Use Attainability Analysis for tidal waters of the Chesapeake Bay Mainstem and its tidal tributaries located in the State of Maryland.

Preamble

In April 2003, the U.S. Environmental Protection Agency (EPA) Region III issued guidance entitled *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries* (*Regional Criteria Guidance*). The development of the *Regional Criteria Guidance* was the realization of a key commitment in the *Chesapeake 2000* agreement. In that agreement, the signatories (the states of Pennsylvania, Maryland and Virginia; the District of Columbia; the Chesapeake Bay Commission and the EPA) committed to, "by 2001, define the water quality conditions necessary to protect aquatic living resources." New York Delaware and West Virginia agreed to the same commitment through a separate six-state memorandum of understanding with the EPA.

The EPA, in the *Regional Criteria Guidance*, defined the water quality conditions called for in the *Chesapeake 2000* agreement through the development of Chesapeake Bay-specific water quality criteria for dissolved oxygen, water clarity and chlorophyll *a*. The EPA also identified and described five habitats, or designated uses, that provide the context in which the EPA Region III derived adequately protective Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll *a*. Collectively, the three water quality conditions provide the best and most direct measures of the effects of too much nutrient and sediment pollution on the Bay's aquatic living resources—fish, crabs, oysters, their prey species and underwater bay grasses. These criteria were developed as part of a larger effort to restore Chesapeake Bay water quality.

The Maryland Department of the Environment, as a partner working in good faith to fulfill the goals of the *Chesapeake 2000* agreement, is currently in the process of promulgating the new Chesapeake Bay water quality standards to protect the Bay's aquatic living resources within the State of Maryland. This Use Attainability Analysis was developed by the Department to be a companion to the new Chesapeake Bay water quality standards (COMAR 26.08.01.01, 26.08.02.02, 26.08.02.03-3, and 26.08.08.08). This analysis describes the development and geographical extent of the designated uses to which the water quality criteria may apply, and as such serves as a resource to the State and its citizens to assist them in the monitoring, assessment, and protection of the Bays' resources.

The Use Attainability Analysis is not law or regulation; it is an assessment of the attainability of the current Bay water quality standards as well as the newly proposed water quality standards.

EXECUTIVE SUMMARY

In May 2003, the U.S. Environmental Protection Agency (EPA) Region III issued guidance entitled *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries (Regional Criteria Guidance)*. The EPA developed this guidance to achieve and maintain the water quality conditions necessary to protect aquatic living resources of the Chesapeake Bay and its tidal tributaries. The *Regional Criteria Guidance* is intended to assist the Chesapeake Bay jurisdictions—Maryland, Virginia, Delaware and the District of Columbia—in adopting revised water quality standards to address nutrient and sediment-based pollution in the Chesapeake Bay and its tidal tributaries. Part of the jurisdictions' water quality standards development process may be to conduct use attainability analyses (UAAs). The EPA also developed the *Technical Support Document for Identifying Chesapeake Bay Designated Uses and Attainability* (*Technical Support Document*) to assist states in developing their individual UAAs.

The UAA process is traditionally conducted by individual states. This UAA document provides the technical background information for the Maryland UAA. This UAA documents why the current designated uses for aquatic life protection cannot be attained in all parts of Maryland's Chesapeake Bay and the associated tidal tributaries. It provides scientific data showing that natural and human-caused conditions that cannot be remedied are the basis for the non-attainment and proposes refined designated uses that Maryland has considered for the current water quality standards development and adoption processes. The document also provides scientific data indicating that the refined designated uses are attainable in most of Maryland's Chesapeake Bay segments and documents that the refined designated uses protect existing aquatic life uses. Finally, this UAA briefly summarizes economic analyses based on implementation of Maryland's Tributary Strategies, including estimates of the cost of implementation of the appropriate control scenarios.

INTRODUCTION TO USE ATTAINABILITY ANALYSIS

The Water Quality Standards Regulation (40 CFR 131.3) defines a UAA as "…a structured scientific assessment of the factors affecting the attainment of a use which may include physical, chemical, biological, and economic factors…" (40 CFR 131.10[g]). The Water Quality Standards Regulation requires a state to conduct a UAA when it designates uses that do not include those specified in Section 101(1)(2) of the Federal Water Pollution Control Act.[1] A state must also conduct a UAA when it wishes to remove a specified designated use of the Federal Water Pollution Control Act or adopt subcategories of those specified uses that require less stringent criteria.

When conducting a UAA, a state must demonstrate that attaining the designated use is not feasible due to one or more of six factors specified in Section 131.10(g) of the Water Quality Standards Regulation. These factors are:

1. Naturally occurring pollutant concentrations prevent the attainment of the use;
2. Natural, ephemeral, intermittent, or low-flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of a sufficient volume of effluent without violating state water conservation requirements to enable uses to be met;
3. Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place;
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modifications in a way that would result in the attainment of the use;
5. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles and the like, unrelated to chemical water quality, preclude attainment of aquatic life protection uses; and
6. Controls more stringent than those required by sections 301(b)(1)(A) and (B) and 306 of the Act would result in substantial and widespread economic and social impacts.

The Water Quality Standards Regulation also specifies that any change in designated uses must show that the existing uses are still being protected. The EPA's 1983 *Water Quality Standards Handbook* provides two definitions for an existing use. First, an existing use can be defined as fishing, swimming or other uses that have actually occurred since November 28, 1975. The second definition of an existing use is that the water quality of a water body is suitable to allow the use to be attained—unless there are physical problems, such as substrate or flow, that prevent use attainment. The Water Quality Standards Regulation, in turn, requires state anti-degradation policies to protect existing water quality. Therefore, any recommendations regarding refined designated uses for Maryland portions of the Chesapeake Bay and its tidal tributaries must ensure that existing aquatic life uses continue to be protected.

ATTAINABILITY OF MARYLAND'S CURRENT WATER QUALITY STANDARDS

Maryland's current water quality standards for the Chesapeake Bay include aquatic life use, commercial shellfish harvest, and water contact recreation uses. To protect the aquatic life uses in the Bay and its tidal tributaries, Maryland adopted a dissolved oxygen criteria of 5 mg/L applied year-round throughout all tidally influenced waters. In 1987, the Bay Program partners set a 40 percent loading reduction goal for "controllable" nitrogen and phosphorus to improve low oxygen conditions in the deep trench of the mainstem Bay. This translated into an actual basinwide nitrogen goal of 20 percent reduction of the controllable nitrogen load, while the basinwide phosphorus goal was about a 31 percent reduction from a 1985 baseline. Caps on nitrogen and phosphorus loads were established through the 1992 Amendments to the Chesapeake Bay Agreement and were allocated to each of the 10 major tributary basins in Maryland. The State developed tributary strategies that laid out schedules for taking the specific reduction actions needed to achieve these loading goals. In 1996, Maryland listed all portions of the Chesapeake Bay and most of its tidal tributaries were listed as impaired by nutrients or sediment on the States' 303(d) list. With the signing of the Chesapeake 2000 Agreement, Maryland and the other Chesapeake Bay Program partners have committed to go beyond setting new loading caps for nutrient and sediment and developing local stakeholder-based implementation plans. They have committed to "correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters (303(d) list) under the Clean Water Act."

To avoid potential negative impacts that a regulatory TMDL process might have on the successful, cooperative efforts being used by the states' tributary strategy programs, the Chesapeake 2000 Agreement lays out a series of commitments directed towards seeking a cooperative solution to restoring Bay water quality. An important initial commitment was defining the water quality conditions necessary to support Bay living resources–fish, crabs, oyster, Bay grasses in 2003 (EPA, 2003). Also, the Bay State partners (DE, MD, VA, and the District of Columbia) agreed to adopt the new water quality standards by 2005.

As part of the new Bay water quality standards adoption process, an analysis of the feasibility of attainment of the current water quality standards must be performed. This is the first step in the UAA process. The determination of non-attainability of the current water quality standards in the Chesapeake Bay and its tidal tributaries is based on three of the six 40 CFR 131 (10)(g) factors noted above— (1) natural factors, (2) human-caused conditions that cannot be remedied, and (3) hydrologic modification (Patapsco River Navigation channels). Output from model-simulated attainment scenarios, TMDL model scenarios for the Patapsco River, and the paleoecological record of the Chesapeake Bay ecosystem provide evidence that these conditions prevent attainment of current designated uses.

To understand the overall feasibility of attaining **current** designated uses in the Chesapeake Bay and its tidal tributaries, the Chesapeake Bay Program analyzed three scenarios: 'all-forest,' 'pristine' and 'everything, everywhere by everyone,' or the E3 scenario. The first two scenarios are the best representations of pre- European settlement conditions (to capture natural pollutant levels). The third scenario (E3) represents the boundary of what is considered physically implausible by Maryland and other State partners for reducing nutrient and sediment pollution. The results of these modeling scenarios demonstrate that even under pristine conditions, the 5 mg/L dissolved oxygen criteria is not attained in the deep channel and deep water (approximately 3% and 1% Baywide, respectively) during the summer months. For the E3 scenario, 59 percent, 23 percent and 2 percent non-attainment are exhibited in the deep-channel, deep-water and open-water areas, respectively, even after implementation of nutrient reduction measures that represent limits of technology.

During the past decade, paleoecological studies of the Chesapeake Bay's late Holocene dissolved oxygen record have been carried out using several proxies of past dissolved oxygen conditions, which are preserved in sediment cores that have been dated using the most advanced geochronological methods. These studies, using various indicators of past dissolved oxygen conditions, are reviewed in Cronin and Vann (2003) and provide information that puts the monitoring record of the modern Chesapeake Bay into a long-term perspective and permits an evaluation of natural variability in the context of restoration targets. Several major themes emerge from the time period studied.

The 20^{th} century sedimentary record confirms the limited monitoring record of dissolved oxygen, documenting that there has been a progressive decrease in dissolved oxygen levels, including the periods of extensive anoxia in the deep-channel region of the Chesapeake Bay that have been prominent during the past 40 years. Most studies provide strong evidence that there was a greater frequency or duration of seasonal anoxia beginning in the late 1930s and 1940s and again around 1970, reaching unprecedented frequencies or duration in the past few decades in the mesohaline Chesapeake Bay and the lower reaches of several tidal tributaries (Zimmerman and Canuel 2000; Hagy 2002).

Extensive late 18^{th} and 19^{th} century land clearance also led to oxygen reduction and hypoxia, which exceeded levels characteristic of the previous 2,000 years. Best estimates for deep-channel mid-bay seasonal oxygen minima from 1750 to around 1950 are 0.3 to 1.4-2.8 mg/l and are based on a shift to dinoflagellate cyst assemblages of species tolerant of low dissolved oxygen conditions. These patterns are likely the result of increased sediment influx and nitrogen and phosphorous runoff due to extensive land clearance and agriculture.

Before the 17^{th} century (pre-settlement), dissolved oxygen proxy data suggest that dissolved oxygen levels in the deep channel of the Chesapeake Bay varied over decadal and inter-annual time scales. These paleo-dissolved oxygen reconstructions are consistent with the Chesapeake Bay's natural tendency to experience seasonal oxygen reductions due to its bathymetry, freshwater-driven salinity stratification, high primary productivity and organic matter and nutrient regeneration (Boicourt 1992; Malone 1992; Boynton et al. 1995).

The combined results of the E3, all-forest and pristine scenarios along with the scientific conclusions from the paleoecological record, strongly indicate that current Maryland aquatic life designated uses cannot be achieved in the Chesapeake Bay's and tidal tributaries' deep-water and deep-channel habitats where natural physical processes and bottom bathymetry-related barriers prevent oxygen replenishment. Natural conditions, as well as human-caused conditions that cannot be remedied have caused the trend towards hypoxia and most recently (especially after the 1960s) anoxia in the main channel of the Chesapeake Bay and some of its larger tidal tributaries. The impact of these patterns has been observed in large-scale changes in benthos and phytoplankton communities, which are manifestations of habitat loss and degradation.

DEVELOPMENT OF THE REFINED DESIGNATED USES

Current designated uses for the Chesapeake Bay and its tidal tributaries do not fully reflect natural conditions and are too broad in their definition of use to support the adoption of more habitat-specific aquatic life water quality criteria. The current uses also change across jurisdictional borders within the same water body. Therefore, the first step in this process was to derive attainable designated uses that protect current and existing uses and propose criteria to protect those uses Baywide. In refining the tidal-water designated uses, the six Bay watershed states and the District of Columbia considered five principal factors:

- Habitats used in common by sets of species and during particular life stages should be delineated as separate designated uses;
- Natural variations in water quality should be accounted for by the designated uses;
- Seasonal uses of different habitats should be factored into the designated uses;
- The Chesapeake Bay criteria for dissolved oxygen, water clarity and chlorophyll *a* should be tailored to support each designated use; and
- The refined designated uses applied to the Chesapeake Bay and its tidal tributary waters will support the federal Clean Water Act goals and state goals for aquatic life uses existing in these waters since 1975.

The five refined designated uses reflect the habitats of an array of recreationally, commercially and ecologically important species and biological communities. The vertical and horizontal extent of the designated use boundaries are based on a combination of natural factors, historical records, physical features, hydrology, bathymetry and other scientific considerations.

> The *migratory fish spawning and nursery designated use* protects migratory and resident tidal freshwater fish during the late winter to late spring spawning and nursery season in tidal freshwater to low-salinity habitats. Located primarily in the upper reaches of many Bay tidal rivers and creeks and the upper mainstem Chesapeake Bay, this use will benefit several species including striped bass, perch, shad, herring, sturgeon and largemouth bass.
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> The *shallow-water bay grass designated use* protects underwater bay grasses and the many fish and crab species that depend on the vegetated shallow-water habitat provided by underwater grass beds.

The *open-water fish and shellfish designated use* focuses on surface water habitats in tidal creeks, rivers, embayments and the mainstem Chesapeake Bay and protects diverse populations of sport fish, including striped bass, bluefish, mackerel and sea trout, as well as important bait fish such as menhaden and silversides.

The *deep-water seasonal fish and shellfish designated use* protects animals inhabiting the deeper transitional water-column and bottom habitats between the well-mixed surface waters and the very deep channels. This use protects many bottom-feeding fish, crabs and oysters, and other important species such as the bay anchovy.

The *deep-channel seasonal refuge designated use* protects bottom sediment-dwelling worms and small clams that bottom-feeding fish and crabs consume. It also protects the meiofaunal community important to biogeochemical cycling processes in the bottom sediments. Low to occasional no dissolved oxygen conditions occur in this habitat zone during the summer.

ATTAINABILITY OF REFINED DESIGNATED USES

The Chesapeake Bay Program assessed attainability for the refined designated uses based on dissolved oxygen for the migratory and spawning, open-water, deep-water and deep-channel designated uses. Attainability for the shallow-water designated use was assessed based on historic and recent data on the existence of underwater bay grass acreage. The Chesapeake Bay Program did not assess attainability for the chlorophyll *a* criteria, which applies to the open-water designated use, because this criteria is expressed in narrative terms and does not provide a numeric value around which to perform attainability analyses.

For the refined designated uses to which the dissolved oxygen criteria apply, the Chesapeake Bay Program evaluated attainability by comparing the modeled water quality response to a series of technology-based nutrient reduction scenarios. This series of scenarios was developed to represent the watershed's nutrient and sediment reduction potential in terms of the types, extent of implementation and performance of best management practices (BMPs), wastewater treatment technologies and storm water controls. These scenarios range from Tier 1, which represents the current level of implementation plus regulatory requirements implemented through 2010, to a theoretical limit-of-technology scenario referred to previously as the "E3" scenario ("everything, everywhere by everybody"). Tier 2 and Tier 3 are intermediate scenarios between Tier 1 and the E3 scenario. These tiers are artificial constructs of technological levels of effort and do not represent the actual programs that jurisdictions will eventually implement to meet the water quality standards. Rather, the state is using the tiers developed by the Chesapeake Bay Program as an assessment tool to determine potential load reductions achievable by various levels of technological effort, and to model water quality responses to controls. Tier 3 level of effort scenarios have been adopted as the starting point for the implementation of Maryland's Tributary Strategies. More recent and precise work has indicated that a level of effort beyond Tier 3 will be necessary to achieve water quality standards.

The Chesapeake Bay Program used the Chesapeake Bay Watershed and Water Quality Models to determine the water quality response to the pollutant reductions in each scenario (Appendix 1) and then compared these modeled water quality observations within the five refined designated uses to determine the spatial and temporal extent of non-attainment with the respective dissolved oxygen criteria. Specifically, comparison of model results for dissolved oxygen were made to a monthly average dissolved oxygen concentration of 6 mg/l for the migratory and spawning use, 5 mg/l for the open-water use, 3 mg/l for the deep-water use and 1 mg/l for the deep-channel use.

ATTAINMENT OF PROPOSED DISSOLVED OXYGEN CRITERIA

Migratory Spawning & Nursery Designated Use: Current monitoring data and Chesapeake Bay Water Quality Model outputs indicate that the migratory and spawning designated use is essentially being attained in the Chesapeake Bay and its tidal tributaries for dissolved oxygen. The few segments that are not fully attaining the dissolved oxygen criterion would fully attain this use in the Tier 1 scenario (lowest level of control technologies).

Open Water Designated Use: Appendix 1 provides the results of the attainability analysis for dissolved oxygen for the open-water (including shallow-water), deep-water and deep-channel designated uses, by Chesapeake Bay Program segment. As Appendix 1 illustrates, current monitoring data (presented under the ‘observed’ column) indicate that the open-water designated use (OW under the DU column) is frequently not fully attained. However, under the “New Confirm” column attainment is more frequent and non-attainment achieves a much smaller magnitude. Non-attainment of 1 percent or less is considered attainable due to natural variability, anticipation of reduced phosphorus flux as a result of greater oxygenation and reduced pollution inputs, and various uncertainties in the models and current load measurements.

Deep Water, & Deep Channel Designated Uses: For the deep-water designated use for dissolved oxygen criteria, very little attainment is achieved based on current monitoring data and existing implementation, and only some degree of attainment is seen at reduction levels equivalent to Tier 2. At the reduction levels represented by the E3 scenario, attainment is achieved for all segments of the Chesapeake Bay except for two: the Patapsco River mesohaline (PATMH), and the middle central Chesapeake Bay (CB4MH). Appendix 1 also illustrates that under observed conditions, the proposed dissolved oxygen criteria are not attained for the deep-channel designated use. With increasing load reductions, represented by Tier 3, percent non-attainment is primarily less than 2 percent, except in the man-made navigation channels serving the Port of Baltimore in PATMH. Due to significant non-attainment (77% when point sources are at E3) resulting from Federally-authorized hydrologic modification (see Appendix 3) and complex circulation patterns that move hypoxic and anoxic waters from the Bay’s main channel into the Patapsco through advection, the State has determined that further refinement of the designated use to preclude aquatic life use during the seasonal application period of June 1 to September 30 was necessary. Therefore, the State has proposed a “Navigation Channel” designated use subcategory with the applicable D.O. criteria being 0 mg/L from June 1 to September 30 inclusive.

ATTAINMENT OF PROPOSED WATER CLARITY CRITERIA

Shallow Water Bay Grass Designated Use: Attainability for the shallow-water bay grass designated use is based on historic and recent data on the distribution of underwater bay grasses. Detailed analyses using this data—including historical aerial photographs—were undertaken to map the distribution and depth of historical underwater bay grass beds in the Chesapeake Bay and its tidal tributaries. These analyses led to the adoption of the single best year method that considers historical underwater bay grass distributions from the 1930s through the early 1970s as well as more recent distributions since 1978 to present. Using this method, the Chesapeake Bay Program and its watershed partners established a baywide underwater bay grass restoration goal of 185,000 acres. Because of limitations associated with mapping underwater bay grasses using historical photography, the estimate of past underwater bay grass distributions is conservative. Therefore, the restoration goals for the Bay and its tidal tributaries (See Appendix) is conservative as well and considered attainable.

CONFIRMATION THAT EXISTING USES ARE MET

In establishing the refined designated uses, Maryland and the state partners in collaboration with the Chesapeake Bay Program, took explicit steps in developing the requirements and boundaries to ensure that existing aquatic life uses would continue to be protected as the EPA water quality standards regulation require. For some refined designated uses—the migratory fish spawning and nursery, the deep-water and the deep-channel—the application of new dissolved oxygen criteria will result in improvements to existing water quality conditions. The refined open-water fish and shellfish designated use dissolved oxygen criteria will continue to provide an equal level of protection as the current state water quality standards afford to the same tidal waters. The refined shallow-water bay grass designated use ensures protection of existing underwater bay grass-related uses because the single best year method is based on historical (1930s through the early 1970s) and more recent (1978–present) underwater bay grass distributions. This method goes beyond the requirements of the federal clean water act that states that existing uses are those uses that actually occurred on or after November 28, 1975.

ECONOMIC ANALYSES

The *Technical Support Document* summarizes three types of economic analyses that the Chesapeake Bay Program performed in conjunction with developing revised water quality criteria, designated uses and boundaries for those uses in the Chesapeake Bay and its tidal waters. An analysis was undertaken to estimate the costs of implementing the hypothetical control scenarios (represented by the Tier 1-3 scenarios). Maryland has performed the same types of economic analyses on the Maryland Tributary Strategies Program, the “Tier 3” implementation plan for meeting the new Bay water quality standards. The Bay program also conducted screening-level analyses to rule out areas that would not experience substantial and widespread economic and social impacts if states implemented controls more stringent than those required by sections 301 and 306 of the Clean Water Act. The results of analyses to model regional economic impacts are also summarized in the *Technical Support Document.*

Cost

The projected total (capital and operating) costs are approximately $10 billion through 2010. This is predicated on a statewide evaluation of the sewage treatment upgrades and best management practice implementation levels necessary to attain the water quality standards in the Bay and tidal tributaries. Implementation measures were used to achieve water quality standards with consideration of cost, cost effectiveness, feasibility, and minimization of undesired impacts such as sprawl. The costs can be broken out into the broad categories of agricultural best management practices, urban best management practices, sprawl and septic systems, and point sources. There is considerable uncertainty about the cost estimates in each category, particularly for urban best management practices and sprawl and septic systems; consequently there is considerable uncertainty about the total cost. There is additional uncertainty about the effectiveness of the BMPs and therefore the level of implementation that will actually be needed. Nevertheless, after considerable review by State program staff, EPA and contractors, this is the best estimate possible at the current time. It is anticipated that as innovative and more effective management practices are developed, the implementation will evolve and change the costs.

A reevaluation of the water quality benefits that can be achieved is scheduled for 2007 and will incorporate a revised watershed model, a refined water quality model, better estimates of best management practice efficiency, and the incorporation of best management practices not currently included in the watershed model. This will likely modify the required implementation levels and therefore the costs.

Economic impact

The relevance of the economic impact of achieving water quality standards to the Use Attainability Analysis is dependent on several factors:

- Whether the costs that will be incurred to meet water quality standards are mandatory or can be incurred as funds become available,

- Whether the costs result from an administrative decision such as a permit or result from legislative action such as the Bay Restoration Fund, and
- As a corollary, whether the costs result from the regulatory promulgation of these water quality standards or would be incurred even if this action didn't take place.

Costs are mandatory for only two components: point sources and urban best management practices. If the costs are not mandatory, e.g., because there are no direct regulatory controls, then economic impact is not relevant to the UAA because the costs and therefore the impact are only incurred on a cooperative basis. It has generally been accepted among the local governments and tributary teams, that where no regulatory requirement exists, implementation will be dependent on providing funding and other incentives. However, without a requirement, the economic impact will be only that which is accepted by the public or provided by funding agencies. Those costs will be spread nationally in the case of federal funding, resulting in a minimal impact or one absorbed into existing programs. In the case of State funding, they will be legislatively directed as a general policy decision, absorbed within existing programs, or will not occur. In any of these cases, the impact will either be acceptable or not result immediately from the implementation of the water quality standards.

For point sources, the Maryland General Assembly has acted prior to the promulgation of the water quality standards, thus promulgation of the standards cannot be the direct cause of any costs incurred for the Bay Restoration Fund. Further, the General Assembly has effectively determined that the costs are not prohibitive by passing Governor Ehrlich's legislation. This provides the funds necessary to leverage bond issuance that will cover the full costs of enhanced nutrient removal at major wastewater treatment plants. The Fund also provides for a significant amount of cover crops, a very cost effective agricultural best management practice, as well as installation of denitrifying septic systems in the critical area, where the benefit of such systems to the Bay will be greatest.

Although implementation of urban best management practices is required, it is required under the NPDES permit system and costs would be incurred regardless of this change in water quality standards. Further, at this time the permits are technology-based, not water quality-based, and therefore not dependent on this regulatory action. The costs of implementation of the National Pollutant Discharge Elimination Systems (NPDES) municipal separate storm sewer system (MS4) permits vary from jurisdiction to jurisdiction, as does the economic impact, because economic factors (i.e., number of households and median household income) and costs vary from jurisdiction to jurisdiction. If there are significant and widespread impacts for stormwater permits they need to be addressed as part of the permit conditions, not at the water quality standards level since the standards will still have general applicability, even if this creates a problem in a particular jurisdiction. In such a case, the issue will be handled at the jurisdiction level.

Finally, the costs for agricultural best management practices cannot be compelled under existing regulations or permit requirements, and it has been generally agreed that implementation will occur as funds are made available. If the funds are actually available, then it is implicit that the economic hardship was not significant and widespread. Further, the Water Quality Improvement Act of 1998 in combination with the Bay Restoration Act funding for cover crops, were both passed prior to this promulgation, and therefore the water quality standards promulgation can be the cause of the costs.

ECONOMIC BENEFITS OF IMPROVED WATER QUALITY

As stated previously, when evaluating use attainability, states may consider whether controls more stringent than those required by sections 30l(b)(l)(A) and (B) and 306 of the Clean Water Act would result in substantial and widespread economic and social impacts. Estimating potential economic benefits also is integral to understanding the economic impacts of improving water quality in the Chesapeake Bay and its tidal tributaries To estimate the potential economic benefits of restoring Chesapeake Bay water quality, a regional forecasting model developed by Regional Economic Modeling, Inc. (REMI), and an economic impact model (IMPLAN) from the Minnesota IMPLAN Group was used. The IMPLAN model indicates that the Tier 3 scenario would result in a net increase in output, employment, and value-added in the six Chesapeake Bay watershed states and the District of Columbia. In addition, the REMI model forecasts that gross regional product in the State of Maryland will grow by 37 percent by 2010, corresponding to 19 percent growth in employment and 17 percent growth in real disposable personal income. This estimated growth is not accounted for in the IMPLAN results (which are based on current economic conditions). The economic stimulus from Tier 3 results from increased spending in high-wage industries (e.g., wastewater treatment technologies) as well as an influx of funds for pollution controls (e.g., federal cost shares for agricultural BMPs); additional market benefits likely to result from improved water quality (e.g., commercial and recreational fishing industries) are not included. Therefore, the regional economy should expand as a result of the tier scenarios.

Although no comprehensive estimate of the benefits from nutrient and sediment reduction actions in the Chesapeake Bay watershed is available, data suggest that the Chesapeake Bay affects industries that generate approximately $20 billion and 340,000 jobs (including commercial fishing, boat building and repair and tourism). Tourism, as a composite industry, represents the 14th largest source of output, and the 8th largest source of employment, in the Chesapeake Bay watershed. It is not clear the extent to which each of these sectors relies on Chesapeake Bay water quality; however, participation rates and expenditures on recreational fishing suggest that a significant percentage of tourism output is likely linked to the quality of water bodies such as the Chesapeake Bay. For example, the U.S. Fish and Wildlife Service’s 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation reports annual expenditures by fishermen of $1,261 million, and 1,859,000 fishing participants, in the states of Maryland, Virginia and Delaware.

Available studies of benefits include Bockstael et al. (1989), which estimate the total value of 20 percent improvement in nitrogen and phosphorous concentrations in the Chesapeake Bay to be $17 million to $76 million in 1996 dollars. Similarly, Krupnick (1988) estimated the total value of a 40 percent improvement in nitrogen and phosphorus concentrations at $43 million to $123 million (in 1996 dollars).

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Appendix 1: Chesapeake Bay Program Attainment Table. MIG=Migratory and Spawning Use, OW=Open Water Use, DW=Deep Water Use, DC=Deep Channel Use. New confirmation run results are used to make attainment estimate. A=fully attained at nutrient allocation. Proportion = proportion of time and volume not in attainment. Less than 0.01 (1%) within margin of error and not considered significant, greater than 1% treated by variance in the designated uses section.

Table 1- Key Scenarios- Summary of Dissolved Oxygen Criteria Attainment*

Segment	Segment		DU	Observed	New Confirm
Mainstem Upper Bay (CB1TF)	CB1TF	CB1TF	MIG	A	A
	CB1TF	CB1TF	OW	A	A
Mainstem Upper Bay (CB2OH)	CB2OH	CB2OH	MIG	A	A
	CB2OH	CB2OH	OW	1.92	0.09
Mainstem Upper Bay (CB3MH)	CB3MH	CB3MH	MIG	0.19	A
	CB3MH	CB3MH	OW	A	A
		CB3MH	DW	4.18	0.46
		CB3MH	DC	13.52	0.40
Mainstem Mid-Bay (CB4MH)	CB4MH	CB4MH	OW	0.05	A
		CB4MH	DW	19.64	6.99
		CB4MH	DC	45.19	1.75
Mainstem Mid-Bay (CB5MH)	CB5MH	CB5MH	OW	A	A
		CB5MH	DW	6.16	0.86
		CB5MH	DC	13.79	0.08
Patuxent Tidal Fresh (PAXTF)	PAXTF	PAXTF	MIG	A	A
	PAXTF	PAXTF	OW	A	A
Patuxent Mid-Estuary (PAXOH)	PAXOH	PAXOH	MIG	A	A
	PAXOH	PAXOH	OW	9.79	0.10
Patuxent Lower Estuary (PAXMH)	PAXMH	PAXMH	MIG	A	A
	PAXMH	PAXMH	OW	7.40	A
		PAXMH	DW	5.52	A
Potomac Tidal Fresh (POTTF)	POTTF	POTTF	MIG	A	A
	POTTF	POTTF	OW	A	A
Potomac Mid-Estuary (POTOH)	POTOH	POTOH	MIG	A	A
	POTOH	POTOH	OW	2.10	0.20
Potomac Lower Estuary (POTMH)	POTMH	POTMH	MIG	A	A
	POTMH	POTMH	OW	0.78	A
		POTMH	DW	6.90	0.58
		POTMH	DC	18.89	0.17
	JMSOH	JMSOH	OW	A	A
Eastern Bay (EASMH)	EASMH	EASMH	MIG	A	A
	EASMH	EASMH	OW	A	A
		EASMH	DW	3.26	0.27
		EASMH	DC	20.23	0.10
Choptank Mid-Estuary (CHOOH)	CHOOH	CHOOH	MIG	A	A
	CHOOH	CHOOH	OW	0.11	A
Choptank Lower Estuary (CHOMH1)	CHOMH1	CHOMH1	MIG	A	A
	CHOMH1	CHOMH1	OW	2.27	0.92
Choptank Lower Estuary (CHOMH2)	CHOMH2	CHOMH2	MIG	A	A

	CHOMH2	CHOMH2	OW	0.33	A
Tangier Sound (TANMH)	TANMH	TANMH	OW	0.15	0.33
Pocomoke (POCMH)	POCMH	POCMH	OW	A	A
Chester Lower (CHSMH)**	CHSMH	CHSMH	MIG	A	A
	CHSMH	CHSMH	OW	5.67	1.98
	CHSMH	CHSMH	DW	0.85	A
	CHSMH	CHSMH	DC	11.80	A

* 4/1/03, Version 15 -- Changes since version 12: SAV Re-calibration, Wetlands Oxygen Demand, No Seasonal Anoxic Zone

** for information purposes only, model not sufficiently calibrated for these areas