Chesapeake Bay Goal Line 2025:
Opportunities for Enhancing Agricultural Conservation Conference Report

October 5-6, 2010

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The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program partnership on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports periodically to the Management Board and Principal Staff Committee and annually to the Executive Council. Since its creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical conferences and workshops, and (5) service by STAC members on CBP subcommittees and workgroups. In addition, STAC has the mechanisms in place that will allow STAC to hold meetings, workshops, and reviews in rapid response to CBP committee, goal implementation team, and workgroup requests for scientific and technical input. This will allow STAC to provide the CBP partner representatives with information and support needed as specific issues arise while working towards meeting the goals of the CBP. STAC also acts proactively to bring the most recent scientific information to the Bay Program and its partners. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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Executive Summary

The Chesapeake Bay Program's Agriculture Workgroup, on behalf of the Chesapeake Bay Program partnership and with the assistance of collaborating agricultural and environmental organizations, obtained financial and technical support from the Scientific and Technical Advisory Committee (STAC) and other academic and organization partners in 2010 to host a two-day workshop on current, and next-generation, agricultural conservation tools.

Over 120 agricultural specialists and topic experts met in Hunt Valley, Maryland on October 5-6, 2010 to discuss opportunities to enhance agricultural conservation through further implementation of existing best management practices (BMPs), and the identification, development, and implementation of new and innovative BMPs in the Chesapeake Bay watershed. The conference brought together recognized agricultural scientists and experts from across the watershed, country, and internationally to discuss specific BMPs and agricultural conservation techniques that could reduce nutrient loads to the surface- and ground-water systems that provide freshwater resources to the Bay. These BMPs will be important for developing Watershed Implementation Plans (WIPs) in Bay localities which will address the Total Maximum Daily Load (TMDL) allocations for nitrogen (N), phosphorus (P), and sediment for each jurisdiction.

Conference Main Objectives

The main objectives of the Goal Line 2025 Conference were to:

- Identify and develop new nutrient and soil conservation tools, and enhance utilization of existing tools, for implementation of the Chesapeake Bay TMDLs and WIPs at the state and local government levels over the short term (2010-2017).
- Identify nutrient and soil conservation tools requiring further research and development for possible future implementation by the Chesapeake Bay Program partnership over the long term (2017-2025).
- Determine the opportunities and challenges regarding implementation costs, tracking and reporting needs, and verification requirements of these nutrient and soil conservation tools.

Conference Breakout Sessions

In breakout sessions, speakers presented diverse techniques for management of nitrogen, phosphorus, dairy feed, ammonia emissions, livestock manure, and alternative manure uses. The management techniques that were considered most important, or most widely applicable, have been summarized for each breakout session in Tables 1 (short-term tools) and 2 (long-term tools). Although the summaries in the tables represent BMPs that are generally applicable to many sub-watersheds, there were other important BMPs discussed that are applicable to smaller regions, or to specific needs and priorities of individual sub-watersheds. Therefore, the reader should also refer to the individual breakout session reports for a more comprehensive summary of the session. The breakout session speakers and audience also participated in facilitated discussions after each session to expand the dialogue concerning which BMPs and techniques are appropriate for implementation and acceptance by both the policy makers and individual producers in the short term, and that are more appropriate for the longer term. Barriers to achieving implementation were also identified.

Summary tables from each conference breakout session list the two main short-and long-term techniques for improving nutrient use efficiency and reducing nutrient loss to the Bay. Further details of these techniques, and other approaches, can be found in the respective Discussion Session summaries, given below in this report.

Table 1. High-priority short-term management techniques identified by Conference Focus Sessions.

Session Topic and page	High Priority Short-term Management Techniques	
	Technique/Approach	Complementary Activities
1. Nitrogen Management p. 13	Cover crops; expand use especially on sites with high residual N	N timing; apply in phase with crop demand, expand use of N soil and N crop tests for adaptive management
2. Alternative Manure Use p. 15	Improve Cost-effectiveness of proven technologies not yet commercially developed	Public funding for nutrient-removal technologies and commercializing nutrient-dense by-products
3. Dairy Feed Management p. 17	Develop more incentives for reducing N and P in dairy rations; verify feeding levels, use milk urea-N and P manure testing	Emphasize the value of greater production and use of homegrown feeds, reduce N and P mass imbalances
4. Phosphorus Management. p. 21	Incorporation or injection of sludge and animal manure	Eliminate the application of P during winter months, establish uniform P-management among states
5. Ammonia Emissions Management p. 24	Diet modification; reduce excess crude protein in diet	Manure application; use injection or conservation tillage to incorporate manure
6. Livestock Manure Management p. 27	State and federal CAFO standards should be consistent, more incentives for manure injection equipment	Encourage incorporation of organic P into soil, no litter on high-P soils, transport litter out of watershed

Table 2. High-priority long-term management techniques identified by Conference Focus Sessions.

Session Topic and page	High Priority Long-term Management Techniques	
	Technique/Approach	Complementary Activities
1. Nitrogen Management p. 13	Incentivize N BMPs; increase economic incentives, improve manure nitrogen use efficiency	Adaptive N management; develop additional N soil and N crop tests with feed-backs to manure and fertilizer N inputs
2. Alternative Manure Use p. 16	Aggregate farm-scale projects for regulatory/environmental marketing	Provide regulatory "safe harbor" for manure use innovators
3. Dairy Feed Management p. 18	Expand whole-farm planning to manage critical interactions e.g., integrate protein precision feeding and N manure management	Develop environmentally friendly manufactured feed products with reduced P and desirable N/amino acid characteristics
4. Phosphorus Management p. 21	Reduce soil P levels to agronomic optimum	Develop whole-farm P-management plans
5. Ammonia Management p. 24	Reduce losses from animal housing; for broilers, use non-litter flooring; for dairy, separate urine	Manure application; better injection techniques to lower greenhouse gas losses
6. Livestock Manure Management p. 27	Develop new markets for manure with state and federal support, watershed clearing-house for alternative manure technologies	Update optimum agronomic P range in state P-indices; develop minimum P performance criteria for poultry and dairy industries

Conference Cross-Cutting Themes

General cross-cutting concepts or themes also emerged from the conference sessions (p. 24). The theme of greatest occurrence was the concept of holistic planning and implementation on the part of producers as well as program planners. Holistic management relies on whole-system nutrient plans whose practices and impacts cross traditional technical domains. An example of holistic planning for dairies includes optimizing dairy ration crude protein (e.g., monitoring milk urea-N) combined with use of manure N analysis and manure application techniques to conserve ammonia (e.g., injecting manure), and use of crop N monitoring techniques (e.g., pre-sidedress soil nitrate test or corn stalk nitrate test). Implementing these practices would likely reduce purchased protein supplements for the dairy and/or reduce purchases of fertilizer N.

The second most important cross-cutting theme was the establishment of minimum conservation standards that producers should follow in managing nutrients. Tying these minimum standards to programmatic funding, regulatory protections, and production criteria was viewed as a critical step toward consistent and meaningful implementation of BMPs that improve water quality in the Bay watershed. An example of an important minimum standard is simple record keeping of N and P inputs (fertilizer and manure) and crop yields from a given field. Such information could be used to track changes in nutrient use over time and provide first-cut estimates of nutrient recovery efficiencies.

Two other cross-cutting themes were: 1) the need to reduce the import of nutrients into the watershed and 2) the need to prioritize resource allocations to focus on nutrient issues that reduce losses while minimizing investment of limited human and financial resources. The first theme recognizes that recycling of existing available nutrients is very important for improving the watershed nutrient mass-balance, which remains an essential underlying principle for achieving long-term Bay water quality goals. The second theme emphasizes prioritizing resource allocations and recognizes the need to identify strategies that increase the economic returns for nutrient management to the producer, and for identifying alternative ways to improve nutrient use efficiency.

An essential part of all of the above breakout sessions and the cross-cutting themes is a continued commitment to education of producers, consultants, advisors, and policy makers across the watershed. Continuing education will accelerate adoption of proven practices, speed the development of new techniques, lead to sound policies that can reduce tensions between environmental advocates and agricultural producers, and spur the recovery and protection of the Chesapeake Bay.

Conference Background

The Chesapeake Bay Program's Agriculture Workgroup (AgWG) under the Water Quality Goal Implementation Team (WQGIT), with the assistance of collaborating agricultural and environmental organizations, obtained financial and technical support from the Scientific and Technical Advisory Committee (STAC) and other academic and organization partners in 2010 to host a comprehensive two-day workshop on next-generation agricultural conservation tools on behalf of the Chesapeake Bay Program partnership.

Over 120 individuals and topic experts met in Hunt Valley, Maryland on October 5-6, 2010 to discuss opportunities to enhance agricultural conservation through the identification, development, and implementation of new and innovative best management practices (BMPs) in the Chesapeake Bay watershed. The conference brought together recognized agricultural scientists and experts from across the watershed, country, and internationally to discuss specific BMPs and agricultural conservation techniques that could reduce nutrient loads to the tidal Bay. Participants also included producers, state and federal conservation agency staff, agricultural and environmental organization representatives.

Speakers presented diverse techniques for management of nitrogen, phosphorus, dairy feed, ammonia emissions, and livestock manure, and alternative manure uses to reduce nutrient losses from agricultural production areas and crop lands. The conference speakers and the audience participated in facilitated discussions on each topic to identify which BMPs and techniques were appropriate for implementation and acceptance by both the policy makers and individual producers in the short term, and those that were more appropriate for the longer term. Barriers to achieving implementation were also identified.

Conference Objectives

The Chesapeake Bay Goal Line 2025 Conference was a two-day forum held for representatives from academic institutions, governmental agencies, and the private sector, with the general objectives of discussing, evaluating, and reaching consensus of enhancing existing agricultural nutrient and soil conservation systems, as well as increasing adoption of innovative or "next generation" tools across the Chesapeake Bay watershed.

Through the facilitated interaction of scientists, recognized topic experts, and participants representing the Chesapeake Bay Program partnership and the agricultural community, the specific objectives of hosting the conference were the following:

- Provide a facilitated forum for the partnership to engage with regional and national experts in scientific and programmatic panel presentations and discussions on management of nutrients, manure, animal diets, ammonia emissions, and alternative manure uses.

- Allow the partnership to gain a comprehensive understanding of potential enhancements for current nutrient and soil conservation practices and systems, as well as innovative or "next-generation" conservation tools for agriculture.
- To identify new nutrient and soil conservation tools for the development and implementation of Chesapeake Bay Total Maximum Daily Load (TMDL) (EPA 2010) and the Watershed Implementation Plans (WIPs) at the state and local government levels for the short term (2010-2017).
- To identify nutrient and soil conservation tools requiring further research and development for possible future implementation by the Chesapeake Bay Program partnership in the long term (2017-2025).
- Determine the opportunities and challenges regarding implementation costs, tracking and reporting needs, and verification requirements of these new nutrient and soil conservation tools.
- Develop an agricultural nutrient and soil conservation "road map" for identifying future scientific research needs, targeting grant program initiatives, and directing future efforts of the Chesapeake Bay Program partnership across the watershed.
- To widely communicate the results of the facilitated workshop with a comprehensive report that provides both consensus results and controversial issues.
- To assist expert panels in developing recommendations for nutrient and sediment simulations in mathematical models.

Status of Chesapeake Bay Restoration Efforts

In May of 2009, the six Chesapeake Bay watershed states, the District of Columbia, and the federal government agreed that bold action was needed to restore the health of the Chesapeake Bay. Subsequently, the partnership agreed that by 2025, measures necessary to restore water quality in the Bay will be completed. The Presidential Executive Order 13508, ***Chesapeake Bay Protection and Restoration***, is part of the President's commitment to federal leadership in that agreement (The White House, 2009). Section 202(a), Section 203(a), and Section 502 of the President's Executive Order directed the Environmental Protection Agency (EPA) to prepare reports on the development of next-generation conservation planning tools and actions for restoring the Bay.

An executive summary of the response to the Executive Order, ***Strategies for Protecting and Restoring the Chesapeake Bay Watershed*** (USEPA 2010a), lists the goals and plans for Bay restoration. The responses to the Executive Order related to agriculture are in the Sections 202(a) (USEPA 2009), 203(a) (USEPA 2010a), and 502 (USEPA 2010b); which underwent public review and comment, identified numerous actions within the agricultural sector to accelerate restoration. One action was the establishment, in December 2010, of a Total Maximum Daily Load (TMDL) for the Chesapeake Bay watershed (USEPA 2010c) with nitrogen, phosphorus, and sediment load allocations by major basin. Other actions included the development of Watershed Implementation Plans (WIPs) by the Bay jurisdictions to address the TMDL load allocations by sector; the initiation by EPA of rulemaking under the Clean Water

Act to expand coverage and set stronger performance standards for Concentrated Animal Feeding Operations (CAFOs); and new agricultural management guidance for federal lands.

The reports for Sections 202(a), 203(a), and 502(Chapter 2) also call for implementation of next-generation conservation planning tools and actions to address reduction of agricultural nutrient and sediment loads. These tools encompass nutrient and sediment controls, feed and manure management, air emission controls, and land management. The WIPs being developed in multiple phases by the Bay jurisdictions include both traditional agricultural conservation tools such as nutrient management and conservation planning, as well as non-traditional conservation tools such as advanced forms of nutrient management and ammonia emission controls. These innovative or next-generation conservation practices could be implemented in both voluntary programs (e.g., cost share) and in regulatory programs (e.g., CAFO permits) as dual approaches to reducing agricultural nutrient and sediment loads.

Individual Conference Breakout Session Summaries of Key Points, Short- and Long-Term Opportunities, and Barriers to Implementation

1. Nitrogen Management: Practices to Improve Nitrogen Use Efficiency of Crops and to Address Nitrogen Leaching

A Nitrogen Management session addressed practices for improving nitrogen (N) use efficiency of crops and nitrogen losses through leaching. The following key points, short- and long-term conservation practices, and barriers to implementation describe the discussions during the session.

<u>Key Points</u>

- The agricultural N cycle is complex (Fig. 1) and leaky (Meisinger et al., 2008a; Meisinger and Delgado, 2002). The fate of fertilizer N applied to cereal crops, like corn or wheat, can be summarized as follows: crop above-ground N uptake (above-ground N content commonly 50-60% with good management), nitrate leaching (10-40% depending on rate and timing of N application), denitrification (10-20% depending on rainfall and N source, i.e., manure vs. fertilizer), ammonia volatilization (5-20% depending on N source and placement), plus a small amount of surface runoff (1-5% due to the high solubility of nitrate which readily infiltrates into the soil before runoff begins).

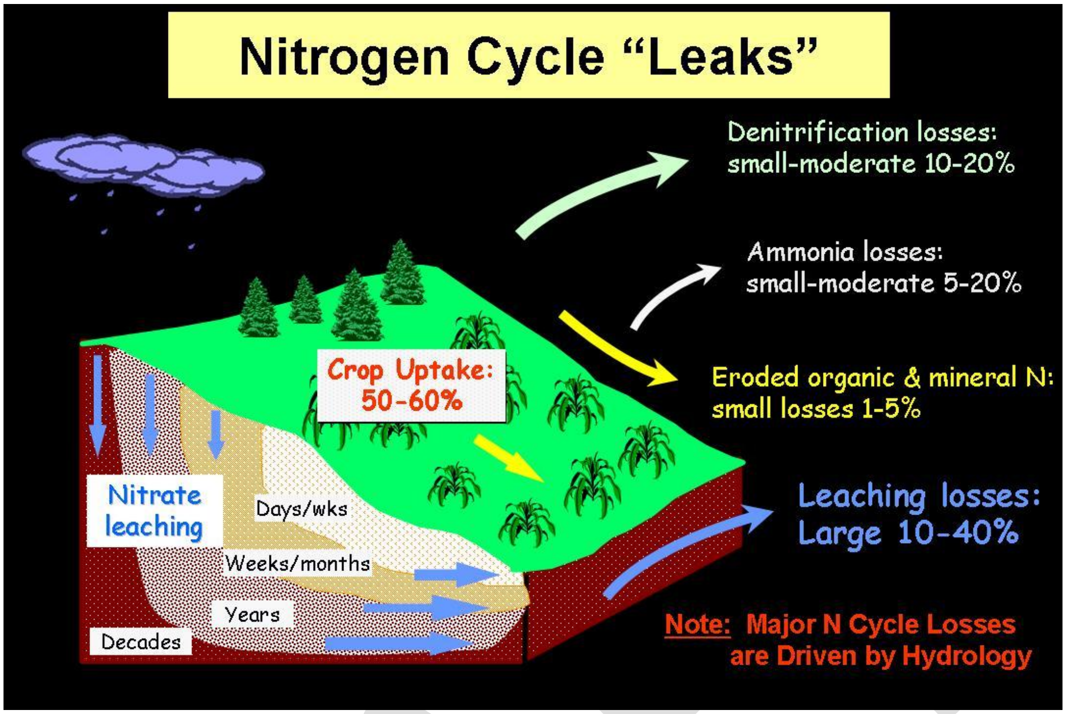

Figure 1. General fate of fertilizer N in the cereal-grain nitrogen cycle (Meisinger et al., 2008a).

- N management is challenging because the main N outputs (crop growth and leaching) are driven by factors in the uncontrollable hydrologic cycle (i.e., rainfall amount and intensity).
- Agricultural scientists have management tools for farmers and nutrient consultants to reduce N losses to the Bay that include:
    - Cover crops (Fig. 2): Using winter covers to take up N before it leaches during the winter water-recharge season, especially on fields with high residual nitrate that often results from repeated manure applications or fields subjected to drought (Staver and Brinsfield, 1998; Meisinger and Delgado, 2002).

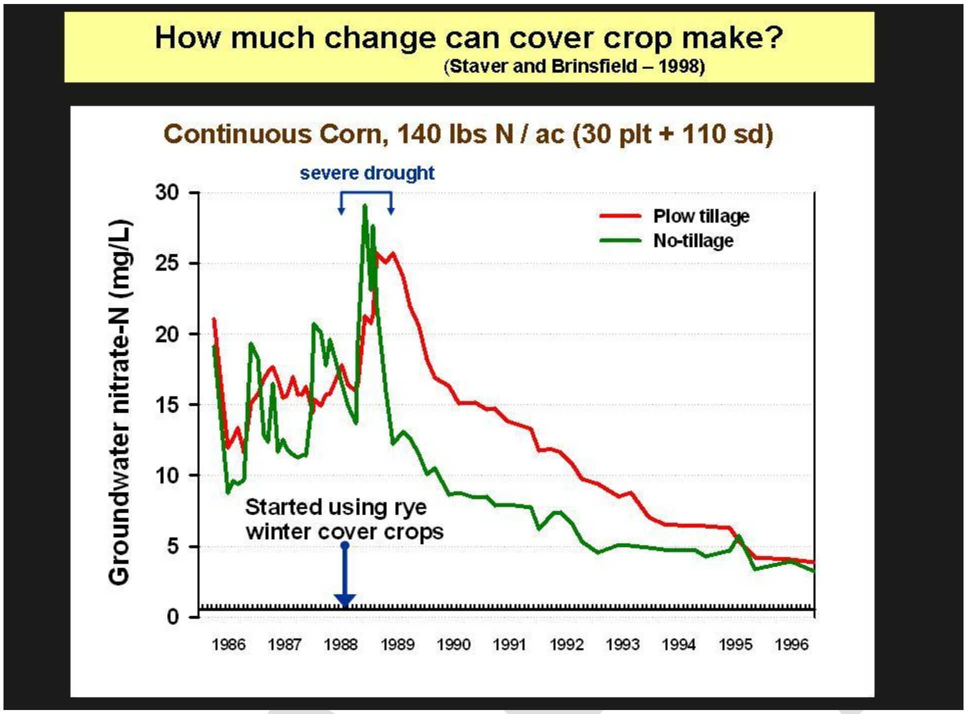

Figure 2. A rye cover crop significantly reduced N leaching to shallow groundwater (Staver and Brinsfield, 1998).

- N applications in phase with crop demand: Using split applications that time N inputs (applications) with crop N needs, minimize autumn N applications to lower leaching losses (Meisinger and Delgado, 2002; Ribaudo et al., 2011).
- N application rates consistent with crop needs: Using realistic expected yields, field N-rate test strips, or including a non-fertilized strip to evaluate soil N supply (Meisinger et al., 2008b; Ribaudo et al., 2011).
- N placed below soil surface: Using immediate tillage or injection, especially for manures to place nutrients under the soil surface and lower surface runoff losses (Maguire et al., 2011).
- Adaptive N management: Regularly evaluating and adjusting N management with tools like the corn-stalk N test (CSNT), pre-sidedress N test (PSNT), and real-time N sensors with variable N-rate applicators to manage field variability.
- Precision livestock feeding: Reducing excess crude protein in rations will reduce N imports to dairy and poultry farms and improve the farm N balance (Ghebremichael et al., 2008).
- Conserving and transforming non-production areas: Lowering N losses by use of buffers, riparian forest, and wetlands will reduce N losses to water resources (Meisinger and Delgado 2002; Ribaudo et al., 2011).
- Enhancing efficiency of N fertilizers: Using techniques such as controlled-release N fertilizers and additives for inhibiting nitrification or urease activity can increase crop N use efficiency (Ketterings et al., 2009).

- Federal and state Nutrient Management Plan (NMP) guidelines and payment structures (cost share, partner contributions) should be revised and updated. The current general broad-scale approach should be shifted to a site-specific prescription of BMPs and NMPs (Nutrient Management Plan) to allow for field to field variability and within-field variability.

- An educational and technology transfer infrastructure should be built and maintained to promote adoption and utilization of current and next generation N management tools on a site-specific basis. The institutions that catalyzed the technological revolution in agriculture, such as the Cooperative Extension Services, should be employed to promote restoration programs.
- N performance evaluation indicators (such as in-field N balances, in-field N yield-response evaluations, and crop N sensors with on-the-go variable rate applications) should be developed and expanded to manage within-field spatial and temporal variability.
- The manure storage capacity of Chesapeake Bay dairies should be expanded from the current six-month capacity, which requires manure applications in the fall, to a one-year storage capacity that would permit annual late-spring applications.

Short-term Opportunities

- When utilizing nutrient trading tools, rank prospective sites and management practices carefully, consider lag time differences when evaluating the impact of nutrient trading, define criteria for meeting baseline NMPs, and utilize cost share funding to achieve baseline threshold levels.
- Expand in-service education of commercial applicators to help them understand the conservation ethic, offer additional services that help meet Chesapeake Bay goals.
- Show farmers the TMDL reductions that are necessary for nitrogen and give them discretion on how to meet the allocations.
- Develop methods for achieving nutrient and sediment reductions with increased emphasis on producers that slowly adopt conservation recommendations.
- More site-specific targeting of practices to sites where the best return on investment is attainable.
- Nutrients are most vulnerable to losses from surface-applied manure on continuous no-till corn due to surface runoff and ammonia volatilization; reduce these losses with injection or conservation tillage (Maguire et al., 2011).
- Expand use of precision soil sampling and small-scale N management zones.

Long-term Opportunities

- Develop adaptive nutrient management recommendations for traditional farm nutrient management plans and provide incentives for their use.
- Build coalitions across production sectors and environmental interest groups.
- Expand USDA Farm Bill pilot programs.
- Prioritize conservation expenditures according to nutrient and sediment loss efficiencies.
- Use a water quality compliance plan to help prioritize farm subsidies and cost share its implementation.

- Establish consistency in federal funding among the Bay states while allowing for individual state's unique nutrient management issues, incentivize N loading reductions by funding based on the pounds of N conserved.
- Identify nitrogen conserving systems such as wetlands preserves and grasslands and incentivize their development.
- Lower N application rates through policies such as a tax on N and payments to farmers for reduced yields.
- Incentivize small and medium sized farms with increased cost share rates for conservation practices.
- Develop long-term incentives for farmers with projects that cover sufficient acres to achieve favorable returns on large conservation investments.
- Give farmers flexibility in meeting nutrient and sediment reduction goals but perform statistical sampling and inspection to determine if practices are properly implemented.

<u>Barriers to Implementation</u>

- Trade-offs exist between managing N and P losses that require multiple BMP adoption, because N moves primarily by leaching while P moves primarily by surface runoff.
- Lack of consensus among states on expected load reductions for specific BMP practices.
- Monitoring N management performance is difficult because it is linked to hydrology; this also makes monitoring expensive and maybe cost prohibitive.
- The price of nitrogen is often too low (relative to commodity prices) to prevent overuse.
- Farmers perceive that nutrient management is costly and increases risk.
- There is no monetary connection between farmers and custom applicators favoring environmentally-friendly practices.
- Custom applicators and industry consultants have little/no economic incentive for expanded use of the pre-sidedress soil nitrate test (PSNT) and the corn stalk nitrate test (CSNT).
- Agricultural suppliers are often only available to apply during pre-plant; need suppliers to custom apply at sidedress as well.
- The nutrient consultant infrastructure is not well established in the Bay watershed.
- The USDA Farm Bill does not currently express goals in terms of pounds of nutrient reduced.
- Paying for performance does not guarantee performance because it does not adequately consider uncontrollable risks.
- Baselines for nutrient trading can be hard to meet, leaving little opportunity for trading.
- The TMDL does not address habitat issues and impacts of habitats on the Bay water quality.
- It will be expensive to upgrade manure storage capacities from 6 months to 1 year.

2. Alternative Manure Uses: Practices for Converting Poultry Litter and Dairy Manure to Energy Production, Precision Fertilizer, and other Marketable Products

The Alternative Manure Uses session addressed practices for converting poultry litter and dairy manure to other products such as energy, precision fertilizer, and other marketable products. The following key points, short- and long-term conservation tools, and barriers to implementation are the most significant points raised during the session.

<u>Key Points</u>

- The panel focused on identifying promising technologies that may generate nutrient loading reductions from the agricultural sector and that may provide additional income streams for farmers. The panel consisted of two separate sessions, one focusing on dairy and the other on poultry.
- Land application of manure remains the preferred alternative for manure management, as long as soils are not phosphorus-saturated. Alternative uses may only promise low cost disposal, not profit potential. Regardless of the alternative use, it is necessary to implement a life-cycle and mass-balance approach to managing excess manure nutrients (Beegle, 2011).
- There are existing biological, chemical, thermal, physical, and other options for treating manure, some of which have been implemented on a farm- or commercial-scale. Biological options are primarily anaerobic digestion, aerobic treatment, and composting. Chemical treatments are coagulation/flocculation and the addition of manure amendments. Thermal conversion processes are pyrolysis, gasification, and combustion. Physical treatments include solid-liquid separation and pelletizing. Other nutrient management strategies that affect manure nutrients include feed management, transport of manure or animals, slaughtering animals at lower weights, and manure conversion to other products such as fiberboard or garden fertilizers. While there are many manure treatment options, commercial development is typically immature, and the current best strategy may be to combine nutrient reduction and energy recovery technologies (Rice, 2011; Porter et al., 2010).
- If new technologies offer a means to manage excess manure, most farmers will need financial and technical assistance to implement the technology. The operational and maintenance skills for these technologies are often beyond the existing skill set and time available at the farm level. Third party service providers should be incentivized to assist farmers.

<u>Short-term Opportunities</u>

- Identify practices that are effective, assess their cost-effectiveness, and expand their implementation. Poultry litter transport outside the watershed and application of litter amendments may be candidate practices.
- Explore opportunities to develop pilot projects within the watershed that utilize thermal conversion processes to concentrate nutrients and generate renewable energy.
- Develop and implement a systems-based approach (Beegle, 2011), conducting life cycle, mass balance, and long-term soil health analyses to identify new integrated technologies solutions for farm-scale evaluation.

- Establish a dedicated public program and fund for accelerating development and implementation of farm-scale nutrient removal technologies and for accelerating the commercialization of nutrient-dense manure by-products.
- Reduce or eliminate importing of biosolids to the Eastern Shore, which already has excess manure to manage.
- Increase the use of manure by-products on public lands requiring fertilization and reduce applications of chemical fertilizers on urban public lands.
- Develop regulatory frameworks that facilitate development of new technologies in innovative projects.

<u>Long-term Opportunities</u>

- Integrate use of time- and temperature-sensitive polymers into manure-based, value-added product development.
- Conduct genetic research to identify opportunities to enhance feed nutrient utilization by livestock and poultry.
- Explore business models (e.g., cooperatives, etc.) to package complementary projects on smaller farms as larger aggregated projects in order to simplify marketing to private entities (e.g., renewable energy investors, nutrient traders).

<u>Barriers to Implementation</u>

- Insufficient market demand for manure-based products such as compost or bio-energy and related ecosystem services such as carbon market trading.
- Lack of public and private resources to finance innovation.
- Lack of objective technical support to evaluate energy, financial, and nutrient aspects of proposed new technologies, and lack of qualified technical staff to give sound advice to producers.

3. Dairy Feed Management

Dairy Feed Management sessions addressed practices for improving dairy feed management and consequently reducing manure nutrient production. The outcomes of dairy feed management pilot projects in four Bay states were extensively discussed. The following key points, short- and long-term conservation tools, and barriers to implementation represent the discussions during the sessions.

<u>Key Points</u>

- Feed management, also known as Precision Feed Management (PFM), has been recognized by many as one of the most technically and economically effective methods to reduce nutrient concentrations in livestock manures and to assist in reducing farm mass imbalances of both N and P (Cerosaletti et al., 2004; Ketterings et al., 2005).

- Unlike the integrated poultry and swine industries, the dairy industry remains largely an non-integrated system consisting of primarily small to medium sized independent operations. Consequently, the potential to increase adoption or further enhance PFM systems is high.
- Integrating PFM with other agricultural planning systems such as nutrient management and soil conservation is critical to implementing a whole-farm planning approach and achieving farm-scale nutrient mass balance (Ketterings et al., 2005).
- Farms participating in PFM technical assistance projects in New York and Pennsylvania have demonstrated net positive economic and nutrient reduction benefits (Ghebremichael et al., 2007). However, these benefits are not always realized due to factors such as the availability of locally manufactured feed by-products (e.g., dried distillers grains) and the land available per animal, which can limit on-farm production of feedstuffs.
- The Maryland technical assistance project was crucial to assisting the dairy industry in correcting long-term Milk Urea Nitrogen (MUN) analysis errors and institutionalizing the new MUN analysis (Peterson et al., 2004). MUN analysis results are now included as a standard informational report to producers to support PFM (Jonker et al., 2001).
- The successes of the New York and Pennsylvania projects were obtained by successful pursuit of the following objectives:
    - Clearly defined PFM objectives and measures of performance (e.g., benchmarks) for producers, nutritionists, veterinarians, and technical service providers.
    - Frequent analysis of feeds, milk, and manure to adjust PFM plans and tracking of PFM effects on production and reproductive health.
    - Measurement of environmental and economic impacts of PFM implementation within and across farms.
    - Maximization of feed and forage quality with emphasis on the use of home-grown feeds and forages to reduce/eliminate imported feedstuffs.
    - A strong working relationship with veterinarians and nutritionists and technical training and certification of over 65 individuals under USDA-NRCS Technical Service Provider (TSP) standards.

Short-term Opportunities

- Create a regional PFM network to coordinate the development of recognized PFM technical assistance and financial tools, definitions, and benchmarks for the six-state region.
- Continue to support the adoption of MUN testing as a standard in the dairy industry for monitoring and evaluating nitrogen utilization.
- Develop more incentives for reducing N and P in dairy cattle feeds and verify feeding levels with MUN and fecal phosphorus testing or use of manure excretion modeling.
- Encourage dairy cattle balanced diets with support from computer models, such as the Cornell net carbohydrate model of Tylutki et al. (2008) that considers nitrogen and

carbohydrate fractions as well as amino acid requirements, with the objective of achieving 10-15% reductions in manure nitrogen concentrations.

- Increase the frequency of feed analysis and diet reformulation to achieve greater feed nutrient efficiency from feed-stocks with varying compositions.
- Integrate the use of non-legumes and legumes into farm forage-crop rotations in order to balance the nitrogen and phosphorus needs of crops with farm manure resources, symbiotic nitrogen fixation, and soil N and P supplies over time (Klausner et al., 1998; Ketterings et al., 2005; Tylutki et al., 2008).
- Integrate whole farm planning into federal and state agricultural programs to address the critical interactions among PFM, nutrient management planning (NMP), and conservation planning (CP).
- Improve participation in the USDA-NRCS Environmental Quality Incentives Program (EQIP) through increased outreach and training for producers, veterinarians, and nutritionists. EQIP is currently under-utilized in most Bay states for PFM.
- USDA-NRCS should consider including PFM in the Conservation Stewardship Program (CSP) as an advanced management practice.
- Incorporate current research-based nutrient reduction efficiencies associated with PFM BMPs into the Chesapeake Bay Program watershed model in order to estimate approximate nutrient reductions.
- Develop new outreach communication tools to educate and assist producers about the economic benefits of implementing PFM. One example to enhance adoption is to make available an on-line software calculator to estimate farm-specific nutrient reductions, as is currently accomplished with nutrient trading tools.
- Emphasize greater production and use of homegrown feeds for reducing soil N and P accumulations from previous nutrient mass imbalances (Klausner et al., 1998; Ketterings et al., 2005).
- Incorporate feed management as a base requirement for livestock operations receiving federal and state financial assistance.

Long-term Opportunities

- Identify opportunities for use of manufactured feed by-products, such as dried distillers grains, to decrease phosphorus imbalances; redirect such by-products into alternative uses such as biofuels, and/or reduce total availability through improved ethanol production systems.
- Develop new rapid testing methods for determining on-farm forage and by-product moisture contents to improve consistency of ration formulation and effectiveness of PFM.
- Add methane emission reduction as a diet formulation criterion for PFM systems.
- Integrate whole-farm planning into farm management systems to address the critical interactions of precision feeding, nitrogen management, and phosphorus management.
- Incorporate farm succession communication and planning into management plans, in order to address generational transfer of operations. Incentivize capital investments by older operators.

Barriers to Implementation

- Fluctuating milk prices, plus high energy and feed prices, make PFM adoption more difficult and will require more management effort by producers.
- Dried distiller grains are an economically attractive feed source because national energy policies currently ignore the environmental consequences of producing an unregulated phosphorous-imbalanced feedstuff that will require careful feed management to be avoid nutrient imbalances (Loy and Strohbehn, 2007).
- Current MUN testing methods are often viewed as inconvenient, inconsistent, and misunderstood; these opinions could be changed by expanding demonstration projects and increasing industry incentives to reduce MUN levels.
- The prevalence of small to medium sized, independently owned and managed dairy operations is problematic for obtaining widespread PFM adoption.
- Feed company nutritionists are the most important provider of dairy feed management plans, especially for small operations. These nutritionists typically lack the proper training or incentives to implement successful PFM systems.
- Although progress has been made (Beegle et al., 2000; Klausner et al., 1998; Ketterings et al., 2005), a consistent and approved methodology to track, verify, and report nutrient reductions associated with PFM has yet to be developed. The development of a methodology will be critical for PFM to be fully recognized and incentivized by federal and state agencies.
- The combination of fluctuating farm profitability, limited time and labor inputs, inconsistent or poor quality forages, low cost feed by-products, and an aging operator population will require dedicated financial and technical assistance to achieve implementation levels proposed in most state Watershed Implementation Plans (WIPs).

4. Improving Water Quality by Management of All Phosphorus Sources

A Phosphorus Management session addressed approaches for improving management of all phosphorus sources to reduce P losses to surface waters from cropland. The following key points, short- and long-term conservation tools, and barriers to implementation were discussed during the session. Animal feeding, alternative manure uses, and manure management prior to field application are covered in sections 2, 3, and 6.

Key Points

- The fate and transport of P differs from N. For example, N readily exchanges with large atmospheric N pools and nitrate-N is water soluble, while P has no atmospheric component and is largely insoluble and binds to particles. Phosphorus additions to cropland arise from fertilizer, manure, and sewage sludge applications. Phosphorus removal from cropland occurs primarily through removal of harvested products, while relatively small amounts of P are lost by runoff (both surface and subsurface). However, much less P is required to drive eutrophication in receiving waters because algae growth requires only $1/7^{th}$ the amount of P as N, by weight.
- Phosphorus losses occur very sporadically from cropland depending on individual precipitation events in relation to P application time and placement. Accurate estimation

of losses from fields and larger watersheds requires expensive monitoring and intensive sampling within individual storm events.

- Historically, P loss control strategies have focused on reducing soil erosion, but have now expanded to address dissolved P losses. Managing dissolved P transport is problematic, especially if soil P levels are high because of surface P applications in no-tillage, high P applications in sewage sludge, or repeated manure applications.
- Effective control of soil erosion by reducing tillage will not necessarily result in reduced P losses, as increases in dissolved P can more than offset reduction in particulate P losses, especially where manure is applied and erosion potential is low (Staver and Brinsfield, 2001). On more sloping, well-drained soils where no-tillage markedly reduces runoff volume and erosion, total P losses can be reduced by no-tillage (Verbree et al., 2010).
- Elevated soil P levels increase the potential for P loss by increasing the P concentration of eroded soil and by increasing dissolved P concentrations in runoff (Staver and Brinsfield, 2001), leachate (Maguire and Sims, 2002), and shallow subsurface storm flow (Kleinman et al., 2007).
- Dissolved P is difficult to capture with traditional edge-of-field practices, such as vegetated waterways and riparian buffers that primarily rely on slowing flow to allow settling of eroded particles (Lowrance et al., 1997).
- Soil P levels above optimum levels for crop production occur primarily in regions of concentrated animal production and result from long-term manure applications at rates that focus on meeting crop N needs (Swink et al., 2009; Sims and Vadas, 1997), which result in excess P inputs. This problem has intensified in regions that import P for high concentration animal production compared to use of local feed sources in lower intensity animal production systems (Lanyon and Beegle, 1989).
- Water solubility of P varies in different manures and determines short-term potential for losses (Kleinman et al., 2005). But the initial chemical composition of manure P has little long-term impact on potential P losses due to microbial decomposition and chemical transformation of the added P into slowly available P compounds (Dou et al., 2009).
- The potential for P loss has short and long-term management components. The short-term component relates to soil-surface or near-surface field management practices that affect the availability of soluble P. High P losses can also occur from soils with low soil P tests when soluble P sources, either inorganic fertilizer (Pote et al., 2006) or manure (Staver, 2004; Verbree et al., 2010), are applied to the soil surface under no-till management. The long-term potential for increased P losses is most often associated with repeated P surpluses in annual field P budget.
- Agricultural P management in the Chesapeake Bay watershed was reviewed previously (Sharpley, 2000) and drew the following relevant conclusion: “The overall long-term goal of efforts to reduce P losses from agriculture to surface waters should aim to balance off-farm inputs of P in feed and fertilizer with P outputs as produce, along with managing soils in ways that retain nutrients and applied P resources.”
- Phosphorus losses resulting from elevated soil P concentrations will decrease slowly over 5-15 years, since annual P crop removals are small compared to soil P reserves on highly enriched sites (McCollum, 1991; Kratochvil et al., 2006). Progress has been made on reducing P surpluses at the farm and regional scale (e.g., McGrath et al., 2010; see sections 3 and 6), but watershed P loadings will be slow to decline due to large soil P reservoirs.

- Achieving P reductions over shorter time frames may require consideration of remediation strategies capable of removing P from runoff.
- The primary constraint to long-term P loss reduction is the potential for negative economic impacts on concentrated animal production facilities and crop producers that have historically relied on manures to supply crop N needs (USDA, 2003).
- Systematic, geo-referenced monitoring of soil P (Weller et al., 2010) is a very useful approach for tracking long-term progress toward meeting P reduction goals and can be used to verify success of efforts to balance field, watershed, and regional P budgets.

<u>Short-term Opportunities</u>

- Link tillage-based P control strategies to soil runoff and erosion characteristics.
- Encourage high-residue incorporation of all organic P sources into the soil.
- Encourage sub-surface application or incorporation of inorganic P sources.
- Eliminate the application of all P sources during winter months.
- Establish uniformity among the Bay states on guidelines and requirements for P management.
- Build databases documenting current practices to better assess the potential for adoption of new or improved management practices.
- Plant cover crops if erosion potential is high.
- Discourage broadcast applications of P sources extending beyond field boundaries or directly adjacent to waterways.

<u>Long-term Opportunities</u>

- Develop a systematic approach for measuring and documenting soil P resources over time, so that changes in soil P resources could be tracked at the farm and watershed scale.
- Develop "whole farm" P-based nutrient management plans to discourage buildup of soil P levels (see sections 3 and 6 for reducing P in manure).
- Establish goals and realistic time frames for drawing down excessive soil P sites.
- Increase manure storage capacity to reduce off-season applications.
- Explore watershed and regional approaches for reducing P surpluses.
- Explore options for improved drainage system management to minimize P losses.

<u>Barriers to Implementation</u>

- Costs of shifting from N-based to P-based nutrient management, including increased costs for manure storage and transport, plus increased costs for supplemental N and potassium due to reduced manure applications.
- Increased wastewater treatment costs if sewage sludge applications are restricted.
- Reduction of no-till erosion benefits resulting from manure incorporation with low-residue implements.
- High cost of manure injection systems and vertical tillage equipment.
- Private property rights issues associated with systematic approaches for tracking field and watershed soil P levels.

- Institutional costs for development of comprehensive nutrient management plans, more extensive tracking of practices, and systematic tracking of soil P.

5. Ammonia Emissions Management: Practices to Control Nitrogen Emissions from Animal Production Areas, Storage, and Field Applications

The Ammonia Emissions sessions addressed practices for controlling nitrogen emissions from animal production areas, storage, and field applications. The following key points, short- and long-term conservation tools, and barriers to implementation were discussed.

<u>Key Points</u>

- Atmospheric deposition of nitrogen compounds forms a significant part of total N loadings to the Chesapeake Bay. According to the Chesapeake Bay Program estimates, approximately 94 million pounds of nitrogen are deposited on the Bay and its watershed each year from atmospheric sources. About one-third of the total atmospheric N loading is from ammonia (NH_3), with over 75% of this ammonia attributed to emissions from agricultural livestock and fertilized soils (Chesapeake Bay Program, 2007). Battye (Chesapeake Bay Program 2000) presented data (Fig. 3) estimating the following sources of ammonia for the Bay watershed:

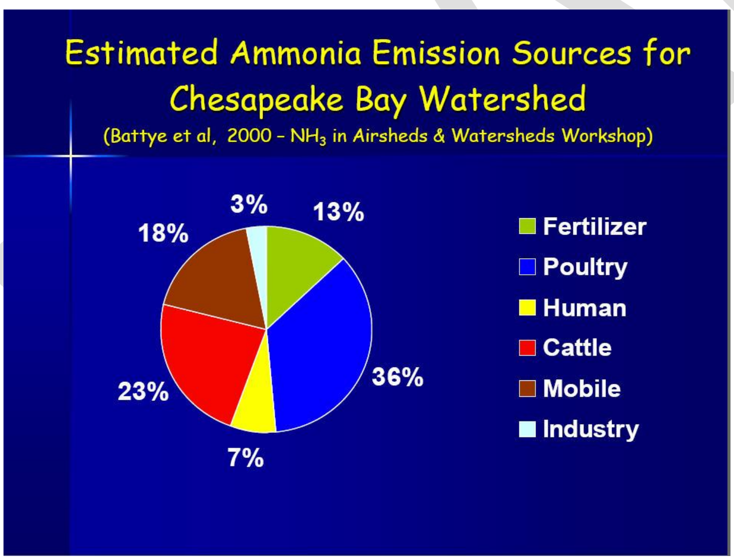

Figure 3. Estimated ammonia emission sources for the Chesapeake Bay watershed (pers. comm. from W. Battye, Chesapeake Bay Program, 2000).

- N losses from manure through ammonia volatilization are part of the N cycle. Losses can be reduced, but mitigation strategies must consider the impacts of such N conservation on other N pools and flows, such as conversion of conserved ammonia to nitrate and the potential for increased leaching and denitrification losses (Dell et al., 2011). Other considerations from reducing ammonia volatilization are ratios of plant-available nutrients in the manure, including N to P and potassium (K) to sulfur (S) ratios.

- There are two basic classes of ammonia mitigation approaches: pre-excretion, such as diets, feed, water additives, or genetics; and post-excretion, such as housing, manure storage, and manure application to land (J.Orogo , pers. comm.). Figure 4 summarizes these alternative types of mitigation methods:

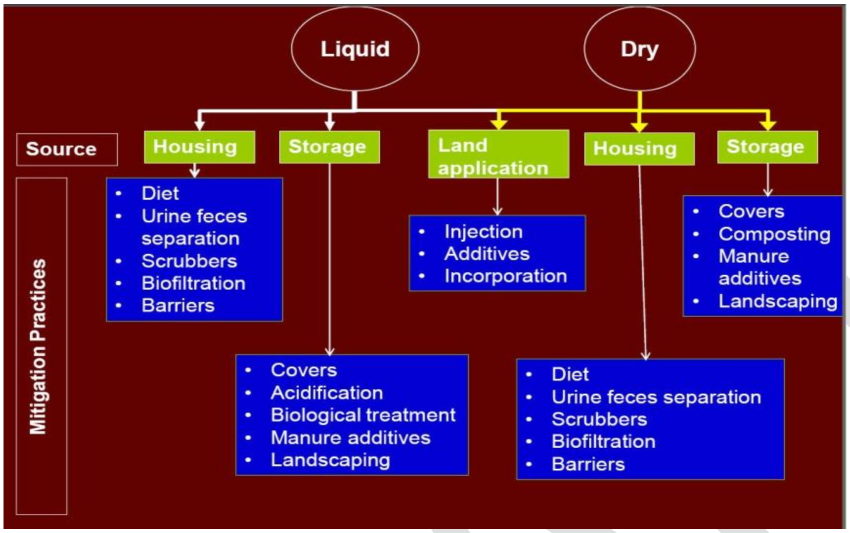

Figure 4. Types of ammonia mitigation practices (J. Oroge, pers. comm).

- Ammonia losses from manure applications to land are affected by manure characteristics, application method, weather conditions, and soil properties.
- Ammonia emissions from surface application of manures are proportional to the quantity of manure left on the soil surface. Non-incorporated surface applications of manure rapidly lose NH_3 to volatilization. Prompt incorporation of manure can reduce NH_3 volatilization by 80-90% (Sommer and Hutchings, 2001; Thompson and Meisinger, 2002). However, incorporation may also exacerbate erosion problems by reducing residue cover, and incorporation is usually not feasible for perennial crops or forage crops.
- Options for mitigation of NH_3 volatilization will differ between poultry litter (dry) and dairy manure (dry or wet) due to their chemical differences as well as differences in practical and economically feasible management options.
- The benefits of treating poultry litter with NH_3-conserving amendments of alum or sodium bisulfate (PLT) or acidification is well-researched (Moore et al., 1995; Arogo et al., 2001) and is becoming a more common practice. Cost-sharing funds are available from USDA-NRCS for early stages of poultry grow-out. However, some amendments are effective for only a limited period, and re-application during the grow-out cycle is neither practical nor feasible.

- A new approach to mitigation of NH_3 losses from poultry houses is the use of litter-less flooring. Preliminary research has indicated very low NH_3 emissions and favorable effects on bird health and growth (J. Harter-Dennis, pers. comm.). This approach should be researched in full-scale tunnel-ventilated houses. Implementation on a broad scale would require substantial new investment.
- Reducing crude protein in dairy rations can also reduce N in urine without affecting milk production (Arriaga et al., 2009; Oenema et al., 2011). Such a practice could reduce NH_3 losses if manure is surface applied, but could lead to N2O (a green house gs) as an intermediate in soil denitrification (Dell et al., 2011). Precision feed management for only N rather than both N and P can reduce the manure N:P ratio for crops and make more supplemental fertilizer N necessary.

<u>Short-term Opportunities</u>

- Expand the practice of manure injection or high-residue soil tillage and incorporation as soon as possible after manure application.
- Expand adoption of litter acidification agents in poultry houses.
- Expand adoption of precision feeding.

<u>Long-term Opportunities</u>

- Conduct further research to explore feasibility of non-litter flooring for broiler production.
- Conduct research on the fate and transport of atmospheric NH_3 within the Bay airshed at both the local and watershed scale.
- Conduct research and develop technologies/practices to inject manure that minimizes N green house gas emissions.
- Conduct research on commercially viable NH_3 scrubbers for poultry houses.
- Conduct research to assess mitigation of NH_3 emissions from dairy barns and manure storage.
- Conduct research on manure treatments to better balance the N:P, K:S ratios of manure for crop production.
- Promote increased production of animal feeds on livestock farms and/or develop markets and technologies that permit cost-effective transport of manure to crop production areas.
- Design and implement cropping rotations that meet animal needs and nutrient recycling goals.

<u>Barriers to Implementation</u>

- Lack of appropriate, cost-effective equipment to inject manure for many cropping systems, soil types, and landscapes.

- Lack of cost-share funds and financing for innovative technologies and practices.
- Lack of consistent regulation and permitting between Water and Air Divisions in EPA and state environmental agencies.
- Lack of effective technology demonstrations to farmers.
- Legal and financial risk to farmers from innovation.

6. Livestock Manure Management in the Chesapeake Bay

The Manure Management session addressed practices for managing poultry litter and livestock manures to reduce nutrient losses from production facilities and cropping operations. The following key points, short- and long-term conservation tools, and barriers were discussed in the session.

Key Points

- The Chesapeake Bay Program watershed model indicates that animal manure contributes about 25% of the nutrient loads to the Bay. Although steps have been taken to address manure management issues, additional concerns have been expressed by PA and USDA over the steady accumulation of phosphorus levels in soils.
- The Shenandoah Valley (VA), Lancaster County (PA), and the Delmarva Peninsula (MD, DE, VA) are manure hotspots. EPA is working to ensure that facilities needing permits obtain them, that facilities with permits follow them, and that state programs are as stringent as necessary. Livestock production facilities are a concern, but land application of manures is the most critical focus. More manure is generated than can be used at agronomic rates.
- Farm nutrient balance is a key goal. The best situation for water quality would be if only as many animals were brought on to the farm as crop uptake is able to handle, but this situation is not economically feasible. New technologies, feed management, manure export, and crop choices can permit increased livestock numbers without stressing the absorptive capacity of the land. Manure transport is a good way to address excess manure, but transport is easier to implement in some areas than others, and significant barriers inhibit transport. These include complicated regulatory requirements to receive manure, a lack of technical assistance for importers, and difficulty in determining where manure is needed. Solutions include encouraging new technology, identifying farms in need of manure, and using manure in public projects.
- Maryland is addressing manure with a variety of programs. Manure storage is a long-standing traditional BMP. The required storage capacity is 180 days, and the state does not cost share at the full year capacity. Maryland has experienced a severe decline in dairy animals and poultry numbers as well. The Delmarva Peninsula is saturated with poultry, and with current waste storage requirements, there is little opportunity for industry expansion. Maryland is seeking to support alternative manure market development. The state has implemented a manure transport program with the intention of moving manure out of the watershed. It is also investigating in manure incorporation for no-till systems. Maryland has required phytase feed enzyme for the poultry industry

since 2000, but observed levels of phosphorus reduction in the rations are greater than those credited in the model (Chesapeake Bay Foundation, 2004).

- Virginia implements many measures to promote manure management. The Department of Environmental Quality inspects permitted farms each year. A transport subsidy program provides incentives for shipping litter from Rockingham and Page Counties. However, the largest poultry litter producing county (Rockingham) exports a large amount of litter, but also imports some litter from adjoining counties. The transport subsidy has been increased, but subsidized litter must be transported outside the Bay watershed.
- Phosphorous Sorbing Materials. USDA-ARS has been investigating phosphorus sorbing by-products to address high phosphorus concentrations in groundwater. The first generation design was based on a ditch filter. Water in a ditch was dammed and forced through gypsum. Removal efficiency was highest at low flow rates. A better design appears to be a permeable barrier in the ground water flow path that will treat groundwater before it reaches the aquifer (Penn et al., 2007).
- Poultry Production Area Storm Water Management – New source construction for poultry operations. Give prior consideration to manure management when designing new facilities. There is a need to address stormwater management better than in the past. Agricultural organization representatives and the Maryland Department of the Environment (MDE) created workgroups to develop stormwater designs. Manure storage should be built at the highest altitude on poultry facilities, and a grassy buffer should be constructed across the flow path. Runoff from the facility roof should also pass through a grassy buffer before entering a swale. Even the area furthest from storage should have its flow path run through a buffer. Storm water should be channeled through grass swales, treatment areas, optional industrial rain gardens, and/or wetlands before reaching the storm water retention pond. Such management represents a major change to standard designs for poultry houses, adding costs to grading, grasses, and treatment.
- Vegetated Environmental Buffers. The University of Delaware and Pennsylvania State University have been investigating dust and ammonia emissions losses with vegetated buffers. Both universities have found reductions in dust and ammonia losses (Adrizal et al., 2008). Buffers also reduce surface runoff and nitrate leaching to groundwater. Additional benefits of vegetated buffers may include nutrient recovery, carbon credits, and biofeedstock production. Growers need assistance to design and implement such buffers, but retrofitting is a challenge.
- Nutrient Removal. Organic material filters have been used on construction sites but should also be considered for agricultural applications. These filters reduce sediment and nutrient concentrations in water. The organic material filler needs to be replaced periodically, but spent filler has a high nutrient content and could be used for compost material. A pilot study has placed filters into an existing drainage system; study objectives are to assess N, P, and sediment reductions, design life, and on-site management issues. This study will also provide insight into costs, and form an engineering/scientific basis for design and installation of such technologies (Fenton et al., 2011; Ruane et al., 2011).
- Poultry House Remediation. A pilot project is addressing nutrient losses from abandoned poultry houses. The estimated life span of a poultry house is forty years, and poultry houses are built over soil pads that accumulate nutrients, primarily nitrogen. When roofs of abandoned poultry houses deteriorate, rainwater can leach these high accumulations of nutrients into drinking water. In the pilot project, these house sites are being processed

with organic waste materials from the deconstructed house. The recovered material is field applied at agronomic rates, and deep-rooted perennials are planted.

- Overview of Value Added Products - Advanced Technologies in Manure Management and the Chesapeake Bay. Considerable discussion took place on projects that reduce nutrients and generate value-added products. Projects of interest included: Bion (http://www.biontech.com/), Energyworks (http://www.energyworks.com/), Cover Area Regional Digester (http://www.covedigester.org/whycard.html), Electrocell - Swine, Central Vermont Public Service Cow Power Project (http://www.cvps.com/cowpower/), and the Texas Dairy Composting project (http://compost.tamu.edu/).

Short-term Opportunities

- Priority Short Term Management Activities
    - Provide state and federal funding to support interdepartmental and interstate coordination to enhance litter transport programs.
    - Provide farmers access to litter injector equipment.
    - Provide farmers with incentive programs to switch from using poultry litter to commercial fertilizer where water quality concerns exist based on high levels of soil phosphorus.
- Better communication and management/coordination between states should be encouraged concerning litter transport.
- Better interagency within-state coordination should occur to enhance manure transport.
- There is a need to remove local jurisdictional barriers to implementation.
- The full range of alternative technologies should be investigated.
- Farmers should be incentivized to switch fertilizer sources in order to address nutrient concerns.

Long-term Opportunities

- Establish a Chesapeake Bay watershed clearinghouse for alternative technologies.
- Establish minimum performance criteria for the poultry and dairy industry that farmers can demonstrate when requesting cost share funds.
- Establish cooperatives so that farmers can have access to expensive new technologies as members of the group.

Barriers to Implementation

- For all short- and long-term strategies and technologies, there must be adequate funding to support research and implementation of approved practices.
- This region needs to remain competitive with the rest of the country in poultry production and additional environmental protection costs may hurt competitiveness.
- Adoption of many technologies is slowed or stopped because regulations are not keeping up with technological advances.
- There is a critical need for additional research and field demonstrations, but these activities are time- and cost-intensive.
- Local jurisdictional barriers to implementation should be removed.

- Economies of scale required for new technologies inhibit adoption.
- Farm operation resources and personnel skill capacity inhibit new technology adoption.
- Bio-security concerns inhibit local or regional solutions to manure management.
- Comprehensive manure management approaches through multi-state and multi-agency cooperation have not been adequately developed.
- Local infrastructure and facility permitting neither support comprehensive manure management nor address TMDL and WIP needs.
- Manure injectors and other technology are not yet available to farmers.
- Current manure injection equipment presents substantial limitations for critical slope and varying soil conditions.
- Water quality agencies understand the new technologies/projects, but permitting agencies slow down the process due to lack of understanding.

General Cross-Cutting Themes from Breakout Sessions

Despite the diversity of the topics covered by the conference agenda, cross-cutting concepts or themes emerged from the conference sessions. The topic session discussion notes were compiled and analyzed to determine similar concepts/themes/issues. To simplify the analysis, a list of descriptive codes was developed for the main topic areas that allowed for grouping of the similar concepts/themes/issues. The objective of this analysis was to extract themes that went beyond the individual topic areas and could assist agency planners in orienting their programs or focusing on specific program investments.

The most frequent theme was the need for holistic planning and implementation on the part of consultants and producers. This was viewed as a key element to achieve the Bay's water quality goals. Holistic planning involves developing management plans that cross traditional technical domains, such as optimizing dairy ration crude protein (e.g., by monitoring milk urea-N), followed by use of manure N analysis and manure application techniques to conserve ammonia (e.g., injecting manure), followed by use of crop N monitoring techniques (e.g., using the pre-sidedress soil nitrate test or corn stalk nitrate test), and followed by reductions in purchased protein supplements for the dairy and/or reductions in fertilizer N purchases.

The second most important cross-cutting theme was the establishment of minimum standards that producers must follow in managing nutrients. Tying these minimum standards to programmatic funding, regulatory protections, and production criteria was viewed as a critical step to setting consistent and meaningful water quality improvement expectations. An example of an important minimum standard could be basic record keeping of N and P inputs (fertilizer and manure) and crop yields from a given field and/or N and P inputs for a herd (ration composition) and herd outputs (milk or meat). Such information could be used to track nutrient use and nutrient recovery efficiencies.

The third most important cross-cutting theme was to reduce imports of nutrients into the watershed by making better use of existing sources of fertilizer and feed. The recycling of existing available nutrients within the watershed is important for addressing current nutrient mass-imbalances. Improving the nutrient mass-balance within the watershed remains an important underlying principle for achieving long-term water quality goals for the Bay watershed (Beegle et al., 2000). It should also be noted that improved nutrient balances will require improving nutrient databases in order to more accurately establish nutrient inputs and outputs from various segments of agricultural enterprises.

The fourth most important cross-cutting theme was the concept of prioritizing resource allocations in order to focus on the nutrient issues that will return the greatest loss reductions from the investment of limited resources. This concept also recognizes the need to identify strategies for increasing the economic returns for nutrient management and identifying alternative ways to achieve greater nutrient management efficiency. This is an essential element due to the limitations of financial and technical resources for deploying nutrient management technologies across the watershed.

Table 3. List of Cross-Cutting themes extracted from Conference Focus Sessions, in order by frequency that the theme occurred in all sessions.

Priority	Themes	Occurrences	Description
1	Holistic Planning	16	The need for better, more consistent, and holistic planning on the part of farmers to use nutrients as efficiently as possible; ideas on how to achieve this.
2	Establishing Standards	15	Establishing minimum standards that producers must follow. Tying those standards to funding, regulatory protection, etc.
3	Nutrient Recycling	11	Efforts to reduce the import of nutrients into the watershed by making better use of existing sources of fertilizer and feed.
4	Targeting Resources	10	The need for and possible ways to achieve greater efficiency in achieving reductions for the dollars invested.
5	Collaboration	9	Suggestions to borrow, share, jointly create, standardize effective systems, approaches, etc. across states, agencies, disciplines.
6A	Economic Impacts	7	Taking measures to account for or address the impacts of standards and regulations on agricultural enterprises.
6B	Private Sector Involvement	7	Getting the private sector more involved in the effort.
7A	New Products/Technology	6	Suggestions for new products/technologies to be developed.
7B	USDA Farm Bill	6	Suggestions about Farm Bill programs
8	Financing	4	Ideas on how to get revenue streams to farmers.

9	Science Based Policies	3	The need to have policy based on science and steps to achieve that goal.
10	Knowledge Transfer	2	Things we need to know.
0	Nutrient Trading	0	Issues/ideas for nutrient trading.

Conclusions

The *Chesapeake Bay Goal Line 2025: Opportunities for Enhancing Agricultural Conservation* Conference drew over 120 agricultural specialists and topic experts to Hunt Valley, Maryland on October 5-6, 2010. The conference discussed opportunities to enhance nutrient and sediment conservation through the identification and implementation of existing BMPs, and the development and implementation of new and innovative BMPs in the Chesapeake Bay watershed.

The conference format was a general session followed by a group of topic breakout sessions, led by subject matter experts and scientists, which presented diverse techniques for managing soil nitrogen and phosphorus, dairy feeds, ammonia, and livestock manures to reduce nutrient losses from agricultural production systems. About half of each breakout session was devoted to audience participation in facilitated discussions in order to identify which BMPs and techniques were appropriate for implementation and acceptance by both the policy makers and individual producers in the short-term, and those that were more appropriate for the longer-term. Barriers to implementation were also identified.

Drawing conclusions about opportunities for improving BMPs is always dangerous in large heterogeneous watersheds like that of the Chesapeake Bay, because BMPs are well known for being site-specific. However, there were several BMPs that are applicable to large areas or to the major livestock enterprises; these practices will be the focus of this conclusion section. The reader is referred to the individual breakout session reports for a more comprehensive summary of the sessions and for discussion of more site-specific opportunities.

There are numerous short-term (less than 2 years) opportunities for further implementation of existing BMPs that can reduce nutrient and sediment losses to the Bay. For example, wider use of cover crops to reduce nitrogen leaching losses, reducing excess crude protein and phosphorus in dairy rations, injection or conservation-tillage incorporation of manures and sludges into the soil, and expanded transport and use of manure across the watershed. However, implementation of many of these BMPs is limited by economic constraints because many carry little direct financial benefit to the producer or are too costly for large-scale public support.

There are also promising BMPs that could be deployed within the next 5 years, i.e., before 2017. Examples of these newer techniques include: methods to reduce the acreage of soils with excessively high soil P levels by tracking soil P test results over time in georeferenced locations, improving watershed nutrient budgets by reducing nutrient imports through precision livestock feeding, recycling/expanding the use of existing nutrient stocks in manure, and increasing N and P efficiencies by linking traditional soil and crop tests to annual feedback loops in order to adjust nutrient timing, application rate, or placement (an adaptive nutrient management approach). Another overarching strategy involves more thorough integration of nutrient-conserving BMPs throughout the entire livestock-crop enterprise (i.e., holistic management) which emphasizes system-wide nutrient management in the animal diet, manure management, and land application of nutrients.

Many long-term opportunities (2017-2025) also exist for reducing nutrient and sediment losses to the Bay. These approaches seek to develop new markets and alternative uses for manure, expand support for year-long manure storage structures, reduce twice-per-year cleanouts, evaluate the potential for broiler production with litter-less flooring, develop minimum nutrient performance criteria for broiler and dairy producers, and develop more economic incentives for improved nutrient management.

An essential part of all of the above opportunities is a continued commitment to the education of producers, consultants, advisors, and policy makers across the watershed. Continuing education will accelerate adoption of proven practices, speed the development of new techniques, and lead to sound policies that can reduce tensions between environmental advocates and agricultural producers and spur the recovery and protection of the Chesapeake Bay.

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