The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

An Evaluation of the Virginia's Nutrient Credit Trading Program

Kurt Stephenson
Dept of Ag & Applied Econ
Virginia Tech
Blacksburg, VA 24061
Email: Kurts@vt.edu
Phone: 540-231-5381

Stephen Aultman
Dept of Ag & Applied Econ
Virginia Tech
Blacksburg, VA 24061
Email: Saultman@vt.edu
Phone: 540-231-5008

Leonard Shabman
Resources for the Future
Washington, DC
Email: Shabman@rff.org
Phone: 202-328-5139

Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California July 23-26, 2006

Copyright 2006 by Kurt Stephenson and Stephen Aultman. All rights reserved. Readers may make verbatim copies of this document for noncommercial purposes by any means, provided that this copy right notice appears on all such copies.

An Evaluation of the Virginia's Credit Nutrient Trading Program

Abstract:

Federal and state regulatory agencies frequently support and encourage the use of market-based effluent trading to achieve social water quality goals. This paper evaluates the design of the recently approved Virginia Nutrient Trading Program. The cost implications of setting a near limit of technology point source cap and requiring new and expanding sources to meet specific technology-based performance standards are examined.

Introduction

Economists have long advocated for the creation of markets for discharge rights as a way to achieve social environmental goals. While such programs have a long history in the nation's air quality program, the Environmental Protection Agency (EPA) is now increasingly professing support for market-based water quality programs. Recently, EPA has produced statements of support, developed technical manuals, and developed several grant programs to promote the development and implementation of "market-based water quality trading" programs (EPA, 2006, 2004; 2003).

The basic requirements of establishing market-based effluent trading programs are well understood by economists. Such programs begin with the definition of a limited number of discharge rights. The sum of those rights defines a mass load cap that establishes the total amount of effluent that can be legally discharged to a water body. Next, a set of well-defined market rules allow dischargers under the cap discretion to allocate resources towards effluent control technology and or the purchase of additional discharge rights. The market price for discharge rights creates a financial incentive for firms to continuously seek new ways to reduce both effluent loads and control costs.

In practice, these basic requirements have proven challenging to implement within the specific statutory and regulatory confines of the Clean Water Act (Shabman, Stephenson, and Shobe; Stephenson and Shabman). In practice, rather than establishing market rules for allocation of rights under cap, many professed trading programs are isolated amendments to an individual point source permits. More comprehensive and regional trading programs are now beginning to emerge. For example, as part of the regional Chesapeake Bay Program, Virginia established a nutrient (nitrogen and phosphorus) trading program for point source dischargers. The program primarily effects municipal wastewater treatment plants and applies to the Potomac, James, Rappahannock and York Rivers. The goal of the legislation was to help Virginia meet its 40% aggregate nutrient reduction goal for the Chesapeake Bay in a cost effective manner. The objective of this paper is to evaluate the Virginia nutrient trading program from a market design perspective, and to estimate the cost implications of key program design features.

Virginia's Nutrient Credit Exchange Program

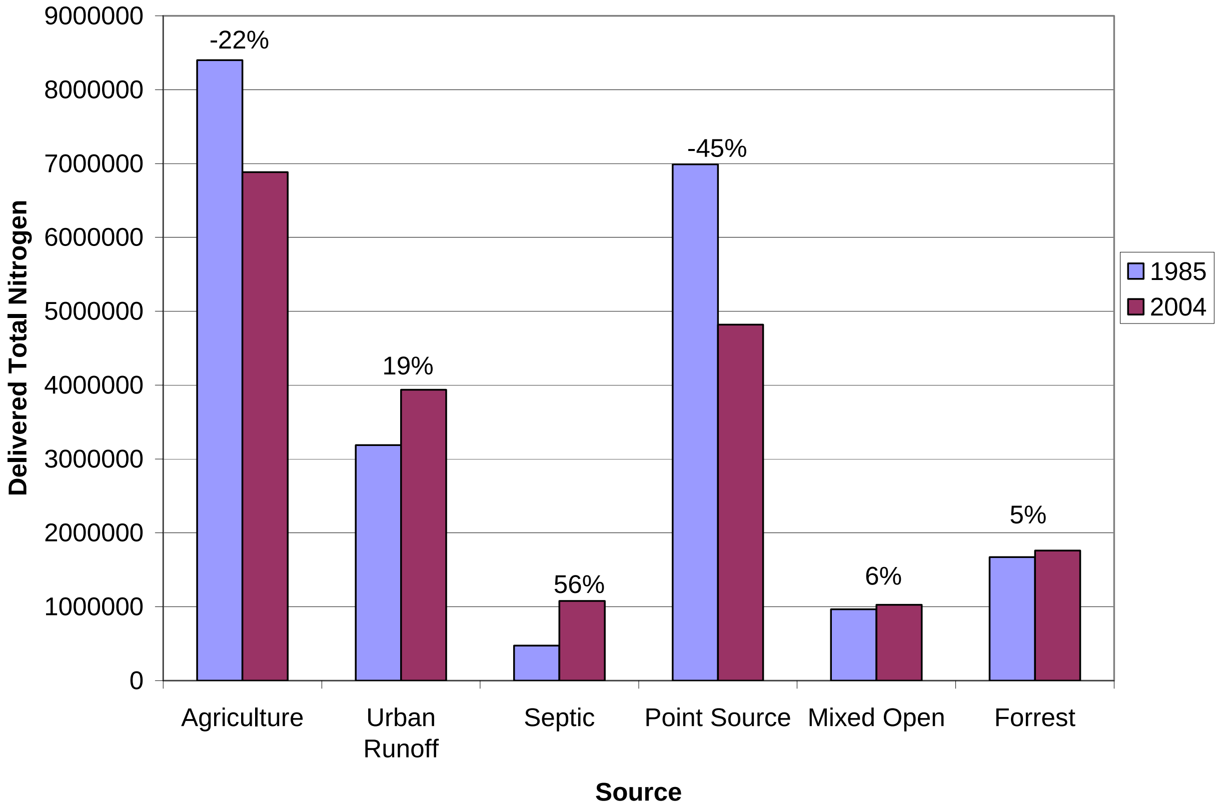
In 2000, Virginia signed the *2000 Chesapeake Bay Agreement*. The 2000 agreement is the latest in a series of cooperative agreements between the Virginia, Pennsylvania, Maryland, the District of Columbia and the Environmental Protection Agency to improve water quality conditions in the Chesapeake Bay. The corner stone of these agreements has been a commitment to achieve a 40 percent reduction in total anthropocentric nitrogen and phosphorus loads entering the Bay (from 1985 baseline) (Chesapeake Bay Program, 2000). The latest agreement establishes 2010 as the deadline to achieve this goal.

Since nutrients are not explicitly classified as a pollutant under the Clean Water Act, the Bay states historically have relied on state programs to achieve Bay program goals. These programs can be generally classified as educational campaigns targeted at specific groups , and cost-share programs to implement best management practices at nonpoint sources and biological nutrient removal (BNR) technologies at wastewater treatment plants.

Since the early 1980s, these voluntary nutrient control programs produced modest gains toward achieving the overall nutrient reduction goals. For example, by 2004 the total nitrogen loads entering the Bay watershed from the Virginia portion of the Potomac/Shenandoah watershed had been reduced by an estimated 20 % from 1985 levels (Blankenship, 2006).

The relative contribution and the progress toward the Bay reduction goals differs considerably between groups of nutrient sources. In the Potomac/Shenandoah basin, for example, the majority (about 60%) of nitrogen loads come from nonpoint sources such as agriculture, urban runoff, and septic tanks (Blankenship) (see Figure 1). Point sources, primarily wastewater treatment plants, contributed about a fourth of all the nitrogen entering the Bay from this watershed. The Potomac/Shenandoah is generally reflective of other watersheds in the Chesapeake Bay watershed in the fact that majority of nutrient loads come from nonpoint sources. In the Potomac/Shenandoah basin, the point sources are the only category of sources to have achieved a 40% reduction in overall nitrogen loads (See Figure 1).

Figure 1. Nitrogen loads in the Potomac/Shenandoah by Source



In an effort to facilitate and accelerate progress toward achieving Chesapeake Bay program goals, the Virginia General Assembly passed the *Chesapeake Bay Watershed Nutrient Credit Exchange Program* in 2005 (Virginia code §62.1-44.19:12-19). The legislation establishes mandatory nutrient control obligations for Virginia point sources discharging in the Chesapeake Bay watershed (nonpoint sources remain under voluntary programs). Each existing point source (over a minimum size) is granted an individual nitrogen and phosphorus wasteload allocation (WLA). The allocation is expressed in a total annual mass load (in pounds) of nitrogen and phosphorus that can be released by the source. Virginia's Department of Environmental Quality set individual WLA based on near limits of technology performance standards (4 mg/l for total nitrogen) multiplied by the point source's permitted design flow. The sum of individual point source WLA in a particular river basin represents the point source nutrient watershed cap. Individual WLAs are established in a general watershed permit and are recorded only as a mass load.

Trading provisions enter the program in two general ways. First, *existing* individual point sources can exchange nutrient "credits" to achieve end of year compliance. A credit is defined as the difference between WLA and total annual discharge (in pounds). If at the end of the year a source's discharge is less than WLA, credits are created and can be sold to point sources whose discharge exceeded the WLA. Unused credits expire at the end of the year. While exchange of credits is allowed, existing point sources are not allowed to exchange the WLA itself. If insufficient point source credits are available to cover all noncompliant sources, a noncompliant point source must pay a fee into a state directed fund to purchase nonpoint source credits.[1] Nonpoint source credits can only be used when point source credits have been exhausted (§62.1-44.19.18A).

A second set of trading provisions relates to *new and expanding* point sources (§62.1-44.19.15). New and expanding sources are not granted any new WLA, but must acquire WLA by purchasing WLA from an existing point source or by sponsoring long-term (as long as the new/expanding source discharges) nutrient reductions from a nonpoint source. In addition, the legislation specifies that new/expanding sources must also meet limit of technology nutrient concentration requirements (3 mg/l for total nitrogen and .3 mg/l for total phosphorus). This technology based concentration standard must be met by all new/expanding sources and applies concurrently to the WLA obligation.

[1] The state is instructed to charge a fee based on "the average cost of reducing one pound of nitrogen or phosphorus from Virginia publicly owned wastewater treatment facilities (§62.1-44.19:18.B)

Assessment of the Virginia Nutrient Exchange Program

The Virginia trading program offers a number of improvements over conventional command-and-control approaches. The emphasis on achieving mass load caps (rather than concentration standards) and implementation of WLA through a general permit offers regulated point sources more flexibility to meet control obligations than through more prescriptive technology oriented individual (NPDES) permits. The ability to exchange point source credits also offers a compliance option for point sources who might experience difficulty meeting their WLA. However, the design of Virginia program may increase costs over what might be achieved under alternative designs. The cost implications are related to both the establishment of the cap and the restrictions on trading under that cap.

Setting effluent caps is an exercise in the distribution of discharge rights. Rights could be auctioned, but in most all programs rights are assigned administratively by regulatory authorities. Rights to discharge can either be assigned based the expected performance of individual source technologies (called here called a “technology-based” cap) or derived from starting from an ambient water quality goal (“ambient-based” cap). The Virginia program represents a technology-based approach to cap setting. An ambient-based cap begins with identifying a cap consistent with public water quality goals. Next, dischargers are assigned responsibility for meeting the cap based on a socially determined decision rule. The social decision to parse the cap and assign responsibility to meet the cap to specific types of sources could be based on the relative cost effectiveness of controls sources, but the typical approach is to assign a proportional reduction across categories of sources. For instance, North Carolina established a watershed nutrient reduction goal of 30 percent for the Neuse and Tar-Pamlico basins and then required groups of sources – point sources, agricultural nonpoint sources, urban nonpoint source, etc -- to each achieve a 30 percent reduction in nutrient loads (Stephenson, Shabman, and Boyd 2005). Under a *proportional* cap, all categories of sources (point, urban nonpoint, agricultural nonpoint, etc) under the Chesapeake Bay program would be expected to achieve a 40 percent reduction in nutrient loads.

Virginia's technology-based point source cap is substantially more stringent than assigning point sources the 40 percent reduction goal consistent with the Bay program goal. In the Potomac/Shenandoah watershed, the existing WLA represents a 73% reduction over 1985 baselines. In addition to the equity issues raised by imposing such a disproportional obligation on point sources, the technology derived point source cap has important cost implications. Point sources are typically considered the high control cost source, and limits of technology controls are likely to exasperate this general outcome.

The Virginia program may also limit the incentive and ability of point sources to reallocate nutrient load. The program is designed primarily to allow point sources additional flexibility to maintain end of year compliance. Trading of WLA is prohibited and trading is limited to temporary exchanges of credits. Furthermore, new and expanding sources must meet a concurrent technology-based performance standard in addition to meeting their WLA obligations. Thus, new and expanding sources cannot avoid limit of technology controls by electing to purchase WLA (discharge rights) from a lower cost source.

Some Cost Implications of Virginia's Nutrient Credit Exchange Program in the Potomac

The cost implications of two design features of the Virginia program, the point source cap level and the technology based performance standards for new/expanding sources, are examined in more detail. The analysis will focus on the Virginia portion of the Potomac/Shenandoah watershed. The Potomac/Shenandoah is the northern most river basin in Virginia, and the second largest contributor of nutrients to the Chesapeake Bay behind the Susquehanna River. Of Virginia's major tributaries, the Potomac basin is the the largest contributor to the low dissolved oxygen problems in the main stem of the Bay.

The cost implications of four policy scenarios are estimated (see Figure 2). Two point source caps are identified – the existing point source cap based on limits of technology controls and a second (less stringent) point source cap based on the 40 percent reduction goal of the Bay program. The cost of achieving these cap levels are estimated with and without the technology-based performance standard on new and expanding sources.

Figure 2. Policy Scenarios

	Technology-Based Performance Standard	No Technology-Based Performance Standard
Virginia Program Cap	Scenario 1	Scenario 2
40% Proportional Cap	Scenario 3	Scenario 4

Cost Model

A cost minimization model for the Shenandoah-Potomac River Basin is used to provide a rough estimate of the cost implications of each scenario. The model calculates the least-cost combination of plant upgrades needed to achieve the total nitrogen cap in Virginia's portion of the Potomac/Shenandoah watershed in the year 2010. Nitrogen is the focus of this study because it is widely considered the nutrient most expensive and technically challenging for point sources to remove. Due to the large and lumpy capital costs required to achieve different effluent concentration standards, integer programming minimization techniques were used to solve the model. The formal model is given below where Xij is the decision of the i-th firm to implement the jth upgrade. In the model, each plant faces four possible decisions. To do nothing, or pursue up to three sequential effluent control upgrades to achieve total nitrogen concentration levels of 8 mg/l, 5mg/l or 3 mg/l. Cij is the coefficient estimating the cost of the ith firm implementing the jth upgrade. Rij is the reduction in nutrient load associated with implementing an upgrade. Equation three represents the technology-based performance standard requirement in the Virginia program whereby new and expanding plants must install limits-of-technology effluent controls (achievement of annual average of 3mg/l of total nitrogen in discharge effluent).

$$(1) Minimize \sum_i \sum_j CijX'ij$$

s.t.

$$(2) \sum_i \sum_j RijX'ij \geq B_1$$

$$(3) \sum_i \sum_j X'ij = B_2$$

The model includes technology, cost, and upgrade information for 29 publicly owned wastewater treatment plants in Virginia. The sample excludes small plants (less than .5 million gallons per day design flow) and private/industrial dischargers. The model also includes only plants operating exclusively under the state of Virginia’s permitting system. With these omissions, the model still accounts for more than 80% of the 2004 nitrogen load from Virginia point sources discharging in the Shenandoah-Potomac River basin.

Like the Virginia Trading program, the model is based on exchange of delivered nitrogen loads into the Chesapeake Bay. Depending on the location of a discharger in the watershed, a portion of the nitrogen discharged at the end of pipe is assimilated during transport to the Bay. The portion of the nitrogen reaching the Bay is called the delivered load. The total delivered nitrogen discharged from the 29 plants in 2004 was 3.99 million pounds. By 2010 assuming no new upgrades but continued growth in flows due to population/economic growth, the nitrogen load is projected to be 4.9 million pounds. The total WLA (nutrient cap) assigned to these same plants under the Virginia program is 3.18 million pounds (delivered load).

Due to incomplete data, the estimated 1985 loads could not be secured for all plants in the model. Therefore, the aggregate 2004 nitrogen loading for these plants was used as a rough approximation of the 40% proportional reduction cap. Recall the Chesapeake Bay Program reported that the Potomac point sources had achieved a 45 percent reduction in nitrogen loads by 2004.

The model calculates the annualized total cost of achieving the cap in 2010. Capital and operating costs of different levels of upgrades was obtained from the Chesapeake Bay Program (Chesapeake Bay Program, 2002). Capital costs are expressed in annualized terms.[2] The Chesapeake Bay Program's nutrient point source database provided discharge information on nutrient discharge levels, plant wastewater flows, and plant design flows (Chesapeake Bay Program, 2006). To estimate nitrogen loads discharged in 2010, estimates of wastewater flows are required. Estimated 2010 wastewater flows for each plant were projected by estimating a linear regression trend line through 10 years of plant flow data (1995-2004).

The plants that are expected to be operating under the technology-based concentration standard for expanding point sources also needed to be identified. Under regulation 9-VAC-720-

[2] The capital and variable costs were annualized over 20 years at a rate of 7%.

50, the Virginia Department of Environmental Quality identifies 5 out of the 29 plants in the model as having pre-existing upgrade plans. For purposes of this model, these plants are considered subject to the technology-based performance standards in 2010.

It should be stressed that the cost model represents only a rough approximation of the cost implications of the policy scenarios. The model takes technology and costs as given and implicitly assumes there will be no innovation effects stemming from more different levels of decision-making flexibility and discharger incentives associated with different program designs. Experience has shown that costs are indeed a function of trading program design (Shabman, Stephenson and Shobe; Speir, Stephenson, and Shabman). In addition, the model also assumes that all mutually-beneficial trades take place. As discussed above, specific design features of the program might reasonably be expected to diminish the ability and incentives for cost reducing trades. Finally, the model also does not take into account how growth in wastewater flows beyond 2010 will increase costs. The technology-based performance standards on new sources will be increasingly costly as existing plants expand to cope with increases in population and economic activity. For these reasons, cost estimates should be considered a lower bound estimate. Emphasis will be placed on the relative difference in costs between the policy scenarios rather than on specific point estimates.

Results

The annualized cost of achieving the four policy scenarios are presented in Figure 3. First, consider the cost implication of the technology-based performance standards on expanding sources. This additional requirement on expanding sources increases costs about $4.5 million per year under either cap scenario. For instance, under the existing Virginia point source cap, the cost of achieving existing Virginia point source cap increases from $13.4 to 18 million per year, a 34% increase in costs. The same requirement imposed on the proportional cap increases nearly doubles total compliance costs.

Figure 3. Annualized Cost to Achieve Policy Scenarios

	Technology-Based Performance Standard	No Technology-Based Performance Standard
Virginia Program Cap	$ 18,042,000	$ 13,442,000
40% Proportional Cap	$ 10,544,600	$ 5,877,500

The model also estimated the cost of achieving two different point source caps – a 3.18 million ton nitrogen cap established in the Virginia Program and a 3.99 million cap that approximates a proportional 40% reduction in point source loads. The cost of increasing the stringency of the point source cap from 3.99 to 3.18 million pounds is estimated to be $7.5 million dollars per year ($5.9 to $13.2 million assuming no technology based performance standard). This represents a 70 to 130 percent increase in costs (depending on whether technology-based standards are required for new/expanding sources).

As implied by these estimates, the marginal costs increase substantially as the stringency of the point source cap is increased. The marginal cost estimate for point sources of achieving a 40% reduction goal is $7.20 per lbs of delivered nitrogen. Marginal costs increase to $16.60 under Virginia's technology-oriented cap. These marginal costs are significantly higher the costs of implementing a suite of nonpoint source practices reported in a highly publicized Chesapeake Bay Commission report (Chesapeake Bay Commission 2004). For example, reported nonpoint source costs range from $1.66 to $4.41 pounds of nitrogen removed (Chesapeake Bay Commission 2004). Thus, more cost effective reductions may be achieved by shifting responsibility of achieving the overall 40% reduction goal for the Bay from point to nonpoint sources.

Discussion

The specific legislative goals of the Virginia Nutrient Exchange Program are to meet point source "cap load allocations cost effectively" and to provide "a foundation for establishing market-based incentives to help achieve the Chesapeake Bay Program's nonpoint source reduction goals" (Virginia Code §62.1-44.19:12). The program offers a number of improvements over conventional permitting programs, including less prescriptive permit requirements that do not specify how point sources will meet their WLA. The program, however, is limited in the ability to cost effectively allocate responsibility to Bay program water quality goals.

Rather than a market-based trading program, the Virginia program is better understood as a compliance mechanism for a conventional point source regulatory program. Point sources remain the only source under direct regulatory control in Virginia. To date, nonpoint source control in Virginia remains a voluntary. Given an unwillingness of state and local officials to design and implement legal requirements to limit discharge from nonpoint sources, the point sources are considered the primary regulatory means to achieve the overall water quality goals in the Bay. Thus, the impetus is to require as much nutrient load reduction as technologically possible at the point sources. The setting of the Virginia point source cap (sum of individual technology-based WLAs) is not motivated primarily by notions of cost effectiveness or shared responsibility, but rather based on maximizing total point source removal (a zero marginal product on the nitrogen removal production function). This analysis provides evidence that the marginal cost of achieving the existing point source cap are 4 to 10 times higher than the reported cost to reduce nitrogen at nonpoint sources.

Furthermore, existing point sources are expected to achieve their individual WLA. The WLA represents the rights to discharge in the system and these rights cannot be transferred. In the event a point source exceeds its WLA, the noncompliant point source can buy credits from a source that over complied in that year. Given that credits do not exist until the end of the year accounting has been completed, it is unclear the extent to which point sources will rely on these credits as a long term nutrient management strategy. Further, the stringency of the cap and the rate of population growth in the much of the Bay region may severely limit any opportunities for any long term transfers of credits or WLA (every source operating at the limits of technology).

New/expanding sources are not allowed to a chose the amount of WLA necessary to offset new loads. New and expanding sources must first meet a limit of technology concentration standard. This obligation is not subject to trade regardless of the relative costs advantages of doing additional controls at another source. The cost analysis in this study found that meeting such requirement can substantially increase overall compliance costs. After all limits of technology controls are applied to the new/expanding source, the remaining load must in turn be offset at another point source or nonpoint source. The expectation is that new/expanding point sources will secure part of the necessary WLA by financing nonpoint source reductions. Indeed a statutory program goal of the Virginia legislation is to use the point source requirements to "help achieve the Chesapeake Bay Program's nonpoint source reduction goals".

It should be stressed that some of the design features of the Virginia program are not an anomaly, but reflective of the general way in which many effluent trading programs across the region and country are being implemented (Stephenson and Shabman 2001; Stephenson, Shabman, and Boyd 2005). Despite the economic efficiency rhetoric used by EPA, many of the trading programs that claim to be cost-effective or market-based are neither. Rather trading is often used as a way to justify or require additional reductions from point sources and then to use regulatory powers to generate financing for additional reductions from nonpoint sources. Furthermore, the distinctions between these programs and more market-like alternatives are not well understood among decision-makers. Without more active participation from environmental economic professionals to delineate, identify and advocate for market-like institutions, the meaning of markets will increasingly be distorted and misunderstood in policy discussions and opportunities for meaningful market-based environmental policy reform may be foregone.

References:

Blankenship, Karl. 2006. “Chesapeake Cleanup Update: A Long Way to Go And Not Much Time Left to Get There.” Bay Journal, January

Chesapeake Bay Commission, December 2004. *Cost Effective Strategies for the Bay: Six Smart Investments for Nutrient and Sediment Reduction.* Annapolis Maryland.

Chesapeake Bay Program. 2002. *Nutrient Reduction Technology Cost Estimations for Point Sources in The Chesapeake Bay Watershed*. Annapolis: Environmental Protection Agency.

Chesapeake Bay Program. 2006. *Chesapeake Bay Program Nutrient Point Source Database.* Accessed May 17th, 2006 from http://www.chesapeakebay.net/data/index.htm.

Chesapeake Bay Program, 2000. *Chesapeake 2000. Accessed May 20th 2006 from http://www.chesapeakebay.net/agreement.htm*

Environmental Protection Agency. 2006 “Water Quality Trading” Office of Wetlands, Oceans, and Watersheds. Online at www.epa.gov/owow/watershed/trading.htm. Accessed May 31, 2006.

Environmental Protection Agency. 2003 “Water Quality Trading Policy” Office of Water, January 31, Online at: www.epa.gov/owow/watershed/trading/tradingpolicy.html

Environmental Protection Agency. 2004. “Water Quality Trading Assessment Handbook” EPA publication 841-B-04-001. Office of Water, Washington DC.

Shabman, L., K. Stephenson, and W. Shobe. 2002. Trading Programs for Environmental Management: Reflections on the Air and Water Experiences. Environmental Practice 4: 153-162.

Speir, C., K. Stephenson, and L. Shabman. “Command-and-Control and Effluent Allowance Markets: Roles of Economic Analysts.” Selected paper presented at the American Agricultural Economics Association meetings, Tampa, Florida, July 30 - August 2, 2000.

Stephenson, K. and L. Shabman. 2001. “The Trouble with Implementing TMDLs” Regulation 24:1 (Spring 2001): 28-32.

Stephenson, K., L. Shabman, and J. Boyd. 2005. “Taxonomy of Trading Programs: Concepts and Applications to TMDLs.” In *Total Maximum Daily Load: Approaches and Challenges.* Ed, Tamim Younos, pp. 253-280. Tulsa OK: PennWell Press.