pollutant loading for resolution of disputed permit renewals, requests for increased constituent loads, or complaint resolution. This monitoring program is designed to compliment the *Watershed monitoring ("Cycling Strategy") for water quality impairment determination and TMDL development* described above. Includes requests from other Administrations for assistance from WMA, Hazardous Waste, Oil Spill, etc. While generally anticipated, the specific resource commitment is unknown until a request comes down. Some of these are short term/one day affairs, some require 4+ mandays per month, for a 12 month

period and include boat work etc.

3.2.4.3 NPDES Permit Compliance Monitoring

Agency: MDE Science Services Administration

Contact: William Beatty WBeatty@MDE.State.md.us
This activity falls under the jurisdiction of the Chemical and Biological Monitoring Div..

Watersheds: Statewide - water bodies with permitted wastewater discharges

Media: water column

Goal: provide data to verify the accuracy of data reported by the permitted facilities under self-reporting requirements established in the permits.
WWTP/NPDES discharge monitoring has devolved to periodic sampling for specific constituents such as nutrients, mercury or PCBs for TMDL model needs. As emerging contaminants monitoring needs increase, this activity will increase until standards are set and permit limits applied.

Program Description:
This function is a required under the Section 106 federal grant to the State. It has been conducted since the early 1980s. It involves monitoring at approximately 60 “major” domestic wastewater treatment plants that discharge more than one million gallons per day. Facilities demonstrating non-compliance with established permit limitations, regardless of flow or facility size, are also included in the monitoring program.

The monitoring protocol involves collection of a series of discreet effluent samples over a two-day period along with a composite sample (generally of 24 hours duration), which is routinely split with the facility. Composite duration may be of either 8- or 12-hour duration if the facility’s permit is written for that interval. Flow measurements are made for discrete samples, and total flow is recorded for the compositing period. Pollutant loadings are then calculated and compared to permit authorizations. Samples are also secured for Whole Effluent Toxicity (WET) testing. These samples are taken to the Department’s contract laboratory to determine whether the effluent demonstrates toxic effects on invertebrate and fish organisms. Any positive findings trigger additional monitoring by the State and facility with a Toxic Reduction Evaluation (TRE) conducted by the facility upon confirmation of toxic conditions.

3.2.4.4 NPDES Stormwater Monitoring (Municipal - Nonpoint source)

Agency: MDE Water Management Administration

Contact: Brian S. Clevenger (410-537-3543); bclevenger@mde.state.md.us

Watersheds: Selected watersheds in 10 large municipalities (Anne Arundel, Baltimore, Carroll, Charles, Frederick, Harford, Howard, Montgomery, and Prince George’s counties, and Baltimore City) and the Maryland State Highway Administration.

Media: water column

Goal: The goals of the municipal NPDES storm water-monitoring program include the pollutant characterization of urban runoff from specific land uses and the assessment of receiving stream morphology and biological integrity to guide management program implementation.

Program Description:
Municipal NPDES storm water individual permits are intended to control storm drain system pollution from places with populations over 100,000. Among the myriad of tasks required by these permits is a significant effort to monitor the effects of storm water runoff on urban receiving waters. These monitoring efforts include chemical, biological, and physical assessments within a very specific area.

Each of ten major Maryland jurisdictions and the State Highway Administration is required to select a major storm drain system outfall to monitor storm events throughout their respective five-year permit terms. The selection of these sampling locations is crucial because each jurisdiction is requested to monitor a specific land use in order to determine the types of pollutants produced by that land use. Therefore, each NPDES municipal permit requires the most populated localities in the State to choose an outfall that discharges runoff from one homogeneous area. In addition to this selected storm drain system outfall, a second, downstream ambient monitoring station is required to be established. Storm events are monitored at this instream location in the same way as the upstream outfall. Data are submitted annually that report the results of the sampling activities that occur during the reporting period.

At both outfall and instream monitoring locations, 12 storm event samples are required to be collected and analyzed each year for a suite of constituents including: temperature, pH, biochemical oxygen demand, total Kjeldahl nitrogen, nitrate+nitrite, total petroleum hydrocarbons, total phosphorus, total copper, total zinc, total lead, hardness, E. coli or enterococcus, and total suspended solids. Additionally, continuous flow measurements are taken at sampling locations and used to calculate annual pollutant loads. When extended dry periods are encountered base flow samples may be taken to meet requirements for monitoring 12 events annually.

For biological assessment, the receiving stream system between the storm drain outfall and the ambient station is monitored in the spring. The United States Environmental Protection Agency's (EPA) Rapid Bioassessment Protocol, or the Maryland Biological Stream Survey is used to determine the health and long-term changes in the benthic community. Data are submitted annually with chemical monitoring results.

Finally, within the selected stream reaches, a geomorphologic assessment is performed annually to detect trends with regard to in-stream changes. A series of permanently monumented stream channel cross sections is required to be established. These cross sections, along with stream profiles, are surveyed annually to track geomorphologic changes that occur.

Information collected as a result of this monitoring program is used locally for evaluating pollutant loads and compiled by MDE for determining the types of pollutants found in runoff from specific urban land uses (e.g., residential, industrial, highway, etc.) and calculating event mean concentrations (EMCs). Taken together with the data generated from biological and physical stream assessments, these data will help to tailor management program implementation for reducing pollutants to the maximum extent practicable. Additionally, this monitoring approach provides feedback for improving the State's storm water management program.

3.2.4.5 pH Monitoring Program

Agency: Maryland Department of the Environment Bureau of Mines

Contact: Constance Loucks (301-689-1461), cloucks@allconet.org

Watersheds: Western Maryland Acid Mine Drainage (AMD)

Media: Non-tidal surface water

Goal: Acid mine pH monitoring is primarily carried out in conjunction with lime doser operations in the North Branch of the Potomac, Georges Creek,
and Cherry Creek.

Program Description:
Historically this program collected over 1000 or more samples a year for chemical laboratory analysis. In 2008, this program was reduced to approximately 300 samples a year. Yearly results include specific AMD seep data as well as influent and effluent data passive treatment systems. Prior to 2008 water quality data was collected at main stem stations in Cherry Creek, Georges Creek, North Branch Potomac, Aarons Run, and the Casselman River watersheds. Only one main stem station (Cherry Creek) was sampled in 2008.

3.2.4.6 NPDES Pretreatment Monitoring

Agency: MDE Water Management Administration

Contact: Michael Richardson (537-3654) MRichardson@mde.state.md.us

Watersheds: Statewide

Media: water column

Goal: The goal of the Pretreatment Monitoring program is to assure that user-provided information about pretreatment reduction of pollutants of concern from industrial facilities will not pass through or interfere with operations of publicly owned treatment works (POTWs) or affect the beneficial uses of POTW biosolids.

Program Description:
Significant industrial users which discharge wastes to municipal wastewater
systems are directly regulated by MDE and are responsible for self-monitoring wastewater at least twice per year. This ensures that representative samples of the industrial wastewater discharges into local sanitary sewers are analyzed for permitted pollutants of concern. This is accomplished by MDE

oversight of local industrial user pretreatment programs as well as MDE permitting of significant industrial users in non-pretreatment areas of the State. In order to confirm and amend these data, MDE samples their sanitary sewer effluent for the same pollutants of concern.

Where applicable, 24-hour composite samples are collected. Grab samples are taken for pH, oil and grease, total petroleum hydrocarbons, volatile organics, sulfides and other parameters where this type of sampling is applicable. Flows are measured where this is a regulated parameter. All samples are collected at the same or a location equivalent to where the SIU takes its samples. All data are forwarded to the Water Management Administration's Pretreatment Section and analytical results are compared with industry permit requirements. Appropriate management and enforcement actions are taken when necessary.

3.2.4.7 Superfund Program

Agency: MDE Waste Management Administration

Contact: John Fairbank (410-537-3475); jfairbank@mde.state.md.us

Watersheds: Ground water wells

Media: Ground water

Goals: Obtain the data necessary to identify the highest priority sites that pose a threat to human health or the environment. Investigate, oversee remediation or perform cleanup of these high priority sites. A primary goal of remediation activities is to protect ground water by ensuring that contaminant sources are removed or contained in a manner which minimizes future impacts to ground water. To the maximum extent practicable ground water resources, which have been impacted by contamination, will be restored to their maximum beneficial use or treated to safe levels prior to end use.

Program Description:
The federal "Superfund' program, authorized by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), was established to identify, prioritize and cleanup hazardous waste sites. The Environmental Restoration and Redevelopment Program within the Waste Management Administration ensures that state requirements are met during investigation and cleanup of sites designated for the National Priority List (NPL) and federal facilities under the federal "Superfund" program. In Maryland, 21 sites have been placed on the NPL; 16 of these sites are currently active. The remaining five sites have been removed from the NPL or are in the final stages of completing the remediation process. Additionally, the MDE has a memorandum of agreement with the Department of Defense (DoD) covering 44 federal facilities, 37 of which are not on the NPL. Currently, the DoD is actively working on 22 sites at which MDE is actively overseeing the investigation or remediation of ground water contamination.

State Superfund Program:
A similar program under State law, the State Superfund Program, conducts investigations and oversees the remediation and cleanup of sites listed on the State Master List that are not included on the NPL or are not owned by the federal government. The State Master List contains 439 sites that have been identified statewide with known or potential contamination. In Maryland, there

are approximately 35 State Superfund sites at which MDE is actively overseeing the investigation or remediation of ground water contamination. For additional program information go to http://www.mde.state.md.us/Land/land_programs/index.asp.

3.2.4.8 Oil Control Program

Agency: MDE Waste Management Administration

Contact: Herb Meade (410-537-3385); hmeade@mde.state.md.us

Watersheds: Ground water supply wells

Media: ground water

Goals: Monitoring activities conducted under the Oil Control Program are designed to identify problem conditions with historic tank operations, track the recovery of remediation efforts, and to verify that the integrity of currently installed systems is secure. These efforts are intended to protect surface and ground waters and associated aquatic life from the harmful effects of petroleum and to ensure that potable surface and ground water quality is maintained.

Program Description:
The Oil Control Program, within the Department of the Environment's Waste Management Administration, is the unit responsible for the implementation of the Underground Storage Tank (UST), Leaking Underground Storage Tank, and Aboveground Storage Tank programs. These programs provide for preventive actions to minimize ground and surface water pollution from the storage of petroleum and hazardous substances and for remedial actions to restore sites that have been contaminated by oil or hazardous substances. Under the oversight of the UST program, which began in 1988, the active universe of motor fuel underground storage tanks in the State has been reduced from over 21,000 to just fewer than 8,500. Those motor fuel underground storage tanks that remain have been required to be replaced or upgraded to meet federal standards that became effective on December 22, 1998. These standards include requirements for corrosion protection, leak detection, and spill and overfill protection. With more than 93 percent of Maryland's underground storage tank owners meeting the 1998 federal compliance deadline, the UST program is actively working with the remaining underground storage tank owners to achieve full compliance with the federal requirements. In addition to the motor fuel facilities, Maryland regulates the storage of heating fuel in over 3,700 underground storage tanks.

One of the major causes of releases from underground storage tank systems has been the corrosion of bare steel tanks and lines. Investigations of releases from these tanks are required and those with groundwater impacts are required to define the vertical and horizontal extent of the contamination. Once defined a Corrective Action Work plan is implemented to mitigate the impact of the contamination. The effectiveness of remediation systems is normally evaluated through groundwater monitoring. The Leaking Underground Storage Tank (LUST) Program has tracked reports of over 14,500 confirmed releases throughout Maryland. Of these releases, over 7,500 cleanups have been completed while the Oil Control Program continues to provide oversight of over 7,500 ongoing cleanups.

The Oil Control Program administers the regulation of the transportation and aboveground storage of oil through a series of permitting requirements. The above ground storage facility permits include requirements for monitoring storm water and test water discharges while petroleum contaminated soil treatment facilities are required to also monitor groundwater.

These storage tank programs all work together to prevent the pollution of surface and ground water from releases that can occur from the handling and storage of oil and hazardous substances. For additional program information go to http://www.mde.state.md.us/Land/land_programs/index.asp.

3.2.4.9 Solid Waste Program

Agency: MDE Waste Management Administration

Contact: Edward M. Dexter, P.G. (410-537-3376); edexter@mde.state.md.us

Watersheds: Ground water supply wells

Media: ground water

Goals: The Solid Waste Program is charged with the maintenance of this monitoring program to insure that the public health, safety and comfort, and the quality of the environment, are not compromised due to pollutants discharged from the regulated solid waste and sewage sludge facilities. Several indicators relate to this important function. For Managing Maryland for Results, the Program reports the number of evaluations of groundwater quality at landfills performed each year, and the percentage of received reports reviewed (MMR Goal #3 - Insuring Safe Drinking Water). For the Environmental Partnership Agreement (EnPA) with the United States Environmental Protection Agency (EPA), SWP reports the number of active municipal waste landfills in compliance with groundwater standards.

Program Description:
The Solid Waste Program (SWP) oversees the environmental monitoring of landfills and sewage sludge storage facilities. This activity includes the direction and review of the groundwater and surface water monitoring systems at these sites, to help protect the public health and the environment from pollution, which could be caused by these facilities. Authority for the program is provided in the Environment Article, Subtitles 9-2 and 9-3 of the Annotated Code of Maryland. Also, federal regulations governing municipal waste landfills (40 CFR 258 are applicable for those sanitary landfills accepting municipal waste which operated after 1993.

Classes of facilities monitored include active municipal waste landfills; active rubble landfills; active industrial waste landfills; closed municipal waste landfills which are subject to the federal regulations; closed municipal waste landfills which are not subject to the federal regulations; closed rubble and industrial waste landfills; and sewage sludge storage lagoons. Approximately 78 facilities are monitored routinely, with over 140 separate reports submitted to the Solid Waste Program each year. In addition, one to three special projects are managed each year, which often involve sampling by SWP of surface water, groundwater, waste, and suspected discharges. Some projects also involve sampling of domestic wells, which is coordinated with the local County Health Departments.

Groundwater and surface water sampling is typically on a semiannual frequency, although due to their geologic setting some facilities are on a quarterly frequency for some parameters, while closed facilities which have stabilized or have not experienced a pollutant release may be reduced to an annual sampling frequency. Some sites only sample groundwater; others not only perform sampling for this program but also sample surface or ground water discharges under the NPDES or State Groundwater Discharge Permit programs.

Sampling is performed by contractors or technicians working for the applicants and analyzed at approved laboratories, in accordance with sampling and analysis plans approved by the Solid Waste Program. Some County governments perform sampling using their own technicians, and some have hired the Maryland Environmental Service or other companies to perform this work. The Maryland Department of Health and Mental Hygiene's laboratory performs the analytical work for some sites, whereas most of the analysis is performed by commercial laboratories approved by SWP. SWP requires that laboratories used be certified by DHMH for analysis of drinking water samples, or have an equivalent certification acceptable to SWP.

Data evaluation is performed by the staff of the Investigations and Remediation Section, consisting of a senior geologist/section head, a staff geologist, and a registered environmental sanitarian. Other duties assigned to this section include review of monitoring plans, groundwater investigations, remedial plans, landfill soil gas monitoring plans and data, and landfill closure plans. Go to http://www.mde.state.md.us/Programs/LandPrograms/Solid_Waste/index.asp for more program details.

3.2.4.10 Voluntary Clean-up Program

Agency: MDE Waste Management Administration

Contact: John Fairbank (410-537-3475); jfairbank@mde.state.md.us

Watersheds: Ground water wells

Media: Ground water

Goals: To provide a streamlined process for the remediation and redevelopment of former industrial or commercial properties that are contaminated, or perceived to be contaminated with controlled hazardous substances.

Program Description:
Sites on the NPL, under active enforcement by MDE, subject to a State issued Controlled Hazardous Substances permit or contaminated after October 1, 1997 and owned by a "responsible party" are not eligible for participation in the program. Upon successful completion of the program, participants are also provided limitations on liability for the eligible property. Upon completion of site remediation and restoration activities, each property owner receives a

Certificate of Completion or a No Further Requirements Determination. Frequently these sites are issued requirements that prohibit the use of ground water beneath the property for any purpose. See http://www.mde.state.md.us/Programs/LandPrograms/ERRP_Brownfields/index.asp for more program details.

3.2.4.11 Waste Water Permits

Agency: MDE Water Management Administration

Contact: Jay Prager (410-537-3780); jprager@mde.state.md.us

Watersheds: All

Media: Ground water

Goals: To protect public health and the groundwater resource through the issuance of State Discharge Permits for the discharge of waste water to ground water and oversight of on-site sewage disposal systems and wells.

Program Description:
This program is divided into four divisions. Two of the divisions issue wastewater discharge permits for wastewater discharges to surface waters under the NPDES program.

The State Groundwater Discharge Permits Division protects the public health and ground water source through the issuance of State Discharge Permits. These permits control the discharge of industrial and municipal wastewater to ground water through a variety of methods such as injection wells, large on-site sewage disposal systems and land application systems.

The On-site Systems Division protects public health and the ground water resource by providing oversight, technical support, project review and enforcement of MDE regulations implemented by local governments and which pertain to on-site sewage disposal systems, subdivision of land and well construction. For additional program details, go to http://www.mde.state.md.us/Water/water_programs/index.asp.

3.2.4.12 Pesticides Management

Aency: MDE Pesticide Regulation Section

Contact: Dennis Howard 410-841-2766

Watersheds: All

Media: Ground water

Goals: To develop pesticide management plans to minimize Ground Water quality impacts associated with specific pesticides of concern.

Program Description:

The Maryland Department of Agriculture (MDA) Pesticide Regulation Section, the State's lead agency for implementing the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), has finalized its generic Pesticide Management Plan (PMP). This plan will be used as the basis for the specific pesticide management plans that will be developed to protect the State's ground water resources from contamination. MDA is currently reviewing certain pesticides, identified by EPA, in cooperation with all States and Tribal representatives. These pesticides have been determined to pose the most significant risk to groundwater and/or surface water. To view a list of the pesticide products and MDA's progress, visit http://www.wq.wsu.edu/reports/default.aspx. For additional program details, please go to http://www.mda.state.md.us/plant/ipm.htm.

3.2.5 (J) Reactive monitoring:

This monitoring is performed in response to episodic or unexpected environmental events.

3.2.5.1 Fish Kill Response and Investigations

Agency: MDE Field Evaluation Division

Contact: Chris Luckett (443-482-2731; cluckett@mde.state.md.us)
Charles Poukish (410-537-4434 or 410-482-2732; cpoukish@mde.state.md.us)

Watersheds: All - wherever kill incidents are reported

Media: water column, fish, and other aquatic organisms including salamanders, crabs, and other invertebrates.

Goals: Investigation and associated monitoring of fish kill events is designed to identify the causes of these events. Results provide information to help prevent or reduce the threat of future events, support enforcement of state regulation, and are used in 305(b)/303(d) decisions.

Program Description:
MDE has the responsibility to investigate all fish kills associated with pollution. Events that are caused by disease are investigated jointly with DNR. Since the cause of an event cannot be determined until an investigation is conducted, MDE takes the lead in receiving and responding to reports. Although MDE is the designated lead agency, the resources of DNR are relied upon heavily to assist in the investigations.
The two agencies operate with a standard monitoring plan to ensure that basic information is obtained in a timely manner. Depending upon the nature of the event and the condition of the fish, field investigators will collect, count, and identify affected organisms. Appropriate water, algae identification and enumeration, and tissue samples are collected for laboratory analysis. This includes samples for nutrients, pesticides (and other hazmats), the presence of harmful algae species and their toxins. Field measurements, such as temperature, pH, dissolved oxygen, and other related water quality measures are taken and recorded. Fish and fish tissue samples for histological and pathological examination are collected, when required, and transported to cooperating laboratories. Go to http://www.mde.state.md.us/programs/multimediaprograms/environ_emergencies/fishkills_md/index.asp for monitoring program details.

3.2.6 (K) Monitoring for Revision of Water Quality Standards:

This monitoring is performed specifically to help develop new water quality standards.

3.2.6.1 Water Quality Standards Development

Agency: MDE

Contact: John Backus jbackus@mde.state.md.us

Watersheds: Waters of the state

Media: water column, sediments, wetlands, aquatic life tissues

Goals: Develop data that will support the retention, revision, or establishment of standards

4.0 Quality Assurance

All State agencies that collect water quality data in fulfillment of the State's Water Monitoring Strategy are required to have a quality assurance project plan (QAPP) that documents quality assurance/quality control (QA/QC) procedures as well as an implementation framework. Overlapping layers of QA/QC procedures ensure that water data collected in these programs are of sufficient quality to meet the project's data quality objectives.

Reinforcing the importance of quality data, EPA requires that recipients of funds for work involving environmental data collection comply with the American National Standard ANSI/ASQC E4-1994, "*Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*". As part of the monitoring planning process, EPA requires:

1. Documentation of the State agency's quality management system, and
2. Documentation of the application of quality assurance and quality control activities to a specific monitoring activity (e.g., QAPP).

Using guidance provided by the US Environmental Protection Agency (1999b), both the Department of the Environment and the Department of Natural Resources have developed and implemented agency-wide plans for water monitoring QA/QC processes (MD Dept. of the Environment, 1999b and MD Dept. Natural Resources, 1999, respectively). These documents describe each agency's Quality Management System and institutionalize the agency processes required to achieve adherence to project-specific data quality objectives. For the multi-jurisdictional Chesapeake Bay Program, a Quality Assurance Management Plan (Chesapeake Bay Program, 1999a) has also been developed and follows the guidelines for EPA programs.

Each water monitoring program funded by the EPA is required to have an approved QAPP that documents project layout, purpose, data quality objectives, staff training needs, sample design and methods, sample handling and analytical methods, quality control, instrument calibration, data management, assessment and reporting, and data validation. EPA provides comprehensive guidance (1999a) to assist groups in the development of these plans.

All water monitoring programs must have an approved QAPP in place prior to beginning field work. Approval is required by the assigned agency QA Officer. For monitoring programs supported by EPA funds (including programs contracted outside of State agencies as well as monitoring efforts used to match EPA-funded projects), EPA's Regional QA Officer also must approve the monitoring plan. Water monitoring programs not funded through EPA still are encouraged to develop and use the QA Project Plan process to ensure that data generated are of the highest quality.

The State is also very committed to documenting the quality of the data in the STORET-WQX system. Maryland will continue to work to centralize the QAPPs for State monitoring programs in MDE's STORET-WQX library located in Baltimore, MD.

Each field operation or laboratory has QA/QC procedures that address aspects of training, vehicle operation, sample handling, custody processes, safety, data entry, and instrument operation. These issues are addressed in Standard Operating Procedure documents that are readily available to field/laboratory staff. Updates to these basic procedures usually are focused on modifications to sampling gear, handling and instrumentation, but new programs require development of new procedures or modifications to existing procedures and training and evaluation programs.

5.0 Data Management

The State of Maryland requires water quality and quantity information for a range of management purposes and recognizes that the value of the information is greatly enhanced by it being easily accessible. The value of data is also directly linked to quality.

Water quality and quantity data are available from many sources including:

- State agencies
  - ✓ MDE - Maryland Department of the Environment
  - ✓ DNR - Department of Natural Resources
  - ✓ SHA - State Highway Administration
  - ✓ MPA - Maryland Port Administration
- Federal agencies
  - ✓ EPA - Environmental Protection Agency
  - ✓ USGS - United States Geological Service
  - ✓ COE - U.S. Army Corps of Engineers
  - ✓ USFWS - U. S. Fish and Wildlife Service
  - ✓ NOAA - National Oceanic and Atmospheric Administration
- Local governments
  - ✓ Counties
  - ✓ Municipalities
- Interstate River Commissions (e.g. Interstate Commission on the Potomac River, Susquehanna River Basin Commission, ORSANCO)
- Academic institutions
- Private consultants
- Volunteer and non profit organizations
- Others

EPA mandates that states enter or submit water quality data that they collect under the Clean Water Act to the EPA STORET through Water Quality Exchange (WQX). Centralized collection and management of data by most organizations is not mandated in this manner. In recognition of the fact that there is no overarching authority to direct the activities of these diverse organizations regarding the management of their data, the State is actively working through the auspices of the Maryland Water Monitoring Council to foster coordination, cooperation, and collaboration in all water monitoring activities, including data management.

The Maryland Water Monitoring Council (MWMC) is a volunteer organization that was created (circa 1995) with the idea that promoting discussion among those interested in water quality would lead to enhanced cooperation among the members, including improved data sharing and information exchange. Encouraging utilization of common database structures will improve both information sharing and the value of the data. The MWMC also promotes consistency and coordination in monitoring plans, monitoring methods, data analysis, and reporting. As consensus is achieved in these activities, data management benefits through more consistent and standardized data collection and handling.

While the ideal situation would be to have all data in a single database that could be readily accessible to all participating groups and the public, it is recognized that this is not possible in the immediate future. Newer computer systems, programming language and software applications enable communication and database consolidation on a real-time basis. Through these mechanisms, an alternative approach to the single database is a network of linked, distributed databases. There are probably an optimum number of distributed databases in a manageable decentralized data-sharing network. It is the goal of the State to work with the various data managers to determine this number and then encourage the consolidation of the existing data sources to achieve maximum efficiency.

There are several major data hubs already in existence or under development and they include:

- EPA's Chesapeake Bay Program - CIMS (Chesapeake Information Management System)
- EPA's STORET-WQX (STOrage and RETrieval-Water Quality Exchange) system, funded thru an EPA Water Quality Exchange Grant
- USGS's WATSTORE
- MDE's Enterprise Environmental Management System (EEMS - currently under development)

Each university, volunteer organization, consulting firm, and local government has, or should have, some system for managing their data. The State is encouraging the use of STORET-WQX to mange databases employed by DNR and MDE. To the extent practicable, the use of the STORET-WQX system is being encouraged because of its mandated national structure. For permitting, compliance and enforcement data, Maryland has negotiated a contract with CGI to license, install, implement and maintain their TEMPO® product for the State's environmental regulatory programs.

Data sharing and migration into a central hub also has the benefit of providing data security. While most large agencies have data backup systems and procedures to secure the data from catastrophic system failures, local entities and small organizations may not. Thus, providing for migration into a centralized data hub has an added security benefit that is not always readily appreciated. For data viewing, the State Water Quality Advisory Committee (SWQAC) is considering to propose the GIS application that is being developing through the Governors Bay Stat initiative.

5.1 Surface Water:

DNR primarily utilizes CIMS for data storage, but also maintains a variety of local databases for selected projects. CIMS data are available from a Web site (http://www.chesapeakebay.net) and even provides access to some online real-time data from remote sensing devices. MDE has established a local STORET (WQX) system for data management. Routine uploads to EPA’s national STORET (WQX) system with DNR/CIMS data is occurring under the WQX II grant. Public access is available to those data uploaded to the national STORET (WQX) system via EPA’s STORET (WQX) Web site (www.epa/gov/storet).

The State plan is to promote the utilization of compatible systems, to encourage the transfer and uploading of data into STORET (WQX), and/or create a limited number of other hubs where data can be easily accessed. Under the auspices of the Maryland Water Monitoring Council, initial efforts have been directed to establish a metadata hub that facilitates data sharing, interagency communication and coordination among groups collecting water-monitoring data in Maryland. Known as the “clickable map”, this system allows interested data generators to post the location of their monitoring network and contact information on a Web-based GIS system (go to http://cuereims.umbc.edu/MWMC/) maintained by MDE and hosted by the University of Maryland, Baltimore County. Links from this site to individually maintained web accessible data as well as the ability to download shapefiles into desktop GIS applications have been developed to enhance information sharing and data analysis. This is the State's initial step in promoting the concept of a web-based distributed database system.

5.2 Groundwater

Although MDE maintains a database for public water supply systems serving 25 people or greater, most county data for private wells are not electronically available. It will be a priority of the State to explore candidate databases to house this information. This data is currently sent in part to the EPA Public Drinking Water Database http://www.epa.gov/ogwdw/dwinfo/md.htm.

The Department of the Environment hopes to overcome local database sharing constraints and eventually incorporate much of this information into the STORET-WQX system. Some counties are more advanced in electronic capture of citizen well data. These counties could be used as a model for broader statewide efforts. USGS is also understood to have groundwater data management capabilities. Looking for ways to improve coordination and data exchange is a state priority.

5.3 Data Access

Public access to water quality data is a prime goal of the State's water monitoring plan. Through the CIMS and STORET (WQX) systems, public access has been greatly improved and continues to be enhanced through improved online query processes. Progress with the Maryland Water Monitoring Council and the "clickable map" project has also made more water quality monitoring data available to a larger audience.

6.0 <u>Data Analysis</u>

Responsibility for collection, compilation, and analysis of water quality monitoring data is shared between the Maryland Department of Natural Resources (DNR) and Maryland Department of Environment (MDE). DNR compiles *Maryland's Inventory of Water Quality* [the "305(b) Report"] every two years pursuant to Section 305(b) of the CWA while MDE is responsible for compiling the State's list of impaired water bodies [the "303(d) Report"]. DNR and MDE share water quality data and assessment methods to ensure that all data received are reviewed in a consistent manner. These two reports were "integrated" by EPA in 2002 and are now referred to as the Integrated Report (IR). The report is also divided into five categories that more explicitly report on watershed status:

Part I: All water quality standards met.
Part II: At least one quality standard met, but not all.
Part III: Insufficient data to determine if water quality standards are met.
Part IV (a): Water quality standards not met, but a TMDL not required because a technical fix (e.g., fixing a broken pipe) will attain standards.
Part IV (b): Water quality standards not met, but a TMDL is completed.
Part V: Water Quality Standards not met and a TMDL is required.

The Integrated Report provides the federal government, citizens, and concerned stakeholders with information on the water quality status of waters throughout the State. This Report utilizes water quality monitoring information collected by the State and other sources, including direct requests to federal agencies, local environmental agencies, colleges and universities, citizen monitoring groups, and private firms.

Part V of the Integrated Report analyzes the available information, applies methodologies for interpretation of compliance with State standards, and identifies water quality impairments that may require a Total Maximum Daily Load (TMDL). Interstate water bodies are considered for non attainment listing only after close coordination with respective water management representatives from neighboring states. Interpretation of neighboring state standards is often problematic but interstate data are given equal consideration prior to formally adding any new interstate water bodies to Maryland's Part V of the IR.

Assessing attainment of water quality standards in Maryland is based on the analysis of all readily available data. A joint Maryland Department of Environment/Department of Natural Resources (MDE/DNR) data solicitation letter is widely distributed one year prior to publishing the biennial IR. Electronic data submittal is preferred in accordance with approved QA/QC guidelines (see Section 4.0). The State actively pursues water quality data that will compare to criteria published in regulation (e.g., temperature, dissolved oxygen, pH, turbidity, fecal coliform, E coli and Enteroccus bacteria, specific toxins - see COMAR §26.08.02.03). Water quality data not specifically defined by State standards (e.g., field measures such as salinity, analysis of nutrients, chlorophyll, alkalinity levels, benthic macroinvertebrate and fish communities, habitat conditions, and field observations of the environment) are also actively solicited and highly regarded as supporting factors for the characterization of water quality conditions. Discharge monitoring reports are submitted to MDE periodically by permitted facilities and are used to determine facility compliance with permit conditions. These data are reviewed and analyzed in comparison to target discharge goals and limits set forth by permit. The permits are designed to achieve water quality standards in the receiving waters.

6.1 Listing Methodology Development

To provide consistency in interpretation of Maryland's designated uses as well as to provide opportunities for stakeholder input, MDE published eight listing methodologies in concert with development of the 2002 303(d) List (see appendix A). They include the Chesapeake Bay Index of Biotic Integrity, Combined and Sanitary Sewer Overflows (CSO/SSO), Sedimentation, Bio-methodology, Dissolved Oxygen in Stratified Lakes, pH, Bacteria, and Toxics. All listing methodologies are publicly reviewed for a period of 45 days and MDE responded to all related comments and concerns in a comment-response document.

Listing Methodologies (Table 5) establish how the State analyzes water quality data to determine water body compliance with WQS. The Methodologies identify the acceptable sampling frequency, minimum data requirements, and statistical analyses to minimize effects of site and seasonal variability, as well as establish phased, tiered, or weight of evidence type approaches that promote standardization and consistency in making water body impairment determinations. The Listing Methodologies also establish the impairment thresholds under which certain waters fall into the various listing categories in the Integrated Report. As a result, independent investigators using the same data should reach similar conclusions about a water body's impairment status. The implementation of publicly reviewed listing methodologies promotes transparency in the regulatory decision-making process and allows more objective interpretation of the State's WQS.

Table 5: Listing Methodologies

Listing Methodology	Use Support Type (aquatic life or human health)	Supporting Regulations in COMAR
Non-Tidal Bio-methodology	Aquatic Life Use Support	§26.08.02.01-B(2)
Tidal Bio-methodology	Aquatic Life Use Support	§26.08.02.01-A3 and §26.08.02.01-B2-c
Bacterial	Human Health	§26.08.02.03-3A-1-5 and §26.08.02.03-3C-1-2
CSO/SSO	Human Health	§26.08.02.03-3A-1-5 and §26.08.02.03-3C-1-2
Dissolved Oxygen in Stratified Lakes	Aquatic Life Use Support	§26.08.02.03-3A-*6*
Chemical Contaminants	Human Health and Aquatic Life Use Support	§26.08.02.03-2-G1
Sediments	Aquatic Life Use Support	§26.08.02.03-3A-9
pH	Aquatic Life Use Support	§26.08.02.03-3A-8

The Department considers the methodologies evolving documents that change to incorporate improved scientific standards and methods as well as the development of new WQS. As the

Methodologies are revised or developed, the public and stakeholders will be given opportunity for review and comment. All comments will be responded to in a comment-response document.

7.0 Reporting

There are a variety of ways that information about water monitoring activities in Maryland is disseminated to managers, funding agencies and other stakeholders (agencies, businesses, scientists, and the public - individuals, students, community groups, consultants, and politicians). The reporting format and media used often are dictated by the perceived needs of the audience.

In compliance with the Federal Clean Water Act (CWA), Maryland submits reports in accordance with sections 305(b), 303(d), 314 and 319. Statewide assessments of water quality are submitted biennially to EPA in Integrated reports (combination of 303d List and 305b Report). All water body types are assessed (and reported) in terms of stream miles or surface area supporting or not supporting designated uses, as well as those waters that cannot be assessed (i.e., insufficient quantity or quality of data). Beginning with the 2008 submittal, Maryland integrated both its 305(b) reporting and 303(d) List into one consolidated report. Now water quality assessments are more closely linked to the impaired waters list. The final Maryland 2008 Integrated Report of Surface Water Quality is now accessible online through a searchable database. This new feature allows users to easily query information on the water quality status of Maryland waters using several different attributes.
http://www.mde.maryland.gov/ResearchCenter/Publications/General/eMDE/vol3no11/database.asp

Section 314 (Clean Lakes Program) of the federal Clean Water Act requires annual reporting of lake status, trophic condition, and a description of lake management programs. Failure to submit this report may result in the State being listed as ineligible for Section 314 monitoring/restoration funds. While Congress has not appropriated any Clean Lakes funding since FY1996, they have directed that Section 319 (Nonpoint Source Program) funds could be used to support Clean Lakes Program activities (diagnostic/feasibility studies; restoration activities; post-restoration monitoring) on defined "significant, publicly-owned lakes". Because the 314 reporting requirements are similar to what is required in the Section 305(b) reports, EPA has modified its 314 and 305(b) guidance and most Clean Lakes reporting requirements are now addressed in the State's Integrated 305(b)/303(d) reports.

Section 319 (Nonpoint Source Program) requires periodic reporting of water quality conditions affected by non-point source pollution and reports of management activities. These reports are developed whenever they are detailed as a deliverable product or a special condition in the Section 319 grant to the State.
http://www.mde.maryland.gov/Programs/WaterPrograms/319NPS/index.asp

In addition to these, funding agencies have specific reporting requirements spelled out under contract that may include monthly or quarterly data submissions or activity reports, summary data and/or interpretive reports (e.g., Section 117 - Chesapeake Bay Program). Managers often need summaries of interpretive reports to develop/support or modify management actions. Some programs produce annual technical reports (e.g., Coastal Bays Program) or reports that focus on specific watersheds (TMDL reports, MD Biological Stream Survey basin reports). For different audiences, less technical summary reports may be developed for more diverse readership (e.g., Chesapeake Bay

Program State of the Bay report, State of the Streams report, Tributary Strategy annual reports). Other programs have regular newsletters (e.g., MD Biological Stream Survey) that are mailed to an open-ended mailing list. These general water quality reports and newsletters are widely distributed to the public through mailings, meetings and exhibitions.

Maryland has a State Repository Library system that collects, distributes and documents State agency reports among State Archives and selected library systems across the State. DNR has an Information Resource Center that serves as a library for the Department and serves the public as well. Long-term document storage is available via storage at Jessup (microfiche/document).

One accessible format being used extensively to provide and distribute both general and technical information about water monitoring activities is through the Internet. All State agencies have Web sites that are accessible 24 hours a day, seven days a week. Local library systems across the State have public Internet accounts permitting access to State information.

Both DNR and MDE have posted information about water monitoring programs on their Web sites (http://www.dnr.state.md.us/and http://www.mde.state.md.us/, respectively). Depending on the program, this information may include descriptive information about monitoring programs, contact information (telephone, e-mail), opportunities to access data in water monitoring databases or access to real-time data. Some Web pages provide summaries of water monitoring results (shellfish harvesting closures, Tributary Team water quality status and trends). Technical or educational reports may be posted and read on-line or downloaded.

7.1 Maryland Beaches Program

MDE works with local health departments to enhance beach water quality monitoring and improve the public notification process regarding beach water quality in Maryland, especially since the enactment of the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000. The program administered by MDE, maintains consistent statewide goals, strategies and objectives; however, the responsibility of monitoring and public notification of beach information is delegated to the local health departments.
http://www.mde.maryland.gov/CitizensInfoCenter/Health/beaches.asp

The main source of data gathered in the program originates from water quality monitoring samples taken at designated beaches. Data is reviewed accordingly, as information is received and entered into the Beaches Program database. All data is properly assessed prior to submittal to EPA. MDE has developed and implements an in-house data quality control/ quality assurance (QC/QA) process.

7.2 Maryland's High Quality Waters (Tier II)

Tier II antidegradation implementation has the greatest immediate effect on local government planning functions. MDE maintains the following web site to provide technical assistance to local governments working to complete the Water Resources Element of their comprehensive plans, as required by HB 1141. This site includes maps depicting locations of High Quality Waters by County

http://www.mde.maryland.gov/ResearchCenter/Data/waterQualityStandards/Antidegradation/index.asp

7.3 Approved Total Maximum Daily Loads (TMDL's)

A TMDL is completed for each waterbody-pollutant combination on the state 303(d) List. Approved TMDL documents may be obtained by accessing the following web site. http://www.mde.maryland.gov/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/index.asp In addition, online maps are provided that geographically depicts waters that are impaired, along with those that have completed TMDLs. These maps are found at http://www.mde.state.md.us/Water/HB1141/Water_Quality_Maps.asp

7.4 Fish Tissue Advisories

Many fish, including the most popular store-bought fish and shellfish, are safe to eat. Some, however, contain chemicals (such as methylmercury, polychlorinated biphenyls (PCBs), and various types of pesticides) at concentrations that may be harmful to children and/or adults. The Department of the Environment monitors and evaluates contamination levels in fish, shellfish, and crabs throughout Maryland and issues guidelines for recreationally caught fish. The guidelines for consuming recreationally caught fish in the state may be obtained by accessing the following site. http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/index.asp

7.5 Eyes on the Bay

The Eyes on the Bay web site is maintained by DNR as an accessible source of near-, real-time and archived water quality data on select tidal and non-tidal water quality conditions in the State. The site also provides information about water quality monitoring programs and summaries of water quality information.

http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm

7.6 Rivers and Stream Monitoring

The Rivers and Stream Monitoring web site is maintained by DNR as a source of non-tidal water quality monitoring and research information focusing on MD Biological Stream Survey data and summaries and as a portal to the volunteer Stream Waders website.

http://dnr.maryland.gov/streams/mbss/current_act.html

7.7 Maryland Shellfish Harvesting Areas

Maryland's Chesapeake Bay waters have long been known as a source of shellfish. To protect this valuable resource and safeguard public health the Maryland Department of the Environment (MDE) is responsible for regulating shellfish harvesting waters. The Maryland Shellfish Harvesting and Closure Area Maps may be accessed at the following web site. http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/harvesting_notices/index.asp These maps summarize MDE's classification status of oyster & clam harvesting waters as of June 1, 2007. The maps depict the classification of shellfish growing waters of the State as restricted, conditionally approved, or approved.

8.0 Program Evaluation

This section describes how Maryland evaluates its monitoring programs and overall State Monitoring Strategy. Section 8.1 describes a broad framework and various processes for program evaluation. Section 8.2 identifies several specific program evaluation activities that are contemplated or are underway. These activities, summarized as part of a ten-year schedule, constitute a work plan outline.

8.1 A Framework for Evaluation

The federal Clean Water Act provides a framework that supports the evaluation of Maryland's Monitoring Strategy. This framework consists of six components;

1) Water Quality Standards
2) Monitoring
3) Data management and analysis
4) 303 (d) Listing
5) TMDL development
6) TMDL implementation

Each stage of this framework generates constructive feedback for the State's monitoring programs and the overall Monitoring Strategy.

Outside this framework, independent evaluation opportunities greatly contribute to the creative processes integral to developing and improving the formal State Monitoring Strategy every five years. They include, but are not limited to, individual program evaluations, interagency technical and budget coordination, publications and reports, conferences and workshops, and public outreach activities.

8.1.1 Water Quality Standards

A significant proportion of the State's monitoring is designed to assess the status of water quality relative to State water quality standards. A separate aspect of State monitoring involves research to support development or refinement of water quality standards. Both of these are discussed below.

Water quality standards should be established in a way that ensures it is feasible to conduct the necessary monitoring needed to assess water quality. For example, a water quality criterion that requires a minimum of six samples per month might conflict with monitoring programs that only have the capacity to collect weekly samples.

The State is required to review its standards every three years through a formal process known as the *triennial review*. This periodic process helps ensure that monitoring methods associated with revised standards are also evaluated.

Research monitoring supports refinement of water quality criteria. This kind of monitoring constitutes a small but important share of the State's monitoring resources. Past examples have included monitoring associated with the establishment of fish and benthic indices of biological integrity, collection of periphyton algae samples in support of nutrient criteria development, and biological monitoring to identify Tier II waters in support of the State's anti-degradation policy.

Outcomes of the Triennial Review(s) are institutionalized in the State Monitoring Strategy via the 5-year update process. The resulting refinements to State water quality standards are reflected in these updates, Section 8.2.

8.1.2 Monitoring

Monitoring activities are conducted to assess State water quality standards, develop TMDLs and to support water quality restoration activities. These programs provide feedback mechanisms for evaluating monitoring programs. Experienced field staff share observations with staff members who are responsible for the key Clean Water Act programs outlined above. Through this collaborative process monitoring designs are refined, additional data needs are identified, monitoring activities are adjusted, lab analysis needs are identified, and modifications to data analysis techniques are considered.

8.1.3 Data Management and Analysis

Monitoring programs and related lab analyses generate vast amounts of data that must be managed. The data management process includes quality control procedures that provide a feedback mechanism for evaluating monitoring procedures. Data analyses identify systemic temporal or spatial gaps, inconsistencies with water quality standards, and missing supplemental information (meta data), all of which represent a routine process of providing evaluation feedback to the monitoring programs.

As Maryland moves forward with planning and carrying out TMDL implementation projects over the next 5 years, monitoring priorities and frequencies may also be reallocated. Implementation plans are rapidly evolving. Recent EPA approval of the MDE stressor identification framework will support development of TMDL implementation pilot studies during the next five years. Data quality objectives for evaluating the success of implementation projects will be different than those developed to support TMDL development. As a result, monitoring designs will change and new programs may be needed. Furthermore, close cooperation with local governments on the evaluation of small-scale local projects will be essential.

Maryland's use of STORET –Water Quality Exchange (WQX) is another programmatic evaluation tool that is used to gauge progress and implementation of State water monitoring programs. The State will continue to improve the availability of monitoring data through the STORET-WQX system. This can be a reliable measure by which the State Strategy is periodically evaluated since monitoring data are a direct result of program implementation. Maryland will continue to make regular monthly uploads to EPA's STORET-WQX as well as work with local jurisdictions and volunteer monitoring organizations to make their monitoring available in STORET-WQX. Maryland's data entry process for the STORET-WQX system includes a data approval process whereby senior personnel must sign-off on data before it enters STORET-WQX. This ensures another level of programmatic review that assists with data validation and ensures consistency with project goals and objectives.

Finally, Maryland's Quality Management Planning and project-specific Quality Assurance

Project Plans (QAPPs) establish internal quality control measures and oversight processes that preserve the integrity of State data. MDE implements an annual self-assessment of QAPPs by their authors to ensure they are refined if needed. Refinement of data quality objectives, field and laboratory protocols, minimum sample sizes, field and lab quality assurance procedures, personnel roles and responsibilities, and departmental as well as project-specific review and evaluation processes provide yet another mechanism for programmatic evaluation of State water monitoring programs. These procedures create a feedback loop where State monitoring programs are continually validated for consistency with data quality objectives.

8.1.4 305(b) Report and 303(d) List – Integrated Reporting

The State's mandatory water quality reporting process to EPA, in accordance with sections 305(b) and 303(d) of the Clean Water Act, provides another source of feedback for revisiting State monitoring programs, goals and objectives. As water quality data is analyzed and interpreted, opportunities for refining the monitoring protocols are identified. For example, the 303(d) Listing Methodologies document how data is analyzed and interpreted to determine whether or not Maryland waters are meeting standards (See Appendix A).

Listing Methodologies are reviewed as part of biennial 303(d) List development. Since these methodologies outline sample frequency, magnitude, and duration necessary to list waters as impaired, as well as the analytical techniques used to make these determinations, this process is recognized as a key avenue for evaluating monitoring program design. All of these changes feed back into the State's Monitoring Strategy. Because the Maryland Department of Natural Resources is responsible for 305(b) and the Maryland Department of the Environment is responsible for 303(d), the feedback process is coordinated between the two agencies.

In addition to the evaluation of monitoring protocols, the integration of the 303(d) and 305(b) water quality reporting is resulting in the collaboration of MDE and DNR on standardized procedures for data solicitation, data management, and data analysis and interpretation as noted above. Furthermore, these reports, particularly the 303(d) List, are used extensively to set goals and priorities for future water monitoring activities and are a valuable tool used in the 5-year State Strategy review.

8.1.5 TMDL Development

TMDL development uses models to establish cause and affect relationships between pollutant loading and water quality responses. These models take various forms including deterministic simulation models and empirical models.

The monitoring needs of the TMDL program have an overt influence on where monitoring is conducted and for what purposes. Although it is somewhat informal, the TMDL program also has an ancillary role of evaluating the monitoring program in a more general sense. The staff of the TMDL program has the expertise to provide peer review of the monitoring designs, sampling techniques, lab analyses, data management and data analyses.

8.1.6 TMDL Implementation

Similar to TMDL development, TMDL implementation has needs that drive the location, the kinds of monitoring, and the parameters assessed. Maryland's monitoring strategy strives to maintain sufficient monitoring support for TMDL development while it shifts primary emphasis to TMDL implementation. This is motivating a general evaluation of monitoring activities in the state.

For example, monitoring discharges of significant non-tidal streams was originally designed to support the calibration of water quality models. This monitoring was conducted as part of MDE's 5-year watershed cycling strategy. The value of continuing this monitoring relative to TMDL implementation is being evaluated.

In addition to evaluation to consider changes in monitoring programs to support TMDL implementation, more subtle evaluations are being motivated by greater interaction of the monitoring programs with the more active TMDL implementation process. For example, it has been observed that a more rigorous analysis of the synoptic survey technique could serve to improve application for TMDL implementation projects.

8.1.7 Water Monitoring Strategy Five-year Updates

In addition to the evaluations performed within the structure of the Clean Water Act framework (discussed above) Maryland evaluates the State Water Monitoring Strategy on a five-year cycle as part of the update process. MDE assembles a workgroup one year prior to each five-year submittal deadline to review Strategy objectives and evaluate options for implementing new priorities over the following ten years.

As a result of this process, four major new strategic monitoring priorities were identified. The new priorities will require time to fully evaluate and implement. They include:

- Greater support for TMDL implementation,
- Improved documentation of incremental water quality improvements,
- Development of more quantitative monitoring designs, and
- Expanded effort to monitor and protect high quality waters.

Another aspect of the five-year Monitoring Strategy update process was a program-level strategic evaluation. A standard survey was developed and provided to the primary programs that have a monitoring component. The survey process requires each program to take the time to reflect on their monitoring activities. Survey results help communicate outcomes to a wider group of peers capable of giving feedback to each program. This strategic analysis is a supplement to annual program reviews described below. A summary of this process is provided in Appendix C.

8.1.8 Other Program Evaluation Processes

State monitoring programs review their protocols, procedures, goals and objectives on an annual basis. Monitoring program goals can rapidly shift when new or heightened public health concerns emerge, new science and analytical techniques become available, and when monitoring results suggest data gaps or emerging issues. These annual reviews, which frequently include interagency participation as well as public input and involvement, result in the incremental changes to monitoring programs that ensure attainment of shifting goals and objectives. These annual program evaluation processes are institutionalized into a larger strategy framework via the 5-year Statewide Monitoring Strategy updating process. (See above).

The motivation for major shifts in Maryland's Monitoring Strategy is also influencing an on-going evaluation of monitoring resource allocations to support regional Chesapeake Bay restoration. The evaluation effort, which is being led by EPA Chesapeake Bay Program's Modeling and Analysis Subcommittee (MASC), are also motivated in part by a desire to target the implementation of restoration actions and evaluate the effects. MDE and DNR staff are actively involved in MASC and its subcommittees.

Another State initiative is underway, which is expected to generate guidance by the fall of 2009 to help direct monitoring efforts to evaluate the effectiveness of remediation projects supported by the Coastal and Chesapeake Bays 2010 Trust Fund. This effort is being undertaken by the Trust Fund Evaluation (TFE) workgroup. The TFE guidance will help managers determine when monitoring of implementation is likely to produce observable results and provide suggestions on monitoring methods.

Interagency coordination and technology transfer occurs through numerous interstate commissions, regional programs, partnerships, symposia, work groups, committees, regular meetings, as well as through inter and intra agency program coordination efforts. These are invaluable forums for sharing information and ideas, and discussing current issues. The knowledge exchanged via these forums is fed back into the State's strategic planning process for water monitoring. Some of these are elaborated upon below.

MDE and DNR participate in the Maryland Water Monitoring Council (MWMC). The MWMC serves as a state-wide collaborative body to help achieve effective collection, interpretation, and dissemination of environmental data related to issues, policies, and resource management involving the Maryland water monitoring community. The MWMC provides a number of forums involving local, State and federal government agencies, academia, the private sector, volunteer groups and non-profit organizations involved with water monitoring activities in Maryland. The MWMC provided State officials valuable insights and suggestions in the development of the current Strategy.

The State has several members on the MWMC Board as well as personnel who serve as chairpersons in MWMC subcommittees. This forum has been essential in soliciting local government perspectives that are factored into the State's water monitoring plan (see Appendix B). The "clickable map project" (see section 5.1.1) developed by the MWMC identifies and geo-references monitoring programs in Maryland waters. The State is working closely with the MWMC to increase participation in this mapping effort by all appropriate organizations and groups. In addition to making consolidated monitoring information available, this effort will help better target limited State resources to the most critical needs by reducing program redundancy and identifying data gaps. Where possible, the State will use existing local government and other water monitoring programs to support the State's Monitoring Strategy. The State can potentially limit monitoring activities in areas where rigorous, quality assured local programs are providing readily available data streams, thereby redirecting State resources to underfunded areas.

MDE and DNR share federal grant funding, which are managed through memoranda of understandings between the two agencies. Examples include funds from sections 106 and 319 of the federal Clean Water Act. Annual negotiations between the two agencies serve a monitoring evaluation function as priorities, methodologies and other issues are discussed.

Annual conferences provide another vehicle for the evaluation of Maryland's monitoring programs. Examples include the annual MWMC conference, the Mid-Atlantic Water Pollution Biology Workshop held in Cacapon State Park, WV, the National Nonpoint Source Monitoring Conference and others.

8.1.9 Summary

The framework and processes described above form the core of the State's programmatic and strategic planning evaluation process for monitoring and data analysis (Table 6). The evaluation activities built into each one of these efforts ensures that monitoring and data analysis designs will be continually re-evaluated to meet their specific goals and outcomes, as well as meeting the State's evolving strategic objectives. Interagency and nongovernmental stakeholder collaboration further ensures that evaluations incorporate a broad range of considerations and expertise.

Table 6: Programmatic Evaluation Elements and Frequencies

Water Monitoring Strategy Element	Evaluation Frequency
State Strategy Working Group	Annually – Quadrennially
Water Quality Standards Triennial Review	Triennially
305(b) Reporting/303(d) Listing	Biennially (annual 305(b) update)
Listing Methodologies	Biennially
Monitoring Program Review	Annually (internal) Biennial/Triennial (external-EPA)
Quality Management and Quality Assurance Project Planning	Annually
TMDL Development, Implementation planning and restoration/mitigation efforts	Monthly, quarterly, annually and biennially
External Coordination Efforts (meetings, work groups, etc.)	Monthly, quarterly, annually and biennially
STORET-WQX Development and Upload	Monthly

8.2 Specific Evaluation and Refinement Activities

The State has identified several water monitoring evaluations that are planned to be performed. This 2009 Monitoring Strategy serves as the 5-year mid-course update of a ten-year implementation plan as defined in EPA's 2003 State Water Monitoring and Assessment Program guidance. In addition to meeting EPA's guidelines, Maryland has elected to lay out near-term and long-term evaluation and refinement goals for the next ten years (See Figure 15). The following are work plan elements to which the State is committing resources.

8.2.1 Non-tidal Bacteria Monitoring

A non-tidal bacterial monitoring design, based on the new E. coli standard, is currently under development, with a goal of implementation by 2012. A Memorandum of Understanding (MOU) is being drafted with the University of Maryland to allocate 319 funds to hire an analyst to help design this monitoring program. This evaluation initiative fills the gap that is not addressed by Maryland's Beaches Program and Shellfish Program.

8.2.2 Refinement of Flow Gage Network

Funding limitations at the State and federal levels have impacted the flow gage coverage in Maryland. An interagency workgroup, being coordinated with assistance by USGS, has initiated a process to maintain and expand coverage as feasible over the next five years. The workgroup is building on the foundation of several recent studies, including recommendations of the Advisory Committee on the Management and Protection of the State's Water Resources (the Wolman Commission), which was convened by State statute following droughts in 1999 and 2002. The workgroup will address both technical and funding issues.

8.2.3 Nontidal Biological Monitoring

Maryland began using DNR's randomized nontidal Maryland Biological Stream Survey (MBSS) fish and benthic indices in the 2002 303(d) Report to EPA. Because the funding source for DNR's MBSS monitoring program has been curtailed, the program is undergoing an evaluation process to determine how to adjust.

Over the next 2-3 years efforts will continue to expand the use of Biocriteria to define Tier II waters and support implementation of the State's anti-degradation policy. Because the original source of MBSS monitoring funds has been curtailed, Maryland's 319 Nonpoint Source Program has been supporting this water quality protection initiative. Because 319 funds are limited, resource allocations are evaluated on an annual basis.

Biological data is also playing a central role in helping understand cause and effect relationships that will guide nontidal stream restoration. MDE's Water Quality Protection and Restoration (WQPR) Program is initiating a process to target restoration to watersheds that have a high potential for removal from the State's 303(d) list. In addition to using MBSS data to help determine the stressors that are causing the degradation, this initiative will depend on MBSS data to ultimately judge its success. Because of funding limitations, the 319 Nonpoint Source Program will likely fund this monitoring and be involved in evaluating how the monitoring is conducted.

8.2.4 Watershed Cycling

In 1998, MDE initiated a 5-year watershed cycling strategy in support of TMDL development. The monitoring information, collected in tidal and non-tidal waters, supported the calibration of watershed and water quality models. It was also envisioned that the monitoring would be conducted in perpetuity to evaluate implementation. However, the existing monitoring design needs to be reevaluated to ensure it supports TMDL implementation needs.

For example, currently, monthly samples are collected during a one-year period from the major nontidal tributaries to tidal rivers of approximately one fifth of the State. This information, which is costly, has been very useful for model calibration; however, it is of unknown utility in evaluating implementation progress. As a consequence, this element of the watershed cycling strategy needs to be evaluated.

As another example, the cycling strategy collects samples from the longitudinal axis of each major tidal river. When done to support TMDL model calibration, samples were collected three times during Spring (higher flow period) and three times during Summer/Fall (lower flow period). Usually, only a subset of the sampling stations in the poorly flushed areas revealed water quality problems. Given the cost of such monitoring, it might make more sense to only collect samples from the areas that had water quality problems.

In both of the examples above, samples collected once every five years are unlikely to have the statistical power to show whether water quality is changing. An alternative design could be considered in which the cycling strategy functions like a screening process. If a one-year sample suggests the waters that were impaired now meet water quality criteria, then follow-up monitoring would be conducted, out-of-cycle for a second and possibly third year. If three years of sampling demonstrate that the water body is meeting standards, then it could be removed from the 303(d) list. In any given year, it is likely that many waters would qualify for follow-up monitoring. Thus, the work load for out-of-cycle monitoring would be limited.

8.2.5 Use Attainability Analysis (UAA)

Over the next 3 years MDE will be forming a workgroup to develop a *process* for conducting Use Attainability Analyses (UAA).UAA's are studies that evaluate and establish designated uses upon which water quality criteria are based. They consider both technical and financial feasibility of achieving different levels of physical, chemical and biological water quality. This initiative might motivate the evaluation of related monitoring and data analysis functions.

8.2.6 Lakes Monitoring

In 2008, five impoundments were sampled by DNR in conjunction with EPA's National Aquatic Resources Survey. The results are available on line at; http://www.epa.gov/OWOW/monitoring/nationalsurveys.html

Maryland does not currently manage a long-term statewide assessment program for lakes. The State hopes to develop this program with federal funds over the next 4 – 9 years.

8.2.7 Wetland Monitoring

An EPA grant was allocated in 2004 to develop a state-wide wetlands monitoring program. Preliminary meetings were held with representatives from State agencies on August 29, 2006, September 19, 2006, and October 19, 2006. Development of this project over the next 3-9 years involves a significant amount of consensus building from stakeholders with a variety of wetland management interests. After some basic consensus is reached, the work group will expand to include representatives from federal and local agencies, academic institutions, and other advisory groups.

In recent developments, an MOU with Virginia Tech has been secured to prepare background information for the project. In addition, a contract with the Association of State Wetland Managers will provide moderator services and additional discussion papers. The first workgroup meeting is tentatively scheduled for the week of September 14, or September 21, 2009.

8.2.8 Coastal Bays Biological Indices

The State is considering the potential of developing a nutrient index, using macroalgae, and a benthic community index for the Coastal Bays, similar to that developed for Chesapeake Bay. The timeframe for these potential investigations is in the range of 3 to 9 years from now, depending on staff resources, other priorities and technical considerations. Such an investigation would require monitoring support. If such indices eventually came to fruition, they would result in the need to develop and adopt new monitoring protocols and a new commitment to conduct that monitoring.

8.2.9 Biological Interpretation

DNR is currently conducting evaluations of alternative analysis methods associated with the Maryland Biological Stream Survey (MBSS). Specifically, the State is considering going beyond the current scoring system for MBSS (i.e., a 1, 3 or 5 scoring framework) to begin looking at things like biological condition gradients, indicator organisms, large/rare taxa, and a more refined scoring network or sensitive scoring range. Monitoring to support this evaluation is on-going. If new analysis methods are adopted, it could affect the MBSS monitoring protocols. The outcomes of this evaluation, if adopted, would occur in the 4 to 9 year timeframe. This evaluation process relates to the TALU topic below.

8.2.10 Tiered Aquatic Life Uses

Maryland is considering tiered aquatic life uses (TALU). Evaluations associated with the development of TALU would likely require monitoring support and would result in changes to existing monitoring programs. As noted above, DNR is beginning to conduct an evaluation of Maryland’s MBSS monitoring and analysis protocols with TALU concepts in mind. This process would be long term, occurring over 4 to 9 years.

8.2.11 305(b) and 303(d) Reporting Obligations

As discussed in the context of the Clean Water Act framework outlined above, Maryland continues to evaluate monitoring and data analysis protocols in relation to 305(b) and 303(d) reporting obligations as required under the federal Clean Water Act. Beginning in 2002, Maryland adopted eight Listing Methodologies to standardize the decision making process by which State waters are listed as meeting or not meeting Water Quality Standards. The process of developing these methodologies included an opportunity for the public and other stakeholders the opportunity to comment on the State's procedures for assessing waters. It also established minimum sample size requirements and data analysis protocols to increase confidence in water body impairment determinations. Over the next decade, Maryland will continue to develop, revise, and improve these Listing methodologies to reflect the best possible science and to evaluate designated use support. The Listing Methodologies, current as of 2009, are included Appendix A. Please refer to the supporting documentation of Maryland's most recent Integrated Report for the most current Listing Methodologies.

<table>
<tr><th colspan="10">Figure 15: 10-Year Implementation Timeline for the State of Maryland's Comprehensive Water Monitoring Strategy</th></tr>
<tr><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td><td>2017</td><td>2018</td></tr>
<tr><td></td><td colspan="3">Use Attainability Analysis (UAA)</td><td colspan="6">Reinstate Statewide Lake Assessment Program</td></tr>
<tr><td colspan="3">Revise Watershed Cycle Strategy</td><td colspan="7">Evaluate potential of IBI for macroalage and benthics for the Coastal Bays</td></tr>
<tr><td colspan="3">Improve Tier II documentation</td><td colspan="7">Evaluate potential for Rapid Assessment Methodology for Wetlands</td></tr>
<tr><td colspan="3">Bacteria Monitoring Methodology</td><td colspan="7">Refine Application of Biological Data for 303(d) List</td></tr>
<tr><td></td><td colspan="9">TMDL Implementation and Alternative Approaches to Water Quality Standards Attainment</td></tr>
<tr><td colspan="10">Evaluate the Options for Tiered Aquatic Life Uses and the Biological Condition Gradient</td></tr>
<tr><td colspan="10">Work to incorporate Non-state Programs into Maryland's Overall Water Monitoring Strategy</td></tr>
<tr><td colspan="10">Continue 303(d) Listing Methodology development, revision and updating as necessary</td></tr>
<tr><td colspan="10">Increase Use of Probabilistic Monitoring Data to Evaluate TMDL Implementation Activities</td></tr>
<tr><td colspan="10">STORET (WQX) (Incorporate groundwater, historical and on-going data, expanded use for 303[d] and 305[b], etc.)</td></tr>
</table>

9.0 <u>General Support and Infrastructure</u>

The following sections highlight some of the State's on-going initiatives designed to improve Maryland's environmental monitoring programs and restore/preserve water quality over the next decade, as well as identifies critical resources.

9.1 Aquatic life Use Support

The State now relies extensively upon non-tidal biological communities to indicate environmental change in the watersheds. Maryland began using biological data in its 2002 Integrated Report to EPA on the status of State waters. The biological data was used to identify high quality (Tier II) waters in support of Maryland's anti-degradation policy. Since 2007, Maryland has used biological data to better define and protect Tier II areas from further degradation. Collaboration between DNR and MDE personnel continues to improve and expand this program.

9.2 STORET- Water Quality Exchange (WQX) and Quality Management

In October 2003, the State made its first upload to EPA's STORET database using a traditional method - ftp. Since that time, Maryland has continued to make regular yearly uploads to STORET. Thanks to an EPA WQX grant, MDE started to develop a new data submission using XML Web Services to EPA starting in 2005. The development is now complete and MDE began incorporating Beaches in 2008. The data submission expanded to other sampling projects beginning in June 2009.

STORET WQX will continue to be a high priority effort in Maryland over the next decade. Although some institutional and staffing obstacles still remain, the State is working to centralize environmental monitoring data in STORET WQX with the goal of relying increasingly on this system to conduct water body assessments and develop the State's Integrated Report.

EPA plans to stop supporting STORET in October 2009 because it is based on an out-of-date Oracle program. Since the state of Maryland now depends on STORET, an alternative database management program must be established. MDE is currently investigating the feasibility of transferring data to the new Ambient Water Quality Management System (AWQMS). It is anticipated however that extensive database revamping will be required. EPA will be asked to assist with this process.

9.3 Resource Needs and Implementation Obstacles

There are several programmatic, institutional and fiscal constraints that currently limit Maryland's Comprehensive Water Monitoring Strategy. Some of these constraints are internal to Maryland while others are external and not directly under Maryland's control.

9.3.1 Internal Constraints

Maryland is currently experiencing difficulty in recruiting and retaining personnel. State monitoring programs need more statisticians, computer programmers and analysts, GIS specialists, database and Web designers, to store, analyze, interpret and publicly disseminate monitoring results and conclusions.

As in many other states, water quality monitoring programs in Maryland are increasingly underfunded. More federal funds need to be appropriated to both monitoring and restoration activities to meet increased federal mandates so that the State can effectively and confidently document water quality improvements, evaluate management/regulatory program success, and partner with local governments and communities on small watershed scale projects. This lack of funding also translates into a heavier workload per staff unit and fewer training and educational opportunities to enhance staff technical knowledge.

9.3.2 External Constraints

The current two year cycle for 303(d) listing and 305(b) reporting is too short to allow for rigorous analysis of monitoring data to support water body impairment determinations. By the time that the Integrated List receives final EPA approval, it is almost time to gear up for the next reporting cycle. A four year listing cycle would allow the State more time to adequately assess all State waters and report on their status, while a five year cycle would better align with Maryland's watershed cycling strategy.

The current federal emphasis on Statewide monitoring and assessment needs to be balanced with more federal money for TMDL implementation and small watershed restoration. Too few restoration projects are currently being implemented at too broad a scale to discriminate among current best management practices and watershed restoration activities.

Lastly, coordination between various government and private groups that conduct monitoring in Maryland always proves a daunting challenge. Maryland is fortunate to have such an active and well-represented State Water Monitoring Council, but the MWMC remains a strictly volunteer group with limited ability to weigh in on interagency management concerns and larger policy decisions.

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11.0 **APPENDIX A – Listing Methodologies**

(Updated every five years-refer to 303(d) List for most recent updates)

11.1 Non-Tidal Biological Listing Methodology

Listing Methodology for Implementation of COMAR §26.08.02.01-B(2): Biological Assessment of Water Quality

The new biological listing methodology (BLM) for non-tidal streams has changed markedly from the previous version in order to address the shortcomings of the old methodology as well as to maintain consistency at the watershed management scale that the state currently uses (8-digit watershed). Some of the principle differences between the old BLM and the new involve the scale of listing, the method used to calculate watershed impairment, and the ability to estimate the size and number of stream miles impaired in Maryland. As a result, the new BLM provides assessments at the 8-digit watershed scale only, to be consistent with a probabilistic monitoring scheme (MBSS). Increasing efforts are being directed toward these watersheds to protect exceptional water quality where it exists and to remedy those parts of the watershed that may be experiencing degradation. Streams exhibiting site-specific, small-scale impairments (within larger ‘Non-degraded’ watersheds) will be targeted by the state for local restoration efforts and for future protection by using the Antidegradation Policy Implementation Procedures (COMAR 26.08.02.04-1). Often, these smaller-scale water quality issues can be better addressed through non-TMDL initiatives such as riparian landowner education and other grassroots outreach efforts. MDE has already initiated such activities in parts of the Deer Creek watershed. In addition, in the future, MDE will be focusing on potential temperature impairments in Class III (Waters supporting naturally reproducing trout waters) waters by working with landowners to increase riparian buffer shading.

The following table highlights some of the major differences between the previous biological listing methodology and the new proposed methodology. The details of the new proposed methodology begin after Table 3.

Table 7: Differences between the previous Biological Listing Methodology and the new proposed listing methodology.

Methodology Characteristic	Previous Bio. Listing Methodology	New Bio. Listing Methodology
Method for producing an 8-digit Watershed Assessment	Uses mean IBI scores calculated from all the stations within the watershed along with a confidence interval to provide a watershed assessment. Implies that approximately half of the stations have IBI scores below this mean IBI score.	This method calculates whether the proportion of degraded stream miles is significantly different than the reference conditions (i.e. healthy stream, <10% degraded). This method also uses confidence intervals but, in addition, it takes

		into account additional error estimates to increase confidence in the assessment.
Scale of Assessment/Listing	Assesses and lists at the 8-digit and 12-digit watershed scales. Often leads to confusion when, in the same watershed, the 8-digit assessment and 12-digit assessments do not agree.	Assesses and lists only at the 8-digit watershed scale (state management scale). This maintains consistency with how other listings are made, how TMDLs are developed, and how implementation is targeted. Is consistent with a probabilistic monitoring design (MBSS).
Description of Impairment at the 8-digit watershed scale	None. If an 8-digit watershed is classified as impaired (Category 5), then it is assumed that every stream mile within the watershed is impaired. With the mean IBI scores provides information only on the magnitude of impairment.	Provides proportion and number of stream miles impaired. This allows for more accurate accounting and enables trend analysis. Allows for the fact that not all streams in a watershed are the same. Possibly useful for BAYSTAT.
Refinement of Area (smaller than an 8-digit watershed) Assessed as Impaired	Assesses at the 12-digit watershed scale (11 sq. mile area), but does so based on a single IBI score from a single station. Implies that all stream miles within the entire 12-digit watershed are impaired. Not consistent with a probabilistic monitoring design. Provides no information on the extent of impairment (i.e. miles of stream).	Assesses at the 8-digit watershed scale but provides proportion and number of stream miles degraded within the watershed. Using the converse one can also obtain the proportion and number of stream miles that are supporting the aquatic life designated use.
Error Estimation	Utilizes coefficient of variation to estimate variability of IBI scores. Captures temporal variability only.	Minimum sample size incorporates measure of spatial representativeness (similarity index), temporal variability and a target value for degradation.
Minimum Data Requirements	Must have 10 stations within a watershed to make an assessment at the 8-digit watershed scale.	As a general rule, the minimum sample size is 8. However, if n<8 common sense is used to list when appropriate (see section III.b.5. Watershed Assessment: The Null Hypothesis).

<u>Biological Assessment of Water Quality for Non-Tidal Streams</u>

Executive Summary

As mandated by the Clean Water Act (CWA), the Maryland Department of the Environment (MDE) is required to describe the methodology used to assess use support and define impaired waters (CWA sections 305b/303d). The assessment methodology should be consistent with the state's WQSs, describe how data and information were used to make attainment determinations, and report changes in the assessment methodology since the last reporting cycle (US EPA 2006).

The MDE is proposing a refinement to the current biological listing assessment methodology. The revised approach maintains consistent application at a single water quality management spatial scale (i.e., MD 8-digit watersheds), maximizes the advantages of a probabilistic monitoring design, includes a report on the level of impact within the stream system (i.e., stream miles), and considers the uncertainty in various components of the assessment approach. This contrasts with the current methodology that reports at multiple watershed scales (i.e., 8 and 12-digit watersheds), but does not have consistency at these multiple spatial scales and does not fully maximize the probabilistic monitoring design, which is the foundation for the Maryland index of biological integrity (IBI) assessments.

The revised biological listing method is consistent with the watershed approach of the original method, but does not assess the condition of watersheds based on single sites. Southerland et al. (2007) demonstrated that IBI results from single sites are not representative of 12-digit or larger watersheds. Therefore, the revised listing method focuses on assessing the condition of 8-digit watersheds with multiple sites by measuring the percentage of stream miles that are degraded. Use of the percentage of degraded stream miles allows quantification of the extent of degradation in a watershed and comparison with a reference watershed. The power of these comparisons increases with the number of sites sampled in the watershed.

The revised methodology follows this process: First is a review of the biological monitoring data quality that removes sites for listing decisions where either the Fish or Benthic IBI is not applicable (e.g., tidal waters, blackwater streams). Once this step has been completed, the next step is the watershed assessment, where a watershed is evaluated based on comparison to a reference condition that accounts for variability in sampling design (i.e. spatial variability and temporal variability) and establishes a target value for degradation. During this step of the assessment, a watershed that is significantly different than reference condition is listed as impaired (Category 5) on the Integrated List (formerly known as the 303d List). If a watershed is not determined to be different than reference condition, the assessment must have an acceptable precision before the watershed is listed as attaining (Category 1 or 2) the biological water quality criterion. If the precision is not acceptable then the watershed is listed as inconclusive (Category 3) and designated for further monitoring. Finally, if a watershed is classified as impaired (Category 5) then a stressor identification procedure is completed to determine if a Total Maximum Daily Load (TMDL) is necessary.

This document describes how biological data is assessed for the purposes of the Integrated [combined 303(d) and 305(b)] Report. The methodology considers all existing and readily

available data and information, and explains the analytical approaches used to infer watershed conditions at the 8-digit scale. A summary table and map of the 2008 biological assessment using MBSS Rounds 1 and 2 data for non-tidal streams (1st through 4th order) are presented below:

Table 8: Biological 303(d) Listings

Integrated Report Final Status	Number of 8-digit Watersheds	Stream Miles (a)	% of Total Stream Miles (a/9,199)	Stream Miles with F or B-IBI<3 (b)	% of Stream Miles with F or B-IBI<3 (b/a)	% of Total Stream Miles with F or B-IBI<3 (b/9,199)	Integrated Report of Watershed Stream Miles Impaired (c)	Integrated Report of % of Total Watershed Stream Miles Impaired (c/9,199)
Category 2	24	1,750	19%	234	13%	3%	0	0
Category 3 (Inconclusive)	19	488	5%	183	37%	2%	NA	NA
Category 3 (No data)	25	148	2%	0			NA	NA
Category 4 or 5	70	6,813	74%	3,494	51%	38%	3,494	38%
Total	**138**	**9,199**	**100%**	**3,911**	**43%**	**43%**	**3,494**	**38%**

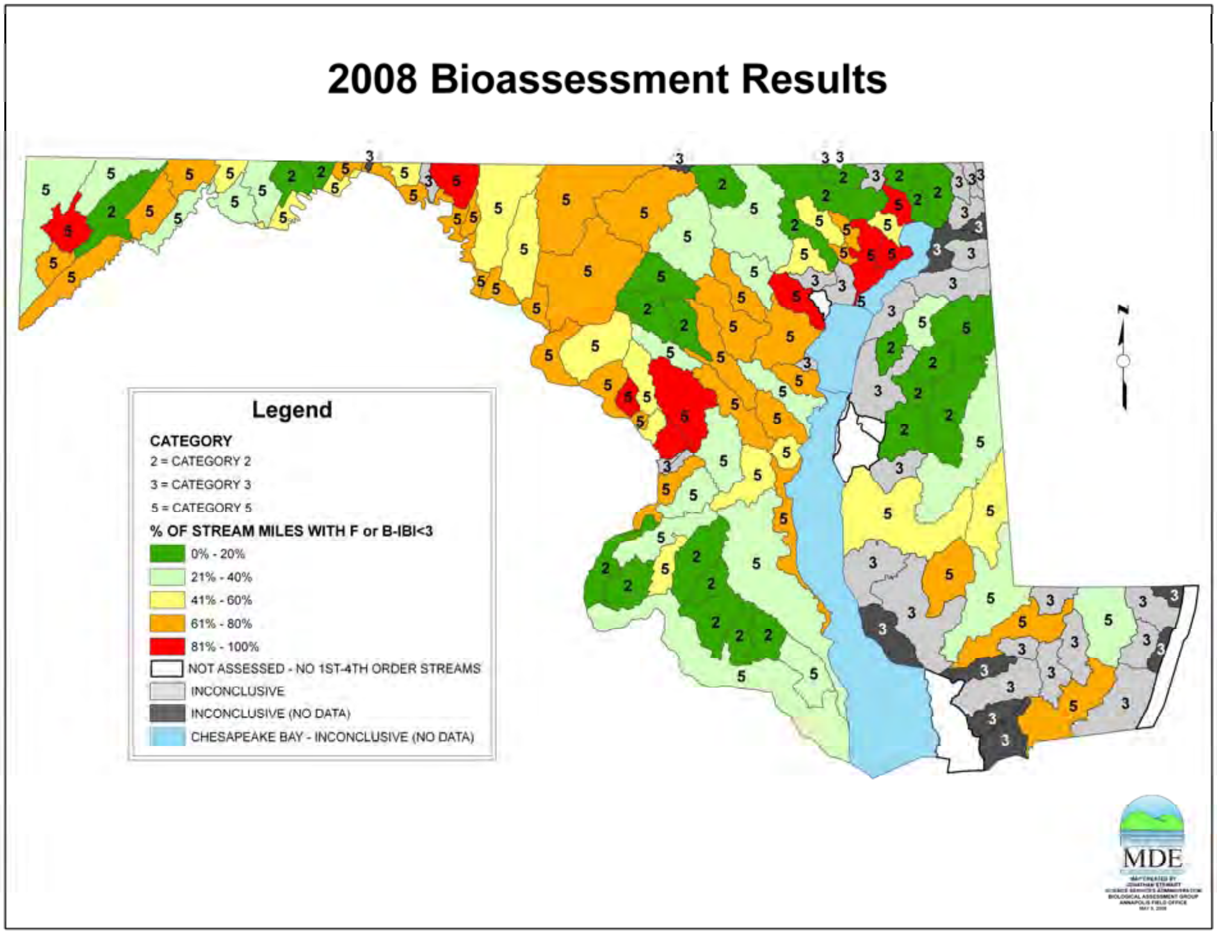

Figure 16: Biological 303(d) Listings

I. Background

All of the State's waters must be of sufficient quality to provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allow for recreational activities in and on the water (40 CFR §130.11). Biological criteria (biocriteria) provide a tool with which water quality managers may directly evaluate whether such balanced populations are present. Maryland's biocriteria uses two multi-metric indices of biological integrity (IBI), one based on fish communities (F-IBI) and the other on benthic (bottom) communities of macroinvertebrates (B-IBI). These indices are developed from reference sites that consider regional differences in biological communities. These indices, as described below, are based on characteristics of fish and benthic communities commonly used to assess the ability of streams to support aquatic life, and can be calculated in a consistent and objective manner. Both indices will be used in Maryland to evaluate biological data for the Clean Water Act requirements.

The condition of all streams could in principle be measured through a census (i.e., without the need to resort to inferring condition), but would require visiting every length of stream in the state. The reality is that monitoring cannot be conducted on every foot or even mile of streams in a state due to resource constraints. Also, the sampling of a targeted non-random stream segment does not provide an unbiased estimate on the conditions of streams within a larger assessment unit. As a result the Department of Natural Resources (DNR) Maryland Biological Stream Survey (MBSS) program, on which the biocriteria methods are based, uses a statewide probability-based design to assess the biological condition of first, second, third, and fourth order, non-tidal streams (determined based on the solid blue line shown on U.S. Geological Survey 1:100,000-scale maps) within Maryland's 8-digit watersheds (Klauda et al. 1998, Roth et al. 2005). MBSS sites are sampled within a 75-meter segment of stream length. Individual sampling results are considered representative at the 75-meter segment, but because of design, the data can be used to estimate unbiased conditions of streams within an assessment unit. The MBSS conducted two rounds of sampling between 1995 and 2004: the first round of MBSS sampling was designed to assess major drainage basins (i.e., Maryland 6-digit) on 1:250,000-scale maps; and the second round was designed to assess smaller (i.e., Maryland 8-digit) watersheds on 1:100,000-scale maps. The use of random assignment of sampling locations within the population of first, second, third and fourth-order streams support the assessment of all of the State's waters.

The results of biological sampling will be applied for management and regulatory purposes (i.e., CWA §303(d)) at the same spatial resolution (i.e., 8-digit watersheds) used in the assessment effort (CWA 305(b)). If a watershed is determined to be impaired, corrective action must be taken. That action may begin with additional monitoring and evaluation to determine the cause of the impairment (i.e., stressor identification). Once the stressor has been identified, it may be appropriate to develop an estimate of the TMDL of the stressor that can be assimilated by the body of water and still allow it to achieve the water quality standards.

II. Rationale for Changing Approach

The current listing methodology uses the average watershed IBI score, for both fish and benthic communities, to determine watershed impairment. While the average IBI score does provide information on the magnitude of the degradation it does not give an indication of the extent of degradation (e.g., length of stream) found within a watershed, a current EPA requirement for integrated reporting. In addition, the current method utilizes a smaller scale assessment (i.e., 12-digit watershed) that classifies a 12-digit watershed (approximately 10 square miles) as impaired if one low IBI value from one site (i.e., 75 meter sample) is present. This site-level listing scale negates the advantage of the random monitoring design and the ability to report on the total stream system. Moreover, Southerland et al. (2007) assessed the average variability of the F-IBI and B-IBI scores at different spatial scales, and demonstrated that single site IBI scores are not representative at the 12-digit watershed scale.

Therefore, MDE requires an integrated biocriteria assessment approach that meets the following criteria:

1. Maintains consistent application at the current water quality management spatial scale (i.e., MD 8-digit watersheds);
2. Maximizes the advantages of a probabilistic monitoring design;

3. Includes a report on the extent of impact within the stream system (i.e., number of stream miles not supporting the aquatic life designated use);
4. Considers the uncertainty in various components of the assessment approach.

Addressing these four key items ensures accurate regulatory decisions regarding water quality in Maryland. Justification for these criteria is first that the Maryland Integrated [combined 303(d) and 305(b)] Report process typically uses a watershed-based water quality management scale for listing purposes. The advantages of this listing scale are (1) an appropriate water quality management scale specific to the pollutant or designated use; (2) promotes consistency with subsequent TMDL development; (3) allows for further spatial refinements during the TMDL development process, where more data may be available; and (4) promotes the use of probabilistic monitoring designs. Next, for biological assessment, Maryland uses a robust statewide random monitoring design that allows the State to estimate, with a specified confidence, the condition of 1^{st} through 4^{th} order streams within a watershed assessment unit.

Third, the biological reporting metric should be changed so that the extent of degradation in stream miles (or proportion of stream miles) can be applied in listing, a metric that is unavailable in the current biocriteria listing methodology. Identifying the extent of degraded stream miles within an assessment unit is consistent with EPA Integrated reporting requirements and meets EPA EMAP reporting recommendations. Using a watershed-based approach and reporting the extent of degraded conditions also allows the converse estimate, i.e., the extent of non-degraded or healthy streams. This allows the inclusion and identification of high quality (Tier II) waters that may be present in assessment units (8-digit watersheds) that are listed as impaired.

Finally, addressing uncertainty is critical to making accurate water quality management decisions that has significant implications on water quality improvement funding. Therefore, it is recommended that the biological listing method incorporate the uncertainty that results from the temporal and spatial variability in the sampling design. Addressing these four key items involves revising MDE’s current biological listing methodology.

III. Revised Biological Listing Method

This section describes the revised biocriteria listing approach. Figure 13 illustrates the critical steps in the listing process. The first step is vetting the biological monitoring data and removing sites from consideration for listing decisions where either the F-IBI or B- IBI is not applicable (e.g., tidal waters, blackwater streams). This process is described in detail in section 3.1. Once this step has been completed, the next step is the watershed assessment, where a watershed is evaluated based on comparison to a reference condition that accounts for variability in sampling design (i.e. spatial variability and temporal variability) and establishes a target value for degradation. During this step of the assessment, a watershed that is significantly different than reference condition is listed as impaired (Category 5) on the Integrated List. If a watershed is not determined to be significantly different from reference conditions, the assessment must have an acceptable precision (margin of error) before the watershed is listed as attaining (Category 1 or 2) the water quality criterion. If the precision is not acceptable, the watershed is listed as inconclusive (Category 3). Details of this process are explained in section 3.2. Finally, if a watershed is identified as inconclusive (Category 3) then an evaluation of additional monitoring options are considered. Suggestions for this process are listed in section 3.3. If a watershed is classified as impaired (Category 5), then a stressor identification procedure is completed to determine if a TMDL is necessary. This process is described in section 3.4.

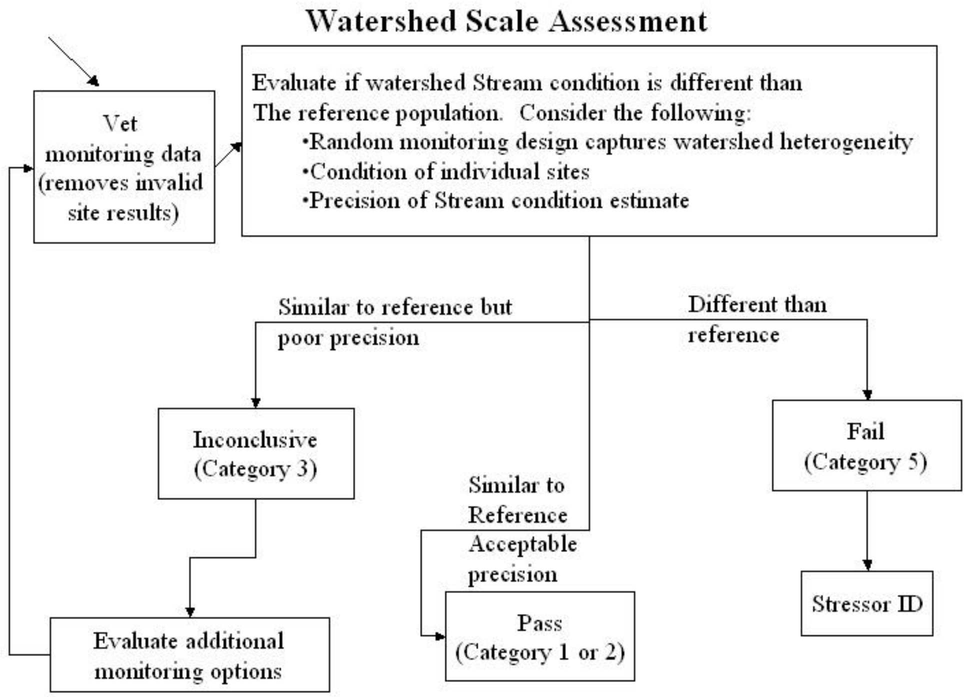

Figure 17: Watershed scale assessment procedure for determining biological impairment.

The revised biological listing method is consistent with the watershed approach of the original method, but does not assess the condition of watersheds based on single sites. Southerland et al. (2007) demonstrated that IBI results from single sites are not representative of 12-digit or larger watersheds. Therefore, the revised listing method focuses on assessing the condition of 8-digit watersheds with multiple sites by measuring the percentage of stream miles that are degraded. Use of the percentage of degraded stream miles allows quantification of the extent of degradation in a watershed and comparison with a reference watershed.

III.a. Vetting Monitoring Data

In all cases, state biologists may use professional judgment in evaluating biological results. However, to aid in the data review, a set of rules is used guide the data vetting process. These rules evaluate specific data parameters such as flow, catchment size, and buffer width to determine if the IBIs are reliable indicators of current watershed conditions. As a specific example, if there was a temporary or significant natural stressor such as drought or flood, sample results were evaluated to determine whether IBI scores resulted from anthropogenic influences or natural conditions. The final master database contains all biological sites considered valid for use in the listing process. The following rules for eliminating site results were developed by MDE with help from DNR to address situations when the IBIs are not representative of stream condition.

(a) Watersheds with less than a 300 acres often have limited fish habitat and naturally low fish diversity. As a result, the F-IBI will not be used for listing decisions at these sites unless the score is significantly greater than 3.
(b) Due to the unique chemistry of blackwater streams and the lack of defined blackwater reference conditions, the IBIs tend to underrate this stream type. For this reason, all blackwater sites (dissolved organic carbon > 8 mg/l and either pH <5 or acid neutralizing capacity (ANC) <200 μeq/L) with either the B-IBI or F-IBI indeterminate or significantly less than 3 will not be used. If the B-IBI and the F-IBI are significantly greater than 3, the stream will be rated as meeting the aquatic life designated use.
(c) If the number of organisms in a benthic sample is less than 60, that sample will not be used unless the B-IBI is significantly greater than 3 or supporting data (e.g., habitat rating, water quality data) indicate impairment and there is no evidence of sampling error or unusual natural phenomena.
(d) Heavy rain and runoff events (e.g., heavy rains, sudden heavy snowmelt) can scour the streambed and transport fish and/or benthics out of a stream segment. As such, samples taken within two weeks of such events may be considered invalid in the best professional judgment of State biologists and not used for evaluation of stream condition.
(e) The IBI scores of stream sampling sites that are tidally influenced will not be used to determine designated use attainment.
(f) The IBI scores of streams affected by excessive drought or intermittent conditions will not be used in listing decisions. Other sampling sites influenced by low flow conditions may also not be used.
(g) The IBI scores of sampling sites that are dominated by wetland-like conditions (e.g., no flowing water, shallow, abundant organic matter) may be considered invalid in the best professional judgment of State biologists.
(h) The IBI scores of streams impounded by beaver dams may be considered invalid. For example, a site within a natural impoundment that was created by beaver activity between the spring benthic macroinvertebrate sampling and the summer fish sampling. Man-made alterations to selected stream segments (e.g., channelization, dredging) should be noted, but they do not invalidate the IBIs.
(i) Sampling sites where the results may be skewed due to sampling error will not be used for assessment purposes.

In addition to these cases, State biologists may use best professional judgment to evaluate any streams sampled under conditions that are not characterized by reference stations.

III.b. Watershed Assessment Procedure

Desirable properties for any assessment or listing methodology are clarity and transparency. While water quality evaluations often deal with complex issues, the priorities for this listing methodology are that it be objective, transparent, and quantitative. Specifically, the revised biological assessment methodology should: 1) use a scientifically defensible numeric indicator (IBI) based on reference sites, 2) produce unbiased results for the assessment units, 3) follow a clear and logical framework and 4) be robust enough to yield the same results when applied by multiple analysts.

The revised listing methodology uses the scientifically robust F- and B- IBI developed by the MBSS program and documented in Southerland et al. (2005). To obtain unbiased results, we invoked a quantitative component to address temporal variability and sampling uncertainty from the MBSS monitoring design. In this report, variability is the year-to-year change in stream conditions that results from non-anthropogenic variation (e.g., climate, hydrology) and uncertainty is the result of inferring condition from the limited number at sites that can be sampled; given available resources. Finally, the listing method employs an assessment approach that is transparent and can be understood by a wide audience.

III.b.1. Reference Sites and Conditions

Reference sites are the foundation for biological assessment. Using reference sites that are minimally disturbed is critical to IBI development because reference conditions define the scoring criteria applied to the individual metrics (Figure 14). Selection of metrics for inclusion in the IBIs is based on how well they distinguish between reference and degraded sites. In Maryland, reference and degraded sites are identified using lists of abiotic criteria. A complete list of criteria for reference and degraded conditions can be found in Southerland et al. (2005).

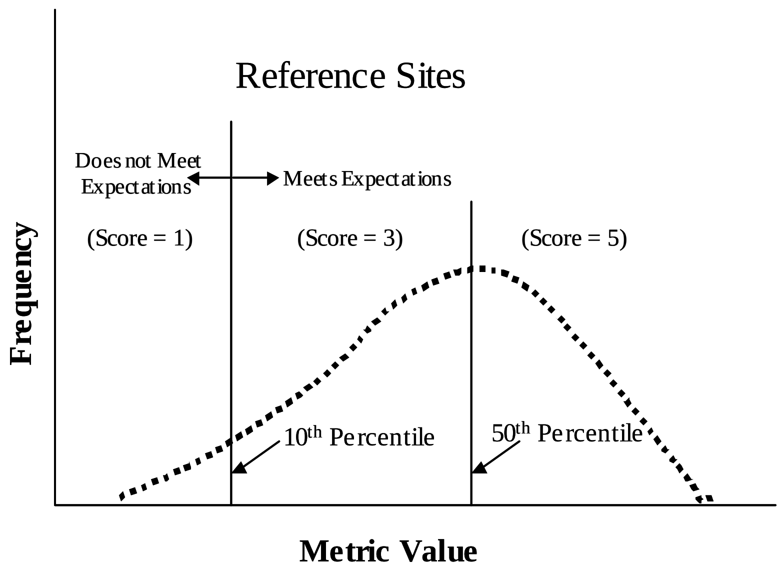

Figure 18: Scoring Criteria based on reference site distribution.

Once reference sites have been identified, they are sequestered into groups at minimal natural ecological variability by geography and stream type. The MBSS dataset provided enough reference sites (approximately 40) for F-IBI development in each of four naturally different stream types: Coastal Plain, Eastern Piedmont, warmwater Highlands, and coldwater Highlands. For the B-IBI, the coldwater stratum was not used because, unlike fish, benthic macroinvertebrates assemblages are not typically depauperate in minimally disturbed coldwater streams.

The MBSS computes the IBI as the average of individual metric scores for a site (see Southerland et al. 2005). Individual metric scores are based on comparison with the distribution of metric values at reference sites within each geographic stratum (Figure 7). Metrics are scored 1 (if < 10^{th} percentile of reference value), 3 (10^{th} to 50^{th} percentile), or 5 (> 50^{th} percentile). The final IBI scores are calculated as the average of the scores and therefore range from 1 to 5.

III.b.2. Year-to-Year Variability

All streams, regardless of anthropogenic changes, experience natural variability. These changes are a result of variability in precipitation and corresponding flows that result in fluctuation in the physical characteristics of the stream systems (Grossman et al. 1990). MBSS sentinel sites used to evaluate the natural year-to-year variability represent the best (based on physical, chemical and biological data) streams in Maryland. Sentinel sites are present in all regions (highland, eastern piedmont and coastal plain) and stream orders (1^{st} through 3^{rd}). Most importantly, they are located in catchments that are not likely to experience a change in anthropogenic disturbances over time.

The year-to-year variability of the sentinel sites was examined by comparing the annual IBI values for individual sites over a five-year monitoring period. The coefficient of variation was used to compare site results since this normalizes the site variability to the mean site score. There were a total of 17 sites that had five years of B-IBI scores and 15 sites with five years of F-IBI scores. The average coefficient of variation was approximately 9% for the B-IBI and 13% for the F-IBI. Therefore, it can be expected that over a five-year period the standard deviation of year-to-year IBI scores will vary by 9 – 13% of the mean score.

III.b.3. Spatial Uncertainty of Stream Condition

The condition of all streams could in principle be measured through a census (i.e., without the need to resort to inferring condition), but would require visiting every length of stream in the state. The reality is that monitoring cannot be conducted on every foot or even mile of streams in a state due to resource constraints. Also, the sampling of a targeted non-random stream segment does not provide an unbiased estimate on the conditions of streams within a larger assessment unit. Therefore, MDE uses the MBSS dataset which is a statewide probability-based sample survey for assessing biological condition of wadeable, non-tidal streams in Maryland (Klauda et al. 1998, Roth et al. 2005) within Maryland's 8-digit watersheds. MBSS sites are randomly selected from the 1:100,000-scale stream network and sampled within a 75-m segment of stream length. Individual sampling results are considered representative at the 75-m segment, but because of design the data can be used to estimate unbiased conditions of streams within an assessment unit.

Realizing that randomly selected sampling sites may not always proportionately represent the assessment unit in which they are selected, MDE investigated the relationship between the number of sampling sites and the representation of watershed heterogeneity (See Appendix A). Generally, it was found that when approximately 10 sites were sampled within a watershed, that the average percent similarity between the number of sites within each land use were 85% similar to the stream mileage found within those same land uses (within the same watershed).

Using this information as a guide, and a precision level of 25%, a minimum sample size of 8 samples was developed so as to capture both spatial heterogeneity and sample uncertainty for the watershed assessments.

III.b.4. Developing a Target Value for Degradation

Using the scoring criteria at reference sites, an IBI > 3 indicates the presence of a biological community with attributes (metric values) comparable to those of reference sites, while an IBI < 3 means that, on average, metric values fall short of reference expectations. Because a metric score of 3 represents the 10^{th} percentile threshold of reference conditions, IBI values less than 3 represent sites that are suspected to be degraded. In contrast, values greater than or equal to 3 (i.e., fair or good) indicate that most attributes of the community are within the range of those at reference sites. However, Southerland et al. (2005) reported that "good" water quality was found at reference sites with low IBIs and that the distribution of reference and degraded site IBI values overlap, thus sites with a metric below the 10^{th} percentile of reference sites (used for scoring) may have good quality waters. It is therefore recommended that an average site IBI score, based on a minimum of three consecutive years of data, be compared to the threshold of 3.

The State recognizes that in most cases three years of data will not be available. If less than three years of data are available, the year-to-year variability will be based on the information from sentinel sites. Given the natural variation of IBI scores in time, it is expected that a site with an average score of 3 will likely have a distribution of annual values above and below 3 (Figure 15). For these cases the coefficient of variation in combination with an assumed normal distribution is used to determine the minimum detectable difference and the subsequent minimum allowable limit (MAL). The MAL decreases the likelihood of a type I error, classifying a site is degraded when it is actually in good condition, given there is only one sample in time. The following formula is applied to estimate the MAL:

$$MAL = IBI_{avg} - z * IBI_{avg} * CV$$

where

MAL = Minimum Allowable IBI Limit to determine if a site is degraded
IBI_{avg} = Average annual allowable IBI value (3 for B-IBI and F-IBI)
z = Standard normal score (1.28 for 90% one-sided confidence interval)
CV = Coefficient of variation

The minimum allowable limit for the F-IBI is 2.5, assuming a coefficient of variation of 13%, while the minimum allowable limit for the B-IBI is 2.65, assuming a coefficient of variation of 9%.

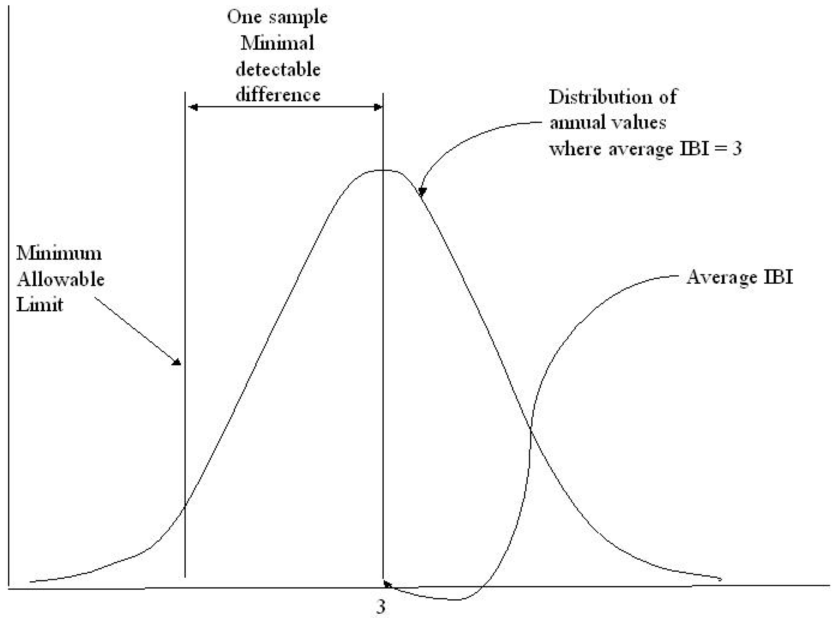

Figure 19: Distribution of annual values at site with average IBI of 3.

III.b.5. Watershed Assessment: The Null Hypothesis

The watershed assessment method tests the null hypothesis that the candidate assessment unit does not violate narrative criteria for the support of aquatic life. In the watershed assessment method there is a general sample size provision to ensure that the random monitoring sites generally represent the spatial heterogeneity in the Maryland 8-digit assessment units. This sample size helps control the type II error (false negative - classifying a water body as meeting criteria when it does not) and an alpha level is set to control the type I error (false positive - listing a water body as impaired when it is not).

To test the null hypothesis (i.e., assess a watershed), the exact binomial confidence intervals are calculated using the monitoring data in an assessment unit. Calculation of the binomial confidence intervals requires the total number of monitoring sites, the number of sites that are degraded, and the confidence level. The null hypothesis is that the populations of streams in the assessment unit are similar to the population of reference sites, which equates to less than 10% of the streams classified as degraded. A degraded site is defined as a site with either the benthic or F-IBI score below the specified threshold of 3 or MAL. With small sample sizes the type II error rate is typically large and can result in accepting the null hypothesis when it is not true (classifying a watershed as meeting criteria when it does not). To reduce the type II error rate, a required precision is specified in the method. The three possible outcomes are as follows:

- Null hypothesis accepted but precision is low: If the lower confidence limit is less than or equal to 10% but half the width of the confidence interval is greater than 25% (low precision), the watershed will be classified as inconclusive and assigned to Category 3 of the Integrated list and considered for future monitoring.

- Null hypothesis accepted and precision is acceptable: If the lower confidence limit is less or equal to 10% and half the width of the confidence interval is less than 25% (acceptable precision), the watershed will be classified as pass and assigned to Category 2 on the Integrated list.
- Null hypothesis rejected: If the lower confidence limit is greater than 10% the watershed will be classified as failing and assigned to Category 5 on the Integrated list.

To further reduce possible listing errors, the development of the methodology took into account the spatial distribution of the random monitoring sites as compared to the spatial heterogeneity of landscape features in the watershed. To do so, the Maryland 8-digit watershed landscape heterogeneity was determined using landscape clusters (groups of similar landscape conditions) that incorporate land use, land use change, soil erodibility, slope, precipitation, and population density (US EPA 2007). For all assessment units, the distribution of streams within landscape clusters were compared to the distribution of MBSS round 1 and round 2 monitoring sites. Results indicate that, on average, approximately 85% of the heterogeneity in 8-digit watersheds is captured with ten monitoring stations (see appendix A).

To ensure clarity and transparency, the assessment method was summarized in a simple lookup table (Table 9). The table incorporates (1) testing the null hypothesis that the candidate assessment unit does not violate narrative criteria for the support of aquatic life; (2) applying 90% exact binomial confidence intervals; (3) requiring a precision of 25%; and (4) ensuring that the monitoring sites capture the watershed landscape heterogeneity. Considering the watershed/monitoring site similarity analysis results and the required statistical precision for a definitive classification, a watershed can be reasonably assessed if there are at least eight random monitoring sites. However, if less then eight sites are within an 8-digit watershed and three of them are classified as degraded the watershed will be classified as not supporting aquatic life and placed on Category 5 of the Integrated List. The rationale is that if five more samples were collected (to total eight) then the watershed would be listed on Category 5 regardless of the results at the new sites. Likewise, if there are less than eight monitoring sites but at least six sites are not degraded then the watershed will be classified as supporting aquatic life and placed in Category 2. Similarly, the rationale is that if two more sites were added to the monitoring design the watershed would be listed on Category 2 regardless of the new site results. However, it is recommended that at least eight sites be used for future monitoring designs.

Table 9: Biocriteria Assessment Table.

Total Number of Random Sites in Assessment Unit	Maximum Number of Degraded Samples in Assessment Unit to be Classified as Pass (Category 2)	Minimum Number of Degraded Samples in Assessment Unit to be Classified as Fail (Category 5)
≤7	(c)	3 (d)
8-11	2	3
12-18	3	4
19-25	4	5
26-32	5	6
33-40	6	7
41-47	7	8
48-55	8	9
56-63	9	10
64-71	10	11
72-79	11	12

Notes:

a. Using 90% one-sided exact binomial confidence intervals.
b. Classification of pass must have a precision <25%.
c. If n<=7 and at least 6 samples are not degraded then watershed classified as Pass (Category 2).
d. If n<=7 and 3 or more samples are degraded then watershed classified as Fail (Category 5).

Reporting for the Integrated Report will be as follows: If a watershed is determined to not meet criteria based on biological data, the watershed will be identified in the Integrated List database as “Not supporting aquatic life uses”, Category 5. A watershed determined to meet criteria, or for which the data are inconclusive, will be identified in the Integrated List in categories 2 (“Fully supporting aquatic life uses”) or 3 (“Inconclusive”), respectively.

III.c. Data Use Limitations
For Integrated Reporting assessments, only biological data from the most recent 10-year moving window will be used so as to ensure the use of accurate and up-to-date information. For instance, for the 2010 IR cycle, only biological data collected between the years 2000 and 2009 (Round II and Round III) will be used for assessment. Round 1 data (1995-1997) would no longer be used to update the 8-digit watershed assessments.

As the MBSS Program continues to collect more data around the state, they may continue to refine and enhance the respective benthic and fish IBIs in order to better discriminate between healthy and degraded stream conditions. In doing so, the IBI scores from an older site may change depending on what metrics are used and how the IBI is calculated. To keep assessments transparent and repeatable for regulatory purposes, MDE will not reassess sites sampled prior to 2008 using IBIs (fish or benthic) created after 2005. In essence, all IBIs from sites sampled prior to 2008, will be frozen at their current values. New sites sampled in 2008 or 2009 may be reanalyzed with a new IBI should one be developed.

III.d. Future Monitoring Priorities
Future monitoring will focus on the watersheds determined to be inconclusive in the final assessment. The watersheds will be categorized based on the number of samples (i.e., 7 having highest priority and 0 having lowest). To allow for the most efficient use of resources, consideration will also be given to the number of stations monitored by the DNR during the Round 3 MBSS sampling being conducted from 2007 to 2009.

Following this categorization of watersheds, monitoring prioritization will be based on the following factors. Firstly, the watersheds with the largest percentage of perennial non-tidal 1st through 4th order stream miles/drainage area will receive preference over basins with a large percentage of tidal stream miles/drainage area. Secondly, the available data for each watershed will be evaluated and best professional judgment applied to determine whether obvious causes of low IBI scores exist due to natural conditions (i.e., a high percentage of intermittent or blackwater streams in the watershed) and/or anthropogenic influences. In these cases, the watershed will be addressed by a Water Quality Analysis or referred for further stressor identification.

III.e. Stressor Identification
Cause/source identification - If a watershed is determined to be impaired based on biological data, the cause of the impairment(s) will then be determined by a review of all relevant chemical, physical, and physical habitat data. If the source of the impairment(s) cannot be determined from the data, an on-site evaluation of the watershed may be undertaken including more detailed diagnostic testing such as sediment and water column chemistry, and toxicity and geomorphic analyses. Habitat evaluation during sampling, along with chemical and physical data, will be used to evaluate the potential causes of impairments. It may be determined in some cases that the appropriate remedy is stream restoration rather than reduction of a specific chemical pollutant.

IV. Use of Non-MBSS data
Given that a key use of these procedures is for the Integrated list of impaired waters, and that the State is required to consider all readily available data. MDE recognizes the need to incorporate

local biological data into the assessment process. Counties or other water monitoring programs that intend to submit their data to support decisions made using the biological framework should carefully follow the general guidelines below.

- Data collected using MBSS (field, laboratory and IBI protocols) or comparable methodology must be:
  - Documented to be of good quality;
  - Can be fully integrated with MBSS data;
  - Provided in a format readily available for merging into the MBSS database;
  - Contain the additional habitat, physical, and chemical information that the MBSS provides that allow for vetting.

- If MBSS methodology is not used but data are documented to be of good quality, in accordance with guidance and technical direction from the State, data will be used to supplement fully integrated MBSS and local data.

Data not meeting the requirements stated above may be helpful for non-regulatory purposes (e.g., targeting, education). Such data will be stored and documented for these uses. State biologists may refer submitters to information sources that will help them to improve the quality of their monitoring data.

V. Using Biological Data for Tier II Designation

As specified in COMAR [26.08.02.04-1] biological assessment data will be used for the purpose of identifying Tier II waters to be protected under the Department's Anti-degradation Policy Implementation Procedures. According to these regulations, when biological assessment data indicates that water quality is within 20% of the maximum attainable value of the index of biological integrity, those waters will be assigned a Tier II designation. For data sampled and scored according to MBSS protocols, this equates to having both a fish and benthic IBI score of 4 or greater at a single site. Using these two pieces of biological information sampled during different seasons of the year helps to independently validate the high quality status of a segment.

Tier II segments can exist in watersheds that are listed as impaired (Category 5) by the methodology spelled out in this document, despite Section 26.08.02.04-1D(2) of the Anti-degradation Procedures. This section states "Water bodies included in the List of Impaired Waters (303(d) List) are not Tier II waters for the impairing substance." The biological listing methodology only assesses the biological condition of streams at the 8-digit watershed scale (approximately 90 square miles) and calculates the percentage of stream miles impaired within this larger scale. As a result, it is possible for smaller stream segments located within 'impaired' (Category 5) 8-digit watersheds to be of Tier II quality due to local variation in stressors and land use. Since local water quality conditions are better characterized through site-specific monitoring, individual stations are used to identify and designate Tier II segments regardless of the watershed assessment result. For maps of current Tier II waters please refer to http://www.mde.state.md.us/ResearchCenter/Data/waterQualityStandards/Antidegradation/index.asp.

VI. Watershed Assessment Summary

MBSS Round 2 data were collected in 2000-2004 at sites allocated randomly among all nontidal streams present on 1:100,000-scale maps. The number of sites sampled in individual MD 8-digit watersheds varied generally with the length of nontidal streams in each watershed. To increase the number of sites in each watershed, MBSS Round 2 data were supplemented with Round 1 data collected in 1995-1997. MBSS Round 1 data were collected on nontidal streams present on 1:250,000-scale maps and therefore sampled larger streams slightly more often than random. Supplementing Round 2 data with Round 1 data does not significantly bias the assessment of nontidal streams at the scale of 8-digit watersheds.

Using the MBSS round 1 and round 2 (2000-2004) data as input into the listing method, a total of 113 out of 135 Maryland 8-digit watersheds were assessed for biological impairments. Table 10 and Figure 16 present a summary of the 2008 watershed assessment. Details of the biological assessment analysis are presented in Table 11. A comparison between the previous the biocriteria method (average IBI) and the revised biocriteria method (% stream mile) is presented in Table 12.

In summary, 25 watersheds do not have any monitoring data. Using the 1:100,000 stream coverage, eight of the watersheds were reported to have zero 1st through 4th order non-tidal wadeable streams. Also many of these watersheds are in areas with a predominance of tidal streams. The remaining 17 watersheds without any data only accounted for 2% (148 miles) of the total 1st –4th order stream miles in Maryland. The 25 watersheds without monitoring data will be placed in Category 3 on the 2008 Integrated list and prioritized for additional monitoring.

A total of 70 watersheds were classified as impaired and will be placed on Category 5 of the 2008 Integrated list. These watersheds represent 74% (6,813 miles) of the 1st through 4th order streams in Maryland. Within these watersheds, a total of 51% (3,494/6,813 miles) of the streams are degraded.

A total of 24 watersheds were classified as similar to reference conditions and fully supporting the aquatic life use. These watersheds account for 19% (1,750 miles) of the 1st through 4th order streams in Maryland. These 24 watersheds will be placed in Category 2 of the 2008 Integrated List.

The remaining 19 watersheds were classified as inconclusive and account for 5% (488 miles) of Maryland's 1st through 4th order streams. These watersheds were classified as inconclusive because either the monitoring data does not capture the heterogeneity of the watershed or the uncertainty is too high for the watershed to be classified as passing. These watersheds will be placed in Category 3 of the 2008 Integrated List and will be targeted for additional monitoring.

Table 10: Summary of 2008 Watershed Assessments Using MBSS Rounds 1 and 2 Data.

Integrated Report Final Status	Number of 8-digit Watersheds	Stream Miles (a)	% of Total Stream Miles (a/9,199)	Stream Miles with F or B-IBI<3 (b)	% of Stream Miles with F or B-IBI<3 (b/a)	% of Total Stream Miles with F or B-IBI<3 (b/9,199)	Integrated Report of Watershed Stream Miles Impaired (c)	Integrated Report of % of Total Watershed Stream Miles Impaired (c/9,199)
Category 2	24	1,750	19%	234	13%	3%	0	0
Category 3 (Inconclusive)	19	488	5%	183	37%	2%	NA	NA
Category 3 (No data)	25	148	2%	0			NA	NA
Category 4 or 5	70	6,813	74%	3,494	51%	38%	3,494	38%
Total	**138**	**9,199**	**100%**	**3,911**	**43%**	**43%**	**3,494**	**38%**

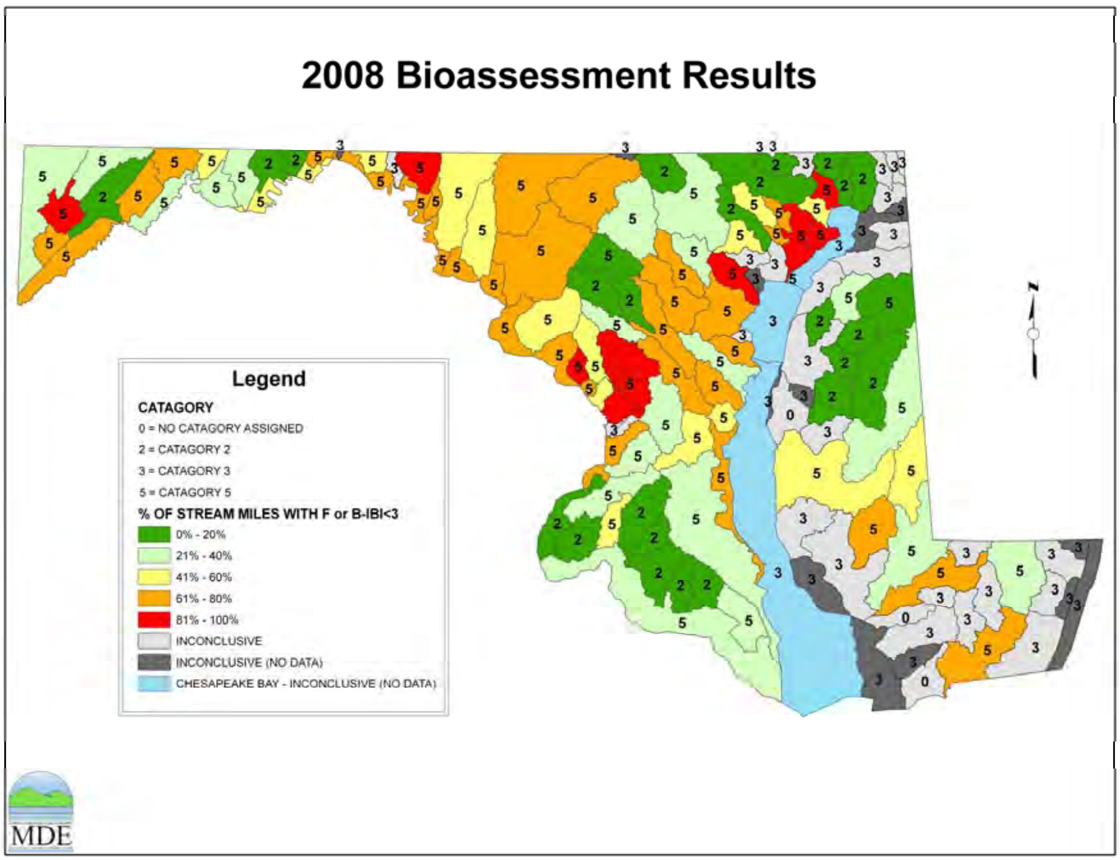

Figure 20: Summary of 2008 Watershed Assessment Using MBSS Rounds 1 and 2 Data.

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11.2 Tidal Biological Listing Methodology

Assessment of 2000 through 2004 Chesapeake Bay Estuarine Benthic Communities
Protocol and Summary of Results for MD and VA
2006 305b/303d Integrated Reports
September 30, 2005

A project has been completed in cooperation among environmental management staff with the State of Virginia (VADEQ), State of Maryland (MDE, MDNR), and EPA (RIII and CBLO) to assess Chesapeake Bay benthic community health. The project examined Chesapeake Bay program benthic monitoring data collected during the 5 year time period of 2000 – 2004 with the goal of determining status of this living resource in relation to the US Clean Water Act sections 305b and 303d (2006 303(D) Assessment Methods For Chesapeake Bay Benthos, Final Report Submitted to: Virginia Department of Environmental Quality, Roberto J. Llansó, Jon H. Vølstad Versar, Inc., Daniel M. Dauer Michael F. Lane, Old Dominion University, September 2005). This document describes the final agreed upon decision protocol on how to use the data analyses results and summarizes the key results for use in the 2006 305b/303d Integrated Reports of Maryland and Virginia.

Protocol

The overall decision protocol is shown in Figure 1. Phase I consists of the evaluation of the sample size (*i.e.*, number of B-IBI scores) available from the waterbody segment during the five-year assessment window. If the sample size satisfies the requirements of the statistical method ($N \geq 10$), a formal assessment of status (i.e. impaired vs. supports aquatic life use) is determined utilizing the "percent degraded area" statistical methodology (Phase II). If the sample size requirement is not met an impairment assessment based solely on these analyses is not possible. Results for segments with insufficient sample size should still be examined for possible use in conjunction with other assessment data of the 305b/303d reporting process.

Phase II consists of the impairment assessment of aquatic life use attainment based on a comparison of Benthic Index of Biotic Integrity (B-IBI) scores and can only be performed when the number of B-IBI scores within a specified waterbody segment is sufficient to meet the sample size requirement of the approved statistical method ($N \geq 10$). Phase II can result in one of two possible outcomes: (1) the segment is not impaired for Aquatic Life use due to benthic community status (note that the segment may still be impaired for aquatic life use due to failure of other aquatic life use criteria), or (2) the segment fails to support aquatic life use due to benthic community status and is assessed as impaired. Best professional judgment can be applied to override (reverse) the outcome of the formal statistical analysis results, but such reversals must be justified and documented.

Phase III consists of the identification of probable causes of benthic impairment of the waterbody segment based upon benthic stressor diagnostic analyses. It is a two step procedure that involves (1) Site Classification, and (2) Segment Characterization.

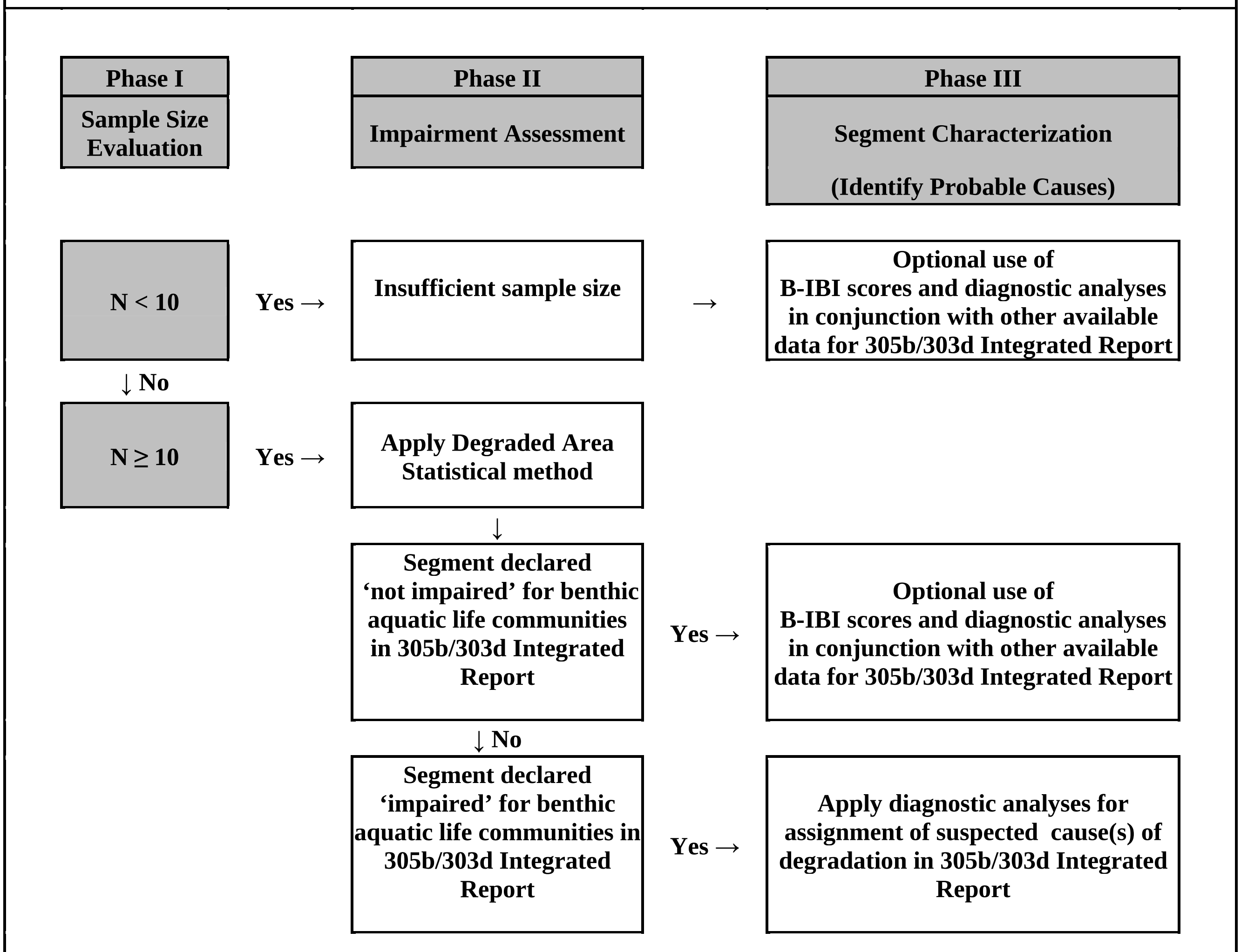
1. Site classification: The first step is to assign probable cause of benthic degradation to each individual "degraded" benthic sample. For purposed of these diagnostic analyses, a sample is considered degraded if the B-IBI score is less than 2.7.

   Site Classification - Step 1a: The application of a formal statistical linear discriminant function calculates the 'inclusion probability' of each degraded site belonging to a 'contaminant caused' group or an 'other causes' group, based upon its B-IBI score and associated metrics. If a site is assigned to the 'Contaminant' Group with a probability ≥ 0.9, this site is considered impacted by contaminated sediment and no further classification is required.

Site Classification - Step 1b: If a site is classified as degraded due to 'other causes' (*i.e.*, not contaminant-related), an evaluation of the relative abundance (and/or biomass) of the benthos is examined. Scores for both abundance and biomass are considered to be bipolar for the Chesapeake Bay Benthic IBI. For either metric; a high score of 5, indicating desirable conditions, falls in the mid-range of the abundance/biomass distributions, while a low score of 1, indicating undesirable conditions, can result either from insufficient abundance/biomass or excessive abundance/biomass. The scoring thresholds for these two metrics vary with habitat type (salinity regime and substrate type) as summarized in Figure 2. In this process, a site is classified as degraded by "low dissolved oxygen" if the abundance (and/or biomass) metric scores a 1 due to insufficient abundance (and/or biomass). Alternatively, if the abundance (and/or biomass) metric scores a 1 because of excessive abundance (and/or biomass) the site is classified as degraded by "eutrophication".

2. Segment classification: The assignment of probable causes of benthic degradation for the overall segment is accomplished using a simple 25% rule. If the percent of total sites in a segment impacted by a single cause (i.e. sediment contaminants, low dissolved oxygen, or eutrophication) exceeds 25%, then that cause is assigned. If no causes exceed 25%, the cause is considered unknown. The cause(s) should be identified as a suspected (vs. verified) cause of benthic community degradation in the ADB database.

Figure 1) Overall Decision Protocol.



Habitat	Metric	Lower Limit (Metric Score = 1)	Upper Limit (Metric Score = 1)
Tidal Freshwater	Abundance (# m^{-2})	< 800	≥ 5,500
	Biomass (g m^{-2})	---	---
Oligohaline	Abundance (# m^{-2})	< 180	≥ 4,050
	Biomass (g m^{-2})	---	---
Low Mesohaline	Abundance (# m^{-2})	< 500	≥ 6,000
	Biomass (g m^{-2})	< 1	≥ 30
High Mesohaline Sand	Abundance (# m^{-2})	< 1,000	≥ 5,000
	Biomass (g m^{-2})	< 1	≥ 50
High Mesohaline Mud	Abundance (# m^{-2})	< 1,000	≥ 5,000
	Biomass (g m^{-2})	< 0.5	≥ 50
Polyhaline Sand	Abundance (# m^{-2})	< 1,500	≥ 8,000
	Biomass (g m^{-2})	< 1	≥ 50
Polyhaline Mud	Abundance (# m^{-2})	< 1,000	≥ 8,000
	Biomass (g m^{-2})	< 0.5	≥ 30

Limiting Values for Abundance and Biomass Metric Scores

From Table 9, pages 24-26 in: Llanso, R.J. 2002. Methods for Calculating The Chesapeake Bay Benthic Index of Biotic Integrity. Versar, Inc., 9200 Runsey Road, Columbia, MD 21045. Available at:

http://www.baybenthos.versar.com/docs/ChesBayBIBI.PDF

Figure 2) Metric Scoring for Eutrophication and Low D.O. Causes

Results

Table 1 shows the possible conclusions from following the above protocol. Table 2 shows the actual results summarized from the Versar report using this protocol. Note that both tables refer to the original source of results in the technical report titled "2006 303(D) Assessment Methods For Chesapeake Bay Benthos, Final Report Submitted to: Virginia Department of Environmental Quality, Roberto J. Llansó, Jon H. Vølstad - Versar, Inc., Daniel M. Dauer Michael F. Lane - Old Dominion University, September 2005." Table 3 shows the segment ID's and corresponding waterbodies. Analysts should review these results as well as the extensive detail provided in the technical report to ensure that conclusions are rational and reasonable. Best profession judgment, common sense, and ancillary information about each segment should be utilized as necessary and available.

Table 1) Possible conclusions.

n>=10 - sufficient sample size for assessment

Scenario	Impairment Analysis		Stressor Diagnostic Analyses		
	CL-L ($P-P_0$) (Table 3 of VERSAR Technical Report)	**Impaired: Degraded Area method? (Table 3 of VERSAR Technical Report)**	**Samples with contaminant Posterior Prob. *p*>= 0.90; % of Total (Table 5 of VERSAR Technical Report)**	**Degraded Samples with excessive Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Degraded Samples with Insufficient Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**
1	≤0	No	review as supplemental info	review as supplemental info	review as supplemental info

- A small, non-significant fraction of IBI scores are within or below the lower range of the reference distribution so water quality conditions in this segment support the benthic community (no impairment).
- Where community samples are degraded, the stressor analyses may provide information that supports other assessment data.

2	>0	Yes	≤ 25% of Total Samples	≤ 25% of Total Samples	≤ 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses do not suggest dominant stressors affecting community composition. Cause of degradation is "unknown".

3	>0	Yes	> 25% of Total Samples	≤ 25% of Total Samples	≤ 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure.

4	>0	Yes	> 25% of Total Samples	> 25% of Total Samples	≤ 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure. Observation of high biomass or abundance is indicative of eutrophic conditions as an additional stressor affecting the benthic community.
-

5	>0	Yes	> 25% of Total Samples	≤ 25% of Total Samples	> 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure. Samples observed with low biomass or abundance are indicative of low dissolved oxygen as an additional stressor affecting the benthic community.

6	>0	Yes	≤ 25% of Total Samples	> 25% of Total Samples	≤ 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses do not suggest sediment contaminants as a stressors affecting community composition. Samples observed with high biomass or abundance are indicative of eutrophic conditions (excessive nutrients) as a stressor affecting the benthic community.

7	>0	Yes	≤ 25% of Total Samples	> 25% of Total Samples	> 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses do not suggest sediment contaminants as stressor affecting community composition. Samples observed with high biomass or abundance are indicative of eutrophic conditions within the segment while other samples observed with low biomass or abundance are indicative of low dissolved oxygen as another stressor within the segment.

8	>0	Yes	≤ 25% of Total Samples	≤ 25% of Total Samples	> 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses do not suggest sediment contaminants as a stressor affecting community composition. Samples observed with low biomass or abundance are indicative of low dissolved oxygen as a stressor affecting the segment.

9	>0	Yes	> 25% of Total Samples	> 25% of Total Samples	> 25% of Total Samples

- A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition).
- Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure. Samples observed with high biomass or abundance are indicative of eutrophic conditions within the segment while other samples observed with low biomass or abundance are indicative of low dissolved oxygen as an additional stressor within the segment.

n<10 – small sample size, insufficient for analysis

	Impairment Analysis		**Stressor Diagnostic Analyses**		
Scenario	**CL-L ($P-P_0$) (Table 3 of VERSAR Technical Report)**	**Impaired: Degraded Area? (Table 3 of VERSAR Technical Report)**	**Samples with contaminant Posterior Prob. *p*>= 0.90; % of Total (Table 5 of VERSAR Technical Report)**	**Degraded Samples with excessive Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Degraded Samples with Insufficient Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**
1	n/a	Unknown, Not Assessed	review as supplemental info	review as supplemental info	review as supplemental info

- There are too few samples to define the confidence interval of benthic sample IBIs, so in this segment – the biological community condition is unknown.
- Where community samples are identified as degraded, information from the stressor diagnostic analyses may provide supplemental information that may support other assessment data.

Table 2) Summary of results for 305b/303d use. NA = Insufficient sample size for impairment decision.

Segment	**Impaired: Degraded Area? (Table 3 of VERSAR Technical Report) NA= insufficient sample size)**	**Mean B-IBI (Table 3 of VERSAR Technical Report)**	**Sample Size (Table 3 of VERSAR Technical Report)**	**Samples with contaminant Posterior Prob. *p*>= 0.90; % of Total (Table 5 of VERSAR Technical Report)**	**Degraded Samples with excessive Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Degraded Samples with Insufficient Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Suspected Sour community c**
LAFMHa	Y (1)	2.4	27	48.15	3.7	3.7	Sediment Contamina
PMKOHa	Y	2.6	11	27.27	0	9.09	Sediment Contamina
EBEMHa	Y	2.2	15	60	0	0	Sediment Contamina
JMSMHb	Y	2.4	16	50	0	0	Sediment Contamina
ELIPHa	Y	2.8	17	17.65	5.88	5.88	Unknown
MAGMH	Y	2.3	17	11.76	5.88	29.41	Low DO
WBEMHa	Y	2.4	19	36.84	5.26	5.26	Sediment Contamina
MOBPHa	Y	3	20	20	5	10	Unknown
JMSOHa	Y	2.9	22	13.64	0	18.18	Unknown
CHOMH2	Y	2.9	22	27.27	9.09	4.55	Sediment Contamina
CB4MH	Y	2.3	28	7.14	21.43	42.86	Low DO
YRKPHa	Y	3	29	10.34	3.45	10.34	Unknown
CHSMH	Y	2.6	33	6.06	15.15	27.27	Low DO
ELIMHa	Y	2.5	37	18.92	8.11	13.51	Unknown
CB5MH	Y	2.7	44	4.55	2.27	34.09	Low DO
JMSMHa	Y	2.7	46	17.39	6.52	15.22	Unknown
SBEMHa	Y	2	47	57.45	14.89	12.77	Sediment Contamina
PATMH	Y	2.4	49	20.41	2.04	36.73	Low DO
CB3MH	Y	2.7	61	14.75	1.64	27.87	Low DO
YRKMHa	Y	2.5	64	25	9.38	9.38	Unknown
POTMH	Y	1.7	91	16.48	2.2	64.84	Low DO
RPPMHa	Y	2.6	98	21.43	2.04	26.53	Low DO
PAXMH	Y	2.4	112	14.29	1.79	41.07	Low DO
APPTFa	NA	3	1	0	0	0	Unknown
YRKMHb	NA	1.7	1	0	100	0	Eutrophication

Table 2) Summary of results for 305b/303d use. NA = Insufficient sample size for impairment decision.							
Segment	**Impaired: Degraded Area? (Table 3 of VERSAR Technical Report) NA= insufficient sample size)**	**Mean B-IBI (Table 3 of VERSAR Technical Report)**	**Sample Size (Table 3 of VERSAR Technical Report)**	**Samples with contaminant Posterior Prob. *p*>= 0.90; % of Total (Table 5 of VERSAR Technical Report)**	**Degraded Samples with excessive Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Degraded Samples with Insufficient Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Suspected Sou[r] community c[...]**
YRKPHd	NA	1.3	1	0	0	100	Low DO
YRKPHe	NA	2.7	1	0	0	0	Unknown
MOBPHe	NA	2.7	1	0	0	0	Unknown
MOBPHf	NA	1.3	1	0	0	100	Low DO
MOBPHg	NA	1.7	1	0	0	100	Low DO
RPPMHd	NA	1.7	1	0	0	100	Low DO
MATTF	NA	1.7	1	100	0	0	Sediment Contamina
CHSTF	NA	2	1	0	100	0	Eutrophication
CHOTF	NA	3	1	0	0	0	Unknown
POCTF	NA	2.5	1	100	0	0	Sediment Contamina
BOHOH	NA	4	1	0	0	0	Unknown
WSTMH	NA	2.2	1	0	0	100	Low DO
MOBPHh	NA	2.7	2	0	0	0	Unknown
RPPMHm	NA	3.1	2	50	0	0	Sediment Contamina
JMSMHc	NA	3.1	3	33.33	0	0	Sediment Contamina
JMSMHd	NA	2.8	3	33.33	0	0	Sediment Contamina
JMSPHd	NA	1.7	3	33.33	0	0	Sediment Contamina
SASOH	NA	3.2	3	0	0	0	Unknown
MIDOH	NA	3.4	3	0	0	0	Unknown
PMKTFa	NA	3.9	4	0	0	0	Unknown
NANOH	NA	3.4	4	25	0	0	Unknown
BACOH	NA	2.1	4	25	0	0	Unknown
EASMH	NA	2.1	4	25	0	50	Low DO
FSBMH	NA	3.6	4	0	0	25	Low DO
NORTF	NA	3.2	4	0	25	25	Eutrophication and I
CHKOHa	NA	3.7	5	0	0	0	Unknown
RPPOHa	NA	3.5	5	20	20	0	Unknown
CHOOH	NA	2.7	5	20	20	0	Unknown
BIGMH	NA	2.9	5	0	0	20	Unknown
HNGMH	NA	2.8	5	0	0	20	Unknown
PAXTF	NA	2.6	6	16.67	16.67	0	Unknown
CHSOH	NA	3.2	6	16.67	0	0	Unknown
LCHMH	NA	2.5	6	0	16.67	33.33	Low DO
PAXOH	NA	2.8	7	14.29	14.29	14.29	Unknown
POCOH	NA	2.5	7	57.14	14.29	0	Sediment Contamina
RHDMH	NA	2.9	7	28.57	0	14.29	Sediment Contamina
CRRMHa	NA	2.4	8	0	0	25	Low DO
CHOMH1	NA	2.6	8	12.5	0	25	Low DO
ELKOH	NA	3.2	8	0	25	0	Eutrophication
SOUMH	NA	2.1	8	50	12.5	12.5	Sediment Contamina
POCMH	NA	2.6	9	11.11	0	22.22	Unknown
NANMH	NA	3	9	11.11	0	11.11	Unknown

Table 2) Summary of results for 305b/303d use. NA = Insufficient sample size for impairment decision.

Segment	Impaired: Degraded Area? (Table 3 of VERSAR Technical Report) NA= insufficient sample size)	Mean B-IBI (Table 3 of VERSAR Technical Report)	Sample Size (Table 3 of VERSAR Technical Report)	Samples with contaminant Posterior Prob. *p*>= 0.90; % of Total (Table 5 of VERSAR Technical Report)	Degraded Samples with excessive Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)	Degraded Samples with Insufficient Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)	Suspected Sou[…] community […]
WICMH	NA	2.8	9	33.33	0	0	Sediment Contamina[…]
BSHOH	NA	2.6	9	11.11	0	11.11	Unknown
JMSPHa	N	3.4	10	0	0	0	Unknown
MPNOHa	N	2.6	11	36.36	0	0	Sediment Contamina[…]
RPPTFa	N	3.5	11	18.18	0	0	Unknown
POTTF	N	3.1	12	16.67	0	0	Unknown
MPNTFa	N	3.5	13	0	0	0	Unknown
MANMH	N	3.1	13	7.69	0	15.38	Unknown
SEVMH	N	2.7	13	7.69	23.08	15.38	Unknown
JMSTFa	N	3.2	14	21.43	0	0	Unknown
GUNOH	N	2.9	15	6.67	6.67	20	Unknown
CB8PHa	N	3.4	15	0	0	13.33	Unknown
CB6PHa	N	3.3	18	5.56	5.56	11.11	Unknown
CB1TF	N	3.1	19	10.53	10.53	0	Unknown
POTOH	N	3.4	21	9.52	4.76	9.52	Unknown
CB2OH	N	3.8	40	0	0	0	Unknown
CB7PHa	N (2)	3.3	43	0	2.33	13.95	Unknown
TANMH	N (2)	3.2	48	2.08	0	10.42	Unknown

1) This Lafayette River segment did not actually "fail" the degraded area statistical test but is considered impaired for benthic communitie[…] professional judgment. Close examination of the underlying data revealed a single abnormally low salinity year which effected the deg[…] statistical test. The segment has a very low mean IBI score (2.4), is located in a highly urbanized sub-watershed, and has a very high p[…] total area impacted by sediment contaminants (48%). The segment was also determined impaired by a Wilcoxon analysis both during t[…] data period and the 2006 assessment data period.
2) These segments will be listed as having "observed effects" in the ADB database for Virginia due to failure using the Wilcoxon statistic[…] discussed in the VERSAR Technical Report, the Wilcoxon is inappropriate for impairment declarations but does suggest a potential de[…]

Table 3) Segment ID's and corresponding waterbody. Map of CBP segments can be found at http://www.chesapeakebay.net/segmentscheme.htm				
Segment	**Waterbody**		**Segment**	**Waterbody**
APPTFa	Appomattox River, Mainstem of APPTF		MOBPHf	Ware River
BACOH	Back River		MOBPHg	North River
BIGMH	Big Annemessex River		MOBPHh	East River
BOHOH	Bohemia River		MPNOHa	Mattaponi River, mainstem of MOBPH
BSHOH	Bush River		MPNTFa	Mattaponi River, mainstem of MPNTF
CB1TF	Maryland mainstem		NANMH	Nanticoke River
CB2OH	Maryland mainstem		NANOH	Nanticoke River
CB3MH	Maryland mainstem		NORTF	Northeast River
CB4MH	Maryland mainstem		PATMH	Patapsco River
CB5MH	Maryland/Virginia mainstem		PAXMH	Patuxent River
CB6PHa	Virginia Bay, mainstem of CB6PH		PAXOH	Patuxent River
CB7PHa	Virginia Bay, mainstem of CB7PH		PAXTF	Patuxent River
CB8PHa	Virginia Bay, mainstem of CB8PH		PMKOHa	Pamunkey River, Mainstem of PMKOH
CHKOHa	Chickahominy River, mainstem of CHKOH		PMKTFa	Pamunkey River, mainstem of PMKTF
CHOMH1	Choptank River		POCMH	Pocomoke Sound
CHOMH2	Choptank River		POCOH	Pocomoke River
CHOOH	Choptank River		POCTF	Pocomoke River
CHOTF	Choptank River		POTMH	Potomac River
CHSMH	Chester River		POTOH	Potomac River
CHSOH	Chester River		POTTF	Potomac River
CHSTF	Chester River		RHDMH	Rhode River
CRRMHa	Corrotoman River		RPPMHa	Rappahannock River, mainstem of RPPMH
EASMH	Eastern Bay		RPPMHd	Robinson Creek
EBEMHa	Elizabeth River Eastern Branch		RPPMHm	Totuskey Creek
ELIMHa	Elizabeth River, mainstem of ELIMH		RPPOHa	Rappahannock River
ELIPHa	Elizabeth River, mainstem of ELIPH		RPPTFa	Rappahannock River, mainstem of RPPTF
ELKOH	Elk River		SASOH	Sassafras River
FSBMH	Fishing Bay		SBEMHa	Elizabeth River Southern Branch, mainstem of SBEMH
GUNOH	Gunpowder River		SEVMH	Severn River
HNGMH	Honga River		SOUMH	South River
JMSMHa	James River, Mainstem of JMSMHa		TANMH	Tangier Sound
JMSMHb	Nansemond River		WBEMHa	Elizabeth River Western Branch, mainstem of WBEMH
JMSMHc	Pagan River		WICMH	Wicomico River
JMSMHd	Warwick River		WSTMH	West River
JMSOHa	James River, mainstem of JMSOHa		YRKMHa	York River, maistem of YRKMH
JMSPHa	James River, mainstem of JMSPH		YRKMHb	Queen Creek
JMSPHd	Willoughby Bay		YRKPHa	York River, mainstem of YRKPH
JMSTFa	James River, mainstem of JMSTF		YRKPHd	Sarah Creek
LAFMHa	Lafayette River		YRKPHe	Timberneck Creek
LCHMH	Little Choptank			
MAGMH	Magothy River			
MANMH	Manokin River			
MATTF	Mattawoman River			

MIDOH	Middle River			
MOBPHa	Mobjack Bay			
MOBPHe	Severn Creek			

11.3 Guidelines for Interpreting Dissolved Oxygen and Chlorophyll *a* Criteria in Maryland's Seasonally Stratified Water-Supply Reservoirs

I. Dissolved Oxygen

A. Introduction.

Maryland's non-tidal water quality standards provide for a minimum dissolved oxygen (DO) criterion of 5.0 mg/l for all waters at all times (COMAR 26.08.02.03-3A(2)), except as resulting from natural conditions (COMAR 26.08.02.03A(2)). Bottom waters in thermally stratified lakes may naturally become depleted of DO during periods of stratification (Wetzel 2001).

New standards approved for the State's tidal waters, including the Chesapeake Bay, recognize the significance of thermal/salinity stratification, and the physical and natural impact thereof on deeper waters. The new standards for estuarine waters recognize three layers: (1) open water (surface); (2) deep water (below the upper pycnocline); and (3) deep channel (bottom waters).

All of Maryland's water-supply reservoirs undergo periods of seasonal thermal stratification similar to that in Chesapeake Bay. In the absence of a standard specifically addressing stratified lakes, MDE (1999) developed an interim interpretation of the existing standard, utilizing the percentage of oxygen saturation in the hypolimnion as a metric. This document updates that interim interpretation, providing a framework for additional technical analyses with respect to hypolimnetic DO in thermally stratified lakes.

B. Background

In idealized cases, lakes stratify into three distinct layers—the epilimnion, metalimnion and hypolimnion. The epilimnion is the well-mixed surface layer of relatively warm water. The metalimnion, the middle layer, is a zone of a distinct downward temperature gradient. The hypolimnion is the bottom layer of relatively cold and undisturbed water. Various analytical methods, typically involving measurement of temperature change over depth, exist to identify and define these layers. (Wetzel, 2001).

Thermal stratification is a seasonal phenomenon resulting from the lower density of warm surface waters, beginning in late spring or early summer, intensifying as summer progresses, decreasing in early fall, and finally ending with the fall turnover, as the lake becomes thermally uniform with depth. Therefore, data from May or June will generally show less stratification and higher hypolimnetic DO levels than data from August and September.

Often, stratified lakes do not exhibit this idealized separation into three distinct layers, but may still exhibit clear temperature gradients from surface to bottom. This phenomenon may be particularly true in the case of artificial impoundments, given the variability in basin and watershed morphometry and geometry. The formulaic determination of the exact point at which one layer grades into another may thus be difficult or impossible, and in such cases, managers may need to explore alternative methodologies or resort to professional judgment.

Various factors affect the ‘natural’ degree of oxygen depletion in a lake or impoundment. These include the degree or ‘strength’ of stratification; the morphometry of the water body itself (*i.e.*, the depth and geometry of the basin); and watershed characteristics, such as watershed size, land cover, and naturally occurring allochthonous loads of organic material.

Chapra (1997) describes hypolimnetic DO saturation as a function of lake trophic status[3]. This relationship, upon which Maryland based its interim interpretation, is summarized in Table 1 below.

Table 1

Relationship between Lake Trophic Status and Dissolved Oxygen Saturation in the Hypolimnion of a Thermally Stratified Lake

Trophic Status	Hypolimnetic Dissolved Oxygen Saturation
Eutrophic	0% - 10%
Mesotrophic	10% - 80%
Oligotrophic	80% - 100%

Adapted from Chapra (1997)

Maryland has no natural lakes; all are artificial impoundments—typically either larger, water-supply reservoirs, or smaller, recreational-use lakes. [In this document, the terms “lake” and “impoundment” are used interchangeably.] In impoundments, the factors outlined above (especially basin morphometry and watershed size) differ inherently from those in natural lakes. Natural lakes are typically deepest in the center with a gradual increase in depth to that point, while impoundments are usually deepest at the downstream extent—the point of impoundment—and exhibit an abrupt increase in depth at that point. Watershed size is also often proportionately greater in the case of impoundments, resulting in a correspondingly larger ‘natural’ load of watershed-derived materials (Wetzel 2001). For these reasons, Chapra’s saturation-based method may not apply well to impoundments.

C. Dissolved Oxygen Guidance for Thermally Stratified Lakes in Maryland

MDE is adopting the following general approach to establish dissolved oxygen guidelines for lakes exhibiting seasonal thermal stratification:

[3] When conducting analyses specifically to assess lake trophic status, Maryland generally uses other, more reliable, metrics (e.g., chlorophyll *a* concentration).

- A minimum dissolved oxygen concentration of 5.0 mg/l will be maintained in the surface layer at all times, including during periods of thermal stratification, except during periods of overturn or other naturally-occurring disruption of stratification.

- A minimum dissolved oxygen concentration of 5.0 mg/l will be maintained throughout the water column during periods of complete and stable mixing.

- Hypolimnetic hypoxia will be addressed on a case-by-case basis. In the event of hypoxia observed in the deeper portions of lakes during stratification, Maryland will conduct an analysis to determine if current loading conditions result in a degree of hypoxia that significantly exceeds (in terms of frequency, magnitude and duration) that associated with natural conditions in the lake and its watershed. This analysis may vary from one lake to another in terms of type, approach and scope. Examples may include a review of setting, source assessment and land use, so as to assess current loads; a comparison of estimated current loads exported from the watershed with analogous load estimates under 'natural' land cover; and model scenario runs simulating natural conditions. This list is not exhaustive, and Maryland expressly reserves the right to determine and conduct the most appropriate type of analysis on a case-by-case basis.

- The primary application of this approach is for use in conducting analyses to support development of Total Maximum Daily Loads (TMDLs) and Water Quality Analyses (WQAs), in satisfaction of the State's obligations under Section 303[d] of the federal Clean Water Act (CWA). It is also envisioned that these guidelines, or natural outgrowths thereof, may be used in the context of listing and inventorying water bodies under Sections 303 and 305 of the CWA.

II. Chlorophyll a

A. Introduction and Background.

Maryland's General Water Quality Criteria prohibit pollution of waters of the State by any material in amounts sufficient to create a nuisance or interfere directly or indirectly with designated uses. Maryland's water quality standards presently do not impose a limit on the concentration of nutrients in the water column.[4] Rather, Maryland manages nutrients indirectly by limiting their effects expressed in terms of excess algal growth and low DO. In impoundments, chlorophyll *a* concentrations serve as a useful surrogate for quantifying the effects of excess nutrient loading.

In establishing chlorophyll *a* guidelines for water-supply reservoirs, Maryland has adopted a two-pronged approach. First, a chlorophyll *a* concentration of 10 µg/l is generally recognized as a boundary between mesotrophic and eutrophic conditions (Carlson, 1977). In water-supply reservoirs, preventing a shift to eutrophic conditions reduces the frequency, duration and magnitude of nuisance conditions—e.g., algal scums (Walker, 1984). Secondly, a

[4] Maryland does limit the ammonia form of nitrogen from wastewater treatment plants, due to its toxic effects on some aquatic organisms.

mean concentration of chlorophyll a not to exceed 10 µg/l is correlated with an absence of instantaneous values exceeding 30 µg/l (see Figure 1). Exceedences of the 30 µg/l threshold are associated with a shift to cyanobacteria (blue-green algae) assemblages, and associated taste/odor treatment costs. Thus, maintaining chlorophyll a concentrations below these respective values ensures that the drinking water designated use will be supported.

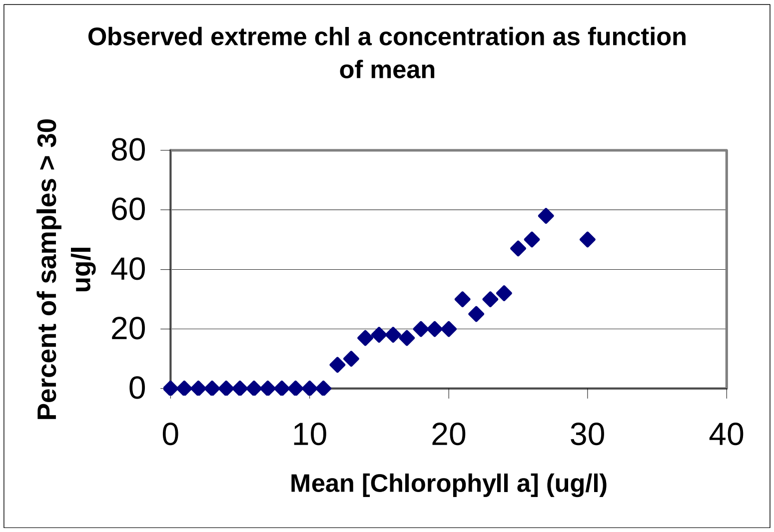


Figure 1. Correlation of instantaneous and growing season mean Chlorophyll *a* concentrations (adapted from Walker, 1984).

B. Chlorophyll *a* Guidelines for Water-Supply Reservoirs in Maryland.

MDE is adopting the following general approach to establish chlorophyll *a* guidelines for water-supply reservoirs:

- Mean concentrations of chlorophyll *a* in representative surface waters shall be maintained at 10 µg/l or less. This may be as measured over a growing season, as a 30-day moving average, or in any other period appropriate to the impoundment of interest.

- The 90th percentile of chlorophyll *a* in representative surface waters shall be maintained at 30 µg/l or less.

III. REFERENCES

Carlson, R.E., 1977. A trophic state index for lakes. Limnology and Oceanography 22:361-369.

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Walker, William W., 1985. Statistical bases for mean chlorophyll *a* criteria. Lake Reserv. Manage. 2:57-62.

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11.4 Listing Methodology for pH and Mine Impacted Waters

All pH impairments are identified based on COMAR §26.08.02.03, which states that: "Normal pH values may not be less than 6.5 or greater than 8.5" in Use I, IP, II, III, IIIP, IV, or IVP waters. It is undesirable to incorrectly identify a waterbody as impaired when the observed condition is of a natural origin. Factors, such as the presence of a peat or black water bog or swamp would be considered as natural conditions, and therefore, not impaired under the CWA §303(d) listing process.

Other natural conditions, which should not be used to identify a waterbody as pH impaired would include an abundance of algae or aquatic plants that elevate pH levels above 8.5 as a result of photosynthetic driven chemical reaction, unless the condition is being caused by a defined nutrient enrichment source. Certain conditions in close proximity to limestone springs may also have natural pH values outside of the standards. Streams that do not meet the criterion for pH and which cannot be demonstrated to result from natural conditions will be listed as impaired.

Streams influenced by abandoned coal or clay mining operations (those that predate the permitting authority or designated as "pre-law") and having a pH below 6.5 would be listed as impaired.

Waterbodies displaying acidic conditions as a result of atmospheric deposition will be placed on the 303(d) list if it is determined that there is not adequate natural buffering capacity in the watershed.

The decision process for evaluating pH in Maryland waters is summarized in the following flowchart shown in Figure 19.

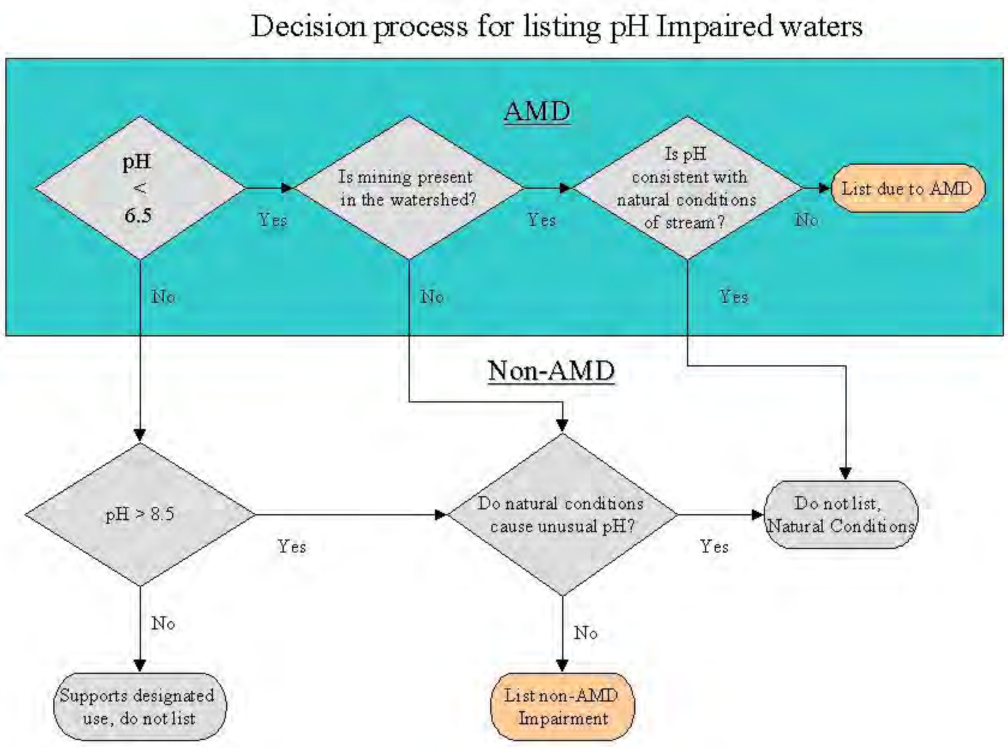

Figure 21: Decision flowchart for pH impaired waters.

The flow chart applies to Maryland 8-digit watersheds evaluated for the 303(d) list.

Ideally, an impairment decision should be based on a sufficient number of samples to adequately characterize potential diurnal and seasonal variations.

If 10% or more of the samples violate the pH numeric criteria and cannot be traced to naturally occurring conditions, the 8-digit stream watershed will be considered to not meet the standards for its designated uses and listed as impaired.

4. If less than 10% of the samples violate the pH numeric criteria, best professional judgement will be used to determine if the 8-digit watershed should be listed as impaired. In the event the waterbody is not listed, additional samples will be collected for future consideration.

11.5 Listing Methodology for Identifying Waters Impaired by Bacteria on Maryland's 303(d) List

Introduction
The rules used by MDE to interpret data and apply the water quality standards are discussed below in three sections. Each of those sections describes the application to a distinct water use: shellfish harvesting; recreational waters; and beaches. Although in each case a bacteriological indicator applies, the criterion and in some cases the indicator itself differs according to the requirements of the National Shellfish Sanitation Program (NSSP), water quality standards, or public health requirements. Data collected and analyzed using approved methods and in accordance with strict QA/QC guidelines may be utilized for decision making with respect to attainment status. All available data will be considered but may be used for prioritization, additional study, or revised monitoring.

Interpretation Of Fecal Coliform Data In Use II, Shellfish Harvesting Areas

(1) RESTRICTED:
Those areas restricted to shellfish harvesting because they do not meet State requirements for Use II waters or do not meet the strict requirements under the National Shellfish Sanitation Program (NSSP) are listed. These requirements are found in the *National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish*, 2003 revision. Copies can be obtained from the U.S. Department of Health and Human Services, PHS, FDA or on FDA's website: USFDA/CFSAN NSSP- Guide for the Control of Molluscan shellfish 2003. Data used to determine these restrictions include routine bacteriological water quality sampling, sanitary survey, and strict adherence to the NSSP procedures, protocols and requirements. In summary, fecal coliform MPN/100 ml must have a median of less than 14 and a 90th percentile of less than 49.
(1A)
Those areas restricted to shellfish harvesting because they are located in the vicinity of a wastewater treatment plant (WWTP) outfall but where there is <u>no evidence of actual bacteriological impairment</u> are not listed. This restriction is an important application of the principals and practices of public health protection and is required under the NSSP. MDE also evaluates treatment plant performance and its impact to shellfish harvesting waters. These administrative closures are not based on water quality criteria but are designed to be protective buffer areas in case of a system failure. <u>These areas meet the bacteriological portion of the standard</u>.
(1B)
The upper Chesapeake Bay is restricted to shellfish harvesting for administrative reasons and is not listed. This area is designated as Use II waters; however there is insufficient shellfish resource for harvesting due to the fresh water input from the Susquehanna River. Since there are no oysters or clams to harvest and the NSSP requirements for sanitary survey is not met, the area is classified as restricted. In order to protect shellfish waters directly below this area, the shellfish harvesting water designation is a valuable protective measure. <u>Water quality is routinely monitored in this area for fecal coliform and meets the bacteriological portion of the standard</u>. If the collected data shows violations with State standards (notwithstanding the fact that the area is under an administrative closure or restriction) it will be listed appropriately.

(2) CONDITIONALLY APPROVED WATERS:

Before being opened for conditional harvesting, areas need to meet the stringent shellfish bacteriological standards. However, those areas classified as conditionally approved are closed to harvesting for three days following a rainfall event of greater than or equal to one inch in twenty-four hours. This happens an average of 10 - 15 times per year when it is not completely certain that bacterial levels are not elevated in response to rain. The rest of the time, these areas meet the water quality standards for Use II waters and are determined to meet the designated use.

(3)APPROVED WATERS:
Areas classified as approved for harvesting meet the water quality standards for Use II waters.

Interpretation Of Bacteria Data For General Recreational Use

Maryland has implemented the EPA recommended enterococcus (marine or freshwater and *E. coli* (freshwater only) standards for all waters except shellfish harvesting waters, where the more stringent FDA standard must be met.

According to EPA's *Ambient Water Quality Criteria for Bacteria -1986*, the indicators E. coli and enterococcus have been found through epidemiological studies to have the best quantifiable relationship between the density of an indicator in the water and the potential human health risks associated with swimming in sewage contaminated waters. "Indicator organisms are a fundamental monitoring tool used to measure both changes in environmental (water) quality or conditions and the potential of hard-to-detect pathogenic organisms. An indicator organism provides evidence of the potential presence or absence of a pathogenic organism that survives under similar physical, chemical, and nutrient conditions. (EPA Beach Guidance, June 2002).

Maryland's bacteria indicator criterion is a conservative measure, which protects the public from the potential risks associated with swimming and other primary contact recreation activities. A few high values of the indicators may or may not be indicative of impairment. Therefore, it is necessary to evaluate the results from indicator organisms from multiple sampling events over time to adequately quantify water quality conditions.

<u>*Recreational Waters:*</u>

Step 1 - A steady state geometric mean will be calculated with available data from the previous year where there is at least 5 representative sampling events. The data shall be from samples collected during steady state, dry weather conditions and during the beach season (Memorial Day through Labor Day) to be representative of the critical condition (highest use). If the resulting steady state geometric mean is greater than 35 cfu/100 ml enterococci in marine/estuarine waters, 33 cfu/100 ml enterococci in freshwater or 126 cfu/100 ml *E. coli* in freshwater, the water body will be included for further assessment. If fewer than 5 representative sampling events for an area being assessed are available, data from the previous two years will be evaluated.

Step 2 – Once a preliminary list is assembled, a steady state geometric mean will be calculated with available data from the previous two (2) to five (5) years. The data shall be from samples collected during steady state, dry weather conditions and during the beach season (Memorial Day through Labor Day) to be representative of the critical condition (highest use). If the resulting geometric mean is greater than 35 cfu/100 ml enterococci in marine/estuarine waters, 33 cfu/100 ml enterococci in freshwater or 126 cfu/100 ml *E. coli* in freshwater, the water body will be listed in Category 3 of the Integrated Report as requiring more data.

Category 3 of the Integrated Report

When waters are listed in Category 3 (insufficient data) of the Integrated Report, a sanitary survey must be conducted to identify potential sources of pathogenic bacteria. If the sanitary survey identifies significant sources of pathogenic bacteria and they are not corrected, the waters will be moved to Category 5 (Impaired) of the Integrated Report. If the sanitary survey is conducted and any potential sources of pathogenic bacteria are remedied, the waters will be removed from Category 3 and placed in Category 2 (Supporting some designated uses) of the Integrated Report.

Category 5 of the Integrated Report

For waters listed in Category 5, a sanitary survey must be conducted if it was not conducted before or after the waters were listed in Category 3 of the Integrated Report. A water body can be removed from Category 5 (A) if it meets the steady state geometric mean standard referenced in 4.4.3.1 and (B) if a sanitary survey is conducted at the water body and there are no sources of pathogenic bacteria found, or if sources of pathogenic bacteria are remedied.

Beaches

Beaches are designated as “Beaches” from Memorial Day through Labor Day (Beach Season). During this period, beaches are monitored closely using a tiered approach based on risk to human health since these are places identified as areas where people are likely to swim. High, Medium, and Low priority beaches are monitored weekly, biweekly, and monthly, respectively. Low priority beaches will be re-evaluated regularly to determine if they should be prioritized higher or removed from the list of beaches. This will mean that eventually, all beaches will have more than the necessary number of sampling events performed to adequately assess them.

MDE has delegated the authority for monitoring and notifying the public regarding beach water quality conditions to local health departments. MDE’s role is to assure that beaches state-wide are managed uniformly. MDE maintains a database of all beaches in Maryland including latitude and longitude coordinates of the endpoints identifying the beach segment, sanitary survey information provided by the local health departments, and monitoring results (all beach monitoring samples are submitted to DHMH for laboratory analysis). This data, along with all other available data will be used to determine which areas are to be listed as impaired.

The listing methodology for all general recreational use also applies to beaches (Section 4.4.3). The single sample maximum criteria applies only to beaches and is to be used for closure and advisory decisions based on short term exceedences of the geometric mean portion of the standard.

Discussion

It is critical that the sampling be carried out in a way that is representative of conditions in time and space. Per EPA’s *Ambient Water Quality for Bacteria - 1986* , the calculated “densities are for steady state dry weather conditions.” A sampling event means samples taken at a beach, or other waterbody to characterize bacterial concentrations with the number and placement of sampling stations sufficient to characterize conditions in the full extent of the beach area or waterbody. High spatial and temporal variability suggest that infrequent or moderately elevated bacteriological levels alone do not necessarily represent a human health risk or impairment. The bacteriological standard is descriptive and includes numerical criteria. The intent of the criteria is to allow the 'number' to be judged in conjunction with the sanitary survey that identifies probable sources of bacteria and allows regulators to assess the probability of human health risk. The standard recognizes the inherent variability of the bacterial measurement and recognizes the inadequacies of indicator organisms. The Most Probable Number (MPN) or Colonies Forming Units (CFU) test used to determine the level of bacteria is not a direct count but a statistical estimation subject to a high degree of variability.

11.6 Listing Methodology for Determining Impaired Waters By Chemical Contaminants for the Maryland 303(d) List

BACKGROUND

The designated uses define the water quality goals of a waterbody. At a minimum, the Maryland Department of the Environment (MDE) must provide water quality for the protection and propagation of fish, shellfish, and wildlife, and provide for recreation in and on the water, where attainable (CWA Section 101(a)). The MDE is required to adopt water quality criteria that protect designated uses. Such criteria must be based on sound scientific rationale, must contain sufficient parameters to protect the designated uses, and can be expressed in either numeric or narrative form. Narrative criteria are descriptions of the conditions necessary for a waterbody to attain its designated use, while numeric criteria are concentration or threshold values deemed necessary to protect designated uses. Narrative criteria can be used to assess water quality, and also to establish pollutant-specific discharge limits where there are no numeric criteria or where such criteria are not sufficient to protect the designated use.

Although several approaches exist to assess water quality (e.g., numeric criteria, whole effluent toxicity, etc.), few approaches exist to assess sediment quality due to its complexities. Nevertheless, sediments are an integral component of aquatic ecosystems, providing habitat, feeding, spawning, and rearing areas for many aquatic organisms and are, therefore, protected under the narrative criteria. Furthermore, sediment quality can affect whether or not waters are attaining designated uses. Consequently, it is necessary and appropriate to assess and protect sediment quality, as an essential component of the total aquatic environment, to achieve and maintain designated uses. The difficulty lies in implementing the narrative criteria, which is qualitative in nature. To circumvent this obstacle, MDE is implementing an approach to quantitatively interpret narrative criteria statements, and determine water quality standard violations from contaminated sediments.

INTRODUCTION

Under section 303(d)(1) of the Federal Clean Water Act (CWA), MDE is required to establish Total Maximum Daily Loads (TMDLs) for those waterbody segments that do not meet applicable water quality standards and are therefore considered “impaired”. To achieve this, MDE is required to consider all existing and readily available water quality data and information, and develop methods to interpret this data for each potential impairing substance (e.g., pH, nutrient, fecal coliform, etc.).

EPA does not provide guidance for interpreting water quality data for the purposes of developing the 303(d) List. However, EPA does provide guidance on making “use support determinations” for the State Water Quality Assessments [305(b) Report] (EPA, 1997). In general, MDE adopted the 305(b) guidance for identifying waterbody segments impaired due to chemical contaminants. Even though the Department will adhere to these methods as closely as possible, there may be instances where determinations may vary based on scientifically defensible decisions. It is important to note that there maybe situations which do not support an impairment determination from chemical contaminants, but rather from another stressor (e.g., dissolved oxygen, biocriteria), and would therefore be addressed elsewhere. This document provides the specific methodology used by MDE for identifying waterbody segments impaired due to *chemical contaminants*.

It is not the intent of this methodology to include waters that do not meet water quality criteria solely due to natural conditions or physical alterations of the waterbody not related to anthropogenic pollutants. Similarly, it is not the intent of this chapter to include waters where designated uses are being met and where water quality criteria exceedances are limited to those parameters for which permitted mixing zones or other moderating provisions (such as site-specific alternative criteria) are in effect. The Department will examine these situations on a case-by-case basis, and evaluate the context under which the exceedance exists. Determination of compliance with water quality criteria may be facilitated through special analyses (e.g. normalization of metals to common reference element to determine anthropogenic influences), or monitoring (e.g. compliance monitoring for mixing zones).

MDE considers all existing readily available chemical, toxicological, and biological data from water column, sediments, and fish tissue in determining if a waterbody segment should be classified as impaired due to chemical contaminants and listed on the 303(d) List. As a result, MDE has divided the impairment evaluation process into three media categories (water column, sediment, and fish tissue). The Department will evaluate the monitoring plans, Quality assurance, and Quality Control (QA/QC) programs of data providers, and will use best professional judgment to include/exclude data where documentation does not exist.

WATER COLUMN

Ambient water column contaminant data are screened against numerical ambient water quality criteria if available. These water quality criteria are utilized because they represent science-based threshold effect values and are an integral part of the Maryland's water quality standards program. These criteria are divided into the following categories that directly relate to Maryland's surface water use designation classification (COMAR 26.08.02):

1) All surface waters of the state (USE DESIGNATIONS - I, II, III, & IV)

- Criteria for the protection of aquatic life
    - Fresh water (Chronic & Acute)
- Saltwater (Chronic & Acute)
- Criteria for the protection of human health from fish tissue consumption (Organism Only)

2) Surface waters used for <u>public water supply</u> (USE DESIGNATION - P)

- Criteria for the protection of human health from fish tissue consumption & drinking water (Water + Organism)
- Drinking water only (Maximum Contaminant Levels-MCLs)

EPA does not provide guidance in interpreting water column data for the purposes of developing the 303(d) list but does for the development of the 305(b) Report (Maryland's Water Quality Inventory). The 305(b) guidance states that, with a minimum of 10 samples over a three-year period, the designated use is not supported if greater than 10% (i.e. 2 out of 10) of the samples exceed the appropriate benchmark (EPA 1997). MDE had adopted this rule to identify waterbodies impaired by chemical contaminants. In other words, with a minimum of 10 samples over a three-year period, an impairment would exist if greater than 10% of the samples exceed the criteria. An appropriate statistical procedure (e.g., confidence interval approach) will be applied if sample size for a segment is deemed adequate. If there are less than 10 samples for a given area, MDE interprets the available data on a case-by-case basis and determines if an impairment exists. In such cases, a number of factors are considered such as:

- The magnitude of the criteria exceedance for any one contaminant,
- The number of criteria exceeded,
- Water column bioassay (toxicity) data indicating toxicity to test organisms.
- Data quality

If it is determined that a potential impairment exists, but there is insufficient data to make an impairment determination, the segment will be placed on Part-3 (Insufficient data), or Part-4 (Impaired/Threatened but TMDL not required due to forthcoming compliance or previous completion of a TMDL). Segment will then be prioritized for additional monitoring. In these instances, the Department will use its best professional judgment based on the available data to make its determination.

In the case that no criteria are available for a particular contaminant or no criteria are exceeded, other impairment indicators (e.g., ambient water column toxicity data) will be evaluated using best professional judgment. During this evaluation process, if toxicity is indicated, a Toxicity Identification Evaluation (TIE) maybe considered to further identify the possible contaminant source(s) causing toxicity. A TIE is a comprehensive approach used in the Whole Effluent Toxicity (WET) Program to identify possible causes of toxicity. When warranted, MDE will also utilize spatial and temporal trend analyses as an additional evaluation tool for making impairment determinations.

As mentioned previously, MDE considers all existing and readily available data, including independent studies conducted by sources external to MDE. These ambient water column data are screened to determine if they are of acceptable quality (i.e., documented methods and an acceptable QA/QC plan). If the data are unacceptable (i.e., poor or no QA/QC) but suggest an exceedance of the appropriate criteria, the segment is targeted for additional monitoring, and evaluated using other approaches.

In many cases, there may be no ambient water quality data (chemical or toxicity) available for an impairment evaluation. In such cases, MDE will apply a weight-of-evidence approach using other data as described below.

SEDIMENT

Protecting sediment quality is an important part of restoring and maintaining the biological integrity of our State’s waters. Sediment is an integral component of aquatic ecosystems, providing habitat, feeding, spawning, and rearing areas for many aquatic organisms. Sediment also serves as a reservoir for chemical contaminants and therefore a source of chemical contaminants to the water column and organisms. Chemicals that do not easily degrade can accumulate in sediments at much higher levels than those found in the water column.

Contaminated sediments can cause adverse effects in benthic or other sediment-associated organisms through exposure to pore water or direct ingestion of sediments or contaminated food. In addition, natural and human disturbances can release chemical contaminants to the overlying water, where water column organisms can be exposed. Sediment contaminants can reduce or eliminate species of recreational, commercial, or ecological importance, either through direct effects or by affecting the food supply that sustainable populations require. Furthermore, some chemical contaminants can bioaccumulate through the food chain and pose human health risks even when sediment-dwelling organisms are not themselves impacted. This specific pathway will be addressed later in the fish tissue approach.

MDE is using the following comprehensive weight-of-evidence approach in making impairment determinations. This approach, also referred to as the Sediment Quality Triad, consists of three components (Chapman, 1992):

- Ambient sediment bioassays - to measure toxicity
- *In situ* biological variables - to measure alteration of resident biota (*e.g.,* change in benthic community structure)
- Ambient sediment chemistry - to measure chemical contamination

These components provide complementary data to each other, that when combined may provide an efficient tool for determining an impairment. However, each component has its limitations, which necessitates a sound scientific interpretation of the data and best professional judgment on a case-by-case basis. The scientific community, in fact, has previously indicated that sediment assessments are strongest when the three data components are used in combination to balance their relative strengths and weaknesses (Chapman, 1992, Long et al., 2000, Anderson et al. 2001, Ingersoll et al., 1997, EPA 1997).

Ambient Sediment Bioassay Data

Ambient sediment bioassays are a type of biological data, in which test organisms are exposed under controlled conditions to the field collected sediment sample. Although we have confidence in this type of data because of the controlled conditions, it can be inconsistent, especially where toxicity is minimal or subtle. Laboratory artifacts, although generally controlled, can produce false results. For this reason, at least two or more non-microbial tests are required to exhibit toxicity to determine that the potential for adverse effects from contaminated sediment is high.

This type of data is essential in assessing sediment contaminants. If toxicity is exhibited to the tested benthic/epibenthic organisms, it is generally considered indicative of water quality that is incapable of supporting aquatic life, which is in violation of our State’s water quality standards. Furthermore, it also suggests that the adverse effects observed in the toxicity tests may be related to chemical contaminants because other non-contaminant related causes (e.g. dissolved oxygen, pH, temperature) are controlled in the laboratory setting. In addition, the information from this data component is quantitative and can be correlated to the toxicity of other sediments or chemicals to the test species. For this reason, the greatest weight is given to toxicity test data among the three data components.

However, a limitation of this data is that it does not identify the causative pollutant, which necessitates the need for sediment chemistry data. The sediment chemistry data provides the best link for establishing an impairment determination resulting from contaminant exposure, which is the basis of this document. Additionally, the laboratory conditions under which bioassays are conducted may not accurately reflect field conditions of exposure to toxic chemicals, and thus introduces uncertainties when extrapolating to population dynamics. This point is important to understand because while attempting to control for non-contaminant related stressors (e.g., dissolved oxygen, pH, temperature), contaminants in the sediments may be rendered toxic to the test organisms that would not be toxic under field conditions, thus providing a false positive result (e.g., sulfide and ammonia in sediments, pH shift for metals).

Sediment Chemistry Data

Although EPA has been working on sediment quality criteria (SQC) for many years, no final numeric water quality criteria have been published. This is due to the difficulty in determining the fraction of the chemical contaminant that is biologically available to exert its toxic effect on the exposed population and in establishing a criteria derivation process that could be shown to be consistent with other evaluative tools. In fact, the EPA has redirected their efforts to derive equilibrium sediment guidelines (ESGs), rather than criteria, for the following five substances; acenaphthene (EPA, 1993a), fluoranthene (EPA, 1993b), phenanthrene (EPA, 1993c), dieldrin (EPA, 1993d), and endrin (EPA, 1993e).

In the absence of such guidelines, a set of screening values devised by National Oceanic and Atmospheric Administration (NOAA) has been generally accepted as a screening tool to evaluate the likelihood of adverse effects (Long and Morgan, 1990/NOAA, 1991; Long *et al*., 1995). The Effects Range-Median (ER-M) values are defined as the median (50^{th} percentile) of the distributions of the effects data for a particular contaminant. However, these values should only be used to screen sediments for levels of possible concern, and should not be construed to indicate an adverse effect in the absence of additional corroborative data (Long and MacDonald, 1998). In their development of a classification scheme for the National Sediment Quality Inventory, EPA also recognized the limitations of the ER-Ms by requiring that the bulk sediment chemistry data exceed two separate sediment benchmarks in classifying sediments as Tier I (probable adverse effects to aquatic life and human health) (EPA 1996).

In the absence of EPA ESGs and NOAA ER-M values, sediment quality benchmarks (SQBs) were derived by MDE for non-ionic organic substances using the EPA-recommended equilibrium partitioning approach, (e.g.**,** alpha-BHC, beta-BHC, lindane, chlordane, chlorpyrifos, heptachlor, etc.). This is also consistent with EPA's National Sediment Quality Inventory. MDE will compare sediment chemistry data according to the described thresholds in the following order (see Table 15):

a) EPA ESGs,
b) NOAA ER-M values,
c) MDE derived SQBs, and
d) Other toxicological sediment benchmarks (*i.e.,* toxicity data)

Both the quality of sediment chemistry data and associated screening thresholds are considered when conducting an evaluation. Once the quality of data has been established, the potential for adverse effect from contaminated sediment is said to be high if either of the following conditions are met:

1. The sediment chemistry data exceeded the EPA ESG, or

2. The sediment chemistry data exceeded the ER-Ms or other screening values by a factor of two[5] for any one contaminant, or

3. The mean ER-M quotient[6] is greater than 0.5 (Long et al. 2000 & Anderson et al. 2001), or

4. The sediment chemistry data exceeded more than 5 ER-Ms[7] (Long et al. 2000 & Anderson et al. 2001).

Furthermore, various environmental conditions in the sediment can have a profound effect on the availability and toxicity of the sediments to aquatic environment (e.g., acid volatile sulfide for metals, organic carbon for organics, etc.). If data on these parameters are available, MDE will use best professional judgment to interpret the effects of these parameters on the sediment chemistry data.

When the measured chemical exceeds the appropriate sediment threshold, any observed adverse effects to the test species may be due to the measured chemical with the likelihood increasing as the chemical concentration increases. When a chemical is measured at a level below the threshold, any observed adverse effects are not likely to be due to the measured chemical. It is recognized, however, that sediments are rarely, if ever, contaminated by a single chemical. Therefore, in cases where a chemical is measured at a level below a threshold, the sediment may still cause adverse effects. Such cases could include, for example, contaminated sediments where chemicals not covered by a threshold are creating or contributing to toxicity, or where bioaccumulation or biomagnification up the food chain is a concern (EPA, 2000).

The mere exceedance(s) of a sediment threshold, however, does not in itself establish an adverse effect from toxicity, but helps to identify the chemical that might be responsible for any observed adverse effects from toxicity. Given these limitations, MDE does not believe that the exceedance(s) of sediment thresholds are appropriate as sole indicators of use attainment. Instead, we recommend using all three data components as a basis for interpreting narrative criteria and developing pollutant reduction strategies.

BIOLOGICAL BENTHIC ASSESSMENT DATA

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[5] The factor of two was derived as the geometric mean of the ratios for those substances for which ER-Ms and SQCs were available; acenaphthene (ER-M/SQC ratio=4.6), fluoranthene (ER-M/ESG ratio=0.6), and phenanthrene (ER-M/ESG ratio=1.6). Although it was possible to calculate a ratio for dieldrin (ER-M/ESG ratio=25), it was not considered because the ratio was greater than 5 times the highest of the other three ratios. This condition serves the purpose of confirming the severity of contamination for any one contaminant above background concentrations, and therefore demonstrating the potential for impairing that segment.

[6] An ER-M quotient is calculated as the ambient sample concentration over the ER-M (toxicity weighted average).

7 Long et al.,(2000) showed that there is a much higher probability (>48%) that samples would be toxic in which six or more ERM values are exceeded or in which mean ERM quotients exceed 0.5.

In freshwater, MDE currently uses biological community data independently in making an impairment determination. The methodology dealing with biological assessments is addressed elsewhere under the biocriteria framework. This type of data is generally considered a good water quality indicator, because it measures a community (population) response to water quality and integrates through time and cumulative impacts. Thus, if this assessment data or other types of assessment data (e.g. Chesapeake Bay restoration goals) do not indicate an alteration (or degradation) of the biological benthic community, the waterbody is not considered for an impairment determination, despite data from the other components because:

1. It is supportive of aquatic life (at a community level), and thus meets its designated use,

2. The biological assessment component is a more rigorous method of assessing water quality than chemical and bioassay data which may be highly dependent on uncontrollable variables

3. It measures a community response to water quality rather than subjective endpoints from the other components (e.g. ER-M, significant level of toxicity, toxicity to one species)

4. It is consistent with the biological assessments method developed elsewhere

It is more likely to observe an alteration of the biological community where none should be present (false positive) than not to observe alteration of the biological community where one should present (false negative). Anderson et al., 2001 found that laboratory toxicity tests were indicative of benthic impacts in Los Angeles and Long Beach Harbor stations in California. Single and multivariate correlations showed significant positive relationships between amphipod survival in laboratory toxicity tests and measured benthic community structure in field samples. For this reason, MDE would further investigate the chemistry and toxicity data where an alteration of the biological community has been observed. These data would be used to confirm that the community effect is due to exposure to contaminants and to identify the probable contaminant of concern. However, although biological assessment data alone could indicate an impairment, it would not necessarily result in a "toxics" impairment determination. This is because non-contaminant effects (e.g., competition, predation, sediment type, salinity, temperature, recent dredging) may confound interpretation of this data with respect to chemical contamination (Anderson et al., 2001).

WEIGHT-OF-EVIDENCE APPROACH (Sediment Quality Triad)

A comprehensive approach using multiple assessment methods helps eliminate false conclusions brought about by relying solely on one method of evaluation. Consequently, MDE would assess sediment quality, and thus an impairment determination, using a weight-of-evidence approach (Winger, et al., 2001). Biological assessments could be used to supplement findings of impaired waters, or as a prioritization tool to determine where additional testing should be performed. These components provide complementary data to each other, that when combined may, provide an efficient tool in determining an impairment. However, each component has its limitations, which necessitates a sound scientific interpretation of the data and best professional judgment on a case-by-case basis. Consequently, the individual use of these data components as sole indicators of use attainment is inappropriate. Instead, we recommend using all three data components as a basis for interpreting narrative criteria and developing pollutant reduction strategies.

Sediment chemistry data provide information on contamination, and when used with sediment thresholds or other indicators, also provide insight into potential biological effects. However, they provide little insight on the bioavailability of the contaminant unless data on other mitigating factors (e.g., AVS for metals, organic carbon for organic contaminants) are collected simultaneously. Sediment bioassays are an important component of sediment assessment because they provide direct evidence of sediment toxicity. However, they do not identify the causative pollutant. Additionally, the laboratory conditions under which bioassays are conducted may not accurately reflect field conditions of exposure to toxic chemicals. *In situ* biological studies (such as benthic community composition analyses) are useful because they account for field conditions. However, interpretation with respect to chemical contamination may be confounded by non-contaminant effects. Because each component alone has limitations, the Triad approach uses all three sets of measurements to assess sediment contamination. Table 15 lists possible conclusions that can be drawn from various sets of test results, followed by possible listing decisions.

Table 11: Possible Conclusions Provided by Using the Sediment Quality Triad Approach (Chapman, 1992)

Scenario	Toxicity	Chemistry	Community Alteration	Possible Conclusions	Listing Decision
1	+	+	+	Strong evidence for chemical contaminant-induced degradation.	**List (Part-5)**
2	-	-	-	Strong evidence for absence of chemical contaminant-induced degradation.	**Do not list for toxics**
3	-	+	-	Chemical contaminants are not bioavailable.	**Do not list for toxics Additional monitoring**
4	+	-	-	Unmeasured chemical contaminants or conditions may exist that have the potential to cause degradation.	**Do not list for toxics Additional monitoring**

5	-	-	+	Alteration is probably not due to chemical contaminants.	**Do not list for toxics**
6	+	+	-	Chemical contaminants are likely stressing the system. However, the waterbody is still meeting its designated use due to the presence of an unimpaired benthic community.	**Do not list for toxics Additional monitoring**
7	+	-	+	Unmeasured chemical contaminants are causing degradation.	**Do not list for toxics Additional monitoring**
8	-	+	+	Chemical contaminants are not bioavailable or alteration is not due to contaminants.	**Do not list for toxics Additional monitoring**

"+" Indicates measured difference between test and control or reference conditions.
"–" Indicates no measurable difference between test and control or reference conditions.

As indicated in Table 15, there may be scenarios where sediment chemistry data, sediment bioassays, and benthic community analyses produce conflicting results. In these scenarios, the interpretation becomes more complex, but it does not necessarily indicate that any of the data sets are "wrong", although this possibility should not be ruled out without sound evidence.

Scenario #1: This decision is due to the overwhelming evidence of impairment from all three data components.

Scenario #2: This decision is based on the overwhelming lack of evidence from all three data components.

Scenario #3: Without evidence of toxicity or a degraded biological community, the most likely conclusion is that the chemical contaminants, although elevated, are not bioavailable. If the biological community data shows no adverse effect, the water quality is deemed to be supportive of aquatic life and its designated use is fully supported.

Scenario #4: The basis for this decision is due to the biological community response, and is supported by sediment chemistry. The clear results from the healthy biological community and the lack of chemical concentrations consistent with toxic impacts suggests that the toxicity test results may be anomalous, due to artifacts and not to chemical contaminants. It is possible that there are unmeasured contaminants, but the impact is not sufficient to impair the designated use, as demonstrated by the biological community. However, if the magnitude of the effect observed in the bioassays were severe (e.g. less than 50% survival), the Department may re-evaluate its listing decision. Nevertheless, additional monitoring would be required to confirm the findings of the Triad, and to determine if further actions are required.

Scenario #5: Without evidence of toxicity or elevated chemical concentrations, the most likely conclusion is that the degraded biological community is not due to chemical contaminants. This scenario, however, is be captured by other Listing Methodologies.

Scenario #6: Where a good tool exists for evaluating the biological community, it is usually a good indicator of water quality in general and is very sensitive because it integrates impacts from different stressors as well as impacts through time. Practical experience has shown that where "IBI"-type indicators are considered, they indicated impairments not supported by the other data components (i.e., toxicity and chemistry). Therefore, where biological community data of this type exist showing non-degraded biological communities, it will be considered as sufficient evidence of a supported designated use, despite the implications of toxicity and chemistry.

However, where no such data exists or where those indicators are not applicable, the Department will apply its best professional judgment, but will likely determine that the designated use is not supported.

Scenario #7: The basis for this decision is the adverse response observed from the toxicity and biological community data. In this scenario, the water quality is not supportive of aquatic life and is likely due to chemical contaminantion with no applicable chemical threshold or some unmeasured chemical contaminant. This scenario would require listing on Part-3 of the new 303(d) list. Additional monitoring would be required to determine the impairing substance(s).

Scenario #8: The basis of this decision is the absence of effect in the bioassays. Although the biological community show adverse effects, the lack of toxicity in the tests are indicative that the adverse effect is not due to chemical contaminants, or that they are not bioavailable. If chemical contaminants were truly affecting the designated use, the impacts of those contaminants should have been observed in the bioassay. These bioassays control for confounding factors such as low D.O., or habitat impacts. This scenario, however, is be captured by other Listing Methodologies.

The scientific community has indicated that in order to obtain a reliable and consistent assessment, data from all three components (i.e., toxicity, chemistry, and biological community) are required (Chapman, 1992, Ingersoll et al., 1997, Long et al., 1998, Long et al., 2000; and Anderson et al., 2001). However, if data are not available for all three components, the Department will use its discretion but will consider an impairment determination if;

a) The magnitude of any single indicator is overwhelmingly suggesting an impairment determination,
b) A Toxicity test shows toxicity and is confirmed either by chemistry data or a degraded biological community, its designated use is not likely supported and an impairment determination will likely be concluded.
c) All other cases are considered to present insufficient evidence of impairment and will be prioritized for additional monitoring as resources become available.

Under the Triad approach, MDE would evaluate appropriate lethal and sublethal sediment bioassays. A finding of toxicity may trigger a sediment chemistry analysis, if one has not already been performed. Sediment chemistry data would be used to support an impairment determination. The chemical analysis should be performed on samples originating from the same composited homogenate used for the bioassays, so that paired data can be obtained (Chapman, 1992). The chemistry data can be compared to sediment thresholds to help determine which chemicals may be causing toxicity. If no sediment thresholds are exceeded, sediment Toxicity Identification Evaluation (TIE) should be performed to determine a chemical cause, if possible.

Chemistry data themselves are useful in determining sediment contamination trends, and may also help identify areas that may have the potential for adverse impacts. MDE uses sediment chemistry data, as an effective prioritization tool to help determine which sediments should be targeted for additional monitoring. That is, other factors being equal, sediments with chemical concentrations exceeding sediment thresholds would have higher priority for additional monitoring compared with sediments that meet the sediment thresholds. Chemical concentrations exceeding these thresholds could also indicate the need to monitor and assess water column concentrations for those chemicals. Sediment chemistry alone should not, however, be used to make an impairment determination.

FISH TISSUE

Section 101(a)(2) of the Clean Water Act established as a national goal the attainment of "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water." This is commonly referred to as the "fishable/swimmable" goal of the Act. Additionally, Section 303(c)(2)(A) requires water quality standards to protect the public health and welfare, enhance the quality of water, and serve the purposes of the Act. Environmental Protection Agency (EPA), along with Maryland Department of the Environment (MDE), interprets these regulations to mean that not only should waters of the State support thriving and diverse fish and shellfish populations, but they should also support fish and shellfish which, when caught, are safe to consume by humans.

Some of the contaminants found in Maryland waters (mainly mercury and PCBs) tend to bioaccumulate to elevated levels in the tissues of gamefish (e.g. largemouth bass) and bottom-feeders (e.g. catfish). When tissue levels of a specific contaminant are elevated to increase the risk of chronic health effects, the State has the responsibility to issue a fish consumption advisory. *Fish consumption advisories* are designed to protect the general as well as sensitive populations (i.e., young children; women who are or may become pregnant). In addition to such advisories, which stop at 4 meals per month, the Department provides *fish consumption recommendations*, which stop at 8 meals per month. These additional recommendations are issued in order to protect the frequent fish consumers.

It has been accepted that when a fish consumption advisory (not a recommendation) is issued for a waterbody, the designated use of that waterbody is not being supported. This usually results in listing a waterbody as impaired for the specific contaminant. To determine if a waterbody is impaired, a sample weighted mean of the contaminant level in the edible portion of the common recreational fish species is compared to the established threshold/criterion. If the threshold/criterion is exceeded, the waterbody’s designated use is not met, and the waterbody is listed as impaired. For the contaminants that do not have an existing criterion (e.g. PCBs), MDE has defined "fishable" as the ability to consume AT LEAST 4 meals per month of common recreational fish species by a 70 kg individual. In such cases, the fish tissue concentration threshold used for impairment listing is the concentration that results in 4 meals per month advisory (see Contaminant Thresholds Section).

Data Requirements

Data requirements for listing a waterbody as impaired are similar to the data requirements for issuing a fish consumption advisory. These include:

1. All available data (measured in the edible portion of fish and shellfish) should be used when making impairment decisions.
2. The data needs to be collected from the specific waterbody in question.
3. The size of the fish sampled should be within the legal slot limit. If no slot limit exists for a specific species, best professional judgment for a minimum size of a given species will be applied.
4. Minimum data requirement: 5 fish (individual or composite of the same resident species) for a given waterbody. At times, in order to protect more sensitive populations MDE might issue an advisory that is based on an incomplete dataset (less than 5 fish of the same species), existence of such an advisory does not automatically result in an impairment listing. In other words, the minimum data requirement needs to be met in order to list a waterbody as impaired.
5. Species used to determine impairment should be representative of the waterbody. Migratory and transient species may be used if they are the dominant recreational species, but should only be used in conjunction with resident species, especially in the case of tidal rivers of the Chesapeake Bay.
6. To ensure that the impairment is temporally relevant, impairments based on the minimum required samples should be re-sampled prior to TMDL development.

Contaminant Thresholds

The acceptable contaminant thresholds are based on a risk assessment calculation that incorporates numerous risk parameters such as contaminant concentration, reference dose/cancer slope factor, exposure duration, lifetime span, and for some contaminants, cooking loss.

Table 12: The concentration thresholds/criterion for the contaminants of concern are currently.

Contaminant	Threshold/Criterion	Bases	Group
Mercury[5]	300 ppb (ng/g – wet weight)[6]	EPA/MDE Fish Tissue Human Health	-

[5] Per EPA recommendation, total mercury concentrations, as opposed to methylmercury, will be used in MDE fish consumption risk-calculation. This approach is deemed to be most protective of human health and most cost-effective.

[6] Currently MDE is in the process of proposing changes to the methylmercury fish tissue criterion through the Triennial Review process. The criterion is expected to be lowered to 235 ppb to create greater consistency in the methods used by the Department to: (1) determine impairments, (2) establish TMDL targets, and (3) issue fish

		Consumption Criteria	
PCBs	39 ppb (ng/g – wet weight)	4 meals/month concentration level	70 kg Individual

Over time, advances in science may require changes in risk assessment parameters that may increase or decrease the currently used contaminant thresholds, and consequently the levels at which impairment decisions are made. When this happens, waterbodies that were listed as impaired may no longer be considered impaired, or new waterbodies may need to be listed.

consumption advisories. This change is not expected to increase the number of listings, as most Maryland mercury fish tissue impairments have been identified in the past with the use of this value.

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Table 13: Table of Sediment Screening Values

Contaminant	*Sediment Screening Values (ppb)*		
	EPA ESGs	**NOAA ERMs**	**MDE SQBs**
α-BHC			4,357
Acenaphthylene		640	
Acenaphthene	2,300	500	
Anthracene		1,100	
Arsenic		70,000	
β-BHC			9,406
Benz(a)anthracene		1,600	
Benzo(a)pyrene		1,600	
Cadmium		9,600	
Chlordane		6	51
Chlorpyrifos			4,214
Chromium		370,000	
Chrysene		2,800	
Copper		270,000	
DDT Sum		46	
Dibenz(a,h)anthracene		260	
Dieldrin	200	8	3,616
Endrin	7.6		7,368
Fluoranthene	3,000	5,100	
Fluorene		540	
Heptachlor			1,433
Heptachlor epoxide			1,433
Hexachlorobenzene			6,114,892
Lead		218,000	
Mercury		710	
Methyl naphthalene, 2-		670	
Naphthalene		2,100	
Nickel		51,600	
p,p-DDD (TDE)		20	
p,p-DDE		27	
p,p-DDT		7	
PAHs (High MW)		9,600	
PAHs (Low MW)		3,160	
PAHs (Total)		44,792	
PCB (Polychlorinated Biphenyl)		180	
Phenanthrene	2,400	1,500	
Pyrene		2,600	
Silver		3,700	
Zinc		410,000	

11.7 Listing Methodology for Solids

In 2002, the Department made a distinction in the sediment listings between "suspended sediment" and "sedimentation". "Suspended sediment' was considered a water column or turbidity impairment while sedimentation was supposed to identify the sediment deposition process that can impair benthic communities and habitat. Since the 2002 List, there has been confusion about the basis for this distinction and what methodology was used for making this determination. Because consistent data requirements and methodologies were not used to make a distinction among sediment impacts, MDE has opted to not make any distinction in sediment impairments but rather leave them listed as sediments. All sediment listings have thus been revised.

In the existing Water Quality Inventory [303(d) List], there are numerous impairments for "sediments." Many of these were assessed and projected based on land use and the likelihood of such impairments. Unfortunately, the term "sediments" does not accurately inform the public as to the nature of the impairment, nor provide helpful guidance to those who need to develop TMDLs to remediate the problem.

In this current list, impairments previously listed for sediments, and new impairments evaluated for this report will be determined and listed as described below.

FREE-FLOWING STREAMS

<u>Water Clarity</u>

Impairing substance: Total Suspended Solids (TSS)
Measure: Turbidity as measured in Nephelometer Turbidity Units (NTUs)
Criterion: Turbidity criteria are addressed in COMAR §26.08.02.03-3(A)(5):

Turbidity

(a) Turbidity may not exceed levels detrimental to aquatic life.
(b) Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time for 50 units as a monthly average. Units shall be measured in NTUs.

<u>Erosional and Depositional Impacts (limited to wadeable streams)</u>

Impairing substance: Soils or sediment
Measure: Biocriteria. The application of biocriteria for assessment decisions for the Integrated 303(d) List is addressed elsewhere in this document.
Criterion: Addressed under the narrative criteria:

26.08.02.02(B) Specific designated uses.

(1) Use I: Water Contact Recreation, and Protection of Aquatic Life. This use designation includes waters which are suitable for:
   (c) The growth and propagation of **fish** (other than trout), **other aquatic life**, and wildlife
(4) Use III: Natural Trout Waters. This use designation includes waters which have the potential or are:
   (a) Suitable for the growth and propagation of **trout**; and
   (b) Capable of supporting self-sustaining **trout** populations and **their associated food organisms**.
(5) Use IV: Recreational Trout Waters.
   (a) Capable of holding or supporting adult trout for put-and-take fishing; and
   (b) Managed as a special fishery by periodic stocking and seasonal catching.

Waters must be protected for these designated uses (26.08.02.02(A)). Key phrases supporting the use of biocriteria to protect against impacts from eroded or deposited sediments are highlighted.

- If MBSS data indicates impairment, the habitat data related to sediments will be assessed.
- If there is no indication of a sediment problem (e.g., embeddedness does not indicate a problem), follow-up monitoring will occur to determine the stressor affecting the biological community.
- If there does appear to be a sediment problem, it will be listed for soils or sediment.

IMPOUNDMENTS

Maryland has no natural lakes. This decision rule covers reservoirs and other manmade lakes. Estuaries, such as Chesapeake Bay will be covered under new regulations currently being developed and which specifically address water clarity and sediment.

Water Clarity

Impairing substance:	Total Suspended Solids (TSS)
Measure:	Turbidity as measured in Nephelometer Turbidity Units (NTUs)
Criterion:	Turbidity criterion are addressed in COMAR §26.08.02.03-3(A)(5):

Turbidity

(d) Turbidity may not exceed levels detrimental to aquatic life.
(e) Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time for 50 units as a monthly average. Units shall be measured in Nephelometer Turbidity Units.

If turbidity exceeds the indicated levels, chlorophyll shall also be measured. If chlorophyll is high, the impairment will be attributed to excessive nutrient enrichment, rather than solids.

Exceptions may be made and professional judgment applied in areas where soil and local geologic conditions would normally have high sediment runoff.

11.8 Listing Methodology – Sewage Releases

INTRODUCTION

Bacteria released during single or rare combined sewer overflows, sanitary sewer overflows or other releases will dissipate naturally after several hours, days, or weeks. However, repeated sewage releases of significant size may result in violations of the water quality standards, particularly if the volumes are large or frequent and the waterbodies are small, slow moving or poorly flushed. Under such spill conditions, violations are presumed to have occurred even in the absence of actual monitoring data. Notwithstanding such documented spill events, if the water quality is consistent with the bacterial water quality standards at that time, a Water Quality Analysis demonstrating the lack of such an impairment will be completed and the waterbody will become eligible for de-listing. However, if data indicates that water quality standards are not being met the waterbody will remain listed.

METHODOLOGY

Based on data in MDE's spill databases, if any waterbody segment has received two spills greater than 30,000 gallons over any 12-month period or after system improvements have been made, that waterbody will be considered as impaired. This listing methodology will be applied only in the absence of bacterial monitoring data; if such monitoring data are available, the decision methodology for bacteria will apply. Further, the part of the list on which the waterbody is listed may be determined by the existence of consent orders, enforcement agreements, work in progress, or other factors that may negate the need for a TMDL.

12.0 APPENDIX B – Maryland Water Monitoring Council's Local Monitoring Programs Summary

MARYLAND WATER MONITORING STRATEGY--Update

In the year 2004, the Maryland Departments of the Environment and Natural Resources prepared the Maryland Water Monitoring Strategy as the State's plan to monitor its water resources. These are the two principal state agencies that conduct water monitoring, focusing on regulatory and ambient water resource issues. The document addressed the importance of clearly identified goals when designing a monitoring program and using a sample design which includes the number of stations and frequency of sampling necessary to provide data to accurately describe conditions and trends at the scale desired to achieve monitoring goals.

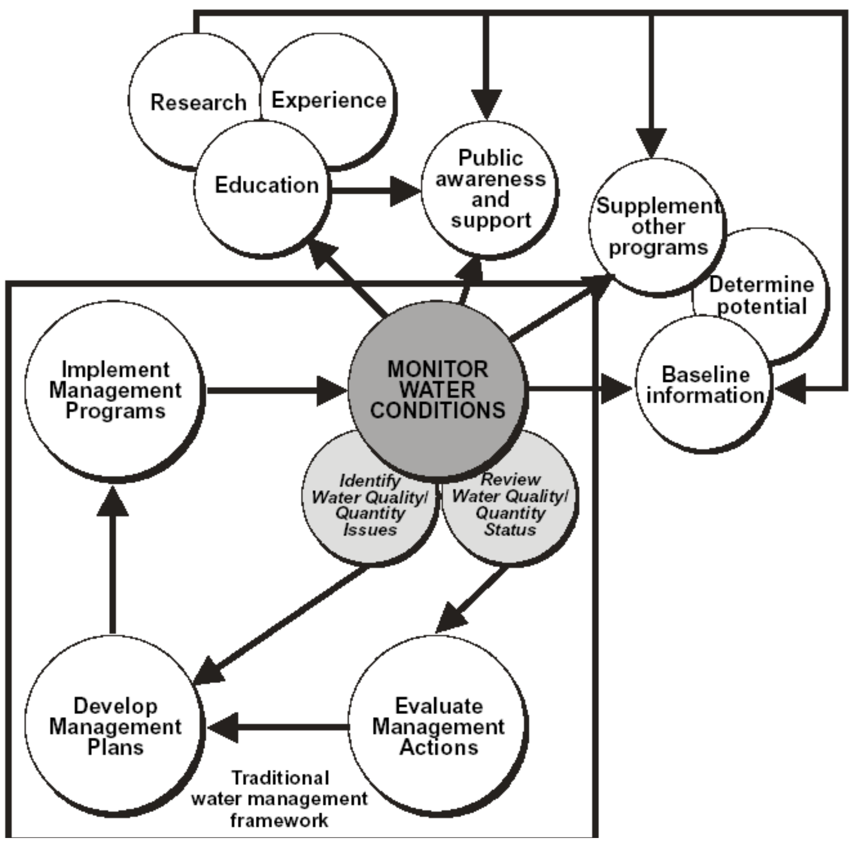

Figure 22: Role of Water Monitoring Within A Universe of Uses/Needs.

The State's plan recognized that academic institutions, local and federal government agencies, community groups, and the private sector were also conducting water monitoring throughout the state. These additional monitoring activities had been established to meet a broader range of goals and objectives, including research, environmental outreach, and in support of other programs. The plan recognized the need to integrate across these programs as part of a statewide water monitoring strategy. Figure 14 is taken from that plan, an attempt to show the relationship between water monitoring, the diversity of uses, and the complexity of feedback among programs.

Toward that end, the Maryland Water Monitoring Council initiated two major work program efforts to facilitate coordination across monitoring groups and encourage integration of results across group program boundaries.

One was the establishment of an annual Monitoring Roundtable, at which groups that plan to do monitoring in the next year can meet and exchange specific information about goals, locations, and parameters. The station location information has been converted to map format and posted on the MWMC web site for reference. This information can be used to minimize duplication of stations, which could lead to more areas being monitored and also provide greater sharing of results for areas of common interest.

The second major coordination and integration effort began with the dissemination of a survey to collect information on water monitoring throughout the state. The first round of responses identified a number of locally based programs. These were typically focused on smaller watersheds than those used for the State's monitoring programs and often for very specific project evaluations. A number of federally-supported monitoring programs were also identified, providing important links across interjurisdictional waters such as the Potomac River and the mainstem Chesapeake Bay.

A second round of survey during 2002-2003 led to this document--a summary of the results. The major categories listed are those of the state's Maryland Water Monitoring Strategy (2000), listed on the next page. Three categories were added: urban best management practice monitoring, water quality, and water use.

One thing which stood out as these results were compiled was that identifying by categories did not exactly reflect the goals or purpose for which the monitoring was being conducted. For example, the Baltimore City Reservoir Tributary Monitoring is listed under the Non-Tidal Rivers and Streams category in this document. The goals for that monitoring though are also tied to Reservoir Water Quality--how are these tributary inputs affecting the receiving water body?

One survey response included monitoring across multiple water resource levels--groundwater, surface water, sediment characteristics. This was the USGS Water Quality Monitoring Program, with a goal to monitor water quality across the State. In the State strategy, this program would have been repeated under each of the media categories. That type of listing, does not, however, reflect the fact that this program was originally set up with the express intent to link water quality across resource boundaries and provide cause and effects between water chemistry conditions in one media and that in another--e.g. Surface water and groundwater.

MARYLAND’S WATER RESOURCES AND MONITORING PROGRAMS.

Non-tidal rivers and streams

- CORE/Trend program
- Maryland Biological Stream Survey
- Watershed monitoring for water quality impairment determination and TMDL development
- NPDES point source permit monitoring
- NPDES permit compliance monitoring
- NPDES pretreatment monitoring
- NPDES stormwater monitoring
- Stream gaging network
- Fish kill investigations
- Algal bloom response program
- Drinking water program
- Source water protection program
- Finished water protection program
- Tissue monitoring program

Estuarine rivers and embayments

- Chesapeake Bay monitoring program
- Coastal Bays monitoring program
- Harmful Algal Bloom monitoring program
- Water quality and fisheries
- Lower Eastern Shore pollutant input monitoring program
- Shellfish monitoring program
- Tissue monitoring
- Fish kill investigations
- Dredge activity monitoring program

Lakes and reservoirs

- Drinking water source water protection program
- Fish kill investigations
- Tissue monitoring program

Ocean

- Shellfish monitoring program

Wetlands

Ground water

- Waste monitoring programs
- Federal “Superfund” programs
- State Superfund program
- Storage tank monitoring programs
- Source water protection program
- Maryland ground water quality network
- Solid waste facility ground water monitoring program

In Table 18, the two Maryland monitoring agencies have summarized the agency mission and water-resource related goals. To develop a comprehensive monitoring strategy, it would seem preferable to list goals first, rather than agency. For example, many of the local jurisdictions are conducting surface water monitoring to characterize storm water runoff. Integrating results from these programs is best done not by mission statements but rather by why the monitoring is being done.

An example of this alternative approach is shown in Table 9. A next step for the Maryland Water Monitoring Council is to expand this framework for water-resource related goals across programs and refine the presentation such that integration across programs is more easily facilitated.

Table 14: Selected Agency Mission Statements and Water-related goals

Agency	Mission Statement	Water-related Goals
MDE - Department of the Environment	Protect and restore the quality of Maryland's air, land, and water resources, while fostering economic development, healthy and safe communities, and quality environmental education for the benefit of the environment, public health, and future generations.	• Ensure safe drinking water • Reduce the threat to public health from the presence of hazardous waste and hazardous materials in the environment • Ensure that water is clean and safe for harvesting of fish and shellfish • Improve and protect Maryland's water quality • Ensure adequate protection and restoration of Maryland's wetland resources • Prevent pollution and increase compliance assistance
DNR - Department of Natural Resources	For today and tomorrow the Department of Natural Resources inspires people to enjoy and live in harmony with their environment, and to protect what makes Maryland unique -- our treasured Chesapeake Bay, our diverse landscapes and our living and natural resources.	• A vital and life-sustaining Chesapeake and Coastal Bays and their tributaries. • Sustainable population of living resources and healthy ecosystems. • Enjoyment of diverse outdoor recreation opportunities for Maryland citizens and visitors. Vibrant local communities in balance with natural systems.

Table 15: MWMC's Proposed Goal-Oriented Approach to Describing Maryland's Water Monitoring Programs.

WATER -RESOURCE MONITORING RELATED GOAL	AGENCY	PROGRAM
Ensure quality and quantity of drinking water	U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District	U.S. Geological Survey Ground-Water Level Monitoring
	Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section	RESERVOIR IN-LAKE PROGRAM
		RESERVOIR TRIBUTARY PROGRAM
Reduce the threat to public health from hazardous waste and hazardous materials	MDE Science Services Administration	Tissue monitoring program
		Shellfish monitoring program
Maintain aquatic ecosystem integrity	DNR Monitoring and Non-tidal Assessment	Maryland Biological Stream Survey
	MDE Science Services Administration	Dredge activity monitoring program
	U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District	U.S. Geological Survey Ground-Water Level Monitoring

GROUNDWATER

AGENCY GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: U.S. Geological Survey Ground-Water Level Monitoring

Contact: Earl Greene, Ground Water Specialist

5522 Research Park Drive
Baltimore, MD 21228
(443)498-5500

eagreene@usgs.gov

Goal/Purpose: Measure and publish ground-water levels for Maryland

Scale: State of Maryland

Watersheds/Aquifer: All 8-digit HUCS/all aquifers that are used for water supply

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Continuous and periodic ground water level monitoring

Media: Ground water, aquifers, artesian wells, confined wells, water table wells

Data uses: State monitoring efforts, other federal agencies, water resources managers, hydrologic study chiefs, consultants, educators, researchers, students, and the general public.

Future: Continuous monitoring.

Publications: Ground water data: http://md.water.usgs.gov/publications/md-de-01-2/

Updated: Published annually and available online: http://md.waterdata.usgs.gov/nwis/gw.

Issues/Needs: Collect statewide ground-water data

LAKES AND RESERVOIRS

AGENCY/GROUP: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: RESERVOIR *IN-LAKE PROGRAM*

Contact: William Stack, 410-396-0732

Watersheds/Aquifer:

Loch Raven 02130907, Liberty 02130805 and Prettyboy Reservoirs - 02130806

Goal/Purpose: 1) Monitor in-lake water quality to determine water quality problems and monitor trends related to restoration and /or perturbations (e.g., development, drought) in the watershed. 2) Better understand the environmental conditions that result in algal blooms and taste, odor problems and disinfection byproducts. 3) Determine the relationship between in-lake stations and raw water at the treatment plants.

Scale (3) 8 digit watersheds

Approach/Description: Water chemistry and chlorophyll a

There are 11 in-lake reservoir monitoring stations distributed among the City's three reservoirs. At each of these stations, a vertical series of samples and field measurements are taken at discrete depths in the water column. Most stations, including the primary sampling stations located near the raw water withdrawal intakes, are sampled in all seasons. The primary stations are sampled more frequently than the other stations.

Media: water chemistry data available in ACCESS

Data uses: Comparisons and trends across reservoirs, verify relationships between nutrients and other parameters

Publications: Reservoir Watershed Management Progress Reports July 28, 2008. http://www.baltometro.org/content/view/10/124/

Issues/Needs: Need to expand program to disinfection byproduct precursors. Need to be able to relate reservoir water quality to watershed loadings

NON-TIDAL RIVERS AND STREAMS

AGENCY/GROUP: Anne Arundel County, Office of Environmental and Cultural Resources

Program Name: ***TOWN CENTER SURFACE WATER QUALITY MONITORING PROGRAM***
Contact: Chris Victoria 410.222.7441, cvictoria@mail.aacounty.org

Goal/Purpose: To characterize water quality of drainage of the Town Center areas in Anne Arundel County.

Scale: Small watershed
Watersheds/Aquifer:
Severn River (02-13-10-02): Picture Spring Branch Weems Creek
South River (02-13-10-03): Broad Creek

Approach/Description: Water chemistry, biological monitoring, physical assessment. A total of 4 stations are monitored as described below:

At two stations (Picture Spring Branch and Weems Creek), water samples are collected during stormflow (12/year) automated water quality monitoring equipment and during baseflow (1 per month) using grab samples. The following parameters are monitored: BOD5, PO4, TSS, Alkalinity, Turbidity, ammonia, COD, NO3-NO2, Total P, TKN, TN, TOC, Ca, Cu, Fe, Mg, Hardness, Zn. All stations have continuous flow and rainfall data collection, logged at 5 to 15 minute intervals. Temperature and pH are measured at Picture Spring Branch.

Biological monitoring has been done occasionally within this watershed. In addition, a stability assessment of channel conditions has been performed in Picture Spring Branch.

At two stations (Picture Spring Branch 2 and Broad Creek), only baseflow water quality samples are collected. Water quality parameters above are also monitored at these stations.

Media: Flow, rainfall, and water chemistry data avail in Microsoft Excel, biological data available in ERDAS, geomorphology data available in Excel.

Data uses: Trend analysis of water quality in Town Center Areas. Loading and EMC calculations, water quality and quantity model calibration.

Publications: Various summary reports available. QAPP done in 1997 scheduled for revision and updating in 2003.

Issues/Needs: Sites unique enough such that results not readily applicable in all county watersheds. Limited stormflow data.

AGENCY/GROUP: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: ***BIOLOGIAL MONITORING PROGRAM***

Contact: William Stack, 410-396-0732

Goal/Purpose: 1) To monitor trends in macrobenthological and fish communities in Baltimore City streams associated with restoration and /or environmental perturbation. 2) Measure health of living resources for targeting restoration.

Scale: entire city

Watersheds/Aquifer: 02130905 - 02130901 - 02130904

Approach/Description: The approach is a probability-based stratified random sampling design using Maryland Biological Stream Survey (MBSS) guidelines. The sampling method is a multi-habitat twenty-sweep dip net approach that the State uses in coastal plain and non-coastal plain regions. This is the beginning of a three-year rotation, focusing on the Jones Falls watershed during the first year.

Media:

Data uses: Assessment of health, targeting for restoration, monitoring trends

Publications: The City of Baltimore NPDES Stormwater Permit Program Annual Report

Issues/Needs:

Program Name: ***RESERVOIR TRIBUTARY PROGRAM***

Contact: William Stack, 410-396-0732

Goal/Purpose: 1) Monitor trends in nutrient and sediment loadings and relate these to activities in the watershed (drought, development, restoration) 2) Relate tributary loadings to receiving water data 3) Identify pollutant sources

Scale: Small watersheds

Watersheds/Aquifer:

Loch Raven 02130907, Liberty 02130805 and Prettyboy Reservoirs - 02130806

Approach/Description: Water chemistry, flow data

There are fifteen tributary sampling stations. Six of these are sampled during both storm and dry weather flows; and the rest are sampled on a fixed monthly schedule.

Media: data available in ACCESS

Data uses: characterize external loads to the reservoirs, load comparisons for wet and dry weather

Publications: 1996 and 2001 Reports

Issues/Needs: Storm sampling has lapsed because of manpower. Need to expand to be able to relate watershed loadings to reservoir quality. Need to include measurements of TOC and DOC to address THM sources. Need to expand storm sampling in Prettyboy watershed.

Program Name: NPDES *STORMWATER PROGRAM*

Contact: William Stack, 410-396-0732

Goal/Purpose: 1) Characterize stormwater discharges from an outfall draining a specific land use and an associated in-stream station 2) Monitor trends in loadings and relate these to changes in the watershed (e.g., development, restoration)

Scale: Medium residential watershed

Watersheds/Aquifer: Moores Run (Hamilton Ave, Radecke Ave.) 02130901

Approach/Description: water chemistry, flow

A minimum of 12 storm events are monitored per year at both stations and baseline samples are collected monthly. Automated samplers are used to collect discrete samples and samples are select to represent the ascending, peak and descending limbs of the storm.

Media: Flow data in EXCEL; chemical data in ACCESS

Data uses: characterize runoff and impacts to receiving streams; estimate pollutant loads; calculate EMC's.

Publications: City of Baltimore NPDES Stormwater Permit Program Annual Report
Updated: annually since 1995

Issues/Needs: Better method for separating storm and baseflow samples. Need to reconcile error introduced by using automated samplers.

Program Name: ***NPDES DRY WEATHER PROGRAM***

Contact: William Stack

Goal/Purpose: Conduct chemical screening downstream of all major storm sewer outfalls during dry weather in order to detect and eliminate significant illicit discharges to the streams 2) Measure changes in ambient water quality associated with changes in the watershed (e.g., restoration)

Scale: 4 large watersheds

Watersheds/Aquifer: 02130905 - 02130903 - 02130901 - 02130904

Approach/Description: water chemistry, flow measurements

Collect monthly stream samples at 37 sites distributed amongst the 4 major watersheds in Baltimore City.

Media*:* chemical data available in ACCESS

Data uses: characterize dry weather flow;

Publications: The City of Baltimore NPDES Stormwater Permit Program Annual Report

Updated: annually

Issues/Needs: field-screening tools

AGENCY/GROUP: Charles County Department of Planning and Growth Management

Program Name: ***Mattawoman Creek Water Quality Monitoring. Charles County MD Partnership with USGS (USGS Project ID# 9B211)***

Contact: Karen Wiggen, 301-645-0683

Goal/Purpose: Develop a long-term trend characterization of water quality in Mattawoman Creek non-tidal watershed, which is the location of the Charles County Development District

Scale: 57.7 sq. mile watershed

Watersheds/Aquifer: Mattawoman Creek 02 - 14 - 01 - 08

Approach/Description: Water Flow and Chemistry at USGS station ID# 01658000, data record Oct 2000-present.
Water flow and chemistry at automated station, including base-flow and high-flow grab samples. Storm event discrete samples are taken to characterize rising, peak, and falling limb of hydrograph and used to generate storm event mean concentrations. Parameters analyzed: Suspended sediment (one third of samples will also be analyzed for sand-fine fractions), Soluble phosphorus, TKN, total phosphorus, Soluble kjeldahl nitrogen, Orthophosphate, Nitrite, Nitrate plus Nitrite, and Ammonium. On 15 minute intervals dissolved oxygen, water temperature, specific conductance, turbidity and pH will be measured.

Once adequate samples have been collected, the measured nutrient concentration values will be related to concurrent values of continuously measured parameters to estimate nitrate, total nitrogen, total phosphorus, and suspended-sediment concentrations in the stream water at 15-minute intervals.

Media: Water column.

Data uses: Characterize trends in pollutant load of stormwater runoff over long term from expected growth of County's Development District. Data available on USGS website. Users may include USGS, county planners or others.

Future: Continue station, and modify as needed**.**

Publications: USGS website posts data at http://md.waterdata.usgs.gov. *Project summary available on USGS website at http://md.usgs.gov/watershed/9B211/index.html.*

Issues/Needs: Long term trend record of water quality in receiving stream of County Development District.

Program Name: ***NPDES MS4 Integrated Monitoring 1999 - 2007 Permit***

Contact: Karen Wiggen, 301-645-0683

Goal/Purpose: Characterize stormwater runoff to Charles County streams

Scale: Small watershed outfall (DA~ 64 ac.) from discrete land use (high density residential) paired with downstream ambient station

Watersheds/Aquifer: Zekiah Swamp, Jordan Swamp

State Watershed: 02 - 14 - 01 - 08

Approach/Description: Water Chemistry, biology, and physical habitat monitoring including stream cross sections.

Water chemistry at outfall and downstream ambient stations includes monthly grab samples during dry weather to contrast with monthly automated storm event sampling. Storm event discrete samples are taken to characterize rising, peak, and falling limb of hydrograph and used to generate storm event mean concentrations for high density residential land use. Parameters measured: COD, BOD_5, TSS, Fecal Coliform, Oil and Grease, Total Petroleum Hydrocarbons (TPH), TKN, Nitrate plus Nitrite, TP, CD, PB, CU, ZN and pH. Also monitor NOx, DO, water temperature, conductivity, TDS, and turbidity.

Media: Water column, benthic macro invertebrates, habitat assessment, and cross sections.

Data uses: Characterize stormwater runoff and impacts to receiving streams from high density residential land use, estimate pollutant loads

Future: Assessing pollutant loads and runoff impacts

Publications: Flow, rainfall, and water chemistry data available in ACCESS; biology and habitat data available in summary tables. Summaries and final report with NPDES Stormwater Permit annual report

Issues/Needs: Comparisons/compilation across jurisdictions for representative estimates of pollutant loads by land use types and impacts on receiving stream resources.

AGENCY/GROUP: Montgomery Co. Department of Environmental Protection/Watershed Management Division

Program Name: ***NPDES MS4 Integrated Monitoring 2001-2006 Permit***

Contact: Meosotis C. Curtis 240-777-7711

Goal/Purpose: Characterize stormwater runoff to County streams

Scale: Small watershed, with paired outfall from discrete land use (high density urban) and downstream ambient station.

Watersheds/Aquifer: Name(s): Anacostia, Paint Branch

State watershed: 02 - 14 - 02 - 05

Approach/Description: Water chemistry, biology, and physical habitat monitoring.

Water chemistry at outfall and downstream ambient stations includes monthly grab sample during dry weather to contrast with monthly automated storm event sampling. Storm event discretes are taken to characterize rising, peak, and falling limb of hydrograph and used to generate storm event mean concentrations. Pre- and post-retrofit monitoring for industrial land use. Parameters required: BOD5, TSS, Fecal Coliform, Oil and Grease, TKN, NO23, TP, CD, CU, PB, ZN, and pH. Also monitor DO, water temperature, conductivity, chloride, hardness.

Biology and physical habitat monitoring above and below where tributary receiving outfall discharges enters stream. Pre- and Post- retrofit monitoring of benthic macroinvertebrates, rapid habitat assessment, and quantitative cross-section measurements to assess effects on stream resources.

Media: flow, rainfall, and water chemistry data available in ACCESS, dBase; biology and habitat data available in summary tables; web page to be developed

Data uses: Characterize stormwater runoff and impacts to receiving streams from urban land use and from mixed use watershed; pre-to-post retrofit changes in stormwater runoff; estimate pollutant loads

Future: Tracking bmp effectiveness; assessing pollutant loads and runoff impacts

Publications: QAPP (2/02); summaries and final report with NPDES Stormwater Permit annual report; Stream Monitoring Protocols (revised 2/1997).

Issues/Needs: Comparisons/compilation across jurisdictions for more representative estimates of pollutant loads by land use types, impacts on receiving stream resources, and retrofit effectiveness.

AGENCY/GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: U.S. Geological Survey Streamflow Monitoring

Contact: Gary T. Fisher, Surface Water Specialist

5522 Research Park Drive
Baltimore, MD 21228

(443)498-5500

gtfisther@usgs.gov

Goal/Purpose: Measure and publish streamflow data for Maryland

Scale: State of Maryland

Watersheds: Back River, Bush River, Chesapeake Bay, Choptank River, Elk River, Gunpowder River, Monongahela River, Patuxent River, Patapsco, Manokin River, Pocomoke River, Potomac River, Severn River, St. Martin River, Susquehanna River, Wye River.

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Streamflow is measured using real-time and continuous recorders following USGS guidelines. Check measurements are made regularly, often monthly.

Media: surface water, streams, lakes, ponds, reservoirs.

Data uses: State monitoring efforts, other federal agencies, water resources managers, hydrologic study chiefs, consultants, educators, researchers, students, and the general public.

Future: Continuous streamflow monitoring

Publications: see District publications: http://md.water.usgs.gov/publications/online.html

Updated: Continuous or ongoing

Issues/Needs: Collect statewide surface-water data

STREAM RESTORATION

<u>AGENCY/GROUP</u>: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: ***STREAM RESTORATION***

Contact: William Stack

Goal/Purpose: Maximize the water quality in a small watershed using efforts that are definable with measurable effects.

Scale: 3 Small sub-watersheds, 10.9 sq. mi.

Watersheds/Aquifer:

Approach/Description: Watershed Restoration plans have been developed for 3 sub-watersheds (Moores Run, Stony Run and Maidens Choice.

Media: ___________________________________

Data uses: ____

Future: ____

Publications: ____

Issues/Needs:

AGENCY/GROUP: Montgomery Co. Department of Environmental Protection/Watershed Management Division

Contact: Keith Van Ness 240-777-7707

Program Name: ***Stream Restoration Project Monitoring***

Goal/Purpose: Evaluate the effectiveness of stream restoration projects in achieving instream habitat and biological community improvement

Scale: Varies

Watersheds/Aquifer: Name(s): Potomac, Anacostia, and Patuxent

State watershed: 02-14-02 (Middle Potomac, not Anacostia or Rock Creek); 02 -14 -02-05 (Anacostia); 02-14-02-06 (Rock Creek); and 02-13-11-07 (Rocky Gorge)

Approach/Description: Channel stability, habitat, and biology (benthics and fish) monitoring.

Monitoring will follow the 1997 DEP Stream Monitoring Protocols (or most recent update as available) which includes benthic macroinvertebrate and fish community sampling, physical habitat assessments, and quantitative stream system measurements (e.g. fixed cross-sections and longitudinal profiles). Contract monitoring will occur for at least three years after construction is completed. In addition, the DEP staff will maintain extensive photo documentation and video capture records before and after restoration throughout the project reaches and periodically re-visit and re-evaluate these sites after contract monitoring is completed.

Media: Biology and habitat in computerized database; biology and habitat data available in summary tables project locations, drainage areas, and practices in GIS (ArcView/Arc Map); web page to be developed

Data uses: Tracking changes in stream reaches with implemented projects

Future: Tracking effectiveness of implemented projects and making recommendations for better designs

Issues/Needs: Comparisons/compilation on parameters to monitor and analyzing data for changes and trends.

URBAN BEST MANAGEMENT PRACTICES

<u>AGENCY/GROUP</u>: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: ***STREET SWEEPING PROGRAM***

Contact: William Stack, 410-396-0732

Goal/Purpose: Test the effectiveness of street sweeping as a BMP for pollution removal
Scale: Large watershed

Watersheds/Aquifer: Hamilton subwatershed -02130901

Approach/Description: Chemical Analysis

Pilot watershed upstream of the NPDES Stormwater stations was selected for bi-monthly sampling. A representative solid and liquid sample is collected and analyzed for a select group of parameters.

Media: chemical data available in ACCESS

Data uses: estimate pollutant removal

Publications: 2006 City of Baltimore NPDES Stormwater Permit Program Annual Report
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/storm_gen_permit.asp

Issues/Needs: Separating trash from solids is a problem and estimating the volume of liquid waste.

Program Name: NPDES MS4 Design Manual Monitoring 2001-2006 Permit

Contact: Keith Van Ness 240-777-7726

Goal/Purpose: Evaluate the effectiveness of a stormwater management system constructed in accordance with the 2000 Maryland Stormwater Design Manual for stream channel protection effectiveness.

Scale: Small watershed of about 1 square mile

Watersheds/Aquifer: Name(s): Seneca Creek, Little Seneca

State watershed: 02 - 14 - 02 - 08

Approach/Description: Channel stability, habitat, and biology monitoring.

Permanently monumented cross-sections and detailed geomorphic analyses following the USFWS 2000 protocols. Biology and habitat monitoring using DEP revised protocols. Groundwater wells and stream flow monitoring following Special Protection Area BMP monitoring Manual.

Media: flow, rainfall, biology, and habitat in computerized database; biology and habitat data available in summary tables; web page to be developed

Data uses: Tracking changes in flow and physical conditions associated with intense development

Future: Tracking bmp effectiveness for channel protection and other stream channel morphological changes

Publications:

Issues/Needs: Comparisons/compilation on how to select test and reference watersheds and analyzing geomorphic data for changes and trends.

WATER QUALITY

AGENCY/GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: U.S. Geological Survey Water-Quality Monitoring

Contact: Cherie V. Miller, Water Quality Specialist

5522 Research Park Drive
Baltimore, MD 21228
(443)498-5500

cvmiller@usgs.gov

Goal/Purpose: Monitor water quality across Maryland

Scale: State of Maryland

Watersheds/Aquifer: Name(s): Potomac River, Chesapeake Bay, Susquehanna River, … ,

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Water chemistry

Media: Surface water, ground water, bed sediments in streams, biology & habitat

Data uses: National USGS water quality programs, research, State monitoring efforts, other federal agencies, water resources managers, hydrologic study chiefs, consultants, educators, students, and the general public.

Future: Continuous monitoring of water chemistry, sediment, biology, habitats

Publications: see District publications: http://md.water.usgs.gov/publications/online.html

Updated: Continuous or ongoing

Issues/Needs: Collect statewide water quality data

WATER USE

AGENCY/GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: USGS Maryland-Delaware-DC District Water Use PROGRAM

Contact: Judith C. Wheeler, Water Use Specialist

5522 Research Park Drive
Baltimore, MD 21228
(443)498-5500

jwheeler@usgs.gov

Goal/Purpose: Collect, analyze, store, and disseminate water-use information for local, State, and national needs.

Scale: Statewide

Watersheds/Aquifer: All 8-digit HUCS/all aquifers that are used for water supply

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Maryland water-use information is collected from various sources, but primarily from the Maryland Department of the Environment (MDE). In Maryland, all water uses, except for homes with individual wells; water used for extinguishing a fire; some temporary dewatering; and agricultural water use less than 10, 000 gallons per day are required to have a water appropriation permit. Water users that withdraw 10,000 gallons or more per day are required to report withdrawals to MDE. Ancillary data used to determine water use are obtained from sources such as the Maryland Office of Planning, Maryland Department of Agriculture, County water and sewerage plans, University of Maryland Cooperative Extension Service, Maryland State Mining Program, U.S. Environmental Protection Agency, U.S. Department of Energy, U.S. Department of Commerce, and the U.S. Bureau of Census. In addition, various estimating techniques and coefficients are used to calculate water use when reported data are not available.

Data are collected, analyzed, and stored annually. Monthly and annual ground-water and surface- water withdrawal data from 1980 to 2008 are currently stored in the USGS Site-Specific Database System (SWUDS) for water users that withdrawal 10,000 or more per day. Other data such as aquifer codes and stream names, latitude/longitude for well fields and surface-water intakes, water use codes, county and hydrologic unit codes, and owner names and addresses are also stored in SWUDS. Since 1985, aggregated annual data for Maryland have been compiled and stored in the USGS Aggregated Water-Use Database (AWUDS). Data are summarized by county and by 8-digit hydrologic unit code for public supply, domestic, commercial, industrial, thermoelectric power, mining, livestock watering, aquaculture, and irrigation uses. The database was originally designed for States to store data necessary for the USGS Circular Estimated Use of Water in the United States that has been published every 5 years since 1950. The USGS Maryland water-use program updates the database annually to provide a useful level of data for water-use information requests.

Media: ground water, surface water, water use

Data uses: Water Resources planning and management, hydrologic studies, evaluating ground-water level networks, land planning and management.

Data users: Water Resources managers, hydrologic study chiefs, State cooperators, other federal agencies, consultants, educators, students, and the general public.

Future: Analyze trends in water use for various categories of use using additional parameters such as precipitation, water rates, and socio-economic factors to assess changes or patterns of use.

- **Publications:** Withdrawal data available in Excel, ACCESS, GIS, and ASCII formats. Summary tables are available on these web pages:
- http://water.usgs.gov/watuse/
- http://md-internal/database/swuds/index.html#MD2000data
- USGS Open File Report 87-540 *Ground-water use in the Coastal Plain of Maryland, 1900-1980*
- USGS WRIR 93-4220 *Water withdrawal and use in Maryland, 1990-1991*
- USGS Fact Sheet FS-115-98 *Freshwater use in Maryland, 1995*
- http://md.water.usgs.gov/publications/fs-98-115/
- USGS Fact Sheet FS-xxx-xx *Freshwater use in Maryland, 2000* (in preparation)

Issues/Needs: More information is needed to determine the quantity of water withdrawn and aquifers sources for certain categories of water use, particularly self-supplied domestic and agricultural water use. Coefficients are currently used for estimating withdrawals for these uses. More information is needed to improve estimates of public-water-supply distribution to residences, commercial establishments, and industries.

Table 16: Table of Programs Surveyed by the Maryland Water Monitoring Council

AGENCY	MEDIA	GOAL/PURPOSE	PROGRAM NAME	ELEMENTS
Anacostia Watershed Society	Streams	daily fecal coliform testing.	**Anacostia and Potomac Rivers Water Quality Monitor**	watertemp, ph, dissolved_ox, conductivity, turbidity; otherbio
Baltimore County DEPRM	Streams	Monitor stream baseflows over 70 sites throughout the Deer Creek and Gunpowder Basins in 2004 In alternate years baseflow monitoring is done in the Patapsco/Back River Basin.	**Baseflow Monitoring Program**	Chemistry, metals, organics, inorganics, watertemp, ph, conductivity; Nutrients, Flow, GIS
Baltimore County DEPRM	Streams	Pre and post project monitoring normally for a 3 year period of stream restoration projects as required by Federal and State Permits.	**Capital Improvement Projects Monitoring Program**	Biology, Fish, Benthos, otherbio
Baltimore County DEPRM	Streams	MBSS protocols for benthic IBI at 100 sites in the Deer Creek & Gunpowder Basins during 2004. During alternate years, samplin throughout the Patapsco/Back River Basin.	**Probabalistic Macroinvertebrate Monitoring**	Biology, Benthos; physhab
Baltimore County DEPRM	Streams	Stream monitoring of storm flows at 17 USGS gaged sites in the Deer Creek/Gunpowder Basins during 2004; during alternate years sampling will be done in the Patapsco/Back River Basin.	**Stormflow Monitoring Program**	Chemistry, metals, organics, inorganics, watertemp, ph, conductivity; Nutrients,Flow, GIS, physhab
Baltimore County DEPRM	Streams	Chemical, biological and geomorphological monitoring on Windlass Run before and after proposed construction of the estension of MD Route 43 (East of Interstate 95) is to evaluate the effectiveness of application of the new Maryland Stormwater Management Design Manual.	**Windlass Run Project**	Chemistry,metals,organics,inorganics,watertemp,ph,;Biology,Fish,Benthos, otherbio; Nutrients,Flow,GIS,physhab
Community College of Baltimore County	Streams	Volunteer monitoring of SAV and certain water parameters (temp, Phosphate, nitrates, salinity, DO) in the Dundee area of the Gunpowder river since 1990.	**SubmergedAquaticVeg monitoring project**	Chemistry,watertemp,ph,dissolved_ox,turbidity;Biology,SAV;Nutrients
Frederick County DPW	Streams	Peter Pan Run, a tributary to Bush Creek, is monitored annual by Frederick County, using MBSS methods, for fish, benthos, habitat, and in situ water quality as part of the County's NPDES program.	**2004 Annual Stream Monitoring**	watertemp,ph,dissolved_ox, conductivity, turbidity; Biology, Fish, Benthos; Flow, GIS,physhab
Howard County DPW	Streams	A five year biological monitoring program that follows MBSS protocols within the Howard COunty watersheds.	**Biological Stream Survey**	Biology,Fish,Benthos;physhab
Howard County DPW	Streams	Restoration Project in the Cherry Creek community near the Rocky Gorge reservoir.	**Cherry Creek Watershed**	Biology,Benthos;Nutrients,Flow,GIS, physhab
Howard County DPW	Streams	Monthly storm sampling under NPDES requirements	**Font Hill NPDES Sampling**	Chemistry,metals,inorganics,watertemp, ph, otherchem; Nutrients, Flow, physhab
Howard County Parks and Recreation	Streams	Monthly macroinvertebrate samples are conducted from April - October at fixed locations using the rapid bioassessment method.	**Volunteer Stream Monitoring**	Biology,Benthos
ICPRB	Streams	Springtime electrofish monitoring of river herring runs in the Anacostia River and stocking of herring fry in Rock Creek and Anacostia tributaries.	**Anacostia & Rock Creek River Herring Monitoring an**	watertemp,ph,dissolved_ox, conductivity, turbidity; Fish
SHA	Streams	Sampling will be conducted to supplement existing data in a planning study for the Inter-County Connector.	**Inter-county Connector**	Chemistry,watertemp,ph,dissolved_ox,conductivity,turbidity;Biology,Benthos;
SHA	Streams	Monitor the biological effect of a stream restoration project on White Marsh Run.	**MD 43 Extended**	Chemistry,watertemp,ph,dissolved_ox,conductivity,turbidity;Biology,Benthos;Flow,physhab
SHA	Streams	Provide pre-, during and post-construction monitoring data for stream mitigation sites associated with the Woodrow Wilson Bridge Project.	**Woodrow Wilson Bridge Project**	Chemistry,watertemp,ph,dissolved_ox,conductivity,turbidity;Biology,Fish, Benthos; Flow,physhab
Smithsonian Environmental Research Center	Streams	Linking watershed land cover to ecological indicators in freshwater streams and subestuaries of Chesapeake Bay	**Atlantic Slope Consortium**	Chemistry,watertemp,ph,dissolved_ox,conductivity;Benthos; Nutrients, GIS, physhab
Susquehanna River Basin Commission	Streams	Quarterly (or annual) biological, physical habitat, and chemical water quality monitoring at stations along the Pa-Md state line to assess stream conditions.	**Interstate Streams Water Quality Monitoring Networ**	Chemistry, metals, watertemp, ph, dissolved_ox, conductivity, turbidity, otherchem; Biology,Benthos;Nutrients,Flow, physhab
Towson University	Streams	Investigation of blacknose dace (Rhinichthys atratulus) biology across an urban-rural gradient, including life history analyses, physiology and molecular biology.	**blacknose dace biology**	Biology,Fish;GIS,physhab
UMD-College Park	Streams	Conducting a number of research projects involving macroinvertebrates, including environmental impacts, bioassessment, and conservation.	**Aquatic Macroinvertebrates, Bioassessment, and Con**	Chemistry, ph, dissolved_ox, conductivity; Biology,Benthos
UMD-College Park	Streams	Collecting data on structural and functional characteristics of streams in urban, suburban, and rural Maryland to linking geomorphological, hydrological, and ecological data to watershed land use practices.	**Linking Economics, Hydrology, and Ecology to Evalu**	Chemistry,watertemp,dissolved_ox, conductivity; Biology,Benthos; Nutrients, Flow, GIS, physhab
US Forest Service	Streams		**Baltimore Ecosystem Study**	Chemistry,inorganics,watertemp;Biology, Benthos,otherbio;Nutrients,Flow,GIS,physhab
USGS	Streams	Automatic water sampling near mouths of NE and NW branch. Real-time water-quality parameters.	**Anacostia River monitoring**	Chemistry,metals,organics,inorganics,watertemp,ph,conductivity;Biology, otherbio;Nutrients,Flow
USGS	Streams	Twice monthly samples and up to 12 storms per year.	**Assateague nitrates**	Chemistry,inorganics;;Nutrients,Flow
USGS	Streams	Monthly and storm sampling near fall line of Potomac, Patuxent, Susquehanna, and Choptank Rivers. Compute loads and trends.	**Chesapeake Bay River Input Monitoring**	Chemistry,inorganics,otherchem; Nutrients,Flow

13.0 APPENDIX C -STRATEGIC ANALYSIS by Program

Maryland Department of Natural Resources worked closely with Maryland Department of Environment staff to contemplate existing state water monitoring strategy initiatives and consider options for improvement. The following list of strategic issues was addressed by respective program managers for this purpose.

BEACHES MONITORING

Strategic issue: Since local governments conduct the monitoring at these beaches, the strategic question comes down to "Is the State exercising sufficient and effective oversight of local programs?"

MDE provides quarterly conference calls and an annual MDE Beaches Workshop. MDE has prepared the Guidance for County Recreational Water Quality Monitoring and Notification Programs, December 2003 document for local health departments, and the program works to provide prompt guidance to local health department officials who seek assistance with their program. At this time the State is exercising sufficient and effective oversight of local programs

Strategic Issue: How often should the assignment of beaches to monitoring tiers be reviewed? Is the correct level monitoring being applied?

"Non-beaches." Non-beaches are areas where government agencies are aware citizens may enjoy full contact water recreation but where the facilities required for permitted beaches (e.g., water and sanitary facilities) are lacking. MDE works with local health departments to identify such locations and tier the amount of monitoring to be consistent with the size of the population using the beach and therefore commensurate with the risk.

Local health departments review the beaches' Tier level (monitoring frequency) annually, which are an appropriate frequency given that change in the amount of visitation is not generally rapid from year to year. The Tier assignment and level/frequency of monitoring is assigned by local health departments in accordance with MDE's Guidance for County Recreational Water Quality Monitoring and Notification Programs, December 2003 which is based on EPA's National Beach Guidance and Required Performance Criteria for Grants, June 2002. The level of monitoring available is currently acceptable to protect public health in approved beaches.

Strategic issue: In times of resource constraints should this aspect of the program be dropped as non-mandatory or subsumed under the more general monitoring for recreational waters?

***Recreational waters*.** Recreational waters, other than beaches, are areas not typically used for full contact recreation, but which must be protected for the recreational use. Numerous areas are impaired and a significant number of TMDLs have been developed. Bacterial source tracking uses multiple antibiotic resistance analysis to evaluate source contributions for human, pet, livestock and wildlife sources. Initial attempts to identify specific sources (as opposed to categories of sources) have not proven very effective when obvious sources such as failed septic or sewage transport systems cannot be identified.

In October 2000, the U.S. Environmental Protection Agency (EPA) passed the Beaches Environmental Assessment and Coastal Health (BEACH) Act and provided funding to improve beach monitoring in coastal states. Maryland's Beaches Program was established to protect the health of Marylanders at public bathing beaches. The BEACH Act requires beach monitoring and notification regardless of resource constraints.

Strategic issues: Where obvious or controllable sources cannot be readily identified, how much of Maryland's monitoring resources should be expended to identify polluting bacterial sources if there is either little chance that they can be identified, or if identified resolved (e.g., wildlife)? If resources are expended, what are the most productive strategies?

Tidal (or coastal) waters. Coastal beaches that are typically our most used beaches are the most intensely monitored beaches. Local health departments are responsible for the monitoring and MDE provides both technical and resource assistance through the BEACHES Act funding (typically about $250,000 per year in total).

Pollution source survey resources should be focused at beaches that are most heavily used or where there are elevated bacteria levels. Can bacteria source-tracking technology be used to address sources of beach impairment?

Strategic issue: The federal funding provides a tremendous resource for monitoring to protect public health, and the program should be continued, with incremental improvements whenever possible to maintain that programmatic support.

Agree

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually?

Approximately 6,200 bacteria samples were collected at beaches during the 2007 beach season.

2) How often are samples collected?

Samples are collected from Tier 1 beaches on a weekly basis. Samples are collected from Tier 2 beaches twice per month. Samples are collected from Tier 3 beaches monthly.

3) What parameters are monitored?

Depending on the salinity of the water at the beach, either *Enterococcus* Group Bacteria or *Escherichia coli* are monitored.

4) Where are samples collected?

Local health departments collect from designated stations representative of the water quality at the beach.

5) Is a watershed cycling (or other rotational approach) used?

Not applicable.

6) Why are samples collected?

Local health departments monitor water quality to assess the risk associated with bacterial indicator levels.

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?

By monitoring water quality at beaches and notifying the public of elevated bacteria concentrations, the MDE Beaches Program fits into Goal 1 (protecting public health from environmental contaminants). Local Health Departments are required to conduct sanitary surveys at beaches in order to identify and remediate sources of potential pathogenic bacteria. By doing this, they inadvertently fit into Goals 2 though 4 (protecting the health and stability of aquatic communities, managing aquatic resources, and determining if water quality/habitat/resources are improving or degrading).

8) What labs and/or equipment are used for sample collection/analysis?

Local health departments monitor water quality through sampling and the Department of Health and Mental Hygiene Laboratories analyze the samples for indicator bacteria. The DHMH Laboratories utilize an IDEXX Colilert® and Enterolert™ Test Kits.

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?

The monitoring is conducted using fixed locations.

10) Is the monitoring program meeting its goals (regulatory, use support, resource information)?
- *How and where should monitoring take place?*

- Is the level of monitoring correct/appropriate?
- Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?

The monitoring program is meeting its goals.

11) Is the monitoring scale proper?
- Should specific sites or large watershed areas be monitored for restoration activities?

The monitoring scale is proper.

12) Are the parameters monitored appropriate to meet goals?

The BEACH Act, an amendment to the Clean Water Act, was enacted in October 2000 to enhance beach protection provisions. The law required states to adopt improved water quality standards for pathogen indicators (*Enterococcus* and *E. coli*) for recreational waters.

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts?

Currently there is a bill in Congress that would require the use of rapid testing methods (results in two hours).

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?

Current bacteria indicator laboratory methods require at least 24 hours before the results are known. Under the BEACH Act, EPA is responsible for developing new and faster methods to detect pathogens and pathogen indicators of fecal contamination. EPA is conducting studies to measure temporal and spatial variation of bacteria because there is potential for considerable variability in measuring bacterial levels in recreational waters.

15) Should resources be allocated to better analysis of data?

The BEACH Act funding covers coastal recreation waters (beaches with Atlantic Ocean and Chesapeake Bay frontage). There are no state funds to support monitoring at the non-coastal beaches and waters at this time. Funds to support any monitoring of non-coastal waters must come from local funding. Resources should be allocated to support collection of samples at non-coastal beaches.

Drinking water supply. Drinking water is monitored as a requirement under the Safe Drinking Water Act. Under the direction of the Water Management Administration (WMA), the Science Services Administration (SSA) routinely collects samples from all public drinking water systems.
See Source General Water Supply

Strategic issue: The Department recognizes that there is probably an issue for public health from emerging contaminants, but in the absence of information from EPA on which substances are of greatest concern, and what levels might require action, the Department has neither the resources nor the expertise to institute a monitoring program. PDBEs are the only emerging contaminants routinely monitored (as part of our fish tissue program). See Source General Water Supply

Shellfish harvesting area monitoring. The emphasis of this monitoring effort and program has been on protection of shellfish waters. Restoration is often complicated when bacteria sources cannot be identified. Bacteria sources that can be identified and are regulated by MDE are systematically mitigated or eliminated. This strategy has been effective in protecting public health. The principle goal is to fully implement the requirements of the National Shellfish Sanitation Program (NSSP), which is designed to minimize the risk of contaminated shellfish reaching markets and/or being consumed. The fundamental elements of the NSSP are carried out by three State agencies, MDE (growing water classification), DHMH (post harvest sanitation and enforcement), and DNR (fishery laws and enforcement).

Strategic Issue: Should station sampling effort be prioritized based on frequency of harvesting, some other measure of risk, or on meeting the minimum required monitoring frequency? To protect shellfish harvesting waters for their designated use the minimum monitoring frequency would be appropriate to protect waters that have or could potentially have a shellfish resource regardless of actual harvesting effort or resource. The strategy should be to protect the waters, sampling the water for bacteria is one part of this effort. A change in this strategy may require input from the Maryland Legislature since MDE is obligated to monitor shellfish harvesting waters frequently and to open waters to harvesting whenever possible.

Strategic Issue: How should our monitoring programs respond to the emerging aquaculture industry? At this point emergence of an aquaculture industry is slow yet requires significant man-hours to meet NSSP requirements. If there is an upward trend and increased rate of new aquaculture businesses, MDE may want to consider seeking compensation from the aquaculture industry and/or seek support from the legislature to maintain proper classification of shellfish harvesting waters to remain in compliance with the NSSP and protect shellfish harvesting waters for both the public and private fishery.

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually?

The number varies slightly since stations may be added for aquaculture.
2007- 688 stations, monthly monitoring- 8,256 samples
Actual collection for 2007- < 4,128

2) How often are samples collected?

The most efficient would be to collect samples a minimum of monthly to meet the various federal and state requirements. An effort to sample at least monthly has proven to show the best results to properly classify and characterize shellfish water quality and monthly sampling also mirrors Virginia's efforts in their shellfish waters. Due to staff and equipment shortages, minimum sampling requirements have not been met for the last 3-4 years.

3) What parameters are monitored?

Fecal coliform bacteria are monitored at the surface for all stations. At all stations observations of wind direction and speed, tide, cloud cover, and rain in last 48-hours are recorded. At selected stations, air and water temperature, pH, D.O., conductance, and salinity are measured at the surface and bottom.

4) Where are samples collected?

Station locations are selected based on the characteristics of the particular site. Consideration is given to potential pollution sources, location of shellfish beds, and the hydrographic and geographic characteristics of the water body.

5) Is a watershed cycling (or other rotational approach) used?

Not applicable.

6) Why are samples collected?

Maryland's participation in the NSSP allows commercial harvest of shellfish. Samples are collect to meet NSSP requirements and support Maryland's seafood industry.

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?

Yes, to protect public health.

8) What labs and/or equipment are used for sample collection/analysis?

Sample collection is conducted by MDE using boats, monitoring equipment, and meters for measuring parameters. The Department of Health and Mental Hygiene, Laboratories Administration does the lab analysis for shellfish waters and must be certified by the US FDA.

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?

Monitoring is conducted randomly using fixed locations.

11) Is the monitoring program meeting its goals (regulatory, use support, resource information)? No, the program is not monitoring at the required frequency.
 - *How and where should monitoring take place?* State and federal requirements determine sampling frequency. The NSSP specifies how and when monitoring

shellfish harvesting waters should occur.

- Is the level of monitoring correct/appropriate? Generally correct and appropriate monitoring is accomplished. State budget constraints and hiring freezes over the last several years has resulted in not meeting minimum state and federal sample frequency requirements due to staff shortages and cuts to the budget for replacement of equipment. Since monitoring data is assessed on a minimum of three years of data, the reduced level of monitoring has been slow to surface.

- Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends? N/A

11) Is the monitoring scale proper? Restoration is not a goal of this monitoring effort.

- Should specific sites or large watershed areas be monitored for restoration activities?

12) Are the parameters monitored appropriate to meet goals? Yes.

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? Current monitoring effort is <u>not</u> sufficient and not because of newer monitoring or analytical efforts, mainly due to budget issues. New monitoring equipment, such as computers and digital recording of field data would increase efficiency in monitoring efforts for this program.

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?

- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted? Sampling frequency is defined by federal and state requirements so this question does not really apply. The monitoring activity must be continuous to meet the requirements and has not been sufficient due to budget constraints.

15) Should resources be allocated to better analysis of data?

Yes, a move towards a paperless data stream (from sample collection-lab analysis-database) would allow for increased efficiencies related to data management and improving data quality.

Fish Tissue Monitoring

<u>Strategic Issue</u>: The entire state has been assessed with respect to fish tissue concentrations of mercury and PCBs. Should a full-scale program continue or should the program be reduced to “maintenance” monitoring?

Due to limited funding, future sampling efforts should be modified to address new contaminants of concern and focus on localized bioaccumulation sources for remediation or TMDL implementation initiatives. A significant portion of available funding should remain focused on maintenance monitoring in order to document trends and address-up-and-coming bioaccumulation toxicants of concern, such as flame-retardants, endocrine disrupters, personal care products, pesticides and pharmaceuticals. Some funding should also be set aside each year to address areas of special public concern, special intensive monitoring effort.

Toxic Compounds

Three categories of toxic compound deserve special attention because they are not routinely monitored: bioaccumulative and non-bioacumulative contaminants, endocrine disruptors, pharmaceutical products and personal care products.

The routine fish tissue-monitoring program may easily expand as necessary to address priority up-and-coming toxic compounds of concern, contingent on lab constraints and analytical funding.

Strategic issue: Particularly for endocrine disruptors and similar emerging contaminants, the linkage to aquatic life is better documented than for human health (e.g., intersex fish). Should Maryland start monitoring to establish either priority areas or priority compounds in any of these categories to evaluate whether action is warranted with respect to aquatic life?
This function can be easily rolled into the annual fish tissue collection program. The additional costs would be strictly analytical.

Additional Questions

1) How many samples are collected annually? 30

2) How often are samples collected?
Once every three years, with occasional intensives as prescribed in response to either TMDL or public health requirement

3) What parameters are monitored? PCB’s, pesticides, metals

4) Where are samples collected?
All over state, flowing water, impoundments and tidal

5) Is a watershed cycling (or other rotational approach) used? Yes, regionally

6) Why are samples collected? To protect public health and to support TMDL initiatives

7) Do any aspects of the program fit into the 2009 strategic monitoring goals? Yes, this program supports both public health and aquatic resource initiatives.

8) What labs and/or equipment are used for sample collection/analysis?
CBL University Lab

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both? Predominately fixed and targeted stations

12) Is the monitoring program meeting its goals (regulatory, use support, resource information)? Yes

- How and where should monitoring take place? The program adequately document ho -spots throughout the state. Data is used to determine risk and serves as the basis for management decisions.

- Is the level of monitoring correct/appropriate? The level may be modified as necessary to address up-and-coming toxins of concern and for TMDL implementation.

- Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends? To be determined once restoration or TMDL initiatives are officially sanctioned and approved.

11) Is the monitoring scale proper?

- Should specific sites or large watershed areas be monitored for restoration activities? Yes

12) Are the parameters monitored appropriate to meet goals? Need input from a toxicologist.

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? Currently the department is significantly delayed by extremely slow or non-existent analytical results from the CBL Lab. Consider finding new lab to analyze samples. This may levy additional costs due to the cost of the bid process and the expense associated with competent private labs capable of performing comparable work as the University of Maryland.

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?

- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted? Seasonal regional rotation is sufficient to meet the general goals of the project

15) Should resources be allocated to better analysis of data? Yes, hopefully this need will be adequately resolved with the hiring of a staff toxicologist.

TMDL Monitoring

Watershed Cycling Strategy

Strategic Issue: Five-year watershed cycling strategy. Should the broad strategy of monitoring approximately one fifth of the state each year continue or should the general

assessment process be more targeted, allocating more resources (e.g., multiple years) to some areas at the expense of others?
If the 5-year cycle remains a valid strategy, within this framework, the broad goals of monitoring are to evaluate progress towards TMDL goals, target implementation, and address biological impairments.

Strategic Issue: Should we evaluate the same suite of substances monitored in the past or should the list of monitored contaminants be revised?
Constituents to monitor should be based on TMDL modeling needs, targets of past TMDLs, or specific data gaps.

Strategic Issue: Can MDE make better use of monitoring data collected under the regulatory/compliance programs to monitor just as effectively at lower cost and/or could some resources be re-allocated by better utilizing data collected under the stormwater permit? There is a possibility of utilizing this data for implementation effectiveness monitoring.

Strategic Issue: Do we need different data management and/or analytical systems to take advantage of these data? Yes. NPDES compliance monitoring in most cases has been turned over to the regulated entity to do self-monitoring. Is appropriate QAQC in place to allow use of this data? Is it collected at frequencies suitable for our needs?

Strategic Issue: The entire state has been assessed twice in the last 13 years with respect to non-tidal biomonitoring (MBSS). Should a full-scale program continue or should the program become targeted for the purposes of TMDL and implementation monitoring and monitoring for particular projects?

Some limited redirection may be useful, especially for biological TMDL needs. Although collaborative studies are good in theory, they are subject to frequent failure due to differing priorities among participants that draw resources away and critical data goes uncollected. Possibly redirection of some resources to the fixed network (core/trend) to better suit our needs, but maintain some random effort too could be an option

Implementation effectiveness monitoring

Significant funding is expended on implementation, but there is relatively little evaluation of the effectiveness of that implementation, either of the practice generally, or of the specific site implementation. Some amount of monitoring is necessary to determine which implementation practices are generally most effective and whether there are certain conditions under which specific practices should not be used.

Strategic Issue: Should progress toward TMDL goals be monitored and quantified by the State? If so, how should that be done, aside from the direct assessment monitoring?
Yes. This is addressed to a large extent with the cyclical monitoring. If listings remain at the eight-digit level, progress towards goals should be addressed at that level as well. While progress towards goals at this scale will be hard to document, small-scale success within the larger watershed could help show progress. To help target implementation activities and follow-up

monitoring, the 12-digit basin monitoring results need to be analyzed to find impacted areas suitable for these activities.

Strategic issue: How should the resource allocation to implementation effectiveness monitoring be determined?
This question will be answered better after the next two issues are settled. Currently the Corsica River Restoration Project is a major priority. More of this type of project may be in the offing as Trust Fund money moves into use.

Strategic issue: Which practices should be prioritized for evaluation?
Need feedback from modelers, practitioners, etc. about state of knowledge and practices that appear important to restoration efforts. Will the practice return a benefit within a time frame useful to parties that need the information i.e. political terms?

Strategic issue: Where and how should that monitoring take place? Should it be for the specific practice/location or at broader scales in small watersheds where a particular practice or set of practices have been implemented? Should practices be tracked by regressing changes in water quality on overall level of implementation in a watershed?

Yes to all with qualifications. If implementation activities cover an entire watershed, do the watershed. If an individual practice at one place is to be implemented, then the monitoring focus has to be focused on that practice. The type of practice has to be considered carefully also.
Is it better to count the number of trees planted in a year versus trying to measure the undetectable change that seedlings produce in a year? If what we want to do is 1) document benefits, and 2) show success stories, then picking the appropriate project is critical. Hunting Lotte Farm (positive results in 1 year) versus German Branch (nothing conclusive after 10 years). Unfortunately the luxury of picking and choosing is rare for a large number of reasons such as timing and access to name two critical ones. Our sources for projects may be limited to those being funded by MDE controlled funds (319, Trust fund). Cultivating other agency and county contacts to keeping us informed of possibilities helps.

Strategic Issue: Are we continuing to monitor for trends at stations that are essentially duplicative or that no longer provide information worth the cost of maintaining the effort at that station?
While it is nice to think a watershed that is currently unimpacted will be protected and remain in good shape, history has put the lie to this. A better question might be – How soon do you want to be able to detect changes that will trigger a management action? In this light, all the monitoring we can do is good.

Strategic Issue: Are we monitoring more stations, or with greater frequency, than the minimum needed to meet our goals? See above. There can never be TOO much monitoring. If within the resources at our disposal (personnel, analytical costs, etc.) we have set priorities (i.e. 1, TMDL model needs 2, progress towards TMDL goals 3, BMP evaluations) then this question will be taken care of. Analysis of existing data sets can help target areas that might benefit from more monitoring, or not suffer greatly from less.

Strategic Issue: Where is trend monitoring worth continuing over the long term? Are we gaining significant new information at all stations each year? See previous 2 comments above. Analysis of existing data sets can help target areas that might benefit from more monitoring, or not suffer greatly from less.

Strategic Issue: Should new stations or sites be chosen? Covered above

Additional Questions

Answers to these questions are generally included above

1) How many samples are collected annually?
2000+

2) How often are samples collected?
Generally, monthly
3) What parameters are monitored?
Nutrients, chlorophyll, physical parameters, discharge
4) Where are samples collected?
All 12 digit watersheds
5) Is a watershed cycling (or other rotational approach) used?
Cycling
6) Why are samples collected?
Progress towards TMDL goals, TMDL model needs, Special studies for WMA, Hazardous Waste, Oil Spill
7) Do any aspects of the program fit into the 2009 strategic monitoring goals?
All do
8) What labs and/or equipment are used for sample collection/analysis?
CBL, DHMH. ISCOs, dredges, Hydrolabs, flow meters
9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?
Fixed locations

10) Is the monitoring program meeting its goals (regulatory, use support, resource information)? Yes
    - *How and where should monitoring take place?*
    - *Is the level of monitoring correct/appropriate?*

- Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?

11) Is the monitoring scale proper?
 - Should specific sites or large watershed areas be monitored for restoration activities? Depends on what us available

12) Are the parameters monitored appropriate to meet goals? Yes

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? See #15 below

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
 - Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted? Yes. Project specific. See comments above.

15) Should resources be allocated to better analysis of data? YES!!!!! Analysis of previous years data will inform us where to go next year

Toxic Compounds

Three categories of toxic compound deserve special attention because they are not routinely monitored: bioaccumulative and non-bioacumulative contaminants, endocrine disruptors, pharmaceutical and personal care products.

Strategic issue: Particularly for endocrine disruptors and similar emerging contaminants, the linkage to aquatic life is better documented than for human health (e.g., intersex fish). Should Maryland start monitoring to establish either priority areas or priority compounds in any of these categories to evaluate whether action is warranted with respect to aquatic life? With recent publicity, we will probably be forced to do at least initial screening to find impacted waterbodies. In preparation, we should identify laboratories able to do required analysis. Next step would be priority areas. Establishing priority substances might better be left to academic/medical researchers.

Revision of Standards

Strategic Issue: Most existing water quality related standards were established in the 1960s, 1970s, or in the 1980s (toxicants). Many of these standards were devised to be applicable at the end of a control system (treatment plant). Current reviews and utilization of the standards in ambient water situations suggest that they may not be appropriate for all circumstances and should be revised. This would require that additional monitoring be conducted to provide the needed justification for new or revised standards.

Monitoring for Quantification of the Narrative Standards

Strategic Issue: At this time the primary narrative concern is trash. There is one listed trash impairment, the Anacostia Watershed, and a second has been proposed for sections of Baltimore Harbor. At the time this document is written, Montgomery and Prince George's Counties have funded baseline monitoring for trash and it is likely that progress monitoring will be incorporated into future MS-4 permits. MDE would anticipate a similar structure with Baltimore City.

Preparation of TMDLs requires a quantitative approach for establishing acceptable limits. Therefore, it has been necessary to consider the development of a means to quantify this otherwise narrative standard.

Revision of Use Classifications

Strategic issue: The use elements of Maryland's water quality standards were developed in the 1970s or earlier. Early water monitoring efforts focused on major water bodies of the state. As waters are monitored in ever-more remote and unusual locations, it is becoming apparent that the originally established standards may not be appropriate in all locations and under all conditions. While TMDL monitoring may provide data necessary to justify changes in use categories, it is also necessary that some confirmatory monitoring be conducted to fully justify changes that might be needed. Monitoring resources will be needed for the establishment of Tiered Aquatic Life Uses, justification of Use Attainability Analyses, and other limited use conditions (navigation channels, urban streams, etc.).

New Standards

Strategic issue: Maryland is already considering promulgation of nutrient criteria and discussing the potential for other standards (dissolved solids or conductivity), but has not made any final decisions. While the utilization of existing data is preferred, it is recognized that as new criteria are considered, monitoring will be required to document, and fully justify the new standards.

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually? Highly variable, utilized existing data to the extent practicable

2) How often are samples collected?

3) What parameters are monitored? Can you establish a standard for esthetics? Logically if presence/absence is the basis of the standard, the standard can never reasonably be achieved..

4) Where are samples collected?

5) Is a watershed cycling (or other rotational approach) used? no

6) Why are samples collected? See above

7) Do any aspects of the program fit into the 2009 strategic monitoring goals? Yes both human health and aquatic resources goals

8) What labs and/or equipment are used for sample collection/analysis? DHMH, CBL

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both? Mostly deterministic.

11) Is the monitoring program meeting its goals (regulatory, use support, resource information)?
   - *How and where should monitoring take place? As needed*
   - *Is the level of monitoring correct/appropriate? Always a need for more data*
   - *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends? N/A*

11) Is the monitoring scale proper?
   - *Should specific sites or large watershed areas be monitored for restoration activities? N/A*

12) Are the parameters monitored appropriate to meet goals? No specific monitoring program supports effort.

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? Use of general monitoring data is probably sufficient

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
   - *Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted? Use of general monitoring data is largely sufficient, except when specialized interpretations are required to develop new state standards that require special interpretation or are subject to undefined variables..*

15) Should resources be allocated to better analysis of data? External review would be a great asset, contingent on available funds?

Monitoring for revision of existing uses and development of numeric criteria.

Strategic issue: Should some resources be allocated for development of Tiered Aquatic Life Uses? If Tiered Aquatic Life Uses are to be a part of regulation (COMAR) then we need to establish criteria. This requires a collaborative effort with DNR. TALU will allow more effective application of the pollution trading principle in support of TMDL implementation and help divert limited remediation resources to areas with highest probability of success.

Strategic issue: Maryland is already considering promulgation of nutrient criteria, but has not made a final decision regarding specific concentrations. Should resources be allocated specifically to develop and/or test the feasibility of nutrient criteria? If we want to have some control over our fate, this might be worthwhile. As we know, there is no "one size fits all", so when criteria are required, there will be a good number of local variables that will probably need to be accounted for (soils, underlying geology, etc). Much of this can be a desktop exercise as there is plenty of data available.

Water Quality Protection Tier II

Strategic Issue: Monitoring to identify high quality waters is not mandatory, and MDE currently identifies high quality waters largely through MBSS random monitoring or through analysis of existing data. Should MDE allocate resources from other activities specifically to identify such waters or to confirm the status of waters with minimal documentation? Redirection of some MBSS resources may be required by DNR to advance this task. Or it may be an assumed MDE responsibility.

Additional Questions

1) How many samples are collected annually? ~24

2) How often are samples collected? In the spring index period for benthos and the summer index period for fish.

3) What parameters are monitored? Typical MBSS suite.

4) Where are samples collected? In targeted stream segments identified using GIS.

5) Is a watershed cycling (or other rotational approach) used? No.

6) Why are samples collected? To identify Tier II (high quality) waters.

7) Do any aspects of the program fit into the 2009 strategic monitoring goals? Yes, into the protection goal.

8) What labs and/or equipment are used for sample collection/analysis? D-frame nets for benthos; electroshockers and block nets for fish; same labs as used for the MBSS samples.

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both? Fixed locations.

10) Is the monitoring program meeting its goals (regulatory, use support, resource information)?
Partially; the monitoring is helping to identify high quality areas needing enhanced protection does not effectively quantify assimilative capacity for maintaining high quality status.
- *How and where should monitoring take place?* In likely Tier II segments.
- *Is the level of monitoring correct/appropriate?*Appropriate for identifying Tier II but not identifying what level of water quality will be necessary to maintain Tier II status.
- *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?* This program requires monitoring at the scale and frequency appropriate to define the limits of the Tier II segment.

11) Is the monitoring scale proper? Yes.
- *Should specific sites or large watershed areas be monitored for restoration activities?*

12) Are the parameters monitored appropriate to meet goals? Partially (see answer to question 10).

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? The program should be enhanced to collect longer-term baseline water quality data to fully characterize ambient conditions in identified Tier II segments. This will provide MDE with legally defensible baseline data that can be used to determine assimilative capacity as well as determine permit limits for any discharges to Tier II waters.

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- *Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?*

See answer to ques. 10.

15) Should resources be allocated to better analysis of data? No.

Bacterial Source Tracking

Strategic Issue: Is our current bacterial source tracking providing sufficient definition of sources and repeatability or should the method be re-evaluated in light of experience and science developed since the method was originally chosen? A repeat of the Corsica BST is on the schedule to begin Nov. 2008 to help answer the repeatability question and the usefulness of archived libraries. Until these questions are answered the program should probably remain as is.

Strategic Issue: Is it worth the cost and effort that would be required to reduce the proportion that cannot be attributed to one of the four categories (humans, pets, livestock or wildlife)? At this point we have not attempted to do enough implementation to test the current results. The Centreville pet waste ordinance may provide this opportunity with the repeat of the Corsica BST. Until these questions are answered the program should probably remain as is.

Additional Questions

1) How many samples are collected annually?
This sampling effort changes from year to year. This current years monitoring includes 38 monitoring sites collected monthly for a total of 456 water samples. Each targeted watershed has specific goals with regards to scatological monitoring that consist of bacteria isolates that comprise what is termed a library. These libraries may vary from watershed to watershed dependent on the number of impaired stations and watershed size. This years monitoring is evaluating 8 different watersheds for a total of 7000 bacteria isolates to be used for analysis. There are within each library targeted categories for bacteria isolates-human, pets, livestock, and wildlife. The maximum of 8 isolates are collected from each scat sample. Example—Severn River requires 2000-SCAT isolates for the library/ 4-seasons/4-targeted categories i.e human, pet, etc/ 8 isolates per sample = a minimum of 15 samples per quarter distributed between the four targeted categories.

2) How often are samples collected?
Water samples are not longer collected from use I waters on a monthly basis. Renewal of the bacteria monitoring program may be warranted in order to support this project. Land based scatological sampling is conducted seasonally/quarterly at each targeted watershed.

3) What parameters are monitored?
No physical parameters are required to be measured as part of this monitoring effort.

4) Where are samples collected?
Samples are collected to support targeted monitoring needs. No routine program currently exists, other than monitoring in estuarine waters to support shellfish sanitation decisions.

5) Is a watershed cycling (or other rotational approach) used?
N/A

6) Why are samples collected?
To identify sources of bacteria to manage diseases of public health concern

7) Do any aspects of the program fit into the 2009 strategic monitoring goals? Goal 1-Public health

8) What labs and/or equipment are used for sample collection/analysis?
Salisbury University. Scat samples are analyzed for bacteria isolates to be further evaluated for antibiotic resistance (ARA).

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?
Water samples are collected at prefixed locations, all SCAT sampling is collected randomly within the confines of the targeted watershed.

12) Is the monitoring program meeting its goals (regulatory, use support, resource information)?
- *How and where should monitoring take place?*
- *Is the level of monitoring correct/appropriate?*
- *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?*

11) Is the monitoring scale proper?
- *Should specific sites or large watershed areas be monitored for restoration activities?*

12) Are the parameters monitored appropriate to meet goals?

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts?

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- *Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?*

15) Should resources be allocated to better analysis of data?

Shoreline surveys-Public Health

Strategic issue: shoreline surveys are now being digitized making the information collected more useful. Should resources be allocated specifically for quantitative analysis of shoreline survey data? No, the digital program performs that function. If so, for what purpose?

Additional Questions

1) How many samples are collected annually? This number varies annually, on average approximately 3800 properties.

2) How often are samples collected? Properties are surveyed on a daily basis by one staff; all other personnel are scheduled to perform these duties on a weekly and/or bi-weekly.

3) What parameters are monitored? All levels and manner of real and/or potential sources of pollution are examined. Properties are inspected to ascertain the functionality of their on-site waste disposal systems (residential, commercial, agricultural). Agricultural manure practices, commercial and chemical washdown, run-off from farm fields, pump-out stations, domestic animal waste and wildlife scat are monitored, evaluated and observed during these investigative surveys.

4) Where are samples collected? Data is collected from residential, agricultural and commercial properties considered to have an impact upon Maryland's shellfish harvesting waters.
5) Is a watershed cycling (or other rotational approach) used? Shoreline surveys are assigned on a 5-year cycle.

6) Why are samples collected? Properties are inspected to track and discover real and/or potential pollution sources that may or may not have an adverse impact upon shellfish harvesting waters.

7) Do any aspects of the program fit into the 2009 strategic monitoring goals? Yes, to protect public health

8) What labs and/or equipment are used for sample collection/analysis? Toughbook Tablet computers, water soluble dyes, gloves, boots.

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both? Survey properties are fixed within a previously mapped boundary using GPS technology.

13) Is the monitoring program meeting its goals (regulatory, use support, resource information)? No, the program is not monitoring at the required frequency. Staffing shortages have hindered the program in meeting its goals.
   - *How and where should monitoring take place?*
   - *Is the level of monitoring correct/appropriate?*
   - *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?*

11) Is the monitoring scale proper? Restoration is not a goal of this monitoring effort.
   - *Should specific sites or large watershed areas be monitored for restoration activities?*

12) Are the parameters monitored appropriate to meet goals? Yes

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? No, program currently understaffed due to vacancies.

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?
Goals would be better met with the addition of personnel.

15) Should resources be allocated to better analysis of data? Yes, along with personnel, the acquisition of 8 more Toughbook tablet computers would enable the program to become more efficient.

Biological Stressor Identification

Strategic Issue: Five-year watershed cycling strategy. Should the broad strategy of monitoring approximately one fifth of the state each year continue or should the general assessment process be more targeted, allocating more resources (e.g., multiple years) to some areas at the expense of others?

The five-year watershed cycling strategy could help for assessment of emerging contaminants related to biological integrity. However, if there is a new or emerging contaminate then we should be clear on why we are monitoring (criteria development or assessment) and how to monitor to achieve those goals (frequency, conditions, etc.). Recommend that the department does not implement a cycling strategy for emerging contaminants if the criteria (or target value) and assessment method (e.g. geometric mean, single sample exceedence) are not defined.

General monitoring Comments:
If a new contaminant emerges and there is an applicable criteria or target threshold value then the department should consider the five-year strategy to target monitoring throughout the state. However, if the department has "reasonably assessed" all of the 8-digit watersheds for appropriate uses or contaminants then it is unclear as to the benefit of a broad five-year cycling for a general suite of contaminants. In the later situations more focused monitoring on TMDL development, restoration targeting or protection would appear more beneficial.

Strategic Issue: Should we evaluate the same suite of substances monitored in the past or should the list of monitored contaminants be revised?

The department should periodically review the efficacy of contaminants being monitored for based on COMAR priority listings, parameters identified through the statewide stressor ID process, and information gaps. Currently, the primary dataset for stressor ID is the MBSS dataset, which is a "survey" of the streams. This type of survey provides an excellent suite of information that can be collected in a relatively short site visit.

Most information is qualitative, where data types include binary and ordinal responses. Consideration should be given to the applicability of other "survey" type parameters that may be applied to the decision process in a reasonably short timeframe (e.g. extent of algal mats, odor, color, etc?). These parameters supplement other qualitative stressors, which render a better picture of the cumulative biological stressors affecting biological health. This association can be easily assessed using basic epidemiological statistical techniques. As an example, if there is a strong association with extensive algal mats then the department could pursue targeted periphyton studies in those areas.

Quantitative chemical data collected only once per site has limited use unless there is an acute criteria or target value. Examples for acute criteria are based on COMAR where pH cannot be less than 6.5 and dissolved oxygen cannot be less that 5 mg/l. Data that exhibits a strong temporal variation and does not have an acute criterion or target threshold has limited usefulness and could create false conclusions.

Strategic Issue: Can MDE make better use of monitoring data collected under the regulatory/compliance programs to monitor just as effectively at lower cost and/or could some resources be re-allocated by better utilizing data collected under the stormwater permit? Do we need different data management and/or analytical systems to take advantage of these data?

MDE could make better use of monitoring data collected as part of MS4 permits. To achieve this, the collection methods should be standardized to support comparison across multiple landscape types (or permits) and be consistent with current listing and stressor identification methods. At a minimum, the methods should be consistent with the MBSS protocol. Cost effective data analysis will also be dependent on establishing one database within MDE this data will be combined. The MS4 program currently requires rapid bioassessment monitoring as a requirement of the permit. This data should be used as feasible to supplement small-scale remediation and TMDL implementation efforts.

Strategic Issue: The entire state has been assessed twice in the last 13 years with respect to non-tidal biomonitoring (MBSS). Should a full scale program continue or should the program become targeted for the purposes of TMDL and implementation monitoring and monitoring for particular projects?

Unless there are significant data gaps for emerging contaminates with new criteria, the program should become more targeted where decisions are made based upon restoration and protection of waters. Locations for restoration monitoring should be based on a decision process that considers the restoration potential (see EPA ORD project) of the watershed(s). The purpose of monitoring these areas would be to establish a baseline condition and refine the spatial resolution of the impairment.

Protection should first be focused on tier II streams. One option is to use the spatial interpolation of the IBI's to identify potential tier II streams without monitoring sites and then confirm these areas with monitoring data. Another option is to overlay tier II streams (or predicted and monitored tier II streams) with the current landuse zoning, priority funding areas and priority conservation areas and identify streams where baseline condition should be established. An example would be a tier II stream with the upstream watershed zoned for residential and is within a priority funding area. This stream could be considered for long term monitoring to determine the impacts of development. This same process could also be used on streams with IBI in the fair range (e.g. 3.0>IBI<4.0).

Additional Comment:

There is benefit to maintaining a long term monitoring (Core) and sentinel network within the state. At these locations it is beneficial to maintain the previously monitored suite of contaminants. The long term data could aide in answer future questions related to trends or possibly the impacts of climate change.

Stategic Issue: It is apparent that monitoring of some sort will be required for this activity, but there is currently only a vague idea of the amount of monitoring that will be needed. As the project develops over the next 6 to 12 months the answer to this question will come forth. A minimum level of resource needs should be anticipated, including necessary training, and need for seasonal personnel.

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually?

2) How often are samples collected?

3) What parameters are monitored?

4) Where are samples collected?

5) Is a watershed cycling (or other rotational approach) used?
Yes

6) Why are samples collected?
Statewide Assessment

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?

8) What labs and/or equipment are used for sample collection/analysis?

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?

14) Is the monitoring program meeting its goals (regulatory, use support, resource information)?

- How and where should monitoring take place?
- Is the level of monitoring correct/appropriate?
- Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?

11) Is the monitoring scale proper?
- Should specific sites or large watershed areas be monitored for restoration activities?

12) Are the parameters monitored appropriate to meet goals?

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts?

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?

15) Should resources be allocated to better analysis of data?

YES!!!

NPDES Stormwater Monitoring (Municipal - Nonpoint source)

Non-tidal

Use I, All nontidal uses are monitored for the presence of contaminants from nonpoint source runoff. Some monitoring is provided through the municipal NPDES storm water-monitoring program. Biological assessments are conducted each spring on 11 stream reaches between a storm drain outfall and an ambient stream location. The EPA's Rapid Bioassessment Protocol, or the Maryland Biological Stream Survey is used to determine the health and long-term changes in the benthic community. Data are submitted to MDE annually with chemical and physical monitoring results. Taken together, these data help local governments to tailor management programs for reducing storm water pollutants to the maximum extent practicable. Additionally, this monitoring provides important feedback for improving the State's storm water management program. Point source toxic discharges are addressed through discharge permits, DMRs, and WET testing.

Strategic Issue: Should we evaluate the same suite of substances monitored in the past or should the list of monitored contaminants be revised? One hundred and thirty-eight substances were required for NPDES storm water application monitoring under the CWA. In 1997, MDE analyzed 150 storm events from across the State to identify the range of pollutants commonly found in Maryland runoff for developing a parameter list for placing in permits. Based on additional information, occasionally the parameters required for monitoring in NPDES storm water permits change. For example, total phenols and total cadmium were dropped because of decreasing detection frequencies. Fecal coliform monitoring requirements were changed to E. coli or enterococcus because they are better indicators of human health problems and appear as State standards. The current list of substances for monitoring support Chesapeake Bay initiatives through nutrient and sediment monitoring. Also, a suite of commonly found metals, bacteria and some basic physical parameters such as flow, pH, and temperature are monitored. Additional biological and habitat assessments required under the NPDES storm water permits serve municipal program goals in showing progress toward restoring local streams and aquatic resources.

Strategic Issue: Can MDE make better use of monitoring data collected under the regulatory/compliance programs to monitor just as effectively at lower cost and/or could some resources be re-allocated by better utilizing data collected under the stormwater permit? Do we need different data management and/or analytical systems to take advantage of these data? Currently MDE's Science Services Administration uses the stormwater data for TMDL and WLA development. MDE's Water Management Administration sum the State's municipal data to provide EMC's for local jurisdictions to aid them when calculating pollutant loads as required by the CWA. Language in NPDES stormwater permits requires consistency with WLAs. More and more, municipalities will be asked to use the best local, state, and federal data available to show progress toward meeting WLAs. Further resources, cost saving practices, and collaboration are surely warranted for ensuring that the State meets TMDL reporting requirements and local municipalities can implement the many watershed restoration practices necessary to restore water quality.

Additional Questions

1) How many samples are collected annually?

(11 municipalities x 12 storm events) x (12 parameters x 3 composites) = 132 x 36 = 4,752.

2) How often are samples collected?

On average once per month.

3) What parameters are monitored?

Temperature, pH, biochemical oxygen demand, total Kjeldahl nitrogen, nitrate+nitrite, total petroleum hydrocarbons, total phosphorus, total copper, total zinc, total lead, hardness, E. coli or enterococcus, and total suspended solids.

4) Where are samples collected?

Anne Arundel, Baltimore, Carroll, Charles, Frederick, Harford, Howard, Montgomery, and Prince George's counties, and Baltimore City, and the Maryland State Highway Administration.

5) Is a watershed cycling (or other rotational approach) used?

Yes, after a watershed has been fully restored.

6) Why are samples collected?

The goals of the municipal NPDES storm water-monitoring program include the pollutant characterization of urban runoff from specific land uses and the assessment of receiving stream morphology and biological integrity to guide management program implementation.

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?

Yes, all of them.

8) What labs and/or equipment are used for sample collection/analysis?

CFR lab requirements are followed by local municipal governments.

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?

Mostly fixed but some randomness is incorporated through biological sampling.

15) Is the monitoring program meeting its goals (regulatory, use support, resource information)?

- *How and where should monitoring take place?*
- *Is the level of monitoring correct/appropriate?*
- *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?*

Ample data are being generated to assess local watershed restoration effectiveness and pollutant load reductions. These data are also being combined with State monitoring data to help show progress toward meeting TMDLs. Additional collaboration between State and local program goals is always warranted and on-going.

11) Is the monitoring scale proper?

- *Should specific sites or large watershed areas be monitored for restoration activities?*

Yes, but additional collaboration between State and local program goals is always warranted and on-going.

12) Are the parameters monitored appropriate to meet goals?

Yes, the current list of substances for monitoring support Chesapeake Bay initiatives through nutrient and sediment monitoring. Also, a suite of commonly found metals, bacteria and some basic physical parameters such as flow, pH, and temperature are monitored. Additional biological and habitat assessments required under the NPDES storm water permits serve municipal program goals in showing progress toward restoring local streams and aquatic resources.

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts?

NPDES storm water monitoring effort is continually updated. First round permits were solely chemical. Second round permits incorporated biological and physical parameters. Additionally, lists of parameter change occasionally based on scientific information.

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?

NPDES storm water programs and restoration projects are hugely expensive. The goal of these storm water permits is to get as many BMPs in the ground as possible to improve water quality. As part of this program are representative monitoring requirements to gauge the effectiveness of management efforts. Current data collection is able to achieve this. Additionally, these data are being used more and more to help aid State scale programs for assessing TMDLs and improving the Chesapeake Bay.

Compliance Monitoring

Non-tidal
Use I, All nontidal uses are monitored for the presence of contaminants from nonpoint source runoff. Some monitoring is provided through the stormwater program. Point source toxic discharges are addressed through discharge permits, DMRs, and WET testing.

Strategic Issue: Five-year watershed cycling strategy. Should the broad strategy of monitoring approximately one fifth of the state each year continue or should the general assessment process be more targeted, allocating more resources (e.g., multiple years) to some areas at the expense of others?
Permit or complaint related intensives have not been coordinated with the cycling strategy.

Strategic Issue: Should we evaluate the same suite of substances monitored in the past or should the list of monitored contaminants be revised? Constituents as requested

Strategic Issue: Can MDE make better use of monitoring data collected under the regulatory/compliance programs to monitor just as effectively at lower cost and/or could some resources be re-allocated by better utilizing data collected under the stormwater permit? Do we need different data management and/or analytical systems to take advantage of these data? Sampling frequency and QA issues may arise using self monitoring data, but these could possibly be addressed in/with permit requirements

Strategic Issue: The entire state has been assessed twice in the last 13 years with respect to non-tidal biomonitoring (MBSS). Should a full scale program continue or should the program become targeted for the purposes of TMDL and implementation monitoring and monitoring for particular projects?

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually?

2) How often are samples collected?

3) What parameters are monitored?

4) Where are samples collected?

5) Is a watershed cycling (or other rotational approach) used?
Permit or complaint related intensives have not been coordinated with the cycling strategy.

6) Why are samples collected?

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?

8) What labs and/or equipment are used for sample collection/analysis?

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?

16) Is the monitoring program meeting its goals (regulatory, use support, resource information)? If the goal is fulfilling request for assistance, yes.
- *How and where should monitoring take place?*
- *Is the level of monitoring correct/appropriate?*
- *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?*

11) Is the monitoring scale proper?
- *Should specific sites or large watershed areas be monitored for restoration activities?*

12) Are the parameters monitored appropriate to meet goals?

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts?

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?

15) Should resources be allocated to better analysis of data?

Drinking Water Supply

Drinking water is monitored as a requirement under the Safe Drinking Water Act. Under the direction of the Water Management Administration (WMA), the Science Services Administration (SSA) routinely collects samples from all public drinking water systems.

Strategic issue: The Department recognizes that there is probably an issue for public health from emerging contaminants, but in the absence of information from EPA on which substances are of greatest concern, and what levels might require action, the Department has neither the resources nor the expertise to institute a monitoring program. PDBEs are the only emerging contaminants routinely monitored (as part of our fish tissue program).

Strategic Issue: Are we adequately monitoring these activities to fulfill regulatory needs and ensure protection of both human health and aquatic life?

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually?
1,200
2) How often are samples collected?
Daily
3) What parameters are monitored?
Chlorine levels, pH, conductivity, VOC, SOC, Radiation, Radon, THM, HAA, IOC, NO3, NO2, Fluoride and Bacteriological.
4) Where are samples collected?
All public drinking water systems (PWS) throughout the State.
5) Is a watershed cycling (or other rotational approach) used?
No
6) Why are samples collected?
To meet the requirements outlined in the EPA's Safe Drinking Water Act and for the protection of public health.

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?

8) What labs and/or equipment are used for sample collection/analysis?
Baltimore, Salisbury and Hagerstown DHMH

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both? Monitoring occurs based on EPA sampling guidelines outlined in the SDWA. Samples are collected from point of entry and within the distribution of a water system.

17) Is the monitoring program meeting its goals (regulatory, use support, resource information)? Yes
- How and where should monitoring take place?Monitoring locations are based on EPA guidelines for various parameters. Monitoring occurs either at the point of entry of the system or within the distribution of the system.
- Is the level of monitoring correct/appropriate?Yes
- Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?N/A

11) Is the monitoring scale proper?
- Should specific sites or large watershed areas be monitored for restoration activities?N/A

12) Are the parameters monitored appropriate to meet goals? Yes

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? Yes

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals? Adequate
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted? Continuous

15) Should resources be allocated to better analysis of data? No

Strategic Issue: Are we adequately monitoring these activities to fulfill regulatory needs and ensure protection of both human health and aquatic life?
WWTP/NPDES discharge monitoring has devolved to periodic sampling for specific constituents such as mercury or PCBs. As emerging contaminants monitoring needs increase, this activity will increase until standards are set and permit limits applied.

Implementation effectiveness monitoring

Significant funding is expended on implementation, but there is relatively little evaluation of the effectiveness of that implementation, either of the practice generally, or of the specific site implementation. Some amount of monitoring is necessary to determine which implementation practices are generally most effective and whether there are certain conditions under which specific practices should not be used.

Strategic Issue: Should progress toward TMDL goals be monitored and quantified by the State? If so, how should that be done, aside from the direct assessment monitoring?
Yes. This is addressed to a large extent with the cyclical monitoring. If listings remain at the eight-digit level, progress towards goals should be addressed at that level as well. While progress towards goals at this scale will be hard to document, small-scale success within the larger watershed could help show progress. To help target implementation activities and follow-up monitoring, the 12-digit basin monitoring results need to be analyzed to find impacted areas suitable for these activities.

Strategic issue: How should the resource allocation to implementation effectiveness monitoring be determined?
This question will be answered better after the next two issues are settled. A major priority is currently underway with the Corsica River Restoration Project. More of this type of project may be in the offing as Trust Fund money moves into use.

Strategic issue: Which practices should be prioritized for evaluation?
Feedback from modelers, practitioners, etc. is essential to identify the state of knowledge pertaining to practices that appear important to restoration efforts. Will the practice return a benefit within a time frame useful to parties that need the information?

Strategic issue: Where and how should that monitoring take place? Should it be for the specific practice/location or at broader scales in small watersheds where a particular practice or set of practices have been implemented? Should practices be tracked by regressing changes in water quality on overall level of implementation in a watershed? Trend analysis
Yes to all with qualifications, if implementation activities cover an entire watershed. If an individual practice at one place is to be implemented, then the monitoring efforts must be focused at that scale. The type of practice has to be considered carefully also.
Is it better to count the number of trees planted in a year versus trying to measure the undetectable change that seedlings produce in a year? If what we want to do is 1) document benefits, and 2) show success stories, then picking the appropriate project is critical. Hunting Lotte Farm (positive results in 1 year) versus German Branch (nothing conclusive after 10 years). Unfortunately the luxury of picking and choosing is rare for a large number of reasons such as timing and access to name two critical ones. Our sources for projects may be limited to those being funded by MDE controlled funds (319, Trust fund). Cultivating other agency and county contacts to keeping us informed of possibilities helps.

Reactive monitoring

Strategic issue: Resources are not allocated for reactive monitoring because the resources needed are unpredictable. When such responses are needed, resources are generally pulled from other programs and neither the cost nor the impact on those other programs area documented. Should this continue? Costs/impacts should be quantified to the best of our ability. Could be informative as to appropriate resource allocation and program direction., budget requests, etc. Reactive monitoring should include requests from other Administrations for assistance i.e. WMA, Hazardous Waste, Oil Spill. While not necessarily emergency issues and generally anticipated, the specific resource commitment is unknown until a request comes down. Some of these are short term/one day affairs, some require 4+ mandays per month, boats etc.

Fish Kill Investigations

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually? (FISH = 40, Algae identification = 50, Harmful algae and toxins = 25, Water for nutrients and man made toxins= 10)

2) How often are samples collected? (Approximately 20 times per month in May through September and four times per month in other months)

3) What parameters are monitored? (Presence and Concentration of algae in Cells/ml. Species composition, size distribution, extent, and magnitude of the kill. Sample depth, Dissolved Oxygen, percent D.O. saturation, pH, Condutivity, Salinity, ORP, Temperature, general appearance and odor of water. Presence, condition and behavior of distressed or dead organisms. Recent weather and GPS coordinates)

4) Where are samples collected? (at locations where fish kills are reported or observed)

5) Is a watershed cycling (or other rotational approach) used? (No)

6) Why are samples collected? (To determine cause, extent and magnitude of fish kills)

7) Do any aspects of the program fit into the 2009 strategic monitoring goals?
By monitoring water quality at fish kill sites and notifying the public of potential contaminants, the MDE fish kill investigation program fits into Goal 1 (protecting public health from environmental contaminants). Goals 2 though 4 (protecting the health and stability of aquatic communities, managing aquatic resources, and determining if water quality/habitat/resources are improving or degrading are also integral to the program

8) What labs and/or equipment are used for sample collection/analysis? (MDE Annapolis Field office, Oxford Cooperative Laboratory for fish histological preparation, UM-COMB for harmful algae and their toxins, DHMH microbiology, and nutrient labs, State Chemists lab at MDA Pesticide Control Section, Annapolis, MDE-Emergency Response Division Infrared Spectorphotometer Lab for HAZMAT identification)

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both? (N/A)

18) Is the monitoring program meeting its goals (regulatory, use support, resource information)?
 - *How and where should monitoring take place?*
 - *Is the level of monitoring correct/appropriate?*
 - *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?* (YES)

11) Is the monitoring scale proper?
 - *Should specific sites or large watershed areas be monitored for restoration activities?* (YES)

12) Are the parameters monitored appropriate to meet goals? (YES)

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? (SUFFICIENT)

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
 - *Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted?* (ADEQUATE)

15) Should resources be allocated to better analysis of data? (NO)

Algae Bloom Response

Additional Questions (Please answer as appropriate)

1) How many samples are collected annually? (ALGAL BLOOM RESPONSE: Approximately 40)

2) How often are samples collected? (ALGAL BLOOM RESPONSE: Upon request. Most sampling takes place between May and September.)

3) What parameters are monitored? (ALGAL BLOOM RESPONSE: Algal Concentration in Cells/ml. Extent of blooms. Complimentary data includes Depth, Dissolved Oxygen, percent D.O. saturation, pH, Condutivity, Salinity, ORP, Temperature, general appearance of water, presence of other organisms such as iron bacteria, sulfur bacteria, other relevant organisms, GPS coordinates)

4) Where are samples collected? (ALGAL BLOOM RESPONSE: All waters of the State)

5) Is a watershed cycling (or other rotational approach) used? (ALGAL BLOOM RESPONSE: NO)

6) Why are samples collected? (ALGAL BLOOM RESPONSE: as above)

7) Do any aspects of the program fit into the 2009 strategic monitoring goals? (ALGAL BLOOM RESPONSE:) By responding to algae blooms early analysis may be performed for potential shellfish bio-accumulation concerns and beach advisories to protect the public Goal 1 (protecting public health from environmental contaminants). The MDE algae-bloom response program also fits into Goals 2 though 4 (protecting the health and stability of aquatic communities, managing aquatic resources, and determining if water quality/habitat/resources are improving or degrading are also integral to the program

8) What labs and/or equipment are used for sample collection/analysis? (ALGAL BLOOM RESPONSE: MDE's Annapolis Field Office, UM-COMB for algal toxin analysis and PCR probe results, ID confirmations occasionally through Md DNR Annapolis Field office and ANSERC-St. Leonards Creek, MD.)

9) Is the monitoring conducted randomly, using fixed locations, or a combination of both?(ALGAL BLOOM RESPONSE: N/A)

10) Is the monitoring program meeting its goals (regulatory, use support, resource information)?

- *How and where should monitoring take place?*
- *Is the level of monitoring correct/appropriate?*
- *Is the priority for monitoring specific restoration practices appropriate and should changes be evaluated by continuous or step-trends?*

(ALGAL BLOOM RESPONSE: YES)

11) Is the monitoring scale proper? (ALGAL BLOOM RESPONSE: YES)

- *Should specific sites or large watershed areas be monitored for restoration activities?* (ALGAL BLOOM RESPONSE: Not at this time.)

12) Are the parameters monitored appropriate to meet goals? (ALGAL BLOOM RESPONSE: Yes)

13) Is the current monitoring effort sufficient, or should the program be updated with newer monitoring/analytical efforts? (ALGAL BLOOM RESPONSE: Advisable updates anticipated for 2008.)

14) Is the monitoring frequency insufficient/adequate/excessive to meet goals?
- Should the monitoring activity be continuous (long-term), less frequent (seasonal), cyclical (biennial) or targeted? (ALGAL BLOOM RESPONSE: Adequate)

15) Should resources be allocated to better analysis of data? (ALGAL BLOOM RESPONSE: Yes, subject of current grant proposal)