

# Nutrient reduction policies and management strategies of the Chesapeake Bay water quality restoration program

C.W. Randall

Department of Civil and Environmental Engineering, Virginia Tech, Blacksburg, VA 24061 USA

**Abstract** The Chesapeake Bay Program is a unique, regional, federal-state-local partnership established in 1983 by a formal Agreement between six signatories, the states of Maryland, Pennsylvania and Virginia, the District of Columbia, the US EPA, and the Chesapeake Bay Commission, to protect and restore the Bay's ecosystem. The system of governance adopted provides for dynamic interaction between the signatories, and provides for input from the interested citizens, the local governments, and the scientific and technical community. The Agreement is periodically reviewed, amended and added to by new agreements, with the most recent being the 2000 Agreement, referred to as "Chesapeake 2000: A Watershed Partnership". The new agreement, signed 28 June 2000, sets numeric goals to be accomplished during the next ten years, and includes land use policies and restrictions.

**Keywords** Chesapeake Bay Program; ecosystem restoration; policies; organizational structure

## Introduction

The Chesapeake Bay is North America's largest, most productive, and most biologically diverse estuary, home to more than 3,600 species of plants, fish and animals, including 295 species of finfish and 45 species of shellfish. It has a watershed area of 165,760 km<sup>2</sup>, one-sixth of the land area of the East Coast of the USA, with a current population in excess of 15 million. The Bay and its tributaries have sustained the region's economy for more than 300 years, and have defined its traditions and culture. It is a resource of extraordinary productivity, worthy of the highest levels of protection and restoration. Accordingly, in 1983 and 1987, the states of Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission and the U.S. Environmental Protection Agency (EPA) signed historic agreements that established the Chesapeake Bay Program partnership to protect and restore the Chesapeake Bay's ecosystem. Amendments to the 1987 Agreement were made in 1992, and the partners reaffirmed their commitment through a renewed agreement in 2000.

## Prologue

One of the major factors contributing to the high productivity of the Chesapeake Bay has been the historical abundance of submerged aquatic vegetation (SAV). The SAV in the Bay include some 20 freshwater and marine species of rooted, flowering plants, which provide food for waterfowl, and critical habitat for shellfish and finfish. SAV also affects nutrient cycling, sediment stability and water turbidity. A baywide decline of all SAV species in the Chesapeake Bay began in the late 1960s and early 1970s. Anoxic (no oxygen) conditions were increasingly observed in the Bay, and fisheries landings showed that there were major declines in most of the harvests.

The water quality and productivity declines of the Bay and its tributaries were investigated in a \$27 million comprehensive study initiated by EPA in 1976, at the direction of the US Congress. The study was completed in 1982 and the final research findings and recommended remedial strategies were published in 1983. The evaluation concluded that major declines in aquatic biota, including fisheries, has occurred for several interrelated

reasons, i.e.: loss of spawning access in the upstream areas, over-harvesting, diseases, loss of habitat, and inputs of toxics and nutrients.

The seven-year study concluded that the primary cause of water quality deterioration was over-fertilization by nitrogen (N) and phosphorus (P) (USEPA, 1982). Large amounts of N and P were stimulating the growth of massive amounts of algae. While alive, the algae blooms block sunlight to underwater grasses. After the algae die and sink to the bottom of the Bay, their consumption by bacteria and fungi consumes much of the dissolved oxygen (DO) in the water, leaving little to no oxygen for other life forms. The reduced conditions that result cause the massive release of nutrients, particularly P, from the sediments, which leads to accumulation of large amounts of dissolved organics in the water, and the stimulation of microbial growths. The growing microbes attach to the SAV leaves and further reduce the amount of sunlight the SAV receives. The circumstances are all the more critical when it is realized that SAV is more sensitive to reduced amounts of sunlight than any other known plant.

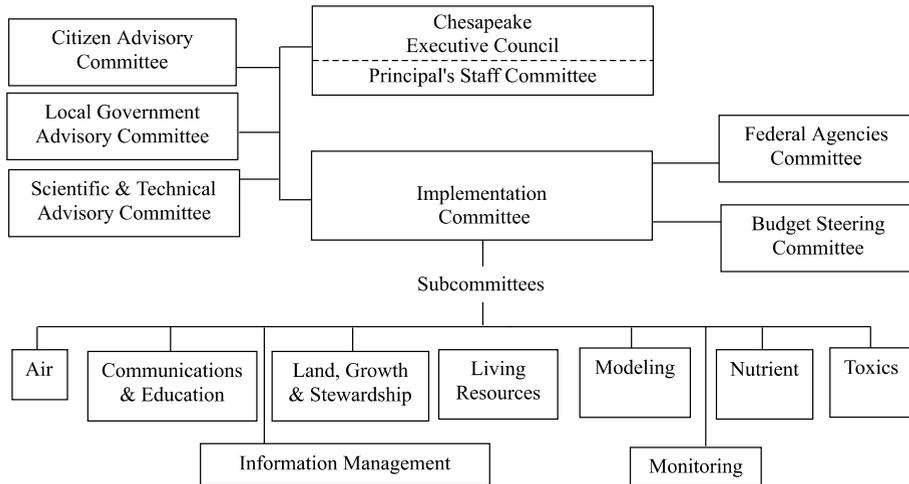
### **The Chesapeake Bay Agreements**

The findings and recommendations of the EPA study formed the foundation for the first Chesapeake Bay Agreement, signed in 1983 by Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission, and EPA, hereafter collectively referred to as the “signatories”. The Chesapeake Bay Commission is a coordinating legislative body specifically developed for the Bay region, and it consists of elected legislators from the three states and the District. The signatories agreed to develop and implement coordinated plans to improve and protect the water quality and living resources of the Chesapeake Bay estuarine system. The 1983 Agreement moved the program out of the research phase and into an action phase by establishing both a management and action structure to resolve Bay issues, and a water quality monitoring program to measure progress. The funding for the Bay Program was established as a line item in the Federal Budget, which is enacted annually by the U.S. Congress for administration by EPA. Because the funds are designated specifically by Congress, they cannot be diverted administratively to other EPA or governmental projects.

#### **The Chesapeake Bay program management structure**

The 1983 Agreement established the major elements of a cooperative structure to develop and coordinate the comprehensive Bay restoration, as illustrated by Figure 1. The Program is a unique, regional, federal-state-local partnership consisting of the six Agreement signatories and the established advisory groups. Effective management of the Bay requires that both its variability and its unity be recognized. The Bay’s water quality needs vary from region to region, as do the controls necessary to support specific regional objectives. Control strategies need to be targeted by geographic area because the Bay and its tributaries are a complex interactive ecosystem. Actions in one part of the Bay watershed may result in water quality degradation and impacts on aquatic ecosystems downstream. Thus, it was necessary for the Bay-wide management structure to have appropriate representation from all regions so that the activities of the Federal, State and local planning and regulatory agencies could be coordinated. The 1983 Agreement did not provide for adequate input from the local areas and this oversight was corrected by the 1987 Agreement, which established the Local Government Advisory Committee (LGAC).

The Executive Council (EC) is the policy-making body for the Program. It consists of the chief executives of the signatories, i.e., the governors of Maryland, Pennsylvania and Virginia, the mayor of Washington, D.C., the administrator of EPA, and the Chairman of the Chesapeake Bay Commission. The EC established a Principal’s Staff Committee (PSC)



**Figure 1** Management structure of the Chesapeake Bay program

to act as policy advisors for the EC. The PSC deliberates the basic policies of the Bay Program, and then develops, conveys and interprets the decisions of the EC to the IC. It also accepts items for EC consideration and approval. The PSC members are directly appointed by the individual EC members, and membership consists of 3 representatives from each state, plus a chair appointed by the EC chair (which rotates), two from EPA, and one each from the District and the Commission.

The IC is the coordinating body of the Program and is responsible for implementing the policy decisions and technical studies mandated by the EC, and for coordinating restoration and protection activities required by the Bay Agreements and their amendments. It has the responsibility of ensuring that appropriate actions are taken to reduce the flow of pollutants to the Bay, and to restore and maintain the Bay's ecological integrity. It is chaired by the Director of the EPA Chesapeake Bay Office (CBO), and has 41 members composed of representatives of the States, the District, the Chesapeake Bay Commission, EPA and other federal agencies, and the chairs of the three advisory committees. The IC has two standing committees, the Budget Steering Committee (BSC) and the Federal Agencies Committee (FAC), and, currently, nine subcommittees. The subcommittee structure is dynamic and the numbers and purposes vary according to need.

The States and the District of Columbia also have established Chesapeake Bay Offices within their environmental regulatory agencies to implement EC and IC decisions and coordinate them with other state and District activities.

The BSC is both a subset and complement to the IC, and is chaired by an EPA official from the Region 3 Office. Its primary role is to assist the IC with work planning and with management of operational budgets for the Program. This includes preparation of annual budget guidance and priorities, review of budget proposals from the subcommittees, advisory committees and others, and making recommendations to the IC for annual spending plans and budget policy considerations. The EPA administers the funds for the Bay Program through the Region 3 Office located at Philadelphia, but the budget is determined by the Budget Steering Committee (BSC). The BSC has 26 members consisting of representatives of all the signatories, the chairs of all of the IC Sub-Committees, and the chairs of the three Advisory Committees.

The federal members of the IC are selected and appointed by the FAC, which coordinates all federal activities related to the Bay Program, and advises EPA, the only federal signatory of the Bay agreements. The FAC is composed of representatives of federal agencies that either own land in the watershed and/or have missions that impact water quality or living resources of the Bay and its tributaries. Fifteen federal agencies have formal agreements with EPA and are partners in the Bay Program, while a total of 21 federal agencies are represented on FAC. Representatives from FAC to the IC are appointed in response to requests from the IC.

The chairs of the IC Subcommittees are all members of both the IC and the BSC. The subcommittee members are selected and appointed by the IC, typically from its own membership, but also by the Advisory Committees, and by the specific subcommittee.

As noted, the 1983 Agreement provided for only two advisory committees, the Citizens Advisory Committee (CAC) and the Scientific and Technical Advisory Committee (STAC). However, the 1987 Agreement established the LGAC to provide local governments with a voice in Program deliberations and decisions, and it is composed of local government representatives from the three states and the District. All three report annually to the EC. The members of the three Advisory Committees initially were appointed by the executive officers of the signatories, and this continues for CAC and LGAC. However, STAC membership subsequently was changed during 1992 to include ex-officio members such as Deans of Agriculture Colleges at the State Universities, Directors of Marine Institutes and Sea Grant Programs, and members selected by STAC, in addition to EC appointees. Currently there are 26 members. The STAC has been particularly instrumental in the development and implementation of nutrient control strategies. Initially formed in 1984, STAC helped unravel the nitrogen and phosphorus limiting nutrient issue and assisted with the pioneering of biological nutrient removal (BNR) wastewater treatment in the Bay region during 1984–86 (STAC, 1986). STAC continuously investigates scientific and technical issues of perceived importance to the Bay Program, both independently and at the request of the IC or one of its Subcommittees. Ad-hoc committees are formed and both workshops and conferences are organized to provide a forum where the leading experts for the issue at hand can meet, define the extent of knowledge, debate potential solutions, and make recommendations. Technical reports, position papers and literature reviews are published and merit reviews of IC Subcommittee activities are provided. Recommendations are conveyed to the IC for consideration and potential action. Recently, Ad-hoc committees and STAC workshops have been used to develop an estimate of the impact of airborne nitrogen on Bay water quality, to evaluate the reliability of the water quality computer model used for Program management decisions, and to develop model input coefficients linking living resources to water quality.

#### **The 1987 Agreement**

The second Chesapeake Bay Agreement was signed in December 1987 (Implementation Committee, 1988). This Agreement expanded the scope of the 1983 Agreement with 29 commitments for action. These commitments outlined steps to be taken in six areas:

1. Living Resources
2. Water Quality
3. Population growth and development
4. Public information, education and participation
5. Public access
6. Governance

The 1987 Agreement established a goal of reducing the overall nutrient inputs to the Bay by 40% by the year 2000, based on the 1985 inputs. Of the many commitments in the 1987

Agreement, the nutrient issue was the only one considered of such significance that it was assigned a numerical goal. On a broader level, this Agreement clearly established that the productivity, diversity and abundance of the estuary's plants and animals (referred to as the living resources) would be used as the ultimate measurement of the Chesapeake Bay's condition and recovery. The 1988 Basinwide Nutrient Reduction Strategy, developed to implement the goals of the 1987 Agreement, addressed both point and nonpoint sources of nutrient inputs. It outlined steps and actions to be implemented to achieve the 40% nutrient input reduction. One of the first actions was the enactment of bans on phosphate-based detergents in each of the States and the District. A second was the establishment of 2 mg/L phosphorus as the maximum effluent concentration for large (>3,785 m<sup>3</sup>/d) wastewater treatment plants throughout the Watershed. Financial incentives were provided for voluntary implementation of agricultural best management plans (BMPs). Another activity was the selection of the Patuxent River Basin as a demonstration project for the nutrient control strategies. This required implementation of nutrient removal at all wastewater treatment plants in the Basin, with effluent requirements of 6 mg/L Total Nitrogen and 1 mg/L Total Phosphorus. The 1987 Agreement focused on the reduction of nutrients to the main body of the Bay.

#### **The 1992 admendments**

The 1987 Chesapeake Bay Agreement was amended in 1992 to expand the control efforts from the main body of the Bay to the tributaries. The 40 percent nutrient reduction goal was reexamined against new and improved information. This review confirmed the 40 percent goal as an achievable target that would indeed result in improved water quality. The resulting 1992 amendments reaffirmed the goal and defined it as a 40 percent reduction of controllable nutrient inputs, i.e., minus those from forested areas. However, it included atmospheric inputs. The amendments directed that specific nutrient reduction goals be set for each of the Bay's major tributaries, and that strategies be developed to achieve these goals as well as protect and improve aquatic habitats in the rivers. Known as the "Tributary Strategies", the Program implementation priorities for 1993–96 were:

1. Meet the nutrient reduction goals through the tributary strategies.
2. Increase stakeholder involvement in the Chesapeake Bay Program, i.e., decisions.
3. Implement habitat restoration projects for key habitat areas.
4. Support fisheries management through inter-jurisdictional cooperation and coordination.
5. Implement critical elements of the Revised Toxics Reduction Strategy.
6. Reinforce federal and state efforts to reduce atmospheric deposition to the Bay and its watershed.

The states established "revolving loan funds" for the upgrading of wastewater plants, and "matching fund construction grants" for BNR implementation. A major emphasis was the reduction of nitrogen inputs to the atmosphere, with the initial focus on reducing power plant emissions. Parallel efforts were made to control agricultural pollution through enactment of stream buffer zones, manure management, erosion control, etc., and these measures were made mandatory in Pennsylvania.

#### **The 2000 Agreement – "Chesapeake 2000: A Watershed Partnership"**

As the year 2000 approached, it became clear that the nutrient reductions would fall short of the 40% reduction goal. The phosphorus reduction goal was within one or two percentage points of achievement, but the nitrogen reduction goal was considerably short of the goal, i.e. 10–20%. It also was recognized that the desired restoration of the living resources would not be complete even with achievement of the 40% nutrient reductions, and that a

renewed commitment was needed to continue the progress and focus of the Program. Therefore, a new agreement was developed during 1999, and distributed for public comment during early 2000. Known as “Chesapeake 2000: A Watershed Partnership”, to emphasise the comprehensive nature of the agreement, it was signed by the EC on June 28, 2000. Chesapeake 2000 is designed to build on the Bay Program’s accomplishments and commitments as outlined in previous Bay Agreements and its own directives. The primary goal of the new agreement is to improve water quality sufficiently to sustain the living resources of the Chesapeake Bay and its tidal tributaries, and to maintain that water quality into the future. Specific restoration commitments and a timeframe for their accomplishment were established by the Agreement. It establishes regional standards for Bay restoration for the next 10 years, including new guidelines to protect open space and curtail sprawl along the Bay.

The 2000 Agreement establishes goals in five areas:

1. Living Resource Protection and Restoration
2. Vital Habitat Protection and Restoration
3. Water Quality Restoration and Protection
4. Sound Land Use
5. Individual Responsibility and Community Engagement

Specific Restoration Commitments and goals include:

1. A goal to increase the number of oysters tenfold by 2010.
2. Improve water quality sufficiently so that the Bay and its tidal rivers will be removed from EPA’s list of “impaired waters” by 2010.
3. A review of current tax policies to create tax incentives that encourage sound land use.
4. Eliminate elements that discourage “sustainable development”.
5. Set goals for wetlands restoration and protection.
6. Establish “No Discharge” zones for boat waste.
7. Redevelop 1,050 abandoned industrial sites (brownfields) by 2010.
8. A goal to expand public access points 30% by 2010.
9. A recommitment to increase underwater grasses (SAV) area to 46,136 hectares.
10. Improve water quality protection for freshwater streams and rivers.

### **Monitoring and assessment methods**

An ambitious monitoring program was established in 1985 under the supervision of the Monitoring Subcommittee of the IC, and it is continuously evaluated and periodically revised and expanded by that subcommittee, with oversight by STAC and the IC. The freshwater tributary streams are monitored by flow and water quality measurements at the fall line of each river. The main stem of the Bay has designated monitoring sites that are periodically occupied by ships from the Bay’s marine institutes, and air sampling sites are located at selected locations in the Bay area. All data collection efforts related to the Program are coordinated by the Monitoring Subcommittee, and must conform to established sampling and analysis quality assurance standards. The results are analyzed and integrated to provide information for management decisions, and made available throughout the Bay community via the internet.

A major component of the restoration strategy has been the development and use of computer models to assist the development of management decisions. Both hydrodynamic and water quality computer models were developed for the Bay during the early days of the Program to assist management decisions. Initially, a 2-D model was developed to estimate the water quality benefits likely to accrue from varying reductions in nutrient inputs. The 2-D model was replaced by a 3-D model built on three sub-models: a hydrodynamic model, a sediment model and an improved water quality model. The combined model is maintained

at the U.S. Army Corps of Engineers Experiment Station, Vicksburg, Mississippi. The combined model was calibrated using monitoring data, and used to gain better insight into the impacts of nutrients in different segments of the Bay, and to predict potential water quality improvements from differing levels of control strategies. The results were used to develop nutrient reduction strategies for consideration by the EC. More recently, a watershed model has been developed and linked to the combined 3-D model, and on-going efforts are linking water quality to living resources so that the combined model can be used to predict the impact of different levels of control strategies on desirable living resources.

### Population growth

The number one threat to the continued recovery of the Bay water quality and living resources is the continuing population increase within the watershed, particularly in the immediate vicinity of the Bay shores. In 1950, the watershed had a population of 8.4 million residents. By 1990 the population had increased to 14.7 million, and it is projected that more than 18 million will be resident by 2020. Most of this growth is taking place in Maryland and Virginia, near tidal tributaries of the Bay and in suburban areas. This growing population requires land for homes, transportation, shops, agriculture, jobs and recreation, often at the expense of forested or environmentally sensitive lands. Unplanned and unregulated, it will result in adverse environmental impacts that will degrade the quality of life of the human population as well as that of the living resources of the Bay. The 2000 Agreement is an effort to control the sprawl, pollution and other detrimental environmental effects that can result from this population growth. It has already been resolved that nutrient discharges from wastewater treatment plants will be capped at the 40% reduction level relative to 1985 discharges. This means that increased flows will require more stringent treatment requirements.

### Conclusions

1. The dynamic organizational structure of the Chesapeake Bay Program has proven to be successful for implementation of multi-jurisdictional water quality improvement and living resources restoration activities.
2. The establishment of numerical goals is necessary to focus implementation activities and obtain timely commitment of resources.
3. The development and utilization of a 3-D water quality computer model to provide guidance for management decisions has been both essential and successful. However, periodic independent evaluation of the model is needed to ensure reliability.
4. Considerable restoration progress has been made, but constant improvement and vigilance is necessary. The number one threat to continued improvement of Bay water quality and restoration of the living resources is the increase of population within the Watershed.
5. Land use management must become part of the overall restoration and protection strategy for the Program goals to be achieved.

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C. W. Randall