# Analysis of the Impact of Proposed Changes to New York CAFO Rules

## 6 NYCRR Parts 360 and 750

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# Executive Summary

1. <u>Conclusion</u>: **The DEC should not waive all permit requirements for medium CAFOs (Concentrated Animal Feeding Operation) in the range of 200-299 cows as proposed. Such a waiver would likely result in increased environmental degradation of water, soil, and air quality.**

- The proposed waiver of permit requirements for non-discharging Medium CAFOs with fewer than 300 mature dairy cows will drastically reduce the level of control and accountability for waste management and stormwater controls. This is likely to degrade water quality of New York State waterbodies the existing permit requirements assure that the dairy operator is responsible for managing the facility without discharge and assuring that land application areas are managed under a nutrient management plan. Particularly important is the requirement for certified planning, recordkeeping, reporting, and inspection, that would be lost under the proposed Part 750 rule change. (See Section II Part 750 Changes.)

- Substantial environmental protections will be lost if the proposed rule changes go into effect. The proposed changes to Part 750 rules eliminate the assurance that dairies are operated in a manner to assure no discharge. There will be no assurance that waste storage and stormwater detention systems are designed properly by professional engineers, nor will there be a requirement for annual reporting on the CNMP if one should exist. New York State is in the humid part of the country, with considerably more precipitation than evaporation, and frequent runoff events. To assure there is no discharge from a dairy, engineering and management are necessary. In the absence of the permit, there is no assurance that such controls are in fact in place (See Section VB). Even though most of the operations that come under the proposed rule change may be assumed to be non-discharging, it is unlikely they will never discharge.

- The Draft Environmental Impact Statement (EIS) developed by the Department of Environmental Conservation (DEC) is generally accurate with respect to identifying the likely environmental consequences of reducing the oversight of small dairies though it omits several key environmental impacts described herein. However, the assumption that these effects will be mitigated by voluntary state and federal programs is unfounded (see Section IV). Voluntary programs should be utilized to support, not replace the regulatory oversight of the CAFO permit program. Voluntary programs provide important support for the pollution control in the dairy industry as shown by the level of signup in the AEM and NRCS programs (See Section VI.), but it will not be sufficient to keep pressure on producers as evidenced by the low rate of participation in Tiers 4 and 5 of AEM. Although many problems have been addressed by such programs, the total impact is small, and few systems are addressed to the level required by the CAFO permit.

- State 305b reports, TMDL plans, and numerous other sources indicate that dairies are important contributors of phosphorus, nitrogen, pathogens, sediment, and other pollutants. Reducing regulations and oversight will not assure that water quality is being managed as intended by the Clean Water Act and New York Water Quality statutes. Water quality impacts of small dairies are well documented and include N (Nitrogen) and P (Phosphorus) in runoff causing enrichment or eutrophication of surface waters and leaching to ground water. Human health risks are substantial if small dairies are allowed to operate without regulatory oversight. There are well-known problems of bacteria, viruses, and enteric protozoa that are associated with dairy wastes. The only assurance that these problems are under control is the documentation associated with a valid CAFO permit (See Section II Part 360 Changes.)

2. **Conclusion: Nutrient Management Planning must be required for all expanding dairy operations. The abundance of fields with high and very high P soil test levels in some counties indicates that land application of manures requires careful management to avoid water quality problems which can only be assured through the CAFO regulatory program.**

- Many of the counties where dairy production is likely to expand already have excess P. Although the situation is not uniform across the counties, we can be sure that many fields are already not suitable for land application of manure or other P- rich waste materials. The need for careful planning and oversight is clearly indicated. (See Section V.C.) The prevalence of high P soils and the trend for increasing frequency of soils where no additional P is needed for crop production underlines the importance of the application of good nutrient management. (See Section **V.** Evaluation of Environmental Risks and Nutrient Mass Balance.)

- Analysis of county-level nutrient balances show that the carrying capacity of some areas has been exceeded or will likely be exceeded in the future. As a result there may be limited capacity to accept additional cows or imported nutrients (from processing plants). Expanding farms should be required to demonstrate through Nutrient Management Plans that they have an adequate land base to apply nutrient without exceeding agronomic rates (See Section V.C.1.)

- It has been shown that phosphorus builds up in soils as a result of continued use of manure for fertilizer, and that high P soils are a source of P in runoff. Phosphorus is building up in agricultural fields, and particularly those on or associated with small dairy farms. This is recognized as a nonpoint source affecting New York waterbodies. (See Section V.C.2)

- The prevalence of high P soils – and the trend for increasing frequency of soils where no additional P is needed for crop production – underlines the importance of the application of good nutrient management and the need for regulation.

**3. Conclusion: If Medium CAFOs manage their waste appropriately, there will be no substantial cost savings associated the proposed deregulation. If Medium CAFOs do not manage their waste in the manner required by the existing regulations, those costs associated with the environmental impacts will be shifted to the public and/or other regulated entities.**

- Most small dairies (under 200 cows) have very simple waste management systems. The upgrade of these systems to meet the needs of pollution control would require substantial investment. (See Section III.A.1.)

- Although the DEC argues that cost saving will be achieved by reducing the regulatory burden, it would be more accurate to say that the costs will be transferred from dairy operators and dairy processing facilities to the public. The public will pay the price in declining water quality. Where a Phosphorus (P) TMDL (Total Maximum Daily Load) exists for a watershed containing dairies, there will also be a shift of waste treatment cost from the dairy industry in general to the permit holding industries and municipalities. This will result because any increasing load from the dairy will have to be made up by the other permit holders. This could have substantial cost to the public. (See section III.C.3.)

- The Farm Credit East and Cornell Pro-Dairy study (June 2012) concluded that burden of CAFO regulations can make expansion of small dairies unprofitable and permit requirements should, therefore, be waived. This study fails to recognize that the cost of operating an effective pollution control system would cost virtually the same with or without the permit. The actual cost of paperwork and planning is very small relative to the cost of implementing the system. (See Section III.B)

4. **<u>Conclusion</u>: The treatment and land application of food processing wastes (particularly whey from dairy processors) should be governed by a permit and a CNMP, recordkeeping and reporting.**

   - The proposed Part 360 rule change could result in application of dairy processing wastes without any permit or regulatory oversight if both the Part 750 and Part 360 rules are changed as proposed. Under these rule changes off-farm wastes up to 50% by volume of on-farm waste could be added to the farm Anaerobic Digestor (AD) and/or land application system with no permit or reporting requirements. Although a Comprehensive Nutrient Management Plan (CNMP) is required, the rule change does not require reporting and inspection of the treatment and/or land application system. (See Section II.B.)

5. **<u>Conclusion</u>: Waste Management systems in the small dairies to which the proposed changes in Part 360 are aimed are not well prepared to expand without significant investment in design, training, structures and equipment. It cannot be assumed this transition will occur without regulatory oversight.**

   - Programs to promote AD as a means to reduce pollution from dairies and the dairy processing industries are well intended, but the cost, technical, and educational needs associated with this technology should not be underestimated. AD technology will not eliminate or even address the disposal of Phosphorus. All Phosphorus and most of the Nitrogen are retained in the AD process and effluent containing these nutrients must be disposed or recycled to the land. Some reduction of greenhouse gases is expected, but this, too, requires proper management and will not be successful without sufficient investment in technology, maintenance, and training. Experience has shown there are substantial financial risks associated with operation of this technology on farm. (See Section VIII.)

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# I. Introduction

## A. Authors of this Report

This report was prepared by a team from Lithochimeia, Inc. lead by Dr. Michael D. Smolen. Analysis and discussion of animal waste treatment systems, including Anaerobic Digestion, were contributed by Dr. Saqib Mukhtar, P.E. Dr. Mukhtar is Professor and Extension Agricultural Engineer at Texas A&M University. He is a graduate of Iowa State University. Dr Mukhtar has been involved in numerous state, regional, and national programs related to animal waste systems. In his Extension capacity he develops and implements educational, technology transfer, and research programs that address water quality, air quality, and manure management issues related to livestock and poultry feeding operations.

Dr. Smolen is Professor Emeritus in the Biosystems and Agricultural Engineering Department at Oklahoma State University. From 1990 to 2010, he served as Coordinator of Water Quality Programs in the Division of Agricultural Science and Natural Resources at OSU, heading up numerous education and research programs on water quality and animal waste management. He was the leader of the State's first CAFO rules implementation program in a cooperative effort with the Oklahoma Department of Agriculture, NRCS, and other environmental agencies. Before coming to OSU in 1990, he was leader of the National Water Quality Evaluation Program at North Carolina State University, where he assisted USDA and EPA in the review and implementation of the Federal Rural Clean Water Program.

## B. Purpose and Scope of this Report

Dr. Smolen, of Lithochimeia, Inc. was retained by the Waterkeeper Alliance, Inc. to evaluate the impact of two proposed rule changes in New York State. One rule change would exempt dairies of 200 to 299 mature dairy cows from seeking coverage under the SPDES discharge permit. The second rule change would allow food product wastes generated off farm to be disposed through existing on-farm waste treatment systems or farm-field application areas without regulatory oversight. The proposed rules are intended to reduce regulatory burden on dairies so they will expand and provide additional feedstock to the yogurt industry and provide a waste treatment and disposal service to this industry.

Although technologies, rules, and programs exist to address the wastes produced by the dairy industry in New York, the proposed rule changes include major revisions to the existing system create several unknowns that should be evaluated before the rule changes are approved. Lithochimeia's review of the proposal includes an evaluation of the water quality impacts of the proposed exemptions, existing pollution, compliance status and waste management issues associated with small and medium dairies, the adequacy of the EIS and alternatives considered, the effectiveness of the AEM Program, and other related issues. The project was designed to review the Rulemaking Documents, Environmental Impact Statement and associated reports, including the June 6, 2012 Cornell Pro Dairy Report.

# II. Proposed Rule Changes

## A. Part 750 Changes

Currently all dairies with 200 – 600 mature dairy cows are considered Concentrated Animal Feeding Operations (CAFOs) and all CAFOS are defined as point sources whether or not they discharge to a water of the State. This definition requires them to seek coverage under the SPDES general permit for CAFOs, with the obligation to install structural and nonstructural systems for pollution control and operate under a Comprehensive Nutrient Management Plan (CNMP) developed by a certified planner. The permit also requires the operator to provide an annual report on the CNMP and undergo inspections. Both the operator and the CNMP planner are responsible for the annual reporting. The proposed change to Part 750 would exempt “non-discharging” dairies with 200 - 299 mature dairy cows from obtaining the SPDES permit, eliminating all documentation to show that the dairy is operating to avoid a discharge.

The Department of Environmental Conservation (DEC) says “…this furthers the legislative goal of using all known available and reasonable methods to safeguard, prevent and control pollution in the waters of the state of New York…”(NY Regulatory Impact Statement). However, by not applying for the permit, a dairy is automatically relieved of the need to document the existence, design, operation, and maintenance of the pollution control systems that is required under the current rules. Further, as New York State is in a humid region, i.e. precipitation exceeds evaporation by a considerable amount, discharge is certain to occur from time to time unless there are are properly designed and operated structural and nonstructural controls in place. Consequently we do not expect the proposed rules to achieve the legislative goals.

Without the permit and its corresponding design, recordkeeping, reporting, and inspections, there is likely to be runoff and even discharge from waste storage areas, animal exercise areas, and other areas in contact with pollutants. Further, without the CNMP there is no assurance that land application areas are not being overloaded in violation of the agricultural stormwater exemption.

The DEC believes these changes will save dairy CAFOs money and promote expansion of dairy and dairy–related industries. The draft EIS identifies numerous environmental concerns related to dairies and dairy waste management but discounts them by assuming that farmers will install and maintain pollution control systems voluntarily. Unfortunately this is rarely the case. Even in the case of New York AEM program, few producers have installed all the pollution control systems needed (Tiers 4 and 5), and even fewer have maintained a complete system over several years (see Section VI).

## B. Part 360 Changes

Part 360 governs land application of solid wastes. Currently animal waste and crop residues are exempt if they originate on the farm where they are applied, but if a farm accepts nutrient laden wastes from off site, Part 360 rules apply. A farm receiving such wastes from off-site would be subject to registration and a SPDES permit, separate from the general permit under Part 750. The proposed rule changes to Part 360 would retain the requirement for registration but would eliminate the solid waste permit requirement if the receiving farm operates under a Part 750 permit and the waste contains no human fecal matter, does not exceed certain limits, and is managed according to a CNMP. The exemption covers yard wastes, compost, anaerobic digester (AD) solids, animal mortalities and slaughterhouse wastes, up to 50 tons per day or 50% by volume of the waste generated on farm on an annual basis.

In addition under the proposed rule changes, material leaching from processed or unprocessed yard waste in a compost facility is considered “not leachate,” and land application of AD solids and liquids would require registration, but no Part 360 permit.

The intent of these changes is to streamline and clarify the rules eliminating the requirement to have two separate permits for the same land application system. It is intended to encourage the investment in building and operating on-farm AD systems, as the increased organic matter would generate more biogas. The anticipated additional loading of Nitrogen-rich waste from dairy processing plants would also increase the fertilizer value of the solids generated by AD.

It is very likely the proposed changes to Part 360 will increase the quantity of waste to be handled on dairies by up to 50%. As the processing wastes are nitrogen rich, the overall fertilizer value of wastes will be enhanced, and fertilizer costs may be reduced. This could be a significant benefit to a dairy operation, if the operation has enough land and crop base to utilize the nutrients (see Section G Land Capacity). If the dairy operation is short of land and already overloaded with phosphorus, the excess nutrients may be a liability. The benefit to the dairy processing industry may be greater than the benefit to the dairies, as the processing industry's costs of waste treatment and disposal will be off-loaded to the dairies. Note as long as the dairy is willing to accept the processing waste and pay the cost of developing a CNMP, there will be no permit involved. Without this change, the waste would have come under a permit either at the processing plant or on the receiving farm.

The streamlining of permit requirements, while maintaining registration seems like a good idea, and the requirement that the operation be managed by CNMP is highly desirable. The biggest concern, however, is that eliminating both 360 and 750 permits would allow disposal of food processing waste without any permit or oversight. This could leave waste disposal with no means of assuring that farms receiving the wastes will follow their CNMP, particularly if, in total, they have more fertilizer nutrients than they can use agronomically (See Section V. Evaluation of Environmental Risks and Nutrient Mass Balance). The redefinition of material draining or leaching from compost as "not leachate," also, is questionable.

## C. Environmental Protections That Will Be Lost Under Proposed Rule Changes

The CAFO permit, which would not be required for certain Medium CAFOs under the proposed rule changes, contains important provisions to protect the environment by making mandatory good management of manures and fertilizers, and all the systems needed for collection, storage, and application of manures and fertilizers to crops. The assumption of "no discharge" inherent in the waiver is that all these systems are being managed, but without the recordkeeping and documentation of the CAFO Permit, there is no assurance that the no-discharge claim is valid. The following is a list of protections that would be lost under the proposed rule change.

- Technical evaluation of open manure storage structures by a professional engineer (one time) – dairies that expand will generally need additional waste storage capacity to maintain proper freeboard to prevent overtopping or structural failure and avoid discharge.
    - Assure design and construction meet NRCS standards
    - Assure that collection and storage are adequate for the CNMP
    - Assure the excess nutrients are protected from runoff or transferred off farm
    - Assure ground water is protected in karst areas

    - Stormwater collection and disposal
- Annual evaluation of storage adequacy by the CNMP planner
- A requirement that a CNMP is prepared and implemented – a thorough technical nutrient management plan that considers collection of manures and waste water and storage and application of all nutrients to lands in a crop production system. The objective of the CNMP is to assure proper use of manure and fertilizers and to reduce the risk of runoff and leaching to groundwater.
- A requirement that silage leachate collection and control facilities are implemented, operated and maintained in accordance with NRCS standards to prevent overflow or discharge of concentrated, low-flow leachate.
- A requirement that fields be soil tested at least once every three years, and the Phosphorus (PI) and Nitrogen (NI) indexes be calculated to manage the risk of P and/or N contamination of runoff.
- A requirement for emergency planning to respond to spills or unanticipated discharge of pollutant. This is very much needed for wet weather, when there may be no nearby location where material from storage may be pumped when overflow is imminent.
- Recordkeeping to assure proper management of waste and nutrient handling systems.

# III. Review of Environmental and Economic Impact Studies

## A. The DEC Environmental Impact Statement (EIS)

### *1. The Trade-Off between Regulatory Cost and Environmental Cost*

The DEC Draft EIS lays out a clear trade-off between the expansion of dairy industries and likely degradation of the environment. The EIS implies that cost-saving to the industry will accrue due to streamlining the regulatory processes and relaxing controls, but if the industry maintains the necessary level of pollution control the only significant cost savings would be those of the regulatory agency, which would no longer be called on to review and grant permits. Protection of the environment will not occur if the wastes identified are not managed and disposed properly. If the industry achieves a significant cost saving, it will be at a cost to the environment and other industries and municipalities that remain under permit. If the industry chooses to avoid the costs of designing and operating proper waste handling, treatment, and storage systems, and land application, the pollution of the state's waterbodies will increase. If and when the quality of these waterbodies declines to the level of violating their water quality standards, the permitted entities will be punished with further effluent restrictions as defined in the TMDL process. Clearly the total loading of pollutant must be controlled and the burden will fall upon those entities that are within the reach of the state permitting system (SPDES).

### *2. The Impact of Discharge*

As stated in the Draft EIS, the wastes in question are sources of excess nitrogen, phosphorus, bacteria, viruses and other pathogens as well as organic matter and other more conventional pollutants. Direct discharge to waterbodies will result in fish kills and public health issues. The problem of cryptosporidium in water supplies is one that New York is all too familiar with. Even though most of the operations that come under the proposed rule change may be assumed to be non-discharging, it is unlikely they will never discharge. New York State is in a humid region, i.e. there is more precipitation than evaporation, any storage tank or pond that is open to the atmosphere will eventually fill up and spill over unless there is a system in place to manage the water level. This is particularly important for existing operations with uncovered storage tanks or ponds. The current rules associated with the 750 permit require recordkeeping on the freeboard in storage tanks and reporting requirements for any discharge. Relaxation of the rules will eliminate recordkeeping and reporting, likely resulting in more frequent "accidental" discharges. Unless such discharges are observed or cause catastrophic damage, they will be unreported but will nevertheless affect nearby waterbodies.

### *3. Mitigation Measures*

The Draft EIS assumes that a range of mitigation measures will be available to dairy operators through environmental enforcement and voluntary programs like AEM and State and Federal cost-share programs. The enforcement option is only likely to be effective in the most egregious cases, where direct discharge has resulted in visible catastrophic damage. Most impacts are likely to be lower level and generally out of sight. A voluntary approach has advantages to producers who are eligible for federal cost-share money because the federal programs only pay for measures not required by regulation. Although this incentive would be appreciated by small dairies, there is not enough cost-share money in all the federal and state programs to cover all the waste storage and other needs that would be associated with dairy expansion at the level projected.

Education programs, voluntary cost-share programs, and regulatory programs all subscribe to the need for a CNMP and the AEM program. The CNMP must be developed by a certified planner, who is also a certified crop advisor. The AEM certification committee oversees the process of certifying AEM planners. Where CAFO permits are required, the CNMP is a critical part, with annual reports and annual updates required. Both the dairy operator and the CNMP planner must take ownership of the CNMP. If a voluntary approach is adopted, there would be no assurance that the CNMP would be developed and followed.

## B. The Cornell Study - Financial Implications of a Dairy Farm Expansion - 190 cows to 290 cows by Farm Credit East and Cornell Pro-Dairy (June 2012)

The Farm Credit East and Cornell Pro-Dairy study estimates a very substantial cost associated with expanding dairies to produce more milk for anticipated needs in producing yogurt. The costs are in two categories, those directly proportional to the expansion and costs associated with CAFO rule compliance. The authors seem to be unaware that it is assumed in the proposed rule change that farmers will institute the necessary pollution controls whether or not the CAFO permit is required. Thus the same expenses exist, whether or not the rule changes occur. Further, the farms that operate below the radar of the current CAFO rules (fewer than 200 dairy cows), too, are responsible for not discharging pollutants. They, too, should have waste storage facilities, nutrient management plans, and sufficient management to assure that they are not causing water quality problems. In many cases these small farms have water quality problems that have not been monitored or well documented. The State 305b report has mention of dairy-related water quality issues throughout the state. Due to their small size and large number, there would be a very large cost associated with documenting each and every problem. Were these operators to expand without addressing the existing problems and investing in full-scale pollution control, the problems would be very significant.

It is not the cost of compliance with the CAFO permitting program that limits the expansion of many small dairy farms but other market forces. Additionally, any savings gained by failure to properly manage their waste will be costs borne by the public through degradation of water, air, and soil resources.

# IV. Analysis of Environmental Impacts of Expanding Dairies under the Proposed Rule Changes

This section examines the water quality impacts currently identified in New York State that are associated with agriculture and particularly with dairy operations. It examines the known issues and the characteristics of small dairies that might affect water quality.

## A. Human Health Risks Associated with Dairy Expansion and Proposed Permit Changes

Public health risks are addressed well in the EIS. DEC indicated there is an increased likelihood that nutrients or pathogens could affect surface and ground waters in the watersheds where CAFOs are located. The issue is particularly important where waste holding facilities are not designed by competent engineers or managed to prevent overflow. In the case of earthen storage ponds, the leakage to ground water is a concern, the particularly in karst areas that are common in central New York State. The EIS acknowledges the concern for bacteria, enteric viruses, enteric protozoa (like cryptosporidia and Giardia) impacting drinking water supplies. The EIS states, "Deregulation of Medium CAFOs between 200 to 299 mature dairy cows may increase the environmental risk of contamination to public water supply wells or surface water intakes to the extent that these CAFOs do not implement management practices currently required by permit."

## B. Potential for Small and Medium Dairies to Discharge under DEC's Proposal

The proposed Part 750 rule change allows dairies from 200 to 299 mature dairy cows to operate without the SPDES permit if they claim to be non-discharging. Under the existing permit, the operation is required to have an approved engineering designed waste storage facility, water level records, and other evidence to document that the system can be operated with no discharge discharge except in a 25-year, 24-hour rainfall event. Without the permit, there is no means of assuring that there is an appropriate design and operation in place. In addition, the runoff from land disposal areas is assumed to be exempt from the federal CAFO Permit under the Agricultural Stormwater exemption only if the disposal area is being operated to assure that all nutrients are handled properly and in accordance with federal regulations. Under the SPDES permit, this would be assured by the CNMP and the records supporting that plan. Basically, the application area must be operated as cropland, not a disposal site. If these operations operate under a CNMP, they are deemed in compliance, however, if there is no CNMP and no record of operating under the CNMP, there can be no assurance that the operation is deserving of the agricultural exemption.

New York State is in the humid part of the country, with considerably more precipitation than evaporation, and frequent runoff events. If the application areas have high soil Test N and P, these materials will be moved in runoff or leached to groundwater. To avoid discharge of wastes, silos must be covered so they do not shed water and leachate. Waste storage facilities must be managed to assure they do not overtop, and liquid storage facilities must retain freeboard to accommodate a 25-year, 24 our storm. If these storage facilities are receiving liquid wastes from the milkhouse, feeding area, or exercise areas, there must be a provision maintain water levels by pumping the storage down to retain the necessary freeboard. Discharge from such facilities often contains the most damaging pollutants, with high BOD and biological contaminants as well as high concentrations of nutrients. Operation of these facilities to prevent discharge and handle emergencies requires planning and diligent operation. Absent permit conditions that require all of this, there is little factual basis for DEC’s implicit assumption that medium CAFOs with 200-299 cows will not be the source of discharges.

## C. Water Quality Impact of Dairies

The Draft EIS (NYSDEC 2012) notes that phosphorus (P), nitrogen (N), pathogens, sediment, and petroleum/chemicals are potential pollutants from CAFOs. The draft EIS goes on to identify manure storage and land application and silage storage as important sources of these agricultural pollutants. Pollutants from CAFOs potentially threaten surface waters (e.g., eutrophication from excess nutrients) and ground water (e.g., nitrate toxicity); pathogens from CAFOs can threaten human and animal health. Turbidity from sediment and toxicity from petroleum and agrichemicals can threaten aquatic life. The draft EIS also mentions air quality impacts from CAFOs, mainly odor issues.

The draft EIS omits several key environmental impacts from its discussion. First, potential impacts of fertilizers and manure applied to agricultural land are not limited to immediate erosion, runoff, and leaching issues. Research has consistently shown that accumulation of excess nutrients in soils (especially P) increases runoff losses of P even without active erosion or catastrophic loss in storm events. This is shown in Figure 1 (taken from Kleinman and Sharpley, 2001).

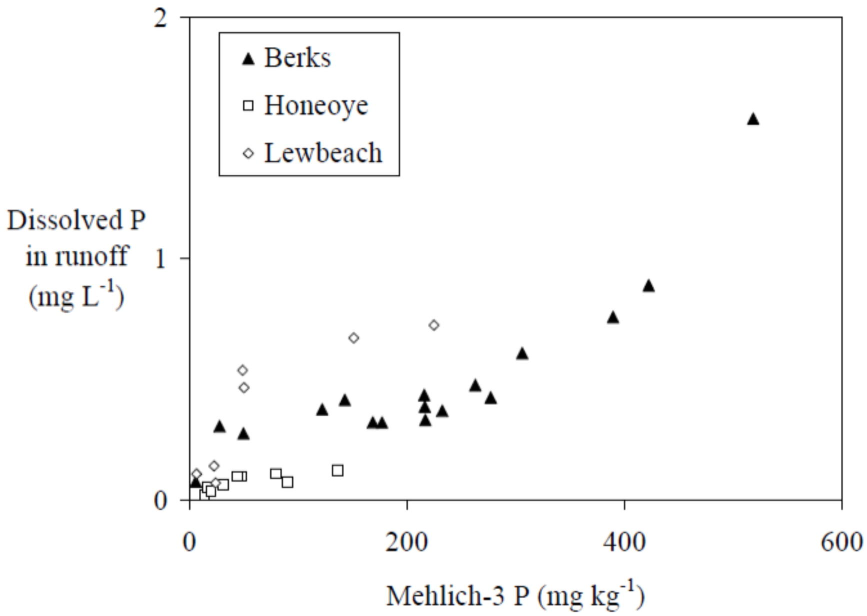


Figure 1. Relationship of soil test P to dissolved P in runoff for three New York soils (adapted from Kleinman and Sharpley, 2001).

**Figure 1 Relationship of soil test P**

Accumulation of excessive soil P can occur even when fertilizers and manure are spread at normal application rates and, as discussed below in Section G, available soil test data from New York show that soil tests showing excessive soil P levels are common in dairy regions of New York.

Secondly, air-related issues associated with CAFOs are not limited to odor. Ammonia (NH3) and Hydrogen Sulfide (H2S) are common airborne contaminants released from animal facilities. Ammonia volatilized from livestock operations can be deposited in nearby waterbodies and contribute to nutrient enrichment (Hutchnson and Viets 1969, Meisinger and Jokela 2000). Dust and pathogens are also airborne emission concerns from animal operations.

## D. Impaired Waterbodies

Numerous waterbodies in New York are impaired by pollutants from agricultural sources. The draft EIS (NYSDEC 2012) states that approximately 41% of all New York CAFOs are located in watersheds that feed impaired waterbodies. The P-impaired waterbodies from the draft EIS are shown in Table 1and Figure 1.

Under Section 303(d) of the Clean Water Act, states are required to assess their waters and document known impairments (i.e., violation of water quality standards) on a list (the so-called 303d list); waters on this list are in line for TMDLs to address their water quality impairments. Following is an extract from the most recent New York 303d list showing waterbodies impaired by agricultural nutrients. As discussed later, many of the P-impaired waterbodies are also subject to runoff from dairies, many of which have buildup of soil test P and excess manure.

The presence of a P-impaired or P TMDL waterbody in selected priority counties has been noted in Table 1. A 2012 list if nutrient impaired waterbodies in the New York Region is show in Figure 2 and Figure 3.

**Table 1 List of Phosphorus-impaired Waterbodies (Draft EIS)**

| Waterbody | **County** |
|---|---|
| **Greenwood lake** | Orange |
| **Lake Champlain** | Essex, Warren, Washington |
| **NYC Water Supply** | Delaware, Dutchess, Green, Putnam, Scholarie, Sullivan, Ulster, Westchester |
| **Onandaga Lake** | Onandaga |
| **Blind Sodus Bay, Port Bay** | Wayne |
| **Cossayuna Lake** | Washington |
| **Findley Lake** | Chautaqua |
| **Kinderhook Lake** | Columbia |
| **Lake Oscawana, Peach Lake** | Putnam |
| **Lake Salubria** | Steuben |
| **Little Sodus Bay** | Cayuga |
| **Moon Lake** | Jefferson |
| **Silver Lake** | Wyoming |
| **Snyders** | Rennselaer |
| **Summit lake** | Scholarie |

NY Impaired Waterbodies and TMDLs (NY 2012 303d list)

Allegheny River Drainage Basin

- Pa-63-13- 4-P122 * Chautauqua Lake, South (0202-0020) Chautauqua Lake A Phosphorus Agriculture 2004
- Pa-63-13- 4-P122 * Chautauqua Lake, North (0202-0072) Chautauqua Lake A Phosphorus Agriculture 2004
- Pa-63-13-P133 Lower Cassadaga Lake (0202-0003) Chautauqua Lake B Nutrients (phosphorus) Agriculture 1998
- Pa-63-13-P133-3-P134 Middle Cassadaga Lake (0202-0002) Chautauqua Lake C Nutrients (phosphorus) Agriculture 1998

Lake Ontario (Minor Tribs) Drainage Basin

- Ont (portion 20) Lake Ontario Shoreline, Western (0301-0071) Orleans G.Lakes A Pathogens Agric, Municipal, other 2012
- Ont 138 * Oak Orchard Creek (0301-0014) Genesee River C Nutrients (phosphorus) Agriculture 1998
- Ont (portion 16) Rochester Embayment - East (0302-0002) 71 Monroe G.Lakes A Phosphorus Agric, Municipal, other 2010
- Ont (portion 17) Rochester Embayment - West (0301-0068) 71 Monroe G.Lakes A Phosphorus Agric, Municipal, other 2010
- Ont (portion 18) Lake Ontario Shoreline, Western (0301-0069) 71 Monroe G.Lakes A Phosphorus Agric, Municipal, other 2010
- Ont (portion 19) Lake Ontario Shoreline, Western (0301-0070) 71 Orleans G.Lakes A Phosphorus Agric, Municipal, other 2010
- Ont (portion 20) Lake Ontario Shoreline, Western (0301-0071) 71 Orleans G.Lakes A Phosphorus Agric, Municipal, other 2010
- Ont (portion 21) Lake Ontario Shoreline, Western (0301-0072) 71 Niagara G.Lakes A Phosphorus Agric, Municipal, other 2010
- Ont (portion 22) Lake Ontario Shoreline, Western (0301-0053) 71 Niagara G.Lakes A Phosphorus Agric, Municipal, other 2010

Genesee River Drainage Basin

- Ont 117 (portion 1) * Genesee River, Lower, Main Stem (0401-0001) Monroe River B Phosphorus various, multiple sources 2004
- Ont 117 (portion 1) Genesee River, Lower, Main Stem (0401-0001) Monroe River B Pathogens various, multiple sources 2004
- Ont 117 (portion 1) Genesee River, Lower, Main Stem (0401-0001) Monroe River B Silt/Sediment various, multiple sources 2004
- Ont 117 (portion 2) * Genesee River, Middle, Main Stem (0401-0003) Monroe River B Oxygen Demand 1 Agriculture 2004
- Ont 117 (portion 2) Genesee River, Middle, Main Stem (0401-0003) Monroe River B Phosphorus Agriculture 2004
- Ont 117- 19 * Black Creek, Lower, and minor tribs (0402-0033) Monroe River C Phosphorus Agric, Municipal 2004
- Ont 117- 19 * Black Creek, Upper, and minor tribs (0402-0048) Genesee River C Phosphorus Agric, Municipal 2004
- Ont 117-19-4 Mill Creek/Blue Pond Outlet and tribs (0402-0049) Monroe River C Phosphorus Agriculture 2012
- Ont 117- 25- 7- 4-P24a LeRoy Reservoir (0402-0003) Genesee Lake A Phosphorus Agriculture 2012
- Ont 117- 40-P67 Conesus Lake (0402-0004) Livingston Lake AA Phosphorus Agriculture 2006
- Ont 117- 40-P67 Conesus Lake (0402-0004) Livingston Lake AA Oxygen Demand 1 Agriculture 2002
- Ont 117- 42 Christie Creek and tribs (0402-0060) Livingston River C Phosphorus Agriculture 2012
- Ont 117- 66- 8-2 Bradner Creek and tribs (0404-0020) Livingston River C Phosphorus Agriculture 2010
- Ont 117- 27-13 Unnamed Trib to Honeoye Cr, and tribs (0402-0081) Monroe River C Nutrients Agriculture 2010
- Ont 117- 57 Jaycox Creek and tribs (0402-0064) Livingston River C Phosphorus Agriculture 2004

Susquehanna River Drainage Basin

- SR- 44-14-27-P35a * Whitney Point Lake/Reservoir (0602-0004) Broome Lake C Phosphorus Agriculture 2002
- SR- 31 thru 37 (selected) Minor Tribs to Lower Susquehanna (0603-0044) 73 Broome River C Phosphorus Agric, Urban Runoff 2010

Black River Drainage Basin

- Ont 19- 51 Mill Creek/South Branch, and tribs (0801-0200) Lewis River C Nutrients Agriculture 2008
- Ont 19- 51 Mill Creek/South Branch, and tribs (0801-0200) Lewis River C Pathogens Agriculture 2008

Saint Lawrence River Drainage Basin

- SL-25- 7- P1 * Black Lake Outlet, Black Lake (0906-0001) St.Lawrence Lake B Nutrients (phos) Agriculture 1998

Mohawk River Drainage Basin

- H-240- 70-P570 Mariaville Lake (1201-0113) Schenectady Lake B Phosphorus Agriculture, Urb Runoff 2012
- H-240- 82-P638a Schoharie Reservoir (1202-0012) Greene Lake(R) AA(TS) Silt/Sediment Streambank Erosion 1998
- H-240- 82- 63-19-9-P589 Engleville Pond (1202-0009) Schoharie Lake A Phosphorus Agriculture 2004
- H-240-187- Steele Creek tribs (1201-0197) Herkimer River A(TS) Phosphorus Agric, Stream Erosion 2004
- H-240-187- Steele Creek tribs (1201-0197) Herkimer River A(TS) Silt/Sediment Agric, Stream Erosion 2004

Lower Hudson River Drainage Basin

H-188-P902 * Robinson Pond (1308-0003) Columbia Lake B(T) Phosphorus Agriculture 1998

H-193-29-P950a * Basic Creek Reservoir (1309-0001) Albany Lake(R) A Phosphorus Agriculture 2002

**Figure 2 List of Nutrient-impaired waterbodies in NY State.**

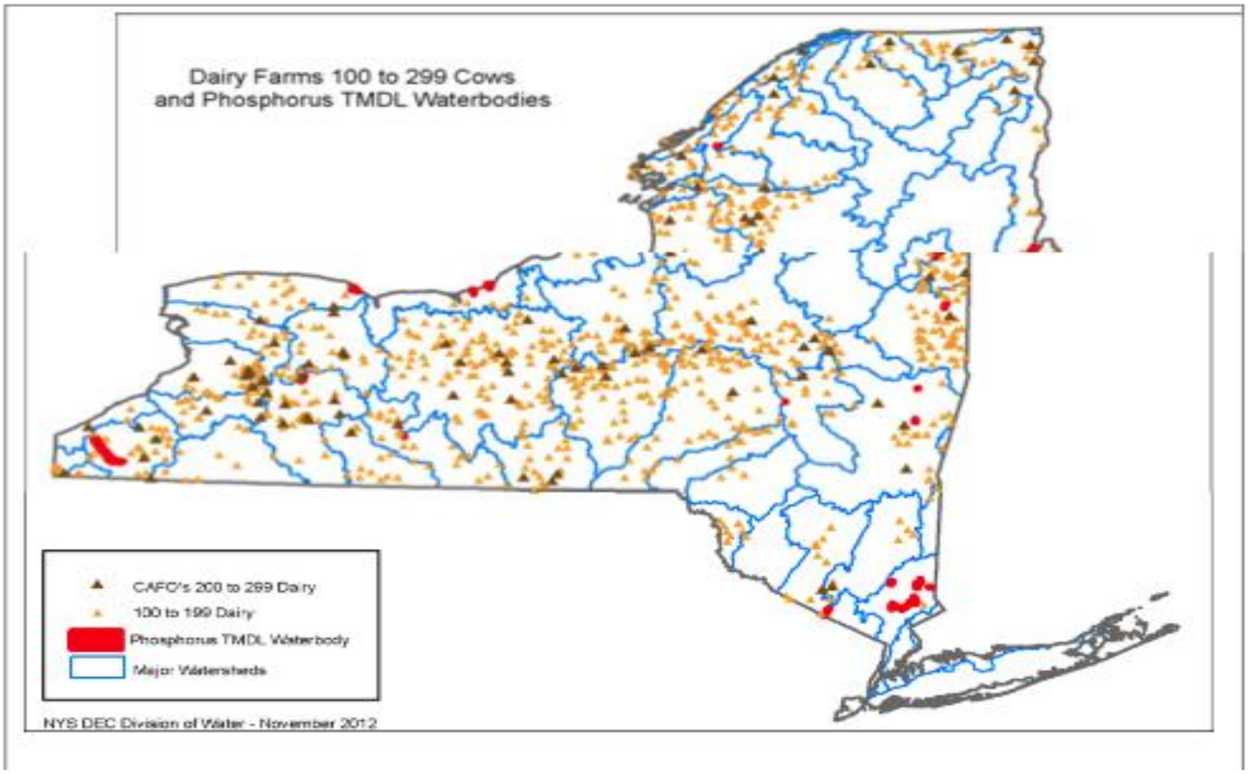


**Figure 3 Location of dairy farms with 100 to 299 cows and P-TMDL waterbodies (from EIS)**

## V. Evaluation of Environmental Risks and Nutrient Mass Balance

Nutrient Management Planning must be required for all expanding dairy operations. The abundance of fields with high and very high P soil test levels in some counties indicates that land application of manures requires careful management to avoid water quality problems which can only be assured through the CAFO regulatory program. Many of the counties where dairy production is likely to expand already have excess P. Although the situation is not uniform across the counties, we can be sure that many fields are already not suitable for land application of manure or other P-rich waste materials. The need for careful planning and oversight is clearly indicated . The prevalence of high P soils ⎵ and the trend for increasing frequency of soils where no additional P is needed for crop production underlines the importance of the application of good nutrient management.

Analysis of of county-level nutrient balances show that the carrying capacity of some areas has been exceeded or will likely be exceeded in the future. As a result there may be limited capacity to accept additional cows or imported nutrients (from processing plants). Expanding farms should be required to demonstrate through Nutrient Management Plans that they have an adequate land base to apply nutrient without exceeding agronomic rates. It has been shown that phosphorus builds up in soils as a result of continued use of manure for fertilizer, and that high P soils are a source of P in runoff. Phosphorus is building up in agricultural fields, and particularly those on or associated with small dairy farms. This is recognized as a nonpoint source affecting New York waterbodies. The 15 counties we deemed most likely to expand in the 200 to 299 category (Table 3) included the top 10 milk producing counties, and all but three of those counties already have documented impairments due to P or a P-TMDL.

### *A. Information on Small and Medium Dairies*

Basic data to characterize New York small dairies were obtained from the 2007 Census of Agriculture (USDA NASS 2013). These data are reported by county and data on individual farms cannot be obtained, nor can disparate statistics such as dairy farms and cropland acreage be directly associated. Thus, all data are aggregated on a county basis. Data on key characteristics for selected counties are summarized in Table 2 below, including number of dairy farms with 100 – 199 animal units (AU), 200 – 499 AU, and >500 AU, harvested acres, cropland receiving commercial fertilizer, and cropland receiving manure. Information from other sources was added to that from the Census, including percent of P soil tests classified as High or Very High (Kahabka et al. 2005) and the presence of dairy product manufacturing facilities in the county (NYSDEC 2012).

**Table 2 Characteristics of dairy farms in selected counties (Sources: NASS, 2013, Kahabka et al. 2005, NYSDEC 2012).**

| COUNTY | Farms 100-199 | Farms 200-499 | Farms >500 | Farms >100 | Harvested Acres | Comm fert (ac) | Cropland Fertlized (ac) | Manured (ac) | % soil test P High or Vy High | Dairy Mfg Facilities |
|---|---|---|---|---|---|---|---|---|---|---|
| Allegany | 16 | 4 | 2 | 22 | 57838 | 23997 | 22084 | 19295 | 39.9 | 2 |
| Chautauq | 23 | 11 | 7 | 41 | 106933 | 72271 | 69015 | 38254 | 29.1 | 3 |
| Chenango | 30 | 5 | 1 | 36 | 72490 | 31899 | 29412 | 28645 | 52.9 | 2 |
| Delaware | 24 | 4 | 1 | 29 | 58430 | 17434 | 15261 | 24957 | 47.1 | 3 |
| Erie | 17 | 12 | 7 | 36 | 81444 | 52317 | 51269 | 30022 | 48.6 | 5 |
| Genesee | 11 | 12 | 14 | 37 | 132333 | 110146 | 109871 | 39895 | 68 | 2 |
| Herkimer | 38 | 8 | 1 | 47 | 64172 | 25482 | 24415 | 24313 | 33.3 | 0 |
| Jefferson | 42 | 18 | 15 | 75 | 147726 | 59012 | 58128 | 58144 | 38.7 | 3 |
| Lewis | 58 | 9 | 4 | 71 | 82977 | 40424 | 39044 | 46911 | 37.6 | 2 |
| Madison | 37 | 13 | 2 | 52 | 98579 | 48745 | 47663 | 35645 | 40.4 | 2 |
| Oneida | 30 | 10 | 4 | 44 | 87040 | 49971 | 49031 | 30094 | 36.4 | 2 |
| St. Lawren | 39 | 2 | - | 41 | 92783 | 68942 | 68293 | 14242 | 34.9 | 5 |
| Steuben | 29 | 17 | 7 | 53 | 171191 | 78822 | 75904 | 41866 | 40.8 | 4 |
| Washingto | 55 | 13 | 9 | 77 | 95018 | 57343 | 55345 | 32396 | 47.6 | 0 |
| Wyoming | 38 | 34 | 27 | 99 | 142442 | 105854 | 103679 | 69782 | 56.9 | 0 |

According to the 2007 data from the Census of Agriculture, there are some 872 dairy farms with 100 – 199 cows and an additional 375 dairy farms with 200 – 499 cows. The number of 100 – 199 cow farms differs slightly from the 855 farms estimated by Cornell University cited in the draft EIS (NYSDEC 2012). The reason for this discrepancy is unknown, although the Cornell estimate may be based on more recent local information than the 2007 Census. According to the 2007, there are some 3.6 million acres of harvested cropland in the state; about 1.1 million acres of this cropland are listed as receiving manure.

Unfortunately, data are not available for associated cropland acres with dairy farms of particular size. Certainly, a substantial proportion of the harvested cropland acres are associated with other types of agricultural enterprises, although it is fair to say that most of the manured acres are probably associated with animal agriculture enterprises.

### *B. Environmental Issues in 15 Counties where Dairy Expansion is most Likely*

In conducting our analysis and discussion we elected to narrow the analysis and focus on the top 15 counties likely to be impacted by the expansion of small dairies sought by the rule changes. The problem may be most acute in these top 15 counties, but similar problems are likely in other counties where manure nutrients may get out of balance. The top 15 counties are shown in Table 3 and subsequent tables. They were selected based on the following four criteria:

- Highest number of small (100-199) dairies;
- Fewest large CAFOS;
- Highest cropland acres among top small dairy counties; and
- Presence of one or more dairy processing facilities in the county.

Application of these criteria was based on several assumptions. First, we believed that counties with many small dairies are likely to have high potential for expansion. Second, counties with many large CAFOs would be less likely to foster expansion of small dairies because of unwanted competition, an existing large milk supply, use of the land by the large CAFOs, and consumption of available labor and other agricultural infrastructure. Third, extensive cropland acres suggests a land base available to support additional feed production and manure application resulting from expanded dairies. Finally, the presence of dairy product processing facilities would tend to encourage expansion of small dairies.

Note that these presumptions are somewhat blurred because all data are on a county basis, e.g., cropland acres available on a county basis does not mean availability to individual small dairies. Also, farms and dairy processing facilities located near a county line are not restricted from interacting with the neighboring county.

The resulting top 15 counties identified were inventoried using additional criteria (see Table 3 below). Eight of the top 10 New York milk producing counties are included. All but three counties include a waterbody impaired by P from agriculture or subject to a P TMDL. Five counties are in areas of probable karst. Nine of the fifteen counties have excess N balance and eleven of fifteen have excess P balance (Kellogg et al. 2000). Twelve of the fifteen counties have two or more dairy product processing facilities within the county (NYSDEC 2012). All the counties have a significant proportion of tested soils in the High or Very High soil test P category. Two of the counties are among the top 10 New York counties with the highest percentage of fields classified as high or very high soil test P. Six counties are ranked within the top 20 counties for frequency of High or Very High soil test P (Kahabka et al. 2005). This indicates that additional manure application in many of these areas must be limited to protect water quality. Such limitation is not likely to be effective without permitting and reporting.

Unfortunately, additional information to specifically characterize small dairies is not available. Because most of the available data are aggregated to a county level and/or are considered confidential, there is no information on farm facilities (e.g., manure storage or treatment), management (e.g., fertilizer or manure application rates), or conservation practices adopted.

**Table 3 Concerns in top 15 counties with high probability of small dairy expansion**

| . County | Top 10 milk producing | P/Ag impaired or TMDL | Probable Karst | Excess N balance | Excess P balance | Dairy processing facility in | % High or Vy High soil test P** |
|---|---|---|---|---|---|---|---|
| **Allegany** | | | | + | + | ++ | 40 |
| **Chautauqua** | + | + | | | | +++ | 29 |
| **Chenango** | | | + | + | | ++ | 53 (14) |
| **Delaware** | | + | | | + | +++ | 47 (19) |
| **Erie** | | | + | + | + | +++++ | 49 (15) |
| **Genesee** | + | + | + | + | + | ++ | 68* (3) |
| **Herkimer** | | + | + | | | | 33 |
| **Jefferson** | + | + | | | + | +++ | 39 |
| **Lewis** | + | + | | | + | ++ | 38 |
| **Madison** | + | | + | + | | ++ | 40 |
| **Oneida** | | + | | | + | ++ | 36 |
| **St. Lawrence** | + | + | | + | + | +++++ | 35 |
| **Steuben** | | + | | + | + | ++++ | 41 |
| **Washington** | + | + | | + | + | | 48 (16) |
| **Wyoming** | + | + | | + | + | | 57* (9) |

* NYSDEC 2012 ** Kahabka et al. (2005) Number in parentheses is rank among NY counties for % soil tests High or Very High

## *C. Nutrient Mass Balance on New York Dairy Farms*

When more nutrients (e.g., N and P) are applied to cropland than are taken up and removed in harvested crops, the remaining nutrients remain on the field (primarily in soil). This imbalance represents not only an agronomic cost (more nutrients are applied than are used by crops) but also a potential water pollution issue. When excess nutrients accumulate over a period of years, the nutrients are available to leave the field through leaching (primarily N) or runoff (both N and P) or accumulate in soils. Whole-farm nutrient budgets by Klausner (1995) and Klausner et al. (1998) showed that 60 to 80% of the P imported onto case study dairy farms in feed and fertilizer did not leave the farm in saleable products. Research has also shown that increasing levels of soil P lead to increased P runoff and leaching losses from agricultural fields to surface and groundwater, especially in dissolved form (e.g., Kleinman et al., 2000 and 2001, McDowell and Sharpley, 2001, Sharpley et al., 2001, Sims et al., 2002, Maguire and Sims, 2002). Thus, it is instructive to examine the balance between nutrient inputs and outputs associated with dairy farms.

### ***1.*** County-Level Nutrient Balance

There have been two major efforts to assess agricultural nutrient balance on a county level that can apply to this issue in New York. Kellogg et al. (2000) conducted a national assessment of manure nutrients relative to the capacity of agricultural land to assimilate the nutrients. Commercial fertilizers were not included in the analysis. The authors used data from the 1997 Census of Agriculture to compare recoverable manure N and P (based on reported animal populations) with crop N and P removal (based on cropland acres and crops harvested from the 1997 Census of Agriculture). Results were tabulated on a county basis and are summarized in Table 4 and Table 5 below. Clearly, the analysis shows that based on 1997 data, many New York counties generated more manure nutrients than could be used by crops and a similar number of counties contained more than 25 farms that generated an excess of manure N and P over crop need on a farm scale. Although the type of farms were not identified in the analysis, many of these counties with excess manure N and P are counties with a high number of dairy farms; all the counties noted as the top milk producing counties in New York are listed in Table 4 and Table 5

**Table 4 Counties with excess N and P, assuming no export of manure from farms, 1997 (Kellogg et al. 2000).**

| **Counties with excess manure N** | | **Counties with excess manure P** | |
|---|---|---|---|
| **50,000 – 200,000 (lb/county)** | 200,000 – 500,000 (lb/county) | 50,000 – 200,000 (lb/county) | 200,000 – 500,000 (lb/county) |
| **Allegany** | Cayuga | Jefferson | Allegany |
| **Chenango** | Clinton | Orange | Cayuga |
| **Genesee** | Erie | St. Lawrence | Clinton |
| **Madison** | Onandaga | Saratoga | Erie |
| **Orange** | Steuben | Sullivan | Genesee |
| **St. Lawrence** | Sullivan | Washington | Livingston |
| **Saratoga** | Wayne | | Onandaga |
| **Seneca** | Washington | | Ontario |
| **Tompkins** | Wyoming | | Seneca |
| | | | Steuben |
| | | | Tompkins |
| | | | Wayne |
| | | | Wyoming |

A more recent analysis by the International Plant Nutrition Institute (IPNI) included both manure and inorganic fertilizer analysis. The Nutrient Use Geographic Information System (NuGIS) compares nutrient inputs to cropland in both commercial fertilizers and manure with nutrients removed in harvested crops. Results from NuGIS for New York counties are shown in Table 6. Fewer counties were shown to have a nutrient imbalance in the 2007 IPNI analysis than in the 1997 Kellogg et al. analysis. Part of the difference can be attributed to differences in methods between the two analyses. One notable difference is that whereas Kellogg et al. assumed no manure export from farms, the IPNI analysis was strictly on a county level and therefore included all cropland in the county as eligible to receive fertilizer and manure nutrients. Additionally, overall nutrient balances across the nation have improved between 1997 and 2007. A companion analysis of 1997 data by IPNI (IPNI 2012) shows more counties with nutrient imbalance than in 2007. Some of this change can probably be attributed to improved nutrient management, higher crop yields, and possibly to reductions in manure nutrient content through changes in animal feeding programs over the intervening decade.

Table 5 Number of farms with the potential for excess N and P, assuming no export of manure from farm, 1997. (Kellogg et al. 2000).

| **Farms with excess manure N** | | **Farms with excess manure P** | |
|---|---|---|---|
| **25 - 50** | 51 - 100 | 25 - 50 | 51 - 100 |
| **Chanango** | | Allegany | Chanango |
| **Wyoming** | | Cattarugus | Lewis |
| | | Cayuga | Washington |
| | | Clinton | Wyoming |
| | | Delaware | |
| | | Erie | |
| | | Franklin | |
| | | Genesee | |
| | | Herkimer | |
| | | Jefferson | |
| | | Madison | |
| | | Montgomery | |
| | | Oneida | |
| | | Orange | |
| | | Otsego | |
| | | St. Lawrence | |
| | | Seneca | |
| | | Steuben | |
| | | Yates | |

It should be noted that nutrient balances expressed on a county level can be deceptive. It is quite possible for individual farms have a nutrient imbalance while the county as a whole has an adequate land base to accept the nutrients imported into or generated into the county. Most dairy farms apply manure to their own land, whether owned or rented; transport of liquid or semi-solid manure is costly and labor-intensive. Consequently, it would be more informative to examine farm-level nutrient balances. Unfortunately, except for a few case studies (e.g., Klausner 1995 and Klausner et al. 1998) such data are not available.

## 2. Soil Test Phosphorus Levels in New York

Because P applied to agricultural land in excess of crop removal tends to accumulate in soils, soil test P can be viewed as an indicator, reflecting the long-term P balance between inputs and outputs. Furthermore, because cropland with high or very high soil test P does not require additional P for crop production and in fact represents an elevated risk for P loss to waterways especially if it does receive more P, soil test P data can also serve as a guide to the availability of land where manure or fertilizers can be beneficially applied for crop production and where additional nutrient application would not benefit crop production and could potentially impact water quality.

Unfortunately, geo-referenced soil test P data for New York are not available directly. However, Kahabka et al. (2005) published an analysis of soil fertility in New York agricultural soils that evaluated data from more than 130,000 soil samples analyzed by the Cornell Nutrient Analysis Laboratory and other approved laboratories from 1995 to 2001.   New York soil test P (Morgan extractable P) results are classified:

| | |
|---|---|
| <0.5 mg/kg | Very low |
| 0.5 – 1.4 mg/kg | Low |
| 1.5 – 4.4 mg/kg | Medium |
| 4.5 – 19.9 mg/kg | High |
| >20 mg/kg | Very High |

The critical soil test level for most field crops in New York is 4.5 mg/kg Morgan extractable P.  A yield response to fertilizer for field crops grown on soils with higher P levels (i.e. high and very high P soils) is unlikely.

Kahabka et al. (2005) reported that 44 – 47% of all samples in their 1995 – 2001 database tested above the critical agronomic soil test level of 4.5 mg/kg.  This represents an increase in the frequency of high or very high soil test P levels compared to soil samples analyzed in the 1970s and 1980s (~26 – 38% of samples testing high or very high) also cited in the report.  The authors noted that trends in high and very high soil test P sites varied regionally, but generally corresponded with areas of high intensity of dairy and vegetable agriculture. The ten counties with the highest percentage of fields classified as high or very high were Suffolk (87%), Orange in the southeastern region (79%). Ontario (77%). Genesee (68%). Monroe (64%), and Livingston (63%) in the western region, Tompkins (60%) in the southern region. Sullivan (59%) in the southeastern region, Oswego (57%) in the Central region, and Wyoming (57%) in the western region.  Soil test P distribution among the top 10 milk producing New York counties is shown in Table 6.

**Table 6 Soil test P distribution among the top ten milk-producing NY counties. (Kahabka et al. 2005).**

| County | # of samples | Very Low and Low | Medium | High | Very High | High and Very High |
|---|---|---|---|---|---|---|
| | | | | | | % of total |
| **Genesee** | 2,572 | 11.9 | 20.1 | 53.0 | 15.0 | 68.0 |
| **Livingston** | 3,038 | 15.7 | 20.9 | 46.9 | 16.5 | 63.4 |
| **Wyoming** | 10,170 | 20.2 | 22.9 | 47.0 | 9.9 | 56.9 |
| **Cayuga** | 4,030 | 18.4 | 26.5 | 44.8 | 10.3 | 55.1 |
| **Washington** | 1,977 | 26.8 | 25.6 | 35.2 | 12.4 | 47.6 |
| **Madison** | 2,444 | 34.7 | 24.9 | 32.0 | 8.4 | 40.4 |
| **Jefferson** | 2,526 | 32.1 | 29.2 | 33.5 | 5.2 | 38.7 |
| **Lewis** | 2,070 | 33.4 | 29.0 | 33.3 | 4.3 | 37.6 |
| **St. Lawrence** | 4,323 | 39.5 | 25.6 | 30.7 | 4.2 | 34.9 |
| **Chautauqua** | 5,726 | 43.1 | 27.8 | 27.8 | 1.3 | 29.1 |

The report also evaluated data from whole-farm nutrient management plans from 30 New York dairy farms (129 to 995 arable ha) located in 14 different counties. The average field size per farm ranged from 1.9 to 10.8 ha with an overall mean of 5.5 ha. Animal densities varied from 0.29 to 1.26 animals/ha. Corn and alfalfa and/or hay rotations were the most typical land use. The authors reported that there was considerable variability among the 30 farms, but on average, 47% of all fields on a farm tested high or very high in P.

The authors concluded that farming practices in the past 40 years in New York have led to an increase in the percentage of soils that test higher in P than the critical agronomic soil test level from 26% in 1957 - 58 to 47% in 1995 - 2001. The greatest increases took place in the dairy-dominated northern and northeastern regions while the highest soil test levels occurred in vegetable production regions on Long-Island and the highly productive dairy, vegetable and fruit areas in Western New York. As these soils reach progressively higher P levels they may require more attentive management to ensure that environmental thresholds are not exceeded.

### 3. Land Capacity

The capacity of land to accept nutrients added in manure and fertilizers without environmental consequences is limited. As noted above, nutrients – especially P – applied to agricultural land in excess of crop needs, tend to build up in soils, increasing the potential for nutrient losses to nearby waterbodies. Available nutrient mass balance data show that several New York counties are accumulating more N and P than they export in agricultural products. Soil test P data show that soil P levels in excess of crop need are already common in the state, especially in heavily dairy counties.

A simple analysis was conducted to roughly assess the current status of nutrients in dairy manure relative to land capacity and to estimate any additional capacity to accept expansion of dairy herds. Capacity was defined as ability to apply manure P up to a threshold agronomic rate on available agricultural land in the county. This analysis was applied to the 15 priority counties identified earlier and was conducted as follows. The quantity of recovered manure P (as $P_2O_5$) for each county was taken from the NuGIS analysis (IPNI 2012) (see Section 3). Recoverable manure represents ~80% of excreted manure to account for manure deposited on pasture and other losses that reduce the quantity of manure for land application (Kellogg et al., 2000). This manure P was allocated first to all harvested acres in the county (from the 2007 Census of Agriculture), then to only the acres identified in the Census as receiving manure, and expressed as lb $P_2O_5$/ac. Finally, the number of additional cows that could be added to the county recovered manure P before reaching an agronomic threshold was calculated based on representative yields. This represents a crude estimate of the number of cows a county could accept before exceeding an agronomic threshold.

This calculation made several assumptions based on standard dairy parameters:

- A mature dairy cow is equivalent to 1.4 AU
- A mature dairy cow excretes 15.24 tons of manure/year/AU
- Dairy manure contains 1.92 lb P/ton ($P_2O_5$ = P * 2.295)
- Crop removal of P was assumed to be 3.1 lb $P_2O_5$/ton for silage corn and 12 lb $P_2O_5$/ton for hay
- Representative NY yields for silage are 2 t/ac silage corn and 15 t/ac hay
- Representative crop removal was estimated to be 46.5 lb $P_2O_5$ /ac for corn and 24 lb $P_2O_5$/ac for hay

Results of this analysis are summarized in Table 7. If all cropland acres are eligible to receive manure, estimated current manure application rates range from 2.5 – 8.7 t/ac. Allocating manure only to acres currently listed as receiving manure results in estimated current manure application rates of about 10 – 57 t/ac. These numbers are likely to be on the high side as the quantity of manure available to spread is the amount of manure excreted and does not account for loss of a non-recoverable fraction. Most importantly in Table 7, the estimated P2O5 application rates when available P is applied only to currently manured acres ranged from ~20 – 185 lb P2O5/ac. For several counties, these rates already exceed crop removal requirements for hay and in a few counties exceed the crop removal rate for silage corn. It is very important to note that these P application rates completely ignore P already available in the soil and any P added in commercial fertilizers or other organic sources.

**Table 7 Estimated manure P application rates and additional capacity for dairy waste for selected NY counties. Source data are from the 2007 US Census of Agriculture and the NuGIS nutrient balance analysis (IPNI 2012).**

| COUNTY | Milk Cows | Manure produced (t/yr) | Recovered Manure P2O5 (tons) | Harvested Acres | Manured (ac) | Manure Applicatin Rate all harvested acres (t/ac) | P2O5 Applicatin rate all harvested acres (lb/ac) | Applicatin Rate manured acres only (t/ac) | Applicatin rate manured acres only (lb/ac) | Additinal cows to max agronomic rate of 50 lb/ac |
|---|---|---|---|---|---|---|---|---|---|---|
| Allegany | 16724 | 254880 | 390.9 | 57838 | 19295 | 4.4 | 13.5 | 13.2 | 40.5 | 2410 |
| Chautauq | 33611 | 512235 | 816.9 | 106933 | 38254 | 4.8 | 15.3 | 13.4 | 42.7 | 3675 |
| Chenango | 25668 | 391174 | 609.5 | 72490 | 28645 | 5.4 | 16.8 | 13.7 | 42.6 | 2810 |
| Delaware | 20689 | 315303 | 244.8 | 58430 | 24957 | 5.4 | 8.4 | 12.6 | 19.6 | 9992 |
| Erie | 21721 | 331028 | 609.5 | 81444 | 30022 | 4.1 | 15.0 | 11.0 | 40.6 | 3718 |
| Genesee | 32325 | 492627 | 878.2 | 132333 | 39895 | 3.7 | 13.3 | 12.3 | 44.0 | 3140 |
| Herkimer | 24234 | 369326 | 529.8 | 64172 | 24313 | 5.8 | 16.5 | 15.2 | 43.6 | 2057 |
| Jeffer son | 45830 | 698455 | 815.8 | 147726 | 58144 | 4.7 | 11.0 | 12.0 | 28.1 | 16809 |
| Lewis | 37016 | 564124 | 881.1 | 82977 | 46911 | 6.8 | 21.2 | 12.0 | 37.6 | 7686 |
| Madison | 30251 | 461028 | 738.2 | 98579 | 35645 | 4.7 | 15.0 | 12.9 | 41.4 | 4029 |
| Oneida | 32304 | 492307 | 710.5 | 87040 | 30094 | 5.7 | 16.3 | 16.4 | 47.2 | 1103 |
| St. Lawrer | 53225 | 811152 | 1319.5 | 92783 | 14242 | 8.7 | 28.4 | 57.0 | 185.3 | |
| Steuben | 28592 | 435745 | 1039.9 | 171191 | 41866 | 2.5 | 12.1 | 10.4 | 49.7 | 177 |
| Washingt | 34734 | 529346 | 928.4 | 95018 | 32396 | 5.6 | 19.5 | 16.3 | 57.3 | |
| Wyoming | 68614 | 1045677 | 1860.4 | 142442 | 69782 | 7.3 | 26.1 | 15.0 | 53.3 | |

The last column in Table 7 shows the estimated cows a county could accept while maintaining a manure $P_2O_5$ application rate of 50 lb $P_2O_5$/ac. This rate represents a crop removal rate for silage corn, with a small additional increment to account for uncertainty in nutrient management. The results show, for example, that manured land in Allegany County could accept manure from an additional 2,410 cows before the average P application rate reached 50 lb $P_2O_5$/ac. Clearly, there are some differences among the selected counties. St. Lawrence, Washington, and Wyoming counties area already exceed the estimated capacity for manure P application to manured land. Steuben County has an estimated capacity to accept less than 200 additional cows, whereas Jefferson County has a much larger growth capacity, due in part to its large land base.

Several important caveats should be mentioned. First, the above analysis does not consider current soil test P in the fields receiving manure, nor does it consider addition of P from other sources like commercial fertilizer, biosolids, silage liquor, or dairy processing wastewater. Based on the analysis set forth in Section V above, many of the counties where additional capacity is indicated by this analysis already have a large percentage of fields with high and very high STP levels.

Secondly, only mature milking cows are counted in the manure production estimates; heifers and calves are not included in the analysis. Thus, the estimates of available manure P are almost certainly on the low side, while the estimates of agronomic capacity for added P are on the high side because existing P supplies in the soil are ignored. Finally, the agronomic threshold of 50 lb $P_2O_5$/ac may be appropriate for silage corn, but is excessive for hay (by a factor of ~2). The combined effect of these simplifying assumptions is to inflate the estimates of capacity for additional cows by an unknown factor.

## 4. Results of Analysis

Nutrient management is a set of practices that address the rate, location, timing, and method of nutrient applications from all sources to agricultural fields to provide for adequate crop growth while protecting water quality. In general, nutrient management considers existing nutrient levels (e.g., soil test P, N fixed from a previous legume crop) and crop need (at a reasonable yield goal) to determine the rate of application of nutrients from all sources (i.e., commercial fertilizer, manure, biosolids). Nutrient management may be N-based, where application rate is determined on the basis of supplying required N to the crop; where manure or other organic sources are used to supply the needed N, P is generally over-applied because the N and P content are not present in proportion to crop need. P-based nutrient management, where organic nutrients are applied based on crop need for P and any additional required N is added in inorganic fertilizer, is more protective of water quality because addition of excess P is avoided. In cases where soil test P levels are already excessive or where a high risk of P loss exists (e.g., determined by the P Index), nutrient management may indicate no additional application of P in any form.

Available nutrient mass balance data show that several New York counties are accumulating more N and P than they export in agricultural products. Soil test P data show that soil P levels in excess of crop need are already common in the state, especially in heavily dairy counties. Both broad-scale nutrient balance analyses and soil test data show that there are areas in New York where nutrient applications and soil P content are already in excess of crop need, and even where a county-level imbalance does not exist, soil test P on a significant proportion (as high as ~50%) of fields on individual farms is already high or excessive, indicating that no additional P is required for crop growth. While soil test P levels alone do not fully indicate risk to water quality (transport factors also need to be considered, e.g., in a Phosphorus Index), reduction of farm-scale nutrient imbalance and soil test P levels is generally desirable from both an agronomic (i.e., cost of added nutrients) and essential from an environmental (i.e., nutrient losses to water) point of view.

The prevalence of high P soils – and the trend for increasing frequency of soils where no additional P is needed for crop production – underlines the importance of the application of good nutrient management and the need for regulation. This is confirmed by the emphasis that agricultural conservation programs have placed on implementation of nutrient management practices (see Section 1.b. and c.). The need for good nutrient management will become all the greater if dairy herds expand in animal populations (and consequently increase the manure N and P to be applied to the land) and especially if additional sources of nutrients (e.g., dairy processing wastewater) are added to the mix. It is essential that good nutrient management be applied and that **<u>all</u>** nutrient inputs are included in the calculation; this applies to all farms, but especially to farms that may dramatically increase their herd size.

# VI. Voluntary Efforts under State and Federal Programs

CAFO rules have been in effect in New York State since 1999, regulating over 450 medium-sized CAFOs. The current General Permit (GP-0-09-000) has been in effect since 2009. Seventy-three Medium CAFOs in the range of 200-299 cows are currently under the permit. Of the 73, 38 have requested compliance extensions based on either "Financial Conditions" or "Low Environmental Risk." The State reports a high rate of compliance in the CAFO program, largely attributable to support from professional CNMP planners and the AEM program (NY State Phase II WIP and Program Capacity at page 20-21).

The assumption that the effects of deregulation will be mitigated by voluntary state and federal programs is unfounded (see Section IV). Voluntary programs should be utilized to support, not replace the regulatory oversight of the CAFO permit program. Voluntary programs provide important support for the pollution control in the dairy industry as shown by the level of signup in the AEM and NRCS programs (See Sections VIA---B), but it will not be sufficient to keep pressure on producers as evidenced by the low rate of participation in Tiers 4 and 5 of AEM. Although many problems have been addressed by such programs, the total impact is small, and few systems are addressed to the level required by the CAFO permit.

## A. The New York AEM program

New York's AEM program, operating under the auspices of the New York State Soil and Water Conservation Committee, is a voluntary, incentive-based program that helps farmers make decisions to help meet business objectives while protecting and conserving the State's natural resources. Farmers work with local AEM resource professionals to develop comprehensive farm plans using a tiered process:

- **Tier 1 – Inventory current activities, future plans and potential environmental concerns.**
- **Tier 2 – Document current land stewardship; assess and prioritize areas of concern.**
- **Tier 3 – Develop conservation plans addressing concerns and opportunities tailored to farm goals.**
- **Tier 4 – Implement plans utilizing available financial, educational and technical assistance.**
- **Tier 5 – Evaluate** to ensure the protection of the environment and farm viability.

Note that no conservation practices are implemented on participating farms through the AEM program until Tier 4 is achieved.

According to the AEM web site, the AEM program is:

- **Voluntary** – Farmers choose to participate.
- **Watershed-based** – The AEM approach is carried out within the context of a holistic watershed planning effort whenever possible.
- **Customized farm-by-farm** –Natural resource and business conditions unique to each farm are considered throughout the AEM process.
- **A Team Approach** – AEM coordinates technical assistance from state, federal and local government programs, as well as the private sector.

- **Cost Effective** – AEM targets program, technical, and financial resources to farms with the greatest potential for impacting the environment.
- **Statewide** – The NYS Department of Agriculture & Markets and the NYS Soil & Water Conservation Committee secure funding for AEM, oversee the educational and training program for Certified AEM Planners, and provide standards and leadership for the program statewide.
- **Locally-led and implemented** – The statewide AEM initiative grew from counties and local watershed groups adopting and refining the planning and implementation process used in AEM. County-level groups have responsibility for directing and carrying out AEM in their counties.
- **Tested and Science-based** – The AEM planning process is based on well-established environmental planning processes. Environmental protection measures are based on scientific principles and research. Procedures are also provided to use and develop new, innovative approaches where appropriate.
- **Confidential** – State law protects the confidentiality of AEM plans, on-farm surveys, and assessments filed with the NYS Department of Agriculture & Markets or County Soil & Water Conservation Districts.

Coordinated with AEM, the State of New York operates the *NYS Agricultural Nonpoint Source Abatement & Control Grant Program*, a program established in 1994 to assist farmers in preventing water pollution from agricultural activities by providing technical assistance and financial incentives. County Soil & Water Conservation Districts apply for the competitive grants on behalf of farmers and coordinate funded conservation projects. Grants can cost-share up to 75% of project costs or more if farmers contribute in the following two areas:

- Planning- funds awarded to conduct environmental planning
- Implementation- funds awarded to construct or apply management practices

The New York State Soil & Water Conservation Committee and the Department of Agriculture & Markets coordinate the statewide program and allocate funds provided by the NYS Environmental Protection Fund on a semi-annual basis. Since the program began in 1994 more than $100 million has been awarded to 53 Soil & Water Conservation Districts across the state to help farmers reduce and prevent agricultural sources pollution.

Information provided in past AEM bi-annual reports gives some examples of AEM activity. The 2004-2005 Annual Report cites enrollment of 9,375 farms in AEM Tier 1 and 5,578 farms in Tier 2. The 2006-2007 Annual Report reported that AEM Base Funding had increased the numbers of new farms involved in AEM and established a consistent trend of farmers progressing through the AEM process from year to year. Some 72% of these farms reported defined waterbodies on or near the farm and potential impact to these waters has been identified or addressed. Between May and November 2006, 43 Districts brought 561 new farmers into the program, completed 257 risk assessments, developed 111 conservation plans, implemented 43 conservation practices, and conducted 49 follow-up evaluations. In the reporting period, 33% of AEM base funds were applied to dairy enterprises.

The 2007-2008 Annual Report reported that in the first three years of the program:

- 4,421 farms began the AEM process.
- 2,440 farm assessments were completed.
- 919 conservation plans were initiated.
- 240 farms received technical assistance to install practices.
- 322 farm evaluations were conducted.

The 2009 Annual Report cited:

- 875 new farms participating
- 406 AEM Farm Conservation Plans developed.
- 283 farms with conservation practices designed or installed.
- 256 conservation evaluations conducted.
- 100% increase in project proposals submitted for funding and conservation projects implemented, based on priority needs identified through AEM planning.
- Over $25 million in project requests.
- Substantial adoption of changes in farm operations that do not require public funds, yet still provide public benefit.

In the 2010 Annual Report, the AEM program reported that 30% of their expenditures for conservation practices addressed grazing systems, 28% involved barnyard runoff management, 11% focused on nutrient management, and 10% was allocated to agricultural waste management.

According to the Draft EIS (NYSDEC 2012), New York State Department of Agricultural and Markets records indicate that the overall AEM participation rate for dairy farms with 100-199 cows is 63% at the Tier 2 level or above (note that AEM data with this level of detail is not publically available). About 56% of these small dairy farms have continued on to AEM Tier 3 conservation planning, and 53% have implemented best management practice systems in Tier 4 (often cost-shared through the NYS Ag Nonpoint Source Abatement and Control Grant Program) based on their conservation plans.

Per our request, AEM personnel provided some information about practices implemented on New York dairy farms since 1995. This information, tabulated on a county basis, did not include information on characteristics of participating farms other than classification as dairy, beef, etc. Selected data from priority counties are shown in Table X. Statewide, conservation practices implemented under the AEM program have included barnyard runoff management and manure storage serving over 180,000 AU and nutrient management applicable to more than 67,000 acres of agricultural land. Silage leachate control has been another measure widely implemented through AEM. Very little manure treatment has been implemented under AEM.

It should be noted that precise definitions of the conservation practices reported by AEM are unclear and have not yet been made available. It is not certain, for example, what “Barnyard Runoff Management” entails (there is no specific USDA NRCS practice standard for this practice), nor is it known how this practice differs from “Barnyard Water Management.” The meaning of several other AEM-reported practices is also unclear. Most importantly, the degree to which any of the AEM-reported practices have been designed, funded, or implemented through USDA-NRCS (See section 1.c.) is unknown.

Finally, note that according to the Draft EIS (NYSDEC 2012), funding for implementation of conservation practices under AEM does not presently meet demand. There are 58 Conservation Districts, and program priorities (stormwater, forestry, public education, aquatic vegetation controls, etc.) vary between districts. Even in districts where the AEM program is a priority, a district may not have adequate qualified staff to prepare the CNMPs for farms in their district.

## B. NRCS contracted conservation practices

In New York, as in other states and territories, the USDA-Natural Resources Conservation Service (NRCS) works on a voluntary basis with agricultural landowners to design, cost-share, and implement conservation practices under a variety of programs such as the Environmental Quality Incentive Program (EQIP). NRCS conservation practices are designed and installed to rigorous standards and specifications through a conservation planning process involving NRCS technical staff and the landowner.

Data on selected conservation practices implemented in New York through NRCS programs were obtained from the USDA-NRCS Performance Results System (PRS), reported by county. These data are summarized below in Table 8.

**Table 8 Implementation of selected NRCS conservation practices in selected NY**

| County | NM 590 (ac) | Waste Storage Facility 313 (no.) | Waste Transfer 634 (no.) | Heavy Use Area Protection 561 (ac) |
|---|---|---|---|---|
| Allegany | 11,611 | 5 | 11 | 177 |
| Chautauqua | 15,265 | 3 | 12 | 155 |
| Chenango | 2,370 | 2 | 0 | 53 |
| Delaware | 48,869 | 10 | 10 | 193 |
| Erie | 50,863 | 8 | 12 | 48 |
| Genesee | 9,804 | 6 | 4 | 87 |
| Herkimer | 3,855 | 10 | 5 | 131 |
| Jefferson | 16,542 | 11 | 14 | 246 |
| Lewis | 18,471 | 9 | 10 | 1 |
| Madison | 4,875 | 7 | 10 | 37 |
| Oneida | 15,610 | 9 | 16 | 110 |
| St. Lawrence | 19,985 | 10 | 8 | 523 |
| Steuben | 13,771 | 7 | 9 | 1304 |
| Washington | 7,267 | 7 | 7 | 92 |
| Wyoming | 16,087 | 3 | 11 | 41 |
| TOTALS | **255,245** | **107** | **139** | **3,198** |

# VII. Review of Alternatives Presented in the EIS

## A. No Action

This alternative consists of operating the current system into the future. As indicated by DEC, this alternative offers the best environmental protection. The cost of the this approach is taken from the Farm Credit East and Cornell Pro-Dairy report (2012), which assumes all the pollution control associated with expansion is a cost of the CAFO permit. This assumption is completely false as protection of the environment would require this cost even if the CAFO permit were not in effect. It should also be pointed out that the State has committed to maintenance of the permit program in its Phase II WIP, as required by the Chesapeake Bay Program. Although this is the best alternative proposed, it may not be sufficient in the future as Phosphorus and Nitrogen continue out of balance into the future such that Phosphorus continues to build up in soils on and near dairy farms.

## B. Mandatory Enrollment in the AEM Program

Although this approach appears to be a better option than the proposed de-regulation, it is unlikely there will be sufficient sign up for the more expensive practices, and there is unlikely to be commitment to recordkeeping. This is borne out by the observation that signup for AEM is high at the Tier 1 and Tier 2 levels, but thins out considerably at the Tier 3 and Tier 4 levels, where real commitment of funds and management are required. Moreover, mandatory enrollment in a voluntary program does not require implementation of environmental protections and because of its confidential nature records kept would not be available to the public. Good intentions are generally not sufficient to assure water quality benefits, when one or two bad actors can create almost as many problems as the entire cohort. To date there have been very few successful nonpoint source programs that are dependent entirely on financial incentives and the conservation ethic of producers. Pollution control is rarely achieved without commitment and expenditure of funds. Although intentions are often good, the level of commitment needed is rarely achieved and maintained without rules and enforcement.

## C. Mandatory Enrollment in the AEM program for CAFOs Located in Watersheds with Impaired Waterbodies

As indicated in the EIS, this option is not easily accomplished. It has the problem that only part of the dairy industry is required to comply, given it an unfair appearance. It may put those in designated watersheds at a competitive disadvantage. It is good that public funds and departmental effort can be targeted to achieve the greatest impact, but the negatives probably outweigh this benefit. An unrecognized problem with this approach is that the designation of waterbodies changes from year to year, making it difficult to administer and to assure compliance. Producers would be watching the announcements each year to see if this year they must comply. Mandatory rules for a voluntary program seems strange. It is not clear how the CNMP requirement could be enforced.

## D. Eliminating the General Permit

This approach would focus on those identified CAFOs that have waste management situations so crucial that they require an individual permit. They would take more staff time for fewer operations. The majority of dairies would not be governed, exacerbating the problems identified throughout this report. Embedded in this option is a suggestion that the program would essentially phase farms into the permitting world. That is they would not be permitted until their expansion moved them into a category requiring it. This phased approach has carries the risk of only regulating when catastrophic failure is encountered. It is likely to have dire consequences for the environment and for the regulated community.

# VIII. Waste Treatment Systems Performance under Proposed Permit Changes

A majority of New York's dairy operations are small, having less than 200 cows per farm. Out of the nearly 6,200 dairy farms, 850 had herd sizes between 100-199 cows. Additionally, 2,100 farms had 50-99 cows per operation and 2,600 farms had herd sizes with less than 50 dairy cows each (USDA-NASS, 2007). The NYSDEC Draft EIS (NYSDEC, 2012) provided information on permitted dairy farm (CAFOs) sizes by county indicating that out of the 467 CAFOs, 73 operations had herd sizes in the range of 200-299 mature dairy cows, 257 operations had herd sizes ranging from 300-699 mature cows and 137 operations had herd sizes having more than 700 mature cows.

The newly proposed changes to Part 750 of Title 6 of the Official Compilation of Codes, Rules, and Regulations of the State of New York, will exempt dairy farms, with herd sizes ranging from 200-299 mature cows that do not discharge to surface waters, from needing SPDES permit coverage. NYSDEC (NYDEC, 2012) also anticipated that as a result of this exemption, "an impediment would be removed for dairy farms below the threshold of 200 mature dairy cows to expand their herd's size, and, thereby increase dairy production." The Draft EIS estimated that due to the reduction in costs associated with regulatory exemption, approximately 285 farms would increase their herd sizes to greater than 200 mature milking cows over the next 10 years. This estimate may potentially increase the number of dairy farms in New York with more than 200 cows to greater than 350.

In addition, as stated in the Draft EIS, an amendments to 6 NYCRR Part 360 will exempt anaerobic digesters (AD) located at permitted CAFOs from needing a separate approval under Part 360, unless certain wastes containing human fecal matter are accepted. The draft EIS further states that "The Part 360 revisions would reduce the regulatory burden, prevent confusion, and assist farms, food processors, and others in the state who are striving to recycle organic wastes in an environmentally sound manner. "

The Farm Credit East Knowledge Exchange Program and the Cornell Pro-Dairy Program (Section III. B.) discussed financial implications of expansion of a hypothetical average dairy farm from 190 cows to 290 cows, with and without permitting requirements in New York. It was estimated that a 190 cow operation expanding to 290 cows would take on $524,500 in new debt to finance both herd expansion and to meet NYSDEC CAFO regulatory requirements but the farm would save $142,000 ($382,500 in debt) if this expansion was exempted from permitting. For permitted medium CAFOs (200-299 cows), an expense of $5,000 annually in CNMP certification fees will also be incurred. Haycook et al. (2012) also stated that "Growth to the next larger level will be incremental and will require learning and managing larger and different waste handling, treatment and storage systems. " T*he question that needs to be answered is whether these reduced expenditures of nearly $150,000 are worth the potential risk of environmental pollution from an unpermitted animal feeding operation (AFO) with no oversight for on and off farm manure, animal mortality, process generated wastewater and comprehensive nutrient management.*

## A. Manure Storage and Treatment

An in-depth search of literature and interactions with technical service providers in the state of New York revealed that no comprehensive information on manure storage and treatment systems for small, dairy operations (AFOs) is available. Information deciphered from incomplete data available revealed that very small dairy operations (less than 50 cows) land-apply manure on a daily basis while small operations (more than 100 cows) store manure and milk house or milk parlor wastewater for a period ranging from one week to six months before land application. Manure and process generated wastewater from small farms is stored in earthen manure structures, and metal or concrete slurry storage structures. These AFOs are not required to participate in USDA-NRCS and other similar state or federal programs to seek technical assistance or to hire a professional engineer to design and build storage structures. Under the proposed permit exemptions, these AFOs will be allowed to increase herd sizes to up to 299 mature cows, potentially resulting in a 2-3 fold increase in waste volumes due to manure, process wastewater and other non-farm organic wastes (e.g., whey and other food waste) permitted to be processed on the dairy farm. For example, increasing the herd size from 199 mature cows to 299 mature cows will increase as-excreted manure production on the farm from 5,400 tons/yr to 8,100 tons/yr (MWPS, 2000). Also, estimated yearly nutrient quantities of N, $P_2O_5$, and $K_2O$ from manure stored in a pit will be 19.9 t/yr (200 lb/cow/yr), 9.7 t/yr (97 lb/cow/yr), and 12.2 t/yr (123 lb/cow/yr), respectively for 199 cows but when the herd size is increased to 299 mature cows, the N, $P_2O_5$, and $K_2O$ quantities will increase to nearly 30 t/yr, 14.6 t/yr, and 18.3 t/yr, respectively (MWPS, 2000).

Haycook, et al. (2012) estimated that a dairy operation expanding from 190 cows to 299 cows will require an earthen structure to store 1.5 million gallons of manure and process generated wastewater for 6 months at the cost of $100,000. *However, lack of the requirement to hire a PE to properly design and build new or expand existing storage for a period between land applications, may potentially impose environmental risk and jeopardize worker and animal safety due to structure failure and waste spills.* Additionally, a dairy AFO of up to 299 cows will no longer be required to land apply manure and other organic residuals in accordance with a CNMP prepared by a certified planner. *This potentially will pose a greater risk of nonpoint source pollution of soil and water with excessive nutrients such as N and P and other pollutants in runoff and infiltration from unmanaged and excessive application of manure and other organic waste and wastewater. Additionally, excessive application of these organic residuals may negatively impact air quality due to emissions of air pollutants including ammonia, VOCs and nitrous oxide.*

## B. Leachate

Another area of major concern is the control of leachate from silage storage at dairy operations throughout the USA. The facilities storing silage should be properly located and silage should be covered. Any silage leachate should be collected and disposed of in a manner that will minimize the risk of soil and water pollution. Additionally, ammonia, methane, and reactive VOCs emissions from improperly covered silage and unmanaged leachate degrade air quality. The low pH (due to acetic acid and lactic acid production during the anaerobic fermentation process) of silage leachate can compromise the integrity of concrete storage structure. Corn silage leachate is very high in Biochemical Oxygen Demand ("BOD") value, ranging from 12,000 to 90,000 mg/L. In comparison, the BOD value of raw sewage is up to 200 times less than the silage leachate BOD concentration. As the smaller dairies increase their herd sizes, size of these storage facilities will increase significantly, requiring greater silage storage and leachate management and frequent producer/operator inspections for these facilities. The newly proposed amendments to the medium CAFO rules will no longer require a dairy AFO of up to 299 cows to implement NRCS standards for silage storage and leachate management systems thereby potentially posing a g*reater risk to environmental pollution from unmanaged on-farm silage storage.*

## C. Anaerobic Digestion

One assumption in the Draft EIS report is that financial incentives and funding opportunities would encourage the unpermitted dairy facilities of up to 299 mature cows to voluntarily adopt BMPs including anaerobic digestion (AD) facilities for converting organic matter from manure and milk products' (yogurt etc.) wastes into soil products. In 2009, USEPA AgSTAR (AgSTAR, 2009) program analyzed AD facilities' capital cost data for 28 dairy farms in the USA. Twenty six of the 28 AD facilities were complete mix digesters (10) and plug flow (16) digesters and covered lagoons (2) that may not be a suitable option for New York dairies. Capital cost for each system included the cost of the digester, the engine-generator set, engineering design, and installation. In this analysis, dairy farms with complete mix type digester ranged in herd size from 700 to 2,300 head and those with plug flow digester ranged in herd size from 654 to 4,000 head. The following equations for estimating capital costs (in 2008 dollar value) for these two types of digesters were provided.

1. Complete Mix Digester: Capital Cost ($) = (615) (Number of Dairy Cows) + 354,866
2. Plug Flow Digester: Capital Cost ($) = (563) (Number of Dairy Cows) + 678,064

Using these equations to estimate capital costs for a dairy farm with 299 cows will show very high capital costs of nearly $540,000 and $850,000 for complete mix and plug flow digesters, respectively. *USEPA recommends biogas recovery systems only for operations with herd sizes of 500 or more dairy cows because the average capital investment of 1.5 million dollars (Lansing and Klavon, 2012) is so high.*

A financial analysis of existing and alternative digester business models discussed by the Innovation Center for U.S. Dairy (2009), used data from New York on-farm anaerobic digester case studies posted on the Cornell Manure Management Web site ( http://www.manuremanagement.cornell.edu/) for dairy farms that use AD facilities and those that are considering to install such facilities in the future. The following assumptions were used.

- No tipping fees were included with this assessment for scenarios when imported substrate is co-digested with manure
- Thirteen cubic feet of biogas per volatile solid converted
- 550 BTU per cubic foot of biogas
- The farm pays $0.12/kWh for electricity. It will sell all excess electricity back to the grid at the avoided cost for the utility at $0.06/kWh.
- No upgrades to the grid were required as part of the capital investment
- Carbon credit revenues were considered a constant at $2 per credit net of any aggregation or exchange costs

- Financing terms were a seven year loan at 8% and 65% of the total capital costs
- Ten-year terminal value

Farms with herd sizes, 100, 250, 500, 750, 1,200, 1,500, 2,000 and 4,200 dairy cows using mostly complete mix or plug flow type digsters were considered in this analysis. It was determined that with and without certain grants applied to each project, the net present value (NPV) calculations indicated that as dairy farm sizes increased from 100 dairy cows to 4,200 dairy cows, the investment seemed more "attractive."[1]

Potential benefits of on-farm anaerobic digestion may include reduction of odor, and manure and process wastewater pathogens, reduction in on-farm energy cost due to biogas production for heat and electrical power generation, reduction in cost of bedding if digested solids are separated and used as bedding material, and reduction in GHG ($CO_2$ and $CH_4$) emissions. *However, it is important to note that anaerobic digestion does little to reduce N and P in the digestate and aids little in nutrient management. In fact, while co-digestion of manure with off-farm food wastes has the potential to significantly increase biogas production, additional nutrients from these feedstocks will have to be properly managed to reduce the risk of environmental degradation.* For example, Scott and Ma (2004) estimated that biogas production from 50 percent cow manure co-digested with 50% food waste will have 2.5 times greater biogas potential as compared to the digestion of cow manure only. *On the other hand, food waste substrates also contain nutrients that may reduce little during digestion and must be managed properly. For example on a dry weight basis, whey may contain about 4.7% N (Hublin and Zelic, 2012).*

From the Hublin and Zelic (2012) data, at 95.3% moisture content, the N content of whey will amount to 18.3 pounds per 1,000 gallons. Cow manure at about 88% moisture content has an estimated N content of 31 pounds per 1,000 gallons. For a farm with 299 dairy cows, total manure volume available to be used for an AD system will be about 2 million gallons per year. The total N content of this manure will be about 60,000 pounds (MWPS, 2000) per year. Adding whey up to 50% by volume, to two million gallons will amount to nearly 1 million gallons of whey per year. This will result in an additional N content of 18,300 pounds per year from whey that will need to be utilized in an environmentally safe manner because little N is utilized from this mixed (manure and whey) feedstock during anaerobic digestion.

Another important aspect of a successfully running AD system on dairy farms is proper training of digester operators and owners. The EPA AgSTAR Handbook on Developing Biogas Systems at Commercial Farms in the United States (AgSTAR, 2004) cautioned that lack of operator skills and the time required to keep a system operating as well as well as inadequate training and technical support to farmers for their AD systems were some of the reasons why several AD systems in the past have failed on US farms. Just as on larger dairies, trained operators will be needed and dedicated to running AD systems on small dairies (up to 299 dairy cows) with the knowledge of equipment, feedstocks and their properties, safety hazards, and emergency action plans. Safety hazards associated with AD systems

[1] The Capacity Incentive provides funding for $500 per kilowatt of electric generator capacity. The maximum amount of funds to be given out to a single project may not exceed the lesser of either $350,000 or 50% of the total purchase, engineering service and installation costs. The Performance Incentive related to new ADs provides a 10 cent per kilowatt generated payment for no more than a three year period.

include operator and worker (also visitors) drowning, falling from elevated locations, electric shock and exposure to biogas in confined spaces. The constituents of biogas and gases from stored raw organic materials (manure and other feedstocks), many of which are colorless, odor less, flammable and toxic, may expose operators and workers to dangers of asphyxiation, burns and other bodily injuries that may be fatal. *Without oversight or required education for training and safety around AD systems at dairy AFOs with 299 mature cows, potential for poor system operation and increased safety hazards may lead to operator injuries and inadequate system performance.*

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Klausner, S.D., D.G. Fox, C.N. Rasmussen, R.E. Pitt, T.P. Tylutki, P.E. Wright, L.E. Chase, and W.C. Stone. 1998. Improving dairy farm sustainability I: An approach to animal and crop nutrient management planning, *J. Prod. Agric.* 11:225-233.

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Meisinger, J.J. and W.E. Jokela. 2000. Ammonia volatilization from poultry and dairy manure. Managing Nutrients and Pathogens from Animal Agriculture, NRAES-130, https://dairyn.cornell.edu/pages/20cropsoil/documents/MeisingerandJokela-NRAES130-2000.pdf (accessed 1-15-2013).

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Sims, J.T., R.O. Maguire, A.B. Leytem, K.L. Garthley, and M.C. Pautler, 2002. Evaluation of Mehlich 3 as an agrienvironmental soil phosphorus test for the Mid-Atlantic United States of America. *Soil Sci. Soc. Am. J*. 66:2016-2032.

USDA National Agricultural Statistics Service (NASS). 2013. USDA 2007 Census of Agriculture. http://www.agcensus.usda.gov/Publications/2007/index.php (accessed 1-15-2013).

***Curriculum Vitae***
**Michael D. Smolen**

**3409 South Washington Av., Stillwater, OK 74074**

**Academic History:**

Ph.D. Environmental Sciences and Engineering, VA Polytechnic Inst. and State University, 1976.
MS. Botany (Minor in Biochemistry), University of Tennessee, 1970.
BS. Biology (Minor in Chemistry), University of Rochester, 1967.

**Honors and Awards:**

The G.B. Gunlogson Countryside Engineering Award 2008
Environmental Institute Oklahoma State University Sterling L. (Bud) Burkes Award for Outstanding Environmental Research 2005
USDA Group Honor Award for Excellence: Poultry Waste Management Education Team 2002
ASAE Blue Ribbon Award for Extension Method: "Trailer-Mounted Models to Educate about Natural Resource," 2001
Natural Resource and Environmental Stewardship Award for Stream Trailers. Oklahoma Extension 4-H Agent's Association. 2001.
Oklahoma Cooperative Extension Service. Team member for the Outstanding Educational Program, Nursery Water Quality. 1999.
Alpha Sigma Epsilon, Honorary Member. Awarded by Students of Biosystems & Agricultural Engineering, Oklahoma State University.
National Awards for Environmental Sustainability, Certificate of Environmental Achievement. Caring for Planet Earth. 1994.
Regional Administrator's Environmental Excellence Award for Outstanding Service in Implementing the Requirements of the NPDES Concentrated Animal Feeding Operations General Permit, U. S. Environmental Protection Agency, Region 6, 1994
North Carolina Cooperative Extension Service, 1993 Extension Education Award for the North Carolina Ground Water Education and Sampling Program.
National Environmental Awards Council, Certificate of Environmental Achievement for the Oklahoma Urban IPM Program, 1992.
National Environmental Awards Council, Certificate of Environmental Achievement for "Caring for Planet Earth, "4-H Program, 1992.
Extension Achievement Award, Cooperative Extension Service, Oklahoma State University, Urban IPM Program, 1992.
ASAE Blue Ribbon Award for Educational Fact Sheet: "Phosphorus and Water Quality," 2009.
ASAE Blue Ribbon Award for Educational Manual: "Erosion and Sediment Control Field Manual," 1991.
ASAE Blue Ribbon Award for Educational Manual: "Erosion and Sediment Control Planning and Design Manual," 1989.
ASAE Blue Ribbon Award for Educational Slide Tape: "Protecting Crops Protecting Water," 1987.
ASAE Blue Ribbon Award for Newsletter: "NWQEP NOTES," 1987.
Gamma Sigma Delta.
Sigma Xi.
US EPA Graduate Traineeship, 1971-1972.
University of Tennessee Non-Service Fellowship, 1968-1970.
Chester A. Dewey Scholarship - University of Rochester, 1967.

**Professional Societies:**

American Society of Agricultural and Biological Engineers (since 1975)
- M155 Gunlogson Countryside Engineering (member 2008-10, chair 2010-11)
- SW-21 Hydrology Group (member)
- T-09 Environmental Quality Group
- ED-208 Extension Committee (Chair, 2000-2001)
- SW-224 (Chair, 2002-2004)

American Geophysical Union (since 1976)

American Association for the Advancement of Science (since 1976)
American Water Resources Association (since 1987)
American Water Resources Association, Oklahoma Section (First President 1995-1997)
Oklahoma Clean Lakes and Watersheds Association (since 1991)

**Professional Consulting:**

Sneed Lang, Attorneys – Consulting Expert
Texas Commission on Higher Education (2003, 2009)
Jason Aamodt, Atty (2003, 2008, 2010, 2012)
Johnston and Associates (2002)
City of Austin, Austin, TX (1998)
University of Nebraska, Lincoln, NE (1997)
Water Environment Research Foundation, Alexandria, VA (1995-97)
US Environmental Protection Agency, Science Advisory Board, Washington, DC (1987)
Woodward-Clyde Consultants (1987)
Research Triangle Institute, Research Triangle Park, NC (1985)
VPI&SU Agricultural Engineering Dept. Blacksburg, VA (1984)
U. S. Army Corps of Engineers. Vicksburg, MS (1983)
GKY and Associates, Springfield, VA (1982)

**Committees and Task Forces:**

ACWI Subcommittee on Sedimentation – 2010
Grand River Dam Authority Technical Committee 2007
Grand Lake 4-State Watershed Collaborative – Chair of Steering Committee 2007
DASNR Water Center Task Force – Chair 2007
Water Issues Team – Member 2006-
DASNR Environmental Quality and Waste Management Initiative Team – Coordinator 2005-
Universities Council on Water Resources – OSU Representative (2002- )
USDA-CSREES Water Quality Program, National Advisory/Leadership Team, Chair 1999-2001
Oklahoma Water Quality Monitoring Council, Academic Representative (1998 -)
Oklahoma Poultry Rules Advisory Committee, Water Quality Representative (1998 -)
Oklahoma Nonpoint Source Work Group (1995-)
NRCS State Technical Committee for EQIP (1997-)
Governor's Task Force on the Illinois River (1991-1994)
Southern Region Extension Water Quality Planning Committee (1991 -), Chair: 1996-1997
Water Quality Initiative Committee, Chair, Oklahoma State University
Urban IPM Committee, Oklahoma State University
Peanut IPM Committee, Oklahoma State University
Wheat IPM Committee, Oklahoma State University
Environmental Sciences Program, Steering Council, Oklahoma State University
Great Plains Agricultural Council, Animal Waste Task Force Water Committee (1993-1994), Chair (1992-93)
Biosystems and Agricultural Engineering Department, Oklahoma State University, Graduate Committee
Center for Agriculture and the Environment, Oklahoma State University, Steering Committee (1992-1995)

**Academic and Professional Appointments:**

**July 2010 -** Professor Emeritus, Biosystems and Agricultural Engineering Department, Oklahoma State University

**July 1994 – 2010.** Professor, Biosystems and Agricultural Engineering Department, Oklahoma State University, Water Quality Coordinator for Division of Agricultural Sciences and Natural Resources. Member of Graduate Faculty.

**November 1990 - June 1994.** Associate Professor, Biosystems and Agricultural Engineering Department, Oklahoma State University, Water Quality Coordinator for Division of Agricultural Sciences and Natural Resources. Associate member of Graduate Faculty.

**August 1985 to November 1990.** Visiting Associate Professor, Biological and Agricultural Engineering Department, North Carolina State University. Leader of the Water Quality Group and principal investigator on all Group projects. Associate member of Graduate Faculty.

**July 1983 to July 1985.** Visiting Assistant Professor, Biological and Agricultural Engineering Department, North Carolina State University. Principal Investigator for the National Water Quality Evaluation Project and related water quality investigations. Associate member of Graduate Faculty.

**January 1980 to July 1983.** Assistant Professor, Agricultural Engineering Department, Virginia Polytechnic Institute and State University (VPI&SU). Research (80%): soil conservation and water quality management for agriculture and surface mining. Developed water quality laboratory and hydrologic/water quality monitoring program. Teaching 20%: Hydrologic Modeling, Animal Waste Management, and Microcomputer Programming.

**July 1976 to December 1979**. Assistant Professor, Southern Piedmont Research and Continuing Education Center, VPI&SU, Blackstone, VA. Project leader for Environmental Quality Research. Developed field monitoring and water quality laboratory.

**February 1975 to June 1976.** Research Associate, Southern Piedmont Research and Continuing Education Center, VPI&SU, Blackstone, VA. Developed proposals and plans for environmental research.

**September 1972 to January 1975.** Graduate Research Assistant, Civil Engineering Department, VPI&SU. Assisted in setting up laboratory and field sampling protocol for the Occoquan Watershed Monitoring Laboratory.

**Grant Support for Extension and Research:**

**Cow Creek Stream Restoration and Streambank Stabilization Project.** 2009-2012. OCC/OWRB/EPA-ARRA. D. Maronek, M. D. Smolen, G. Fox, G. Brown. Total: $2,000,000.

**Water Conservation in Oklahoma Urban & Suburban Watersheds through Modification of Irrigation Practices.** 2010-2011. OWRRI. J. Moss, D. Adams, M. D. Smolen, T. Boyer, D. Martin. State: $50,000.

**Alternative Water Conservation Policy Tools for Oklahoma Water Systems.** 2009-2010. OWRRI. D. Adams, M. D. Smolen, L. Sanders. State: $50,000.

**Southern Region Watershed Resource Management Project.** 2008-2012. USDA/CSREES. M. D. Smolen. Federal: $80,000. Special Projects Program 9/1/08-8-31-09 M. D. Smolen, D. Adams, H. Zhang, D. Hamilton, J. Sallee, L. McCowan-Ferrier. $65,335. Total: $145,335.

**Planning Retreat for Environmental Quality and Waste Management Team.** 2008-2009. OCES. M. D. Smolen, et al. Total: $8,500.

**Water Conservation Programming and Website Development for Coordinating Extension and Research for the Environmental Quality and Waste Management Team.** 2008-2009. OCES. M. D. Smolen, L. Sanders, M. Kizer, R. Daugherty, et al. Total: $27,808.

**Deliberative Forum Framework for Water Issues for the Environmental Quality and Waste Management Team.** 2008-2009. OCES. R. Daugherty, C. Bess, M. D. Smolen, L. Sanders, L. McDaniel Total: $19,011.

**Oklahoma Water Law Handbook for the Environmental Quality and Waste Management Team.** 2008-2009. OAES/OCES. D. Adams, S. Ferrell, M. D. Smolen, L. Sanders OAES: $14,572; OCES: $18,407; Total: $32,979.

**Oklahoma Tribal Institute for On-Site Wastwater Treatment Systems.** 2007-2008. US EPA. M. D. Smolen, M. Kizer, L. McCowan OSU: $18,101; Federal: $32,750; Total: $50,851.

**Development of a Stakeholder Involvement Component for the 2005 Oklahoma Comprehensive Water Plan (Listening Sessions).** 2007-2011. OWWRI/OSU. M. D. Smolen, M. Kizer, L. Sanders, J. Schatzer, R. Daugherty, L. McCowan, S. Williams. OWRRI: $86,240; OSU: $26,662; Total: $112,702.

**Communication, Coordination and Public Information for the Environmental Quality and Waste Management Team.** 2006-2008. OCES. M. D. Smolen, et al. $18,000.

**Grand Lake Education Support.** 2006-2008. EPA, OCC, and OSU. M. D. Smolen. EPA/OCC: $49,000; OSU: $32,667; Total: $81,667.

**Partners Cooperating to Enhance Rural Waste Management Programs and Protect Natural Resources.** 2006-2007. USDA and RUS. G. Doeksen, S. Kimball, M. D. Smolen, L. McCowan Total: $82,000.

**Reducing Nutrient Loss from Lawn, Garden, Parks and Golf Courses in the Grand Lake.** 2005-2008. EPA and OCC. H. Zhang, D. Martin, M. D. Smolen Federal: $119,933; State: $79,837; Total: $199,770.

**Bioretention Cell Design, Evaluation and Technology Development in Grand Lake Watershed.** 2005-2008. EPA and OCC. G. Brown, D. E. Storm, M. D. Smolen. Federal: $249,313; State: $166,206; Total: $415,519.

**Soil Sampling Technique and Nutrient Variability Demonstration in a Nurtrient Limited Watershed.** 2004-2008. EPA and OCC. H. Zhang, M. D. Smolen. Federal: $28,402; State: $18,935; Total: $47,337.

**Water Quality Collaborative Conference – 1890, 1862, and 1994 Land Grant Institutions.** 2004-2005. USDA/CSREES. M. D. Smolen. Federal: $5,000.

**Southern Region Watershed Management.** 2004-2008. USDA/CSREES. M. D. Smolen. Federal: $308,960.

**Nonpoint Source Education Program for Spavinaw Creek Watershed.** 2004-2007. OCC. M. D. Smolen, J. Hollenback, M. Beem, B. Ross. OCC: $172,848; State: $116,120; Total: $288,968.

**Drinking Water Education for Under-Served Communities.** 2003-2007. USDA/CSREES. M. D. Smolen, L. McCowan. USDA: $250,000.

**Erosion Control on Rural Unimproved Roads in Stillwater Creek Watershed.** 2002-2006. OCC. M. D. Smolen, D. Turton, D. Wright, M. Hinkston. EPA: $102,600; OSU: $68,400; Total: $171,000. (Completed)

**Nonpoint Source Education Program in Stillwater Creek Watershed.** 2002-2006. OCC. M. D. Smolen, B. Barfield, D. Martin, D. Hillock, M. Schnelle, T. Bidwell, P. Bolin. Federal: $87,000; State: $58,000; Total: $145,000. (Completed)

**A Nutrient Management Decision Support System for the Eucha Basin.** 2002-2005. USDA/CSREES and EPA. M. Matlock, I. Chaubey, B. Haggard, D. E. Storm, M. D. Smolen, W. Focht. Federal: $686,000.

**Oklahoma Green Country Watershed Education Project.** 2001-2004. USDA/CSREES. M. D. Smolen and W. Ross. Federal: $267,000. (Completed)

**Illinois River Basin Education Program (Continuation).** 2000-2002. USDA/CSREES. Federal: $56,700. Total: $94,500. (Completed)

**National Advisory/Leadership Team for Cooperative Extension Water Quality Program.** 1999-2002. USDA/CSREES. Federal: $100,142. (Completed)

**Demonstration of Best Management Practices in the Salt Fork Watershed**. 1997-2001. US EPA. M. D. Smolen, D. E. Storm, G. Cuperus, R. Gribble, J. Stiegler, G. Johnson, G. Krenzer, R. LeValley, S. Price, H. Zhang. Federal: $90,000; OSU: $60,000; Total: $150,000. (Completed)

**Water Quality Special Project.** USDA/CSREES. 1999-2002. Federal: $80,000. (Completed)

**Well Head Protection Education in the South Canadian Watershed**. 1997-2001. US EPA. M. Beem, N. Lansford, M. D. Smolen. Federal: $90,000; State: $60,000; Total: $150,000. (Completed)

**Little Deep Fork.** 2/2001-9/2001. US EPA and OCC. Federal: $20,000; Total: $33,333. (Completed)

**Southern Region Watershed Management.** 2000-2004. USDA/CSREES. Federal: $208,000.

**State Water Quality Program (ODA).** 1995-2001. Oklahoma Department of Agriculture. Total: $210,000. (Completed)

**Illinois River Basin Non-Point Source Management.** 1991-1997. US EPA and OCC. Federal: $40,400; Total: $67,334. (Completed)

**Battle Branch Hydrologic Unit Area Project.** 1990-1998. USDA/CSREES. Federal: $560,000; Total: $840,000. (Completed)

**Peacheater Creek Hydrologic Unit Area Project.** 1991-1999. USDA/CSREES. Federal: $425,000; Total: $637,500. (Completed)

**Water Quality Initiative.** 1990-1999. USDA/CSREES. Federal: $500,000; Total: $1,000,000.

**Trailer-Mounted Stream Hydrology Models for Youth and Adults**. 1999-2000 US EPA. B. Chambers, M. Beem, M. D. Smolen, and W. Ross. Federal: $24,980. (Completed)

**Farm*A*Syst /Home*A*Syst.** 1999-2000**.** USDA/CSREES. M. A. Kizer and M. D. Smolen. Federal: $10,000; Total: $15,000. (Completed)

**Well Head Protection and Water Testing in Rural Minority Communities**. 1999-2000. USDA/CSREES. R. Vick, M. D. Smolen, K. Williams. (Langston University). Federal: $33,500; Total: $41,040. (Completed)

**Technical Assistance for the Establishment and Maintenance of Riparian Corridors**. 1998-2000. U.S. EPA and OCC. M. D. Smolen. Federal: $57,390; OSU: $38,260; Total: $95,650. (Completed)

**Estimating Watershed Level Nonpoint Source Loading for the State of Oklahoma**. 1998-1999. U.S. EPA and OCC. Lead PI: D. E. Storm; Co-PI: D. Gade, M. S. Gregory, M. D. Smolen, C. T. Haan. Federal: $25,000; OSU: $16,667; Total: $41,667. (Completed)

**Technical Assistance to Improve the Quality of Ground Water-Surface Interaction**. 1998-2000. U. S. EPA and OCC. Federal: $82,979; State: 55,319; Total: $138,298. (Completed)

**Manure Marketing in Eastern Oklahoma**. 1997-2002. U.S. EPA. D. Peel, D. Hamilton, H. Zhang, and M. D. Smolen. Federal: $100,000; State: $67,667; Total: $167,667. (Completed)

**Environmentally Sound Grazing System for Utilization of Nutrients from Poultry Litter**. 1997-2001. U.S. EPA and OCC. Leading PI: M. D. Smolen, Co-PI: J. Britton, S. Smith, H. Zhang, D. E. Storm. Federal: $185,792; OSU: $123,862; Total: $495,446. (Completed)

**Capture and Recycle Technology for Pollution Prevention in the Nursery Industry.** 1996-2001. U.S. EPA. S. von Broembsen, M. Schnelle, R. Elliott, and M. D. Smolen. Federal: $94,500; State: $63,000; Total: $157,500. (Completed)

**Characterization of Stream bank Erosion on the Illinois River in Northeast Oklahoma.** U.S. EPA and OCC. Lead PI: C. T. Haan; Co-PI: M. D. Smolen, D. E. Storm. Federal: $12,000; OSU: $8,000; Total: $20,000. (Completed)

**Estimating NPS Phosphorus and Sediment Loading to the Upper Deep Fork Watershed**. 3/1/97-9/31/97. U.S. EPA and OCC. PI: D. E. Storm; Co-PI: W. Marshall, M. S. Gregory, M. D. Smolen, C. T. Haan. Federal: $10,000; OSU: $6,667; Total: $16,667. (Completed)

**Management Program for Riparian Wetlands to Protect Water Quality.** 1994-1998. U.S. EPA and OCC. M. D. Smolen and J. Hassell. Federal: $140,000; State: $60,000; Total: $200,000. (Completed)

**Small Farm Animal Waste Education Program.** 1995-1999. U. S. EPA/OCC. D. Hamilton and M. D. Smolen. Federal: $160,000; State: $120,000; Total: $280,000. (Completed)

**Swine Waste Management Education.** 1994-1998. U.S. EPA and OCC. D. Hamilton and M. D. Smolen. Federal: $26,000; State: $17,333; Total: $39,333. (Completed)

**Review of Animal Waste Control Options.** 1994. In cooperation with the University of Oklahoma. Oklahoma Office of Secretary of Environment. M. D. Smolen, P. Norris. $10,000. (Completed)

**Poteau River Comprehensive Watershed Management Program.** 1994-1999. U.S. EPA and OCC. M. D. Smolen, D. E. Storm. Federal: $245,000; OSU: $163,334; Total: $408,334. (Completed)

**Demonstrating BMPs to Protect Surface Water Quality from Land Application of Animal Wastes.** 1994-1996. U. S. EPA and OCC. D. E. Storm, R. Huhnke, E. Allen, N. Basta, M. D. Smolen. Federal: $115,763; Total: $192,938. (Completed)

**Pollution Prevention through "Blue Thumb" Education in the Oklahoma City Metropolitan Area.** G. Cuperus and M. D. Smolen. 1994-1998. U S. EPA and Oklahoma Conservation Commission. Federal: $35,000; State: $23,333; Total: $58,333. (Completed)

**Farm & Ranch Wellhead and Ground Water Assessment - Pilot Program.** 1994-1995. EPA and OCC. M. D. Smolen, M. Kizer, and B. Brown. Federal: **$**66,164; Total: $110,273. (Completed)

**Evaluation of BMPs to Protect Surface Water Quality from Pesticides and Nitrogen Applied to Common Bermudagrass Fairways.** 1995-1998. U.S. Golf Association. J. Baird, R. Huhnke, D. E. Storm, M. D. Smolen. $38,889. (Completed)

**Determining the Nutrient Status of the Upper Illinois River Basin Using a Lotic Ecosystem Trophic Index.** 1994-1995. EPA and OCC. D. E, Storm and M. D. Smolen. $11,612. (Completed)

**Estimating the Nonpoint Source Pollution Loading for the Grand Lake Basin Management Plan.** 1994-1995. EPA and OCC. D. E. Storm and M. D. Smolen. $12,963. (Completed)

**Support for Implementing Effective Statewide Water Quality Programs in Oklahoma.** 1994-Completion. Oklahoma Board of Agriculture. M. D. Smolen and D. E. Storm. $35,000. (Completed)

**Educational Support for Implementation of BMPs in Southwestern Oklahoma.** 1992-1995. EPA and ODA. M. D. Smolen and G. W. Cuperus. Federal: $328,400; State: $220,274; Total: $548,647. (Completed)

**Educational Programming Support to the Illinois River Basin**. 1991-1994. EPA and OCC. .M. D. Smolen. Federal: $40,400; State: $16,160; Total: $56,560. (Completed)

**Tulsa County Urban Water Quality Improvement Project.** 1992-1995. EPA and OCC. M. D. Smolen. Federal: $139,750; State: $93,167; Total: $232,917. (Completed)

**Support for Modification to Farm-A-Syst, Farmstead Assessment Program.** 1992-1993. EPA and ODEQ. M. D. Smolen. Federal: $3,000; Total: $3,000. (Completed)

**Support for Implementing Effective Statewide Water Quality Programs in Oklahoma.** 1993-Completion. Oklahoma Board of Agriculture. D. E. Storm and M. D. Smolen. $35,000. (Completed)

**Evaluating Poultry Litter Management to Reduce Surface Water Contamination.** 1992-1995. USDA..D. E. Storm, R. L. Huhnke, and M. D. Smolen. Federal: $74,677; State: $74,677; Total: $149,354. (Completed)

**Evaluation of Best Management Practices Implementation for the Tipton Wellhead Project.** 1991-1994. OCC. D. E. Storm, M. D. Smolen, and M. A. Kizer. Federal: $25,000; State: $16,667; Total: $41,667. (Completed)

**Illinois River Basin: Treatment Prioritization.** 1991-1994. OCC. D. E. Storm and M. D. Smolen. Federal: $30,780; State: $20,520; Total: $51,300. (Completed)

**Evaluation of Hydrologic/Water Quality Models.** 1993-1994. U.S. Geological Survey. C. T. Haan, D. E. Storm, and M. D. Smolen. Federal: $13,500; State: $27,000; Total: $40,500. (Completed)

**Evaluating Best Management Practices to Control Nitrate Contamination in Ground Water.** 1993-1994. U.S. Geological Survey. D. E. Storm, M. D. Smolen, and M. A. Kizer. Federal: $13,314; State: $26,628; Total: $39,942. (Completed)

**Food and Agricultural Science National Needs Graduate Fellowship Program**. 1995-2000. USDA. Leading PI: D. J. Turton; Co-PI: D. E. Storm, C. T. Haan, R. L. Elliott, G. O. Brown, D. L. Nofziger, N. Basta, M. D. Smolen, M. A. Kizer. Federal: $108,000; OSU: $0; Total: $108,000.

**Food and Agricultural Science National Needs Graduate Fellowship Program**. 1991-1996. USDA. Leading PI: D. E. Storm; Co-PI: C. T. Haan; R. L. Elliott, G. O. Brown, D. L. Nofziger, D. J. Turton, N. Basta, M. D. Smolen, M. A. Kizer. Federal: $108,000; OSU: $0; Total $108,000.

**Food and Agricultural Science National Needs Graduate Fellowship Program.** 1991-1996. USDA. C. T. Haan, R. L. Elliott, G. O. Brown, D. E. Storm, D. L. Nofziger, D. J. Turton, J. F. Stone, M. D. Smolen, M. A. Kizer. Federal: $108,000; OSU: $48,606; Total: $156,600.

**Upper Poteau River Project (Nutrient and Sediment Loading to Wister Lake).** D. E. Storm, M. D. Smolen, C. T. Haan. Combined sources. Oklahoma Department of Agriculture: $47,926; Oklahoma Conservation Commission: $10,833; Oklahoma Department of Pollution Control: $2,406; Oklahoma Agricultural Experiment Station: $46,245. Total: $107,410. (Completed)

**Application of Geographic Information Systems for Developing a Total Maximum Daily Load (TMDL) System for the Upper Poteau River Basin.** 1992-1994. Targeted Research Initiative Program, Oklahoma Agricultural Experiment Station. D. E. Storm, M. D. Smolen, C. T. Haan, G. W. Sabbagh, and M. S. Gregory. Total: $17,000. (Completed)

**Examination of Potential Risks to Water Quality from Animal Waste Applied to Soils of Eastern Oklahoma.** 1990-1992. USDA/SCS. R. L. Huhnke, D. E. Storm, G. O. Brown, M. D. Smolen, B. J. Carter. Federal: $50,000; OSU: $45,000; Total: $95,000. (Completed)

**Basin-wide Pollutant Inventory for the Ilinois River Comprehensive Basin Management Program.** 1992-1994. OCC. D. E. Storm, M. D. Smolen, D. W. Toetz, J. Wilhm, D. J. Turton, and C. T. Haan. Federal: $57,000; State: $24,075; Total: $81,075. (Completed)

**Influence of Media, Fungicide Application Methods and Wetting Agents on the Amount of Fungicides Leaching from Container Grown Crops.** 1992-1994. Targeted Research Initiative Program, Oklahoma Agricultural Experiment Station. S. L. von Broembsen, N. T. Basta, J. M. Dole, and M. D. Smolen. Total: $16,860. (Completed)

**Poultry and swine litter disposal system.** 1992-1993. Targeted Research Initiative Program, Oklahoma Agricultural Experiment Station. D. E. Storm, M. D. Smolen, C. T. Haan, R. L. Huhnke, N. T. Basta, and A. Sharpley. Total: $10,600. (Completed)

**Previous Support (VPI&SU and NCSU):**

**National water quality evaluation project.** 1981-1992. USDA, US EPA. Evaluation and technical assistance to the Rural Clean Water Program. M. D. Smolen and F. J. Humenik. Total: $1.95 million.

**North Carolina Extension Service ground water education and well water testing program.** 1989-1990. USDA Extension Service. F. J. Humenik and M. D. Smolen. Total: $25,000.

**Technical support for state nonpoint source programs.** 1988-1990. US EPA. M. D. Smolen and F. J. Humenik. Total: $289,478.

**Enhancement of the effectiveness of vegetative filter strips by dispersion of agricultural run-off**. 1989. North Carolina, WRRI. E. C. Franklin, J. D. Gregory, and M. D. Smolen. Total: $39,831.

**Natural resource quality in Gaston County phase I: Data base to evaluate quality of natural resources (water quality component).** 1990. Gaston County, NC. M. D. Smolen and M. Levi. Total: $25,800.

**Development of a guidance document entitled `Watershed Screening for Point and Nonpoint Source Impacts and Controls**. US EPA and USDA. M. D. Smolen and F. J. Humenik. Total: $40,436.

**Development of a database system on the performance and selection of agricultural nonpoint source control practices.** US EPA. M. D. Smolen and F. J. Humenik. Total: $38,000.

**Impact of conservation practices and resource management systems on the quantity and quality of surface and ground water: a review of existing data sources.** USDA. M. D. Smolen and F. J. Humenik. Total: $32,992.

**Adaptation of existing material and development of new information for extension water quality programs.** NC Agricultural Foundation. M. D. Smolen. Total: $8,000.

**Development of field manual and video instructional materials for erosion and sediment control.** NC Sediment Control Commission. M. D. Smolen and F. J. Humenik. Total: $118,734.

**Estimation of nonpoint source loading factors for the Chesapeake Bay model.** US EPA and USDA. M. D. Smolen and F. J. Humenik. Total: $77,000.

**Developing fact sheets for preventing water resource contamination from agricultural pesticides.** NC Pollution Prevention Program. M. D. Smolen, R. Maas, and F. J. Humenik. Total: $29,331.

**Educational program for preventive pesticide management and disposal.** NC Pollution Prevention Program. M. D. Smolen, R. Maas, and F. J. Humenik. Total: $29,650.

**Economic analysis of alternative cropland selection algorithms to promote water quality benefits under the Food Security Act of 1985.** US EPA. M. D. Smolen and F. J. Humenik. Total: $64,989.

**Development of design manual for control of sediment from construction sites in North Carolina**. NC Sediment Control Commission. M. D. Smolen and F. J. Humenik. Total: $92,000.

**Guidance document on economic targeting of NPS implementation.** US EPA. M. D. Smolen and F. J. Humenik. Total: $15,700.

**Evaluation of Cooperative Extension's soil and water programs.** USDA-Extension. M. D. Smolen and F. J. Humenik. Total: $75,000.

**Overview and evaluation of the Section 108a Pollution Control Demonstration program.** US EPA, Great Lakes Program. M. D. Smolen and F. J. Humenik. Total: $10,000.

**Best management practice evaluation study.** Virginia State Water Control Board. M. D. Smolen. Total: $119,903.

**Simulating the hydrologic response of small forested watersheds.** US Forest Service. M. D. Smolen. Total: $12,654.

**Predicting soil loss for surface mined areas**. Virginia State Mining and Minerals Research Institute. M. D. Smolen. Total: $20,000.

**Effect of tillage practice on runoff quantity and quality**. Virginia Water Resources Research Center. M. D. Smolen. Total: $10,329.

**Effect of agricultural land use on the chemical quality of runoff and ground water.** Virginia Water Resources Research Center. M. D. Smolen and V. O. Shanholtz. Total: $39,000.

**Workshops, Conferences, and Tours Organized (OSU):**

**Tribal Onsite Waste Treatment. Workshop Organizer.** October 21, 2009. Stroud, OK.

**From Dust Bowl to Mud Bowl: Sedimentation, Conservation Measures and the Future of Reservoirs. Conference Planner.** September 14-16, 2009. Kansas City, KS.

**Southern Region Biennial Water Quality Conferences. Program Chair: 2001, 2003, 2005, 2007.** Sponsored by the Southern Regional Water Quality Program and USDA-CSREES. Gulf Shores, AL., Ruidoso, NM. , Lexington, KY., Fayetteville, AR.

**Southern Region Extension Biennial Water Quality Workshops. 1991-1999. Planning Committee Member.** Sponsored by the Southern Region Extension Water Quality Planning

Committee and the Southern Extension Directors. Atlanta, GA., Charleston, SC., New Orleans, LA., Tulsa, OK. , Raleigh, NC.

**National Extension Water Quality Coordinators Conferences. Program Chair: 1999, 2000, 2001.** Sponsored by USDA-CSREES. St. Louis, MO., San Antonio, TX., Boise, ID.

**Oklahoma Stream Team Conference on Urban Protection. Oklahoma City, OK.** Member of Planning Committee. Sponsored by EPA Region 6 and Southern Region Water Quality Planning Committee, USDA-CSREES. February 2007.

**Water Quality Collaborative Conference, 1890-1862-1994 Land Grant Institutions** Chair of Planning Committee Sponsored by the Southern Region Water Quality Program and CSREES. July 12-14, 2004

**Oklahoma Water Symposium 2003-2007.** Member of Planning Committee. Sponsored by OSU-Environmental Institute.

**Riparian Area Management Workshops.** One-day workshops for technical staffs of NRCS, Extension, Tribes, and other organizations. Conducted at 9 locations around Oklahoma, October 1998 through June 1999.

**Water Quality and Animal Waste Conference.** Oklahoma Chapter of AWRA. Oklahoma City. April 4-6, 1998.

**Water Quality Day Camps**. Three days of water quality day camp were conducted in Adair, Delaware, and Cherokee counties (annually since 1996). Camps were planned and conducted by Water Quality Team members.

**Caring for Planet Earth Display at Tulsa State Fair**. (October 1994-2001) With B. Chambers and an interdisciplinary committee.

**Eco-Camp. Environmental Issues Camp.** (June 1997, 1998) With Joe Bullard, Billie Chambers, Larry Sanders, Marty Green, Becki Rhea, and Marley Beem) Three days of camp for teenage youth were conducted in LeFlore County. Camp was initially funded by EPA Environmental Education Grant.

**Great Plains Animal Waste Conference on Confined Animal Production and Water Quality.** Denver, CO. Great Plains Agricultural Council. Member of Planning Committee. October 1994.

**Storm Water Management and Sediment Control Training for Inspectors, Oklahoma City.** One-day shourt course. Sponsored by the Oklahoma City Department of Public Works and EPA. Developed with the Oklahoma Conservation Commission and Soil Conservation Service. September 1994.

**Regional CAFO Conferences for Producers.** Educational support for animal producers to explain the EPA General Permit for Discharge from Concentrated Animal Feeding Operations (CAFOs). Five one-day conferences were held in: Broken Bow, Muskogee, Ft. Cobb, Enid, and Guymon. November 1993.

**Animal Waste Management, Technical Conference.** Conference to introduce the EPA General Permit for Discharge from CAFOs to the technical support agencies and private consultants. Conducted with the Oklahoma RC&D Council and SCS. Oklahoma City, October 6-7, 1993.

**Storm Water Management and Sediment Control Training for Developers and Contractors.** Sponsored by the Tulsa Builders Association. Developed with the Soil Conservation Service. September 1993.

**Satellite Teleconferences on Greenhouse IPM.** Two educational programs down linked in 26 states. Developed and appeared in water quality segment. July and August 1993.

**Storm Water Management and Sediment Control Training for City of Tulsa Engineers and Inspectors.** Planning committee with the Soil Conservation Service. June 1993.

**Satellite Teleconferences on the EPA Region 6 General Permit for Discharge from Concentrated Animal Feeding Operations (CAFOs).** Two broadcasts, one afternoon telecast to answer questions for Extension and SCS staffs, a second evening telecast to answer questions from livestock producers. Both conferences featured EPA staff, the Commissioner of Agriculture, and the CAFO work group. April 21, 1993.

**Tulsa Blue Thumb Volunteer Water Quality Training.** Thirty-three volunteers participated in eight-week water quality training. February through April 1993.

**Tulsa Resource Management Conference.** Planning committee and presenter with the Tulsa Conservation District, Extension Service, SCS, and the Oklahoma Conservation Commission. Tulsa, Oklahoma. February 1993.

**Southern Region Meeting of Extension Agricultural Engineers, Plan Exchange, and Housing Specialists.** Planning committee and presenter. San Antonio, October, 1992.

**Oklahoma Greenhouse Grower's Association seminar.** Planning committee and presenter. with the Greenhouse IPM committee, October 1992.

**ASAE Urban Storm water and Sediment Control Tour.** Planned and conducted at the 1992 ASAE Summer Meeting. Charlotte, NC. June 1992.

**Basic Greenhouse Production Practices Shortcourse.** Developed by the Greenhouse IPM Program to include ground water quality. June 1992.

**Oklahoma-Arkansas Illinois River Tour.** Three-day tour of the Illinois River Watershed coordinated with the Oklahoma Conservation Commission, the Arkansas Conservation Commission, the Arkansas Cooperative Extension Service and the Oklahoma Cooperative Extension Service. May 1992.

**Extension Water Quality Workshops.** Oklahoma Cooperative Extension, Northeast, Northwest, Southwest, and Southeast Districts, November 1991 through April 1992.

**Public Meetings for the Illinois River Basin project.** Four separate public meetings for Decision Makers, Nursery and Greenhouse Operators, Recreation Industry Operators, and Agricultural Producers to discuss water quality concerns and explore possible solutions. Conducted with the Oklahoma Conservation Commission. February 1992.

**Battle Branch Tour of Best Management Practices for Public Officials.** Adair County Cooperative Extension Service. June 1991.

**Teaching:**

**Environmental Impact Assessment. ENVR 4530.** Oklahoma State University, Stillwater, OK. 2008. 3 credit hours.

**Stream Health Assessment BAE 6520.** Oklahoma State University, Stillwater, OK. 2008. 3 credit hours.

**Woolpert Research Scholars BAE 4400.** Oklahoma State University, Stillwater, OK. 2007. 3 credit hours.

**Special Topics in Rangeland Science: Rangeland Hydrology** Chihuahua, Mexico. June 6-17 and July 4-15, 2005

**Stormwater and Sediment Control Short Course** – (with Ellen Stevens and Reid Christianson), Three-day short course for Oklahoma Department of Environmental Quality.Oklahoma City, OK, June 2004.

**Stormwater and Sediment Control Short Course** – (with Ellen Stevens and Reid Christianson), Three-day short course for Oklahoma, Stillwater, OK June 2004.

**Stormwater and Sediment Control Short Course** – (with B.J. Barfield and Ellen Stevens), Three-day short course for New Mexico. Santa Fe, NM, February 2003 and June 2003.

**Stormwater and Sediment Control Short Course** – (with B.J. Barfield), Two-day short course. Texas Natural Resources Conservation Commission. Summer 2000.

**BIOEN 3113, Quantitative Biology for Engineers,** (with D. E. Storm, and B. J. Barfield). Oklahoma State University. Spring 1997.

**Stormwater and Sediment Control Design Short Course** – (with B. J. Barfield, C. T. Haan, and J. Hayes) Four-day short course taught Summer 1995, 1996, and 1997.

**ES 5100, Assessment and Management of Nonpoint Source Pollution in Oklahoma,** Oklahoma State University. Spring 1994.

**Parametric Watershed Modeling** - VPI&SU Agricultural Engineering Department (Graduate Level)

**Microcomputer Programming** - VPI&SU Agricultural Engineering Department

**Dissertations (7) and MS Theses (7):**

**Steven Bond.** 2010. MS Thesis Topic: Rhizospheric Phosphorus and Nitrogen Reduction and Increased Infiltration in Bioretention Cells wiith Vascular Plants.

**Adrian Sherman**. 2009. MS Thesis Topic: Occurrence and Distribution of Fecal Indicator Bacteria with Respect to Urban and Rural Land Uses.

**Khrishna E. Wright**. 2007. MS Thesis Topic: Feasibility of Aquifer Storage Recovery for the Mustang, Oklahoma Well Field.

**Carol V. Crouch**. 2004. PhD Dissertation Topic: An Investigation of Perceptions, Concerns, and Awareness of Environmental Issues among American Indians.

**Maifan Silitonga**. 2004. PhD Dissertation Topic: Framework for Evaluating Impact of a CAFO in a Wellhead Protection Area. Oklahoma State University. Dissertation. Oklahoma State University.

**Peter A. Kish**. 2004. PhD Dissertation Topic: Effects of Roundup, Glean, Aatrex, and Their Active Ingredients (Glyphosate, Chlorsulfuron, and Atrazine) On Periphyton Communities Studied by Using Matlock Periphytometer and Bottle Tests. Oklahoma State University.

**Brian R. Tucker**, 2000. MS Thesis Topic: Poultry Litter Management Strategies to Reduce Phosphorus and Nitrogen in Runoff from Pastures. Oklahoma State Univeristy.

**Thomas Jack Alexander**, 1999. PhD Dissertation Topic: Evaluation of Performance and Management Strategies for a Nursery Irrigation Recycling System Designed for Pollution Control. Oklahoma State University.

**Scott Stoodley**, 1998. PhD Dissertation Topic: Economic Feadibility of Riparian Buffer Implementation – Case Study: Sugar Creek, Caddo County, Oklahoma. Oklahoma State University.

**Maifan Silitonga**, 1998. MS Thesis Topic: Evaluation of Risk Screening Versus Oklahoma Risk-Based Corrective Action for the Wellhead Protection Areas. Oklahoma State University.

**Joseph D. Eigel**. 1989. PhD Dissertation Topic: Application of Body Conforming Grids to Drainage Problems. North Carolina State University. (Co-Chairman with R. W. Skaggs).

**Andrezj Baniukiewicz**. 1983. PhD Dissertation Topic: Approximate Analytical Solutions for Modeling Subsurface Flow. Dissertation. Virginia Polytechnic Institute and State University. (Co-Chairman with C. Y. Kuo)

**Eugene R. Yagow.** 1983. MS Thesis Topic: Erosion and Nutrient Loading Characteristics in Two Small Agricultural Watersheds in Piedmont Virginia. MS Thesis. Virginia Polytechnic Institute and State University.

**Susan M. Trapanese**. 1982. MS Thesis Topic: A Systems Approach to Evaluate Water Quality Oriented Land Management Plans. MS Thesis. Virginia Polytechnic Institute and State University.

**Publications:**

**Books (and Book Chapters):**

**Best Management Practices to Reduce Pesticide and Nutrient Runoff from Turf.** 2000. Baird, J. B., N. T. Basta, R. L. Huhnke, G. V. Johnson, M. E. Payton, D. E. Storm, C. A. Wilson, M. D. Smolen, D. L. Martin and J. T. Cole. p 268-293 in Fate and Management of Turfgrass Chemicals. J. M. Clark and M. P. Kenna. (eds.). Am. Chem. Soc. Washington, D.C. 20036.

**North Carolina Erosion and Sediment Control Field Manual.** 1991. North Carolina Department of Natural Resources and Community Development. Raleigh, NC.

**North Carolina Erosion and Sediment Control Planning and Design Manual.** 1987. North Carolina Department of Natural Resources and Community Development. Raleigh, NC.

**Videos (14):**

**Natural Creekbank Vegetation.** Co-author with Marley Beem. Stream Trailer Project. 2001.

**Oklahoma Aqua Times, Unit 4.** Developed script and acted in video. Oklahoma 4-H Program. 1992.

**Principals of Erosion and Sediment Control on Construction Sites.** Developed script and oversaw production. North Carolina Cooperative Extension Service. 1990.

**Use of Vegetation for Erosion and Sediment Control on Construction Sites.** Co-author with Juanita Lichthardt. North Carolina Cooperative Extension Service. 1989.

**Fact Sheets and other Extension Publications:**

**Whose Water is it Anyway? Comparing the Water Rights Frameworks of Arkansas, Oklahoma, Texas, new Mexico, Georgia, Alabama, and Florida.** M. D. Smolen, A. Mittelstet, B. Harjo. E-1030. Division of Agricultural Sciences and Natural Resources, OSU 2012.

**Phosphorus and Water Quality,** Fact Sheet BAE-1512. M. D. Smolen. Division of Agricultural Sciences and Natural Resources, OSU 2009.

**Treatment Methods for Removal of Pharmaceuticals and Hormones from Drinking Water.** Fact Sheet BAE-1523. M. A. Kizer, M. D. Smolen. Division of Agricultural Sciences and Natural Resources, OSU 2008.

**PPM Plus: A Tool to Aid in Nutrient Management Plan Development.** Fact Sheet BAE-1522. M. J. White, D. E. Storm, H. Zhang, M. D. Smolen. Division of Agricultural Sciences and Natural Resources, OSU 2008.

**Riparian Buffer Systems for Oklahoma.** Co-authored with R. D. Harmel, A. Fallon, and M. D. Smolen. Oklahoma Cooperative Extension Water Quality Series. OSU Facts 1517. 1999.

**Using Vegetation for Erosion Control on Construction Sites.** S. Morrow and M. D. Smolen. Oklahoma Cooperative Extension Water Quality Series. OSU Facts 1514. 1999

**Drinking Water Testing.** H. Zhang and M. D. Smolen. Oklahoma Cooperative Extension Water Quality Series. OSU Facts 878 (revised). 1999.

**Home*A*Syst.** N. Gurski, M. D. Smolen, S. Williams, B. Brown and M. A. Kizer. Five fact sheet-worksheet combinations**.** 1995.

**Pesticides in Residential Areas -- Protecting the Environment.** J. Criswell, L. Nofziger, J. Pruitt, G. Cuperus, M. D. Smolen. Oklahoma Cooperative Extension Water Quality Series. OSU Facts 7461. 1994.

**Pesticides in Ground Water.** J. H. Stiegler, J. T. Criswell, M. D. Smolen. Oklahoma Cooperative Extension Water Quality Series. OSU Facts 7459. 1993.

**Information Sheet: EPA Region 6 General Permit of Concentrated Animal Feeding Operations (CAFOs).** Publication developed with USDA Soil Conservation Service. 1993.

**EPA's General Permit for Storm Water Discharge from Concentrated Animal Feeding Operations (CAFO): Question and Answer Series Supplement. Numbers 1 through 4.** Developed by the CAFO Work Group to explain details of the general permit. 1993.

**Using Biocontrol Agents in the Commercial Greenhouse.** L. A. Topliff, K. N. Pinkston, S. L. von Broembsen, M. A. Schnelle, M. D. Smolen. Oklahoma Cooperative Extension. IPM in the Greenhouse Series. OSU Facts 6713. 1991.

**Other Water Quality Series Publications from WQI Committee (9):**

**Water Rate Structure: A Tool for Water Conservation in Oklahoma.** D. Adams, C. Boyer, M. D. Smolen**.** Oklahoma Cooperative Extension Fact Sheet AGEC-1017. 2009.

**Phosphorus and Water Quality.** M. D. Smolen**.** Oklahoma Cooperative Extension Fact Sheet BAE-1521. M. D. Smolen. 2007.

**Capturing and Recycling Irrigation Runoff as Pollution Prevention Measure.** S. L. von Broembsen and S. K. Wilson. BAE-1518. 2000.

**Emergency Water Supplies.** M. Beem, M. Fram, B. Brown, and A. Guest. Oklahoma Cooperative Extension Water Quality Series.BAE-1519. 1999.

**Household Hazardous Waste Handling Procedures to Prevent Environmental Contamination.** Oklahoma Cooperative Extension Water Quality Series. OSU Facts F-7463. 1994.

**Rinsing and Disposing of Pesticide Containers.** R. T. Noyes, P. E. Norris, and J. T. Criswell. Oklahoma Cooperative Extension Water Quality Series. EPP-7462. 1994.

**Riparian Forest Buffers.** S. Anderson and R. Masters. Oklahoma Cooperative Extension Water Quality Series. BAE- 5034. 1993

**Ground Water Quality and Treatment.** M. A. Kizer. Oklahoma Cooperative Extension Water Quality Series. BAE-1512. 1991.

**Community Wellhead Protection Programs.** Freshwater Foundation. Oklahoma Cooperative Extension Water Quality Series. BAE- 890. 1992

**Citizen Involvement in Pollution Control in Oklahoma.** P. Norris. Oklahoma Cooperative Extension Water Quality Series. BAE- 877. 1991

**Handbooks and Manuals:**

**No Till Cropping Systems in Oklahoma**. M. D. Smolen. Oklahoma Cooperative Extension E-996. Chapter 3. 2007.

**Water Quality Handbook for Nurseries**. M. Schnelle, Criswell, Cuperus, Fallon, Kizer, Smolen, von Broembsen, White. Oklahoma Cooperative Extension E-951. 37p. 1998.

**Riparian Area Management Handbook.** A. Fallon and M. D. Smolen. Oklahoma Cooperative Extension E-952. 97p. 1998.

**Pollution Prevention at Exploration and Production Sites in Oklahoma. Best Management Practices for Prevention and Control of Erosion and Pollution.** B. A. Fulgenzi and M. D. Smolen. Oklahoma Cooperative Extension E-940. 42p. 1995.

**CAFO Record Book**. A record keeping system for compliance with the EPA permit for discharge from concentrated animal feeding operations. Designed by the CAFO Work Group. 1993.

**Oklahoma Water Quality Reference Notebook.** General reference notebook for Oklahoma Cooperative Extension Offices. Contains fact sheets, and subject matter brochures and reports relating to water quality and pollution control for farms and rural and residences. Developed by the Water Quality Initiative Committee for use in County Extension Offices. 1992.

**Reports:**

**Water Quality and Water Quantity Issues in the Southern Region: an Overview.** 1999. M. D. Smolen. Southern Perspectives Volume 3, Number 3. Southern Rural Development Center.

**Land application of sewage sludge: Impact on water quality**. Smolen, M. D. (1995). Land Application of Biosolids: A review of research concerning benefits, environmental impact, and regulations of applying treated sewage sludge. (ed. Basta, N. T.) Cooperatively published by the Oklahoma Agricultural Experiment Station and Center for Agriculture and the Environment Division of Agricultural Sciences and Natural Resources. No. B-808, p. 27-30.

**Policy Options for Animal Waste Management in Oklahoma**: A Report to the Governor's Animal Waste Task Force. (1994) Mark Meo, Michael D. Smolen, Patricia E. Narris, Julie M. Smith, John L. Roll, Charles L. Jacques, Patrice M. Mareshal. Available from the Science and Public Policy Program, University of Oklahoma, Norman, OK.

**Articles in Refereed Journals and Refereed Research Bulletins (46):**

Mahler, R., Smolen, M.D., Borisova, T., Boellstorff, D.E., & Sochacka, N. The National Water Survey Needs Assessment Program. Journal of Natural Resources & Life Sciences Education (in review).

Adams, D. C., Allen, D., Borisova, T., Boellstorff, D., & Smolen, M.D. The Influence of Water Attitudes, Perceptions, and Learning Preferences on Water-Conserving Actions. *Journal of Natural Resources & Life Sciences Education* (in review).

Boellstorff, D.E., Borisova, T., Smolen, M.D., Evans, J.M., Calabria, J, Adams, D.C., Sochacka, N., McFarland, M.L., & Mahler, R.L. Audience Preferences for Water Resource Information from Extension and Other Sources. *Journal of Natural Resources & Life Sciences Education* (in review).

Borisova, T., Useche, P., Smolen, M.D., Boellstorff, D., Sochaka, N., & Calabria, N. Differences in Opinions about Surface Water Quality Issues in the Southern United States: Implications for Watershed Planning Process. *Journal of Natural Resources & Life Sciences Education* (in review).

Borisova T., J. Evans, M. Smolen, M. Olexa, D. C. Adams, J. C. Calabria. (2012). Current and Future Water Availability: Public Opinion in the Southern US States. (accepted for publication).

Borisova, T., Adams, D., Smolen, M., & McFarland, M. Public Preferences for Water Resource Topics and Information Sources in the Southern United States. 11236RIB, *Journal of Extension* (in press).

Borisova, T., Adams, D., Olexa, M., Evans, J., Calabria, J., & Smolen M. Water availability, precipitation, and climate change: Public opinion in southern US states. 11191RIB, *Journal of Extension (JOE)* (in press).

Borisova, T., A. Flores-Lagunes, D. Adams, M. Smolen, M. McFarland, D. Boellstorff, and B. Mahler, 2012. “Participation in Volunteer-Driven Programs and Their Effects on Homeowners’ Landscaping Practices.” Journal of Extension, [online] 50(3)(2012):3RIB4. http://www.joe.org/joe/2012june/rb4.php.

Mittelstet, Aaron R., Michael D. Smolen, Garey A. Fox, and Damian C. Adams, 2011. Comparison of Aquifer Sustainability Under Groundwater Administrations in Oklahoma and Texas. Journal of the American Water Resources Association (JAWRA) 47(2):424-431.

Demissie, T., D. E. Storm, M. S. Friend, N. T. Basta, M. E. Payton, M. D. Smolen, H. Zhang. 2010. Rainfall Sequence Effects on Phosphorus Loss in Surface Runoff From Pastures That Received Poultry Litter Application. American Society of Agricultural and Biological Engineers. 53(4): 1147-1158.

White, M. J., D. Storm, P. Busteed, M. D. Smolen, H. Zhang, G. Fox. 2010. Quantitative Phosphorus Loss Assessment Tool for Agricultural Fields. Environmental Modelling and Software 25(10): 1121-1129

White, M. J., D. E. Storm, M. D. Smolen, H. Zhang. 2009. Development of a Quantitative Pasture Phosphorus Managmeent Tool Using the Swat Model. Journal of the American Water Resources Association 45(2):397-406.

Turton . D. J., M. D. Smolen and E. Stebler. 2009. Effectiveness of BMPs in Reducing Sediment from Unpaved Roads in the Stillwater Creek, Oklahoma Watershed. Journal of the American Water Resources Association. 45:1343-1351.

Gallimore, L. E., N. T. Basta, D. E. Storm, M. E. Payton, R. H. Huhnke, and M. D. Smolen. 1999. Water treatment residual to reduce nutrients in surface runoff from agricultural land. Journal of Environmental Quality, 28: 1474-1478.

Matlock, M. D., D. E. Storm, M. D. Smolen and M. E. Matlock. 1999. Determining the lotic ecosystem nutrient and trophic status of three streams in eastern Oklahoma over two seasons. Aquatic Ecosystem Health and Management, 2:115-127.

Matlock M. D., D. E. Storm, M. D. Smolen, M. E. Matlock, A. McFarland and L. Hauck. 1999. Development and application of a lotic ecosystem trophic status index. Transactions of the ASAE, 42(3):651-656. (ASAE Honorable Mention Paper Award. 2000).

Toetz, D., D. E. Storm, T. Tetong, T. Mihue, M. D. Smolen. 1999. Assessment of predictors of stream eutrophication potential. Journal of American Water Resources Association, 35(4): 853-865.

Matlock M. D., M. E. Matlock, D. E. Storm, M. D. Smolen and W. J. Henley. 1998. A quantitative passive diffusion periphytometer for lotic ecosystems. Journal of the American Water Resources Association, 34(5): 1141-1147.

Ramanarayanan, T.S., D. E. Storm, M. D. Smolen. 1998. Analysis of Nitrogen Management Strategies Using EPIC. Journal of American Water Resources Association, 34(5): 1199-1211.

Cole, J. T., J. H. Baird, N. T. Basta, R. L. Huhnke, D. E. Storm, G. V. Johnson, M. E. Payton, M. D. Smolen, D. L. Martin, and. J. C. Cole. 1997. Influence of buffers on pesticide and nutrient runoff from bermudagrass turf. Journal of Environmental Quality. 26:1589-1598.

Hession, W. C., D. E. Storm, C. T. Haan, K. H. Rechhow, M. D. Smolen. 1996. Risk analysis of total maximum daily loads in an uncertain environment using EUTROMOD. Journal of Lake and Reservoir Management. 12(3): 331-347.

Ramanarayana, T. S., D. E. Storm, M. D. Smolen. 1995. Seasonal pumping variation effects on wellhead protection area delineation. Water Resources Bulletin 31:3, 1-10.

Matlock, M. D., D. E. Storm, S. L. Burks, M. D. Smolen, C. T. Haan. 1994. An ecological risk assessment paradigm using the Spatially Integrated Model for Phosphorus Loading and Erosion (SIMPLE). Journal of Aquatic Ecosystem Health, 3:287-294.

Chen, Z., D. E. Storm, M. D. Smolen, C. T. Haan, M. S. Gregory, and G. J. Sabbagh. 1994. Prioritizing nonpoint source loads for phosphorus with a GRASS-modeling system. Water Resources Bulletin, 30:589-593.

Spooner, J. L., W. Wyatt, S. W. Coffey, S. L. Brichford, J. A. Arnold, M. D. Smolen, G. D. Jennings, and J. A.. Gale. 1991. Fate and Effects of Pollutants. Nonpoint Sources. Water Pollution Control Federation, 63(4):527-536

Arnold, J. A., F. M. Nevils, Jr., and M. D. Smolen. 1991. North Carolina's Sediment Control Program. Public Works, 122(13): 48-50.

Spooner, J., L. Wyatt, W. Berryhill, A. L. Lanier, S. L. Brichford, M. D. Smolen, S. W. Coffey, and T. B. Bennett. 1989. Nonpoint Sources (review of 1988 literature). J. Water Pollution Control Federation, 61(6):911-924.

Coffey, S. W., W. S. Berryhill, D. W. Miller, and M. D. Smolen. 1989. Making Molehills Out of Mountains: Using Models to Identify Nonpoint Sources. Lake Line, North American Lake Management Society, 9(4):14-18.

Bottcher, A. B. and M. D. Smolen. 1988. Crackdown on NPS Pollution. Agricultural Engineering, 69(3):6-7.

Hoag, D., S. Lilley, M. D. Smolen, M. Cook, and J. Wright. 1988. Extension's Role in Soil and Water Conservation. J. Soil and Water Conservation, 43(2):126-129.

Maas, R. P., S. L. Brichford, M. D. Smolen, and J. Spooner. 1988. Agricultural Nonpoint Source Control: Experiences from the Rural Clean Water Program. Lake and Reservoir Management, 4(1):51-56.

Spooner, J., S. L. Brichford, R. P. Maas, M. D. Smolen, D. A. Dickey, G. Ritter, and E. Flaig. 1988. Determining the Statistical Sensitivity of the Water Quality Monitoring Program in the Taylor Creek-Nubbin Slough, Florida Project. Lake and Reservoir Management. 4(2):113-124.

Humenik, F. J., M. D. Smolen, and S. A. Dressing. 1987. Nonpoint Sources - Where Do We Go from Here? J. Environmental Science and Technology, 21:737-742.

Younos, T. M., M. D. Smolen, S. Mostaghimi, and J. Spooner. 1987. Fate and Effects of Pollutants: Nonpoint Sources (review of 1986 research). J. Water Pollution Control Federation, 59(6):487-490.

Spooner, J., C. A. Jamieson, R. P. Maas, and M. D. Smolen. 1987. Determining Statistically Significant Changes in Water Pollutant Concentrations. Lake and Reservoir Management, 3:195-201.

Maas, R P., A. Patchak, M. D. Smolen, and J. Spooner. 1987. Benefit/cost Analysis of Nonpoint Source Control in the Tillamook Bay, Oregon, Watershed. Lake and Reservoir Management, 3:157-162.

Maas, R. P., M. D. Smolen, and S. A. Dressing. 1985. Selection of Critical Areas for Control of Nonpoint Source Pollution. J. Soil and Water Conservation, 40:68-71.

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Younos, T. M., M. D. Smolen, C. A. Eiden, R. P. Maas, S. A. Dressing, and T. A. Dillaha. 1984. Review of Nonpoint Source Pollution Research. J. Water Pollution Control Federation, 56:689-692.

Trapanese, S. A., M. D. Smolen, and T. M. Younos. 1984. A Systems Approach for Agricultural Land Management and Water Quality Control. Transactions of ASAE, 27:817-821.

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