CONTENTS

(Links are available to titles in blue)

INTRODUCTION

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OUR OBJECTIVES

In April 1998, the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) held a Conference to examine issues related to agricultural phosphorus (P) and water quality with the Chesapeake Bay Watershed. This publication presents the invited papers and posters given at the Conference, along with the views of several Bay farmers, key Bay resource users, and recommendations from the Conference workgroups - Soil Phosphorus Testing for Environmental Risk Assessment, Nutrient Management Planning, and Best Management Planning Development and Implementation. The objectives of this Conference were to evaluate the following:

***Impact of Phosphorus on the Bay* -** Determine the loading of P to agricultural lands in the Bay watershed, their spatial and seasonal distribution, and where the main areas of impact in the Bay are and how they are affected by the type, amount, timing, and location of P flows in the Bay.

***Sources and Transport of Agricultural Phosphorus Within the Bay Watershed* -** Identify and evaluate critical source areas and processes controlling the export of P from agricultural soils in the watershed to the Bay itself. Discuss procedures and protocols for delineating critical source areas of P over a range of scales (farm field to subwatershed) within the Bay Watershed.

Transfer of Phosphorus from the Farm to the Bay Scale - Identify and delineate what processes control the critical sources and pathways of phosphorus export over a range of scales in the Bay Watershed. Determine the effects of river channel, impoundment and river processes on P transfers, as one scales up transport processes from the farm to Bay scale.

Development of Integrated Nutrient Management Planning in the Bay Watershed - Discuss how nutrient management plans can be developed for P as well as nitrogen (N) in efforts to maintain farm profitability and the quality of water resources in the Bay Watershed, particularly where animal and manure production is localized.

Future Trends for Phosphorus Management in the Bay Watershed - Discuss what can be done with current technology to minimize agricultural P losses and Bay inputs and prioritize future trends for phosphorus management in the Chesapeake Bay Watershed.

From the author's area of expertise or experience, each addressed the questions; what do we know, what do we still need to know, where are there major gaps in our knowledge, and how does the information relate to P management strategies in the Bay Watershed? As a result, this series of papers provides a unique collation of information of regional, national, and international significance and provides prioritized P management options for the Chesapeake Bay Watershed.

BACKGROUND

Phosphorus is an essential element for plant and animal growth and its input has long been recognized as necessary to eliminate deficiencies and to maintain profitable crop and livestock production. Additional P can also increase the biological productivity of surface waters by accelerating eutrophication. Eutrophication is the natural aging of lakes or streams brought on by nutrient enrichment. While the process is natural, human activities can change the land use of a watershed, greatly accelerating the rate of eutrophication -- principally by increasing the rate at which P is added to the aquatic system. Eutrophication of most fresh waters is accelerated by increased P inputs. Phosphorus is often the limiting element and its control is of prime importance in reducing the accelerated eutrophication of fresh waters in the Bay. When salinity increases, as in estuarine parts of the Bay, N rather than P generally limits aquatic productivity.

Although urban and other sources contribute P to the Bay, the papers presented at this conference focused on the role of P in agriculture and its impact on water quality in the Chesapeake Bay. This focus was necessary because of recent concerns with P-related water quality issues, changes in agricultural production within the Bay, and a shifting emphasis from N to P-based manure management strategies.

Eutrophication has been identified by USEPA as the main problem in surface waters having impaired water quality in the U.S. Eutrophication restricts water use for fisheries, recreation, industry, and drinking, due to the increased growth of undesirable algae and aquatic weeds and oxygen shortages caused by their die-off and decomposition. Associated periodic surface blooms of cyanobacteria (blue-green algae) occur in drinking water supplies and may pose a serious health hazard to livestock and humans. Recent outbreaks of the dinoflagellate *Pfiesteria piscicida* in the eastern U.S., and Chesapeake Bay tributaries in particular, have been linked to high nutrient levels in affected waters. Neurological damage in people exposed to the highly toxic volatile chemical produced by this dinoflagellate has dramatically increased public awareness of eutrophication and the need for solutions.

The major contributors of P to the Chesapeake Bay are point sources (34%) and agricultural runoff (49%) (Chesapeake Bay Program, 1995). These inputs accelerate eutrophication of the P-sensitive fresh waters of upper Chesapeake Bay. Greater than expected reductions in P discharges from wastewater treatment plants have occurred because of limits on discharge permits and from the 1990 P detergent ban. However, the reduction in P inputs from agricultural runoff have been less dramatic, and has thus drawn attention to the implementation of nutrient management plans and farm conservation practices to reduce P losses.

Confined livestock operations are now a major source of agricultural income in Chesapeake Bay states. However, the rapid growth and intensification of the livestock industry has created regional and local imbalances in P inputs and outputs. On average, only 30% of the fertilizer and feed P input to farming systems in the Bay is output in crops and livestock produce. In Confined Animal Feeding Operations (CAFOs), this P tends to accumulate in manure. Because manure has a much higher P:N ratio than that needed by plants growing on manured lands, and is applied based on its N content, amounts of P added via manure often exceed crop requirements and uptake of P. A major and rapid buildup of P in soils has resulted, which has increased the potential for P enrichment of runoff. In Pennsylvania, 48% of the soils analyzed for P by State Soil Testing Laboratories in 1995 were in excess of that needed for agricultural production. This value is 64% in Delaware, 48% in New York, and 58% in Virginia.

Prior to World War II, farming communities tended to be self-sufficient in that enough feed was produced locally and recycled to meet livestock requirements. After World War II, increased fertilizer use in crop production fragmented farming systems, creating specialized crop and livestock operations that efficiently coexist in different regions. As farmers did not need to rely on manures as nutrient sources (the primary source until fertilizer production and distribution became cheaper), we could spatially separate grain and livestock production. By 1995, the major livestock producing states imported over 80% of their grain for feed. In fact, less than a third of the grain produced on farms in the Bay is fed on the farm where it is grown. Thus, the inefficient utilization of P by crops and animals and specialization and concentration of production systems, exacerbates the accumulation of in the Bay.

Phosphorus accumulation on farms has built-up soil P to levels that often exceed crop needs. Today there are serious concerns that agricultural runoff (surface and subsurface) and erosion from high P soils may be major contributing factors to surface water eutrophication. Phosphorus loss in agricultural runoff is not of economic importance to farmers, amounting to only 1 or 2% of that applied. However, the environmental problems associated with P losses from soils can have significant off-site economic impacts on water quality. In some cases, these impacts are manifested many miles from the site where P loss in soil erosion and runoff originally occurred.

By the time the water quality impacts are noticeable, remedial strategies are difficult and extensive to implement. Remediating surface waters impacted by P is further complicated by the time involved (years to decades) and the fact that surface waters often cross political boundaries (e.g. state lines).

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Impact of Phosphorus on the Bay

Inputs of Phosphorus to the Chesapeake Bay Watershed

A.W. Taylor[1] and H.B. Pionke[2]

ABSTRACT

The water quality problems in the Chesapeake Bay are dominated by nutrients from both point and non-point sources in the Basin. Close to three-quarters of the phosphorus load is contributed by the non-point sources which are almost exclusively of agricultural origin. The sources of this phosphorus include both fertilizers and animal manures. The factors controlling the applications of these vary in differing parts of the Basin depending on the different soils and farming systems, but the generally increasing concentration of phosphorus in many soil reflect continued applications of both fertilizers and manures in excess of their removal in harvested crops and the retention of the surplus by adsorption and fixation in the soil. In some areas of the Basin,

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applications of manure, regarded as a waste material to be disposed of rather than used as a renewable resource, has caused significant environmental impacts on water quality. The advances in fertilizer technology that have led to this discounting of the value of manures are reviewed together with the development of techniques for the identification of soils that contain high phosphorus concentrations due to over-application of either fertilizers or manures. The fact that a very small fraction of the applied phosphorus - usually less than 3% - is environmentally significant needs to be recognized in the development of improved Best Management Practices for the reducing entry into the Bay and Basin waters.

Impact of Nutrient Inflows on Chesapeake Bay

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ABSTRACT

The purpose of this paper is to summarize selected research and monitoring conclusions developed in the last decade regarding the sources, fate and effects of nutrients in Chesapeake Bay. Compared to other estuarine systems, loading rates to Chesapeake Bay are moderate to high for nitrogen (N) and low to moderate for phosphorus (P). While the effects of nutrient additions vary among estuaries, current loads in Chesapeake Bay are sufficient to cause severe seasonal hypoxia and to cause large declines in seagrass communities. Diffuse sources of N and P are the dominant inputs but point and atmospheric sources are also important in tributary systems. On an annual basis N was exported to the coastal ocean while P was imported. Estuarine sediments are capable of large releases of P, especially when dissolved oxygen concentrations near sediments are low (<2 mg L^{-1}). However, laboratory and field measurements indicate that sediment reserves of labile N and P are sufficient to support high sediment nutrient releases for months to a year or so but not for decades. Mesocosm and bioassay experiments indicate that during warm periods of the year phytoplankton communities are limited by N while P limits production in tidal freshwater regions. Field, mesocosm and laboratory studies all suggest that Chesapeake Bay and tributary systems are responsive to changes in nutrient loading rates on relatively short time scales.

<u>Sources and Transport of Agricultural Phosphorus within the Bay Watershed</u>

Phosphorus Dynamics in Soils of the Chesapeake Bay Watershed: A Primer

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ABSTRACT

Changes in the phosphorus (P) content of agricultural soils are primarily dependent on management decisions made by farmers. Soil total P content and P partitioning among the numerous forms of P present in soils are the cumulative result of land management decisions made over many years. Soil P can be broadly and loosely organized into four categories based on physical characteristics and relative reactivity with in the soil: soil solution P, labile organic P, stable organic P, inorganic solid phase P. The only means by which the total amount of P in an agricultural soil can be substantially increased is through the purposeful activities of the managing farmer. Over the past 40 years, the P status of the agricultural soils in the Chesapeake Bay watershed has been increasing. Elevated soil test phosphorus levels are most pronounced in regions of intense animal agriculture production. Production of traditional agronomic crops will reduce the P level of very high P soils that pose environmental concern, but the rate of soil P reduction will be slow and soil-type specific. There are three main pathways by which P may be transported from a soil with field drainage water: surface runoff water, subsurface lateral flow, and leaching to groundwater. Surface runoff P is usually the dominant mechanism for P loss from most soils in the Chesapeake Bay watershed. The proposed use of conventional soil test P fertility evaluation as a predictor of potential P loss with surface runoff water is highly questionable. Conversely, the P Index is a valuable nutrient management planning tool that incorporates soil physical and chemical properties and landscape characteristics to assess the site-specific potential for P loss with surface runoff water from. A useful P management plan for a farm operation must include an evaluation of soil characteristics and farm management alternatives on a field by field basis.

The Role of Soil Testing in Environmental Risk Assessment for Phosphorus[3]

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ABSTRACT

Risk assessment is the process by which we estimate the probability that injury, loss, or damage will occur to an organism, an ecosystem, or sector of the environment. This paper argues two points. First, that a formal approach to risk assessment is needed for soil phosphorus (P) because erosion and runoff (surface and subsurface) of P from agricultural soils is widely accepted as a causative factor in the eutrophication of surface waters in the Chesapeake Bay watershed. Further, it has recently been suggested that nonpoint source pollution of coastal rivers and estuaries by agricultural P is a potential contributing factor to health-based risks for humans caused by blooms of toxic algae and dinoflaggelletes. And, second, that soil testing, when properly conducted, is an essential and vital component of the risk assessment process. To fully use soil P testing in risk assessment, it is essential to consider: (i) the most effective means to use current agronomic soil P tests and data bases for environmental purposes; (ii) the value of and future research needed with newly developed environmental soil P tests (e.g. soluble P, potentially desorbable P, degree of P saturation); and (iii) integration of current and new soil P tests into more holistic approaches to risk assessment, such as the multi-parameter *Phosphorus Index* and watershed-scale P transport models.

Critical Areas of Phosphorus Export from Agricultural Watersheds

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ABSTRACT

Phosphorus (P)-focused management of all fields having high soil P levels or high rates of P input via fertilizer or manure is not necessary to reduce P export from a watershed. Rather, management should focus on the areas representing the intersections of high P source-areas with areas of actual or potential transport mechanisms, primarily surface runoff and erosion. These intersections define the critical source areas (CSAs) controlling P export. In this paper, we extend the generalities of phosphorus soil chemistry and pathways of transport addressed in previous papers in this symposium to the watershed scale. Based on the watershed-scale findings, we suggest modifications to the NRCS Phosphorus Index, a user-oriented tool for

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identification of CSAs controlling P export from agricultural watersheds and evaluation of management options available.

Transfer of Phosphorus from the Farm to the Bay Scale

Pathways of Phosphorus Transport

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ABSTRACT

The hydrological pathways enabling transport of potentially mobile P from agricultural land to receiving waters are examined. While surface runoff remains an important pathway of P loss, recent research demonstrates the potential for subsurface transport of P in macropore flow and from drained land. The forms of mobilised P differ according to the transport pathway. For grassland, dissolved P is transported in surface runoff but particulate P is proportionately more important in macropore and drainflow - especially during storm events. Tilled land generally shows high particulate P transport. Where livestock intensification has increased the rate of manure returns to land, there is clear evidence of enhanced P transport, both as incidental losses in surface runoff and through matrix or preferential flow in subsurface pathways.

Transfer of Phosphorus from the Farm to the Bay

David L. Correll, Thomas E. Jordan and Donald E. Weller
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ABSTRACT

Phosphorus is a key element related to the eutrophication of Chesapeake Bay. Farm fields are a major source of P in land discharges. Most of the P is transported from fields to the receiving waters via overland flows during storm events, particularly in wet seasons of the years. The flux of total-P from Rhode River cropland was 58, 1350, and 10800 g P ha^{-1} in very dry, average precipitation, and very wet years, respectively. Almost all of the P transported in storm events is particulate organic-P and particulate inorganic-P. Some of this P is released as dissolved inorganic phosphate after entering the Chesapeake. The integrated mean particulate-P concentrations during storm events were directly correlated with peak water discharge during the storms. Increased fluxes of P in wet periods was due to both higher water discharges and higher P concentrations, especially in the spring. Rhode River watershed fluxes of P were higher in general than those we measured in other parts of the Coastal Plain and Piedmont. Riparian

buffers will only intercept large amounts of P from overland storm flows if they are managed to prevent concentrated flows during storms. Reservoirs have a major impact on the transport of both particulate and dissolved forms of P.

Development of Integrated Nutrient Management Planning in the Bay Watershed

Nutrient Management: Regional Issues Affecting the Bay

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ABSTRACT

The perception of animal manure in agriculture recently has changed from viewing it as a valuable resource to seeing it as a threat to environmental quality. Knowing the history of P use in agriculture and recognizing the structure of contemporary agriculture can be the basis for understanding the connections involved in managing P and envisioning nutrient management in the future. The key to the transformation of agriculture was the privatization of industrial N-fixation capacity following WW II for fertilizer production. From that point, nutrients could be supplied for agricultural uses in totally new ways without the historic constraints due to quantity or location. Farms could be organized based on feedback messages other than the biological dimension and agriculture changed dramatically as a result. Crop and animal production intensified in specialized regions and nutrients flowed from one to the other and began to accumulate where the animals were located. These changes were encouraged by a variety of policy and economic incentives that originated beyond the boundaries of individual farms. Our visions of the future must not perceive animal manure as a problem to be solved by farmers, but as a symptom requiring more sweeping reforms. A large "community" of concern can help create the strategic change necessary for farmers and agribusiness to make choices that reconcile the need for economic production and environmental protection.

Integrating Phosphorus and Nitrogen Management at the Farm Level

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ABSTRACT

There are environmental concerns with both nitrogen (N) and phosphorus (P) from agriculture. Accumulations of N and P have occurred on many farms because of the structure of modern intensive animal agriculture systems. Most nutrient management systems are based on balancing N with less attention being paid to P. This is because of the greater environmental concern with nitrogen and generally lower economic consequences related to N management due to the higher

risk associated with improper N based management and the greater costs associated with P based management. When manure nutrients are applied based on N there will usually be an excess of P applied. Traditional management systems have tried to deal with this excess by emphasizing best management practices to minimize the potential environmental impact of this excess P. Phosphorus-based nutrient management plans usually require greater cropland area to balance the P which results in a greater economic cost for nutrient management. As concern increases about the potential for environmental problems with P, integrating N and P management will require innovative management systems that combine a variety of management strategies. Components of this system might include: changes in cropping systems; improved feeding systems such as addition of enzymes to improve P utilization by the animals; improved best management practices to control N and P transport; manure additives such as alum to reduce availability of P to the environment; and site specific management to delineate critical source areas for N and P loss and manage them accordingly. While these measures will help to minimize the environmental impact of excess nutrients, the ultimate solution to the nutrient management problems that will enable sustainable agricultural production for the long term will require bringing nutrients inputs into balance with nutrient requirements.

On-Farm Management Options for Controlling Phosphorus Inputs to the Bay

Patricia Steinhilber and Richard Weismiller
University of Maryland

ABSTRACT

A wide array of options for on-farm phosphorus (P) management is being discussed and debated by agricultural advisors, citizens' action groups, tributary teams, journalists, environmentalists and farmers, often without regard to the current state of knowledge, effectiveness, or the long-term sustainability of each practice. The discussion that follows will examine the status, effectiveness and limitations of options currently being discussed in Maryland. Practices that can impact the soil P status and as well as those that can affect transport of P from a field will be discussed.

AUTHORS' BIOGRAPHIES

Andrew Sharpley is a Soil Scientist at the USDA-ARS, Pasture Systems and Watershed Management Research Laboratory, University Park, PA. Andrew's research has investigated the cycling of phosphorus in soil-plant-water systems in relation to soil productivity and water quality and includes the management of fertilizers, crop residues, and animal manures. He has developed models that simulate soil chemical processes and transport of phosphorus in runoff. Currently, Andrew is leading research to develop ways of identifying agricultural fields that are vulnerable to phosphorus loss in runoff, so that more flexible and effective best management practices can be targeted.

Doug Beegle is a Professor of Agronomy and extension soil fertility specialist in the Department of Agronomy, The Pennsylvania State University, University Park, PA. Doug's program has focused on extension programs and applied research in soil fertility, nutrient management, soil testing, and related topics. He has worked extensively with farmers, county agents, ag industry, public agencies, and farm organizations to develop and conduct educational programs to help farmers manage nutrients for maximum agronomic and economic benefit with minimum environmental impact.

Walter R. Boynton is a Professor at the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD. Walter's research interests involve estuarine ecology with emphasis on nutrient and organic matter processes; seagrass ecology; ecosystem modeling and analysis; materials budget; food web dynamics; and environmental education.

Dave Brubaker is employed at Hershey Ag in Marietta, PA. This company raises hogs in Central Pennsylvania. He is responsible for overseeing the nutrient management implementation for the company's farms.

Bill Carmean, Snow Hill, MD, is a poultry and grain crop farmer who has been involved in nutrient management issues for several years.

Frank Coale is Associate Professor of Agronomy and Nutrient Management Specialist, University of Maryland, College Park, MD. Frank has a research and extension education appointment with statewide responsibilities for soil fertility and nutrient management for crop production and environmental protection.

David Correll has been a Chemist and Ecologist with the Smithsonian Environmental Research Center, Edgewater, MD, for the last 35 years. David's research has focused on the chemistry, biochemistry, microbiology, and ecology of phosphorus. His current research includes a major study of nutrient sources on the Chesapeake Bay Watershed and how their fluxes are affected by land use, geology, and interannual variations in weather.

Tony Esser is Water Quality Specialist and EQIP Program Coordinator for New York State with USDA-NRCS, Syracuse, NY. Tony has been a District Conservationist, RC&D Project Coordinator and Water Quality liaison with the NYS Dept. of Environmental Conservation.

Turp Garrett is the Worcester County Agricultural Extension Agent, Snow Hill, MD. Worcester Co. is located on the southern Delmarva Pennsiular, where there is a very concentrated area of poultry broilers production, the epicenter of phosphorus and water quality concerns.

Bil J. Gburek has been a Hydrologist at the USDA-ARS, Pasture Systems and Watershed Management Research Laboratory, University Park, PA, for the past 27 years. His current research interests include: hydrology of the near-stream environment as related to storm runoff production and phosphorous loss from the watershed, ground water recharge, numerical simulation of subsurface flow and transport in fractured aquifers, and hydrology/water quality interactions at the watershed scale.

Louise Heathwaite is Senior Lecturer in Geography at the University of Sheffield, UK. Louise has been researching the impact of nutrient export from agricultural land on surface water quality for the past 15 years. Her main focus is phosphorus and nitrogen transport in hydrological pathways linking land to stream. In the UK, she is presently leading a major research programme with the Institute of Grassland and Environmental Research (IGER) to examine colloidal organic matter and phosphorus transfer in grassland hydrological pathways. Currently, Louise is a Fulbright Scholar on sabbatical from the University of Sheffield and is working with Andrew Sharpley at the USDA-ARS Pasture Systems and Watershed Management Research Laboratory.

Jerry Hostetter is owner and president of Hostetter Management Company (HMC). HMC is a swine production and management company currently managing approximately 13,000 sows and 50 finisher barns. He is responsible to see that each farm resubmits their manure management plan in accordance to the PA Act 6 requirements. Jerry is also very active in supporting agricultural growth and development throughout Pennsylvania.

Les Lanyon is a Professor of Soil Fertility in research and extension, Department of Agronomy, The Pennsylvania State University, University Park, PA. Since 1977, he has been at Penn State working on the soil fertility of forage crops, utilization of animal wastes in crop production systems, and nutrient management.

William Matuszeski has been Director of EPA's Chesapeake Bay Program Office since November of 1991. As such, he is Chairman of the Implementation Committee for the Bay Program, a cooperative restoration effort by the states of Maryland, Pennsylvania, and Virginia; the District of Columbia; the Chesapeake Bay Commission representing the three state legislatures; and EPA as the representative of the Federal Government. The Bay Program is the premier watershed restoration effort in the United States, and is recognized worldwide for its clear goals, measurable achievements, comprehensive approach to such complex problems as air deposition and population growth, and use of computer models to test management options. The

Program reflects the increasing importance EPA is placing in the integration of all its programs as they apply to critically important water bodies such as the Chesapeake Bay.

Harry B. Pionke is Research Leader of the USDA-ARS, Pasture Systems and Watershed Management Research Laboratory, University Park, PA. The mission of the laboratory is to conduct research leading to the development of land, water, plant and animal management systems, which ensure the profitability and sustainability of northeastern grazing and cropping enterprises while maintaining the quality of ground and surface waters. Harry's personal research is to determine land source areas and hydrologic origins of stream flow and associated nutrient and pesticide loads using isotopically and geochemically-based methods.

Tom Simpson is Coordinator of Chesapeake Bay Agricultural Programs, a joint position with the Maryland Department of Agriculture and the University of Maryland. Tom coordinates activities regarding agriculture and the Chesapeake Bay in Maryland. He currently chairs the Chesapeake Bay Program's Nutrient Subcommittee which oversees nutrient reduction efforts throughout the watershed. During 1997, Dr. Simpson helped organize and spoke at four Congressional and one Federal Administrative briefings on Pfiesteria and/or phosphorus and has provided technical leadership on soil and water issues regarding phosphorus/Pfiesteria.

Tom Sims is Professor of Soil and Environmental Chemistry in the Department of Plant and Soil Sciences at the University of Delaware, Newark, DE. In 1997, he was appointed Director of the Delaware Water Resources Center where he now leads the research and educational efforts of the College of Agricultural Sciences in nutrient management and water quality, interacting with all key agencies in Delaware and the mid-Atlantic region. Tom's research has focused on the development and implementation of environmentally sound soil management programs for production agriculture and for industries and municipalities with significant waste management problems. He has worked extensively with the poultry industry and production agriculture to develop nitrogen and phosphorus management programs that maximize crop yields while minimizing the environmental impact of these nutrients on ground and surface waters.

Trish M. Steinhilber is a Professor with the Cooperative Extension Service, University of Maryland, College Park, MD. Since June of 1993, Trish has served as Coordinator of the Nutrient Management Program for the University of Maryland Cooperative Extension Service, overseeing all phases of BMP development and implementation in the state.

Alan Taylor was Chief of the USDA-ARS, Soil Nitrogen and Environmental Chemicals Laboratory, Beltsville, MD, with leadership responsibilities for projects on the chemistry of strontium and heavy metals in soils, the environmental chemistry of pesticides agricultural phosphorus, and the fate of nitrogen in soils. After Alan retired in 1983, he became Consultant to the Director of the University of Maryland Agricultural Experiment Station and is currently Consultant to the Executive Director of the Chesapeake Research Consortium, Edgewater, MD. He is responsible for technical liaison between the Consortium and the Chesapeake Bay Program of the EPA and other governmental and public interest groups working of the restoration of the Chesapeake Bay.

Ann Wolf has been Director of the Agricultural Analytical Services, Pennsylvania State University, University Park, PA since 1991, when the soil testing, plant analysis and environmental testing programs were merged into one operation. Ann is involved in national efforts to standardize analytical methods for testing agricultural materials as well as to improve and document the quality of the analytical results. She helped initiate and develop the North American Proficiency Testing Program for agricultural laboratories which will be implemented by the Soil Science Society of America in 1999 and is currently President of the Soil and Plant Analysis Council.