Pollutant Monitoring of Effluent Credit Trading Programs For Agricultural Nonpoint Source Control

by

Daniel Jackson March

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APPROVED:

William E. Cox, Chairman

Daniel L. Gallagher

Saied Mostaghimi

Kurt Stephenson

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ABSTRACT

This study discusses the monitoring requirements of an effluent credit trading system that allows point source discharges to purchase effluent reductions by financing agricultural nonpoint source best management practices. It describes the results of a national survey of existing trading programs that assessed how each program determines nonpoint source baseline pollutant discharges, pollutant reductions attributable to best management practices, verification of best management practice(s) installation and maintenance activities, and how often this verification is performed.

This study surveyed the nonpoint source discharge monitoring programs of several of the successful effluent credit trading systems in the U.S. It documents and discusses specific characteristics of nonpoint source pollutant discharge monitoring strategies. Finally, this thesis compares trading program discharge monitoring characteristics to the current Virginia Cost-Share nonpoint source monitoring program. The goal of this study is to recommend elements of a nonpoint source discharge monitoring strategy to the Commonwealth of Virginia that can be used in a trading program of its own.

The study shows that the majority of existing effluent credit trading programs use watershed models and land use evaluation algorithms to indirectly monitor nonpoint source pollutant discharges on a watershed basis rather than relying on empirical sampling and analysis activities for individual farms of fields. Monitoring takes a variety of forms to provide the diverse information necessary to indirectly determine nonpoint source discharges. Most trading programs monitoring strategies are no more comprehensive than agricultural cost-share programs even though many stakeholders believe that a trading program's monitoring activities should be exact enough to determine contributions from individual nonpoint sources to support the payments for individual activities. This objection is a barrier to the acceptance of trading programs by the public. A Virginia trading program must enhance its agricultural best management practice cost-share program monitoring practices to track nonpoint source discharges from individual farms or fields to be accepted and successful.

ACKNOWLEDGMENTS

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Special appreciation to Terri, without whose love and support I would never have undertaken this graduate school odyssey. A big thank you to Graham for being a school guy with me and helping me rediscover the fun and wonder of learning.

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INTRODUCTION

This is a thesis about water pollution, the progress that has been made to reduce pollutant discharges to rivers and streams and the work that is ahead to attain the Clean Water Act goal of fishable and swimmable waters. The quality of our Nation's waters has increased dramatically in many regions since the formation of the Environmental Protection Agency and passage of the Clean Water Act in 1972. However, recent nationwide water quality evaluations show that 35 to 40 percent of our rivers and streams remain impaired – they are not clean enough to meet their designated uses. The Environmental Protection Agency estimates that agricultural nonpoint pollution sources are responsible for almost two thirds of these impaired waters (EPA, 1996).

AGRICULTURAL NONPOINT SOURCES

The 1998 National Water Quality Inventory Report to Congress says that pollutants, primarily nutrients and sediment, in runoff from agricultural sources contribute 59 percent of the reported water quality problems, resulting in about 170,000 miles of impaired or threatened rivers. In toto, more than 20,000 individual waterbodies, representing approximately 300,000 miles of river and shoreline and approximately five million acres of lakes, do not meet state water quality standards (EPA, 2000).

On a regional basis, the effects of nutrient enrichment have had profound impacts on Chesapeake Bay. These impacts began about the time modern industrial farming methods were introduced to the Mid-Atlantic coastal region and were exacerbated during the "Green Revolution" beginning in the 1960s. Over the years shellfish, fish, and shrimp catches in the Bay have steadily declined. The economic impact of these reduced catches due solely to nutrient enrichment is difficult to estimate. The effects of toxic pollutants, such as herbicides, pesticides, metals, and many organic compounds including halogenated solvents, and the effects of overfishing all contribute to the problem. However, the Chesapeake Bay Program believes that the problems of the Chesapeake Bay are largely the result of nonpoint source pollutants:

> "It is unquestionable that the conversion of forests to agriculture throughout the watershed, but particularly on lands adjacent to streams and rivers, has adversely affected the vitality of our water resources" (CBP, 1993).

EFFLUENT CREDIT TRADING AND NONPOINT SOURCE DISCHARGES

Most states have agricultural nonpoint source cost-share programs that subsidize the capital costs of best management practices used to protect water quality. Best management practices are land use practices that control the delivery or transport of pollutant discharges. These programs monitor cultivated area, crops planted, fertilizers used, land characteristics such as soil type and slope, and the area and type of best management practices used. These voluntary programs are typically underutilized because they only reimburse a part of the cost of installing a best management practice and they do not credit the value of the installed practice to the participants so that value can be traded. Effluent credit reduction trading programs have been proposed to augment cost-share programs role in protecting water quality.

Trading of effluent reductions is defined as a market-place transfer of credits gained by reducing effluent discharges below an allocated or permitted amount. Trading these reductions is believed to have great potential to reduce the impacts of nonpoint sources on water quality and bring many more nonpoint source dischargers into a control system.

In 1995, the EPA began promoting the use of watershed-based trading (EPA, 1995a). The EPA believes that trading of effluent credit reductions provides an opportunity for water quality agencies to develop workable, cost-effective solutions for water quality problems in watersheds by expanding nonpoint source pollution reductions beyond current levels. Trading may give dischargers new opportunities to comply with anti-degradation policies that limit industrial expansions and new facilities by financing pollution discharge reductions from existing sources. EPA also believes that trading can produce environmental benefits by increasing the use of pollution control measures, such as best management practices, from agricultural sources (EPA, 1996a).

However, effluent credit trading has several obstacles. Foremost among them, in terms of market system requirements, is the ability of a buyer to accurately monitor and quantify effluent reduction amounts to compare seller prices on a price per unit reduction basis or simply to verify the value received for an investment. Furthermore, buyers must be assured that the reductions received from a trade are real and acceptable to a regulatory agency so that the agency will not charge that the buyers discharges are over its permitted or allocated discharge limit.

In this context, monitoring assumes a broader definition than is normally attributed to it. Monitoring, as used in this thesis, includes all the information gathering activities associated with the input variables that influence nonpoint source pollutant discharges. These variables include:

- Water quality measures such as chemical or biological concentrations;
- Land use measures such as cultivated land area, cultivation methods, and fertilizer use;
- Soil erosion measures such as soil type, slope, rain fall, and proximity to stream;
- Pollution prevention methods such as best management practices, cropland retirement programs, and wetland restoration programs.

A second obstacle, in terms of administering a trading program, is the ability of a regulatory agency to accurately monitor and quantify discharges from nonpoint sources to verify compliance with permit limits or contractual obligations to reduce nutrient discharges. This verification is necessary to encourage additional pollutant reduction capacity to protect receiving water quality.

Another agency need is to identify areas that contribute a higher portion of the pollutant load. The latter applications imply water quality planning using information generated by trading.

A regulatory agency has several specific pollutant discharge quantification needs that monitoring serves. Monitoring is used to determine:

- Baseline pollutant discharges - What amount of pollutants are discharged with no controls or best management practices in place or without the benefit of any agency oversight?

- Pollutant reductions attributable to best management practices - What pollutant amount will be reduced by the use of specific best management practices or administrative controls?

- Verification of best management practice installation and maintenance - Are the best management practices contracted for or specified in a permit actually in place and are they maintained as per agency specifications?

- Monitoring frequency - How often are the best management practices and maintenance activities verified?

Some of these quantification needs are not directly quantifiable at least not in any continuous program-wide sense. To serve these needs many water quality and land use programs rely on monitoring indicators of pollutant discharge loads and impacts of best management practices. These indicators include the type and areas dedicated to best management practices. Delivery ratios or control efficiency percentages are assigned to best management practices and the amount of pollutant discharge averted by their use is calculated. The efficacy of best management practices is influenced heavily by proximity to streams, rainfall, and the timing of fertilizer application or land disrupting activities. Consequently, these parameters are monitored also.

EPA, in describing the North Carolina Pollution Reduction Trading Program of the Tar-Pamlico River Basis, says:

> “For a regulatory agency to justify an innovative [trading] program, measures of water quality improvement must be established, even if such measures are qualitative in nature . . . Where nonpoint source control is necessary to achieve meaningful water quality improvements and the existing infrastructure to implement such controls is insufficient, the uncertainty regarding the exact amount of nutrient reduction achievable from nonpoint source controls should be weighed against the benefits of initiating a program at least to minimize the loadings from nonpoint sources (Kilpatrick, 1995).

In writing about the North Carolina program, EPA further advised other trading programs nationwide to establish some type of effluent discharge assessment method. Essentially, EPA believes that a monitoring program or assessment method should be instituted even if such a program is partially or wholly "qualitative in nature." The 37 actual, proposed, demonstration, or pilot trading programs in the U.S. have different levels of and approaches to pollutant discharge monitoring. Some program monitoring strategies are direct water quality evaluations - streams are sampled and analyzed for the pollutants of concern. Other programs rely on indirect water quality evaluations - land use practices in a watershed are documented and calculations predict nutrient discharges to a stream segment or to receiving waters. Indirect monitoring strategies include modeling and algorithms on a field or watershed basis.

Each of these monitoring strategies has its own challenges due to the nature of nonpoint source pollution. At least three quantification problems are associated with nonpoint source pollution calculations. First, there is imperfect knowledge about the relationships between loadings and farm-level choices regarding input use and land management, and about transport of chemical residues and sediment to waterbodies. Second, loadings cannot be monitored or measured directly at the individual source level because nutrients, sediment, and other chemicals enter waterbodies over a dispersed area. Third, loadings depend on random climatic events and combinations of events including wind, rainfall, and temperature that act in concert with site-specific conditions of soil type, slope, and management practices (Letson, et al, 1993).

THESIS OBJECTIVES AND GOALS

This study will survey the nonpoint source discharge monitoring programs of several effluent credit trading systems in the U.S. It will document and discuss specific characteristics of nonpoint source pollutant discharge monitoring strategies. Finally, this thesis will compare trading program discharge monitoring characteristics to the current Virginia Cost-Share nonpoint source monitoring program.

The goal of this study is to recommend elements of a nonpoint source discharge monitoring strategy to the Commonwealth of Virginia that can be used in a trading program of its own.

EFFLUENT CREDIT TRADING BETWEEN POINT AND NONPOINT SOURCES

Effluent credit reduction trading is an economic-oriented method of solving water quality problems by focusing on cost effective, local solutions to problems caused by pollutant discharges to surface waters. In a trade, a party facing relatively high pollutant control costs is able to compensate another party to achieve an equivalent or greater, though less costly, pollutant reduction. Parties trade only if both are better off as a result of the trade. Several authors have called for the establishment of a marketable effluent credit reduction trading system in the United States (Joeres, 1983).

Based on its success in trading air credit reductions since the 1970s, EPA decided to promote similar system for water dischargers. As part of a strategy for reinventing environmental regulations, EPA developed a policy to support and promote effluent trading within watersheds to achieve water quality objectives. EPA's policy states that trading is an innovative way to develop more common sense solutions to water quality problems in watersheds and it offers several environmental, economic, and social benefits (EPA, 1995). The EPA developed an interim policy for trading water pollution reductions in its document *Draft Framework for Watershed Based Trading* (EPA, 1996a). This document also provides evaluation criteria for new trading programs.

The EPA considers the term "trading" to represent any agreement between parties contributing to water quality problems on the same waterbody that alters the allocation of pollutant reduction responsibilities between the sources. The EPA recognizes several types of water pollution trading possibilities. Trading can be between sources within a facility, known as intraplant trading. Pretreatment trading occurs between industrial sources that discharge to a municipal wastewater treatment plant. Trades can occur between point (industrial or municipal) sources or between point and nonpoint sources such as agricultural, urban, or forested areas. Finally, trades can occur between nonpoint sources. Regardless of the type of trading arrangement, EPA guidance says the total pollutant reductions must be the same or greater than what would be achieved had no trade occurred (EPA, 1996a).

For all trading program types and structures, the EPA believes that trading effluent credit reductions offers several potential economic and environmental advantages. The EPA believes that trading programs:

- Take advantage of differing marginal control costs. This is especially true for broad industrial classifications and when different types of sources must control the same pollutant.

- Allow new facilities to enter the market and older facilities to expand.

- Avoid costs of alternative regulatory requirements. Purchasing discharge credits can avoid the need for a discharger to install technology-based nitrogen or phosphorus controls.

- Impose longer-term regulatory goals in the absence of currently evaluated control technologies.

- Create an economic incentive for dischargers to go beyond minimum pollution reduction and encourage pollution prevention and the use of innovative technologies.

- Address broad environmental goals within a trading area.

- Reduce the overall cost of addressing water quality problems in the watershed. The savings can then be invested in return-producing activities.

- Overcome economic/political obstacles to environmental progress by linking the paths of point and nonpoint sources to work toward a common water quality goal (Kerr et al, 2000 and EPA, 1995).

In a trade, a buyer compensates the seller to reduce pollutant loads. Buyers purchase pollutant reductions at a cost lower than they would have had to spend to achieve the reductions themselves. Sellers provide the pollutant reductions over a prescribed period and receive compensation for the amount of reductions they effect. For example, in a nutrient trade between a point source and an agricultural practice, the seller (farmer) receives a monetary return for reducing the loss of purchased raw materials (fertilizers) or land resources (nutrients in topsoil) to a waterbody and the buyer (point source) receives credit for the nutrient reductions toward its discharge permit limit. It is the credit, earned from a reduction, that is actually traded.

Both point and nonpoint sources can create marketable pollutant reduction credits. A water quality trading program contains provisions to help nonpoint sources reduce their pollutant discharges by following specific design, maintenance, and monitoring requirements to ensure a net environmental benefit (a reduction of pollutant discharges) from each trade. Point sources can trade for credits gained from the pollutant reductions. Limits on each point source's ability to trade prevent degradation of local water quality that could result from trading. Reporting requirements and a readily accessible trade tracking database help ensure appropriate parties are accountable for trade results. Trading ratios are applied to each trade to ensure that trades result in reductions that can accommodate the differences between source pollutant loadings and the variability of the weather-influenced nonpoint sources discharges.

A trading program creates an incentive for facilities with lowest reduction costs (control device, process change, or technological enhancement) to reduce emissions below their permitted amount and to bank the unused credit or transfer it to a trading partner. In this system, both parties can profit since overall compliance costs are reduced. Facilities that invest in reduction measures can recoup some of their investment, and monies that had historically been considered "lost" or "the cost of doing business" can now provide some return.

Initially, in the *Draft Framework for Watershed-Based Trading* document, EPA suggested two types of trading structures if one of the partners is required to have a point source discharge permit under Section 402 of the Clean Water Act. Trades could occur through development of a Total Maximum Daily Load (TMDL) allocation framework. In this structure, the TMDL allocation process establishes a collective discharge cap and trading partners negotiate within that loading capacity. Alternatively, trades could occur within the context of a point source discharge permit. In this structure, similar trading partners would arrange a trade with the approval of the permitting authority. In effect, traders pool their discharge limits and collectively discharge below that limit. In addition to direct trades, EPA suggested that trading partners could participate in public or private banks that could buy and sell pollutant reductions or even bank them for future use (EPA, 1996a).

Trading program structures vary among three general types. Cap-and-trade markets trade effluent credit reductions between partners subject to a declining regulatory cap. These programs "cap" or limit total pollutant discharges to receiving waters for all discharges in the watershed. The TMDL process could establish the cap amount. The collective discharge cap or load gets smaller incrementally over time. Open markets do not have such a system-wide reduction goal. These programs allow facilities to participate at their own discretion according to their need. This structure uses the discharge permit limit to determine individual reduction needs. For example, sources that receive a lower pollutant credit in a permit renewal are allowed to purchase reductions in lieu of greater treatment. Case-by-case programs review and approve individual trades. These administrative tasks require significant transaction costs from the partners and the agency to negotiate the trade (Kerr et al, 2000).

VIRGINIA WATER QUALITY IMPROVEMENT ACT

The Virginia Water Quality Improvement Act includes a clause which requires investigation of trading as a means to meet its goals. The Virginia Department of Environmental Quality (DEQ) is currently in the process of working with stakeholders to develop a point-to-point source trading program in Virginia. DEQ is working with the Virginia Water Resources Resource Center to hold stakeholder meetings for this purpose. DEQ has also formed a Water Resources Committee consisting of stakeholder groups to advise the DEQ Director on matters relating to Virginia's water resources. One of the topics this group plans to address is trading.

CHESAPEAKE BAY PROGRAM NUTRIENT TRADING

The Chesapeake Bay Program is also considering nutrient trading. In 1999, the Chesapeake Bay Program established a Nutrient Task Force to determine actions to supplement the existing tributary strategies to maintain the 40 percent nutrient reduction goal. The Task Force's report recommended nutrient trading as a way to maintain the discharge cap despite increased loads expected from increases in agricultural loads from expansion and further intensification of animal agriculture, sewage flows, and polluted runoff from new development.

The Chesapeake Bay Program intends to have an oversight role for nutrient trading coordination and assessment. Each jurisdiction (e.g., state agency, watershed management group, or stakeholder association) should form a central coordinating office to track, enforce, monitor and assess trades. Trades would be administered in the form of a general permit and each proposed trade must give public notice of the intent to trade. A public comment period would allow stakeholders to evaluate the detailed trading information that is submitted to the states (CBP, 2000).

SUMMARY

Trading seems to offer compelling economic and water quality protection or enhancement advantages. Point source buyers of effluent reduction credits are able to achieve pollutant reductions at a lower cost by trading. Nonpoint source sellers of effluent reduction credits receive financial incentives from trading to install best management practices on their land rather than use a cost-share program that only subsidizes a portion of installation costs. Receiving waters benefit from bringing previously uncontrolled nonpoint source dischargers into a system that actively promotes adoption of best management practices.

MONITORING TO VERIFY NUTRIENT REDUCTIONS FOR TRADING

Monitoring and reporting activities are critical elements to any effluent credit trading program. They provide the basis of information for the stakeholders to objectively evaluate whether pollutant target levels and other responsibilities are being carried out. Indeed, accurate results and timely reports are necessary for oversight agencies to verify that the goals of an effluent credit trading program are met at periodic reviews. In this way, nutrient reductions from best management practice implementation can be quantified, and trading or control device deficiencies can be identified and addressed. This monitoring issue is crucial to the success of a trading program (EPA, 1995a).

Basic to monitoring a trading system is the set of management measures used. Management measures can generally be classified by control technique. Source reduction techniques can be thought of as ways to reduce the land area that discharge pollutant or to reduce the pollutant use on the land.

Delivery reduction techniques are ways to reduce the amount of pollutants that reach receiving waters. These techniques rely on the efficiency of best management practices and are quantified through calculations developed by USDA and others or by modeling. Experimentally, the relative upstream and downstream pollutant loads can be compared to calculate a pollutant removal efficiency.

Reduction of direct impact techniques are ways to mitigate the impact of pollutants once they reach a stream. Forested riparian buffers are one example of this technique that is promoted by the Chesapeake Bay Program (CBP, 1995) and the USDA. The buffers promote precipitation infiltration and incorporate nutrients into their growth, thus preventing steam impacts (EPA, 1993).

Each of these techniques has its strengths but, in general, they all must either determine the pollutant load delivered to receiving water or the water quality status of the receiving water (Coffey and Smolen, 1990). Loading is defined as the rate or mass influx of a pollutant to receiving water. Load monitoring can be used to assess the change in mass influx or to assess the change in pollutant export at a fixed station. Monitoring water quality status often means measuring a physical attribute, chemical concentration, or biological condition, and may be used to assess baseline conditions, trends, or the impact of treatment on the managed resource (EPA, 1993).

Instream monitoring of water quality is the most direct method to determine the effect of management measures on nonpoint sources but the sensitivity (i.e., ability to detect change) may be low if a large number of samples are not collected and analyzed over the full range of climatic and operational conditions. When the likelihood of detecting water quality trends is low, load monitoring near the source may be necessary.

The alternative to sampling and analysis based monitoring systems is to monitor water quality by indirect methods such as modeling and land use evaluations. Indirect monitoring methods use indicating or indexing information that relate measured parameters to water quality. For example, soil type, slope, and distance to a stream are all parameters that influence soil erosion. The amount of soil reaching a stream determines how much water quality is degraded directly by soil or by the pollutants attached to soil (mainly phosphorus). Indirect monitoring methods use measured values of soil phosphorus, rainfall, and erosion potential to calculate the stream eutrophication potential.

Some authors suggest that the TMDL provisions of the Clean Water Act could be the program vehicle to reduce pollutant discharges by allocating stakeholder discharges on impaired water segments (FACA, 1998). Presumably, TMDLs would require additional monitoring to document individual source discharges. Consequently, EPA proposed a discharger offset program for new and "significant expansion" of existing sources that would have required these dischargers to offset any new or increased pollutant loading to an impaired waterbody by obtaining reductions in the loading of the same pollutant from an existing source located on the same waterbody. The offset would have to be at least 1.5:1 to ensure "reasonable further progress" in reducing pollution.

However, based on comments, EPA did not propose using offsets to achieve "reasonable further progress" toward attaining water quality standards through revisions of the Federal antidegradation policy or the National Pollutant Discharge and Elimination System (NPDES) permit regulation. Commenters said that nonpoint source pollution reductions would be difficult to measure or quantify due to the variability in flow, pollutants, and loading. They also suggested that the impact of reductions achieved by nonpoint sources using best management practices would be difficult to demonstrate. Additionally, they asserted that the offset provision would be a disincentive for point sources to trade because they would be held liable for a nonpoint source's failure to achieve the requisite reductions (Federal Register, 2000). This view of offsets in the TMDL program has no impact on EPA's policy on trading effluent credit reductions.

Commenters are correct in their assessment of the difficulty in directly measuring and quantifying pollutant reductions for nonpoint sources. It is difficult and expensive to conduct these evaluations. It is equally difficult and expensive to measure cumulative nonpoint source pollutant reduction impacts from many dispersed locations on water quality. These monitoring criticisms are central to trading program objections.

Trading criticisms focus on the ability of administrative agencies to quantify and then verify over time the amounts of nonpoint source materials involved in individual trades. The four areas of monitoring concerns are:

- Baseline pollutant discharges.
- Pollutant reductions attributable to best management practices.

- Verification of best management practice installation and maintenance.
- Monitoring frequency and credit reassessment.

SUMMARY

Monitoring baseline and controlled nonpoint sources is difficult due to the site-specific weather-related nature of discharges. Direct and indirect monitoring strategies have been developed to determine baseline and controlled discharges and to verify the pollutant quantities over time. The choice of monitoring strategy is based on the pollutants to be tracked, the cost of conducting the monitoring, the level of accuracy acceptable to agencies and stakeholders. Trading programs need a system that economically monitors and quantifies the magnitude of controlled and uncontrolled nonpoint source discharges and provides an annual estimation of the reduction credits earned by each source.

MONITORING REQUIREMENTS OF FEDERAL AND STATE NONPOINT SOURCE AND WATER QUALITY PROGRAMS

Two Federal entities share the responsibility to improve water quality or to prevent its degradation: the United States Environmental Protection Agency through the Federal Water Pollution Control Act of 1972 and the United States Department of Agriculture indirectly through its soil conservation programs. Since 1972, the United States Environmental Protection Agency (EPA) has regulated pollutant discharges, including some forms of nutrients, from municipal and industrial facilities into the nations waters. Beginning in the 1980's, the United States Department of Agriculture (USDA) began several farming-related soil erosion control programs that have indirectly improved water quality. Both programs use extensive water quality monitoring systems to gauge their progress.

ENVIRONMENTAL PROTECTION AGENCY CLEAN WATER ACT

The Federal Water Pollution Control Act (FWPCA) of 1972 [33 U.S.C.A. Section 1251 et seq.], commonly called the Clean Water Act (CWA), and its amendments "federalize" water pollution control efforts and focus on pollutants discharged and water quality itself. The amendments address in great detail "point sources," which are:

> "any discernable, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged." [40 CFR, Part 122.2]

This definition includes stormwater runoff from certain industrial facilities and local municipal stormwater collection systems as well as wastewater treatment plant effluents. Some activities, such as runoff from agricultural fields and orchards and return flow from irrigation, are specifically excluded. Section 402 requires point sources that discharge any pollutant to surface waters to have a National Pollutant Discharge Elimination System (NPDES) permit. All point sources must monitor their discharges and submit periodic discharge monitoring reports. In this context, monitoring includes sampling and analyzing effluent streams plus, in some instances, upstream and downstream samples. The NPDES permit sets maximum discharge limits for various pollutants based on uniform national limitations that reflect the technological capabilities of different industries.

Three CWA sections are the primary regulatory tools for nonpoint source controls and reporting and each, directly or implicitly, requires water quality monitoring (sampling and analysis). Section 305, "Water Quality Inventory", requires states biennially to complete Comprehensive Water Quality Assessment Reports that describe causes of polluted waters and where and when waters need special attention. Section 305 makes clear that "all navigable waters" and all dischargers are to be included. Section 305 says:

> "…a description of the nature and extent of nonpoint sources of pollutants, and recommendations as to the programs which must be undertaken to control each category of such sources…" (305(b)(E), 86 Stat. 854)

In this situation, samples are typically collected from the mouth of a watershed and the analytical results are assumed to indicate the health of the entire watershed. Reports are used to support watershed and environmental policy decision making and resource allocation to meet water quality protection or improvement needs. Section 305 is instituted as state-wide ambient water quality monitoring programs.

Section 319, "Nonpoint Source Management Program", requires states to prepare Nonpoint Source Assessment Reports that identify:

> "Those navigable waters within the State which, without additional action to control nonpoint sources of pollution, cannot reasonable be expected to attain or maintain applicable water quality standards…" (319(a)(1))

The reports are to identify categories of nonpoint sources, the state's process for identifying best management practices, the state's best management practice control measures for each category, and the state and local programs for controlling pollution from nonpoint sources. Section 319 also requires a nonpoint source management plan.

Section 303, "Water Quality Standards and Implementation Plans", requires states to adopt water quality standards and to identify and establish a priority ranking for waters that do not, or are not expected to, achieve or maintain those standards (impaired waters) with existing or anticipated technological point source controls. States are required to establish Total Maximum Daily Loads (TMDLs) for impaired waters following such a ranking. The TMDL process calculates the maximum pollutant load a waterbody can receive without exceeding the state-established water quality standards. The maximum waterbody load (assimilative capacity), minus a margin of safety, is then allocated to all dischargers to the waterbody. Thus, TMDLs represent an upper limit or cap of pollutant loads to a waterbody and they must not be exceeded or the receiving water quality will degrade (backsliding). This section's goal was to set standards for all the Nation's waters based on the various needs of each (Pronsolino vs. EPA Region IX, 2000). Section 303 holds promise to be the vehicle by which states will control NPS pollution.

On July 13, 2000, EPA published final rules for establishing TMDLs. In the preamble to the Federal Register notice, EPA said it believed that:

> "…these regulations are necessary because the TMDL program which Congress mandated in 1972 has brought about insufficient improvement in water quality." (EPA, 2000).

All three of the above CWA sections require periodic water quality reports for each of the stream segments they address. This information is supplied through an extensive stream monitoring program and augmented by the Section 402 NPDES discharge monitoring reports of point source dischargers. Together, the water quality information is used to assess water quality trends, to identify watersheds or actual stream segments that need additional protection or changes in water quality management practices, the condition of the entire watershed , or the cumulative pollutant contributions by all dischargers. In this context, monitoring means actual sampling and analysis of stream segments.

Sections 305 and 319 provide for water quality monitoring plans. These plans contain certain design and review elements for the information they generate to be acceptable to EPA:

- Monitoring approach (chemical, biological, or physical parameters).

- Parameters measured and analyses used.

- Quartile values for chemical parameters based on historical or first-year data for each season and monitoring station.

- Monitoring frequency. Chemical monitoring must be performed with at least 20 evenly-spaced grab samples per season.

- Monitoring design and monitoring station identification (paired watersheds, upstream-downstream, reference sites, or a single downstream site).

- Drainage area and land use for each water quality monitoring station (EPA, 1991).

Virginia CWA Monitoring

In support of CWA programs, the Virginia Department of Environmental Quality (DEQ) operates almost 1,000 ambient water quality monitoring stations on about 49,000 steam miles. The objective of the Ambient Water Quality Monitoring (AWQM) program is to collect information on the 17 river basins in the state. The goal is to provide the basis on which to determine whether State waters support their designated uses (DEQ, 1999).

The AWQM program has several regulatory goals as well. It is to generate data to:

- Develop designated use classifications and water quality standards.
- Provide input to the CWA Section 305(b) report.
- Provide background data for establishing point source discharge permit limits.
- Provide background data for establishing TMDL’s.
- Monitor discharge permit compliance (DEQ, 1999).

Although the AWQM program can provide background data for specific dischargers (i.e., to establish TMDLs or to bracket a significant nonpoint discharger to show water quality impacts) its purpose is broader. Its purpose is to determine water quality trends in river systems, watersheds, or inputs to estuaries. Basically, the AWQM reflects the constraints and goals of the CWA programs it serves.

As seen in the above descriptions, the water quality monitoring requirements of the CWA are watershed based evaluations. They are not able to, except in certain circumstances, quantify, show trends for, or establish the impacts of individual nonpoint source control practices. Even as part of water quality databases such as EPA's STORET, these data can only show general program effectiveness trends. But, that was their intent. These regulations are unlikely to provide monitoring support to effluent credit trading programs except in the sense that they demonstrate watershed water quality trends after such programs are instituted. Verification of individual trade reductions are outside the scope of CWA programs.

UNITED STATES DEPARTMENT OF AGRICULTURE

The other Federal agency with a nonpoint source pollution mandate is the United States Department of Agriculture (USDA). The Farm Services Agency has, since 1985, administered USDA programs that provide direct payments (cost-share assistance) to landowners to subsidize conservation practices. Many of these programs provide direct water quality benefits that augment the initial USDA soil erosion focus. The Federal Agriculture Improvement and Reform Act of 1996 (PL 104-127, 16 U.S.C. 3811, et seq.), known as the 1996 Farm Bill, revised USDA's conservation programs to address high priority environmental protection goals. Three of the most influential water quality protection conservation programs are the Environmental Quality Incentives Program, the Conservation Reserve Program, and the Conservation Reserve Enhancement Program. The water quality monitoring activities of the three are similar so only the Conservation Reserve Enhancement Program is discussed below.

Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program (CREP) is the embodiment of the increasingly environmental focus of USDA programs. It is a state and federal conservation partnership that targets significant agricultural water quality, soil erosion, and wildlife habitat issues. The CREP program uses financial incentives to encourage farmers voluntarily to remove lands from agricultural production (rent) and install conservation best management practices. This program subsidizes 50 percent of the per acre costs for all approved conservation practices plus maintenance incentive payments. Additionally, they annually provide additional incentive payments of 25 to 50 percent of the base rental rate for riparian buffers, filter strips, or restored wetlands. Soil and Water Conservation Districts (SWCDs) also develop conservation plans for CREP lands with identified natural resource problems and conduct annual performance reviews to access how well the activities address environmental issues.

The environmental returns for CREP can be substantial. For example, the Virginia Department of Conservation and Recreation (DCR) submitted two CREP proposals to USDA in 1998. Table 1 shows that DCR calculated nutrient reduction benefits of the CREP programs to be comparable to those of the State-sponsored cost-share best management practice program for selected rivers (FSA, 1999).

Table 1. Comparison of Cost-Share BMP and CREP Nutrient Reductions

<table>
<tr><th rowspan="2">Watershed</th><th colspan="2">Cost-Share BMP
Nutrient Reductions</th><th colspan="2">CREP
Nutrient Reductions</th></tr>
<tr><th>Nitrogen,
(tons/yr)</th><th>Phosphorus,
(tons/yr)</th><th>Nitrogen,
(tons/yr)</th><th>Phosphorus,
(tons/yr)</th></tr>
<tr><td>Roanoke</td><td>13.07</td><td>2.16</td><td>7.95</td><td>1.85</td></tr>
<tr><td>New</td><td>7.36</td><td>2.99</td><td>10.06</td><td>4.14</td></tr>
<tr><td>Potomac</td><td>76.39</td><td>8.98</td><td rowspan="4">258.44</td><td rowspan="4">33.48</td></tr>
<tr><td>Rappahannock</td><td>41.62</td><td>3.13</td></tr>
<tr><td>York</td><td>11.61</td><td>1.05</td></tr>
<tr><td>James</td><td>37.00</td><td>6.27</td></tr>
</table>

(FSA, 1999)

All of the CREP nutrient reductions described above are based on information gathered by local SWCDs. The SWCDs use the standardized Universal Soil Loss Equation (USLE) evaluation system to calculate erosion potential and soil loss to the edge of a cultivated field. This system incorporates soil erodibility, rainfall, plant cover, slope geometry, and agricultural conservation practice factors to calculate the average annual soil loss from a field or farm. Nutrient reductions are based on soil erosion reductions.

The USLE was developed from measurements on small plots with an average length of about 22 meters. A delivery ratio parameter is used to extrapolate erosion estimates beyond this scale. The delivery ratio is obtained by calibration of a USLE-based watershed model using measured field data to overcome the difference between upland erosion estimates and measured sediment yields. Consequently, the delivery ratio factor is a scaling parameter by which the erosion estimate is adjusted to measured sediment yields. However, the concept of a delivery ratio is a combined adjustment factor for a number of processes that contribute to temporal or permanent deposition of sediments in a watershed. These processes are highly variable and intermittent and can be described only in a statistical sense (Novotny, 1994).

Wischmeier (1976), USLE's developer, designed the soil loss algorithm for the following applications:

1. Predicting average annual field soil erosion under specified conditions.
2. Guiding the selection of conservation practices for specific sites.
3. Estimating the soil loss reductions available from various land use changes.
4. Determining how intensively a field could be cropped under various land uses.
5. Providing local soil loss data to agricultural erosion control agencies.

From these objectives, it seems USLE is well suited to calculate soil loss from individual fields, a collection of fields (a farm), or from all the fields in a watershed. These calculations are routinely performed by local Soil and Water Conservation District staff and the information is (as will be discussed later) used for effluent allocation trading programs once the soil loss information is transformed to reflect pollutant loading.

Researchers, and state agencies responsible for nonpoint source pollution control, have developed factors that relate soil loss to nutrient or pollutant discharges. For example, the Wisconsin DNR has extensive lists of factors and land conditions that show the relationship between applied phosphorus and that controlled by certain best management practices (WI DNR, 1999). Other state nonpoint source programs have developed similar factors for use in their state-wide evaluations of agricultural nutrient or pollutant discharges. In these programs, nutrient reductions are based on USLE and on data from different sources including the work of Roehl (1962) - a commonly referred to research paper that presents summarized delivery ratios and nutrient loading rates based on land use and morphological factors.

However, there are some concerns about using USDA soil loss evaluations as the basis of calculating nutrient discharge rates from agricultural sources. Some believe the link between agricultural management practices and the pollutant loading of waterbodies is uncertain about assigning a known amount of loading per acre of cropland, per type of crop, or per field (Malik, 1992). In general, the accuracy of the evaluation depends on several assumptions and estimates of actual site conditions to calculate soil losses. For example, USLE applies estimated soil type, soil slope, rainfall, and plant cover factors to the entire area evaluated. It does not account for variations in these factors over the entire area, nor does it account for proximity to the edge of field to influence soil loss calculations. Its successor however, the Revised Universal Soil Loss Equation (RUSLE), does account for distance to the edge of field.

VIRGINIA PROGRAMS

The Commonwealth of Virginia has several laws concerning nonpoint source pollution. The discharge law (VAC 62.1-44.5) reads:

> "Except as otherwise permitted by law, it shall be unlawful for any person to dump, place, or put, or cause to be dumped, placed or put into, upon the bank of

> or into the channels of any state waters, any object or substance, noxious or otherwise, which may reasonable be expected to endanger, obstruct, impede, contaminate or substantially impair the lawful use or enjoyment or such waters and their environs by others."

The DCR is the lead agency for nonpoint source discharge control but it shares some tasks with the Department of Environmental Quality. Together they devised the following monitoring and tracking objectives to protect water quality:

- Evaluate the state's waters for nonpoint source pollution related problems.

- Evaluate the state's waters, on a watershed basis, for nonpoint source pollution related problems for targeting nonpoint source pollution prevention activities.

- Coordinate with other public/private groups that contribute to the state's understanding of nonpoint source pollution related issues.

- Prioritize watersheds based on the potential of adverse impacts due to nonpoint source pollution.

- Determine the effectiveness of nonpoint source pollution control projects, programs, or strategies across various geographical scales from river basin to watershed to site-specific.

- Investigate and determine nonpoint source pollution related contributions or potential contributions on groundwater statewide.

- Improve support and use of citizen monitoring resources (DCR, 1999).

None of the monitoring and tracking objectives address individual nonpoint source discharges. They are all watershed-based activities. Two highly funded and more commonly used Virginia nonpoint source control programs that do address individual nonpoint source discharge loading are discussed below.

Agricultural Best Management Practices Cost-Share Program

The cost-share program is administered in Virginia by the DCR, but locally the SWCDs conduct day-to-day activities. The purpose of the program is to subsidize installation of best management practices by farmers and landowners to control nonpoint source discharges. The SWCDs work with a prioritized list to correct land use practices that most impact water quality (ELI, 2000).

The effectiveness of each best management practice is calculated from land conditions and existing pollutant reduction efficiencies (DCR, 2000). Thus, the evaluation requires no water quality monitoring to verify the nutrient or other pollutant reductions it is intended to accomplish. The SWCDs perform a visual inspection of some portion of all installed best management practices each year. This inspection does not include a true evaluation of the critical criteria. It is more an appraisal of the dimensions and a survey of the condition of the best management practices used at each farm.

Agricultural Best Management Practice Tax Credit Program

Virginia has an income tax credit program that rewards the installation of agricultural best management practices when installed under a soil conservation plan approved by the SWCD. The program reimburses part of the out-of-pocket best management practice installation capital expenses as a tax credit. Pollutant reduction credit is automatically awarded provided the best management practice is covered in the soil conservation plan and is listed in and complies with the specifications in the *Virginia Agricultural BMP Manual*. Follow up verification of the installation or maintenance of the best management practice is meager. The SWCD staff only inspect five percent of the plan installations each year (ELI, 2000).

The agency applies a best management practice control efficiency to erosion loading rates to calculate overall nutrient reductions. With development of the Chesapeake Bay model, DCR has a more sophisticated tool to use to calculate nutrient loadings and reduction and they now rely heavily on that model and others.

Within the Chesapeake Bay watershed, DCR uses the output from the Chesapeake Bay Watershed model to perform all nutrient tracking calculations. Currently, the Soil and Water Conservation Districts report to DCR the type and extent of best management practices installed using data from their best management practice tracking program. Using the Chesapeake Bay model efficiencies for each best management practice DCR calculates the phosphorus loading to the Bay, which is closely associated with sediments, and nitrogen loading, which is less so. DCR believes the model contains the best information available.

DCR does not have a model of similar utility for the entire state, but they have tried to extrapolate information from the Chesapeake Bay model into other areas that have similar slopes, soils, and land use. These efforts are augmented with other models and techniques that can be used, kind of in between just using the USLE. Although some of them rely very heavily on USLE for sediment and in part for the phosphorus, but for nitrogen they usually take other measures into consideration, because again, nitrogen is not as directly connected to the sediment as phosphorus is. Of particular use is the HSPF model, which, like the Chesapeake Bay Watershed model, is not a field-based model. Most of the statewide type assessment projects conduct modeling on a watershed basis, a small watershed basis but still a watershed basis. The rational is that although conditions vary on a field by field basis, on average, DCR believes that the loadings are correct (Bennett, 2000).

Mark Bennett, of the Virginia DCR, speaking about his departments' effort to accurately calculate nutrient loading to streams based on soil loss calculations said,

> "You've got a [farming] community out there that wants to make sure that they get credit for what they're doing to the greatest degree, and we've also got another community that's making sure that [farmers] not getting too much credit for what they're doing. Our job is to make sure that we do our best in picking the number that we feel is supportable (Bennett, 2000).

Recently DCR implemented a new assessment model to identify watersheds at risk for nonpoint source pollution. The model uses geographic information system inputs of land cover, soils, and topographical data to estimate nutrient and sediment loadings for each of the 493 state watersheds (Hession et al, 2000). DCR will use this model to track hydrologic units at risk for nonpoint source pollution and to assess the effectiveness of control practices. The DCR model provides a consistent method of determining nonpoint source control effectiveness based on local Soil and Water Conservation District information.

In summary, the DCR uses a different strategy than DEQ to monitor or quantify water quality impacts. DCR uses United States Department of Agriculture inspection procedures based on years of farming practices experience and soils engineering data to calculate agricultural nonpoint source pollutant discharges.

CHESAPEAKE BAY PROGRAM

The Chesapeake Bay and its tributaries have special conservation requirements as part of an agreement made with neighboring states in 1987. Pennsylvania, Maryland, and Virginia, as part of the Chesapeake Bay Preservation Act [9 VAC 10-20 et seq.], established Chesapeake Bay Preservation Areas. These are lands, which, if improperly developed, "…may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries." Lands within these regions must incorporate water quality protection measures into their zoning and subdivision regulations [9 VAC 10.20-160].

These regulations require landowners in 29 eastern Virginia counties to, among other things, maintain 100-foot wide permanently vegetated stream buffer strips for new development projects. The Chesapeake Bay Local Assistance Board (CBLAD), created by the Chesapeake Bay Preservation Act, funds SWCD staff to perform site-specific evaluations of the effectiveness of these buffers other appropriate best management practices. Evaluations include an analysis of the potential for erosion and of the nutrient loadings, such as phosphorus, from each site. Staff may recommend additional control measures to augment existing practices to reduce soil loss and protect water quality (Crafton, 2000).

The completeness and thoroughness of Chesapeake Bay Preservation Act program follow-up evaluation is in contrast to the other Virginia nonpoint source control programs. The CBLAD program is periodic, complete, site-specific, and compares pollutant runoff values to a standard threshold value and to a reduction criteria for redeveloped sites. Furthermore, the program has a component to recommend additional controls to the owners to come into compliance with the threshold limit. Funding for enforcement personnel, however, has not kept pace with program expectations.

SUMMARY

The two Federal entities use very different approaches to monitor the water quality impacts of nonpoint sources. The EPA uses a water quality approach that relies on instream sampling and analyses to monitor the health of watersheds. The USDA and its soil erosion prevention approach monitors land characteristics and land use activities to calculate the delivery of pollutants to receiving waters. The two approaches use very different activities to conduct monitoring. Their results are different and are used in different ways.

The EPA approach generates data that quantify the mass or load of pollutants discharged from a watershed but does not identify individual dischargers. The USDA approach generates data that shows the contributions of specific areas within the watershed but, again, it does not identify individual dischargers - although it could.

Regional or state efforts to institute nutrient effluent credit trading programs seem poised to use the resources available to monitor and assess the impacts of trading. These resources, in the form of existing state nonpoint source control programs could form the basis of a trading program monitoring system. The various agricultural control programs, collectively or individually, have knowledge of specific nonpoint sources, nonpoint source operators, and the mechanics of controls and contributing factors that influence the magnitude of nonpoint source discharges. They already have an administrative system that evaluates and monitors agricultural nonpoint sources. To incorporate an additional monitoring component, based on the existing USLE calculations, modeling results, or an empirical sampling and analysis program would be in keeping with their program goals.

One benefit of using these state-level programs in concert with or in addition to a trading program is to prevent double counting of reduction credits (i.e., can not allow nutrient reduction trading credits for reductions required by these programs). On the other hand, Rich Gannon of the Tar/Pamlico Trading Program sees potential competition for nonpoint source reduction between new state nonpoint source programs and trading program needs. Sources required to implement nutrient reduction best management practices under these programs will not have excess nutrient reduction potential to use in a trading program (Gannon, 2000).

The problem with using state-level programs to monitor trading program effluent credit reductions is that none of the programs currently calculates reductions on an individual farm or field basis. All the SWCDs report to DCR best management practice utilization and crop acreages on a county basis. However, the tools to perform nutrient reduction calculations are in place. SWCDs have best management practice use records on a farm and field basis. They have soil type, soil slope, and crop use records on a farm and field basis. SWCDs have access to county level rainfall, temperature, and stream flow data. They may also have county level delivery ratio values for certain pollutants or nutrients that are more accurate than those found in the literature.

METHODS

There are about 37 effluent credit trading programs in the US (Environomics, 1999). Of the 37 programs , eleven are operating, with trades under way or completed. These eleven existing programs have all established administrative and technical monitoring and evaluation procedures that are available for comparison, and they have enough history to allow their administrators to discuss monitoring strengths and weaknesses. Consequently, these eleven programs were chosen for study. However, only nine separate, unique programs could be identified. Some states have multiple effluent credit trading programs that are duplicates of each other. These nine individual trading programs or state initiatives are included in this study.

In order for this study to be of value in Virginia in developing its own trading program, it addresses the five trading programs addressed in a recent dissertation concerning accountability issues (White, 2000). That dissertation explores the legal accountability for nonpoint source reductions in relation to point source trading partners, an association of trading partners, or to a state/local authority. White's dissertation calls for additional research into "…how nonpoint source reductions are estimated and monitored…(White, p.167, 2000)."

RESEARCH DESIGN

The research design is primarily a qualitative study that uses available information to describe selected trading programs. That information is augmented by more detailed monitoring information obtained from program administrators during telephone surveys. Fisher defines qualitative research in policy studies as those that use interpretive methods rather than empirical methods that are used in quantitative research (Fisher, 1995). Quantitative data readily lend themselves to numerical representation but qualitative date must be mathematically transformed to perform statistical evaluations. Rossi and Freeman suggest that qualitative data, such as unstructured interviews and observation notes are not easily summarized in numerical form. They also note that, "…the dividing line between the two types of data [qualitative and quantitative] is fuzzy." (Rossi and Freeman, 1993). This study uses the Total Design Method survey question construction techniques of Dillman (1978) to overcome quality control objections to telephone survey results. It also uses a statistical analysis method to evaluate differences between trading programs.

Survey Tool

The telephone survey consisted of questions to determine the monitoring system type followed by two question sets for each of the three monitoring system observed. The first question set evaluates the initial nutrient discharge amounts and the projected reductions. The second question set evaluates how nutrient discharge amounts are verified over the permit or contract period. Responses are limited but each question allows participants to provide alternate answers. All three surveys are included in Appendix II.

Both question sets attempt to show programmatic differences in the types of entities that administer trading programs and the approaches they use to calculate the amounts of materials discharged to streams. The questions are vague enough to be asked of very different programs and still receive an answer that can be used in a statistical analysis of the responses. Earlier discussions with four trading programs revealed that more specific questions would simply provide too many responses and that no real trends would emerge from the data. Thus, the general nature of the questions is dictated by the diversity of trading program objectives and methods to obtain those objectives.

Evaluation Tool

Hierarchical cluster analysis is a statistical evaluation tool that identifies and quantifies dissimilarities between data sets (Johnson, 1998). The Number Cruncher Statistical Systems (NCSS) tool used for this evaluation calculates how dissimilar data sets for each trading system are from each other and reports the magnitude of dissimilarity. For multivariate data sets, the distance between individual variables is combined to calculate the overall dissimilarity, and this difference is presented graphically in a dendrogram.

The horizontal axis of the dendrogram is a measure of the dissimilarity between data clusters. The vertical axis represents the objects as clusters. Each connection of two clusters is represented on the graph by a vertical line place at the level of dissimilarity between the two clusters (NCSS, 1997). The dendrogram portrays similar trading program monitoring systems in a “cluster”. The similarity of clusters is read from the dendrogram axis as the value where the two diverge, those with lower divergence values are more similar.

Information from the telephone survey of effluent credit trading programs was transformed into mathematical values that were entered into a NCSS agglomerative hierarchical clustering algorithm that uses Wards Minimum Variance Method. The method uses alpha and beta values of 0.50 and a gamma value of 0.90. The distance type is Euclidean and the scaling method is by standard deviation. The cluster cutoff value is 1.0.

RESULTS

SURVEY RESULTS

Results of the effluent credit trading program survey are presented in the following tables. The summary tables address two monitoring aspects of effluent credit trading programs:

1. How initial pollutant discharges from agricultural lands are calculated and what potential reductions from adoption of best management practices are available (Table 2).

2. How the adoption and maintenance of best management practices is verified over the life of the trade (Table 3).

In some instances, data was unavailable or not applicable to the trading program. In these cases, the symbol NA was used in the summary table. In some instances, individual trading programs were addressed, in others, state-wide programs are described.

HIERARCHICAL CLUSTERING ANALYSIS RESULTS

The dendrogram of the trading program's monitoring strategy (Figure 1) shows three clusters of effluent credit trading programs. These clusters relate to the basis of the information system(s) used to monitor and track nutrient discharges. There are no outliers to the clusters of programs.

Of the nine watershed or state trading programs surveyed, four use modeling to calculate nutrient discharge reductions, two use sampling and analysis activities, and three use land use evaluations.

Table 2. Trading Program Baseline Monitoring of Nonpoint Source Discharges

Trading Program	Agency that establishes baseline discharges	Baseline discharge calculation method	Baseline study duration	BMP choice	Site-specific plan/ agreement	Reduction credits documentation
Tar/Pamlico River, North Carolina	•Local County Advisory Committee •Tar/Pamlico Basin Association	Nitrogen Loss Estimation Worksheet (NLEW)	1 Year	•Local County Committee list •Farmer choice	Yes	Local County Advisory Committee
Michigan	Soil/Water Conservation District	•Modified Universal Soil Loss Equation	3 Years	•Agency list •Farmer choice	Yes	Agency internet-based registry
Dillon Reservoir, Colorado	State Agency	Jones-Bachman Watershed Model	1 Year	Attach to sewerage system only	No, attachment to sewerage system only	Point source NPDES permit
Minnesota	Trading Board	•Universal Soil Loss Equation •Revised Universal Soil Loss Equation	1 Year	Farmer choice	Yes	•Registry of permit -contracted reductions. •Annual report of permit and credit
Grassland Area Farmers Tradable Loads Program, California	Regional Drainage District	•Tributary sampling and analysis •Source sampling and analysis	Greater than 4 years	•Agency list •Farmer choice	Yes	Registry, calculated annually

Trading Program	Agency that establishes baseline discharges	Baseline discharge calculation method	Baseline study duration	BMP choice	Site-specific plan/ agreement	Reduction credits documentation
Lower Boise River, Idaho	State Agency Trading Program	•NPDES data •USGS tributary monitoring in main river	1 Year	•Agency list •Farmer choice	Yes	Contract between point and nonpoint sources
Fox-Wolf Basin 2000, Wisconsin	Stakeholder Association	Soil/Water Conservation District Assessment Tool (BASINS)	Greater than 5 years	•Agency list •Farmer choice	Yes	•Point source NPDES permit •Contract between point and nonpoint sources
Neuse River, North Carolina	Wetland Restoration Program	Land use specific export coefficient	NA	Wetland development or restoration only	Yes	Wetland Restoration Program
Cherry Creek Reservoir, Colorado	State agency	Jones-Bachman Watershed Model	1 Year	Agency list	No, only general regulations apply	Trading Credit Pool

Table 3. Trading Program Verification Monitoring of Nonpoint Source Discharges

Trading Program	Agency that verifies discharge reductions and loads	Pollutant discharge estimation method	Pollutant reduction credits change from year to year	Changes that influence pollutant reduction credits	Are overall pollutant loads tracked or only reductions?
Tar/Pamlico River, North Carolina	•Local County Advisory Committee •Tar/Pamlico Basin Association	Nitrogen Loss Estimation Worksheet (NLEW)	Yes	•SWCD survey of cultivated land, installed BMPs •State Agricultural Statistics	Overall nutrient loads by year
Michigan	Soil/Water Conservation District	Revised Universal Soil Loss Equation	No	Annual farmer letter describing: •Land use •Crop type •Crop area •Tillage method •Fertilizer use	Individual loads by NPS participant
Dillon Reservoir, Colorado	State Agency	Jones-Bachman Watershed Model	No	Reversion to septic tank system after attach to sewerage system.	Overall loads by year
Minnesota	Trading Board	•Universal Soil Loss Equation •Revised Universal Soil Loss Equation	No, assign reduction credit for BMP life	•Land use •Crop type •Crop area •Tillage method •Fertilizer use	Overall loads for BMP contract period

Trading Program	Agency that verifies discharge reductions and loads	Pollutant discharge estimation method	Pollutant reduction credits change from year to year	Changes that influence pollutant reduction credits	Are overall pollutant loads tracked or only reductions?
Grassland Area Farmers Tradable Loads Program, California	Regional Drainage District	•Tributary sampling and analysis •Source sampling and analysis	No. Based on TMDL allocation to each Drainage District.	CWA Sections 303, 305, and 319 reporting.	Individual loads by month.
Lower Boise River, Idaho	Soil/Water Conservation District	•NPDES data •Nonpoint source downstream data	Yes. Can change monthly, based on CWA Discharge Monitoring Report	•Up/downstream data •CWA Section 319 report	•Individual loads by month. •Reductions
Fox-Wolf Basin 2000, Wisconsin	Stakeholder Association	Soil/Water Conservation District Assessment Tool (BASINS)	Yes	Downstream data	•Individual loads by year. •Reductions
Neuse River, North Carolina	Wetland Restoration Program	Land use specific export coefficient	No, credit good for 30 years.	Wetland destruction	Reductions only
Cherry Creek Reservoir, Colorado	State agency	Jones-Bachman Watershed Model	No	NA	Overall loads by year

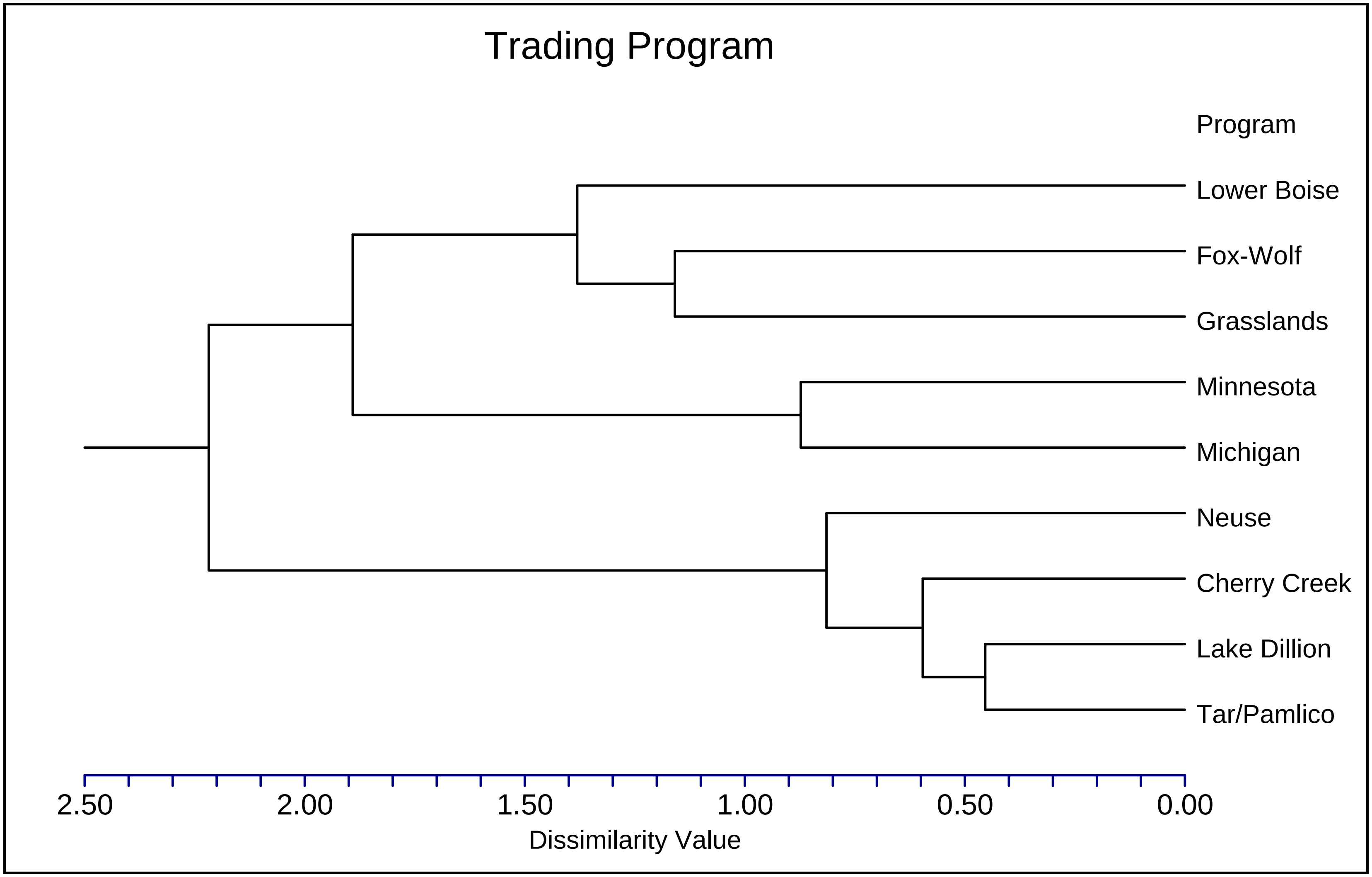


Figure 1. Trading Program Dendrogram

DISCUSSION

This section discusses trading program monitoring elements from the survey (Tables 2 and 3). In this context, monitoring is defined as all the information gathering activities associated with the variables that influence nonpoint source pollutant discharges. Direct monitoring includes sampling and analysis strategies. Indirect monitoring includes documenting land use practices and calculating nutrient discharges to a stream segment or to receiving waters. Indirect monitoring strategies include modeling and algorithms on a field or watershed basis.

MONITORING PROGRAM ADMINISTRATION

Effluent credit trading programs typically have a local watershed orientation.

The most common state trading program administrative oversight strategy is an ad hoc group within a larger statewide water quality department. This group coordinates information gathering from diverse sources and monitors the overall compliance of trading partners with discharge limits or contracts. The group calculates periodic and cumulative pollutant discharges and reduction credits. The benefit of this organizational structure is that a statewide water quality department can oversee the big picture - how the effects of individual trading programs or parts of a larger program are manifest in a large receiving water body such as an estuary.

The second trading program administrative strategy is an association of point source dischargers. These associations allow a certain distance between individual traders and they shield traders from individual enforcement actions for failure of the association to meet its collective discharge goal. For example, the Tar/Pamlico Basin Association trades by depositing money into a best management cost-share program. The cost-share program then disburses the money to nonpoint sources who deposit pollutant reduction credits into the program. This distance allows the umbrella state agency to monitor the trade without becoming a party to it.

A third trading program administrative oversight strategy identified was local committees or stakeholder associations. Nationally, the constraint of working in a specific watershed has prompted several states to adopt local program bodies to manage trading programs. This strategy is in keeping with the EPA’s stated goal of using a watershed approach to manage water quality. From programmatic and administrative perspectives, this approach makes sense. Trading is conducted on a local basis among sources known to the local trading program administrators.

Local committees or stakeholder groups can oversee part of a trading program (e.g., on a tributary of a watershed) or provide specific inputs to an umbrella state agency. For example, North Carolina Local County Advisory Committees are charged with bringing all the area stakeholders together to make fair requests for and allocations of pollutant discharge credits. They also coordinate monitoring of best management practices in terms of the types and areas involved.

Another local committee example is the Grasslands program. Its local presence arises from the western United States appropriative water allocation system. In California, Regional Drainage Districts oversee individual discharge monitoring as an outgrowth of their water district approach to water management. The drainage districts collect water samples and monitor flow rates to calculate weekly pollutant loading from each member.

Both local examples demonstrate a local knowledge of nonpoint sources, conditions, and most importantly the individuals that operate the sources. The interaction between stakeholders representing different interests is the glue that binds individual actions to collective watershed goals.

Virginia employs a top-down approach to monitor nonpoint source water quality impacts. The Department of Conservation and Recreation (DCR) relies on Soil and Water Conservation Districts (SWCDs) to monitor and report land use and best management practice implementation information. The DCR uses the county-wide summary information from SWCDs, with rainfall and stream flow data, to calculate the impact of the best management practices on water quality. DCR uses models and spreadsheets to perform these calculations.

Virginia should adopt a locally-oriented approach to monitor the water quality impacts of nonpoint source trading program partners. Local committees, based on the North Carolina administrative structure, are more responsive to landowner and stakeholder concerns and have first-hand knowledge of individual farms and fields. Committees could consist of local stakeholders including SWCD staff, farmers, regional DCR staff, and associations of point sources. Since the committees are composed of local stakeholders, 'selling' a trading program is easier and interactions between stakeholders is promoted.

INDIRECT MONITORING METHODS

All indirect discharge estimation methods rely on information from disparate sources and meld that information into an estimate of overall nonpoint source discharge loads to the ultimate receiving water.

Although trading programs use direct and indirect discharge estimate methods, the indirect methods of modeling and land use evaluation dominated the observed programs monitoring methods. Model or algorithm inputs are generally not gathered directly by trading programs. Land use evaluation information, provided directly or indirectly from local SWCDs, is the most widely used information. They also report soil types, land slope, and distance to receiving water. The USGS provides water flow monitoring data and, in some instances, water quality data to trading programs. Local meteorological monitoring stations or national climatic information organizations provide rainfall data. Nutrient transport coefficients are either from research literature, developed for the watershed or state, or are based on the best technical judgement of the oversight agency.

The Universal Soil Loss Equation (USLE), or a modified form of it, is used in all the indirect monitoring trading programs. USLE is a component of the models and algorithms used to calculate soil loss from land and then relate it to nutrient loss using a nutrient transport coefficient. How this relationship between soil loss and nutrient loss is handled is a major difference between trading programs.

By far, the source and use of model or algorithm nutrient transport coefficients used by trading programs varied more than any other information input. Transport coefficient factors varied by the information source used to establish them and by the way they are applied. For example, Wisconsin reported pilot program and literature review transport coefficients in “A Review of Agricultural and Urban Best Management Practices for the Reduction of Phosphorus Pollution.” The coefficients are used in “Economics of Trading-Spreadsheets” that enable trading partners to quickly calculate credits from specific best management practices under specific conditions. In contrast, Minnesota exclusively uses literature source nutrient transport coefficients. Factors from studies in the upper Midwest are given preference in their compilation.

The other observed nutrient transport coefficient difference was their application on a state-wide or a watershed scale. For example, Michigan uses nutrient transport coefficients that are applicable state-wide in all trading watersheds. Wisconsin, however, supplies nutrient transport coefficients that are watershed specific (at least for the three pilot watershed trading program studies).

One strategy to improve the use of USLE would be a standardized nutrient reduction calculation method or a guidance document that addresses the effect of best management practices. A group such as the National Water Quality Monitoring Council (NWQMC) may be the organization to develop such a guidance document or method for trading programs nationwide. The NWQMC has members in most state, federal, and local water quality programs who could bring the diverse knowledge and date gathering techniques together to formulate such guidance.

Initially, Virginia’s modeling efforts used transfer coefficient data from the literature. Over the life of their nonpoint source evaluation program Virginia DCR revised and sharpened those coefficients based on research study results. They now use Chesapeake Bay Program transfer coefficient data, some of which is being updated by a literature review by researchers at Virginia Tech.

Virginia should continue to revise its transfer coefficient database by incorporating additional research data from specific best management practices under specific conditions. These data should preferably be from studies in Virginia or at least from the Mid-Atlantic coast region.

BASELINE MONITORING STUDY DURATION

Most trading programs use the same methods to determine baseline pollutant loads and verify loads or reductions for each best management practice. The data generally covers a single year due to program implementation directives.

Despite the statistical advantage of using multiple years of discharge data, most programs were proposed and codified by their respective state legislatures for immediate implementation and use. The most common trading program practice is to use information from some year, preferably one that has sufficient relevant data, and call that the baseline data for the watershed best management practices. Generally, the amount(s) of reductions credited toward individual best management practices are based on that year.

Michigan, however, uses the most accurate information available for a representative three-year period to establish baseline loading. The evaluation includes 10 years of meteorological data, or the period of record, whichever is longer. Additionally, every five years the program must conduct ambient monitoring to assess water quality and quantify actual nonpoint source loading reductions. Grasslands also uses multiple years of monitoring information to establish a pollutant baseline. Five years of stream selenium data and up to 15 years of flow data were used to determine historical discharge trends.

The Michigan and Grasslands programs reflect an understanding that land use practices change yearly, seasonally, or even weekly. The baseline discharge calculation from individual farms or fields should consider the range of conditions that influence nonpoint source discharges over several years.

Virginia uses the Chesapeake Bay model and its own models to evaluate baseline pollutant contributions from watersheds. Discharge reductions from best management practice implementation from individual farms or fields is not calculated.

Virginia should modify its own models to calculate individual farms or fields develop discharges. Historical rainfall and water flow data, covering multiple monitoring years, should be used to calculate baseline discharges.

BEST MANAGEMENT PRACTICE CHOICE

Most trading programs allow the nonpoint source owner/operator to choose from a list of approved best management practices.

Nonpoint source owners/operators are generally allowed to choose the best management practice(s) to install and use on their property from a list developed by the trading program. Nonpoint sources owners choose from the approved best management practice list those practices they are familiar with, are appropriate to their operations, or can afford. David

Batchelor of Michigan DEQ summarized his department's view as, "Whatever works on the farm." This pragmatic approach allows farmers to be part of the solution process and promotes their use of techniques they understand and will actually use. Most trading programs do not develop best management practice lists de novo. They use available, experienced technical resources such as the State-level Soil and Water Conservation District office and/or the voluntary State agricultural nonpoint source control program.

Virginia also allows farmers to choose best management practices from an agency list of approved practices. This list was developed by DCR and SWCDs based on what is appropriate to the region and what is used by farmers.

Virginia should continue to use its system of approved best management practices.

SITE SPECIFIC PLAN

Most trading programs require a site specific plan that documents the best management practice(s) installed.

A site specific nonpoint source control plan is a way for the trading program and the owner/operator to agree on what is to be done, over what period, and what is to be accomplished by installing a best management practice. It provides clear measurable goals that, if met, assure a reliable quantity of pollutant discharge reductions. Many program plans incorporate or reference conservation plans or nutrient management plans required by other programs. The trading program plans typically cite the Natural Resources Conservation Service Field Manual as the best management practice technical reference.

Virginia also uses site specific nonpoint source control plans to define the actions to be taken to control discharges. Virginia also uses the Natural Resources Conservation Service Field Manual as the best management practice technical reference.

Virginia should extend its use of site specific management plans to include all nonpoint source control activities used in a trading program. Trading programs should incorporate nutrient management plans by reference.

REDUCTION CREDIT DOCUMENTATION

There is no consensus on how to document reduction credits.

Trading by permits is recommended by EPA and supported by environmental groups but only the Wisconsin trading program issues a NPDES permit to both participants. Four programs keep track of nutrient reduction credits in a registry. The Tar/Pamlico, Michigan, Minnesota, and Grasslands programs either use a local commission or a state agency to register credits available for trading with point sources. Michigan actually keeps its registry posted on its internet website for public inspection. The Grasslands registry is recalculated and the running credit total is faxed weekly to participants. This heightened level of record keeping is necessary because credits accrue daily and are traded monthly to meet a collective annual pollutant discharge limit.

The cost and availability of credits or allocations are central to any decision to participate in a trading program. Trading program administrators seem to agree that a documentation system must be visible by all present and potential trading partners and by all stakeholders.

One neat administrative solution to reduction credits is to assign them all to a specific nonpoint source control program. The Colorado Cherry Creek and the Neuse programs both enter credits into a pool for financing, installing, or improving wetlands in the watershed.

In Virginia, reduction credits are calculated on a watershed or county-wide basis by DCR. A good portion of this accounting supports Chesapeake Bay agreement goals. However, pollutant contributions from individual farms or fields are not quantified - they are combined in a county-wide or watershed total.

Virginia should either permit all trading program nonpoint sources or include their reduction credits in a registry. A nonpoint source permitting program should be based on the NPDES permitting system and it should describe the elements of the best management practice used at a site, reporting requirements, annual reduction credit calculation provisions, and enforcement provisions for the life of the best management practice.

ANNUAL REDUCTION CREDIT ADJUSTMENT

Individual nonpoint source effluent credit reduction credits generally do change from year to year.

The ability to adjust credits annually is central to the accounting requirements of many trading programs. Nonpoint source credit producers generally want the flexibility to react to different economic conditions that prompt crop production variations and to receive credit for their actions. Trading program administrators need the ability to have the total number of credits in a watershed be determined by the receiving water quality.

The Minnesota program realized a multiple year tracking system did not provide responsive enough data for planning and they plan to tighten their reduction credit tracking. They will require 100 percent annual reporting that includes photo documentation and a certification by the landowner that the best management practice is installed and maintained properly. Reduction credits are adjusted accordingly. All of the trading programs studied that use indirect reduction calculation methods, except one, currently calculate, or plan to calculate, reduction credits annually.

One exception is the Michigan program. Michigan considers that the value of credit continuity over the life of a best management practice permit necessary to economic stability and adoption of the program. Consequently, reduction credits are earned for three to five year periods.

Dillon Lake and Neuse River both have program structural components that do not allow yearly credit changes. Dillon Lake nonpoint sources produce credits when they change from a septic tank system to a sewerage system. Credits are awarded for the life of the connection. Neuse River nonpoint sources produce credits when they install or restore wetlands. Credits are awarded for the 30-year life of the wetlands.

The current Virginia Agricultural Cost-Share Program lacks a method to annually update reduction credits earned by each nonpoint source. The Cost-Share Program assigns nonpoint source discharge reduction credits over the life of the installed best management practices. Currently, these reduction credits are credited toward Chesapeake Bay agreement goals despite annual or seasonal changes in cropping practices.

Virginia should calculate and award reduction credits to individual sources annually. Reduction credits for the life of best management practices should be discontinued.

MONITORING POLLUTANT LOADS

Most trading programs monitor overall and area loads to ultimate receiving waters for program justification but do not monitor individual loads. Only three programs monitor individual loads.

Additional monitoring is necessary to prevent "cultivation creep". Cultivation creep typically takes two forms. In one form, land previously dedicated to best management practices gradually reverts to cropland. For example, a vegetated filter strip originally designed to provide a certain control efficiency at a certain width is, over its useful lifespan, whittled down in size. Without periodic inspections, the farmer is credited with the same amount of nutrient reductions over the entire lifespan of the best management practice. This situation is not fair to the buyers of those nutrient reduction credits. Nor is it accounted for in water quality agency evaluations of nutrient discharges in a watershed so they can reallocate funds or personnel to address the impacts of higher nutrient discharges.

The second form of cultivation creep is created when a farmer cultivates other lands to compensate the loss of land to best management practices. Although additional land is under cultivation, and presumably discharges nutrients to the streams, there is no accounting for the additional impacts. For example, Option 1 in Table 4 compares program credits from an initial evaluation that are applied over the entire period permit or contract period, regardless of the land use, to Options that credit change yearly and Options that account for putting additional land under cultivation.

Option 1 is a permit based system in which the permittee is credited with a certain amount of nutrient reductions each year of the permit period regardless of the land uses after the initial evaluation. In this example, the permittee is credited with 400 pounds of nutrient reductions per farm and debited 30 pounds for fallow land. Thus, 370 pounds are available for trading each year. Over the 3-year permit, 1,110 pounds of nutrients are prevented from entering water bodies and are available for trading but 1,890 pounds of nutrients are discharged.

Option 2 is a practice based system in which the permittee is credited with additional nutrient reductions each year of the permit period based on the increased land uses after the initial evaluation. In this example, the permittee is credited with 200 pounds of nutrient reductions per 100 cultivated acres each year and debited 10 pounds of nutrient reductions per 100 uncultivated acres. Over the 3-year permit, 1,950 pounds of nutrients are prevented from entering water bodies and are available for trading but 3,050 pounds of nutrients are discharged.

Option 3 is a party based system. It annually assesses the permittees's land use and assigns trading reduction credits accordingly. Over the 3-year permit, 390 pounds of nutrients are prevented from entering water bodies and are available for trading but 2,650 pounds of nutrients are discharged.

Without at least annual verification monitoring, trading programs quickly lose their ability to accurately calculate reduction credits. Moreover, without at least annual verification monitoring trading programs begin to generate data that prevents regulatory agency personnel from allocating the proper resources necessary to address watershed problems.

Only the Grasslands trading program directly monitors individual pollutant discharge loads, all but three of the other programs indirectly monitor overall and area loads. Generally, it is thought the cost of directly monitoring individual loads would make program administrative costs prohibitively expensive.

The Michigan trading program also requires annual reporting by agricultural nonpoint sources. Participants submit a form letter with simple direct statements to verify the extent of best management practices and crops. Michigan, however, assigns reduction credits for the life of the best management practice. The purpose of this strategy is to promote trading program adoption and stability during its first years.

Idaho allows a source to verify pollutant reductions by direct measurement or by calculation and all reductions are reported monthly as part of the point source's NPDES discharge monitoring report (DMR). Verification of those reported nonpoint source reductions are not performed on an as-needed basis and a reassessment of reduction credits can occur at any monthly DMR review. This system puts much of the best management practice verification burden on the point source, who may not have the expertise to make such a judgement.

Table 4. Example Nutrient Reduction Credit Strategies

Activity/ Area (acres)	Best Management Practice	Nutrient Contribution (pounds)					
		Option 1 Permit Based		Option 2 Practice Based		Option 3 Party Based	
		Reduction	**Additions**	**Reduction**	**Additions**	**Reduction**	**Additions**
Year 1 - 1000 pound Baseline Nutrient Contribution							
Corn / 200	VFS*	400	-	400	-	400	-
Fallow / 300	N/A	-	30	-	30	-	30
Subtotal	-	400	30	400	30	400	30
Total	-	370		370		370	
Year 2 - 1000 pound Baseline Nutrient Contribution							
Corn / 300	VFS	400	-	600	-	400	200
Fallow / 200	N/A	-	30	-	20	-	20
Subtotal	-	400	30	600	20	400	220
Total	-	370		580		180	
Year 3 - 1000 pound Baseline Nutrient Contribution							
Corn / 500	VFS	400	-	1000	-	400	600
Fallow / 0	N/A	-	30	-	-	-	-
Subtotal	-	400	30	1000	0	400	600
Total	-	370		1000		-200	
Grand Total		**1,110**		**1,950**		**350**	

*Vegetated Filter Strip

The Tar/Pamlico trading program uses an association of point sources collectively to monitor and trade for nutrient reductions. The association contributes to a state-administered best management practice cost-share fund if it exceeds a basin-wide nutrient credit cap. In this organizational structure, no one point source is at fault for excessive discharges, they purchase credits if their collective limit is exceeded. To date, this has not happened despite a declining discharge cap. The point sources have complied through process modifications and their pretreatment programs.

The Neuse trading program monitors its nutrient reductions through the North Carolina Wetland Restoration Program. All nutrient discharge reductions are earned by financing, installing, or improving wetlands and the credits from these activities are monitored in the State agency program.

The Colorado Dillon Lake program does not actively monitor pollutant reductions. The Dillon Lake program is primarily a sewage tank to a sewerage line conversion program and credits earned by this conversion are not documented per se. The changes in nutrient discharges to the lake are reflected by chlorophyl a concentrations. High chlorophyl a concentrations dictate tighter reductions by point source dischargers.

The Boise River program uses contracts between traders to document reduction credits. The contracts are very structured and contain the information necessary to delineate responsibilities of the parties involved. EPA Region IX has final authority to arbitrate disputes between parties and to change the terms of the contract if the river water quality does not meet its designated use(s).

The Virginia Cost-Share Program does monitor the implementation of best management practices on individual farms, however, the information is used only as a county-wide or a watershed total in resource allocation planning or calculating impacts to the Chesapeake Bay.

Virginia should indirectly monitor individual nonpoint sources using a computer-based tracking program that incorporates annual cropping information. Reduction credits should be calculated annually for each nonpoint source trading partner.

CONCLUSIONS

The current literature is unanimous in asserting that the water quality strategies used in the past three decades have made tremendous advances in improving and protecting the Nations' water quality. The literature is equally clear, however, that continuing to focus on point sources will not bring the remaining 35 to 40 percent of impaired waters into compliance with water quality standards. To attain that goal we must bring nonpoint sources into a control system. Effluent credit trading programs can link the current point source control strategy to the under-addressed area of nonpoint source pollution control.

Trading programs have several issues that must be addressed before they are widely accepted. Foremost among those issues is the ability of buyers to accurately monitor and quantify effluent reduction amounts to compare seller prices or simply to verify the value received for an investment. Furthermore, buyers must be assured that the reductions received from a trade are real and acceptable to a regulatory agency so that the agency will not charge that the buyers discharges are over its permitted or allocated discharge limit.

In general, stakeholders and the public expect a higher degree of nonpoint source discharge monitoring by trading programs than by agricultural cost-share or other state programs. This expectation may stem from a perception that some point source buyers purchase reductions that are not equal to the credit they claim toward their NPDES permit limit(s) or that the purchased value diminishes over time. Stakeholders demand a clear measure of the efficacy of the best management practices used to control nonpoint source discharges to counter this crediting uncertainty.

This study evaluated currently operating effluent credit trading programs to identify monitoring elements that could be incorporated into a Virginia trading program. The following elements were identified:

1. Virginia should adopt a locally-oriented approach to monitor the water quality impacts of nonpoint source trading program partners. Local committees, based on the North Carolina administrative structure, are more responsive to landowner and stakeholder concerns and have first-hand knowledge of individual farms and fields. Committees could consist of local stakeholders including SWCD staff, farmers, regional DCR staff, and associations of point sources. Since the committees are composed of local stakeholders, 'selling' a trading program is easier and interactions between stakeholders is promoted.

2. Virginia should continue to revise its transfer coefficient database by incorporating additional research data from specific best management practices under specific conditions. These data should preferably be from studies in Virginia or at least from the Mid-Atlantic coast region.

3. Virginia should modify its own models to calculate individual farms or fields develop discharges. Historical rainfall and water flow data, covering multiple monitoring years, should be used to calculate baseline discharges.

4. Virginia should continue to use its system of approved best management practices.

5. Virginia should extend its use of site specific management plans to include all nonpoint source control activities used in a trading program. Trading programs should incorporate nutrient management plans by reference.

6. Virginia should either permit all trading program nonpoint sources or include their reduction credits in a registry. A nonpoint source permitting program should be based on the NPDES permitting system and it should describe the elements of the best management practice used at a site, reporting requirements, annual reduction credit calculation provisions, and enforcement provisions for the life of the best management practice.

7. Virginia should calculate and award reduction credits to individual sources annually. Reduction credits for the life of best management practices should be discontinued

8. Virginia should indirectly monitor individual nonpoint sources using a computer-based tracking program that incorporates annual cropping information. Reduction credits should be calculated annually for each nonpoint source trading partner.

STATISTICAL EVALUATION

The dendrogram of the trading program's monitoring strategy (Figure 1) shows three distinct clusters. The Michigan/Minnesota cluster is the programs that use land use evaluations to determine nonpoint source discharges. The other two clusters do not entirely relate to the basis of the information system used to determine nutrient discharges. There are no outliers.

A second cluster includes the two North Carolina programs and the two Colorado programs. Tar/Pamlico and the two Colorado programs do use models to determine impacts on lakes or estuaries. Each of these programs is more like the other (less dissimilar) and the entire cluster shares more similarities than the other two clusters.

The third cluster includes the Boise, Fox-Wolf, and Grasslands programs. Both Boise and Grasslands use sampling and analysis programs exclusively or with other monitoring information sources. This cluster contains the least similar programs.

No real conclusions can be drawn from the statistical evaluation. Perhaps had more trading programs been evaluated, more conclusions could be drawn and more similarities could be identified.

APPENDIX I - LITERATURE REVIEW

INTRODUCTION

Agricultural sources contribute the majority of the mass of pollutants and the number of nonpoint sources that discharge pollutants to receiving waters. More than half of the fresh water used annually in the United States daily is irrigation water for agriculture. Some of this water is returned to receiving waters in streams, rivers, or lakes and carries with it dissolved and suspended materials. Rainwater also picks up and transports soil sediments, herbicides, pesticides, and nutrients from agricultural processes to receiving waters, often to the detriment of waters' other, more beneficial, uses.

ENVIRONMENTAL IMPACT OF AGRICULTURAL NONPOINT SOURCE DISCHARGES

Nutrient addition to a water body, particularly the elements nitrogen and phosphorus, is a process known as eutrophication. This process promotes algal growth that has several serious impacts on the water quality of receiving streams but is most severe in lakes and estuaries. These water impacts include:

1. Spring and summer algae blooms, fueled by high nutrient levels, produce low dissolved oxygen levels when the algae die and decompose. The decomposer organisms compete more effectively than fish for the dissolved oxygen in the water and the resulting low concentrations can be lethal to aquatic animals (CBP, 1994).

2. High algae concentrations, in combination with erosion sediments, reduce the amount of ambient light that reaches submerged aquatic vegetation thus causing die-offs of this important food source and cover for young fish and insects. The cumulative effects of algae and sediments drastically reduce the amount and diversity of aquatic life in affected waters.

3. Conventional treatment processes do not remove algal toxins that result from eutrophication. Carmichael found toxins in 80 percent of surveyed utility water systems in the US and Canada (Carmichael, 1999). Some toxins can produce central nervous system or liver diseases and may be linked to cancer (AWWA, 1999). Algae also produce compounds that impart taste and odors to drinking water thus reducing its aesthetic value and necessitating additional treatment steps to remove.

4. Algal toxins can alter the taste of fish, by that reducing the revenues from commercial and recreational fishing.

5. Algae reduce the recreational value of water and may degrade its quality to the point that it cannot meet the Clean Water Act goal of "fishable and swimmable" waters.

6. Algae can foul the heat-transfer piping of steam-powered utility boilers.

7. The microorganism *Phisteria piscicida* thrives in nutrient enriched waters. It causes skin lesions on and ultimately kills fish. In humans it causes memory loss, nausea, chronic fatigue, and disorientation (Wright, 1999).

8. Agricultural nutrients, in association with sediments, herbicides, and pesticides, are suspected as the cause of a hypoxic zone in the Gulf of Mexico at the mouth of the Mississippi River (Wright, 1999).

The National Water Quality Inventory Report to Congress for 1998 says that many of the Nation's waters are impaired or are threatened. The report says that pollutants in runoff from agricultural sources contribute 59 percent of the reported water quality problems, resulting in about 170,000 miles of impaired or threatened rivers. Table 5 summarizes the extent of waters that do not meet designated water quality standards. In toto, more than 20,000 individual waterbodies, representing approximately 300,000 miles of river and shoreline and approximately five million acres of lakes, do not meet state water quality standards (EPA, 2000).

Table 5. National Summary of Waters That Do Not Meet Water Quality Standards - 1998

Waterbody Type	**Assessed Waterbodies (%)**	**Assessed Waterbodies Not Meeting Water Quality Standards (%)**	**Assessed Waterbodies Threatened (%)**
Rivers and Streams	23	35	10
Estuaries	32	44	9
Lakes, Ponds, and Reservoirs	42	45	9
Great Lakes, (shoreline miles)	100	45	9

(EPA, 2000)

The Virginia Department of Conservation and Recreation estimates that in 1996, controllable nonpoint sources of the six major Virginia tributaries to Chesapeake Bay contributed 17,339 tons of nitrogen and 1,975 tons of phosphorus to the bay. Although these amounts represent a 12 percent reduction in nitrogen discharges and a 16 percent reduction in phosphorus from 1985, there is still a tremendous amount of nutrient reductions that could still be earned (DCR, 1998).

In the past several decades, the Chesapeake Bay's water quality has diminished and so have the food production, employment opportunities, and economic benefits associated with the Bay that the Mid-Atlantic region has enjoyed for so long. The decline in water quality is primarily anthropogenic - it arises from human activities on croplands, rangelands, and forests and from municipal and industrial effluents to Bay tributaries and the Bay itself. Figure 2 shows the relationship that as more nutrients are released into the Bay its overall biodiversity diminishes. Biodiversity is related to fish catches, jobs, and overall economic benefits derived from the Bay (Correll, 1998).

Nutrient additions to the Chesapeake Bay have several sources. In 1996, nitrogen inputs to the Bay come 42 percent from agriculture, 22 percent from sewage effluents, 16 percent from forests, 14 percent from urban sources, and 7 percent from air deposition. Phosphorus inputs come 51 percent from agriculture, 25 percent from sewage effluents, 5 percent from forests, 10 percent from urban sources, and 9 percent from air deposition (CBP, 2000). Fertilizer inputs are primarily from agriculture and, to a lessor extent, from urban sources. Oxides of nitrogen from fuel combustion in utility and industrial boilers and from mobile sources are the major nitrogen air deposition sources. Sewage sources include municipal and industrial wastewater treatment plants and private septic tank/field line systems. Phosphorus inputs are almost entirely from agricultural and urban fertilizer sources. This is certainly the case since the statewide ban on the use of phosphate-containing detergents in 1988.

In 1987, Virginia, Maryland, and Pennsylvania, signed the Chesapeake Bay Agreement, a plan to address water quality in the main stem of the Bay. This agreement called for a 40 percent nutrient reduction, from 1987 levels, in Virginia's rivers contribution to the Bay by 2000 and to maintain this level of reduction after that. A 1997 Joint Legislative Audit and Review Commission committee of the Virginia legislature study of the issue concluded that:

> "...it is unlikely that Virginia will produce a 40 percent nutrient reduction in its portion [nutrient reductions] of the Potomac by the year 2000. In addition, whether Virginia could maintain a 40 percent reduction [of nutrients to the Bay] in the years after 2000 is in great doubt (JLARC, 1997)."

The report goes on to say that population growth is the primary cause of rising nutrient levels. The implication is that the burgeoning Virginia population will require increasing agricultural food products, will produce increasing amounts of nitrogen from power generation and transportation, and will discharge increasing wastewater effluents, all of which release nitrogen into the ecosystem. Nitrogen and phosphorus reductions from 1987 levels are expected to be only 21 and 32 percent respectively by 2015 (Figures 3 and 4).

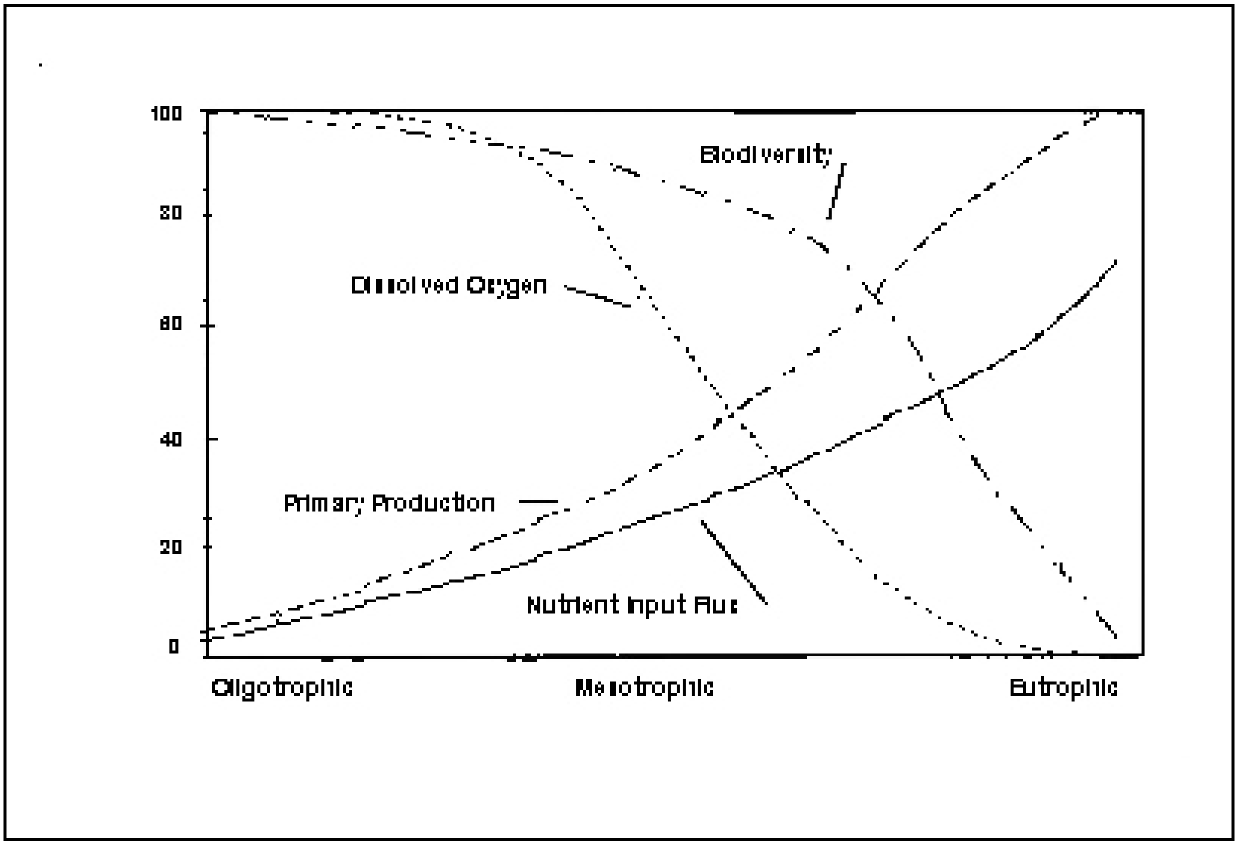
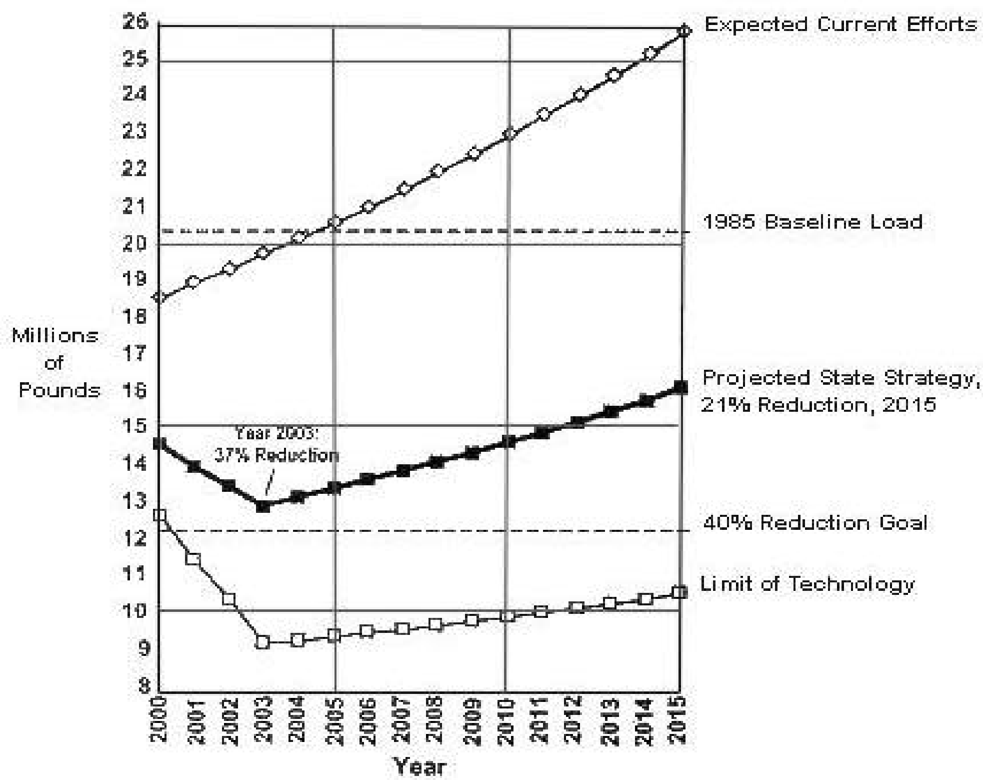


Figure 2. Relationship Between Nutrient Discharges and Chesapeake Bay Biodiversity

Figure 3. Nitrogen Comparison: Reduction Goals, Expected Current Efforts, Projected State Strategy, and Limits of Technology (JLARC, 1997).



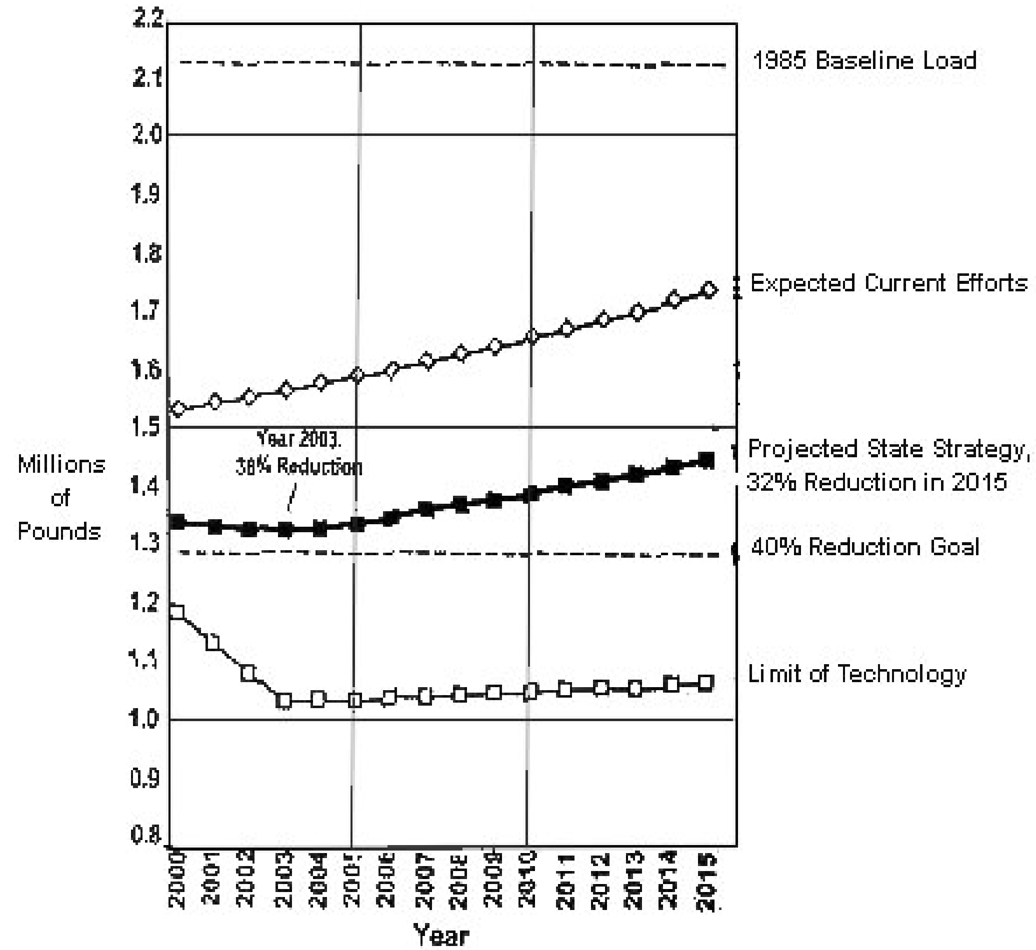


Figure 4. Phosphorus Comparison: Reduction Goals, Expected Current Efforts, Projected State Strategy, and Limits of Technology (JLARC, 1997).

FEDERAL AND STATE PROGRAMS TO CONTROL NONPOINT SOURCE DISCHARGES

Federal, State, and local agencies have regulations that mandate control of some forms of nutrients discharged into water bodies from point sources (e.g., those sources that discharge effluents from a discrete point) such as municipal and industrial wastewater treatment plants. They have also developed voluntary programs for nonpoint sources (e.g., pollutants released from diffuse sources) such as agriculture and stormwater runoff.

The Environmental Protection Agency (EPA) has primary responsibility to protect the quality of the Nations' waters. The Agency uses several voluntary programs contained in the Clean Water Act (PL 92-500, 33 U.S.C. §§ 1251-1387 (1987)) to address nonpoint source pollutant sources from different perspectives. The three main nonpoint source programs include:

- Nonpoint Source Management Program (Section 319). Requires states to assess water impairments and develop plans to manage nonpoint sources.

- Water Quality Inventory (Section 305) Requires states biennially to complete reports that describe the location and causes of polluted waters for watershed and environmental policy decision making purposes.

- Water Quality Standards and Implementation Plans (Total Maximum Daily Load program) (Section 303 (d)), which is a watershed cleanup program designed to allocate total allowable pollutant amounts between point and nonpoint sources.

The other EPA regulatory vehicle concerned with nonpoint source pollutants is the Coastal Zone Act (PL 92-583) and its Reauthorization Amendments of 1990. Section 6217 of the amendments, also voluntary, provides protection for coasts and estuaries threatened with polluted runoff by imposing application of best management practices in environmentally sensitive areas.

The major deficiency of the EPA nonpoint source programs, until the 2000 revision to the TMDL program, is that they are voluntary and do not provide enforcement powers to address nonpoint sources. The more significant influences on state programs to control agricultural pollution arise from federal assistance and land management programs of the United States Department of Agriculture (USDA) (Novotny, 1994). The USDA programs were initially entirely concerned with preventing erosion of topsoil but, since the passage of the 1996 Farm Bill, USDA programs have incorporated an increasingly important water quality focus. The three main soil and water conservation programs include:

- Conservation Reserve Program, which rents agricultural lands at risk for soil erosion to take them out of production and renews soil cover crops.

- <u>Conservation Reserve Enhancement Program</u>, which addressees water quality, soil erosion, and wildlife habitat issues related to agricultural lands by taking them out of production.

- <u>Environmental Quality Incentive Program</u>, which focuses assistance to locally identified conservation priority areas or areas where agricultural improvements will help meet water quality goals.

In 1998, the Clinton administration introduced the Clean Water Action Plan. It is an interagency endeavor headed by EPA and the U.S. Department of Agriculture to combine efforts and bring new tools to the challenge of improving water quality. Nine federal agencies are involved in implementing the plan, which promotes a watershed-based approach to solving nonpoint source pollution problems (EPA, 1999c). The purpose of the joint agency approach is to encourage crossover of water quality protection and evaluation techniques and avoid duplication of effort. The plan promotes the use of USDA land use evaluation strategies to evaluate nonpoint source discharges to receiving waters. These evaluation and monitoring activities can be used to support another EPA water quality improvement strategy: trading of effluent allocations.

TRADING EFFLUENT LIMIT ALLOCATIONS TO CONTROL NONPOINT SOURCE DISCHARGES

In 1995, the EPA, in response to President Clinton's Reinventing Environmental Regulation initiative, began promoting the use of watershed-based trading (EPA, 1995a). The EPA believes that trading provides an opportunity for water quality agencies to develop workable, cost-effective solutions for water quality problems in watersheds by expanding nonpoint source pollution reductions beyond current levels. Trading may give dischargers new opportunities to comply with anti-degradation policies. It can provide an option of a new source or and existing sources to offset the new loading by arranging for pollution from an existing source. EPA also believes that trading can produce environmental benefits by increasing the use of pollution control measures, such as best management practices, from agricultural sources (EPA, 1996a).

EPA realized that of the three strategies commonly used to address environmental challenges: 1) strengthen environmental laws and enforcement, 2) incorporate sustainable environmental goals in existing regulatory programs, or 3) use market incentives, the latter represents an untapped opportunity to address water quality issues (Hinds, 1994).

EPA proposed that nonpoint source control programs could be addressed through the marketplace by marketing discharge permit limit or allocation reductions. This trading idea was developed in the 1960's and has been successfully applied to air permitting programs, specifically sulfur dioxide emissions allowances from utility boilers. This Clean Air Act program places a value on each ton of sulfur dioxide emitted and places limits on sulfur dioxide emissions from 110 coal-fired power plant boilers nationally. Those facilities that can emit lower sulfur dioxide amounts than their permits allow, through technology enhancements, process alterations, or fuel substitutions, are permitted to sell the difference to other utilities who cannot afford, or do not otherwise employ those methods of sulfur dioxide reductions (Brownwell, 1993).

As demonstrated in the air pollution example above, trading of effluent credits is a market-based system that allows dischargers who can control pollutants at a low cost to sell (trade or bank) the amount of reductions, below their permitted limit, to others who have a higher control costs. In agricultural nonpoint source trading, this means that dischargers with low control costs (presumably farmers, landowners, and ranchers) can sell their pollutant reductions to dischargers with higher control costs (presumably municipal and industrial wastewater treatment plants). Both participants benefit, sellers because they reap an economic benefit from what was previously a material to be disposed of or they prevent the loss of a purchased raw material. Buyers benefit because they pay less for controlling effluent discharges.

It is believed that effluent credit trading can optimize the cost of improving water quality. Trading integrates environmental goals and economic treatment cost differentials to work toward the water quality "fishable and swimmable" goal of the Clean Water Act. Trading provides environmental benefits at lower costs and at greater regulatory flexibility than conventional strategies. Nutrient trading has potential provide incentives to reduce effluents beyond command and control permit limits by using emerging technologies and multimedia pollution reduction strategies (Michigan DEQ, 1999).

AGRICULTURAL CONTRIBUTIONS TO WATER POLLUTION

"Farming looks mighty easy when your plow is a pencil, and you're a thousand miles from the corn field." - Dwight D. Eisenhower (Eigen, 1993)

Water pollution sources are generally classified as point or nonpoint sources. Point sources discharge into waterbodies from a single process or a collection of processes through a clearly defined point or pipe. These sources are regulated by law and the control of pollutant discharges is required. A permit is required to discharge from point sources and the amount and, sometimes, the timing of pollutant discharges is defined. The frequency of compliance monitoring and reporting are also set out in the permit. States have extensive periodic reporting systems and enforcement of noncompliance conditions is a routine matter.

In contrast, nonpoint sources discharge pollutants into waterbodies in a diffuse manner at intermittent intervals related to meteorological events. The pollutant load comes from an extensive land area and it travels overland and through ground water before it enters a stream. Therefore, the magnitude of the impact depends on the interaction of climatic events, land use practices, and soil conditions. Furthermore, the timing of fertilizer applications and the stage of plant growth influences the nutrient amounts available to be transported to streams. Consequently, the quantification of pollutant discharges and their impact is much more difficult to monitor for nonpoint sources than for point sources. No permits, per se, are required to discharge nonpoint source pollutants into a water body. Controls are not technological reduction devices as for point sources but are land use practices that must be set up and maintained seasonally or on an ad hoc basis. Typically, no effluent discharge monitoring and no regulatory agency reporting of pollutant discharges is required.

Several classes of materials discharged from agricultural and industrial sources degrade water quality. Some, like metals, herbicides, and pesticides, are inherently toxic to aquatic plants or animals and produce immediate effects. Others, like some halogenated hydrocarbons, produce any of a series of chronic cumulative health effects. Some materials exert a temporary dissolved oxygen demand on the water directly through a chemical reaction or indirectly by acting as food for microorganisms who use dissolved oxygen to metabolize the material. Some materials are micro or macronutrients necessary for plant or animal growth. These materials can be limiting, (i.e., if they are not available in sufficient quantities they limit plant or animal growth). Conversely, if limiting nutrients are available in large quantities, they can promote plant or animal growth to a point that overwhelms the capacity of an ecosystem to cope with the growth and it crashes due to the overabundance or depletion of some compound. Two of the most common agricultural nutrients are nitrogen and phosphorus. Both nutrients are building materials for DNA and protein.

AGRICULTURAL NUTRIENTS CONSIDERED

Nutrients are necessary for aquatic plant and algae growth. Excessive nutrients, in the various forms of nitrogen and phosphorus, from agricultural practices contribute to eutrophication - the enrichment of surface waters with plant nutrients. Plant growth from eutrophication causes a host of water quality problems.

Although both nitrogen and phosphorus contribute to eutrophication, discussions about the extent of the problem usually focus on the limiting nutrient which, in inland waters is phosphorus. Blue-green algae can convert elemental nitrogen from the water as a nutrient source so it is generally not found in limiting amounts. In estuary waters, either nitrogen or phosphorus may be limiting (EPA, 1999a). Also, the total nitrogen to total phosphorus ratio dictates the type of algae that predominates in a water body and thus determines what effects are incurred. For example, some nitrogen-fixing blue-green algae might be favored at a low nitrogen content, a ratio of less than 10:1 (Novotny, 1994).

Nitrogen

Nitrogen enters aquatic systems through many routes other than agricultural and urban fertilizers. These routes include:

- Industrial and municipal wastewater treatment plant effluents.
- Atmospheric deposition from man-made (combustion) and natural (lightening/rain) sources.
- Dissolution of geologic formations.
- Forest litter.
- Soil leaching.

The magnitude of agricultural nitrogen contributed to the environment is striking. Nationally, agricultural nonpoint sources account for about 93 percent of the total nitrogen added to the environment while point sources contribute only about 6 percent. Even in high population watersheds, nonpoint nitrogen sources contribute more than 50 percent of the nitrogen in streams (Puckett, 1994). Nationally, only 18 percent of the fertilizer nitrogen applied to fields leave farms as produce, annually 155 pounds of surplus nitrogen per acre is left behind on croplands to enter the environment (Carpenter, 1998). Since this continent was first settled, it is estimated that agriculture has increased nitrogen input rates to coastal estuaries by more than 300 percent (Howarth, 1998). In Southeastern watersheds, fertilizers are the primary water pollution nitrogen sources. This is due to the intensive agricultural activity of the region and the high rainfall the region receives. Regionally, animal manure, used as fertilizer or directly discharged to water bodies, is the second largest nitrogen source, followed closely by atmospheric deposition (Puckett, 1994). In the Chesapeake Bay watersheds, point sources contribute about 25 percent of the nitrogen entering the bay, air sources contribute another 25 percent, and agricultural and urban runoff contributes about 50 percent (EPA, 1997b).

The amount and timing of agricultural nutrients that eventually enter waterbodies depend on many factors including land use(s), fertilizer application timing, cropping strategies, soil types, and precipitation. Only a small percent of the nitrogen deposited in a watershed immediately reaches surface water. Part of the nitrogen is removed with crops or volatilized to the atmosphere. The rest, which is incorporated into vegetation or sequestered in the soil or groundwater eventually reaches surface water (Puckett, 1994). Nitrogen cycling and discharge location influence the effects of nitrogen on receiving waters. Nitrogen cycles through different molecular states and some is lost to the atmosphere or incorporated into plant matter (Kilpatrick, 1995).

Agricultural practices use or produce nitrogen in many forms, including organic nitrogen incorporated in cellular amino acids and proteins, dissolved nitrogen gas, ammonium, nitrate, and nitrite. In soils that are not waterlogged, soil nitrogen (held as protein in plant matter) and fertilizer nitrogen are microbiologically transformed to ammonium through the process of ammonification. The nitrogen cycle for aquatic environments (Figure 5) shows the complexity of nitrogen conversions and interactions (Stevenson, 1965). Both aerobic and anaerobic reactions take place in the sediments and the sediment-water interface to convert nitrogen from one form to another. The rates of conversion from one form to another are sensitive to temperature, moisture content, and oxygen content (Stewart et al, 1975). Ultimately, the effect of nitrogen in an estuarine system in part a refection of where it is introduced, nitrogen removed at the head of a watershed does not have as much effect on an estuarine system as that removed at the head of the estuary.

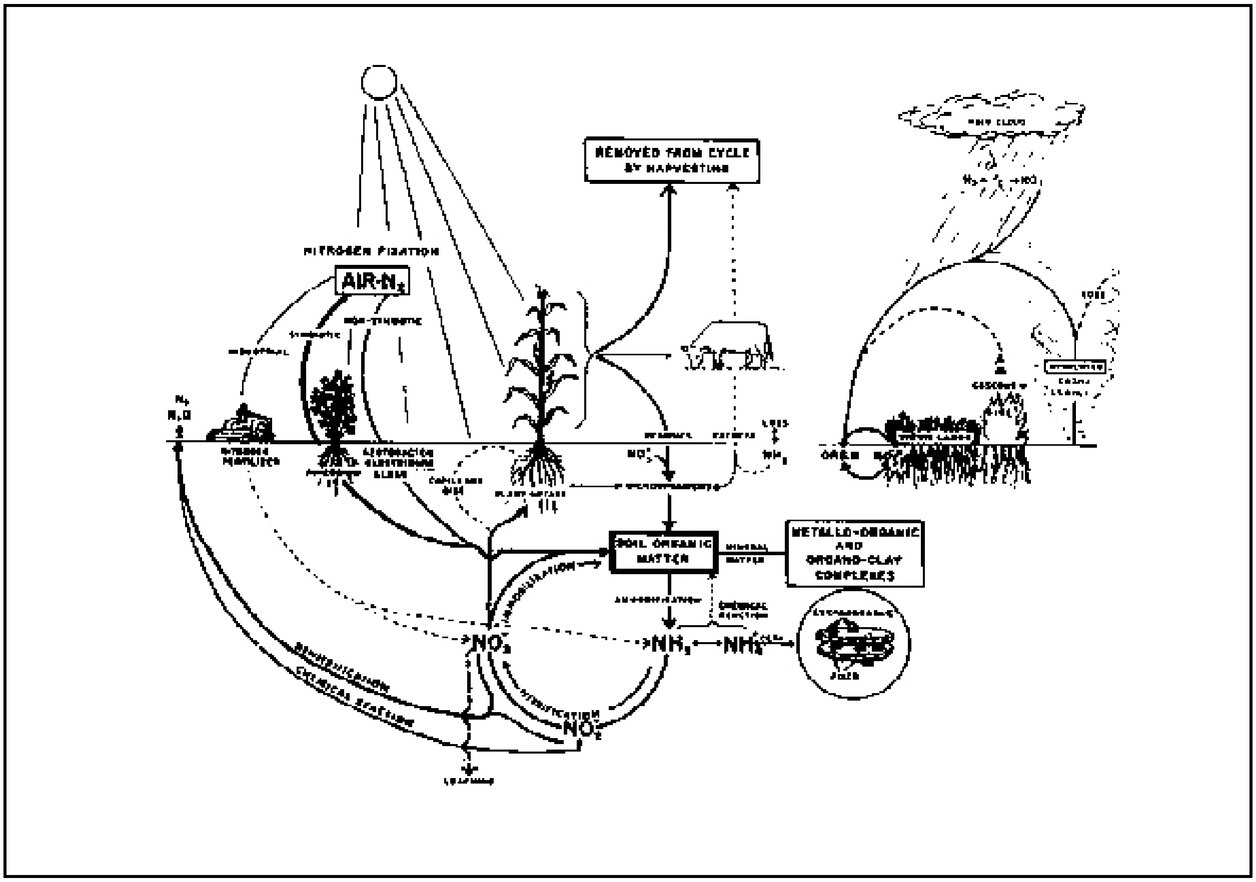


Figure 5. Nitrogen Cycle

Phosphorus

In contrast to nitrogen's physical states and cycling, phosphorus's behavior in the environment is simpler. Phosphorus exists as:

- Mineral phosphorus (apatite).
- Non-mineral phosphorus (non-apatite).
- Organic phosphorus.
- Dissolved soluble reactive ortho-phosphorus (Ongley, 1997).

Nationally, phosphorus stream contributions from agricultural fertilizers and livestock wastes represent less than 20 percent of the total amount applied annually to the land (USGS, 1999). This is in part a reflection of phosphorus's relative lack of solubility and its tendency to attach to soil particles. Only the various pentavalent forms of phosphorus are found in aquatic systems. The particulate-bound phosphates introduced to the water column are chemically or enzymatically hydrolyzed to orthophosphate, the only chemical state that can be assimilated by bacteria, algae, and plants.   Figure 6 is a representation of the phosphorus cycle (Correll, 1998).

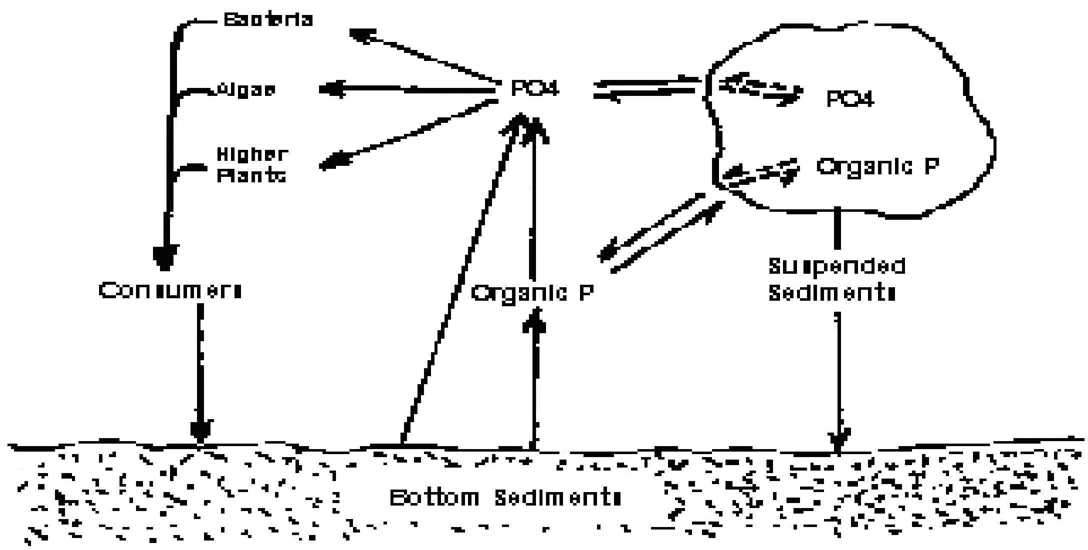


Figure 6. Phosphorus Cycle

The soluble reactive phosphorus is so readily absorbed by plants that the amount measured in water may only represent a residual amount. Often, control measures and monitoring strategies focus on phosphorus-containing sediments since they dominate the total phosphorus flux. The non-mineral form is available to plant roots and is quickly solubilized under anoxic conditions (Ongley, 1997). However, Sims et al report that phosphorus losses to subsurface runoff (interflow or groundwater flow) can be an important component of the total export from some agricultural watersheds. Soluble phosphorus losses are most prevalent in areas where soil phosphorus concentrations are high, soil sorption capacities are low, and subsurface transport is enhanced by artificial drainage systems (Sims, 1998).

Although background nitrogen concentrations are rarely low enough to limit aquatic plant growth in fresh waters, background phosphorus concentrations often are low enough to be limiting and any additions can have profound impacts. Thus, freshwater agricultural eutrophication is often due to elevated phosphorus concentrations in runoff from fertilizer or livestock manure used as fertilizers. Since such low amounts of phosphorus can have such large impacts, additional control strategies have been suggested that focus on reducing the phosphorus content of animal feeds or the resulting manure. The enzyme phytase, when added to nonruminant animal feed, may increase the efficiency of phosphorus uptake during digestion. Another example is the use of corn that contains reduced levels of phytic acid phosphorus. Both strategies have the potential to reduce the phosphorus content of manure (Daniel, 1998).

NUTRIENT TRANSPORT TO STREAMS AND RIVERS

In the last decade, concentrations of nutrients in the 20 largest U.S. rivers generally reflect the proportion of agricultural land in the watershed. Major watersheds with large proportions of agricultural land had high nutrient concentrations that are comparable to smaller, more confined agricultural watersheds. Overall, the amount of nutrients in streams increases as the total nonpoint nutrient input increases. Nutrient concentrations in rivers draining major watersheds with mixed land uses were lower, presumably due to dilution by water from undeveloped areas and the mitigating effects nutrient uptake by riparian vegetation. Hydrology and land use are the major factors controlling nutrient concentrations in major rivers. Soil type and slope are key factors in determining the magnitude of nutrient transport (USGS, 1999). In general, the USGS says that the potential for nutrient transport to steams increases with:

- High rainfall, snowmelt, and/or excessive irrigation, especially following recent fertilizer application.

- Steeply sloping areas with insufficient vegetation to slow runoff and sediment.

- Clayey and compacted soils underlain by a poorly drained substrate (USGS, 1999).

Both nitrogen and phosphorus move from agricultural fields and urban areas to streams by stormwater flow or wind erosion. Phosphorus is sorbed to soil particles and organic matter and is primarily transported with soil erosion to streams. Inorganic nitrogen is not as strongly sorbed to soil as phosphorus but it can be transported by soil particles or dissolved in the stormwater runoff. Dissolved inorganic nitrogen can also be transported to streams via ground water flow (baseflow) or through the unsaturated soil zone (interflow).

Upon entering a waterbody, nitrogen and phosphorus are transported differently due to their chemical properties. Soluble nitrogen species are transported with stream flow and are readily available for microorganisms to metabolize. Inorganic nitrogen is less soluble but it is transported with soil particles. Various nitrogen species cycle through oxidized or reduced states to provide energy or oxygen to microorganisms in the water column or the bottom sediments. Ultimately, most of the nitrogen that enters a stream is transported to a lake, reservoir, or estuary and little is lost, through denitrification, as gaseous nitrogen.

Phosphorus is readily adsorbed on soil particles near its application area, and it moves primarily by erosion to streams. As phosphorus levels increase in some soils, a larger amount is available for transport in the dissolved form (based on the adsorption capacity of the soil). In the water column, phosphorus is bound to suspended solids and thus available for microorganisms to use. In bottom sediments, phosphorus is generally unavailable for microbiological uptake unless the sediments are disturbed and become suspended. Some bottom reducing conditions can desorb phosphorus from sediments. Sediment represents a significant "phosphorus sink" in lakes and reservoirs where accumulations may be so deep that phosphorus is effectively removed from the environment.

Current understanding of soil phosphorus dynamics indicates that high soil concentration is a critical factor in determining phosphorus losses. Consequently, considerable efforts have been directed toward developing land use practices to minimize this build-up, primarily using soil test programs to guide fertilizer and manure applications (Sims, 1993). A general application of this strategy has had limited success and recent efforts have targeted areas with high soil phosphorus concentrations that have high surface runoff and erosion potential. Gburek et al recently reported that most phosphorus (highest concentration, highest mass loading) is lost from watersheds during storm events and that the storm event represents the "greatest opportunity for controlling P loss to streams, whether the major P transport occurs in association with water, suspended sediment, or a combination thereof" (Gburek, 1998).

Nutrient contributions to streams is seasonal. Discharge patterns reflect many factors but the timing and amount of fertilizer use and the frequency and magnitude of runoff from precipitation interact to dominate nutrient transport. Land management activities including irrigation and best management practices that promote infiltration also influence nutrient transport. Nutrient runoff concentrations are highest following fertilizer applications and before plant uptake. Climate also plays a part. Areas with long growing seasons that can accommodate double cropping may contribute more nutrients.

NUTRIENT EFFECTS ON STREAMS AND RIVERS

The effects of nutrient addition and the resulting eutrophication of lakes and estuaries primarily, but also of rivers, are extensive. The diminished environmental quality of water reduces the variety and biomass of aquatic organisms and replaces indigenous populations with rough fish species in fewer numbers. The various stages of eutrophication in waterbodies affect the economic benefits derived from them and of the water itself. The direct costs to clean up water for its intended use are relatively straightforward to calculate, but the indirect costs of reduced waterbody uses are less obvious.

While the effects of eutrophication, such as algal blooms, are readily visible the process of eutrophication is complex and its measurement is difficult. In addition to eutrophication's many direct costs, it has environmental and health effects as well. Those impacts are discussed below.

Water Treatment Plants

Municipal drinking water treatment plant water cleaning costs are directly related to the intake water quality (Holmes, 1988). Surface water treatment plants that remove large amounts of nutrient-produced biomass or sediment have higher treatment costs than those that do not. These costs include the capital costs of flocculation and sedimentation basins and the operational costs of coagulant doses and sludge disposal. Additionally, high algae-induced turbidity levels complicate the disinfection process and may necessitate larger disinfection chemical doses, which can produce potentially carcinogenic disinfection byproducts called trihalomethanes.

Algae in reservoirs can produce taste and odor problems even in treated water. The algae metabolic byproducts responsible; geosmin, methylisoborneol, and $-cyclocitral, are only removed by add-on control devices such as carbon filters or oxidation devices (Dietrich, 2000).

Industrial facilities must also condition water to meet their equipment specifications. Their water quality needs are often more stringent than Federal drinking water quality standards or aesthetic drinking water demands. The additional operating costs due to diminished water quality are passed along to consumers.

Water Storage Reservoirs

Algae can clog reservoir water intakes to the point that operation and maintenance costs are prohibitively expensive. The only remedy is to treat the reservoir and kill the algae. This can produce additional problems since aquatic macroinvertebrates and fish can be killed by the treatment process. The copper compound typically used to kill algae in a reservoir can, if not carefully applied, be incorporated into the drinking water. At a minimum, it ends up in the bottom sediments and can be released later if disturbed. When algae die from the treatment, decomposer organisms that feed on them impose an oxygen demand on the water that can impact fish populations. Additionally, the mass of dead algae that collects at the bottom of the reservoir can produce odors and impart tastes to the water (Ongley, 1997).

Recreational Activities

Excessive algae growth can form floating mats of dead and living material that interfere with boating, swimming, and fishing. The material can envelope and stop boat propellers. Swimmers are reluctant to enter the water because the algae produces an unpleasant slimy feeling. Fishermen cannot retrieve lures cast into an algae mat and fish are unable to swim freely within the heavy growth.

Health Effects

Many of the blue-green algae produce toxins. The three most common species in North America include the filamentous species, *Anabaena flosaquae* and *Aphanizomenon flosaquae*, which produce neurotoxins and the colonial species, *Microcystis aeruginosa*, which produces a hepatotoxin (affecting the liver) (AWWA, 1999).

Most reports of poisonings by blue-green algae involve animals. The few well-documented cases describing humans involve only a few people at a time, presumably because few people would drink water covered by a thick algal bloom (AWWA, 1999). However, a more serious problem may be the chronic effects of hepatoxins, which have been linked to liver tumors and cancer (Nishiwaki-Matsushima, 1992). Conventional water treatment plants do not remove toxins and some treatment processes, such as prechlorination, actually release more toxins to the water than were in the source stream initially. This occurs when algae cells die and lyst. Carbon adsorption or ozonation is required to remove or destroy toxins. Both processes are expensive as add-on treatments.

Nitrate concentrations above 10 milligrams per liter (mg/L) can produce methemoglobinemia in babies, a potentially life-threatening condition. This condition is know as “Blue Baby Syndrom” because the nitrate reacts with oxygen in a baby’s blood stream producing a blue cast to the skin. In extreme exposures, the condition can cause death by oxygen deprivation.

Fish/Aquatic Macroinvertebrate Populations

Eutrophication inhibits fish reproduction by deleting the dissolved oxygen available in the water for oxygen-sensitive fish eggs. Fish fry are much more oxygen-sensitive than adults and are less able to relocate to more hospitable environments. Extreme oxygen-deleted conditions can also kill the fish and the macroinvertebrates that fish feed on. These conditions are especially problematic for those fish species, such as shad and menhaden, that live in estuarine or marine waters and migrate into fresh water tributaries and rivers to spawn.

The effects of eutrophication are magnified in estuaries because of the compounding effects of sediment and the relatively long retention time of water in the system. Suspended sediments and algae and floating algae mats obscure light from reaching the bottom and thus inhibit submerged aquatic vegetation, which reduces fish food resources and protective fish fry cover.

Businesses on or near impaired waters lose revenues from declines in fishing licences sales, boat rent or launch fees, and also from declines in ancillary profits such as those from restaurants, hotels, and equipment sales. Both economic declines represent lost economic opportunity. The secondary costs of impaired waters include decreased home and vacation property values nearby.

Steam Power Cooling

Power plants incur additional operating and maintenance expenses from addressing fouled heat transfer equipment and pumps. Secondary effects may include higher discharge water temperatures to receiving waters that may further reduce the ability of the water to support fish.

DISCHARGE MONITORING REQUIREMENTS OF FEDERAL AND STATE NONPOINT SOURCE PROGRAMS

Two Federal entities share the responsibility to improve water quality or to prevent its degradation: the United States Environmental Protection Agency through the Federal Water Pollution Control Act of 1972 and the United States Department of Agriculture indirectly through is soil conservation programs.

Several other governmental agencies have some responsibility to control or limit pollutant amounts that reach streams or estuaries. The National Oceanographic and Air Administration (NOAA) oversees the Coastal Zone Management Act, the Army Corps of Engineers administers the Wetland Mitigation Banking Program and the Dredge and Fill Regulations, and the Fish and Wildlife Service (FWS) administers, among other things, the Habitat Conservation Act. Each of these programs play some part in assisting EPA and USDA or addressing nonpoint source pollution sources for their own purposes.

ENVIRONMENTAL PROTECTION AGENCY PROGRAMS

Clean Water Act

The Federal Water Pollution Control Act (FWPCA) of 1972 [33 U.S.C.A. Section 1251 et seq.], commonly called the Clean Water Act (CWA), made it clear that waterways are no longer acceptable waste disposal conveyances. The CWA and its amendments "federalize" water pollution control efforts and focus on the pollutants discharged and water quality itself. The amendments address in great detail "point sources," which are:

> "any discernable, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged." [40 CFR, Part 122.2]

This definition includes stormwater runoff from certain industrial facilities and local municipal stormwater collection systems as well as wastewater treatment plant effluents. Some activities, such as runoff from agricultural fields and orchards and return flow from irrigation, are specifically excluded. Point sources that discharge any pollutant to surface waters must have a National Pollutant Discharge Elimination System (NPDES) permit. All point sources must monitor their discharges and submit periodic discharge monitoring reports. The NPDES permit sets maximum discharge limits for various pollutants based on uniform national limitations that reflect the technological capabilities of different industries.

The CWA also uses water quality standards to protect water resources. The act sets a "fishable and swimmable waters" goal intended for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water. If the technology-based effluent limitations are not sufficient to attain the “fishable and swimmable waters” goal, more stringent water quality related effluent limits will be imposed (Gould, 1995).

Although the FWPCA focuses on point source dischargers, it recognizes the need to control nonpoint source discharges. Before 1972, there was limited understanding of the site-specific diffuse nature of nonpoint source pollutants and their transport to receiving waters that prevents direct monitoring and reporting of their discharges. At that time it was acknowledged that nonpoint sources contributed a large portion of the total suspended solids, total dissolved solids, phosphorus, and nitrogen discharged. Since point source control technologies were reasonably well developed, the FWPCA focused on them and left nonpoint source control regulations to be completed later. Despite generally high permit compliance rates by regulated point source dischargers since 1982, about 40 percent of US waterways continue to show some water quality impairment and the nonpoint sources still contribute a high percent of these pollutants (EPA, 1996). It is now widely accepted that if water pollution loads are to be reduced, the regulatory focus must explicitly include nonpoint sources.

All three of the above CWA sections require periodic water quality reports for each of the stream segments they address. This information is supplied through an extensive stream monitoring program and augmented by the NPDES discharge monitoring reports of point source dischargers. Together, the water quality information is used to assess water quality trends and to identify watersheds or actual stream segments that need additional protection or changes in water quality management practices. Sections 305 and 319 actually require monitoring and provide for water quality monitoring plans. Overall, the reports indicate the condition or contribution of the entire watershed. These plans must contain certain elements for the information they generate to be acceptable to EPA. Monitoring plan elements must include:

- Monitoring approach (chemical, biological, or physical parameters).

- Parameters measured and analyses used.

- Quartile values for chemical parameters based on historical or first-year data for each season and monitoring station.

- Monitoring frequency. Chemical monitoring must be performed with at least 20 evenly-spaced grab samples per season.

- Monitoring design and monitoring station identification (paired watersheds, upstream-downstream, reference sites, or a single downstream site).

- Drainage area and land use for each water quality monitoring station (EPA, 1991).

In 1998, the Director of the Office of Water said that for watersheds impaired by a blend of point and nonpoint sources, the TMDL process provides that where any wasteload allocation to a point source is increased based on an assumption that loads from nonpoint sources will be reduced, the State must provide “reasonable assurances” that the nonpoint source load allocations will in fact be achieved (Perciasepe, 1998). Thus, where loading allocations are influenced or altered by effluent allowance reduction trading between sources, Mr. Perciasepe says that State regulatory agencies must assure themselves that the reductions are achieved. However, Mr. Perciasepe did not suggest how, or to what extent, an agency must assure itself. Generally, states have continued to use the Section 305 and 319 reports to document nutrient reductions.

In the Virginia TMDL program, there is no provision to monitor water quality to determine the individual impacts of nonpoint source pollution or the reductions made by any individual control practice. The program only monitors the quality of receiving waters at the discharge point of high risk watersheds or hydrologic unit. If the water quality is still impaired after implementation of the negotiated TMDL allocation, the state may renegotiate the allocation among stakeholders. No water quality monitoring of individual land holdings or control practices is contemplated (Yagow, 2000).

Coastal Zone Act Reauthorization Amendments

Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) is the Coastal Nonpoint Pollution Control Program, which provides protection for coasts threatened with polluted runoff. States with approved coastal zone management plans must establish runoff control plans for nonpoint sources. Specifically, CZARA provides for:

> “…economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.”(EPA, 1993).

The basic monitoring objective is to assess over time the success of the measures in reducing pollution loads and improving water quality. Although desirable, CZARA considers monitoring to establish a true cause and effect relationship between land use management measures and water quality to be beyond the scope of affordable program monitoring activities. CZARA does consider it prudent to document associations between land use management measures and trends in pollutant loads or water quality. Consequently, CZARA uses the Natural Resources Conservation Service, Conservation Management System to calculate management program effectiveness (EPA, 1993). In this respect, CZARA is different than other CWA programs and it seems to embody the spirit of the 1998 Clean Water Action Plan.

The National Wildlife Foundation points out that these control plans and monitoring objectives apply only to areas that the states define as the coastal zone and may or may not apply to areas higher in the watershed. Program effectiveness monitoring is conducted by measuring the water quality of the receiving estuary or marine waters. Monitoring does not address individual best management practices or land uses and it is intended, as are CWA Sections 305 and 319, only to indicate the condition or contribution of the entire watershed (NWF, 2000).

UNITED STATES DEPARTMENT OF AGRICULTURE

The other Federal agency with a nonpoint source pollution mandate is the United States Department of Agriculture (USDA). The Farm Services Agency has, since 1985, administered programs that provide direct payments (cost-share assistance) to landowners to subsidize conservation practices. Many of these programs provide direct water quality benefits that augment the initial USDA soil erosion focus. The Federal Agriculture Improvement and Reform Act of 1996 (PL 104-127, 16 U.S.C. 3811, et seq.), known as the 1996 Farm Bill, revised USDA's conservation programs to address high priority environmental protection goals. Three of the more influential water quality protection conservation programs are discussed below.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) establishes conservation priority areas where agricultural lands pose a serious threat to water resources. Among other provisions, this program pays up to 75 percent of the costs of conservation practices designed to help meet water quality objectives. Nationally, the EQIP is funded at $130 million in FY 1996 and $200 million annually after that (USDA, 1999). It is administered through the National Resources Conservation Service. The EQIP is a funding vehicle for USDA to finance State conservation priority areas. State agencies (in Virginia, the State Technical Committee) have great discretion in determining what conservation practices will be used in what areas and how to rank applicants for funding. Nationally, USDA sets a national goal of 50 percent of the funding to go to livestock operations, the balance to agriculturally related water issues.

Conservation Reserve Program

The Conservation Reserve Program (CRP), administered by the Farm Service Agency, is the largest and oldest of the USDA conservation programs. It was initiated in 1985 with the intent of reducing soil erosion by encouraging farmers to stop growing crops on highly erodible and environmentally sensitive lands. Producers must submit bids during specified periods to be considered for enrollment (FSA, 1996).

Initially, the CRP's focus was soil erosion, but that direction was modified in the 1996 Farm Bill. Now, the CRP protects highly erodible or environmentally sensitive lands by renting them and installing long-term ground cover to prevent soil erosion and allow the soil to recondition itself. Bids for CRP contracts are ranked according to set criteria and higher ranking (more erodible or sensitive) lands are selected for the program. Farmers plant selected lands in grass or trees and receive an annual rental payment for the term of the 5- or 10-year contract period.

As an example of its water quality benefits, the CRP is expected to annually reduce total kjeldahl nitrogen discharges by 8.7 to 11.2 percent in the Appalachian and Southeastern States and total phosphorus by 7.1 and 7.8 percent. Overall, the per-acre water quality benefits from the CRP are estimated to be seven times greater than those from traditional soil conservation (Ribaudo, 1989).

Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program (CREP) is the embodiment of the increasingly environmental focus of USDA programs. It is a state and federal conservation partnership that targets significant agricultural water quality, soil erosion, and wildlife habitat issues. The CREP program uses financial incentives to encourage farmers voluntarily to remove lands from agricultural production (rent) and install conservation best management practices. As with EQIP and CRP, this program subsidizes best management practices to address environmental issues.

Lands accepted into CREP must incorporate several features. Land use plans for the acreage must:

1. Address resource issues of state and national significance (e.g., nutrient reduction in Chesapeake Bay or water quality in salmon spawning waters).

2. The projects must be cost-effective in comparison to other conservation programs.

3. Projects must be results oriented by providing measurable goals and outline a monitoring program to evaluate whether the program goals are accomplished.

4. Administratively, CREP proposals must provide for about 20 percent of non Federal funding and display support from impacted groups (USDA, 1999).

The Federal commitment is to annually provide 50 percent of the per acre costs for all approved conservation practices plus maintenance incentive payments. Additionally, they will annually provide additional incentive payments of 25 to 50 percent of the base CRP rental rate for riparian buffers, filter strips, or restored wetlands. SWCDs also develop conservation plans for lands with identified natural resource problems and conduct annual performance reviews. States can include funds such as additional cost-share assistance, a lump sum bonus payment, monitoring costs, technical assistance, or long term easements to meet the 20 percent program copayment cost (FSA, 1996).

This program has great promise to control the transport of nutrients from agricultural fields into waterbodies. It removes the agricultural acreage from production that has the most impact on streams and it installs best management practices that reduce the nutrients that discharge from it. Farmers tend to favor the program because the best management practices it promotes are not only resource management practices, many were designed to protect soil or grass to increase the economic return of farmers by improving productivity by decreasing costs or increasing yield.

Table 6. Summary of Federal Programs Used to Control Nonpoint Source Pollution from Agriculture

Agency and Program	**Program Description/ Agency Responsibilities**	**Resources Available/ Possible Role(s)**
US EPA - Permits	NPDES permits for confined animal feeding operations, enforcement for noncompliance.	Staff for technical assistance with modeling and permit drafting, site inspections, and compliance monitoring.
US EPA - Water Quality	Overall water quality planning and management: 1. Nonpoint source control program that oversees and approves state development of water quality assessments and implantation of management programs designed to control NPS. Directs funds to high-priority watersheds. 2. Water quality standards program provides technical assistance in developing numeric, narrative, and biological standards to protect water quality	Staff for technical assistance to state and local agencies, review and approval of state programs, research and special studies. Grants to states fro most water quality protection activities, educational materials and programs.
USDA - Farm Bill	1. Programs to conserve/protect highly erodible or other environmentally sensitive land from production by putting it in permanent vegetative cover through 10-year easements and annual rental payments. 2. A watershed treatment program designed to improve or protect soil and water resources in watersheds impacted or threatened by NPS pollution.	
USDA- Soil and Water Conservation Service	Technical assistance on the planning, site specific design and installation and management of soil and range conservation, animal waste, and water quality management systems and special land and water resource assessments and inventories. Cost-share funds for installation of BMP's on private lands are available from some programs listed below.	Staff and equipment in field offices for technical assistance including engineering design, survey work, and planning for water resource protection.

USDA - Small Watershed Program (PL-566)	Evaluation and treatment of small agricultural watersheds with multiple resources to protect; including land and natural resource inventories and assessments, basinwide planning, and targeting of resources, technical assistance, and educational programs.	Staff for technical assistance to landowners and decisions-makers in the basin, funds for demonstration projects, reconnaissance, and intensive inventories of resources.
USDA - Resource Conservation and Development Program	Voluntary program to promote the economic development and to intensify resource protection in priority areas through public participation in RC&D councils.	Planning assistance for small communities for community wide resource protection.
USDA - Natural Resource Assessment Programs: Soil Survey, Natural Resources Inventory, River Basin Studies	Various programs to map and assess the condition of natural resources (generally soil, water, vegetation, and wildlife) and conservation treatments.	Maps, reports, data information, statistical analyses.
USDA - Agricultural Stabilization and Conservation Service	Provides administrative oversight and cost-sharing for approved conservation practices from ASCS and other USDA administered programs. Tracks crop production and other statistics. Distributes crop subsidy and deficiency payments.	Maps, conservation practice status information, cost-share funds.
USDA - Agricultural Conservation Program	Cost-sharing annually for most soil-conserving, production efficiency improving, and water quality practices.	Funds for cost-share, generally limited to $3,500 per farm per year.
USDA - Water Bank Program	Designed to improve and restore wetland areas through financial compensation for 10-year easements on private property.	Funds for easement compensation on eligible lands in participating states.

USDA - Cooperative Extension Service	Educational programs and information to aid individuals in the selection, operation, and maintenance of the most beneficial conservation treatments. Economic analysis and data for each farm. Provides technical assistance in integrated pest management. Programs generally carried out in cooperation with state land grant universities.	Staff for educational programs and technical assistance, personalized economic analysis, and to coordinate small-scale demonstrations on local farms.
USDA - Air and Watershed Programs	Overall environmental planning and technical support for forest management decisions. Special studies and watershed demonstration projects in certain areas.	Funds for special studies and watershed demonstration projects. Natural resource inventories and reports, water quality/ habitat monitoring, environmental analysis of resource trends and conditions.
USDA - Farmers Home Administration	Loans and loan guarantees to eligible producers for operating expenses, land purchase, and conservation measures.	Funds and loans for property improvement and conservation treatment installation and water-conservation practices.
USDA - Agricultural Research Service	Basic and applied research on agricultural production and conservation measures, including fertilizers, pesticides, and BMP effectiveness.	Reports, BMP effectiveness and environmental fate and transport data, demonstration sites, occasionally funds for joint-sponsored projects. Research stations found throughout each state.
USDOI - Fish and Wildlife Service	Oversight and regulation of the nation's wildlife resources. Management of national wildlife reserves and cooperative administration of national wetlands programs with COE and EPA. Cooperative projects to enhance fisheries' investigations.	Staff for enforcement on public and private agricultural land, research reports, and data on habitat, populations, and management of wildlife. Funds for cooperative projects.

USDOD - Army Corps of Engineers	Oversees construction and operation of large flood-control and public water supply reservoirs. Conducts water quality monitoring on lakes. Cooperatively administers the wetland's dredge and fill permit program with EPA.	Maps, special studies, water quality monitoring dat. Staff for review and oversight of 404 (Wetlands) permits.
USDOC - National Oceanic and Atmospheric Administration	Administers programs in cooperation with states to inventory and manage coastal resources. Maintains data base for agricultural pesticides and nutrient loadings.	Staff for technical assistance. Data, reports, educational materials. Occasionally funds for special demonstration project.

VIRGINIA PROGRAMS

The Agricultural Best Management Practices Cost-Share Program and the Agricultural Best Management Practice Tax Credit Program are discussed in the body of the thesis. Several of the other more highly funded and more commonly used Virginia nonpoint source control programs are discussed below.

Virginia Nutrient And Pesticide Application Equipment Tax Credit

This program gives a tax credit for the purchase of more precise nutrient or pesticide application equipment. The program is managed by DCR and the SWCD's and it pays up to 25 percent of purchases up to $15,000 on farms that have an approved nutrient management plan (ELI, 2000).

Nutrient Management Program

The DCR operates a voluntary nutrient management program to encourage the proper land application and efficient use of fertilizers manures, sewage sludges, and other nutrient sources used for agricultural purposes. Program staff help farmers prepare nutrient management plans that are effective administrative best management practices.

Virginia Water Quality Improvement Act

The Virginia Water Quality Improvement Act includes a clause which requires investigation of trading as a means to meet its goals. The Virginia Department of Environmental Quality (DEQ) is currently in the process of working with stakeholders to develop a point-to-point source trading program in Virginia. DEQ is working with the Virginia Water Resources Resource Center to hold stakeholder meetings for this purpose. DEQ has also formed a Water Resources Committee consisting of stakeholder groups to advise the DEQ Director on matters relating to Virginia's water resources. One of the topics this group plans to address is trading.

CHESAPEAKE BAY PROGRAM

Chesapeake Bay Preservation Act

The Chesapeake Bay and its tributaries have special conservation requirements as part of an agreement made with neighboring states in 1987. Pennsylvania, Maryland, and Virginia, as part of the Chesapeake Bay Preservation Act [9 VAC 10-20 et seq.], established Chesapeake Bay Preservation Areas. These are lands, which, if improperly developed, "…may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries. Lands within these regions must incorporate water quality protection measures into their zoning and subdivision regulations [9 VAC 10.20-160].

These regulations require landowners in 29 eastern Virginia counties to, among other things, maintain 100-foot wide permanently vegetated stream buffer strips for new development projects. The Chesapeake Bay Local Assistance Board (CBLAD), created by the Chesapeake Bay Preservation Act, funds SWCD staff to perform site-specific evaluations of the effectiveness of these buffers other appropriate best management practices. Evaluations include an analysis of the potential for erosion and of the nutrient loadings, such as phosphorus, from each site. Staff may recommend additional control measures to augment existing practices to reduce soil loss and protect water quality (Crafton, 2000).

The completeness and thoroughness of Chesapeake Bay Preservation Act program follow-up evaluation is in contrast to the other Virginia nonpoint source control programs. The CBLAD program is periodic, complete, site-specific, and compares pollutant runoff values to a standard threshold value and to a reduction criteria for redeveloped sites. Furthermore, the program has a component to recommend additional controls to the owners to come into compliance with the threshold limit.

Chesapeake Bay Program Nutrient Trading

The Chesapeake Bay Program is also considering nutrient trading. In 1999, the Chesapeake Bay Program established a Task Force to determine actions to supplement the existing tributary strategies to maintain the 40 percent nutrient reduction goal.

The Bay Program realized that trading was a serious strategy to meet the nutrient reduction goals as did some of the Bay jurisdictions who were actively exploring trading on their own. In fact, Virginia's state legislature enacted the Virginia Water Quality Improvement Act in 1998, which provided funds for many nutrient reduction actions called for in their Potomac tributary strategy, included a clause requiring the concept of trading be explored as a means of nutrient management. The Maryland Department of the Environment (MDE) developed a trading concept paper entitled "A Maryland Department of the Environment Concept Paper for a Nutrient Trading Policy," in August 1997, to address the issue of allowing for continued development of municipal wastewater treatment plants while still meeting the Chesapeake Bay nutrient reduction goals. Additionally, the Water Environment Research Foundation is sponsoring a study to design a trading program for Maryland.

The Nutrient Taskforce developed six major elements of a trading framework. These elements are described below:

1. Nutrient Reduction Goals - The bay-wide goals established by the Chesapeake Bay Program are for nutrient reduction or individual tributary specific goals. In the context of a trading program, these goals will correspond to and be congruent with appropriate allowances (or caps) associated with tributary strategies. The effects of moving caps (cap changes with new model analyses for example) would also be delineated for the trading program.

2. Eligibility - Activities to determine the number and types of credits which may be traded. An entity may need to be established to apply guidelines and policies to determine if candidate credits are eligible for trading. Various classes of credits and/or trades may be specified to address issues of equity, trading ratios, minimum qualifications of a trader, past performance of classes of credits, and other similar qualifications.

3. Trade Administration - The market in buyers and sellers trade credits under specific terms and conditions (e.g., price, type of credit, etc.). The type of trade would need to be specified, (e.g., standard auction, Dutch auction, etc.). Additional activities would include the recording of the transactions and similar brokerage services.

4. Accountability - Post-trade monitoring and assessment of the effectiveness of the trade, including but not limited to enforcement of the terms and conditions of a trade, provisions for extraordinary agreements, and recording updates to the trade. Issues of default and/or expiration of credits would be monitored and managed based on the terms and conditions established prior to the trade. Monitoring of local water quality conditions also is addressed.

5. Assessment/Indicators - Tributary and bay-wide assessment of the effectiveness of the trading program outcomes, especially in terms of the nutrient reduction goals.

6. Stakeholder Involvement - A set of activities and opportunities for any interested party to observe the trading program, monitor non-proprietary information about the trading program operation and accomplishments, and offer comments for improvement.

All best management practices that are part of a trade must meet National Resource Conservation Service standards and agricultural sources must have a approved conservation plan. States must develop mechanisms to collect and track trading information and at a minimum, use the CBP Trade Reduction Certification Form and the Trade Notification Form.

States must also perform ambient monitoring and modeling to assess the effect of trading programs in meeting its reduction goals. Concurrently, the Chesapeake Bay Program will conduct a bay-wide assessment to determine the nutrient reductions accomplished by trading (CBP, 2000).

TRADING EFFLUENT REDUCTIONS BETWEEN POINT AND NONPOINT SOURCES

Shabman and Norris proposed coordinating Virginia point and nonpoint nutrient source controls in 1987 (Shabman, 1987). More recently, Bartfield suggested that point-nonpoint source trading programs present a tradeoff between cost-savings and reliable water quality improvement (Bartfield, 1993). Letson suggested trading to mitigate coastal and estuarine impacts of agriculture (Letson, 1993). Stephenson and Shabman point out that an effective trading system provides flexibility to sources to choose how and at what level to control effluent discharges (Stephenson et al, 1995).

Based on its success in trading air allowance reductions since the 1970's, EPA decided to develop a similar system for water dischargers. As part of President Clinton's strategy for reinventing environmental regulations, EPA developed a policy to support and promote effluent trading within watersheds to achieve water quality objectives. EPA's policy states that trading is an innovative way to develop more common sense solutions to water quality problems in watersheds and it offers several environmental, economic, and social benefits (EPA, 1995). The EPA developed an interim policy for trading water pollution reductions in its document *Draft Framework for Watershed Based Trading* (EPA, 1996a). Although outdated today, this document provides a basis for new programs.

In contrast, the standard command and control permitting system does not provide any incentive to reduce emissions below a permit limit. In fact, it may inhibit emissions reductions below permitted levels because, all too often, regulatory agencies will simply adjust permit limits to reflect the use of the more efficient production process or more costly control measure(s). Thus, the facility will not receive any credit for the reduction but will thereafter have to comply with the lower limit. This lower emissions limit increases the likelihood of noncompliance, a situation facilities attempt to avoid at any cost (Swift, 1997).

Initially, in the *Draft Framework for Watershed-Based Trading* document, EPA suggested two types of trading structures if one of the partners is required to have a point source discharge permit under Section 402 of the Clean Water Act. Trades could occur through development of a Total Maximum Daily Load (TMDL) allocation framework. In this structure, the TMDL allocation process establishes a collective discharge cap and trading partners negotiate within that loading capacity. Alternatively, trades could occur within the context of a point source discharge permit. In this structure, trading partners would arrange a trade with the approval of the permitting authority. In effect, traders pool their discharge limits and collectively discharge below that limit. In addition to direct trades, EPA suggested that trading partners could participate in public or private banks that could buy and sell pollutant reductions or even bank them for future use (EPA, 1996a).

EPA EFFLUENT TRADING PRINCIPLES

The EPA has established the following set of principles to guide effluent allowance trading:

1. *Trading participants meet applicable Clean Water Act technology-based requirements.*
This principle is difficult to apply to nonpoint sources because they do not have any technology-based requirements. They may have imposed upon them best management practices (BMPs). The principle could be modified to include BMPs set by the local soil and water conservation district. Point sources, on the other hand must purchase pollutant reductions equal to or greater that required by CWA technology-based requirements for their industry.

2. *Trades are consistent with water quality standards throughout a watershed, and anti-backsliding, other requirements of the CWA, other federal laws, state laws, and local ordinances.* Trading cannot produce local water quality impairments despite the overall good they may engender.

3. *Trades are developed within a TMDL process or other equivalent analytical and management framework.* Since TMDL's are established for waterbodies where technology-based requirements alone are insufficient to attain water quality goals, they provide estimates of pollutant loadings from all sources, including a margin of safety, and predict resulting ambient pollutant concentrations.

4. *Trades occur in the context of current regulatory and enforcement mechanisms.* Failure to provide permitted or contractually agreed upon reductions results in enforcement actions.

5. *Trading boundaries generally coincide with watershed or waterbody segment boundaries, and trading areas are of a manageable size.* Interbasin trades are not allowed.

6. *Trading will generally add to existing ambient monitoring.* Trading programs must prove, through monitoring, that trades are occurring and that they work toward attaining water quality goals.

7. *Careful consideration is given to the types of pollutants traded.*

8. *Stakeholder involvement and public participation are key components of trading* (EPA, 1996a).

INFORMATION SYSTEM NEEDS TO SUPPORT TRADING

In water quality management systems, water quality data is necessary to generate information that is used to evaluate the control systems devised to protect water resources. Data is analyzed to show water quality trends or demonstrate that certain pollutant standard exceedances are within the inherent variability of the water system being monitored or are or are not within the capacity of a monitoring system to detect. The ability of a measurement system to produce this information depends greatly upon how well the system was designed.

WATER QUALITY MONITORING SYSTEMS

Timmerman et al describe the monitoring cycle as the "long-term, standardized measurement and observation of the aquatic environment in order to define status and trends" (Timmerman et al, 2000). Timmerman's monitoring cycle (Figure 7) shows the interrelatedness of monitoring system elements. Information from one step is used to

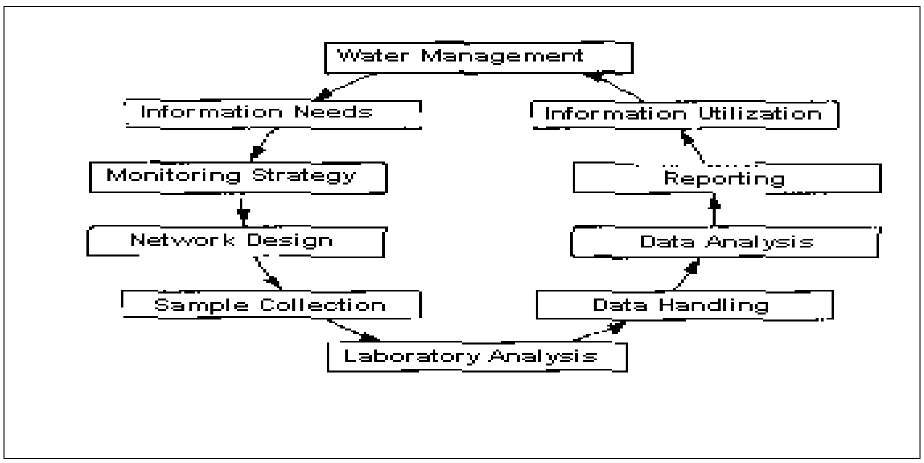


Figure 7. The Monitoring Cycle (Timmerman, J. et al, 2000).

develop information for the next step. In this document, monitoring is considered to be all the measurement and observation parameters necessary to describe a water body and determine the impacts of nutrient additions. Additionally, the monitoring cycle defines the elements required of a monitoring system. Figure 8 makes the point that the elements of a water management programs are interrelated and that designing such a system is an iterative process (ECE TFMA, 1996).

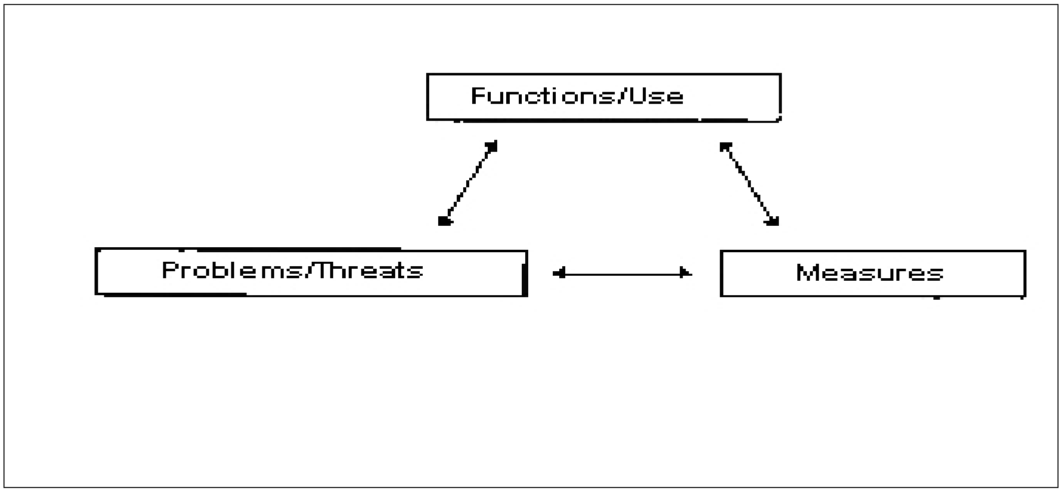


Figure 8. Water Management Program Elements (ECE TFMA, 1996).

A common problem with such systems is that information expectations of the monitoring exceed the capability of the monitoring to produce (Ward, 2000). Ward et al, describe the essential components of water quality information monitoring systems as data collection, information generation, and information utilization (Ward et al, 1990). They present a five-element framework for designing a water quality monitoring system:

1. *Define information needs of management*
   •identify information needs of each management tool
   •summarize information needs of agency
   •relate agency information needs to monitoring strategy
   •define reporting and information utilization procedures desired by management
   •determine appropriate statistical means for producing the desired information

2. *Define information that can be produced by monitoring*
   •statistically characterize water quality "population" to be sampled
   •review statistical methods applicable for generating the desired information, including their data requirements
   •state what information can be produced
   •compare information sought with information that can be produced

3. *Design monitoring network*
   •document sampling locations
   •determine what to measure
   •compute sampling frequency

4. *Document data collection procedures*
   - field sampling operations and procedures
   - laboratory analysis methods and operations
   - data storage and retrieval system

5. *Document information generation and reporting procedures*
   - data analysis hardware and software
   - reporting formats and frequency
   - information utilization procedures (Ward et al, 1990)

MONITORING TO VERIFY NUTRIENT REDUCTIONS FROM TRADING

Three methods can be used to determine baseline discharges or to verify nutrient reductions:

1. Modeling.
2. Sampling and analysis projects.
3. Land use evaluations.

So, how can modeling, sampling and analysis projects, and land use evaluations be used to determine baseline nutrient loads, potential nutrient reductions from best management practices, and verify best management practices? Before answering this question, it may be illustrative to discuss how another environmental program area addresses quantifying nonpoint source discharges.

AIR MONITORING EXAMPLES

This section reviews air pollution reductions trading, offset, or banking programs that have each developed methods and strategies to monitor their effectiveness and progress even for fugitive pollutant dischargers. Monitoring each program type simply requires appropriate administrative and technical approaches. Incorporation of these indirect measuring strategies could be useful to agricultural nonpoint source effluent monitoring.

Leaded Fuel Phasedown Program

One of the first successful national environmental emissions trading examples was the leaded fuel phasedown from 1979 to 1988. Under a banking program, gasoline processing facilities gained credits by early achievement of phasedown limits and could delay the use of these credits until 1987 to receive credit for compliance with later, more stringent standards. Or, these credits could be sold to other facilities. Between 1985 and 1987, up to 20 percent of the total leaded gasoline produced nationally passed through the banking program.

During this period, the lead in gasoline was reduced from more than 200,000 tons per year to less than 50,000 tons per year. Health benefits from reduced blood lead levels were noticed years earlier than expected - during the period 1976 to 1980, national average blood lead levels dropped from more than 15 micrograms per deciliter (mg/dL) to less than 10 mg/dL (Whiteman, 1992).

This example is analogous to agricultural nonpoint source nutrient loading (lead discharges) and receiving water quality (blood lead levels). Diffuse sources (vehicles and agricultural fields) influenced by random events (human behavior and weather) produce environmental impacts (receiving water quality and human blood lead levels).

The lead phasedown program baseline emissions were calculated from gasoline refinery lead purchase records and gasoline sales in an area in terms of 'potential to emit'. Pollutant reductions attributable to the lead phasedown program were calculated in a similar fashion. Verification of the programs' effectiveness was monitored indirectly using the amount of lead purchased by industry and the blood lead amounts in human populations. Lead purchasing reports were generated as often as monthly as were ambient air lead levels and blood lead levels.

New Source Performance Standards Offset Program

Another trading monitoring example comes from the Clean Air Act program for permits for new or modified major sources (those that emit hazardous air pollutants or criteria air pollutants above certain levels or in nonattainment areas). These high volume or highly toxic emitters must include provisions in permit applications to offset the impact of any additional emissions (i.e., trade for another source's emissions reductions.) The offset concept is similar to the leaded gas reductions banking program described above; the offsets act as banked reductions before an emission source is permitted to emit increased amounts of pollutants. These offsets are emissions reductions from the same source or other sources in the same nonattainment area. (Wooley, D., 1995).

In the Los Angles area, some industries used this provision to gain volatile organic compound emissions reduction credits by purchasing older, less fuel efficient vehicles. In other cities, some industrial facilities have financed additional emission control measures at other facilities, including fugitive sources, whose process emissions rates are controlled at a lower cost per ton of pollutant removed. Both examples are similar to agricultural nonpoint source diffuse sources. Point/nonpoint source trading in the vehicle example is obvious. The industrial example can be viewed as fugitive emissions reductions (agricultural nonpoint source discharges) from some manufacturing process being traded for point source emissions from another.

In the vehicle example, the volatile organic compound baseline emissions were calculated from vehicle miles driven and gasoline sales in an area. Pollutant reductions attributable to the volatile organic compound program are calculated in a similar fashion by substituting more efficient vehicle miles for less efficient vehicle miles. Verification of the programs' effectiveness was monitored indirectly using ambient air monitors in the area. Ambient air reports could be generated as often as monthly.

In the industrial fugitive emissions example, the pollutant baseline emissions were calculated from process air permit calculations using mass balance techniques or actual air monitoring data. Pollutant reductions attributable to the financed control device are calculated using EPA-accepted control efficiencies or emissions factors for the device. Verification of the programs' effectiveness was monitored using process-specific industrial production data. Reporting frequency is based on the permit conditions but it could be as often as quarterly.

Acid Rain Program

A third trading monitoring example, the acid rain program (Title IV of the Clean Air Act Amendments), introduced two new trading concepts to control sulfur dioxide emissions from 110 of the largest coal-fired power plants in the country:

1. Industry-Wide Emissions Cap Title IV sets a national annual sulfur dioxide (SO_2) emissions cap based on average emissions between1985 and 1987 (baseline). Reductions are conducted in two phases. Phase I addresses reductions of SO_2 emissions from the 110 largest coal-fired power plants to attain a collective emissions cap calculated as the baseline level minus 10 million tons (e.g., an emissions cap of 5.7 million tons) beginning in 1995. Phase II starts after 2000, all utility plants larger that 25 megawatts are brought into the system and must, in toto, operate within an emissions cap of 8.95 million tons.

2. Emissions Allowance Trading Program An allowance trading program allows utilities to buy, trade, or bank emissions credits. To operate within their individual emissions limit, facilities may bank credits for later use or trade or purchase reductions from other facilities that emit SO_2 below their allowance of the industry-wide cap (Wooley, D., 1995).

The Title IV program was quite effective during its initial years. The period 1995 through 1996 saw no violations of the SO_2 standard by any of the 110 affected facilities. This compliance was achieved without enforcement actions at a program cost of about $2 per ton of SO_2 controlled. Nationwide, the Title IV program is operated by less than 100 employees in state and federal offices (Swift, 1997).

In the acid rain example, pollutant baseline emissions were calculated from process air permit calculations using mass balance techniques or actual air monitoring data. Pollutant reductions attributable to the SO_2 control device are calculated using EPA-accepted control efficiencies or emissions factors for the device. Verification of the programs' effectiveness was monitored using a national ambient air monitoring system. Reporting frequency is based on the permit conditions but it could be as often as quarterly and the continuously-operating ambient air monitoring system can generate reports as often as needed.

Other Air Monitoring Systems

Some air permitting programs use direct monitoring measures such as sulfur dioxide concentration converted to a mass emission rate in tons per year. Others programs use indirect measures. For example, in a hazardous waste incinerator, carbon monoxide concentration (a relatively inexpensive continuous emission monitor) is used as a measure of hazardous waste incineration combustion efficiency. Thus, it serves as an indicator of dioxin emissions (a very expensive sampling and analysis strategy) that also arise from incomplete combustion of the waste materials.

Industrial production can be used as an indirect measure of air emissions. The EPA developed emissions factors for common point and fugitive (nonpoint sources) industrial processes that relate a production or fuel use rate to emissions of certain compounds. Given the easily tracked production or fuel use rate for specific processes and the emissions factors, one can calculate air emissions.

Emissions factors are generally thought of as conservative measures of controlled or uncontrolled emissions. A facility can use EPA published factors with the assurance that a regulatory agency will accept that their calculated emissions are no higher than those reported. This is a powerful legal and technological advantage. Facilities do not worry about challenges to their reported emissions and they do not have to conduct costly evaluations to verify their periodic reports.

Another air monitoring concept is Continuous Assurance Monitoring (CAM). The idea is to identify some easily tracked measure(s) that indicate air capture and control devices are working properly and then monitor and report these indicator values. For example, a facility uses a vapor incinerator to control volatile organic compounds from a production process located in a single building. The entire enclosure acts as a capture device and vents all the air in the enclosure to the incinerator. Standard test methods initially establish that capture and control devices work properly and record specific monitoring values at those conditions. An example would be an air pressure monitor in the enclosure verifies that the vapors from the process are induced to enter the incinerator (lower pressure area) and not escape the enclosure. The incinerator temperature and exhaust pressure are also monitored to verify that the vapors are treated at a critical temperature/residence time set point. Ultimately, the regulatory agency reviews the periodic monitoring reports of pressure differential, temperature, and air flow rate to verify compliance with volatile organic compound emissions limits.

The point of these monitoring examples is to show that regulatory agencies accept indirect process-related measures as indicators of emissions. Emissions factors address operational variations by using the average emissions results from many actual test reports. The CAM method uses verified process-specific indicators. Both examples are used by a variety of air emissions control programs.

Comparisons of air and agricultural water quality program monitoring issues show that the two programs address stunningly similar issues. Both have a defined impact area. Air programs use an airshed basis to delineate attainment or nonattainment areas and water programs use a watershed basis to delineate impaired stream segments. Both programs address point and nonpoint pollutant discharge sources and both have successful point source permitting systems. Both use environmental quality standards. In setting area air emissions caps EPA uses National Ambient Air Quality Standards to allocate a portion of the emissions load to industrial, mobile, and other sources. In setting watershed effluent caps, EPA uses water quality standards to allocate a rivers' assimilative capacity load to each class of dischargers. Both programs establish industry-specific discharge concentration or mass loading levels and mandate certain control technologies.

Air programs address fugitive sources using a bubble concept. Materials that enter the bubble (purchased material) are assumed to exit in the product or as fugitive air emissions. Water programs are beginning to address agricultural nonpoint sources using a watershed or 'bowl' concept. Fertilizers, or other nutrient materials, that enter the bowl can be assumed to exit in the farm product, remain sequestered in the soil, groundwater, and other vegetation or are discharged to receiving waters. The main difference between air and water program bubble concept use is that water programs are much more susceptible to degradation of discrete stream segments (i.e., air emissions are generally more easily and widely dispersed than water discharges). Clean Air Act permitting programs use several methods to calculate regulated pollutant emissions from sources.

The similarities between air and water programs can serve as a basis to use common monitoring strategies. Of course, program differences must be incorporated into the water strategy. The primary uncertainty in nonpoint source agricultural discharges is the timing and magnitude of meteorological events. Letson asserts that tradeoffs between point and nonpoint sources involve uncertainty, he says, "limitations in predicting storm-driven [nonpoint source] loadings imply difficulties in selecting the trading ratio that would appropriately substitute continuous [point source] loadings for them." (Letson, 1992). Weather-related agricultural discharge uncertainties are in contrast to the primary uncertainty in fugitive air programs, which are the variations in industrial practices.

APPENDIX II - SURVEY QUESTIONS

TRADING PROGRAM MONITORING SURVEY
Modeling

<u>Baseline Evaluation of Pollutant Discharge Rate and Potential for Reduction</u>

1. Who/What agency establishes the baseline of pollutant discharges? How long is the baseline period?

A. SWCD
B. State Agency
C. Consultant
D. Trading Program
E. Stakeholder Association

2. What model is used?

A. EPA
B. USDA
C. USGS
D. NOAA
E. Statewide model
F. Watershed model
G. Other

3. Duration of baseline study?

A. None
B. 1 season
C. 2 seasons
D. 1 year
E. 2 years
F. 3 years
G. 4 years
H. Greater than 4 years

4. Data Source(s)?

A. Point source discharge (NPDES data)
B. Section 305 data
C. Section 208 data
D. Section 319 data
E. Other

5. What are the primary factors considered in modeling? Rank the five most important factors in conducting this activity:

_Upstream concentration	_Downstream concentration	_Stream flow
_Precipitation	_Monitoring plan	_Soil type
_Soil pollutant content	_Fertilizer application rate	_BMP
_Crop cultivation area	_Fertilizer application timing	_Slope

6. How are BMP's chosen?

A. Based on site-specific conditions
B. Agency list
C. Farmer choice
D. Combination
E. Other

7. Is a site-specific plan/agreement developed?

A. Yes
B. No

8. How are reduction credits documented?

A. NPDES permit
B. Registry
C. Contract
D. NPS permit
E. Other

<u>Verification of Pollutant Discharge Rate Reduction By Modeling Methods</u>

9. Who/What agency verifies pollutant discharge rate reductions? How long is the baseline period?

A. SWCD
B. State Agency
C. Consultant
D. Trading Program
E. Stakeholder Association.

10. How often are modeling evaluations conducted?

A. 1 per contract or permit period
B. 1 per year
C. 2 per year
D. 3 per year
E. 4 per year
F. Other

11. What model is used?

A. EPA
B. USDA
C. USGS
D. NOAA
E. Statewide model
F. Watershed model
G. Other

12. Data Source(s)?

A. Point source discharge (NPDES data)
B. Section 305 data
C. Section 208 data
D. Section 319 data
E. Other

13. What are the primary factors considered in modeling? Rank the five most important factors in conducting this activity:

_Upstream concentration	_Downstream concentration	_Stream flow
_Precipitation	_Monitoring plan	_Soil type
_Soil pollutant content	_Fertilizer application rate	_BMP
_Crop cultivation area	_Fertilizer application timing	_Slope

14. Do pollutant reduction credits change from year to year?

A. Yes
B. No

15. What initial condition changes account for changes in pollutant reduction credits in successive years?

A. Paired watershed
B. Upstream/Downstream
C. Downstream only
D. Point source discharge (NPDES data)
E. Section 305 data
F. Section 208 data
G. Section 319 data
H. Other

16. Are overall pollutant loads tracked or only reductions?

A. Overall loads for permit/contract period
B. Overall loads by practice
C. Overall loads by participant
D. Overall loads by year

TRADING PROGRAM MONITORING SURVEY
Sampling and Analysis

<u>Baseline Evaluation of Pollutant Discharge Rate and Potential for Reduction</u>

1. Who/What agency establishes the baseline of pollutant discharges? ? How long is the baseline period?

A. SWCD
B. State Agency
C. Consultant
D. Trading Program
E. Stakeholder Assoc.

2. What pollutant discharge estimation method is used?

A. Paired watershed
B. Upstream/Downstream
C. Downstream only
D. Point source discharge (NPDES data)
E. Section 305 data
F. Section 208 data
G. Section 319 data
H State monitoring program
I Other

3. Duration of baseline study?

A. None
B. 1 season
C. 2 seasons
D. 1 year
E. 2 years
F. 3 years
G. 4 years
H. Greater than 4 years

4. Sampling frequency?

A. Annually
B. Seasonally
C. Biannually
D. Quarterly
E. High flow/Low flow
F. Other

5. What are the primary factors considered in sampling and analysis? Rank the five most important factors in conducting this activity:

_Upstream concentration	_Downstream concentration	_Stream flow
_Precipitation	_Monitoring plan	_Soil type
_Soil pollutant content	_Fertilizer application rate	_BMP
_Crop cultivation area	_Fertilizer application timing	_Slope

6. How are BMP's chosen?

A. Based on site-specific conditions
B. Agency list
C. Farmer choice
D. Combination
E. Other

7. Is a site-specific plan/agreement developed?

A. Yes
B. No

8. How are reduction credits documented?

A. NPDES permit
B. Registry
C. Contract
D. NPS permit
E. Other

<u>Verification of Pollutant Discharge Rate Reduction By Sampling/Analysis Methods</u>

9. Who/What agency establishes the baseline of pollutant discharges? How long is the baseline period?

A. SWCD
B. State Agency
C. Consultant
D. Trading Program
E. Stakeholder Assoc.

10. What pollutant discharge estimation method is used?

A. Paired watershed
B. Upstream/Downstream
C. Downstream only
D. Point source discharge (NPDES data)
E. Section 305 data
F. Section 208 data
G. Section 319 data
H. State monitoring program
I. Other

11. How often are on-site inspections conducted?

A. 1 per contract or permit period
B. 1 per year
C. 2 per year
D. 3 per year
E. 4 per year
F. Other

12. Sampling frequency?

A. Annually
B. Seasonally
C. Biannually
D. Quarterly
E. High flow/Low flow
F. Other

13. What are the primary factors considered in sampling and analysis? Rank the five most important factors in conducting this activity:

_Upstream concentration	_Downstream concentration	_Stream flow
_Precipitation	_Monitoring plan	_Soil type
_Soil pollutant content	_Fertilizer application rate	_BMP
_Crop cultivation area	_Fertilizer application timing	_Slope

14. Do pollutant reduction credits change from year to year?

A. Yes
B. No

15. What initial condition changes account for changes in pollutant reduction credits in successive years?

A. Paired watershed
B. Upstream/Downstream
C. Downstream only
D. Point source discharge (NPDES data)
E. Section 305 data
F. Section 208 data
G. Section 319 data
H. Other

16. Are overall pollutant loads tracked or only reductions?

A. Overall loads for permit/contract period
B. Overall loads by practice
C. Overall loads by participant
D. Overall loads by year
E. Overall loads by season
F. Reductions only

TRADING PROGRAM MONITORING SURVEY
Best Management Practices / Land Use Evaluation

<u>Baseline Evaluation of Pollutant Discharge Rate and Potential for Reduction</u>

1. Who/What agency establishes the baseline of pollutant discharges? How long is the baseline period?

A. SWCD
B. State Agency
C. Consultant
D. Trading Program
E. Stakeholder Association

2. What pollutant discharge estimation method is used?

A. SWCD
B. State Agency
C. Trading Program
D. Stakeholder Association
E. USDA/NRCS
F. Other

3. What are the primary factors considered in land use evaluations? Rank the five most important factors in making this calculation:

_Crop cultivation area	_Proximity to receiving water	_Soil type
_Transport/Retention factor	_Cropping practice	_Slope
_Fertilizer application rate	_Fertilizer application timing	_BMP
_Streambank condition	_Delivery area	_Erosion rate
_Animal density	_Manure application rate	_Soil pollutant content
_Stream flow	_Precipitation	_Other

4. How are BMP's chosen?

A. Based on site-specific conditions
B. Agency list
C. Farmer choice
D. Other

5. Is a site-specific plan/agreement developed?

A. Yes
B. No

6. How are reduction credits documented?
A. NPDES permit
B. Registry
C. Contract
D. NPS permit
E. Other

<u>Verification of Land Use and Pollutant Discharge Rate Reduction By Land Use Methods</u>

7. Who/What agency verifies land use and pollutant discharge rate reductions?
A. SWCD
B. State Agency
C. Consultant
D. Trading Program
E. Stakeholder Assoc.

8. How often are on-site inspections conducted?
A. 1 per contract or permit period
B. 1 per year
C. 2 per year
D. 3 per year
E. 4 per year
F. Other

9. What pollutant discharge estimation method is used?
A. SWCD
B. State Agency
C. Trading Program
D. Stakeholder Association
E. USDA/NRCS
F. Other

10. What are the primary factors considered in land use evaluations? Rank the five most important factors in making this calculation:

_Crop cultivation area	_Crop type	_Soil type
_Cropping practice	_Erosion rate	_Slope
_Pollutant Transport/Retention factor		_Instream pollutant conc.
_Fertilizer application rate	_Fertilizer application timing	_BMP
_Streambank condition	_Delivery area (to stream)	_Stream flow
_Animal density	_Manure application rate	_Soil pollutant content
_Proximity to receiving water	_Precipitation	_Other

11. Do pollutant reduction credits change from year to year?

A. Yes
B. No

12. What initial condition changes account for changes in pollutant reduction credits in successive years?

A. Land use
B. Crop type
C. Crop area
D. Tillage method
E. Fertilizer use
F. Other

13. Are overall pollutant loads tracked or only reductions?

A. Overall loads for permit/contract period
B. Overall loads by practice
C. Overall loads by participant
D. Overall loads by year
E. Overall loads by season
F. Reductions only

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VITA

DANIEL J. MARCH, Q.E.P.
915 West Main Street
Christiansburg, Virginia 24073

<u>EDUCATION/PROFESSIONAL DEVELOPMENT</u>:

JANUARY 1998 - 2000: GRADUATE STUDENT; VIRGINIA TECH CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT; BLACKSBURG, VIRGINIA.

Masters degree candidate for Environmental Science and Engineering degree. Thesis topic concerns trading of agricultural nonpoint source pollutant reductions for point source permit limits to reduce their economic burden. It focuses on monitoring activities to support economic valuation of reduction credits to promote trading of excess pollutant control capacity between dischargers.

B.S., Biology, Western Carolina University, Chemistry minor, 1981.

- ! Hazardous Waste Incineration, EPA Course 502, 1989
- ! Combustion Evaluation, EPA Course 427, 1989
- ! Analytical Quality Control Workshop, South Carolina Water Quality Institute, 1985

<u>PROFESSIONAL EXPERIENCE</u>:

APRIL 1994 -DECEMBER 1997: MANAGER, AIR PROGRAMS,
OLVER LABORATORIES INC., BLACKSBURG, VIRGINIA.

Managed air program staff in source testing, permitting, modeling, and reporting activities for a variety of industries including pulp and paper, basic and refined metals, synthetic organic chemical manufacturing, rubber, and pharmaceuticals. Provided technical services including evaluation and design of air pollution control devices, permit limit negotiation, Virginia Department of Environmental Quality interaction, reporting, and:

- ! Managed or led Title V major source or synthetic minor permitting projects. Negotiated Construct and Operate permit limits and applicability with DEQ. Conducted Consent Order and Agreement program to completion with DEQ.

- ! Performed, led, and managed stationary source emissions test projects to evaluate pollutant emissions levels. Information used for compliance reporting, emissions inventories, modeling, and industrial research programs to design/evaluate air pollution control equipment.

- Conducted industrial hygiene evaluations using NIOSH methods for OSHA compliance.

1986 - 1994: ENVIRONMENTAL SCIENTIST, MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MISSOURI and CARY, NORTH CAROLINA.

Provided technical assistance on contracts with EPA's Office of Air Quality Planning and Standards, State, and industrial clients. Conducted multimedia field testing programs, including the preparation of test and work plans, project proposals, and reports.

Technical Assistance/Regulatory Support

- Identified and quantified Title III hazardous air pollutant emissions from the pulp and paper and iron and steel industries for EPA/Emissions Standards Division work assignments. Emissions information used to determine Maximum Achievable Control Technology levels for National Emission Standards for Hazardous Air Pollutants under development by the CAAA.

- Developed and/or revised AP-42 emissions factors for the EPA/Emission Inventory Branch.

- Produced test plans, work plans, and reports for EPA/Emission Measurement Branch. Prepared guidance document on capture efficiency using temporary total enclosures. Conducted and reviewed stationary source emission tests.

Field Sampling Programs

- Led sampling for five industrial processes under investigation by EPA/OSW for listing hazardous waste streams under RCRA. Implemented sampling plans, prepared budgets, developed sampling methods, and directed and trained field personnel.

- Served as field crew chief for three EPA/Office of Research and Development projects. Projects objectives: Determined the effectiveness of a dry lime spray/baghouse combination to control metals emissions; evaluated a hazardous waste incinerability ranking system; and measured the ability of sulfur hexafluoride to act as an indicator of incineration efficiency.

- Directed a California Air Resources Board research program to determine dioxin/furan, PAH, and metals emissions from waste oil fuel users and from steel drum reconditioning facilities.

- Performed as project leader and field crew chief for RCRA trial burns at hazardous waste incinerators, boiler and industrial furnace (BIF) facilities, and medical waste incinerators. Wrote sampling and QA plans, directed field personnel in sampling activities, collected samples by official EPA methods, and prepared technically sound reports.

- Audited source sampling programs as an EPA representative at two Department of Defense chemical warfare incineration facilities and RCRA and TSCA hazardous waste incinerators.

1982 - 1986: ENVIRONMENTAL SCIENTIST AND LABORATORY MANAGER, ENVIRONMENTAL TESTING, INC., ASHEVILLE, NORTH CAROLINA.

Scheduled, collected, and analyzed client wastewater streams to ensure accurate, reliable data for NPDES DMR reports and for the Municipal Pretreatment Program. Operated wastewater treatment plants and conducted hazardous waste determinations. Conducted an ambient air quality monitoring program around a coal-fired power plant.

PROFESSIONAL REGISTRATION

Waste Water Treatment Plant Operator, Grade III, North Carolina Department of Natural Resources and Community Development, Registry No. 7101, 1984.
Air and Waste Management Association, Qualified Environmental Professional, 1996.

PROFESSIONAL ASSOCIATIONS

Air and Waste Management Association
Carolinas Air Pollution Control Association

PUBLICATIONS/PRESENTATIONS

Collection of seven guidance documents, articles, presentations, and reports concerning RCRA hazardous waste testing and analysis. Also, over 70 test reports, workplans, and other environmental evaluations.