DATE: January 8, 2010

TO: Federal Leadership Committee on the Chesapeake Bay

FROM: Bion Environmental Technologies, Inc.

RE: **Comments on Draft Strategy for Protecting and Restoring the Chesapeake Bay (Document ID EPA-HQ-OW-2009-0761-002) Pursuant to Executive Order 13508**

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Bion Environmental Technologies appreciates the opportunity to comment on the *Draft Strategy for Protecting and Restoring the Chesapeake Bay* ("*Draft Strategy*" or *DS*) as compiled by the Federal Leadership Committee on the Chesapeake Bay. Bion is proposing that the DS engage livestock agriculture in the Chesapeake Bay (CB) basin to solve the excess nitrogen problem by creating incentives and policies that will enable the free market to look at solving the problem as an opportunity.

Bion is a livestock waste treatment technology company that distinguishes itself by addressing the multi-media impacts (land, water and air impacts) of livestock waste. Its unique technology platform enables Bion to reduce nutrient loss from livestock operations (including significant reductions in airborne ammonia) while also reducing greenhouse gas emissions, odor, pathogens and endocrine disrupting compounds. Bion's technology also generates renewable energy from captured cellulose in the waste stream. Airborne ammonia emission reduction from livestock waste is a critical multi-media core competency of Bion's waste treatment technology.

Our comments are based on Bion's core competency: the cost effective management of multi-media nitrogen flows from livestock agriculture, as well as the policy initiatives needed to successfully accomplish that task. While we acknowledge that Bion staff does not have access to the same data sets as the *DS* authors, we provide our response to the DS based upon generally understood principles of livestock nitrogen accounting/movement, Bion's waste treatment operating experience, data from its monitored installations and position papers from Bion consultants who are acknowledged experts in their respective scientific fields.

Bion has focused its comments on Pennsylvania's Susquehanna River watershed as that is the single largest origin for non-point source (NPS) nitrogen to the CB. **Based on Bion's calculations, the amount of nitrogen emitted by livestock manure ammonia from Pennsylvania's Susquehanna River watershed dairy, cattle, and layers is greater than**
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any other individual source of nitrogen to the CB watershed, as estimated in the CB Draft Strategy (See Attachment 1: Estimate of Nitrogen Loss to the Environment from Selected Susquehanna Watershed Livestock). Federal and state regulatory agencies, including the EPA, currently lack the authority to regulate air emissions from livestock. As a result, regulatory agencies focus their efforts to reduce excess nitrogen loadings to the CB watershed on sources they can regulate rather than necessarily on those that contribute the greatest nutrient load.

The problem is further exacerbated by the fact that nitrogen losses in ammonia emissions from livestock waste are completely omitted from the nutrient management plan (NMP) accounting process. Farm operation based nutrient NMP's are the principle regulatory mechanism for monitoring animal agriculture's nutrient use and control. As a result, nitrogen losses in ammonia emissions from livestock waste of approximately 40% or greater of that contained in manure as excreted from livestock results in significant under accounting of nitrogen in the NMP process. The end result is that the single largest source of nitrogen entering the CB from the Susquehanna is left unaddressed while public resources and taxpayer funds are directed towards less effective and more expensive programs treating pathways for nitrogen to the CB rather than sources.

There are several realities with regard to nitrogen from livestock ammonia that do not appear to be appropriately reflected in the DS that need to be understood to cost effectively construct solutions to the CB nitrogen loading problem:

1) **Almost all nitrogen from livestock waste derived ammonia redeposited into the CB watershed represents excess loading, and therefore essentially all of the re-deposited nitrogen becomes load to the CB.** Further, it is Bion's position that a significant portion of nitrogen load allocated to other non-point sources in reality originates as ammonia volatilized from livestock manure. Other than direct deposition into waterways, the *DS* does not take into account that:
   - All of the re-deposited nitrogen that falls onto watershed farmland is excess as farm NMP's do not account for this source and therefore operator application of nutrients will have already satisfied crop agronomic needs for nitrogen.
   - Nitrogen that deposits onto impervious surfaces such as roadways, parking lots, roofs, etc. has no place to go until the rains come to wash it away at which point it quickly solubilizes.

   Basically all land use types, other than perhaps forests which release little nitrogen, are likely to provide little opportunity for uptake, leading to much higher expected loss to water bodies as compared to agronomically applied nitrogen. Mature forests uptake of external nitrogen inputs is minimal.

2) **Under-representation of nitrogen from livestock waste derived ammonia in the nitrogen delivered load allocation results in a series of misallocations, from agricultural sources to other NPS categories such as stormwater, which to a great**

extent simply serve as conduits for nitrogen from agricultural sources. Because livestock nitrogen is a significant contributor to these other NPS categories, the *DS* allocation of nitrogen to them confuses the reality that these NPS categories are not necessarily the source of nitrogen but are acting in large measure as channels or pathways for delivery of nitrogen to the CB that actually originates with livestock agriculture. Understanding the distinction between nitrogen source and delivery pathway is critical to cost effectively solving the CB nitrogen problem.

A critical step to solving the CB excess nutrient problem is to account for the impact of livestock ammonia as a source of nitrogen load to the CB. The *DS* estimates that 6% of the nitrogen load to the Bay comes from 'agricultural atmospheric deposition', which equates to approximately 17.5 million pounds per year. Bion projects that the annual release of nitrogen in the form of ammonia from dairy, swine and poultry livestock within the Susquehanna Watershed of Pennsylvania (USDA NASS statistics) at 100 - 140 million pounds depending on specific feed rates, animal weights and census interpretation. Of that release of nitrogen, Bion estimates that approximately 80% or 80 - 110 million pounds is re-deposited within the basin, and of that conservatively 70 - 90 million pounds results in nitrogen load to the CB through various NPS categories. Details of Bion's ammonia nitrogen deposition calculations can be found in Attachment 1 (analysis and calculations by Bion) and Attachment 2 (a Bion commissioned report from Trinity Consultants on air re-deposition of nitrogen from emission of livestock manure ammonia at a Lancaster County, PA farm) of this submission.

3) **Under representation of nitrogen from livestock waste ammonia within the CB basin directly leads to the promulgation of programs targeted at the agricultural sector that will be severely limited in their effectiveness.** The *DS* regulatory initiative of extending Concentrated Animal Feeding Operations (CAFO) regulatory status and nutrient management plan (NMP) requirements to smaller livestock producers that are presently exempt is an example of focusing on areas of regulatory authority that result in a low scoring cost-benefit. Approximately 40% or more of the nitrogen voided by livestock is released to air in the form of volatilized ammonia before the livestock waste is land applied, which is where the NMP begins to account for livestock nitrogen. In addition, since the bioavailability of land applied manure is in the range of 35% (as per the PSU Agronomy Guide and other sources), 60% or greater of land applied nitrogen is lost to the environment in this compliance scenario. In the end, the financial cost to the small livestock producers presently exempt must be weighed against the projected benefit from reducing excess application when 60% or greater is lost to the environment assuming compliance under an NMP. Based upon this approach, it makes greater sense to focus on livestock ammonia which is 100% excess on every livestock facility every day year round.

4) **The misallocation of nitrogen from livestock waste ammonia to other NPS within the CB basin directly leads to a focus on solutions that will be extremely and unnecessarily costly.** As long as the loss of nitrogen from livestock waste through volatilization of ammonia to the environment is largely ignored, programs aimed at reducing

livestock nitrogen impacts to the CB will be limited in their effectiveness as they continue to focus on pathways of delivery rather than its source. The combined capital and operating cost of reducing nitrogen delivered load from livestock waste once it has escaped into the environment is 3 to 10 times greater than when treated at scale at its agricultural source. For a cost estimate to reduce nitrogen from municipal waste water treatment facilities, see a Metcalf & Eddy study commissioned by the PA Legislative AND Budget Committee: (http://lbfc.legis.state.pa.us/reports/2008/25.PDF). For the cost to remove nitrogen from stormwater, see the Chesapeake Bay Tributary Strategy: (http://www.depweb.state.pa.us/portal/server.pt/community/chesapeake_bay_program/10513). With ammonia nitrogen, it makes much more sense to focus on preventing loss at the livestock facility.

When considering the *DS* from a cost/benefit standpoint, the policy implications of the current version of the *DS* versus the proposed approach by Bion have large financial ramifications. The Chesapeake Bay Tributary Strategy calls for a reduction of 37 million pounds of nitrogen delivered load from Pennsylvania's Susquehanna watershed. Consider the cost impacts if the price per pound of nitrogen reduction is modified from $25/lb (POTWs) and $75/lb (municipal stormwater) down to between $6-$10/lb for reducing nitrogen from livestock waste. Assuming 35 million pounds of annual reduction from livestock waste nitrogen in the Susquehanna watershed at a blended cost benefit of $30 per lb would result in an annual savings to public agencies and private ratepayers in excess of $1B from the Susquehanna watershed alone. A reduction of 10 million pounds in nitrogen from livestock derived waste ammonia on a similar basis would result in an initial annual cost benefit of $300 million per year -- greater over time -- to federal and state taxpayers and local ratepayers.

5) **Current and proposed NPS trading programs also create excess cost and reduced demand by directing trades though governmental authorities and their extensive levels of regulatory coverage.** Pennsylvania's nutrient trading program and the basin trading program in the proposed Cardin Bill are free market programs. Yet the only significant buyers of credits are point source (PS) municipal waste treatment plants, which over the years have accumulated increasingly detailed and onerous regulatory mandates that apparently must transfer over to NPS-generated credits as a part of the trading process (e.g. short term compliance verification periods).

   Further, while these PS represent 11% of the excess nitrogen load to the CB from the Susquehanna River watershed, they are obviously expected to be the generators/buyers of a 35% reduction coming primarily from NPS's. If PS municipal facilities reduced their nitrogen discharge to zero, there would still be a need to reduce NPS by 20 million plus pounds per year. The existing trading system proposals lack any structure that could create a market for NPS credits outside of PS buyers.

This conflicted and illogical market for NPS credit generation is the single biggest driver of cost in the CB basin nitrogen reduction initiative. Essentially, the PS industry supported by

EPA policy requires NPS nitrogen credit suppliers to provide nitrogen credits that are the "regulatory equivalent" of PS municipal reductions from a regulatory and risk perspective. The problem is that PS regulations, designed to reduce impacts from sources directly discharging an assortment of nutrients and other waste products into navigable waterways, are being imposed upon livestock operations that have controlled and essentially organic waste streams and do not discharge into navigable waterways. As stated above, NPS credit generators face a difficult hurdle in meeting the regulatory 'equivalent' standards imposed on municipal waste treatment plants as (1) farm operations are biological operations with inherent load variability over seasons, herd types, age distribution, etc, (2) the risk factors associated with short term compliance averaging periods with corresponding penalty clauses and a lack of force majeure protections can neither be quantified nor cost effectively priced by the private NPS credit generator since they will lack both the taxing authority of the community to collateralize these risks as well as the political representation to essentially reduce the financial consequences of these risks to a small fraction of their true cost.

The *DS* needs to adopt innovative programs and policies that foster the needed investment in technology by reducing both risk and costs without allowing environmental backsliding, by providing a funded market for NPS credits absent excess regulatory and associated financial burdens.

The Need for Creative Policy Initiatives:

An excellent precedent exists for a creative public policy approach to incentivize the private livestock industry to significantly reduce its excess nitrogen contribution on a voluntary basis as recently summarized in an article entitled "Testing, Testing" by Atul Gawande in the December 14, 2009 issue of "The New Yorker"**.** Prior to World War I, our country was still a relatively poor nation, in large part because of the low productivity of U.S. agriculture characterized by fragmentation, disorganization and an inborn reluctance to adopt improved practices. The result was low crop yields, unreliable quality, limited consumer choices and high market costs. Agriculture was, as it had been for centuries, inordinately labor intensive with close to half of the country's workforce dedicated to the sector. Farmers relied on human resources because labor was relatively inexpensive, just as the structure of agriculture today is based on cheap land, abundant water, inexpensive energy and less than full accounting for its environmental impacts.

As a consequence, food costs consumed more than 40% of an average family's income. Given these conditions, it was not possible for the nation to raise its standard of living and emerge as an industrial power without a reduction in food costs to allow discretionary income to be spent on goods and services in other economic sectors accompanied by a reduction in labor requirements to allow human resources to redeploy into emerging industrial sectors. What was needed then was nothing short of a fundamental restructuring of agricultural, **just as today, it will not be possible to cost effectively solve the CB's nutrient loading problem without a modern transformation of the livestock industry.**

In response, the federal government instituted a series of initiatives, programs and policies that helped millions of farmers change the way they worked while honoring individual land ownership and the value of private sector initiative. State programs at land grant institutions followed the creation of federal programs that were based on the understanding that farmers were not going to change their methods without seeing for themselves the benefits of adopting new techniques and practices. The federal government initiated the Extension Service, conducted a series of demonstration farms and pilot programs across the country and created what has become a network of agricultural experiment stations in every state of the country to develop and teach the most productive methods for growing livestock and producing crops. The government invested in providing timely and accurate data to farmers, initiated a statistics service, began to provide more accurate forecasts to the marketplace, produced new genetic varieties of crops and livestock and developed and taught improved approaches to productivity.

There are problems that are amenable to a technical solution and other problems that cannot be solved completely, but rather are managed. The government never took over or otherwise attempted to proscriptively regulate solutions to agriculture, but through a creative network of public policy and support programs effectively shaped the basis for transformation. The results can be seen today as retail food prices have fallen to about 8% of household income and a work force that represents just 2% of the nation's workforce. The transformation resulted in considerable consolidation of farms and failure of inefficient operations. However, the approach was ultimately successful because federal and state agencies remained flexible, adjusting policies over time based on results, not ideology.

The same approach is now required to effectively respond to the issue of nitrogen loading to the CB. Now, as at the turn of the prior century, reforming the agricultural system and specifically the livestock sector so that it can meet the environmental challenges of the CB will be a process involving thousands of farmers pursuing their individual interests. The solution will not happen by government fiat alone; there is no easy 'one time fix'. These problems will require policies that foster a private sector solution to meet required standards. Such policies need to combine regulatory standards and voluntary initiatives, effectively both carrots and sticks. The policies/programs need to be attractive to those whose adoption is sought and, therefore, the policy makers need to have a thorough understanding of both existing environmental problems and what solutions can be implemented that will also enhance the livestock producers overall quality of life.

Bion proposes that the DS engage livestock agriculture in the CB basin to solve the excess nitrogen problem by creating incentives and policies that will enable the free market to look at solving the problem as an opportunity. Our policy proposals are a combination of a number of elements including: new initiatives, relief from some legacy PS regulatory requirements, risk reduction policies to constrain costs by not having to artificially price risk absent environmental benefit into the per pound cost of reduction and to enable restructuring of livestock agriculture in a manner that is environmentally and economically sustainable. The key is that these policies are not standalone solutions but all part of a coordinated package of solutions that will result in a cost effective voluntary solution. The main proposals are as follows:

POLICY PROPOSALS:

Creation of an effective basin wide nitrogen trading program will require attention to a number of interrelated considerations:

Real financial opportunity: A basin wide agency that has the financial capacity to directly purchase nitrogen credits from NPS generators on long term basis.

PS legacy regulatory requirements: Municipal waste treatment plants must verify their nutrient loads on a monthly and sometimes annual basis, and they pass on those same verification standards to their purchased credits. What is needed is a commitment to adopt policies that will reduce nitrogen reduction costs without environmental backsliding. For example, one such policy would support the ability on the part of NPS generators to make up any periodic shortfall in nitrogen credits. Bion has proposed that its credit generation be based upon a 3 year averaging to meet forward credit sale commitments so that any short term system interruption could be satisfied and the risk could adequately be valued. Bion secured an opinion from recognized CB experts that 3 year nitrogen averaging from NPS installations would have no negative impact on the CB nitrogen load reduction effects (see Attachment 3: Robillard Memo).

Restructuring and transition: The livestock industry will need to restructure to reduce its nitrogen impacts and policy makers will need to create the policy and economic tools to enable that restructuring. While there is no single silver bullet solution, a consensus has developed around aggregating livestock waste to create a critical mass to cost effectively support various advanced treatment technologies capable of achieving the required nitrogen reductions. Some producers will opt for a regional treatment option requiring manure transportation. In some cases, livestock production will aggregate either within or outside of the watershed via new expanded facilities that may be the successors of existing livestock operations with either the same or new ownership.

In all of the above scenarios, the currency to cover the cost of the required transition will be nitrogen credits generated as a result of the differential between the existing nitrogen baseline and the baseline of the treatment system with the beneficial impact to the CB watershed. Whatever the marketplace reality, policies need to provide a consistent framework of support based upon measured nitrogen reduction results per economic unit of support extended without environmental backsliding. Such a transition and its beneficial impact to the CB cannot be accomplished absent a coordinated effort consisting of technology, state and federal policies and financial support. These policy modifications would allow a portion of the cost benefit from on-site treatment of livestock waste to be utilized in providing the livestock industry both transition and long term funding for being part of the solution on a voluntary basis.

To be sure, the required transformation of the regional livestock industry cannot happen quickly. Restructuring will require a long-term perspective by both public policy makers and private industry participants to enable the necessary components of change to develop: agreements between parties, choice and implementation of technologies, identification, development and permitting of appropriate sites, accumulation / consolidation of herd, creation of marketplace contracts, etc. Each of these steps will require a stable environment over the long-term dependent upon policies providing a consistent framework of support based on measured nitrogen reduction results per economic unit of support extended. These same policies will need to be shaped to reflect that the necessary decisions are voluntary and will be made by the private sector based on economic conditions in the marketplace within the context of public programs and policies. The public will achieve its desired environmental benefit only by establishing stable incentives that the private sector can rely upon in making their investment and other business decisions, and then allow the process to unfold.

Risk management: Livestock waste treatment systems are capital intensive projects that need to be financed over the long-term useful life of the project, normally 10-20 years. Without regulation requiring the livestock producer participates in such a waste treatment system, their participation will be voluntary. This situation leads to a number of risk factors beyond the control of any livestock waste treatment facility/operator that will essentially preclude the participation of private market funding in such projects absent adoption of policies to address them.

Both participating herd size and potential farm closure are beyond the capability of the livestock waste treatment operator to control. The treatment facility lacks control over its volume and the continuation of the source of manure raw material. The risk of closure by the livestock producer needs to be addressed since these facilities will need a predictable revenue stream to attract capital to construct a treatment facility as well as pay their debt service. At the same time it should be noted that upon closure the livestock facility will no longer be a source of excess nitrogen to the CB -- the excess nitrogen pollution no longer being produced. But because these risks cannot be effectively managed, they cannot be efficiently priced as part of the credit generation cost.

Another risk is presented by livestock herd sizes that typically vary within the permit authority based both upon seasonality and marketplace conditions. However, any livestock waste treatment facility would need to be built to treat at the permit limit. To address these variabilities, credit generation needs to be normalized based upon permit limits or some economically feasible percentage of the permit limit.

Simply stated, risks that cannot be managed and quantified cannot be efficiently priced into a private transaction and will result in refusal by any qualified borrower or investor to financially participate in such a project. Absent the adoption of needed risk mitigation policies, all projects will be dependent upon federal and state grants or non-recourse financing for both debt and operating financing. The power and innovation of the free market to participate in solving the excess nitrogen problem will be lost.

The most significant factor is that adoption of policies required for private investment does not result in environmental backsliding. For this reason, the existing policies represent excess cost with no environmental benefit to the CB restoration effort.

In conclusion, livestock waste nitrogen ammonia emissions need to be both properly quantified and sourced so that financial resources can be cost effectively allocated to address this issue. The economic costs in wet deposition areas of the country needs to take into account the impact of this large underestimated source of ammonia on PM emissions and the related public health costs. Bion believes that the combination of creative public policy and incentives will enable the existing private sector livestock industry to restructure and create a new environmental and economically sustainable industry producing green jobs and livestock products. The CB solution to the excess nitrogen issue is the laboratory for how the impacts of excess nitrogen on a national basis will be addressed. The Mississippi basin represents a larger number of states and the dead zone is much larger. The successful application of these cost saving and environmentally beneficial and sustainable policies can lead the way to vast environmental improvements while benefitting municipalities, the animal agriculture industry and taxpayers.

MEMORANDUM

DATE: January 7, 2010

TO: Dominic Bassani

FROM: James Morris & Jeremy Rowland

RE: **Technical Back-up for Susquehanna Watershed Livestock Nitrogen Loss Estimates**

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Bion technical staff generated an estimate of ammonia nitrogen loss from selected livestock species manure (dairy, cattle and calves, and layers) located in Pennsylvania's Susquehanna River watershed, a major source of delivered nutrients to the Chesapeake Bay. The estimate is based on loss of nitrogen through the volatilization to ammonia from manure prior to its application to cropland. To complete the picture, we have also estimated nitrogen loss to the environment from livestock manure after land application based on principals of nutrient management planning within the same watershed from the same selected livestock species. We have attempted to fully document our assumptions so that the interpretations from this data can be conducted in a transparent manner.

The summary results of our analysis are presented in four sections below, consisting of an assortment of data summaries in table form, a step by step description of calculation steps, along with the core assumptions used in the analysis and the sources for these assumptions. Because of timing and logistical issues, Bion staff did not include broilers or hogs and swine in this analysis despite their high population levels within the Susquehanna watershed, neither were other livestock types considered for this exercise. Including nitrogen losses from these and other existing livestock species would increase the nitrogen loss estimates enclosed herein. In addition, our projections for nitrogen delivery into the Chesapeake Bay watershed from livestock manure ammonia also ignore contributions from livestock within the Chesapeake Bay air shed but not within the CB watershed.
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Part one: Summary of Steps Used to Generate the Susquehanna Livestock Ammonia Nitrogen Loss Calculations

(1) The first step was to establish livestock population estimates for the Susquehanna watershed as shown in Column (2) of Table 1 below, using USDA's census estimates cited in Table 6 at the end of this document.

Table 1
PA Livestock in the Susquehanna Watershed

Susquehanna Watershed Livestock	
(1) Species	**(2) # of Head**
Dairy	469,800
Manure as Slurry	70,470
Manure as Solids	399,330
Cattle & Calves	1,288,500
Layers	13,772,000

Bion used PA/DEP watershed models to determine which counties to include in the overall Susquehanna livestock census.

(2) The next step was to consider the amount of total nitrogen as voided from this livestock population. As cited in Table 6, Bion predominantly used manure characteristic factors from the American Society of Agricultural and Biological Engineers (ASABE), which were adjusted somewhat to account for anticipated herd variations, such as the percent of milk cows that are non-lactating, smaller average size of Pennsylvania dairy cows compared to national averages used in data bases consulted, and age distribution factors for cattle and calves. (See Column (3) of Table 2 below.)

(3) Once total nitrogen as voided was determined, Bion conducted a calculation to determine the amount of that nitrogen which was lost to the environment as volatilized ammonia prior to the land application of the manure stream. (See Column (4) of Table 2 below.) Bion based this calculation on a straight mass balance approach: based upon the difference between

the total amount of nitrogen voided (step 2), and the amount of nitrogen that is accounted for in the manure stream as it is land applied, as estimated in the Pennsylvania State University (PSU) Agronomy Guide. Years of livestock industry and agency documentation and actual measurements regarding both of the described variables serve to support the logic of this approach.

Table 2
Loss of Nitrogen via Volatilization of Ammonia from Selected Susquehanna Watershed Livestock Prior to Land Application

Susquehanna Watershed Livestock	Nitrogen Prior to Land Application (lb / yr)		
(1) Species	(3) Total Nitrogen as Voided	(4) Nitrogen Loss via Ammonia Volatilization	(5) Ammonia Nitrogen Redeposited within the CB
Dairy			
Manure as Slurry	24,178,257	12,572,694	10,058,155
Manure as Solids	137,010,123	33,567,480	26,853,984
Cattle & Calves	164,605,875	67,488,409	53,990,727
Layers	18,817,188	11,290,313	9,032,250
TOTALS	**344,611,443**	**124,918,895**	**99,935,116**

(4) Once the ammonia is volatilized, the question then becomes where does it re-deposit? For the purposes of these calculations, Bion relied on a review of literature on the topic along with an assessment of Susquehanna watershed meteorological conditions conducted by Trinity Consultants (http://www.trinityconsultants.com/AirDispersionModeling/). Bion commissioned Trinity to provide its opinion on how much of the livestock ammonia nitrogen is likely to re-deposit back into the Bay watershed. The results of their analysis were used in our calculations, and the analysis is provided as Attachment 2 of Bion's Draft Strategy response letter. (See Column (5) of Table 2 above.)

As Shown in Table 2, the results of our analysis show that approximately 100 million pounds of nitrogen derived from livestock ammonia are deposited within the Chesapeake Bay watershed. While some of the assumptions Bion used to generate this analysis could certainly be refined with additional studies and evaluations, the basic structure of the point remains firm – that when considering nitrogen ammonia loss from a mass balance perspective, as opposed to attempting to calculate ammonia loss via other means such as direct measurement, there is a significantly larger amount of nitrogen loss to the environment from livestock ammonia than is accounted for in most state and federal inventories on the topic. Simply stated, if the nitrogen is voided, and it is not in the land applied manure, then it must be lost to the environment.

Part Two: Summary of Steps Used to Calculate Nitrogen Loss to the Environment After Land Application from Livestock in the Susquehanna Watershed

Bion also calculated values for our assessment of nitrogen loss to the environment after the application of manure to the land. We conducted this calculation using the following steps:

(1) The key for this calculation, as with the ammonia loss calculation described above, is to follow basic mass balance principles. Therefore the first step is to consider the total amount of nitrogen that is available for land application, following manure collection, storage, etc., which is the core reason the Agronomy Guide was developed. Bion used the recommended factors commonly used from the PSU Agronomy Guide for this calculation (See Column (6) of Table 3 below.)

Table 3
Nitrogen Losses from Selected Susquehanna Livestock after Land Application

Susquehanna Watershed Livestock	Nitrogen After Land Application (lb / yr)		
(1) Species	(6) Total Nitrogen Land Applied	(7) Nitrogen Retained by Crops	(8) Nitrogen Loss to Environment
Dairy			
Manure as Slurry	11,605,563	4,642,225	6,963,338
Manure as Solids	103,442,643	31,032,793	72,409,850
Cattle & Calves	97,117,466	29,135,240	67,982,226
Layers	7,526,875	1,505,375	6,021,500
TOTALS	**219,692,548**	**66,315,633**	**153,376,915**

(2) The next step is to determine nitrogen that is available to be retained by the crop, as there is no way for that portion of the nitrogen to escape to the environment. Bion made these calculations by generating a bioavailability factor, or the amount of nitrogen in the waste that is available for uptake. (See Column (7) of Table 3 below.) Bion derived the bioavailability factors from the PSU Agronomy Guides combined with tools used by Pennsylvania certified nutrient management planners, as described in more detail below.

(3) The determination of land applied nitrogen lost to the environment from this point was to simply subtract the amount of land applied nitrogen from the amount of nitrogen that was available for uptake. (See Column (8) of Table 3 above.)

(4) The final step was to total this loss across livestock type, then in Column (9) of Table 4 below we totaled the losses from both ammonia loss and loss after land application.

Table 4
Total of Nitrogen Loss to the Environment from Selected Livestock within the Susquehanna Watershed of Pennsylvania

Susquehanna Watershed Livestock	Nitrogen Prior to Land Application (lb / yr)	Nitrogen After Land Application (lb / yr)	(9) Total Nitrogen Lost to the Environment from Selected Susquehanna Livestock (lb / yr)
(1) Species	(5) Ammonia Nitrogen Redeposited within the CB	(8) Nitrogen Loss to Environment	
Dairy			
Manure as Slurry	10,058,155	6,963,338	17,021,493
Manure as Solids	26,853,984	72,409,850	99,263,834
Cattle & Calves	53,990,727	67,982,226	121,972,953
Layers	9,032,250	6,021,500	15,053,750
TOTALS	**99,935,116**	**153,376,915**	**253,312,031**

In conclusion, Bion projects that just from dairy, cattle and calves and layers within the Susquehanna Watershed of Pennsylvania that a total of approximately 250 million pounds per year of nitrogen is lost to the environment.

Part Three: Process for Estimation of Nitrogen Bioavailability

Despite the critical importance of farm level determinations of nitrogen bioavailability from land applied manure, there is a lack of direct representation in the PSU Agronomy Guides and other similar agronomic sources on this topic. We therefore thought it would be useful to provide some more explanation as to how Bion understands that nitrogen bioavailability or crop uptake efficiency assumptions are generated at the farm level. Following that step by step listing, we explain how we went about determining generic bioavailability factors for the purposes of calculating nitrogen loss from livestock manure on a Susquehanna-wide basis.

Starting out at the most basic and practical farm level approach, Bion staff understands the following basic steps to calculate bioavailability / crop uptake efficiency, using a large dairy farm in the example:

1) Obtain nitrogen analysis of manure slurry to be applied, specifically ammonium nitrogen (NH_4^+-N) and organic nitrogen (Org-N) content. The bioavailability of these two components is then determined.

2) Using PSU Agronomy Guide Table 1.2-15 determine the NH_4^+-N component availability factor for the specific application area (crop management unit) based on the type of manure, season of application and the incorporation factor/management of the applied manure supplied by the farm for each crop management unit.

3) Again use Table 1.2-15 of the PSU Agronomy Guide to determine the amount of organic nitrogen that will become available during the cropping year based on the amount of organic nitrogen in the manure, percent dry matter, and type of manure. This is the current year Org-N bioavailability.

4) The NH_4^+-N component availability factor determined in step 2 is multiplied by the total nitrogen in the manure slurry to be applied, the Org-N component availability factor determined in step 3 is multiplied by the total nitrogen in the manure slurry to be applied, and these two quantities are added together to obtain the total pounds of nitrogen that will be bioavailable for crop uptake in the year applied (current year).

Organic nitrogen applied will also become available and contribute to crop uptake in subsequent years. Thus, under continuous manure application, the Org-N decomposed from past applications which becomes available must also be determined.

5) The PSU Agronomy Guide Table 1.2-15 also provides the amount of nitrogen becoming available from Org-N decomposition occurring over a five year period. The total Org-N in the

manure slurry is then multiplied by the decomposition factor for each year (i.e.: 0.12, 0.05, 0.02, 0.02, 0.01 for manure from guide). The five quantities are then totaled to arrive at the total current year contribution of nitrogen from the decay of Org-N applied previously.

6) The total nitrogen available for crop uptake yearly from all these sources, current year NH_4^+-N and Org-N plus Org-N available from previous years, is then the sum of current year total from step 4 and the residual decomposition contribution from step 5.

7) If the farm operates more than one crop management unit, steps 1 through 6 are repeated for each crop management unit and the manure type applied.

8) The farm NMP based nitrogen bioavailability is the sum of the crop management unit(s) total nitrogen available from step 6. This mass of nitrogen is taken up by the crops managed (pounds nitrogen uptake or bioavailable per year). To obtain the nitrogen bioavailability factor or crop nitrogen uptake efficiency, the total (sum) for the overall (or average) farm operation's NMP crop management unit(s) nitrogen crop uptake or bioavailable nitrogen is divided by the total (sum) manure nitrogen applied to the crop management unit(s).

For the purposes of our broad Susquehanna-wide bioavailability estimates, we relied on the nitrogen availability factors contained in Table 1.2-14 from the PSU Agronomy Guide (including residual nitrogen availability from decomposition).

Part Four: Assumptions Used in this Analysis

As stated at the outset of this document, it is important to document assumptions made in generating the analysis so as to promote transparency. Therefore Table 5 was generated to present the basic input assumptions on which our calculations were based, and Table 6 contains the sources and references on which the basic assumptions were determined. Not all assumptions are documented in these tables, just the major ones.

Table 5
Assumptions for Calculation of Loss of Nitrogen to the Environment from Selected Livestock Types within the Susquehanna Watershed of Pennsylvania

Input Assumptions:

Dairy		
# of head in the Susquehanna watershed [1]		469,800
amount of nitrogen voided daily per head (if # of milkers are included than 0.88 lb/day) (lb / day) [2]		0.94
Characteristics of Manure Management System Utilized		
	Manure as Solids	**Manure as Slurry**
% of milkers by manure management type [3]	85%	15%
% of voided nitrogen lost through ammonia volatilization prior to land application [4]	24.5%	52.0%
bioavailability of manure nitrogen after land application [5]	30%	40%
Cattle & Calves		
# of head in the Susquehanna watershed [1]		1,288,500
amount of nitrogen voided daily per head (blended between beef cattle @ 0.42 and calves @ 0.29) (lb / day) [2]		0.35
% of voided nitrogen lost through ammonia volatilization prior to land application [4]		41%
bioavailability of manure nitrogen after land application (typically same as dairy solids) [5]		30%
Layers		
# of head in the Susquehanna watershed [1]		13,772,000
amount of nitrogen voided annually per AU (lb / yr) [2]		414
% of voided nitrogen lost via ammonia volatilization prior to land application (Kreider measured barn losses @ 65%) [4]		60%
bioavailability of manure nitrogen after land application [5]		20%
Ammonia Redeposition		
% of volatilized ammonia that remains within the watershed [6]		80%

Table 6
Sources and References for Calculation Assumptions

Sources & References:

[1] http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp

[2] ASAE D384.2 2006 Manure Characteristics

[3] USDA NASS (12% on farms over 500 head), conversations w/ regional farm planners, Bion estimation

[4] ASABE 384.2 2006 for N as excreted and PSU Agronomy Guides for N as land applied

[5] Derived from PSU Agronomy Guides as appled to individual farm NMP's (see Gerlach memo attached)

[6] Ammonia redeposition from the Trinity Report (Attachment 2)

ATTACHMENT 2 (Bion DS Comments)

Trinity Consultants

MEMORANDUM

TO: Dr. James Morris, Bion Environmental Technologies, Inc.
CC: Dr. Weiping Dai, Trinity Consultants
Ms. Ashley Queen, Trinity Consultants
FROM: Mr. Robert Liles, Trinity Consultants

DATE: September 10, 2009
RE: Review of Mr. Lewis Linker's Response to Bion's Credit Application

Bion Environmental Technologies, Inc. (Bion) has requested that Trinity Consultants, Inc. (Trinity) review readily available literature and, combined with our experience in deposition of ground level ammonia emissions as occur from agricultural sources and the models developed describing the transport and fate of these emissions, provide an opinion as to the reasonably expected deposition of airborne ammonia into the Chesapeake Bay watershed. The ammonia emissions in question emanate from the Kreider Farms Dairy in Manheim, Lancaster County, Pennsylvania. Bion is proposing to install a processing system that would greatly reduce the ammonia emissions, thereby generating nitrogen credits in the watershed. Trinity reviewed the following Bion documents as part of this opinion:

- Memorandum from Dr. James Morris, P.E. and Mr. Jeremy Rowland, Bion Environmental Technologies, Inc. to Mr. Harry Campbell, Chesapeake Bay Foundation, February 16, 2009
- Memorandum from Mr. Jeremy Rowland and Dr. James Morris, P.E., Bion Environmental Technologies, Inc. to Mr. Matt Ehrhart, Chesapeake Bay Foundation, and Ms. Jan Jarrett, PennFuture, May 4, 2009
- Memorandum from Dr. James Morris, P.E., Bion Environmental Technologies, Inc. to Ms. Ann Smith, Pennsylvania Department of Environmental Protection, May 29, 2009

In addition, Bion requested that Trinity evaluate the recent review provided by Mr. Lewis Linker in response to the Bion credit application. In addition to reviewing Mr. Linker's response, Trinity was tasked with providing an opinion as to whether Mr. Linker's approach is the most appropriate method for determining the expected deposition of airborne ammonia from Kreider Farms into the Chesapeake Bay watershed. The opinion provided below regarding Mr. Linker's review is based on our experience related to ammonia deposition in addition to the review of Mr. Linker's response, the specific modeling studies referenced by Mr. Linker, and readily available scientific literature.

Trinity Consultants is an air quality environmental consulting firm that specializes in industrial air quality permitting, air dispersion modeling, and regulatory compliance. Founded in 1974, Trinity has established itself as a national leader in the use and application of a wide array of air dispersion models including AERMOD, CALPUFF, CAMx, CMAQ, and others. In addition, Trinity's BREEZE™ group actively develops specialty models for customers and sells advanced graphical user interfaces for many U.S. EPA models. Our modeling staff has a thorough understanding of air dispersion modeling principles and their appropriate application. Resumes of our reviewers are included as an attachment to this memo.

EXECUTIVE SUMMARY

Based on Trinity's review of the literature and our experience with the principles of air dispersion modeling, it is our opinion that an annual average 70 to 80% near-field deposition rate is reasonable for ground-level sources of ammonia emanating from operations such as those at Kreider Farms. As discussed in detail below, it is Trinity's opinion that the information provided by Mr. Linker is not appropriate for characterizing the ammonia emissions and eventual deposition from Kreider Farms and does not provide conclusive evidence to dispute the estimated annual average deposition rate of 70 to 80%.

Per direction from Bion, Trinity's review was limited to the deposition of airborne ammonia from the Kreider Farms in Lancaster County, Pennsylvania. In the aforementioned memoranda, Bion shows that a significant portion of the ammonia emitted to the air is retained in the watershed, and that as much as approximately 80 to 85% of the ammonia is deposited in the vicinity the source. In Mr. Linker's response, he disputes the approximated deposition and states that only a small portion, if any, of the ammonia emissions could be credited as returned to the Chesapeake Bay watershed.

Trinity acknowledges that the science surrounding the fate of airborne ammonia is very complex and is the subject of several ongoing studies. Trinity's modeling experience and the current literature reviewed by Trinity supports the position that a significant amount of ammonia emissions emanating from confined animal operations has the opportunity to deposit in the near-field (i.e., less than 50 km from the emission sources). As discussed below, it is Trinity's opinion that an annual average deposition rate of 70 to 80% in the watershed appears to be reasonable for Kreider Farms emission sources. Further, upon review of Mr. Linker's response and the regional modeling studies referenced in his response, Trinity believes that the modeling results are inappropriately applied to Kreider Farms in characterizing the potential deposition of ammonia emissions resulting from this source. Instead, a more site-specific approach should be utilized to determine the potential deposition rates from a single emission source, like Kreider Farms.

The following sections discuss Trinity's review and opinion regarding estimated deposition rates from Kreider Farms along with a specific review of Mr. Linker's response to Bion's credit application and the regional modeling studies referenced in his response.

DEPOSITION FROM KREIDER FARMS

From basic air dispersion modeling principles, it stands to reason that there is substantial opportunity for the ammonia to be deposited in the near-field. Zhang indicates that the overall lifetime for ammonia is short (less than a day) "due to its fast dry deposition rate to the surface."[1] This observation of a significant near-field dry deposition rate is further supported by studies

[1] Zhang, Y., et.al., Atmospheric Environment, No. 42 (2008), p. 3220.

described in other literature as well.[2, 3] Typical emissions sources present at Kreider Farms would be at ground-level and would not have inherent buoyancy. As such, emissions would be subject to low-level mixing and therefore subject to contact with ground-level or near-ground-level obstacles that can adsorb or absorb the ammonia.

Because the distance to the point of opportunity for deposition is likely to vary widely depending on meteorological conditions, Trinity reviewed local climatological data for the area using Middletown/Harrisburg International Airport data obtained from the National Oceanic and Atmospheric Administration (NOAA) National Data Center. The Middletown/Harrisburg International Airport is approximately 35 kilometers west northwest of the Kreider Farms in Manheim, PA. Based on 66 years of meteorological data (through 2008), the maximum average wind speed for the area is 7.7 miles per hour (mph). The highest average wind speeds tend to be in the winter and spring months (maximum average of 9.7 mph in March) when ammonia emissions are likely at their lowest; and the lowest average wind speeds tend to occur in the summer and fall months (minimum average of 5.9 mph in August) when ammonia emissions tend to be most elevated. The area's general tendency to experience winds less than 10 mph on average, combined with the tendency of the ammonia to be subject to deposition, suggests that the opportunity for deposition of the ammonia should occur in the near-field (within 30 miles) a majority of the time.

REVIEW OF REGIONAL MODELING STUDIES OF AMMONIA EMISSIONS AND SINKS

Based on current scientific knowledge and scientific literature review, ammonia emissions can have both local and regional impacts. Variations in impact will depend on the surface and atmospheric conditions that may contribute to horizontal and vertical transport of emissions along with the potential chemical transformation to particulate form as an ammonium salts. The studies presented in Mr. Lewis Linker's response to Bion's application for nitrogen credits also support the idea of regional transport of ammonia emissions based on modeling studies conducted with the Extended Regional Acid Deposition Model (RADM) and the Community Multi-scale Air Quality (CMAQ) model. While the results presented in the two Dennis presentations (2003 and 2009)[4,5] address the potential mechanisms leading to regional transport of ammonia emissions from agricultural emission sources, specifically Sampson County, North Carolina, Trinity does not believe that results from regional scale modeling are appropriately applied to determining the fate of ammonia emissions from Kreider Farms located in Lancaster County, Pennsylvania. Specifically, Trinity believes that the application of these regional scale modeling results to determine the potential deposition of ammonia emissions from Kreider Farms as outlined in Mr. Linker's review raises the following concerns:

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[2] See the proceedings of the 2003 Ammonia Workshop in Washington, D.C. (http://nadp.sws.uiuc.edu/nh4ws/). Sources provided by Bion in the referenced memoranda support this general position as well. The list of citations is not repeated here.

[3] Sources provided by Bion in the referenced memoranda support this general position as well. The list of citations is not repeated here.

[4] Dennis, R.L., et al., Air Quality Modeling of Ammonia: A Regional Modeling Perspective. Presentation (2003), Ammonia Workshop, Washington, D.C.

[5] Dennis, R.L., Importance of Ammonia in Modeling Atmospheric Transport and Deposition of Air Pollution. Presentation, (2009).

- Uncertainties in the treatment of ammonia emissions and associated sinks by the regional model (e.g., dry and wet deposition),
- Inability of model to accurately represent and treat emission "hot spots", and
- Impact on model resolution on simulated ammonia deposition.

UNCERTAINTIES IN THE TREATMENT OF AMMONIA EMISSIONS AND ASSOCIATED SINKS BY REGIONAL MODELS

As part of the information presented in the 2009 presentation referenced by Mr. Linker, Dennis examines the CMAQ model's ability to predict wet deposition of three species, including ammonium. As highlighted in the results, predictions for ammonium have the most uncertainty of the three species. The scatter plots provided in the Dennis (2009) presentation specifically tend to show an underestimate of ammonium wet deposition as compared to observed values obtained from the National Acid Deposition Program (NADP). While the presentation does not specifically outline the potential reasons for the underpredictions, the model's inability to accurately represent ammonia emissions and associated transportation and sinks are likely the causes. Dennis does imply that the current algorithms contained in CMAQ that are used for the treatment of ammonia and ammonium species do need improvement as shown in the highly uncertain model predictions. In his earlier presentation from 2003, Dennis addresses another model deficiency for ammonia predictions and states that the dry deposition parameterizations contained in another regional model, Extended RADM, also need improvements and are "erroneous and out-of-date." The inaccuracies of the dry deposition parameterizations, specifically canopy resistance, were also examined in Appendix C of Sullivan et al. (2003).[6] Sullivan et al. (2003) shows that the ammonia dry deposition flux is underestimated by Extended RADM when compared to actual observations. As shown in the Dennis presentations (2003 and 2009), Sullivan et al. (2003), and other current scientific literature, additional research and model development is necessary to improve the current model representations of ammonia emissions and their ultimate fate within regional models like Extended RADM and CMAQ. Because of the uncertainty introduced by inaccurate model representations, Trinity believes that the application of results from regional modeling studies is not the appropriate method to characterize the fate of ammonia emissions from Kreider Farms.

INABILITY OF REGIONAL MODEL TO ACCURATELY HANDLE EMISSION "HOT SPOTS"

In addition to uncertainties in model treatment deposition processes, Dennis (2003) presents information regarding uncertainties in the treatment of sub-grid "hot spots". In the case of the Extended RADM modeling study, the horizontal grid is 20x20 km. Based on this horizontal grid scale, it is likely that an emission source like Kreider Farms would be defined as a sub-grid "hot spot" because of its relatively small size and elevated ammonia emissions. The Dennis (2003) presentation identifies that grid models "dilute" the effects of these "hot spots" and information is not currently available to understand what level of bias may be introduced by misrepresenting these sources. Dennis acknowledges this treatment as a weakness in the model performance for Extended RADM. Therefore, Trinity believes that without properly addressing and correcting for

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[6] Sullivan, T.J., et al., Assessment of Air Quality and Related Values in Shenandoah National Park. Technical Report, (2003), Appendix C.

this type of model error any conclusions on the impacts of emissions from a sub-grid “hot spot”, like Kreider Farms, based on model results from this study do not take into account the weakness identified by the same study.

IMPACT OF MODEL RESOLUTION ON SIMULATED AMMONIA DEPOSITION

Similar to the concerns regarding regional models’ inability to accurately represent sub-grid “hot spots”, there are also concerns regarding the model’s capability to accurately represent processes taking place on a scale smaller than the horizontal grid. As previously mentioned, the horizontal grid resolution of the Extended RADM modeling study is 20-km (Dennis 2003). The processes contributing to ammonia deposition take place on a scale much smaller than 20-km. Therefore, these processes must be parameterized within the model, rather than explicitly simulated. As previously mentioned, Dennis and others have questioned the parameterizations currently used within regional-scale models. In addition to sensitivity of model results to model parameterizations, the ammonia deposition results will be sensitive to the model’s representation of atmospheric conditions and surface characteristics (Bajwa et al., 2008; Skiba et al., 2005).[7,8] Similar to ammonia deposition processes, regional models with large horizontal grids may not be able to accurately represent and simulate the surface characteristics and atmospheric conditions, which may directly introduce bias into the predictions ammonia deposition. Inherent uncertainties resulting from large horizontal grid spacing used in the Extended RADM modeling study presented by Dennis (2003) also raises concerns on the appropriateness of drawing conclusions from this study on the processes taking place at Kreider Farms.

In summary, the previous sections have described three specific concerns Trinity has regarding drawing conclusions about the deposition of ammonia emissions from Kreider Farms based on results from regional-scale modeling studies. These three concerns specifically addressed weakness that exist in the models used within the studies referenced by Mr. Linker in his response to the Bion application, some of which were acknowledged within the referenced presentations.

In addition to the potential misrepresentations of ammonia emissions and their fate within regional models, Trinity also questions the appropriateness to apply regional-scale modeling studies completed for North Carolina (Dennis 2003) to a single emission source in Lancaster County, Pennsylvania (i.e., Kreider Farms). As previously mentioned, the ammonia deposition processes are highly dependent upon both the surface characteristics and atmospheric conditions present at a given location and time. Dependency of ammonia deposition on specific surface and atmospheric parameters is expected to result in both temporal and spatial variability. Therefore, Trinity believes that to appropriately characterize the deposition of ammonia emissions from Kreider Farms, site-specific conditions should be used instead of applying general conclusions from regional modeling studies to the specific local emission source. Further, Trinity does not believe that the information presented in the two Dennis presentations (2003 and 2009) is conclusive enough to dispute that 60-80% of ammonia emissions from the Kreider Farms will be deposited into the Chesapeake Bay watershed, either via near-field deposition or via eventual

[7] Bajwa, K.S., et al., Journal of the Air & Waste Management Association, Vol. 58 (2008), pp. 1198-1207.
[8] Skiba, U., et al., Biogeosciences Discussions, No. 2 (2005), pp. 977-995.

deposition within the watershed following transport within the airshed identified by Dennis to influence the Bay (2003).

CONCLUSIONS

As discussed in the previous sections, based on Trinity's review of the literature and our experience with the principles of air dispersion modeling, it is our opinion that an annual average 70 to 80% near-field deposition rate is reasonable for ground-level sources of ammonia emanating from operations such as those at Kreider Farms. The actual short-term deposition percentage and distance to deposition at any point in time is likely to vary to higher or lower levels depending on the atmospheric and surface conditions (e.g., wind speed, wind direction, atmospheric stability, temperature, relative humidity, surface type, and surface roughness). However, climatological data suggests that average wind speeds for the area are less than 10 mph (relatively low wind), which supports a position that more, rather than less, of the ammonia would be deposited in the near-field. Specifically, during warm weather when ammonia emissions are higher from Kreider Farms, the atmospheric conditions are more conducive to near-field deposition.

We understand that this conclusion is not consistent with the information contained within Mr. Linker's review response of Bion's credit application. However, as previously mentioned, Trinity believes that Mr. Linker has inappropriately cited results from regional modeling studies to characterize a site-specific issue. Instead, Mr. Linker should evaluate the conditions present at Kreider Farms to determine what amount of ammonia deposition is expected. We believe that a site specific evaluation would support our previously stated opinion that an annual average 70 to 80% near-field deposition rate is reasonable for ground-level sources of ammonia emanating from operations such as those at Kreider Farms. In addition to the inappropriate application of the regional modeling study results, Mr. Linker failed to address the inherent weaknesses of the regional models (i.e., Extended RADM, CMAQ) used within the studies he referenced. Specifically, concerns regarding reduced modeling performance because of inability to accurately represent ammonia emission sources and sinks, ammonia emission "hot spots", and ammonia deposition processes using a coarse horizontal grid scale were not addressed by Mr. Linker in his response. Further, these model weaknesses were explicitly identified in the two studies cited by Mr. Linker (Dennis 2003 and 2009), but based on review of Mr. Linker's response it seems that he did not take into account these limitations of the regional modeling studies.

Based on Trinity's review of the literature and our experience with the principles of air dispersion modeling, it is our opinion that an annual average 70 to 80% near-field deposition rate is reasonable for ground-level sources of ammonia emanating from operations such as those at Kreider Farms. Therefore as discussed above, the contradicting information provided by Mr. Linker is not appropriate for characterizing the ammonia emissions and eventual deposition from Kreider Farms and does not provide conclusive evidence to dispute the estimated annual average deposition rate of 70 to 80%.

Attachments. Trinity Reviewer Resumes

WEIPING DAI, PH.D., P.E., CERTIFIED MANAGER

Principal Consultant, SMU Adjunct Assistant Professor

wdai@trinityconsultants.com; 972-661-8100 (Office)

AREAS OF SPECIALIZATION

- Air Quality Modeling (Near field, regional, photochemical, offshore)
- Mesoscale Data Modeling
- Accidental Release Assessment
- Environmental Compliance Analysis
- Environmental Impact Studies
- Air Quality Permitting
- Industrial Risk Analysis and Management
- Health Risk Assessment
- Control Technology Analysis
- PSM/RMP
- Emissions Quantification
- Litigation Support

- **Industry Focus -** Chemical, Oil & Gas, Portland Cement, Pulp & Paper, Semiconductor

EDUCATION – ENVIRONMENTAL ENG. & ECONOMIC MANAGEMENT

Ph.D., Carnegie Mellon University
M.S., University of Cincinnati
B.S., Tsinghua University

CERTIFICATIONS

Licensed Professional Engineer in Texas
Certified Manager by the Institute of Certified Professional Managers (ICPM)

Dr. Dai currently serves as a principal consultant in Trinity's Dallas Office as well as the responsible manager for Trinity's China Operation. Dr. Dai is also an adjunct assistant professor at the Southern Methodist University (SMU) and teaches the senior/graduate level environmental program courses in air quality management and engineering. Dr. Dai is a licensed professional engineer in the state of Texas and a certified manager.

Dr. Dai has 10 years of environmental consulting experience as well as comprehensive education in environmental engineering. He has authored more than 25 technical publications in various specialty areas. At Trinity, Dr. Dai is involved with projects related to air quality permitting and compliance strategies, air quality modeling (including offshore operations impact analysis), regional scale modeling including photochemical modeling, emission evaluation and strategies related to ozone nonattainment issues, control technology analysis, industrial risk management, health risk assessment, process safety management, risk management planning and hazard assessment, regulatory compliance analysis, emissions quantification, and litigation support.

In particular, Dr. Dai has extensive experience applying various air quality models such as CALPUFF, AERMOD, ISCST3, ISC-PRIME, HARP, SCREEN3, OCD, FDM, OBODM, LNGFire/Source5, DEGADIS, SLAB, INPUFF, HGSYSTEM, PHAST, and ALOHA in many projects. Dr. Dai is also a leading consultant at Trinity in performing urban/regional scale modeling analyses (e.g., photochemical modeling and MM5 mesoscale data modeling) as well as technical analysis/critical review of ozone nonattainment related issues. Dr. Dai has substantial experience in performing the CAMx ozone modeling analysis along with various pre-processing and post-processing utilities such as EPS3, SMOKE, and PAVE. Moreover, Dr. Dai has significant experience in the portland cement industry, semiconductor industry, chemical industry, and pulp and paper industry. He obtained significant experience with chemical processes (especially batch processes) through various air quality permitting and emission quantification projects.

Dr. Dai is also an active instructor providing both introductory and in-depth training courses in air quality modeling and management.

AFFILIATIONS

Air & Waste Management Association

During the course of his undergraduate and graduate studies, Dr. Dai obtained comprehensive education in air pollution engineering, water pollution engineering, and environmental management. In particular, Dr. Dai received rigorous training on air quality modeling and assessment, atmospheric chemistry and physics, air pollution meteorology, and advanced statistical and numerical analyses of environmental systems. At Carnegie Mellon University, Dr. Dai was the technical lead in a U.S. EPA-funded air quality research project that involved numerical simulations and wind tunnel studies of transport, dispersion, and deposition of fine particles and particle-surface interactions in turbulent flows. Dr. Dai proposed an improved stochastic model by incorporating particle-eddy interactions and eddy decay. Several peer-review papers and conference presentations have come forth from his study. In addition, Dr. Dai has also conducted studies on compost biofiltration of odorous and volatile organic compounds (VOC) in composting gas streams.

Dr. Dai also has extensive experience on environmental information management systems. At Tsinghua University, Dr. Dai led a three-member team to design and develop a database system for emission charges on air, wastewater, hazardous waste, and noise pollution in China. The system was sponsored by the Chinese National Environmental Protection Agency. Moreover, Dr. Dai has also been a key player to design and supervise the development of a web-based information management system for environmental compliance. This experience was gained during his tenure with WISeDOM LLC.

DIRECTLY RELATED EXPERIENCE

Health Risk Assessment (HRA). Managed and performed comprehensive HRAs (including cancer risk, zone of impacts, cancer burden and population exposure, and chronic/acute non-cancer risk) for air toxics emissions from hazardous waste combustion facilities and other industrial facilities (e.g., chemical plants) by following relevant guidance documents. Considerations in the analyses include hazard identification, multi-pathway exposure assessment, dose-response assessment, risk characterization, multi-tiered risk assessment, site-specific parameters, refinement on dioxins/furans emissions with Toxic Equivalency Factors (TEF), and refinement on emission source representation in modeling.

Near Field Dispersion Modeling Experience. Managed and conducted near field dispersion modeling (within 50 km from emission sources) projects utilizing air dispersion models such as ISCST3, ISCLT3, ISC-PRIME, AERMOD, CALPUFF, SCREEN3, VISCREEN, OBODM, and ISC-OLM in support of various permitting applications. These modeling projects have included various industries (e.g., Refinery, Oil and Gas, Portland Cement, Chemical, and Semiconductor) in several states (e.g., Texas, Oklahoma, New Mexico, Colorado, and South Dakota) and overseas. Performed dispersion modeling analyses for both criteria pollutants and air toxic pollutants (e.g., Texas Health Effects Review). Moreover, air dispersion modeling analyses have also been performed for applications other than regulatory permitting (e.g., litigation support).

Long-Range Transport Modeling Experience. Managed and conducted long-range transport modeling (greater than 50 km from emission sources) projects utilizing the CALMET/ CALPUFF modeling system to perform regional haze analyses (including BART analyses), acid deposition analyses, increment analyses, and other Air Quality Related Values (AQRV) analyses for Class I/II areas. These were conducted in support of permitting applications or environmental impact assessment for various industrial facilities including Portland cement plants, coal-fired power plants, and off-shore facilities in various states (e.g., Colorado, Oklahoma, Arizona, South Dakota, Arkansas, Nevada, Louisiana, Iowa, and Texas). Performed both screening and refined modeling analyses, and have utilized mesoscale prognostic meteorological data (MM4 and MM5). Applied advanced techniques in verifying and visualizing modeling results. In-depth experience and expertise have been developed to optimize parameter values and modeling domain setup. Moreover, significant experience has been developed in interacting and communicating with Federal Land Managers (National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service) and related state environmental agencies and interpreting various issues following rules and guidance documents such as Regional Haze Rule, FLAG Phase I Report, IWAQM Phase 2 Report, and state modeling guidance.

Photochemical Modeling and Ozone Attainment Strategies Experience. Managed and performed evaluations of emissions impact on ground-level ozone concentrations using several techniques such as regional photochemical model (e.g., CAMx), Reactive Plume Model, and Scheffe screening method. In particular, experience has been gained through conducting ozone modeling analyses and technical reviews for the Dallas/Fort Worth (DFW) non-attainment area, Las Vegas non-attainment area, and Kansas City area. Actively participated in the stakeholder DFW Photochemical Modeling Technical Committee and North Texas Clean Air Steering Committee. Provided technical support (e.g., critical review of the modeling techniques, modeling results and interpretation, and potential deficiency in the analysis) to clients by reviewing technical reports prepared by the other party. Moreover, performed suitability studies of ozone monitoring locations and alternative ozone monitoring sites. Also analyzed ozone season identification and validity of monitored ozone data.

Process Safety Management/Risk Management Planning. Managed and performed development and review of the required documentation and systems (hazard assessment, prevention program, and emergency response program) for the EPA Risk Management Program (RMP) and OSHA Process Safety Management (PSM). Provided expert technical support to facilities on RMP/PSM inspection/auditing/ development.

Accidental Release Analyses and Hazard Assessment Experience. Managed and performed accidental release analyses and hazard assessments as required by the EPA Risk Management Program (RMP) and industrial health and safety planning. Numerous projects have been performed for evaluating accidental releases of both toxic and flammable chemicals from various industries (e.g., pulp and paper, semiconductor, chemical, water/wastewater treatment plants, and oil and gas) in several states. Chemicals analyzed included toxic chemicals such as ammonia (NH_3), chlorine (Cl_2), chlorine dioxide (ClO_2), ethylene oxide (EO), hydrogen sulfide (H_2S), stannic chloride ($SnCl_4$, reactive) sulfur dioxide (SO_2), and vinyl chloride (VC), flammable chemicals such as propane (C_3H_8) and trichlorosilane (TCS), Liquefied Natural Gas (LNG) and highly reactive chemicals such as trichlorosilane (TCS) and silicon tetrachloride (STC). Applied many accidental release models including ALOHA, DEGADIS, SLAB, HGSYSTEM, FDM, INPUFF, AFTOX, LNG fire models, TNT-Equivalent Vapor Cloud Explosion Models, and Multi-Energy Model. Moreover, performed accidental release analyses for litigation support.

Offshore Operations Impact Analysis. Managed and performed environmental impact analyses (including ambient concentration levels, fire/explosion hazards, overpressure, heat radiation, and plume temperature profiles) due to emissions of criteria and toxic pollutants from offshore operations. Various dispersion models (e.g., CALPUFF, ISCST3, CALPUFF, OCD, PHAST, DEGADIS, and INPUFF) were utilized for different types of emission sources (e.g., flare/combustion and mobile vessel emissions) and events (e.g., continual emissions from normal operations or short-duration accidental releases).

Emission Quantification, Netting Analyses, and Emissions Inventories Experience. Managed and conducted emission quantification and netting analyses in support of annual emissions inventory report and permitting applications. Utilized various quantification methods (e.g., AP-42, calculations based on stack testing data, and mass balance) and software (e.g., TANKS, WATER8, GRI-HAPCalc, GRI-GlyCalc, and EDMS). Moreover, developed numerous user-friendly spreadsheets to streamline emission calculations.

NSR/PSD Permitting Experience. Managed and prepared NSR/PSD permitting applications for several industries (e.g., Oil and Gas, Portland Cement, Refinery, and Semiconductor) in several states (e.g., Texas, New Mexico, Oklahoma, Colorado, and South Dakota).

Title V Permitting Experience. Performed several Title V operating permit projects. For example, a comprehensive Title V operating permit application was performed for the Ford Tulsa Glass Plant, Oklahoma.

Minor Source NSR Permitting Experience. Managed and prepared permit applications or conducted dispersion modeling analyses in several states such as Texas, Oklahoma, New Mexico, Colorado, and South Dakota. Project tasks included permit application preparations, regulatory negotiations, emission quantification, dispersion modeling, control technology assessment, and regulatory applicability assessment.

Litigation Support on Technical Issues. Managed and performed air quality impact analyses and developed technical documents for litigation support for various cases including: particulate dispersion and exposure due to water tower sand blasting operation, emission quantification for a truck fire that involved various chemicals and materials, accidental release and dispersion of ammonia from a chemical plant, and accidental release and dispersion of molten sulfur in a roadside accident, air dispersion modeling analysis from landfill fires.

Chemical Industry. Direct experience includes air permitting, compliance strategy, control technology, emissions quantification, air quality impact analyses, health risk assessment, hazard assessment, and risk management planning. In particular, significant experience was obtained through conducting product-by-product emissions quantification and developing air quality impact analyses and permit applications for many specialty chemical plants.

Oil & Gas Industry. Direct experience includes air permitting, emissions quantification, air quality impact analyses (including off-shore and Class I area analysis), accidental release modeling (toxic, fire, and explosion) and impact assessment.

Portland Cement Industry. Direct experience includes air permitting for cement plants and terminals, due diligence studies, permitting strategy, regulatory applicability and compliance management, control technology analysis, emissions quantification, health risk assessment, PSD netting analysis, and air quality modeling analysis (including ambient standards, PSD increments, and Class I area AQRVs analyses).

Pulp and Paper Industry. Direct experience includes air permitting, emissions quantification, air quality impact analyses, risk/hazard assessment, and risk management planning.

Semiconductor Industry. Direct experience includes air permitting and strategy, regulatory applicability and compliance, air quality modeling analysis, accidental release analysis, risk/hazard assessment, and risk management planning.

PUBLICATIONS/PRESENTATIONS

R.H. Schulze, C.M. Otto, and W. Dai (2007). How Health Related Issues Are Likely to Drive Dispersion Modeling Over the Next Decade. Proceedings of the 11th International Conference on Harmonisation within Atmospheric Dispersion Modeling for Regulatory Purposes, July 2-5, 2007, Cambridge, U.K.

W. Dai, B. Wulf (2006). Utilizing CAMx Modeling Analyses to Explore 8-hour Ozone Attainment Strategies. A&WMA Specialty Conference, April 26-28, 2006, Denver, Colorado.

W. Dai, C. Otto, F. Bian (2006). Utilizing CALPUFF for Offshore and Near-shore Dispersion Modeling Analyses. A&WMA Specialty Conference, April 26-28, 2006, Denver, Colorado.

W. Dai, R. Liles, E. Prater (2006). Performing Safety Modeling Analysis to Comply with LNG Facility Siting Requirements. Proceedings of the Gas Processors Association (GPA) 85th Annual Convention, March 6-8, Grapevine, Texas.

R. H. Schulze, W. Dai, C. M. Otto (2005). Using Visibility Analyses as an Alternative Approach to Regulate Air Quality.

Proceedings of the 10th International Conference on Harmonisation within Atmospheric Dispersion Modeling for Regulatory Purposes, 17-20 October, Crete, Greece.

W. Dai, S. Sung, C. DeVore (2005). Applying Appropriate Techniques in Environmental Impact Assessment for Air Emissions from Semiconductor Facilities. SEMICON® China.

W. Dai (2005). Applying Proper Dispersion Models for Industrial Accidental Releases. Accepted by Chemical Engineering Progress (CEP), pp35-41, Nov. 2005.

W. Dai (2004). Applying Proper Dispersion Models for Industrial Accidental Releases. Proceedings of A&WMA 97th Annual Meeting, Indianapolis, Indiana.

W. Dai (2004). Managing Risks Utilizing Air Dispersion Modeling for Offshore Production Industry. Invited presentation at AWMA West Coast Section Annual Meeting, Ventura, California.

W. Dai (2004). Risk Management Plan 5-Year Review. Invited presentation at Arkansas Environmental Federation Workshop, Little Rock, Arkansas.

D. Reeves, W. Dai, S. Schneider (2004). Application of Distributed Computing Concepts to Atmospheric Dispersion Models. Proceedings of A&WMA 97th Annual Meeting, Indianapolis, Indiana.

W. Dai, C. Otto, D. Reeves (2003). Performing CALPUFF Analyses with Pseudo-station Data Derived from MM5 Data. Proceedings of A&WMA 96th Annual Meeting, San Diego, California.

R. H. Schulze, W. Dai, C. M. Otto (2003). Managing Air Quality During Regulatory Changes. Special Issue of International Journal of Environment and Pollution (IJEP).

R. H. Schulze, W. Dai, C. M. Otto (2002). Managing Air Quality During Regulatory Changes. Proceedings of the 8th International Conference on Harmonisation within Atmospheric Dispersion Modeling for Regulatory Purposes, pp. 164-168, October 14th – 17th, 2002, Sofia, Bulgaria.

W. Dai, C. I. Davidson, V. Etyemezian, and M. J. Zufall (2001). Wind Tunnel Studies of Particle Transport and Deposition in Turbulent Flows, Aerosol Science and Technology, Volume 35, pp. 887-898

W. Dai, S. S. Sung, C. V. DeVore (2000). Implication of Applying CALPUFF to Demonstrate Compliance with the Regional Haze Rule, Proceedings of A&WMA 93rd Annual Meeting, Salt Lake City, Utah.

V. Etyemezian, C.I. Davidson, M. Zufall, W. Dai, S. Finger, M. Striegel (1999). Impingement of Rain Drops on a Tall Building. Atmospheric Environment.

W Dai (1999). Numerical and Wind Tunnel Studies of Particle Transport, Deposition, and Rebound in Turbulent Flows. Ph.D. Dissertation, Carnegie Mellon University, Pittsburgh, Pennsylvania.

M. Zufall, W. Dai, C. I. Davidson, and V. Etyemezian (November 1999). Dry Deposition of Particles to Wave Surfaces: I. Mathematical Modeling. Atmospheric Environment, Volume 33, Issue 26, pp. 4273-4281.

M. Zufall, W. Dai, and C. I. Davidson (November 1999). Dry Deposition of Particles to Wave Surfaces: II. Wind Tunnel Experiments. Atmospheric Environment, Volume 33, Issue 26, pp. 4283-4290

W. Dai and C. I. Davidson (1999). Numerical and Wind Tunnel Studies of Particle Transport and Deposition in Turbulent Flows, Proceedings of A&WMA 92nd Annual Meeting, St Louis, Missouri.

W. Dai and C. I. Davidson (1998). Wind Tunnel Study of Particle Transport and Dry Deposition in Turbulent Flow. Presentation at the 17th Annual Conference of the American Association for Aerosol Research (AAAR), June 1998, Cincinnati, Ohio.

W. Dai and C. I. Davidson (1997). Particle Dry Deposition in Turbulent Boundary Layer. Presentation at the 16th Annual Conference of AAAR, October 1997, Denver.

W. Dai and C. I. Davidson (1996). Mechanisms and Modeling of Particle-Surface Interactions during Dry Deposition. Presentation at the 15th Annual Conference of AAAR, October 1996, Orlando, Florida.

W. Dai (1996). A New Approach to Modeling Particle Transport and Deposition. Presentation at the Inaugural Meeting of Spray Systems Technology Center, October 1996, Pittsburgh, Pennsylvania.

W. Dai (1994). Biodegradation of Composting Gas (Butanal) with Compost Biofilter. M.S. Thesis, the University of Cincinnati, Cincinnati, Ohio, p124.

W. Dai (1991). Design and Development of the Computer Management System for Emission Charge Regulations in China. B.S. Thesis, Tsinghua University, Beijing, China, p99.

EMPLOYMENT HISTORY

October 2001 - Present, Trinity Consultants, Dallas, TX
February 2001 - October 2001, WISeDOM LLC, Dallas, TX
1998-February 2001, Trinity Consultants, Dallas, TX
1994-1998, Teaching and Research Assistant at Carnegie Mellon University, Pittsburgh, PA
1993-1994, Part-time Lab Assistant at USEPA, Cincinnati, OH
1992-1994, Teaching and Research Assistant at the University of Cincinnati, Cincinnati, OH
1991-1992, Manager Assistant for Environmental Affairs at the Jiangmen Pesticide Plant, Guangdong, China
1990-1991, Project Development at Tsinghua University, Beijing, China

HONORS AND AWARDS

Carnegie Mellon Graduate Scholarship (1994-1998)
University Graduate Scholarship (1992-1994)
Carnegie Mellon Graduate Presentation Award (1996)
Distinguished Thesis Award (1991)

ROBERT J. LILES, R.E.M.
Principal Consultant

AREAS OF SPECIALIZATION

- Permit work in Texas, Colorado, Utah, and Wyoming
- PSD and Nonattainment New Source Review
- State-level New Source Review Permitting, Applicability Determination, and Negotiation
- Environmental Data Management Systems
- Compliance Audits
- Air Dispersion Modeling
- Accidental and Hazardous Release Modeling

EDUCATION

M.S., Atmospheric Sciences, Texas A&M University
B.S., Atmospheric Sciences Texas A&M University

AFFILIATIONS

Air & Waste Management Association (A&WMA)
Gas Processors Association
National Registry of Environmental Professionals
Society for Mining, Metallurgy and Exploration
Society of Petroleum Engineers

CERTIFICATIONS

Registered Environmental Manager (REM)

Mr. Liles has more than 15 years of experience in the environmental consulting field, including state and federal air quality permitting, environmental data management system development, ambient monitoring, air dispersion modeling, emissions inventories, control technology reviews, litigation support, and air toxics evaluations. His primary regional responsibilities are in Texas and the Rocky Mountain states, with a specific focus on Texas, Colorado, Utah, and Wyoming, where he is responsible for managing project work, teaching regulatory courses, and contributing to stakeholder processes. He presently manages consulting operations in Trinity's Dallas and Austin offices.

Since joining Trinity, Mr. Liles has provided services to numerous industries including mining, electric utilities, petroleum refining, coating/painting, upstream and downstream oil and gas, chemical, pulp and paper, steel, agriculture products, and food production. He actively contributes to and manages large permitting projects involving Prevention of Significant Deterioration (PSD), nonattainment review, and Title V operating permits. He has extensive experience with permit strategy development, agency negotiations, application review facilitation, netting and offset calculations, Best Available Control Technology (BACT) analyses, and air dispersion modeling.

In addition to regulatory services, Mr. Liles is highly involved in designing and implementing environmental data management solutions for clients, participating in project planning and scoping, design implementation and testing, and project management. He has managed and implemented stack test data, emissions inventory, and regulatory applicability and compliance tracking databases.

Mr. Liles' air dispersion modeling experience includes the use of ISC, SCREEN, CALPUFF, Caline, CAL3QHC, MOBILE, CTSCREEN, Offshore Coastal Dispersion model, INPUFF, RPM, DEGADIS, SLAB, and Shell Spills. In addition, he has performed numerous accidental release evaluations using DEGADIS and SLAB for litigation and 112(r) purposes and has co-written two technical papers on the subject.

In addition to his principal consultant responsibilities, Mr. Liles serves as an instructor for Trinity's regulatory courses, providing in-depth training on permitting procedures and strategies, PSD, nonattainment, Title V, and state regulations. Mr. Liles is also a Registered Environmental Manager (REM) with the National

Registry of Environmental Professionals. He graduated cum laude in Atmospheric Sciences from Texas A&M University, where he also earned an M.S. degree in Atmospheric Sciences.

PROJECT EXPERIENCE

PSD Permitting. Conducted PSD permitting for the oil and gas, mining, electric utility, chemical manufacturing, steel manufacturing, and pulp and paper industries. Performed numerous PSD applicability determinations, assisted with retroactive PSD issues, performed netting analyses, and conducted air dispersion modeling. Worked with sensitive historical PSD applicability issues as well as greenfield PSD projects. Also fluent in the air dispersion modeling aspects of the PSD permitting process.

Nonattainment Permitting. Conducted nonattainment permitting and offsets evaluation/acquisition in the Los Angeles and Baltimore areas.

Minor Source NSR Permitting and Modeling. Prepared permit applications and/or conducted dispersion modeling analyses in more than 25 states. Current expertise includes Colorado, Utah, Wyoming, Nevada, Nebraska, Texas, and New Mexico. Involved in successful negotiations over permit terms and provisions, regulatory applicability and interpretation, control technology determinations, hazards assessments, air dispersion modeling analyses and interpretations, and general permitting requirements.

Title V Permitting. Performed Title V permitting for oil and gas, mining, electric utility, and coatings industries. Performed periodic monitoring, applicability determinations, compliance audits, permit negotiation, and provisions drafting.

Synthetic Minor Permitting. Conducted Title V synthetic minor work for numerous industries including food production, steel manufacturing, agricultural products, and coating/painting operations. Negotiated/proposed recordkeeping and monitoring techniques to demonstrate compliance with emission limitations.

Environmental Data Management Systems. Developed and implemented a database for tracking emissions data for a nationwide agricultural corporation. Managed development of a Maximum Achievable Control Technology (MACT) applicability, emissions inventory, and regulatory tracking database for 5,000 sites for a national oil and gas firm.

Ambient Monitoring. Specified and installed meteorological and continuous PM_{10} monitoring systems used to demonstrate compliance with National Ambient Air Quality Standards (NAAQS). Provided on-going maintenance, data management, and project management services.

Control Technology Evaluation. Prepared or supervised control technology reviews for many process units including oil and gas, power boilers, pulp and paper processes, refinery operations, and chemical manufacturing sources. Conducted Lowest Achievable Emission Rate (LAER) determinations and evaluations for particulate matter and Volatile Organic Compound (VOC) sources in California and New Jersey.

Emissions Inventories. Extensive experience conducting and auditing emissions inventories for the purposes of permitting, annual reporting, and compliance audits. Quantified emissions for a large spectrum of sources including agricultural processing, painting/coating, printing, steel production, mining operations, petroleum refining, chemical production, electricity generation, food manufacturing, natural gas production, incineration, general manufacturing, flares, accidental releases, roadways, and others.

Compliance Audits. Audited air quality permits, air dispersion modeling, and plant-wide compliance with air quality regulations. Conducted permit clean-up and reconciliation.

Mobile Source Modeling. Conducted air quality modeling analyses for emissions of carbon monoxide from traffic at proposed and adjacent parking facilities and for road intersections. Involved in U.S. EPA study to determine mobile source impacts on criteria pollutant increment consumption.

Accidental Release Modeling (Hazards Evaluation). Conducted numerous air dispersion modeling studies for the assessment of public threat in the event of an accidental release. Examined and analyzed dense, neutral, and flammable gasses.

Accidental Release Modeling (Litigation). Performed dispersion modeling analyses for use by industry in litigation. The SLAB, DEGADIS, and SCREEN models have been used in defense for the petroleum refining, chemical manufacturing, petroleum transport, and other industries.

PUBLICATIONS

Liles, Robert J., "The EMS/EMIS Critical Link," Proceedings from the National Registry of Environmental Professionals Annual Technical Conference, November 2002.

Liles, R.J., "Environmental Data Management Systems for E&P Operations," Proceedings for the Society of Petroleum Engineers, Environmental Conference, February 2001.

Liles, R. J. and M. Miller, "Air Dispersion Models: Regulatory Applications and Technological Advances," Environmental Protection, September 1995, Vol. 6, No. 9.

Sung, H. M. and R. J. Liles, "A Review of the Accidental Release Analysis Procedure for the Clean Air Act Section 112(r)," Proceedings of the Petro-Safe Conference, Houston, Texas, 1995.

Liles, R. J. and H. M. Sung, "Case Study: An Air Risk Assessment for a Water Treatment Plant," Proceedings of the Water Environmental Federation, Chicago, Illinois, 1994.

EMPLOYMENT HISTORY

1990 – Present, Trinity Consultants, Inc.
1986 – 1990, Texas A&M University

ASHLEY N. QUEEN
Consultant

AREAS OF SPECIALIZATION

- State Permitting
- Title V Permitting
- Dispersion Modeling
- Photochemical Modeling
- Emissions Quantification
- Annual Emissions Inventories
- Toxics Release Inventories
- MACT and NSPS Review
- Greenhouse Gas Emissions Inventories
- Emission Reduction Credits Negotiation and Trading
- Environmental Management Systems
- ArcGIS Site Mapping Analysis

EDUCATION

M.S., Atmospheric Sciences, North Carolina State University

B.S., Meteorology, North Carolina State University

Ms. Queen serves as a Consultant in Trinity's Dallas office, where she assists clients with state and federal air quality permitting, emissions quantification, air dispersion modeling, greenhouse gas emissions inventories, compliance management, environmental management systems (EMS), and emission reduction credits acquisition. She has assisted companies in numerous industries including petroleum storage and transportation, cement plants, telecommunications, fiberglass manufacturing, oil and gas operations, food and beverage companies, and other general manufacturing operations. Ms. Queen has worked on projects in many states including Texas, California, Colorado, Hawaii, Nebraska, New Mexico, North Carolina, South Dakota, Utah, Wisconsin, and Wyoming.

Ms. Queen's air quality modeling background includes the use of the SCREEN3, ISCST3, AERMOD, CMAQ, and CAMx modeling systems.

Ms. Queen received her Master's degree in Atmospheric Science from North Carolina State University. Her thesis, entitled "Examining the Sensitivity of Wet Deposition Processes to Meteorological Inputs", explored the impacts of meteorological model settings on the predictions of both meteorological and chemical parameters by a 3-dimensional air quality model. She earned her Bachelor of Science in Meteorology with a minor in Statistics from North Carolina State University.

DIRECTLY RELATED EXPERIENCE

State Air Quality Permitting. Prepared permit, permit amendment, emissions certification, and permit waiver applications for facilities in several states, including Texas, Utah, Colorado, Wyoming, Hawaii, and New Mexico. Tasks include permit application preparation, emissions quantification, dispersion modeling analysis, and regulatory applicability review. Performed emission quantifications using published emission factors, U.S. EPA's TANKS 4.09d software package, GRI-HAPCalc software, and GRI GLYCalc software. Completed state permitting tasks for various processes and industries including, but not limited to, the cement, oil & gas, telecommunications, and other manufacturing industries.

Title V Permitting. Assisted with Title V permitting for projects in Texas and Wyoming. Prepared Title V initial, renewal, and revision permit applications. Performed regulatory applicability determinations and assisted with compliance options and notification requirements evaluation.

Compliance Evaluation. Assisted in the preparation of a current equipment listing and permit auditing for multiple permitted facilities. Compiled compliance task spreadsheet based on facility-wide permit conditions and federal and state regulatory requirements. Conducted emission calculations and state and federal regulatory reviews for existing combustion and storage tank sources located within Texas, Utah, Colorado, Wyoming, Hawaii, and New Mexico to determine notification and authorization strategies.

Dispersion Modeling. Performed air dispersion modeling and analysis for toxics and criteria pollutants using SCREEN3, ISCST3, and AERMOD as part of initial and amendment permit applications following state and federal agency air dispersion modeling guidance. Conducted air dispersion modeling for oil & gas, product manufacturing, and power generation industries.

Photochemical Modeling. Performed photochemical modeling and analysis for emission source characterization in the Dallas-Fort Worth (DFW)-area using CAMx. Utilized existing Texas Commission on Environmental Quality (TCEQ) baseline and control simulations to validate and compare with additional emission source sensitivity simulations. Evaluated modeling methodologies and results of previous CAMx and CMAQ photochemical modeling analyses to identify potential improvements

Emissions Reporting. Prepared annual emissions inventories for a variety of industrial sources in California and Texas. Performed emission calculations and prepared associated emissions reporting documents for Annual Emissions Reporting (AER), Toxics Release Inventory (TRI), and Air Toxics Inventory Report (ATIR) programs and Emission Events and Maintenance, Start-up, Shutdown (EE/MSS) activity reporting requirements.

MACT and NSPS Applicability. Reviewed and determined the applicability of numerous Maximum Available Control Technology (MACT) and New Source Performance Standards (NSPS) regulations to a variety of industries as part of applicability analyses and compliance tracking tool development.

GHG Emissions Calculation and Reporting. Conducted a review of five greenhouse gas (GHG) emissions reporting programs and created a summary document comparing and contrasting each program. Assisted with data validation as part of a global facility data collection and GHG inventory preparation project. Reviewed and updated GHG inventory information maintained in GHG EMIS system. Performed GHG emission calculations and prepared a GHG gas inventory report.

Emission Credits Negotiation and Trading. Assisted in emission reduction credits (ERCs) negotiation and acquisition. Followed-up with regulatory agencies regarding evolving ERC banking and trading regulations.

ArcGIS Mapping. Completed ArcGIS mapping analysis and prepared summary map documents for numerous states to determine collocation of existing sources and sites.

PUBLICATIONS

A. Queen, Y. Zhang, R. Gilliam, and J. Pliem, "Examining the sensitivity of MM5/CMAQ predictions to explicit microphysics schemes and horizontal grid resolution, Part I – Database description, evaluation protocol, and precipitation predictions" Atmospheric Environment, 2008.

A.Queen, Y. Zhang, "Examining the sensitivity of MM5/CMAQ predictions to explicit microphysics schemes and horizontal grid resolution, Part II – Wet deposition predictions" Atmospheric Environment, 2008.

A.Queen, Y. Zhang, "Examining the sensitivity of MM5/CMAQ predictions to explicit microphysics schemes and horizontal grid resolution, Part III – Sensitivity to horizontal grid resolution" Atmospheric Environment, 2008.

A.Queen, and Y. Zhang, "Examining the sensitivity of meteorological and chemical predictions to explicit microphysics schemes" Proceedings of the 87th AMS Annual Meeting / 9th Conference on Atmospheric Chemistry, San Antonio, Texas, 2007.

Y. Zhang, S.-Y. Wu, J.-L. Hu, S. Krishnan, K. Wang, A. Queen, V. P. Aneja, and P. Arya, "Modeling agricultural air quality: Current status, major challenges, and outlook." Atmospheric Environment, 2006.

Y. Zhang, P. Liu, A. Queen, C. Misenis, B. Pun, C. Seigneur, and S.-Y. Wu, "A comprehensive performance evaluation of MM5-CMAQ for summer 1999 Southern Oxidants Study Episode, Part II – II?. Gas and aerosol predictions." Atmospheric Environment, 2006.

A.Queen, S. Krishnan, Y. Zhang, S.-Y. Wu , J. Pleim, S. Roselle, and R. Gilliam, "MM5 precipitation physics and their impact on the wet deposition predictions of CMAQ." Proceedings of the Workshop on Agricultural Air Quality: State of the Science, Potomac, Maryland, 2006.

Y. Zhang, P. Liu, C. Misenis, and A. Queen, B. Pun, and C. Seigneur, “Performance evaluation of CMAQ for summer 1999 Southern Oxidants Study Episode.” Proceedings of the Models3 Users’ Conference, Chapel Hill, North Carolina, 2004.

EMPLOYMENT HISTORY

2007 – Present, Trinity Consultants, Inc.
2005 – 2007, North Carolina State University, Graduate Research Assistant
2004 – 2005, North Carolina State University, Teaching Assistant

WATER RESOURCES ENGINEERING INTERNATIONAL, INC.

955 Massachusetts Avenue, #349 ■ Cambridge, MA 02139-3233
Phone: (617)492-1011 ■ Fax: (617)868-8209
Email: www.wrei98@yahoo.com

James W. Morris, Ph.D.,P.E.
Chief Technology Officer
Bion Environmental Technologies, Inc.

Dear Dr. Morris;

I have contacted three experts in the field of nonpoint source monitoring and modeling of estuarine ecosystems. All three have extensive experience in nutrient loading estimation, impact analysis and control practices. Each of the three has agreed with my analysis and statement sent to you on April 18, 2009, which is attached for reference.
The three experts offering support include:

Barry M. Evans, Ph.D. - expert in non-point source modeling, including extensive Chesapeake Bay applications
William F. Ritter, Ph.D.,P.E. - expert in water quality monitoring and control systems, including extensive Chesapeake Bay applications
Robert Shannon, Ph.D. - expert in biogeochemistry and pollutant impacts on aquatic systems

Please find enclosed, supporting statements by the three experts, the resumes of three experts and the introductory letter I sent to each. I have also included the original N loading question and my response statement as well as my resume.

In summary, All four of the professional water quality experts that reviewed the "Nitrogen Loading Example" agreed that their was no expected significant difference between a "3 year average reduction with variation around the base level" and the" 3 year constant base value" as stated in the original example. In addition to the supporting expert opinions, it should be noted that other large-scale nutrient reduction programs for nutrient stressed ecosystems such as the Lake Okeechobee – Everglades (South Florida Water Management District) project utilize a 5-year running average method to achieve load reduction objectives.

Please do not hesitate to contact me if you have further questions about these opinions.

Sincerely,
Paul D. Robillard
(signed electronically 4/30/09)

Paul D. Robillard, Ph.D.
President

Benefits to the Chesapeake Bay ecosystem resulting from nitrogen load reductions averaged over a three-year period.

Background

The Pennsylvania Department of Environmental Protection's document, " Pennsylvania's Chesapeake Bay Tributary Strategy" (2005) provides the following context information on the Chesapeake Bay.

- The Bay is under stress from excessive nitrogen load.
- A total average annual nitrogen load to the Bay is approximately 285,000,000 lb N/year.
- The goal is to reduce the annual nitrogen load to about 175,000,000 lb N/year.
- Roughly 109,000,000 lb N/year is contributed by sources within Pennsylvania.
- Pennsylvania's agricultural activities are responsible for approximately 54,000,000 lb N/year to the Bay, or about 49% of the load from Pennsylvania .

Core question

A hypothetical nitrogen reduction program is being considered that will reduce nitrogen loads on a targeted three-year running average basis. Will variation around a yearly target amount result in negative impacts to the overall load reduction benefit experienced by the Bay's ecosystem over a three-year period from the same load received at a constant yearly amount equal to the three-year average, even though the load reduction in any given year will vary from the three-year period's targeted average?

Example to consider

The example hypothetical nitrogen reduction program is expected to result in <u>average</u> reductions in the nitrogen load reaching the Chesapeake Bay's ecosystem of about 200,000 lb N/year. This represents a reduction in the Bay's current total load of around 0.0007 (0.07%). Compared to the target Bay load goal of 175,000,000 lb N/year, the hypothetical nitrogen reduction program is about 0.0011 (0.11%).

For example, if the variations in this hypothetical example result in 300,000 lb N/year reduction in load to the Bay in the first year, a reduction of 100,000 lb N/year in the second year, and a third year Bay load reduction of 200,000 lb N/year, which is roughly a reduction of total Bay load of 0.07%, ± a variation of 0.035% with the three-year average remaining at the target 200,000 lb N/year.

Would there be any substantive difference to the benefit realized by the Bay between the example varying load each of the three years (300,000; 100,000; 200,000 lb N/year) for an overall average of 200,000 lb N/year compared to the benefit that would be provided if the load reduction each year was a constant equal to the average at 200,000 lb N/year?

To simplify the core question and example, "Case 1" and "Case 2" will be referenced in this document, where:

Case 1- a three year running average of mass N load reduction, where the annual load varies each year but the average over the three-year period is equal to the target load reduction. (In the example, 300,000; 100,000; and 200,000 in years 1, 2, and 3 respectively, with the yearly average equaling 200,000 lb N/year.

Case 2 –A mass N load/year equal to the target load reduction with no variation from year to year. A constant delivered nitrogen mass load reduction all three years equaling 200,000 lb N/year.

Review Statement by Paul D. Robillard, Ph.D.

After reviewing the above "Nitrogen Loading Background, Core Question and Example" information, it is my opinion that for the range of mass load reductions and the mass variation as described, the difference in delivered N load reduction benefit between a load of 200,000 lb N/year with no variation and the same running average load with a variation around that average load of 100,000 lb N/year will not result in significant difference in impact to the Chesapeake Bay ecosystem. Stated another way, the benefit to the Bay's ecosystem due to the described reductions for the two cases would be essentially the same or a total reduction of 600,000 lb N/ 3years at an average of 200,000 lb N/year. This conclusion is based on the following points:

- The N loads indicated in the hypothetical example are very small compared with the total target delivered N load to the Bay (approximately 0.11%).

- Flow rates through the Bay will typically vary greatly between events, seasons and annual values. Changes in climate and Bay dynamics control much of the year-to-year variability. Thus the Bay's ecosystem is somewhat buffered from the dynamic nature of surface inflow and nitrogen loads.

- The time lag for an ecological response from annual nutrient loads for a large water body such as the Chesapeake Bay is often measured in years and even decades.

- The existing average fixed N load in the Bay is likely much larger than the N reductions variation given in the example above based on the total monitored load estimated at approximately 285,000,000 lb N/year. (Case 1 & 2)

- Given the relatively small component of load associated with the variability in the example above (Case 1), it would be expected that the impact of this variability on Bay ecosystem processes would be very small or negligible. For example, total monitored N load could vary by 10%* or more each year (approximately 28,500,000 lb N/year). The variations described above for case 1 are approximately 100,000 lb N/year or 0.035% of the total monitored N load. Therefore, the relative impact of a 10% variation in N load compared with a 100,000 lb N/year variation in N load reduction would be 285 to 1. Thus the variation in N load reduction would have to increase by 2 or 3 orders of magnitude to even approach levels that could be interpreted as a significant impact on the Bay's ecosystem.

- Generally evaluation and predictive estimates of ecosystem impacts are based on long-term average parameter values recognizing that often, substantial variation occurs around these averages.

In summary, variations in nutrient loads are inevitable due to the dynamic nature of climate and related flow processes. The Bay's ecosystem has adapted to this dynamic environment over decades. Estimated target loads are generally based on parameters with long-term average values. In addition, when the variability of a particular average N load reduction is very small compared to the total delivered load and the variability around that average is even smaller, negligible impacts due to that small variation are likely to be observed. The most important parameter is the target delivered load reduction over a period of years, which is the same value in the 3-year running average (Case 1) and the no variation (Case 2) hypothetical examples described above. Therefore the example given realistically reflects the load reduction goals and sound methods to incorporate unavoidable variability in the implementation of those goals. I would consider the 3-year running average N load reduction calculation (Case 1) to be a sound method associated with an effective program to reduce N loading and improve ecosystem health and sustainability in the Chesapeake Bay.

*Based on my professional experience, it is not uncommon for annual monitored mass nutrient loads to vary from 10-50 % from year to year, and higher when periods of extreme climatic events (such as flooding and drought events) are included in the average annual load calculation.

Dear_____, **April 21, 2009**

I have been retained by an entity to obtain an expert opinion concerning a particular scenario for the reduction of nitrogen stress on the Chesapeake Bay . This request is for an independent, peer level, third party opinion on the specific situation detailed in the attached document. To retain independent detachment the nature of the entity will not be revealed; whether regulatory, environmental advocate, industry, agricultural, consultant, legislative or legal; other than to say they are interested from a Pennsylvania perspective.

The attached document details the question to be addressed and provides you my professional response. The situation to be considered is fairly straightforward and the statement to describe it is brief (well under three pages total including my response). Your response can be at the level of effort you feel appropriate. Thus, you may respond with a very few sentences (even one would suffice) stating your concurrence with the opinion I have offered; or you could use the attached document as a draft to which you can make edits as needed to accurately reflect your opinion, or indeed you may feel free to create your own opinion document; whichever approach serves you best.

The opinion is requested from you as an expert and not as a representative of your employer or other organization with which you may have an affiliation. Since your opinion is at the peer level, I would respectfully request that you append a vitae or resume to your response.

Since a professional opinion is being requested, please invoice

me directly (Paul Robillard, 955 Mass. Ave., #349, Cambridge, MA 02139) at your usual professional services fee rate.

Thanks for taking the time to consider this request. Please let me know whether you will be responding or not.

Sincerely,

Paul

Paul D. Robillard , Ph.D.

Supporting Statements by Experts

Robert Shannon, Ph.D.

"I looked over your scenarios and question, and see no significant difference in benefits between the Case 1 scenario (wide annual variability in N load reduction) vs Case 2 (no variability over three years). That is, I agree with your statement."

Barry M. Evans, Ph.D.

"I've read your review and agree with your conclusions."

William F. Ritter, Ph.D.,PE

"I concur with your statement regarding nitrogen loads to the Chesapeake Bay. You can get considerable variation in nitrogen loads from year to year from nonpoint sources given the fact that you can get largest extremes in hydrologic events and runoff from year to year. Nitrogen transported from Pennsylvania has a fairly long detention time in the Bay itself so you should not see a great effect from the variation in nitrogen load in one given year. Resulting effects in the Bay from nitrogen load reductions will occur gradually over many years. "

BARRY M. EVANS

EDUCATION

Pre-Engineering. Vincennes University, 1970-71.
B.S., Natural Resources. The Ohio State University, 1975.
M.E.P.C., Environmental Pollution Control. The Pennsylvania State University, 1978.
Ph.D., Soil Science. The Pennsylvania State University, 2002.

CAREER SUMMARY

2002-Present Senior Research Associate, Penn State Institutes of Energy and the Environ.

Dr. Evans is Director of the GIS Support Center, a research unit affiliated with the Penn State Institutes of Energy and the Environment (PSIEE). At PSIEE, he is primarily responsible for obtaining and managing research projects funded by a variety of governmental and institutional sponsors. One of his primary activities recently has been to manage a multi-year, multi-million dollar open-end contract to provide environmental /GIS support services to the Pennsylvania Department of Environmental Protection (PaDEP), as well as other state agencies. Of late, he has been primarily involved in developing specialized software applications to support water resource/water quality assessment needs. To date, Dr. Evans' group has developed numerous software applications (e.g., AVGWLF, MapShed, AVStreams, PRedICT, AVNPSTool and SWAP-GIS) to support ongoing activities in the areas of watershed modeling, TMDL assessment, source water protection, and evaluation of pollution mitigation strategies at the watershed level. Dr. Evans has also completed a number of water quality assessment projects for the PaDEP, National Park Service, and USEPA that have involved BMP evaluation, nutrient trading, water quality data analyses and water quality modeling. In addition to his state and national work, he has also provided technical expertise to various international groups such as the Joint Research Commission of the European Union; Mexican Institute of Water Technology; the State of Nuevo Leon, Mexico; the Swedish Meteorological and Hydrological Institute; the Environment Agency (of England and Wales), the National Water Commission of Israel; the Argentine Institute of Oceanography; and to local and provincial groups in Ontario, Canada.

1995-2002 Senior Research Assistant, Environmental Resources Research Institute, Penn State University

Primarily responsible for obtaining and managing GIS projects funded by a variety of governmental and institutional sponsors. Managed a multi-year, multi-million dollar contract to provide GIS services to the Pennsylvania DEP and other state agencies.

1988-1995 President, Geo Decisions, Inc., State College, PA

Responsible for corporate management as well as obtaining and managing GIS and environmental projects undertaken by GDI, a large, nationally-recognized firm specializing in geo-spatial technologies..

1984-1988 Research Assistant, Environmental Resources Research Institute, Penn State University

Managed and conducted a variety of environmental assessment and mapping projects conducted using GIS and remote sensing technology.

1981-1984 Manager of Environmental Mapping Section, Resource Technology Corporation, State College, PA

Managed and supervised contracted work related to environmental mapping, geomorphology, and landscape analysis.

1980-1981 Owner/Manager, Remote Sensing Consultants, State College, PA

Obtained and managed contracted work such as septic system surveys, development of a wetlands analysis manual, and various non-point pollution source inventories.

1978-1980 Consultant, Development Sciences, Inc., Sagamore, MA

Worked on engineering sanitary surveys, various EPA-sponsored projects, and environmental resource inventories.

1976-1978 Project Manager, Trident Engineering, Warrenton, VA

Worked as an on-site contractor at the U.S. EPA's Environmental Photographic Interpretation Center. Projects completed involved use of aerial photography for various environmental analyses and mapping activities such as hazardous waste inventories, septic system analyses, oil spill emergencies, and land use/cover mapping.

PROFESSIONAL MEMBERSHIPS

Soil and Water Conservation Society
American Water Resources Association
International Environmental Modeling and Software Society
International Water Association

RECENT CONSULTANCIES

Greenland International Consulting, Inc.
Skelly & Loy, Inc.
Clear Creeks Consulting, Inc.
Louis Berger International, Inc.
CH2M-Hill, Inc.
Amazon Center for Environmental Education and Research
Swedish Meteorological and Hydrological Institute
Mexican Institute of Water Technology
National Water Commission, State of Israel
Argentine Institute of Oceanography
The Cadmus Group, Inc.
Environment Agency of England and Wales

OTHER

U.S. Representative on Management Committee of the Diffuse Pollution Sub-Group of the International Water Association

PUBLICATIONS AND REPORTS

Evans, B. M., 2008. An Evaluation of Potential Nitrogen Load Reductions to Long Island Sound from the Connecticut River Basin. Report to the New England Interstate Water Pollution Control Commission, Penn State Institutes of Energy and the Environment, 66 pp.

Strobl, R.O., B.M. Evans, F. Somma, E. Garcia-Gorriz, A. Stips and J.M. Zaldivar, 2008. Feasibility Study of the Application of the LOICZ Budget to the Mediterranean Sea. Joint Research Commission, European Union, 25 pp.

Markel, D., F. Somma, and B.M. Evans, 2006. Using a GIS Transfer model (AVGWLF) to evaluate pollutant loads in the Lake Kinneret watershed, Israel. Water Science & Technology, Vol. 53, No. 10.

Evans, B.M., 2006 A Statewide Approach to Identifying, Quantifying and Mitigating Diffuse Pollution-Related Problems. In: Managing Rural Diffuse Pollution, Proceedings SAC and SEPA Biennial Conference, Edinburgh, Scotland, April 2006.

Evans, B.M., 2005. Recent Enhancements to AVGWLF and Related Software Tools to Support Pollutant Load Estimation and Evaluation of Pollution Mitigation Strategies. In: Proc. of Specialist Conference on Diffuse Pollution, Johannesburg, South Africa, p. 36.

Watts, S., B. Gharabaghi, R.P. Rudra, M. Palmer, T. Boston, B. Evans, and M. Walters, 2005. Evaluation of the GIS-Based Nutrient Management Model CANWET in Ontario. In: Proc. 58th Natl. Conf. Canadian Water Resources Assoc., June 2005, Banff, Canada.

Evans, B.M. and T. Hristov, 2004. Simulation of Stream Flow in the Yantra River Basin, Bulgaria via a GIS-Based Modeling Approach, 2004. In: Pahl-Wostl, C., Schmidt, S. and Jakeman, T. (eds) iEMSs 2004 International Congress: "Complexity and Integrated Resources Management". Intl. Environ. Modelling and Software Soc., Osnabrueck, Germany, June 2004.

Sheeder, S.A. and B.M. Evans, 2004. Development of Nutrient and Sediment Threshold Criteria for Pennsylvania TMDL Assessment. J. American Water Resources Association, Vol. 40., No. 4, pp.881-888.

Sheeder, S.A., B.M. Evans, and E. Louis. 2004. Developing Statistical Models to Establish the Relationship Between Urban Nonpoint Source Pollutant Loads and Watershed Characteristics in the Chesapeake Bay Watershed. Prepared for U.S. EPA, Chesapeake Bay Program Office, Project ID: LU-B.

Graczyk, T.K., C.J. Shiff, E. Nizeyimana, B. Evans, and J.A. Patz, 2003. Ecology of zoonotic cryptosporidiosis in watersheds containing cattle farming operations. In: "Cryptosporidium from Molecules to Disease", R.C.A. Thompson, U. Morgan, and A. Armson (eds.). Elsevier Science, Amsterdam, pp. 353-358.

Evans, B.M., S.A. Sheeder, and D.W. Lehning, 2003. A Spatial Technique for Estimating Streambank Erosion Based on Watershed Characteristics. J. Spatial Hydrology, Vol. 3, No. 2., (www.spatialhydrology.com).

Evans, B.M., 2003. A Generic Tool for Evaluating the Utility of Selected Pollution Mitigation Strategies within a Watershed. Proc. 7th International Conf. On Diffuse Pollution and Basin Management, Dublin, Ireland, Vol. 2 of 4, pp. 10.7 – 10.12.

Evans, B.M., D.W. Lehning, K.J. Corradini, G.W. Petersen, E. Nizeyimana, J.M. Hamlett, P.D. Robillard, and R.L. Day, 2002. A Comprehensive GIS-Based Modeling Approach for Predicting Nutrient Loads in Watersheds. J. Spatial Hydrology, Vol. 2, No. 2., (www.spatialhydrology.com).

Evans, B.M., D.W. Lehning, K.J. Corradini, and M.C. Anderson, 2002. Description of GIS-Based Methodology Used to Conduct Source Water Assessments for Small Community Water Systems in Pennsylvania. Environ. Resources Research Institute, Penn State University, 23 pp.

Chang, H., B.M. Evans, and D. Easterling, 2001. The Effects of Climate Change on Stream Flow and Nutrient Loadings. J. Amer. Water Resources Assoc., Vol. 37, No. 4, pp.973-986.

Hamlett, J.M., B.M. Evans, C.G. Knight, J.J. Carmichael, T.N. Hristov, D. Dimitrov, V.D. Ioncheva, I.I. Nikolov, M.P. Staneva and H. Chang, 2001. Yantra decision support system: Linking GIS with nonpoint source and in-stream models. ASAE Microfiche No. 01-2123. ASAE, St. Joseph, MI.

Ghebremichael, L.T., J.M. Hamlett, and B.M. Evans, 2001. Incorporating a pesticide component into the AVGWLF model for water quality assessments. ASAE Microfiche No. 01-2129. ASAE, St. Joseph, MI.

Evans, B.M., S.A. Sheeder, and K.J. Corradini, 2001. AVGWLF, Version 4.03: Users Guide. Environmental Resources Research Institute, Penn State University, 73 pp.

Dávila, J.I., M.A. Gómez, F.A. Córtez, B.M. Evans, R. Heidl and M.A. Mijangos, 2000. Evaluation of Diffuse Contamination in the Rio Apatlaco Basin Via Application of the ArcView-GWLF Interface. Proc. 29th Latin American Congress on Hydrology, Cordoba, Argentina.

Graczyk, T.K, B.M. Evans, C.J. Shiff, H.J. Karreman, and J.A. Patz, 2000. Environmental and Geographical Factors Contributing to Watershed Contamination with *Cryptosporidium parvum* Oocysts. Environmental Research, Section A, Vol. 82, pp. 263-271.

Arnold, J., R. Binger, D. Burrows, P.A. DeBarry, E.T. Engman, B.M. Evans, T.A. Evans, J. Garbrecht, L. Garcia, L.E. Johnson, J.D. Jorgeson, V. Krysanova, G. Leavesley, D.R. Maidment, E.J. Nelson, F.L. Ogden, F. Olivera, R.G. Quimpo, T.A. Seybert, W.T. Sloan, and F. Theurer, 2000. GIS Modules and Distributed Models of the Watershed. American Society of Engineers, Reston, VA, 120 pp.

Mustalish, R.W., C. Tucker, K. Klein and B. Evans, 1999. The Development of a GIS for Managing Natural Resources in the Peruvian Amazon. Proc. Manejo de Fauna Silvestre en la Amazona (Conf. on Wildlife Management in the Amazon), Lima, Peru.

Evans, B.M., 1998. Development of an Historic State-Wide Defoliation Database in Pennsylvania. In: Proc. 1st International Conference On Geospatial Information in Agriculture and Forestry, Lake Buena Vista, FL, pp. 309-313 (Vol. II).

Evans, B.M. and E. Nizeyimana, 1998. GIS-Based Quantification of Regional Nutrient Loads. Proc. 3rd International Conf. On Diffuse Pollution, Edinburgh, Scotland, pp. 48-55.

Evans, B.M., 1998. GIS-Based Quantification of Statewide NPS Nutrient Loads in Pennsylvania. In: Proc. Watershed Mgmt: Moving from Theory to Implementation, Denver, CO, pp. 841-848.

Petersen, G.W., E. Nizeyimana, and B.M. Evans, 1998. Applications of Geographic Information Systems in Soil Degradation Assessments. In: B.A. Stewart (ed) Methodologies for Assessing Soil Degradation, Advances in Soil Science, CRC Press, Boca Raton, FL.

Nizeyimana, E. and B.M. Evans, 1997. Evaluation of Potential GIS/Groundwater Model Linkages. Environ. Resources Research Institute, Penn State Univ., Pub. No. ER9711, 24pp.

Nizeyimana, E., B.M. Evans, M.C. Anderson, G.W. Petersen, D.R. DeWalle, W.E. Sharpe, J.M. Hamlett, and B.R. Swistock, 1997. Quantification of NPS Pollution Loads within Pennsylvania Watersheds. Environ. Resources Res. Institute, Penn. State University, Pub. No. ER9708, 61pp.

Mustalish, R.W., B.M. Evans, C. Tucker and K. Klein, 1996. Development of a Phytohabitat Index for Medicinal Plants in the Peruvian Amazon. Proc. Int. Symp. Medicinal and Aromatic Plants, Acta Hort. 426, ISHS.

Evans, B.M., M.C. Anderson, E. Nizeyimana and G.Baumer, 1996. Specification of a GIS-Based Spatial Decision Support System for Use in the Statewide Evaluation of Non-Point Source Pollution Problems: Final Report to the PA Dept. of Environmental Protection. Environmental Resources Research Institute, Pennsylvania State University, Pub. No. ER9605, 43pp.

Myers, W.L., B.M. Evans and M.C. Anderson, 1996. Spatial (In)consistency of Watershed Delineations Among Agencies and Scales in Pennsylvania. In: Proc. 2nd Intl. Symp. Spatial Accuracy Assessment in Nat. Res. and Environ. Sciences, Colo. State Univ., Fort Collins, CO.

Nizeyimana, E., G.W. Petersen, M.C. Anderson, B.M. Evans, J.M. Hamlett and G.M. Baumer, 1996. GIS/Census Data Assessment of Nitrogen Loadings from Septic Systems in Pennsylvania. Journal of Environmental Quality, Vol. 25, pp. 346-354.

Hamlett, J.M., G.W. Petersen, B.M. Evans, L.A. Deichert, S.R. Messier, M.C. Anderson, and G.M. Baumer, 1995. Statewide Screening of Groundwater Nitrate Pollution Potential from Agricultural Lands in Pennsylvania. Environ. Res. Res. Inst., Penn. State Univ., Pub. ER9502.

Evans, B.M., R.A. White, G.W. Petersen, J.M. Hamlett, G.M. Baumer and A.J.McDonnell, 1994. Land Use and Nonpoint Pollution Study of the Delaware River Basin. Environmental Resources Resources Research Institute, The Pennsylvania State University, Pub. No. ER94-06, 76 pp.

Mercado, R.M. and B.M. Evans, 1993. Regional Impact Assessment of Agricultural/Industrial Practices on Water Resources Using Integrated GIS/Remote Sensing/Computer Modeling Technology. In: Proc. Workshop on Development of Water Related Information Systems, Alexandria, VA, May 1993.

Evans, B.M., J. Grimm, L. Thornton and P. Saunders, 1992. Linking GIS with Hydrologic Modeling. In: Proc. Water Forum '92, Baltimore, MD, pp. 499-504.

Sasowsky, K.C., G.W. Petersen, and B.M. Evans, 1992. Accuracy of SPOT Digital Elevation Model Derivatives: Utility for Alaska's North Slope. Photog. Engineer. & Remote Sensing, Vol. 58, No. 6, pp. 815-824.

Evans, B.M. and W.L. Myers, 1990. A GIS-Based Approach to Evaluating Regional Groundwater Pollution Potential with DRASTIC. Journal of Soil and Water Conservation, pp. 242-245.

Walker, D.A., E. Binnian, B.M. Evans, N.D. Lederer, E. Nordstrand, and P.J. Webber, 1989. Terrain, Vegetation and Landscape Evolution of the R4D Research Site, Brooks Range Foothills, Alaska. Journal of Holarctic Ecology.

Evans, B.M., D.A. Walker, C.S. Benson, E.A. Nordstrand, G.W. Petersen. 1989. Spatial Interrelationship Between Terrain, Snow Distribution and Vegetation Patterns at an Arctic Foothills Site in Alaska. Journal of Holarctic Ecology, 12:270-278.

Evans, B.M. and D.A. Miller, 1988. Modeling Nonpoint Pollution at the Watershed Level with the Aid of a Geographic Information System. In: Proc. Symp. on Nonpoint Pollution: Policy, Economy, Management, and Appropriate Technology, American Water Resources Assoc.

Evans, B.M. and D.A. Miller, 1988. Quantifying Hydrologic Model Input with a Geographic Information System. In: Proc. Symp. on Floodplain and Stormwater Management, Penn State University Office of Continuing Education.

Evans, B.M. 1987. Assessing Regional Groundwater Pollution Potential with a Geographic Information System. In: Proc. 3rd Annual Groundwater Technology Conf., The City University of New York, NYC.

Myers, W.L., B.M. Evans and G.M. Baumer, 1987. Synergism Between Human Interpretation and Digital Pattern Recognition in Preparation of Thematic Maps. ISPRS J. Photogramm. Remote Sensing, 44: 85-96.

Evans, B.M. and L. Mata. 1984. Acquisition of 35-mm Oblique Photographs for Stereoscopic Analysis and Measurement. Photogrammetric Engineering and Remote Sensing, 50 (11).

Evans, B.M. and L. Mata. 1984. Aerial Photographic Analyses of Hazardous Waste Disposal Sites. Proceedings, National Conference on Hazardous Waste and Environmental Emergencies, Houston, TX.

Evans, B.M. 1983. Using Aerial Photography to Detect Vegetation Damage in a Large-Scale Air Quality Monitoring Program. Proceedings, Ninth Biennial Workshop on Color Aerial Photography in the Plant Science, Orlando, FL.

Evans, B.M. 1982. Aerial Photographic Analysis of Septic System Performance. Photogrammetric Engineering and Remote Sensing, 48(11).

Evans, B.M. 1979. Aerial Sanitary Surveys in Rural Lake Wastewater Planning. Proceedings, Sixth National Conference on Individual On-site Wastewater Systems, National Sanitation Foundation, Ann Arbor, MI.

PAUL DAVID ROBILLARD

Executive Director
World Water Watch
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Education

Ph.D. Agricultural Engineering, Cornell University
- Research focus: Watershed Monitoring and Conservation Systems

M.S. Resource Economics, Cornell University
- Research focus: Nonstructural Flood Control Methods

B.S. Civil Engineering, University of Notre Dame
- Concentration: Water Resources Engineering

Foreign Language: Spanish (Foreign Service Institute 3/5)

Professional Experience

EXECUTIVE DIRECTOR: World Water Watch, 2003-present
Watershed monitoring and conservation systems in support of community water supply; surface and groundwater quality protection and restoration; conservation programs

DIRECTOR: Center for AI in Water Quality Control Systems, Environmental Resources Research Institute, Penn State University, 1996-2003. Led team of researchers and graduate students in watershed water quality research and outreach programs

ASSOCIATE PROFESSOR: Penn State University, Agric. and Biological Engineering, 1993-2003
Knowledge-based systems applications for water quality control processes

FULBRIGHT SCHOLAR: Council for the International Exchange of Scholars and the J. William Fulbright Commission, 1995-1996. Research and lecturing on "Design of Water Quality Monitoring Networks" with primary applications for ecological reserves in Ecuador

VISITING PROFESSOR: Dept. of Civil and Environmental Engineering, Tufts University, 1995-1996
Integration of hydrologic models and statistical methods into expert systems software

ASSISTANT PROFESSOR: Penn State University, Agric. and Biological Engineering, 1987-1993
Watershed monitoring and control systems for surface and groundwater quality

RESEARCH ASSOCIATE: Cornell University, Agricultural Engineering, 1986-1987
Watershed monitoring and evaluation applications

RESEARCH ENGINEER: Cornell University, Agricultural Engineering, 1977-1985
Design and operation of laboratory and field experimental research methods for water quality monitoring and remediation measures

TEACHING AND RESEARCH ASSISTANT: Cornell University, 1973-1976
Conducted research related to nonstructural flood control measures

INSTRUCTOR: Wardlaw School, Plainfield, New Jersey, 1970-1971
Teacher of mathematics, Spanish and mechanical drawing at the high school level

CIVIL ENGINEER: Peace Corps/Ecuador, 1968-1970
Design and construction of potable water systems and irrigation distribution systems

ENGINEERING INTERN: Fay, Spofford and Thorndike, Boston, Massachusetts, summer 1967

Awards and Honors

2001: W. Lamar Kopp Award, Pennsylvania State University. Awarded annually to one faculty member in the 23 campus Penn State system for international contributions
1995-96: Fulbright Scholar, Council for the International Exchange of Scholars
1994: National Gunlogson Engineering Award, The Society for Engineering in Agricultural, Food, and Biological Systems for career contributions in water resources engineering
1990 and 1993: National Software Awards, The Society for Engineering in Agricultural, Food, and Biological Systems for Drinking Water Solutions (DWS) software system (93) and Computer-Aided Water Well Design Instruction Modules (90)
1993-Present: National Expert and Advisor, South Florida Water Management District
1987-93: Advisor to USDA-EPA National Rural Clean Water Program
1992-93: Technical Advisor to NOAA-EPA-USDA Coastal Zone Management Program
1990-92: Evaluation Team, National Water Quality Evaluation Project
1985: General Electric 'Faculty of the Future Award', Cornell University
1968: Federal Water Pollution Control Administration (FWPCA) Fellowships in Civil Engineering to Cornell University and Stanford University.

Academic Honor Societies and Public Service

Chi Epsilon, Civil Engineering (officer)
Alpha Epsilon, Agricultural Engineering
Gamma Sigma Delta, Agricultural Sciences (officer)
Sigma XI, Scientific Research Society

World Water Center, Board of Directors, Washington, DC
Cambridge Water Board, Cambridge, Massachusetts
Fresh Pond Advisory Board, Cambridge, Massachusetts
Institute for Environmental Science and Policy Board, University of Illinois at Chicago
Reviewer of Fulbright Applications

Lecturing, Research and Outreach for Watershed Monitoring and Conservation Systems
Summary of Accomplishments

- 200+ publications related to research and outreach contributions
- 50+ invited lectures, seminars, workshops and presentations in the U.S., Canada, Central and South America
- Worked extensively on international water resources engineering and conservation research and educational outreach applications.
- Recipient of $4 million+ in research and outreach grants
- Advised 27 graduate students (Ph.D. and M.S.)

Recent and Representative Publication

Strobl, R.O. and P.D. Robillard. 2008. Network design for water quality monitoring of surface freshwaters: a review. IN: Microbial and nutrient contaminants of fresh and coastal waters. Journal of Environmental Management (Special Edition).

Strobl, R.O., P.D. Robillard, R.D. Shannon, R.L. Day, and A.J. McDonnell. 2006. A water quality monitoring network design methodology for the selection of critical sampling points: Part I. Environmental Monitoring and Assessment 112: 137-158.

Strobl, R.O. and P.D. Robillard. 2006. Comparison of united states and german wellhead protection area delineation methods in agricultural settings. Journal of the Water Research Commission-Water SA 32(4) 507-518.

Strobl, R.O., P.D. Robillard, and P. Debels. 2006. Critical sampling points methodology: case studies of geographically diverse watersheds. Environmental Monitoring and Assessment 129 (1) 115-131.

Strobl, R.O., P D. Robillard, R.D. Shannon, R.L. Day, and A.J. McDonnell. 2006. A water quality monitoring network design methodology for the selection of critical sampling points: Part II. Environmental Monitoring and Assessment 122: 319-334.

Strobl, R.O. and P.D. Robillard. 2006. Artificial intelligence technologies in surface water quality monitoring. Water International 31(2) 198-209.

Strobl, R.O. and P.D. Robillard. 2005. Review of USEPA-recommended and German wellhead protection area delineation methods. Journal of Environmental Hydrology, Vol. 13, Paper 3.

Robillard, P.D., W.E. Sharpe, and B.R. Swistock. 2004. Reducing radon in drinking water. The Encyclopedia of Water, J.H. Lehr (ed.), John Wiley and Sons, Hoboken, NJ.

Swistock, B.R., W.E. Sharpe, and P.D. Robillard. 2004. The influence of well construction on bacterial contamination. Penn State Institutes for the Environment, Pennsylvania State University, University Park, PA.

Srivastava, P., J.M. Hamlett, P.D. Robillard, and R.L. Day. 2002. Watershed optimization of best management practices using AnnAGNPS and a genetic algorithm. Water Resources Research 38(3).

Parson, S., J.M. Hamlett, P.D. Robillard, P. Johnson, M. Urquidi-MacDonald. 2002. Development of the internet watershed education tool (InterWET). Informing Science (3) 185-193.

Robillard, P.D., M.A. Foster, R. Zhao, D.W. Lehning. 2002. STEWARD: A knowledge-based system for selection, assessment, and design of watershed water quality control systems. Center for AI in Water Quality Control Systems, Environmental Resources Research Institute, Pennsylvania State University, University Park, PA., 32 pp.

Srivastava, P., R.L. Day, P.D. Robillard, and J.M. Hamlett. 2001. AnnGIS: integration of GIS and a continuous simulation model for non-point source pollution assessment. Transactions in GIS, 2001, 5(3): 221-234.

Robillard, P.D., R.H. Galarraga, D.B. Klindienst, J.M. Madsen, O. Parra, J. Pritchard, A. Villarroel, and V. Zapata. 2000. Local to global environmental interactions: Sustaining Earth Systems: Water-The Lifeline of Biodiversity. Environmental Resources Research Institute, Pennsylvania State University, University Park, PA.

Parson, S.C., J.M. Hamlett, P.D. Robillard, M.A. Foster. 1998. Determining the decision-making risk from AGNPS simulations. Transactions of ASAE 41(6):1679-1688.

Foster, M.A. and P.D. Robillard. 1997. GIS, model, and internet-based decision support for targeting water quality control practices. IN: Proceedings of the American Water Resources Association Symposium: GIS and Water Resources. Fort Lauderdale, FL. pp.142-148.

Robillard, P.D. 1992. Extending the RCWP knowledge-base to future nonpoint source control projects. The National Rural Clean Water Symposium. Center for Environmental Research, U.S. Environmental Protection Agency, Cincinnati, OH. pp.375-384.

Robillard, P.D. and R.L. Droste. 1992. Design and maintenance of rural water supply systems for improved performance. Proceedings of the Water Resources Division, American Society of Civil Engineers, Baltimore, MD. pp.523-528.

Robillard, P.D., J. C. Clausen, E.G. Flaig, and D.M. Martin. 1992. Research needs and future vision for nonpoint source projects. The National Rural Clean Water Symposium. Center for Environmental Research, U.S. Environmental Protection Agency, Cincinnati, OH. pp. 385-392.

Robillard, P.D. and P.B. Kubek. 1992. Use of contaminant mobility and transport parameters to determine water testing protocol. Proceedings of the Water Resources Division, American Society of Civil Engineers, Baltimore, MD. pp.831-836.

Robillard, P.D., P.B. Kubek, and M.A. Foster. 1991. Nonpoint source database (NPSDB) development and design. Coastal Zone Applications. U.S. Environmental Protection Agency, Washington, DC. 58 pp.

Robillard, P.D. and R.L. Droste. 1990. Water supply systems: Applications to developing countries. American Water Resources Association, Denver, CO. November. 12 pp.

Robillard, P.D. 1990. Linking GIS to expert systems for water resources management. Proceedings of Geographic Information Systems, Simulation Models and Knowledge-based Systems for Landuse Management. Virginia Polytechnic Institute, Blacksburg, VA. pp.1-10.

Robillard, P.D. 1990. Innovative nonpoint source control practices. Microfiche No. 90-2058. American Society of Agricultural Engineers, St. Joseph, MI. 12 pp.

Robillard, P.D., R.C. Brandt, and J.M. Hamlett. 1990. Applications of GIS in water resources engineering. Microfiche No. 90-3032. American Society of Agricultural Engineers. St. Joseph, MI. 14 pp.

Robillard, P.D., W.E. Sharpe, B.R. Swistock, K.S. Martin, and C. Doscher. 1990. Incidence of lead and nitrate contamination in rural Pennsylvania water supplies. Technical Paper NABEC 90-303. Northeast Agricultural and Biological Engineering Conference. Pennsylvania State University, University Park, PA. 14 pp.

Robillard, P.D. and P.B. Kubek. 1990. Staged water contaminant testing protocols. American Water Resources Association, Denver, CO. November. 15 pp.

Robillard, P.D. and H.A. Elliott (Eds.). 1989. Water conservation and waste management in the food processing industry. Proc., Food Industry Council of Penn., Harrisburg, PA. 164 pp.

Robillard, P.D. and M.F. Walter. 1982. The technical grouping of soils to retain nutrients from livestock manure applications. International Federation of Organic Agriculture, Massachusetts Institute of Technology, Cambridge, MA. 14 pp.

Robillard, P.D., M.F. Walter, and L.M. Bruckner. 1982. Planning guide for evaluation of agricultural nonpoint source water quality controls. Environmental Research Laboratory, U.S. EPA. National Technical Information Service, Washington, DC. 733 pp.

Resume

William F. Ritter
Professor
Bioresources Engineering Department
University of Delaware
265 Townsend Hall
Newark, DE 19716-2140

Professional Experience:
University of Delaware, Newark, DE:
I have been involved in teaching, research, extension and administration, Active areas of research include Groundwater Pollution, Waste Management, Water Quality Modeling, Surface Water Contamination and Irrigation Management.
2003 – Present: Department Chair of the Bioresources Engineering Department, Professor in Bioresources Engineering Department and Civil and Environmental Engineering Department, Senior Policy Fellow in Center for Energy and Environmental Policy
1998 – 2003: Professor in Bioresources Engineering Department and Civil and Environmental Engineering
1993 – 1998: Department Chair and Professor in the Bioresources Engineering Department and Professor of Civil and Environmental Engineering
1982 – 1993: Professor in Bioresources Engineering Department
1977 – 1982: Associate Professor in Bioresources Engineering Department
1971 – 1977: Assistant Professor in Bioresources Engineering Department

Wik Associates, Inc., New Castle, DE
Environmental consulting in hazardous waste management and sediment and storm water management.
Jan. 1992 – Jun. 1992: Project Manager

Iowa State University, Ames, Iowa
1966 – 1971: Research Associate

Education
Iowa State University, Ames, IA
Ph.D.; Sanitary Engineering and Agricultural Engineering, 1971

Iowa State University, Ames, IA
M.S., Water Resources, 1968

B.S., University of Toronto, Toronto, Ontario, Canada
Civil Engineering, 1966

B.S., University of Guelph, Guelph, Ontario, Canada
Agricultural Engineering, 1965

Professional Memberships:
Diplomat, American Academy of Environmental Engineers
American Society of Civil Engineers
American Water Works Association
Canadian Society of Agricultural Engineers
Canadian Water Resources Association
American Society of Engineering Education
Water Environment Federation
Delaware Association of Professional Engineers

Professional Registration

I have been a registered P.E. in Civil Engineering since 1970. Presently registered in Delaware and Pennsylvania . I am also a diplomat of the American Academy of Environmental Engineers and certified in water and wastewater

Honors And Awards

1979 EPA Superior Achievement Award.
ASAE North Atlantic Young Engineer of the Year, 1981.
Distinguished Toastmaster Award (highest award in Toastmasters International).
1984 New Castle County Water Resources Award.
University of Delaware Fellow to Salzburg Seminar, 1987.
ASAE Gunlogson Countryside Engineering Award, 1988.
College of Agricultural Sciences, F.D. Chester Outstanding Research Award, 1990.
ASCE Irrigation and Drainage Division Outstanding Service Award, 1993.
Elected a Fellow of ASAE, 1994.
ASAE - NABEC Distinguished Lecturer, 1994-95.
ASCE Water Resources Engineering Division Service Award, 1995.
ASCE Fellow, 1997.
ASCE Outstanding News Correspondence Award, 1997.
AWWA Life Member, 1998
ASCE Delaware Section Member of the Year Award, 1999.
ASAE-NABEC Distinguished Service Award, 2003.
ASCE Royce Tipton Award, 2004

Selected External Support:

I have been principal investigator or co-principal investigator on contracts and grants with total funding of over $4,000,000.
2008-2010. U.S. Department of Agriculture National Research Initiative Program. “Characterization of PM2.5 and PM10 Particulate Emissions and the Relationship to Activity in Typical Poultry Houses”. $537,000.
2007 – 2008: Delaware Department of Natural Resources and Environmental Control. “Evaluation of Rapid Infiltration Basins For Wastewater Disposal: Phases I and II.” $210,000
2004 – 2009: New Castle County. “Monitoring and Evaluation of Land Application of Wastewater.” $125,000
2004-2007: University of Delaware Soils and Environmental Quality Institute. “Modeling BPMs in the Inland Bays Watershed”. $51,000
2004 – 2007: Wicomoco County. “Wicomoco County. Environmental Impact of long Piers on Vegetated Tidal Wetlands.” $179,220
2004 – 2005: U.S. Environmental Protection Agency. “Evaluation of Land Application of Wastewater as a Nutrient Reduction Control Strategy.” $39,132.
2003 – 2006: U.S. Environmental Protection Agency. “Hydrology and Water Quality of Freshwater Wetlands.” $198,000
2003 – 2005. Sussex Country Conservation District. “Evaluation of Vegetative Control with the Weed Wiper.” $13,500
2003 – 2004. Blue Moon Foundation. “Health, Ecological, Energy and Economic Impacts of the 4 in 1 System and Institutional Strategies for its Successful Application in Rural China.” $50,000
2002 – 2003. State of Delaware. “Odessa National NPS Monitoring.” $13,000
2002 – 2003. Sussex County Conservation District. “Evaluation of Vegetative Control with the Weed Wiper.” $5,000
2002 – 2003. DuPont Company. “Composting of Biomax Material.” $25,474

2001 – 2002. EPA Chesapeake Bay Program. "Identification of Improved Nonpoint Source Best Management Practices for Consideration in Revised Tributary Strategies". $72,500
2001 – 2002. New Castle County. "Optimization Study of M-O-T Wastewater Treatment Plant and Spray Irrigation." $14,800
2001 – 2002. CABE Associates. "Wastewater Biodegradability Studies for Nitrogen." $4,143
2000 – 2003: U. S. Department of Interior: "Environmental Policies for a Sustainable Poultry Industry in Sussex County." $48,000
2000 – 2001: U. S. Department Interior. "Nutrient Management Undergraduate Student Research Internships." $10,000

Publications:
Author of over 300 publications and papers, 64 refereed publications, 7 book chapters, 3 books and manuals, Over 170 papers presented at meetings and 84 invited presentations. Some recent publications
Williams, M.K. and **W.F. Ritter. 2007**. Evaluation of land application of wastewater as a nutrient reduction control strategy in the Chesapeake Bay watershed. In Proceedings of ASABE International Symposium on Air Quality and Waste Management for Agriculture, September 16-19, 2007, Bloomfield, CO. CD-ROM.
Ritter, W.F. and L.M.Stehr. 2007. Environmental and economic policies for a sustainable poultry industry in Sussex County, Delaware. In Proceedings of ASABE International Symposium on Air Quality and Waste Management for Agriculture, September 16-19, 2007, Bloomfield, CO. CD-ROM.
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Curriculum Vitae

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Education:

1993 Ph.D., Environmental Science, Indiana University, Bloomington, IN

1988 M.S., Environmental Science and Engineering, Virginia Polytechnic Institute & State University; Blacksburg, VA.

1979 B.S., Environmental Resource Management, secondary major in Biology, The Pennsylvania State University, University Park, PA.

Professional Experience:

2002-present **Program Coordinator, Environmental Resource Management program**, College of Agricultural Sciences, The Pennsylvania State University. Serve as faculty administrator for interdepartmental undergraduate program (~100 students) in College of Agricultural Sciences.

2001-present **Associate Professor of Agricultural Engineering**, Department of Agricultural and Biological Engineering, The Pennsylvania State University. Teaching and advising appointment in Environmental Resource Management program; member of graduate faculty in Environmental Pollution Control and Ecology programs. Currently teach the following courses: Careers and Issues in Environmental Resource Management (ERM 151), Resource Systems Analysis (ERM 412), Wetland Conservation (ERM 450), ERM Internships (ERM 495)

1995-2001 **Assistant Professor of Agricultural Engineering,** Department of Agricultural and Biological Engineering, The Pennsylvania State University.

1994-1995 **Adjunct Assistant Professor**, School of Public and Environmental Affairs, Indiana University

1988-1994 **Research Assistant and Postdoctoral Researcher and Research Assistant,** School of Public and Environmental Affairs, Indiana University

1993 **Consultant to Environmental Protection Agency,** Arctic Contaminant Research Program, Brooks Range, AK

1986-1987 **Graduate Teaching Assistant,** Department of Civil Engineering, Virginia Tech

1980-1986 **County Conservationist,** Dauphin County Conservation District, Harrisburg, PA

Recent Research Publications:

Confessor, R.B., Jr., J. M. Hamlett, R.D. Shannon, and R.E. Graves. 2008. Potential Pollutants from Farm, Food and Yard Waste Composts at Differing Ages: Physical and Chemical Properties. Part I. *Compost Science & Utilization* 16(4): 228-238.

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Awards, Honors, and Accomplishments related to Teaching and Advising:

2006 University Excellence in Academic Advising Award
2002 Community of Teaching Excellence Award, College of Agricultural Sciences
2001 Nomination for University Outstanding Advising Award
1998 Excellence in Academic Advising Award, awarded by Penn State University's College of Agricultural Sciences Alumni Association

Scientific and Professional Societies - Membership and Current Activities:

Society of Wetland Scientists (Professional Wetland Scientist Certification Review Panel, 2000-present)
Sigma Xi
American Society of Agricultural and Biological Engineers
American Society of Limnology and Oceanography
American Geophysical Union
Soil Science Society of America
American Association for the Advancement of Science

Service on 33 graduate committees (10 Ph.D., 21 Master's)