Setback Standards and Alternative Compliance Practices to Satisfy CAFO Requirements: An assessment for the DEF-AG group

Dave Hansen, PhD, University of Delaware, Research and Education Center;

Jennifer Nelson, Delaware Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation, Nonpoint Source Program; and

Jennifer Volk, Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Watershed Assessment Section

October 9, 2009

This assessment was designed to facilitate discussions between officials from the Environmental Protection Agency (EPA) and the State of Delaware's Department of Natural Resources and Environmental Control (DNREC) and Department of Agriculture (DDA), regarding CAFO permit requirements. The State of Delaware's current Regulations Governing the Control of Water Pollution address permit requirements for Concentrated Animal Feeding Operations (CAFOs) and include three options for setback standards. These options include a 100-foot manure application setback, a 35-foot vegetated buffer, and alternative compliance practices for drainage ditches and other surface waters. The alternative practices allowed by State CAFO regulations include manure incorporation and/or winter cover crop plantings.

The DDA, on behalf of the Delaware Federal Advisory Group (DEF-AG), convened several scientists and researchers from DNREC and the University of Delaware's Research and Education Center (the CAFO-BMP Workgroup) to evaluate the effectiveness of various alternative practices. This resulting analysis indicates that the practice of applying cover crops on a field, in most scenarios, is as effective as a 35-foot vegetated buffer, and always more effective than a 100-foot application setback. This review supports the use of cover crops as an acceptable alternative to the 100-foot application setback and the 35-foot vegetative buffer. In contrast, very little published and peer reviewed information regarding the practice of incorporation was found. As a result of this analysis, the DDA plans to propose minor revisions to their current regulatory setback standards.

Methodology

The CAFO-BMP workgroup proposed using the work done by the Chesapeake Bay Program (CBP) for this assessment since all work done by the CBP is thoroughly reviewed by a Scientific and Technical Advisory Committee as well as experts from each partner agency. It was determined that the CBP watershed and water quality models would not allow for a simple BMP comparison and would require significant staff time and expertise. The underlying calculations, loading rates, and efficiencies used in the CBP models however could be used in an empirical spreadsheet model. Published CBP reports were consulted to obtain these procedures and values.

Assumptions and constraints:

- As written, the EPA and State regulations prohibit the application of CAFO manure, litter, and process wastewater in the 100-foot application setback. Since this application setback affects a significant amount land area, farmers will almost certainly apply inorganic nutrients (commercial fertilizer) in this area instead. As such, the area within the 100-foot setback will have the same land use loading rate (same amount of N and P applied) as the rest of the crop field. This is referred to as the "Base Load."

- It is assumed that any buffers will be grass buffers versus forest buffers, although forest buffers would provide a greater water quality benefit.

- The CAFO-BMP workgroup was unable to identify published and scientifically reviewed efficiencies and methodologies to calculate the effects of manure incorporation.

- It is assumed that for any scenarios with cover crops, the cover crop will be applied to the entire field and there will be a manure application setback of 10-feet. The setback provides a margin of safety for application equipment and other field application challenges. Additionally, while cover crops are applied as a seasonal BMP, it is commonly assumed that the efficiency of the practice applies to the annual load of the field because the cover crop captures nutrients when they are most likely to leach or run off from the field- that is, when the field is fallow.

- Various field sizes (10 acres, 100 acres, and 1,000 acres) and shapes were considered (Figure 1):

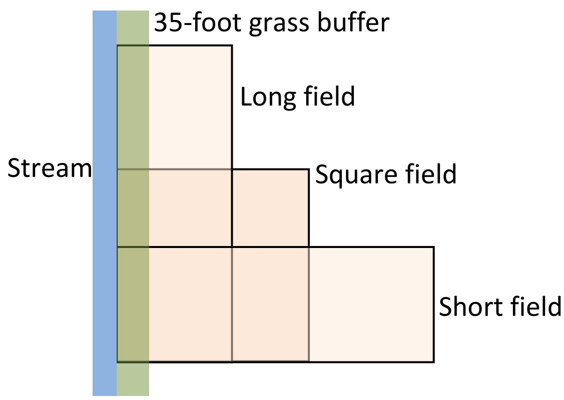


Figure 1: Various filed sizes and shapes considered in BMP effectiveness analyses.

Land use loading rates (Linker et al., 2000):

Land use loading rates are coefficients that represent the annual export of a substance per unit area and time. Often, these values are expressed as pounds per acre per year (lb/acre/year). Natural land uses, such as forests, have lower land use loading rates than anthropogenic land uses like agriculture and developed areas. The land use loading rate values shown in Table 1 below are for total nitrogen (TN) and total phosphorus (TP).

Table 1. Examples of Land Use Loading Rates	TN (lb/acre/year)	TP (lb/acre/year)
Conventional Tillage and Conservation Tillage Cropland	21	1.9
Pasture (Grass Buffer)	8	0.3

BMP efficiencies (Simpson and Weammert, 2009):

BMP efficiencies describe how effective a best management practice is at reducing the pollutant load from the area the practice treats. Efficiencies are expressed as percentages where the higher the percentage, the more effective the practice is at reducing pollutants. A range of efficiencies for riparian grass buffers and cover crops are presented below.

Because buffers treat both overland runoff and ground waters that flow within and through the riparian zone, their effectiveness depends on the hydrology and geology of the region. The CBP has determined efficiencies for all of the hydrogeomorphic regions found in the Chesapeake Bay Watershed. Within Delaware, the major hydrogeomorphic regions are inner coastal plain, outer coastal plain well drained, and outer coastal plain poorly drained (Figure 2; Table 2). For the following calculations, we have utilized the average efficiencies (35% TN and 42% TP).

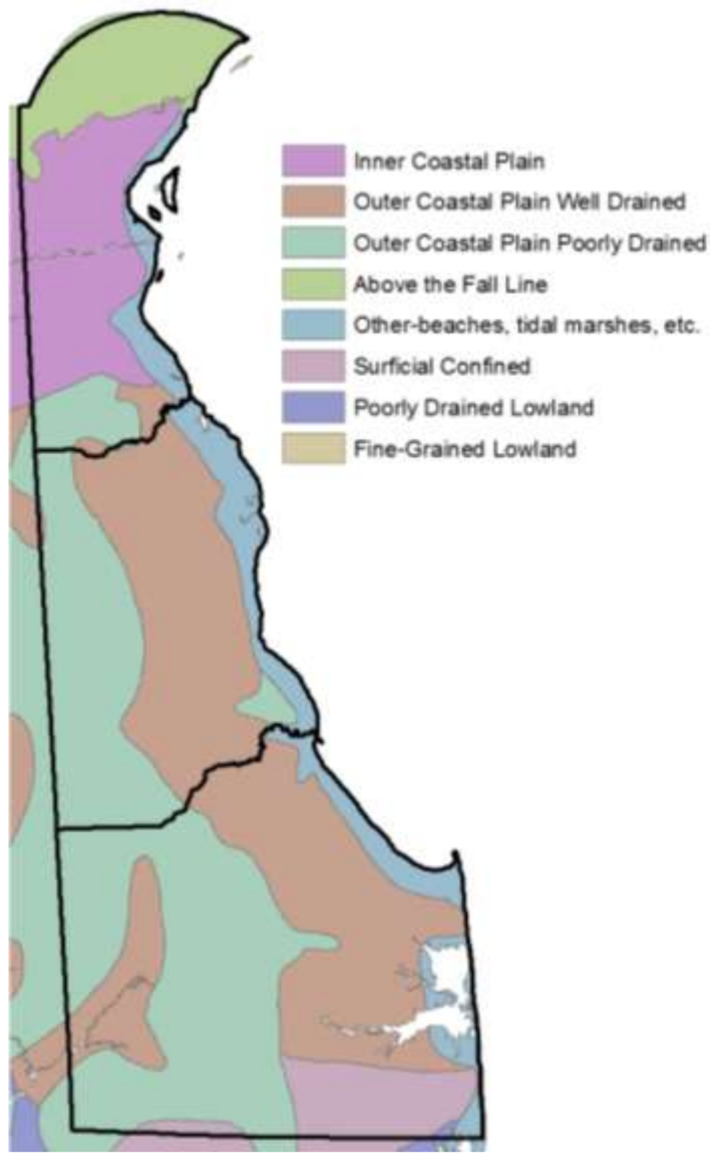


Figure 2. Hydrogeomorphic Regions of Delaware.

Table 2. Riparian Grass Buffer Efficiencies	TN %	TP %
Inner Coastal Plain	46	42
Outer Coastal Plain Well Drained	21	45
Outer Coastal Plain Poorly Drained	39	39
Average	*35*	*42*

The effectiveness of cover crops, especially with respect to TN, depends on a number of factors including type of species planted, method of installation, and timing of planting. The values displayed in Table 3 below represent the efficiencies anticipated if cover crops are planted during standard planting times (2 weeks prior to average frost date up to average frost date; roughly October 1 – October 15). If cover crops are planted earlier (any time prior to 2 weeks before average frost date; roughly before October 1), the efficiency will be higher since there will be more time for the cover crop to take up nutrients. Efficiencies for TN when the crop is planted early range from 27-45% and average 35% while the TP efficiency is 15%. If cover crops are planted later than the standard planting time (from the average frost date to 3 weeks later; roughly October 16 – November 5) the efficiency will decrease. Efficiencies for TN when the crop is planted late range from 11-19% and average 15% while the TP efficiency is 0%. We have used the average values for standard plantings in the following calculations (30% TN and 7% TP).

Table 3. Cover Crop Efficiencies – Standard Planting	TN %	TP %
Drilled Rye	41	
Other Rye	35	
Drilled Wheat	29	7
Other Wheat	24	
Drilled Barley	29	
Other Barley	24	
Average	*30*	*7*

Calculations (CBP, 1998):

The land use loading rates and BMP efficiencies discussed above are utilized in the following calculations in order to compare nutrient loads for a variety of scenarios. In the scenarios, the field shape and orientation is changed, which impacts the percentage area of the field treated by the respective BMPs. In each case, the final value represents the load from the entire field.

Base Load: The cropland loading rate is applied to the entire field area since inorganic fertilizer could be applied to the 100-foot setback area; hence no load reduction is applied.

Cropland loading rate (lb/acre/yr) X total acres = lb/yr

Grass Buffer Load: This calculation has several parts. First, the area where the buffer is installed is considered a land use change and the load from this part of the parcel will decrease as a result of converting from a higher loading cropland use to a lower loading pasture use (a). Second, each acre of buffer is assumed to treat 2 upland acres so that the buffer efficiency is applied to the cropland loading rate for these acres (b). Finally, any portion of the parcel not within the actual buffer area or the upland area treated by the buffer will have the typical cropland loading rate (c).

Buffer area load (lb/yr) + crop area load (lb/yr) – upland load reduction (lb/yr) = lb/yr

(a) Buffer area load: pasture loading rate (lb/acre/yr) X buffer acres = lb/yr

(b) Upland load reduction: 2 X buffer acres X cropland l.r. (lb/acre/yr) X efficiency = lb/yr

(c) Crop area load: cropland loading rate (lb/acre/yr) X cropland acres = lb/yr

Cover Crop Load: Since cover crops are assumed to be installed on the entire field, the cover crop efficiency is applied to the cropland loading rate for the entire parcel area.

Cropland loading rate (lb/acre/yr) X acres X efficiency = lb/yr

Results

The nutrient loads resulting from the 100-foot application setback, 35-foot buffer, and use of cover crops on the entire field were examined for fields of various sizes and shapes (refer to Figure 1). Resulting TN and TP loads (lb/year) are shown in Tables 4 and 5, respectively, for long, square, and short fields ranging between 10, 100, 1,000 acres. Figures 3 and 4 show the areal unit loading (lb/acre/year) for each of these scenarios. The percentage of the entire field that the buffer encompasses is displayed along the 2nd y-axis in both of these figures.

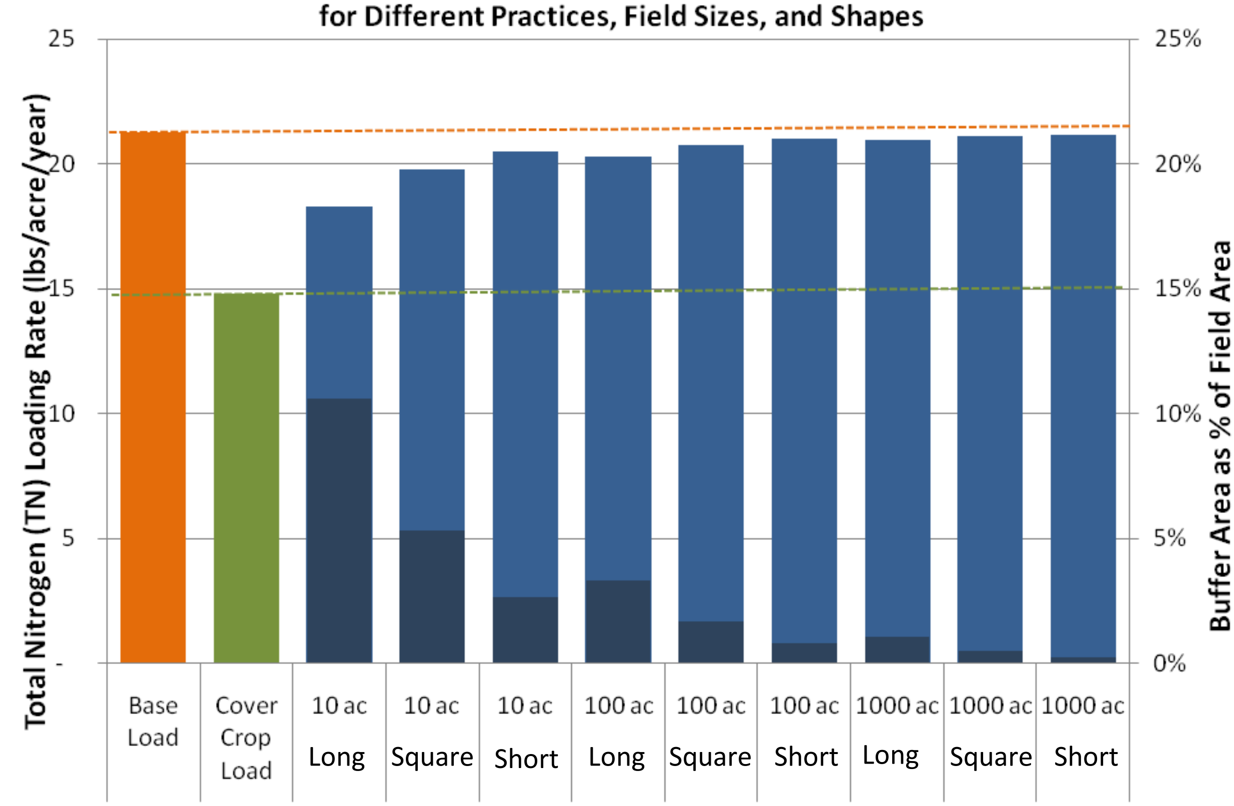
Since there are no constraints prohibiting the application of inorganic nutrients within the 100-foot setback, no load reductions are applied to the 100-foot application setback areas and this is considered the “Base Load” from fields of any size or shape. Therefore, fields with buffers will always have lower loads than fields with just the application setback. However, in all but the smallest fields, a field that is entirely treated with cover crops has a lower phosphorus load than the same field treated by a 35-foot buffer. This is because buffer strips can occupy more than 10% of the area of a small field.

Table 4. Total Nitrogen Results

	Acres	Base Load	Buffer Load	Cover Crop

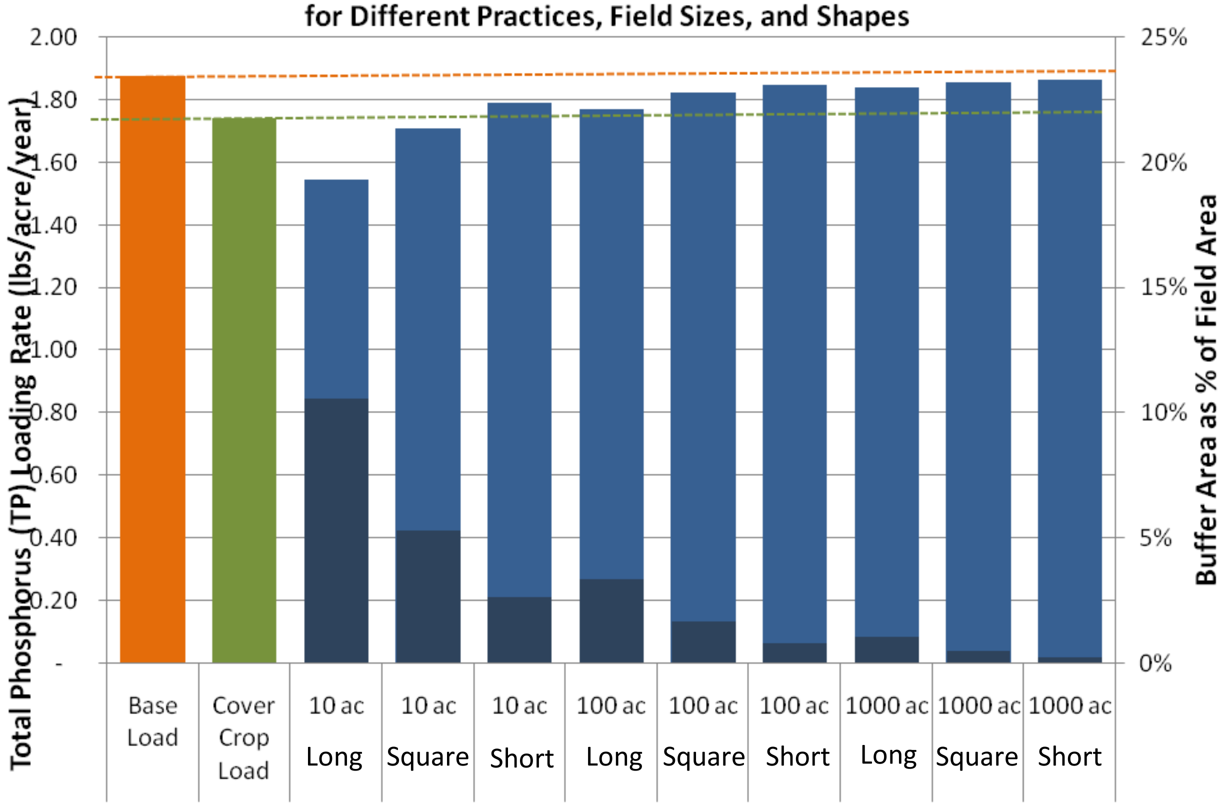
	Acres	Base Load (lb/yr)	Buffer Load (lb/yr)	Cover Crop Load (lb/yr)
Long Field	10	212	183	148
Square Field	10	212	198	148
Short Field	10	212	205	148
Long Field	100	2,124	2,030	1,480
Square Field	100	2,124	2,077	1,480
Short Field	100	2,124	2,100	1,480
Long Field	1,000	21,238	20,942	14,796
Square Field	1,000	21,238	21,090	14,796
Short Field	1,000	21,238	21,164	14,796

Figure 3. Total Nitrogen Loading Rate Comparison for Different Practices, Field Sizes, and Shapes



Long Field	10	19	15	17
Square Field	10	19	17	17
Short Field	10	19	18	17
Long Field	100	187	177	174
Square Field	100	187	182	174
Short Field	100	187	185	174
Long Field	1,000	1,874	1,841	1,743
Square Field	1,000	1,874	1,857	1,743
Short Field	1,000	1,874	1,866	1,743

Figure 4. **Total Phosphorus Loading Rate Comparison for Different Practices, Field Sizes, and Shapes**



Discussion

These loading estimates are based on average efficiency values for both vegetated buffers and cover crops. The effectiveness of both practices varies depending on numerous conditions including local hydrology and geology, plant species utilized, timing and method of installation, and (in the case of a buffer) maintenance. In certain extreme cases of actual installation, the average values may significantly over or underestimate the resulting nutrient loads. There is no reason to expect more variation in the alternative cover crop approach than in the standard vegetative buffer approach.

It should be noted that there are benefits and drawbacks of each practice. Individual farmers can perform cost-benefit analyses to determine the best option for their operation. Buffers tend to be more expensive to install and take land out of production. But, they are only installed once and remain in place indefinitely. Cover crops take no land out of production, but are an annual practice and planting often depends on weather and cropping cycles. Thus, cover crops may require additional compliance monitoring and procedures. Both buffer and cover crop practices, however, are easier to verify and enforce than a 100-foot application setback. Furthermore, a 100-foot application setback affects a significant amount of land area and therefore justifies the decision to apply commercial fertilizer. The group felt that most farms will go out of their way to apply commercial fertilizer and keep the manure application setback area in production. If this option is chosen, little or no nutrient reductions will be realized. In addition, a setback would not provide any sediment reduction benefit.

For all cover crop scenarios, it was assumed (and will be required through proposed regulatory changes) that a 10-foot application setback will be imposed. The setback provides a margin of safety for application equipment and other field application challenges. Practitioners noted that farmers often leave a similarly sized strip along ditches alone and allow grassed vegetation to grow, and in affect they have self-impose a production setback. If the 10-foot application setback is treated as a production setback and the area is allowed to vegetate, additional nutrient reductions will be realized. However, due to a lack of data regarding buffer effectiveness estimates at such a narrow width, this analysis was not able to quantify those potential effects. When allowed to vegetate, the 10-foot setback will add an extra margin of safety to the nutrient benefits already expected from the cover crop implementation.

High P Soils: Members of DEF-AG inquired if the effectiveness of the best management practices investigated would change when implemented on high phosphorus soils. The CAFO-BMP work used the same BMP efficiencies recently adopted by the CBP. The CBP hired the Mid-Atlantic Water Quality Program (MAWP), housed at the University of Maryland (UMD), to develop definitions and effectiveness estimates that reflect the average operational conditions representative of the entire watershed. This meant that they attempted to incorporate the "variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data" (Simpson and Weammert, 2009).

Additionally, the MAWP-UMD exercise ensured that all data was thoroughly peer reviewed and when more specific efficiencies were developed for certain BMPs, they ensured that an adequate amount of data was available to support those specific classifications. If a substantial amount of data on buffer and cover crop effectiveness on high P soils was available, they would have differentiated those efficiencies. Thus, the effectiveness estimates utilized in this analysis should adequately reflect the expected nutrient reductions when these practices are implemented on high P soils.

Anecdotally, it seems that any BMP – 100-foot application setback, buffer, and cover crop – will have a lower effect on total loads reduced when used on soils overwhelmed with phosphorus. A recent article by Hoffmann et al. (2009) reviewed phosphorus retention in riparian buffers. They found that when there is significant P accumulation, the P retention efficiency may weaken and possibly result in P release, especially if the riparian area is flooded. Regardless of degree of effectiveness, other researchers have promoted the use of both buffers and cover crops as viable options to manage high phosphorus soils. An excerpt from *Building Soils for Better Crops, 2nd Edition* (Magdoff and van Es, 2000), recommends four methods to deal with high P soils: reduce the amount of P in feed and the amount of P excreted; reduce applying extra P; reduce runoff and erosion;

and continue monitoring soil P levels. Cover crops are identified as a means to reduce the application of extra P to soils since they supply nitrogen and organic matter and minimize the need to apply other fertilizers. Cover crops and buffers were both identified as practices to reduce runoff and erosion, which minimizes the impacts of the extra P on surface waters. Thus, a comparison of BMPs under high P conditions would not likely differ from the result of a comparison of BMPs under average conditions, which we have produced.

Recommendation

Based on this analysis, the DDA is requesting that EPA accept cover crops (along with a minimum 10-foot application setback) as an alternative to the 100-foot manure application setback and the 35-foot vegetated buffer, so that farmers may choose any one of these three options. This request would result in modifications to the current State of Delaware CAFO regulations (Appendix A). Two primary changes would occur.

First, the current regulations provide an option of manure incorporation with or without cover crops and smaller application setbacks. Very little published and peer reviewed information on methods to calculate the nutrient reductions due to incorporation were found in this analysis. Therefore, since we cannot validate the effectiveness of this practice using similar calculations, DDA is comfortable with eliminating this option.

Secondly, the current regulations provide for different reduced application setbacks based on the type of water feature present (drainage ditches versus other surface waters) and whether incorporation and cover crops are being utilized individually or in combination. This two-prong approach is no longer necessary since this analysis has proven that cover crops used on the entire field, regardless of whether that field is located next to a ditch or other surface water feature, will in fact be as effective if not more effective than the 100-foot setback and 35-foot vegetative buffer. Additionally, since setback requirements only limit the application of manure and not inorganic nutrients, setback requirements are not expected to produce additional nutrient reductions, especially for larger setbacks where it will more advantageous for the farmer to ensure productivity in that area. When manure application setbacks are smaller, it will be less advantageous for the farmer to expend the time and effort to apply additional inorganic nutrients in the setback area and they may even allow the area to go out of production and turn into a narrow vegetative buffer.

The majority of Delaware's surface waters are impaired by excess nutrients, and both buffers and cover crops have been proven to be valuable, cost-effective BMPs. To protect and improve the quality of our waters, pollution control strategy analyses have shown that implementation of both of these practices must be substantially increased across most of the state. By having both buffers and cover crops as compliance options, this may be a mechanism to increase implementation of these needed practices. Additional scenarios that contemplate combinations of these and other BMPs can still be considered for trading or credit programs.

References

CBP, 1998. *Chesapeake Bay Watershed Model Application and Calculation of Nutrient and Sediment Loadings – Appendix H: Tracking Best Management Practice Nutrient Reductions in the Chesapeake Bay Program*, a report of the Chesapeake Bay Program Modeling Subcommittee, Annapolis, MD. http://www.chesapeakebay.net/content/publications/cbp_12439.pdf

Hoffmann, C.C., C. Kjaergaard, J. Uusi-Kamppa, H.C.B. Hansen, and B. Kronvang. 2009. *Phosphorus Retention in Riparian Buffers: Review of Their Efficiency.* Journal of Environmental Quality 38: 1942-1955.

Linker, L., G.W. Shenk, and K. Hopkins. 2000. *Watershed Model Phase 4.3 Calibration Rules.* A report to the Chesapeake Bay Program, Annapolis, MD. http://archive.chesapeakebay.net/temporary/mdsc/calibration_0700.pdf

Magdoff, F. and H. van Es, 2000. *Building Soils for Better Crops, 2nd Edition.* Sustainable Agriculture Research and Education, 240pp.

Simpson, T. and S. Weammert. 2009. *Developing Nitrogen, Phosphorus and Sediment Reduction Efficiencies for Tributary Strategy Practices – BMP Assessment: Final Report*. A report from the University of Maryland/Mid-Atlantic Water Program to the Chesapeake Bay Program. http://archive.chesapeakebay.net/pubs/bmp/BMP_ASSESSMENT_FINAL_REPORT.pdf

Appendix A – Proposed Regulatory Revisions - Excerpt from the Regulations Governing the Control of Water Pollution (9 DE Reg. 440 (9/1/05))

9.4 The Concentrated Animal Feeding Operation (CAFO)

9.4.6 Requirements for General CAFO NPDES Permits

9.4.6.2.5 **Manure and processed wastewater application setbacks**. These setbacks are defined as the distance between the application area and any down gradient surface waters, open tile line, intake structures, sinkholes or other conduits to surface waters. The direct application of manure or processed wastewater to ditches or surface waters is prohibited. These setback standards are provided as three options:

9.4.6.2.5.1 **100-foot application setback**, or

9.4.6.2.5.2 **35-foot vegetated buffer** where applications of manure, litter, and process wastewater are prohibited, or

9.4.6.2.5.3 **Alternative compliance practices** as follows:

9.4.6.2.5.3.1 ~~**For surface waters other than drainage ditches:**~~

~~9.4.6.2.5.3.1.1~~ **~~5~~10-foot application setback** for the field under the conservation practice of **~~incorporation or~~ planting a winter cover crop** following the crop receiving manure, litter or process wastewater.

~~9.4.6.2.5.3.1.2 **15-foot application setback** for the field under the conservation practice of **incorporation within 2 days of application and planting a winter cover crop** following the crop receiving manure, litter or process wastewater.~~

~~9.4.6.2.5.3.2 **For drainage ditches**:~~

~~9.4.6.2.5.3.2.1 **20-foot application setback** for the field under the conservation practice of **incorporation or planting a winter cover** crop following the crop receiving manure, litter or process wastewater.~~

~~9.4.6.2.5.3.2.2 **10-foot application setback** for the field under the conservation practice of **incorporation within 2 days of application and planting a winter cover crop** following the crop receiving manure, litter or process wastewater.~~

9.4.6.2.5.3.~~3~~2 Any alternative compliance practice approved by the Commission.