United States Environmental Protection Agency

EPA/600/R-15/092 | March 2015
www.epa.gov/ord

ECOSYSTEM SERVICES APPROACHES TO RESTORING A SUSTAINABLE CHESAPEAKE BAY AND ITS TRIBUTARY WATERSHEDS

Background

Many of the nation's watersheds and estuaries are suffering from water quality impairments that limit their ability to support recreation, shellfisheries, and aquatic ecosystem diversity. Under the Clean Water Act (CWA), one of the main mechanisms for addressing impairment is through the establishment of total maximum daily loads (TMDLs), which limit the allowable amount of pollutant loads to a water body. Despite significant progress in Chesapeake Bay and its tributary watersheds over the past two decades, meeting TMDL limits often presents challenging tradeoffs regarding where and how to control sources of pollution. In recognition of past unsuccessful restoration strategies for the Chesapeake Bay, President Obama signed Executive Order (EO) 13508 "Strategy for Protecting and Restoring the Chesapeake Bay Watershed" in 2009. This order requires federal agencies to work together to bring new resources and tools to the Bay restoration effort, including new approaches to implementing the CWA and new funding to promote voluntary efforts by farmers. The first test of the strategy involves implementing plans to achieve the Bay-wide TMDLs, which set maximum nitrogen, phosphorus and sediment target loads for the major tributaries of the Bay. The goals are ambitious and long-term success requires that all new sources be offset in order to maintain target loads in the face of population growth. While there is expansive public support for the Bay restoration goals, the substantial costs create barriers to success.

Under the framework of the EO, EPA's Office of Research and Development undertook a project to explore the cost-effectiveness and the legal and social feasibility of innovative policies and institutional arrangements to reduce the costs of meeting the TMDLs for nitrogen, phosphorus and sediment required under the EO, while at the same time promoting the creation or restoration of bonus ecosystem services (co-benefits) not related to water quality in the Bay. The project involved linking ecosystem services benefits into the Chesapeake Bay Program's modeling framework, refining ecosystem services quantification and valuation, and evaluating market-based mechanisms and scenarios. Overall, results have shown that:

1) Including monetized ecosystem services in optimization shifts the optimal solution to more non-point controls and lowers net costs;
2) Managers must creatively navigate existing regulations and programs to find the flexibility needed to promote effective strategies and to coordinate actions to reduce costs;
3) Policies that inhibit nutrient trading or offsets between point and nonpoint sources increase compliance costs and reduce ecosystem service co-benefits relative to a least-cost solution;
4) The TMDL can provide at least six additional benefits that cannot be monetized but can be linked to human welfare;

5) Providing additional incentives for delivered load reductions that originate farther upstream may improve the overall efficiency of meeting TMDL goals;

6) Nutrient trading provided only limited incentives for the agricultural sector to meet its TMDL goals; and

7) Simplified crediting (based on average regional load reductions rather than on site-specific conditions) would increase TMDL costs and may encourage placement of nutrient controls in less effective areas. The results are reported in a series of online documents, described below:

U.S. Environmental Protection Agency. 2011. *An Optimization Approach to Evaluate the Role of Ecosystem Services in Chesapeake Bay Restoration Strategies*. U.S. EPA Final Report, EPA/600/R-11-001.

http://www.epa.gov/sites/production/files/2014-03/documents/chesapeake-bay-pilot-report.pdf

This report describes the development and application of an analytic framework to assist policymakers in evaluating TMDL-related tradeoffs between project costs, load reductions, and bonus ecosystem services. The framework is designed to incorporate measures of both the cost-effectiveness and ecosystem service effects of individual pollution-control projects. The inclusion of ecosystem services is a unique feature of this framework. It accounts for not only the targeted pollutant reductions but also the societal co-benefits—i.e., bonus ecosystem services (carbon sequestration, recreation/ hunting, air quality)—provided by certain pollution-control projects. When these social benefits are expressed in monetary terms, they can be evaluated in terms of their ability to offset some of the costs of the pollution-control projects.

The analysis showed that including monetized ecosystem services as cost offsets in the optimization model shifts the optimal management solution towards the inclusion of more nonpoint-source controls; in particular, natural re-vegetation of cropland and pastureland adjacent to streams. This strategy results in substantially lower costs and greater bonus ecosystem services than a strategy that emphasizes traditional gray infrastructure. Because the lowest cost model solutions usually involve taking substantial amounts of agricultural land out of production, the model highlights the tradeoffs between low-cost nutrient and sediment reductions and retaining farmland. The model results are not intended to be prescriptive but to show the relative cost-effectiveness of alternative management scenarios. As expected, the total costs of control increase and bonus ecosystem services decrease significantly when **(1)** transaction costs of trading are increased, **(2)** the pollutant removal effectiveness of BMPs is reduced (to account for uncertainty), **(3)** agricultural land rental rates increase (to reflect increased profits in agriculture), and **(4)** WWTPs are required to implement the most advanced removal technologies.

Wainger, L.A., J.J. Messer, M.C. Barber, R.M. Wolcott and A.L. Almeter. 2012. *Lowering Barriers to Achieving Multiple Environmental Goals in the Chesapeake Bay.* U.S. Environmental Protection Agency (US EPA) Ecosystem Services Research Program.

http://www.epa.gov/sites/production/files/2014-03/documents/lower-barriers-multiple-env-goals-chesapeake-bay.pdf

This report addresses the broad question, "What policies promote Chesapeake Bay restoration goals by removing barriers to innovation and cost-efficiency?" This white paper includes five chapters that address this question from different perspectives:

Chapter 1

Lowering Barriers to Achieving Multiple Environmental Goals in the Chesapeake Bay: Innovations Suggested by Case Studies (L. Wainger and M. Barber) compares five innovative case studies as models for restoration approaches throughout the watershed. The reviewed case studies include a water quality trading program that was successful at reducing costs and a payment for ecosystem service program that stressed paying for performance outcomes rather than practice implementation. The chapter assesses whether the case studies' success could be replicated broadly in the Bay watershed by considering the topics of securing funding, engaging landowners and managers, and developing effective methods for ensuring environmental outcomes. This work was used to inform the following publication: Wainger, L.A., and J.S. Shortle. 2013. Local Innovations in Water Protection: Experiments with Economic Incentives. Choices: The Magazine of Food, Farm & Resource Issues 28. http://www.choicesmagazine.org/choices-magazine/theme-articles/innovations-in-nonpoint-source-pollution-policy/local-innovations-in-water-protection-experiments-with-economic-incentives.

Chapter 2

Ecosystem Services and the Clean Water Act: Strategies for Fitting new Science into Old Law (J.B. Ruhl) looks broadly at the flexibility offered by the Clean Water Act (CWA) for policy innovation to address multiple ecosystem services in the context of TMDLs, and highlights some of the opportunities for working within the "policy space" of CWA regulation. Although statutory language in the CWA offers constraints, this analysis suggests government officials should not underestimate the flexibility to adjust programs solely through changes in program administration. This work was later published as: Ruhl, J.B. 2010. Ecosystem Services and the Clean Water Act: Strategies for Fitting New Science into Old Laws. Environmental Law 40:1381.

Chapter 3

Opportunities for Reducing TMDL Compliance Costs: Lessons from the Chesapeake Bay (L. Wainger) discusses opportunities for enhancing cost-effectiveness of TMDLs, by examining how program design and implementation can be made consistent with market-based approaches and efficient targeting of effort. Some key challenges discussed are using regulatory authority so as to promote, rather than hinder the ability to innovate, trade, or use the most cost-effective offsets. Other considerations include ensuring the environmental performance of programs and rectifying diverse goals. The challenges of establishing water quality credit markets suggests that alternative approaches may be needed to successfully engage the agricultural sector and lower costs of achieving TMDLs. Later published as: Wainger, L.A. 2012. Opportunities for reducing total maximum daily load (TMDL) compliance costs: Lessons from the Chesapeake Bay. Environmental Science & Technology 46:9256–9265.

Chapter 4

Environmental Services Programs for the Chesapeake Bay (L. Shabman et al.) discusses an innovative approach for engaging communities in collective action, called Reward for Environmental Services (RES) Programs. The RES idea recognizes that community groups may offer unique advantages and approaches to collectively managing resources, and may therefore be effective at reducing loads to the Bay while also promoting outcomes that resonate strongly with the local community.

Chapter 5

The Use of Nutrient Assimilation Services in Water Quality Credit Trading Program (K. Stephenson and L. Shabman) considers the potential for using a new set of technologies - nutrient assimilation - within a water quality trading program. Nutrient assimilation technologies enhance natural processes that remove nutrients directly from ambient waters such as uptake by plants or animals, sediment burial, or dispersal to the atmosphere. The chapter reviews the potential for generating nutrient assimilation credits, describes what is known about their efficacy and capacity to remove nutrients, and how their equivalence to other nutrient removal approaches can be measured given the larger context of emission market requirements and concerns. Such practices are similar to using non-point source practices to reduce nutrients, but appear to offer increased certainty that offsets are equivalent to point source emissions.

Achieving the Bay restoration goals requires a suite of tools and innovative approaches at multiple scales, including the approaches presented in this report. These approaches use strategies that promote innovation and use available funds efficiently, which include: **(1)** Allowing regulated parties and local stakeholders to decide how best to achieve goals; **(2)** Ensuring outcomes through monitoring, adaptive management, and robust testing of technologies; and **(3)** Targeting public money to actions with high cost-effectiveness and seeking economies of scale by enlarging promising pilot programs. Managers must navigate existing regulations and programs creatively to find the flexibility needed to promote effective strategies and to coordinate actions to reduce costs.

Wainger, L.A., G. Van Houtven, R. Loomis, J. Messer, R. Beach, and M. Deerhake. 2013. Tradeoffs among Ecosystem Services, Performance Certainty, and Cost-efficiency in Implementation of the Chesapeake Bay Total Maximum Daily Load. Agricultural and Resources Economics Review 42(10): 196-224.

http://ageconsearch.umn.edu/bitstream/148408/2/ARER%202013%2042x1%20WaingerEtal.pdf

The cost-effectiveness of total maximum daily load (TMDL) programs depends heavily on program design. This paper describes an optimization framework developed to evaluate design choices for the TMDL for the Potomac River, a Chesapeake Bay sub-basin. Scenario results suggest that policies inhibiting nutrient trading or offsets between point and nonpoint sources increase compliance costs markedly and reduce ecosystem service co-benefits relative to a least-cost solution. Key decision tradeoffs highlighted by the analysis include whether agricultural production should be exchanged for low-cost pollution abatement and other environmental benefits and whether lower compliance costs and higher co-benefits provide adequate compensation for lower certainty of water-quality outcomes.

Wainger, L., J. Richkus, and M. Barber 2015. Additional beneficial outcomes of implementing the Chesapeake Bay TMDL: Quantification and description of ecosystem services not monetized. EPA/600/R-15/052.

http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=308098

The report provides quantification and description of the magnitude of improvements to conditions in the Bay that cannot be monetized but can be linked to human welfare. The authors evaluate benefit indicators (e.g., reductions in disease-causing organisms), rather than benefits in the strict sense because they have not evaluated what people would have been willing to pay to achieve these benefits. Yet, non-monetary benefit indices are used routinely to establish cost-effectiveness of management actions and can enrich the context in which the benefit-cost results are considered. The authors analyzed and synthesized existing scientific literature and data to quantify and describe how the practices that the Bay states have proposed to meet the TMDL could positively affect selected ecosystem services produced by the Chesapeake Bay system. The authors estimate that in support of public health, food supply, and recreation, the TMDL practices collectively have the estimated potential to decrease disease-causing pathogen loads to the Bay by at least 19-27%, reduce human exposure to West Nile Virus, and reduce incidence of harmful algal blooms. Perhaps most significantly, the authors found that implementing the practices to meet the TMDL would also promote benefits derived from enhancing or maintaining Bay ecosystem resilience. The report describes how resilience to multiple stresses, including climate change effects, is fostered by the regrowth of submerged aquatic vegetation, increased fish diversity, and reduced hypoxia. These changes would be expected to promote a system that recovers more readily from disturbance and avoids tipping points that could shift the system to a less desirable state.

Van Houtven, G., R. Loomis, and J. Baker. 2015. *Ecosystem Services and Environmental Markets in Chesapeake Bay Restoration*. EPA/600/R-15/061.

http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=308072

The first analysis in this report considers how including benefits from water quality improvement in freshwater rivers and streams expands alters the optimal distribution of nutrient reductions in the watershed. The analysis uses the optimization framework developed by EPA (2011). The results show that these non-tidal water quality co-benefits are larger than the other co-benefits combined and would result in greater nutrient control efforts in upstream portions of the watershed. Compared to cost-minimization results that do not account for co-benefits, the optimized solution while including all co-benefits would increase annual nutrient control costs by $16 million in the Susquehanna River Basin in Pennsylvania but also increase the co-benefits by $31 million, for a net gain of $15 million per year. In the James River Basin in Virginia, including monetized co-benefits results in an estimated increase in nutrient control costs of $17 million but an increase in co-benefits of $42 million for a net gain of $25 million per year. Based on these findings, providing these additional incentives for delivered load reductions that originate farther upstream may improve the overall efficiency (in a net-cost sense) of meeting TMDL goals.

The second analysis evaluates the ability of nutrient trading to provide an incentive for agricultural entities to meet their load allocation under the TMDL. This analysis expands on previous applications of the optimization framework focused on the potential cost savings from allowing nutrient trading in the Chesapeake Bay watershed (Van Houtven et al., 2012, http://www.chesbay.us/nutrienttrading.htm). These applications do not include the co-benefit estimates. Unlike previous applications, this analysis does not assume that the agricultural sector would fully meet its load allocation, but examines how the requirement of a trading “baseline” (that is consistent with TMDL) would affect farmers’ incentives to meet their load allocation as a precondition for generating credits. The results suggest that nutrient trading alone (without additional incentives) would only support achieving 11% and 4% of the required agricultural load reductions for nitrogen and phosphorus respectively in the Susquehanna River Basin in Pennsylvania. In the James River Basin in Virginia, nutrient trading would be a somewhat more effective incentive, with 35% of the nitrogen reduction and 41% of the phosphorus reduction achieved through nutrient trading. Overall, they concluded that nutrient trading by itself would not be a particularly effective mechanism for encouraging the agricultural sector to meet its TMDL goals, as it supports only a portion of the required load reductions.

The authors also examined how “simplified” crediting of nutrient reductions–where credits are assigned to BMPs based on average regional load reductions rather than on site-specific conditions –would influence the nutrient control costs and load reductions. The estimates showed that simplified crediting would result in higher costs (by 8% across the watershed) for achieving nutrient reductions, because it discourages placement of nutrient controls where they would be most effective. In addition, simplified crediting is estimated to result in failure to meet the load reduction requirements in some subwatersheds, as it would assign average load reduction credit to practices that would actually generate below-average reductions.

Wainger, L.[1], G. Van Houtven[2], B. Rashleigh, N. Detenbeck, S. Jordan, J. Messer, A. Rea[3].
[1]Oneida Total Integrated Enterprises, [2]RTI International, [3]US Environmental Protection Agency